Post-maternity Body Changes

Obstetric Fundamentals and Surgical Reshaping

Mónica Gomes-Ferreira
Jesús Olivas-Menayo
Editors

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ISBN 978-3-030-43839-5 ISBN 978-3-030-43840-1 (eBook)
https://doi.org/10.1007/978-3-030-43840-1

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Preface

Post-Maternity Body Changes: Obstetric Fundamentals and Surgical Reshaping is an international collaborative which brings together experts in different fields of obstetric and plastic surgery with a special focus on maternal body changes.

This book is the first to represent the union of obstetric and aesthetical visions in woman body changes after and during pregnancy. On the one hand, we develop the obstetric view of the several obstetric changes from pregnancy to the puerperium, also emphasizing the birth process, explaining how it can cause changes in the female body. On the other hand, we cover all the medical and surgical procedures to restore or improve the women physical aspect after childbirth and breastfeeding from an aesthetic view. The junction of both fields will facilitate the comprehension of maternal body changes as a unique subject, making it easier for the different specialists who treat this condition. Readers could also become aware of how and why performing the mommy makeover procedures for both novel and experienced doctors is challenging.

The format of each part of the book includes some initial chapters that introduce the topic to be developed, dedicated to the anatomical, physiological, and hormonal changes during and after pregnancy. After that, following chapters will be developed to explain the various techniques, and the most pioneering, used to restore the anatomical change in each part of woman's anatomy.

We hope that when reading this book, you became well versed in the detail involved in assessing women with post-maternity body changes. The incredibly relevant experience and different point of view shared by both co-authors throughout this book should educate and expand your knowledge in this evolving field of maternal body changes.

We will apport several representative images and diagrams of each anatomical change. In addition, we will supply each part of the book, with many videos explaining, in detail, every surgical technique that will improve your understanding. Enjoy!

Lisbon, Portugal — Mónica Gomes-Ferreira
Lisbon, Portugal — Jesús Olivas-Menayo

Contents

Part I

Introduction

Post-maternity Body Changes

1

Miguel Oliveira da Silva and Joaquim Silva Neves

Take-Home Points

- Pregnancy induces maternal anatomical and physiological body changes. Puerperium is the time following term or post-term delivery.
- Pregnancy, labour, and delivery can significantly change maternal body and body image: weight gain, *abdominum striae*, body fat redistribution, breast and abdominal augmentation, hair growth, skin changes (*striae gravidarum* and pigmentation with cloasma/melasma, capillary telangectasia), vaginal and bladder prolapse (cystocele), hemorrhoids, and edema are among the most common and obvious body change examples.
- Maternal body changes are frequently a serious subject of concern and sometimes even dissatisfaction and fear for women. This is an issue for women and future parents that health professionals should comprehensively approach within routine antenatal and prenatal care.
- Concerns and fears are related not only to maternal and fetal outcomes but also sometimes specially to body image, self-esteem, and self-image changes.
- Self-identification body changes are not only due to personal, media and societal ideals (e.g. feminist theories about the so-called 'tirany of the reproduction'), myths and misconceptions. The partner anxiety and misinformation is also one additional reason to approach and overcome such issues, including the partner as an essential dialogue element.
- A considerable number of women believe that their maternal body changes often have a negative influence on their future image and sexuality, considerably decreasing their sexual performance and capacity in general, as well as their partner erotic attraction, with less ability to give and receive shared pleasure.
- Some women consider and deeply regret that their body will never become the same after their pregnancy and childbirth.
- Cosmetic female surgery after childbirth is a serious and increasing ongoing individual and societal concern that deserves a comprehensive approach by health professionals and public policies.

1.1 Introduction

All these facts, concerns, anxieties, and misconceptions allow us to consider the necessity of all maternal health professionals (nutritionists

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_1

included) to cooperate in order to help mothers to achieve their desirable body aspect and image. This is not necessarily the same exact body aspect existing before pregnancy, being sometimes essential to cope with natural and permanent body changes. Sometimes, the mediatic and trendy 'thin post-pregnancy ideal' cannot always be achieved and lived as an obsessive goal. This is a must for most mothers and couples.

Maternal health professional team has a unique role dealing with both maternal body changes prevention and recovery. Midwifes, general practitioners, obstetricians, nutritionists, social workers should work together and cooperate in order to achieve such goals.

However, some previous basic and evidence-based facts and principles should never be denied or avoided.

Every informed and empowered future pregnant, every partner, and citizen should a priori be educated, learned, and know about the general facts:

1. Maternal adaptations during pregnancy are physiological phenomena;
2. Pregnancy is not a time to lose weight, neither for calories restriction diets;
3. Exercise during pregnancy has no contraindications; it shall be provided and performed according to appropriated indications and surveillance;
4. The older the mother is, the more difficult and time consuming it can be for postpartum recovery and/or achievement of the desired body goal;
5. Many women become obese with such a condition after pregnancy;
6. Maternal and childhood obesity can be a consequence of excessive weight gain during pregnancy;
7. Post-partum is the right time for those women to exercise in order to achieve their physical goals. Additional interventions may be needed to assist women in returning to pre-pregnancy fitness;
8. Some maternal body changes cannot frequently be avoided neither predicted and have not (yet?) full successful treatment (such is the case of abdominal, legs, and breast *striae gravidarum*); and
9. Sexuality (also during pregnancy and after) is not limited or restricted to genitalia contacts.

Body change concerns and sexual phantasies and inhibitions must straightly be approached by maternal health team during pre-conception and antenatal care, with women and their partner.

Misconception and misinformation can be so devastating that sometimes doctors and women consider a priori a preventive cesarean section 'at request' (with no maternal neither fetal indication), in order to prevent future sexual dysfunction due to a bladder or vaginal descent or a too much large vaginal introitus.

Such an attitude – as a rule – is bad maternal medicine and bad ethics. It is not at all evidence based, no studies supports such a measure, which is a preconception or, worse, sometimes an unethical and artificially induced business.

After delivery, the routine practice and trend now supports and encourages so early as possible ambulation and discharge.[1]

Numerous well-controlled studies confirm the many advantages of early ambulation and early discharge.

Even so, it is mandatory to be very cautious when comparing different data, routines, and practices among different post-partum health realities.

Many variables shall be considered and not biased, including responsibility level in different maternal health players, namely, eventual specialized and trained midwifes puerperium home access.

Immediate post-maternity is the time when genital and urinary tract involutions can occur, reduce size from the vagina, rugae reappearance, perineum lacerations or stretching (leading to vaginal outlet relaxation), damage on pelvic floor

[1]It is interesting to compare, even among the European Member States, how different are the routine discharge timings from maternity after a normal vaginal delivery with no maternal and fetal complications—it ranges from several hours to several days.

Of course, the existence of home personal post maternal care availability has to be considered.

(predisposing for organ prolapse), changes in mammary glands (nipples cleanliness; skin fissures; painful and negative influence on milk production; cracks and risk for bacterial invasion), breast feeding, after pains, *lochia*, home return, menstruation cycle activation, and ovulation. Abdominal wall can be flacid and soft, with atonic muscles including rectus abdominis separation.

Exercise can be practiced soon (a few days, progressively) after a normal delivery.

The follow-up with comprehensive team takes care of breasts and nipples, adequate diet, bowel, and bladder functions.

It should as well prevent, diagnose, and treat any mild maternal depression or 'postpartum blue'.

Return to menstruation and ovulation can occur by the third week after delivery in women not breastfeeding and taking a dopamine inhibitor (e.g. bromocriptine).

In such cases, it is advisable to start hormonal contraceptive 15 days after delivery, not forgetting that sexual activity and sexual intercourse return cannot be surely predictable, which changes according to different people and different cultures.

1.2 Conclusion

Most of post maternity body changes are partly a consequence of previous life style, before and during pregnancy. Not all body changes can be avoided or predicted, due to body maternal adaptations to pregnancy. In any case, it is mandatory that the whole maternal health team – since pregnancy is planned or has started – has a proactive and comprehensive approach with woman. Excessive weight gain and obesity have to be prevented, self-esteem, sexuality, intimacy, and body image concerns are part of a global maternal health care and dialogue. Post-maternity evaluation of body changes and sexual life should also be an integrative part of a modern and global women's health approach.

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Part II

Pregnancy, Birth and Postpartum

Physiological and Hormonal Changes During Pregnancy

2

Tatiana Costas and Mónica Gomes-Ferreira

Take-Home Points

- Understanding pregnancy as a dynamic and physiological process in the woman's body.
- Mostly, the physiological changes are due to the influx of fetal-placental hormones.
- All the physiological changes are for the sake of developing and nurturing the fetus.
- Although other changes may be "adverse effects" of this process, thankfully most of them are resolved on their own.

2.1 Introduction

The pregnant woman's body is a place of dynamic change for the sake of the developing fetus. There are anatomical, physiological, and biochemical alterations in the woman's body even before fertilization continuing throughout pregnancy and puerperium.

Most of these adaptations occur due to the influence of hormonal changes and the creation of new organs such as the placenta. Mother, fetus, and placenta interrelate to cover the new metabolic and spatial needs of the new life.

These adaptations are physiological during pregnancy but could be interpreted as pathological in a non-pregnant woman. For this reason, it is important to establish a difference between physiological changes during pregnancy and diseases prior to gestation. That is our objective as obstetricians.

Pregnancy is not an illness. The daily life of an expecting woman could be similar to her previous state in absence of medical or gynecological complications. Many of her activities may be adapted with better, comfortable positions or a reduction of her working week. Maintaining her daily life with normality (with adaptations) as far as possible is important for her good physical, mental, and social well-being [1].

2.2 Physiological Maternity Changes

The fetal-placental unit (from the 13th week onwards, before this function is developed by the corpus luteum) secretes hormones and proteins (estrogen, progesterone, human chorionic gonadotropin [β-HCG] and human placental lactogen [HPL]) that are going to manage the function and the changes in almost all the body systems. Also, the corpus luteum produces other hormones such as relaxin, which seems to play a role in renal hemodynamics.

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_2

Although hormonal secretion is the main factor at play, part of the adaptations corresponds to anatomical changes due to the uterine enlargement and the new arrangement of the organs in the pelvic, abdominal, and thoracic spaces [1].

2.2.1 Reproductive Tract

The most dramatic changes occur in the reproductive tract, mainly in the uterus:

2.2.1.1 Uterus

During pregnancy, the uterus is transformed into a relatively thin-walled muscular organ with enough capacity to accommodate the fetus, placenta, and amniotic fluid. In the non-pregnant woman, this organ weighs 70 g and is almost solid (except for a cavity of 10 mL or less). At the end of pregnancy, the content averages 5 L. The uterus has achieved a capacity that is 500–1000 times greater than in its non-pregnant state and it weighs nearly 1100 g [1]. This enlargement is due to myocyte hypertrophy, accumulation of fibrous tissue and an increase in elastic tissue, which explains why the uterus walls are thin.

The main stimulation in this process comes from estrogen and, to a lesser extent, from mechanical distension in the first weeks (Fig. 2.1). The role changes from the 12th week onward. Also, at the 12th week, the uterus has become too large for the pelvis and it starts to displace adjacent organs [1].

While the uterus is growing, it is necessary for the uterine blood flow to increase accordingly. For that reason, estrogen causes vasodilation that increases uterine flow. Furthermore, uterine vessels irrigate the placenta and this rise in flow is essential for the function of the placenta.

2.2.1.2 Cervix

The cervix is formed by collagen-rich connective tissue (mostly), smooth muscle, and cervical glands. Estrogen increases vascularization, edema, and hypertrophy and hyperplasia of the cervical gland [2].

This enlargement is necessary to maintain the pregnancy, as well as dilation and repair in the postpartum period.

In addition, the proliferation of columnar endocervical glands gives the cervix a red and bloody look with a friable surface (Arias Stella reaction) (Fig. 2.2). These cells produce a greater amount of mucus. This mucus, with the action of progesterone, creates an immunological and anti-infective barrier due to the cytokines and immunoglobulins it contains [3].

The friable surface of the cervix during pregnancy produces slight bleeding with minimal

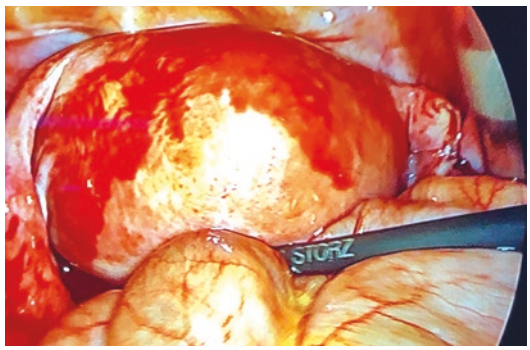

Fig. 2.1 Extrauterine pregnancy in week 8 in the right fallopian tube (letter A). Despite gestation taking place outside the uterus, it is growing according to gestational age due to hormonal mechanisms

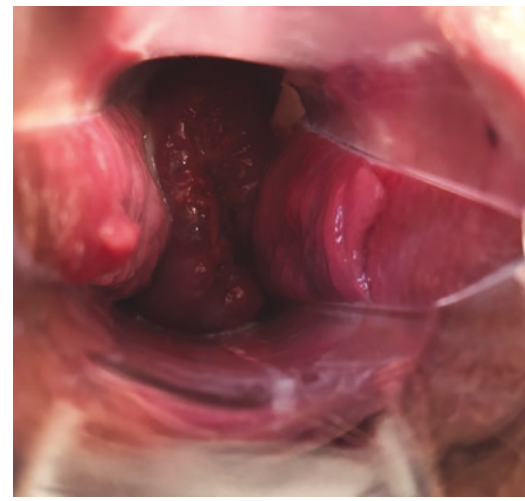

Fig. 2.2 Cervix eversion of a woman in week 13 viewed through speculum. The friable surface with the cervical glands can be observe (arrowhead)

trauma that may scare a pregnant woman. For this reason, this condition should be explained to them.

In the same way, a cytology or Pap test is advisable before pregnancy due to the fragility of the tissue at this stage, which has the same look as atypical glandular cells.

2.2.1.3 Ovaries and Fallopian Tubes

Due to hormonal mechanisms, the maturation of new follicles is suspended. The corpus luteum that maintains pregnancy until the sixth or seventh week and produces progesterone disappears at that moment. For that reason, ovarian surgical interventions before these weeks could result in abortion.

Fallopian tubes suffer slight hypertrophy during pregnancy, but they are not involved in a general increase in size [1].

2.2.1.4 Vagina, Perineum

With the same mechanism as the cervix, the tissue of the vagina suffers an increase in its vascularity and hyperemia. This results in a violet color called "Chadwick sign" (Fig. 2.3).

In order to prepare the vagina for the partum where the mucosa tissue grows, connective tissue is reduced, and smooth muscle cells could increase. Also, there is a growth in papillary epithelium in order to maximize cervical secretions and the production of lactic acid by Lactobacillus acidophilus, so as to maintain an acidic pH. This factor strengthens vulvovaginal infections [1].

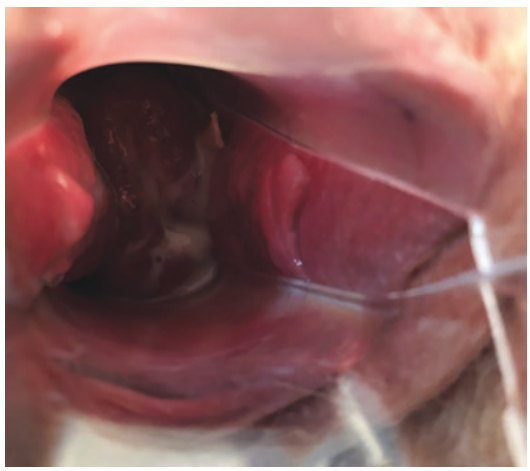

Fig. 2.3 Vagina and vulva through speculum (woman in week 13). The "Chadwick sign" should be identified in the right side of the image (left labium minus of the patient, under the arrowhead)

A summary of the entire reproductive tract can be seen in Table 2.1.

2.2.2 Breasts

Breasts must be understood as dynamic organs, and during pregnancy and breastfeeding, they are going to suffer the most dramatic alterations. They are inactive during most of a woman's life, and they have an aesthetic function. During pregnancy, some changes are needed in order to activate the function of the gland: breastfeeding.

These changes can be attributed to various hormones such as estrogens, progesterone, and prolactin. Vascularization, skin, tissue composition, and pigmentation changes are examples of the multiple adaptations to which breasts are going to be subjected. These changes may resolve spontaneously, or they could require surgical procedures.

2.2.2.1 Basic Physiology

Breasts are an ectodermal derivative (specialized skin). They are exocrine glands that are able to secrete milk thanks to a differentiation process. Hormones and protein factors such as prolactin, aldosterone (responsible for duct differentiation), and placental lactogen are involved in the fetal breast development, and progesterone and estrogens also participate.

During pregnancy, the breasts have to be prepared for their function: breastfeeding. Nowadays, the inherent mechanism involved is still a mystery.

It is known that the increased levels of estrogens, progesterone, and placental lactogen induced by pregnancy (due to the corpus luteum and placenta) are involved in breast changes due to their mammotropic effects.

During the first weeks of pregnancy, there is simply growth of ducts and lobules. In the third trimester, due to an increase in the level of hormones, the breast undergoes remarkable

Table 2.1 Summary of mechanisms, changes, functions of the changes, and main problems in the reproductive tract during pregnancy

System		Hormonal mechanism	Physiological changes	Function	Main problems
Reproductive tract	Uterus	↑E, ↑P	Increased enlargement Increased vascularization	Embracing gestation Placental nutrition	Displacement of adjacent organs
	Cervix	↑E, ↑P	Increased vascularization Edema Hypertrophy Hyperplasia	Pregnancy maintenance Immunological and anti-infection barrier	Slight bleeding
	Ovaries	↑E, ↑P	Lack of maturation of follicles Corpus luteum	Pregnancy maintenance the pregnancy until week 6 or 7	Avoid surgical interventions in the first trimester
	Fallopian tubes	↑E, ↑P	Hypertrophy of musculature	None?	–
	Vagina and perineum	↑E, ↑P	Increased vascularization Edema Hypertrophy Hyperplasia	Preparing birth canal	Infections

↑E: increase of estrogen levels
↑P: increase of progesterone levels

changes: it grows further, with proliferation of the duct epithelium and creation of new lobules, and the lumen of the ducts dilates due to an accumulation of secretions. The involution of fatty and connective tissue to allow this enlargement is mediated by progesterone. The first colostrum is formed. Also, the nipple–areola complex grows.

After childbirth, the levels of estrogens, progesterone, and placental lactogen decrease dramatically and, for that reason, prolactin can carry out its function: lactogenesis. During pregnancy, levels of prolactin are similar to those of the puerperium stage, but the other hormones were previously inhibiting it.

At the end of breastfeeding, the spacing of baby breastfeeding intake stops the stimulation of prolactin and breasts gradually come back to normal.

In menopause, the hormonal decrease also causes changes in the mammary tissue, which involutes and loses firmness. However, there are other anatomical factors, such as changes in the connective tissue or in ligaments, which also have an influence on this process [1].

This topic will be widely covered in *Chap. 14: Mammary Tissue Changes during Pregnancy and Breast Feeding.*

2.2.3 Cardiovascular System

The first system that changes in the maternal body is the cardiovascular system. It needs to adapt to the necessary requirements in nurture and oxygenation that the fetus demands. Moreover, these demands are constantly changing and increasing, and the cardiovascular function becomes more difficult due to the weight and the position of the uterus and the fetus.

2.2.3.1 Cardiac Output

The most important event is the increase in cardiac output. In the non-pregnant woman, the cardiac output accounts for 30% of the global output. During pregnancy, it reaches 50%.

Half of these changes take place in the first 8 weeks of pregnancy. At the end of pregnancy, output decreases due to the obstruction of the inferior vena cava. At the moment of childbirth, during contractions, the cardiac output can rise up to more than 40% [4].

The increase in cardiac output takes place through two mechanisms: the first of them is an increase in the systolic volume and the second one is an increase in cardiac frequency; both of them are mediated by hormones.

An increase in the systolic volume is the prevalent mechanism in the first months. It is mediated by the rise in the blood volume (see hematological system) and the decrease of peripheral resistance due to progesterone and other vasodilators.

When the heart cannot improve the cardiac output with an increase in volume anymore, the cardiac frequency rises—also mediated by hormones—by 10 beats/min [4] (Fig. 2.4).

2.2.3.2 Blood Pressure

The blood pressure in pregnant women is significantly lower than in non-pregnant women in the first weeks [1]. It reaches its minimum in weeks 24–32, and from that moment on, it rises gradually. At childbirth, blood pressure could increase by 10 mmHg, mostly due to pain [4].

It is important to highlight illnesses during pregnancy related to blood pressure, such a preeclampsia, where a vascular endothelial dysfunction creates a hypertensive state.

2.2.3.3 Uterine Blood Flow

The uterus receives around 2% of the cardiac output in the non-pregnant woman and in the first trimester during gestation. At the end of the pregnancy, the uterus receives more than 20% of all the cardiac output [4]. This could be due to the increase of the total cardiac output and also to the distribution of the output itself. Structures such as the musculoskeletal tissue receive less input than in a non-pregnant state.

2.2.3.4 Anatomical Changes

Owing to the enlargement of the uterus, the abdominal viscera are displaced. This modifies the diaphragm, which is elevated. For that reason, the heart changes to a more horizontal position and it is displaced upward and to the left, while it rotates laterally. This can be observed with X-rays (slight changes) and in an ECG, which shows a slight deviation of the axis.

Also, due to the increase in the systolic volume, the heart is enlarged, and ventricles are remodeled without hypertrophy of the myocytes [1, 5].

Uterine enlargement causes a compression of inferior cava vein (aorta does not suffer compression due to it has muscle war). This compression reduces the vein lumen and it causes a venous stasis in lower limbs. Edema, typically at the end of the day, should appear (it is caused also by hormones). Lifestyle and position recommendations may be enough to allow complications.

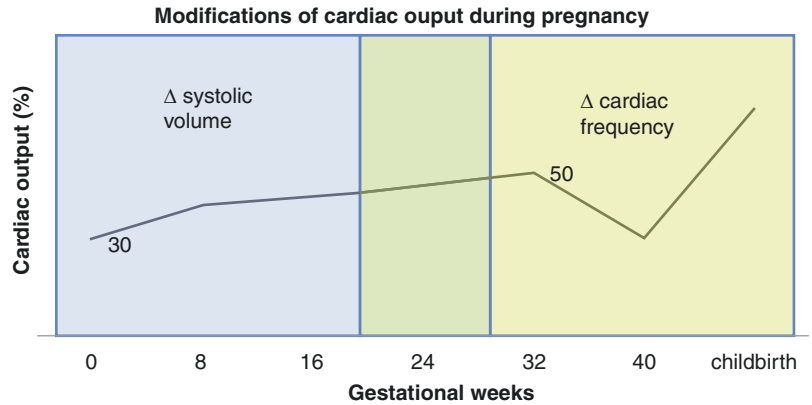

Fig. 2.4 Modifications of cardiac output during pregnancy and its mechanism

Inferior cava vein compression is also related with sickness and dizziness due to the reduction of cardiac output. Liberation of cava vein from uterus compression with left lateral decubitus position should improve this condition.

2.2.3.5 Repercussion of Cardiovascular Changes

Pregnancy is considered a hyperdynamic state. In this state, it is normal to find a split S2 during inspiration. In addition, a slight systolic murmur (never diastolic) may be heard.

2.2.4 Respiratory System

Since the moment of fertilization, the need for oxygen increases. Changes in the respiratory system have two components: first of all, an increase in oxygen uptake, together with anatomical changes due to uterine enlargement.

Most mechanisms are mediated by progesterone.

2.2.4.1 Anatomical Changes

The diaphragm rises 4 cm at the end of pregnancy due to visceral displacement. As a way of compensation, the subcostal angle increases, and also the diameters of the chest walls. With this mechanism, the pregnant woman does not lose respiratory capacity (Fig. 2.5).

2.2.4.2 Functional Adaptation

The anatomical changes induce physiological changes. These changes usually deteriorate the respiratory function slightly, and it may be compensated physiologically.

Due to diaphragm elevation, residual volume decreases from 1000 to 800 mL in the pregnant woman. Also, with the same mechanism, the expiratory reserve mechanism decreases from 700 to 550 mL. Both of them

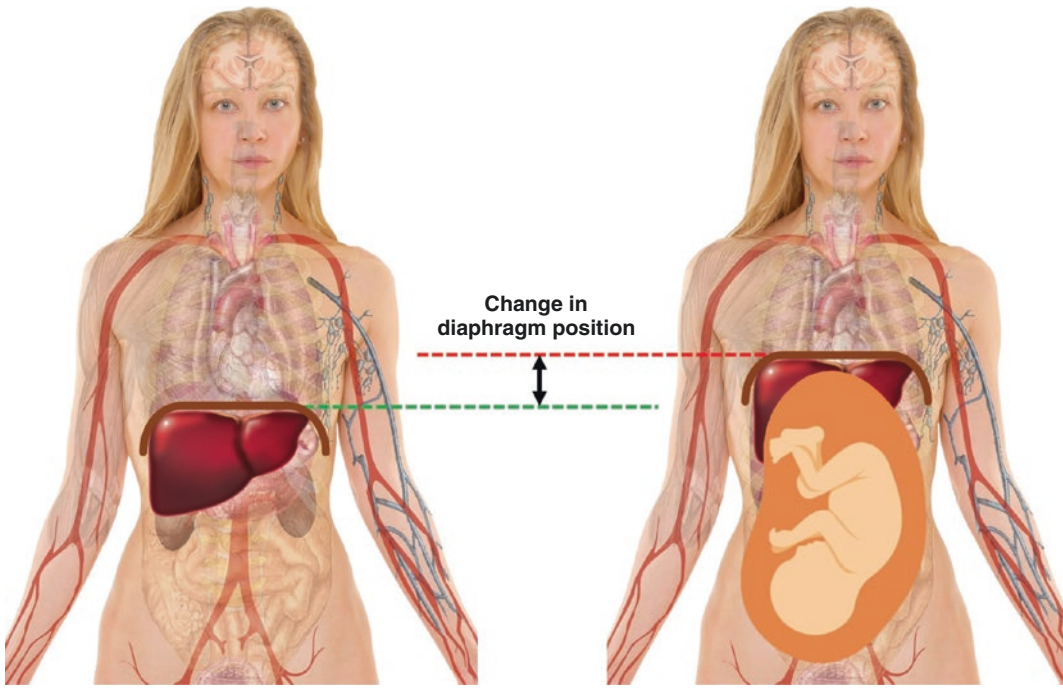

Fig. 2.5 Anatomical changes in the diaphragm. Left: non-pregnant woman. Right: pregnant woman. It should be observed that the diaphragm rises more than 4 cm. Also, the anteroposterior and transverse diameters of the thoracic cavity increase

make up the functional residual capacity, which consequently decreases. Also, the movement of the diaphragm reduces the total lung capacity by 5%.

As a way to compensate these changes, the respiratory rate does not change, but the tidal volume (the volume of air that is displaced between normal inhalation and exhalation) increases markedly, from around 450 mL in a non-pregnant woman to 650 mL during pregnancy. Similarly, the inspiratory capacity rises from 2500 to 2750 mL at the expense of inspiratory reserve. The vital capacity remains the same.

The pregnant woman has more air in movement and less air in reserve. This causes an increase by 30–40% in minute ventilation.

All these adaptations are necessary because the body and fetal requirements are near to 50 mLO_2 per minute, 20% more than in a non-pregnant woman.

These requirements come from the uterus, which receives approximately 50% of this increase, as well as the heart, kidneys, muscles, and breast.

During labor, the needs increase by 40–60% [1].

Changes in the tidal volume and the sensitivity of central chemoreceptors to progesterone alter the acid–base equilibrium due to the larger elimination of CO_2. This respiratory alkalosis does not lead to global alkalosis. Thankfully, the Bohr effect compensates it by excreting more bicarbonate through the kidney. Therefore, the acid–base maternal equilibrium remains normal [4].

2.2.4.3 Repercussion of Respiratory Changes

One of the typical symptoms in pregnant women is dyspnea, which is caused by the decrease of PCO_2. This dyspnea may not affect the daily life of the pregnant woman. If it does, other non-physiological causes should be considered.

Commonly, the woman reports pseudo-allergic or cold-like symptoms due to mucosal hyperemia mediated by estrogen and progesterone [1].

2.2.5 Hematological System

Changes in the hematological system aim to maximize oxygen transport to the fetus and to minimize the deteriorated venous return and childbirth-associated bleeding.

Most of them are mediated by estrogen and progesterone.

2.2.5.1 Plasma

From the sixth week of pregnancy, the plasma volume starts to rise. It reaches its maximum at weeks 30–40. The increase is at least 50% more plasma volume (more in multiple pregnancies).

This change tries to meet the metabolic demands of the enlarging uterus and to nurture the fetus and the placenta.

2.2.5.2 Red Blood Cells

The red blood cell volume needs to increase. It grows by at least 450 mL. For that reason, slight erythroid hyperplasia is normal during pregnancy.

2.2.5.3 Iron

Iron is necessary not only to increase red blood cell volume but also for the fetus and to compensate the normal loss. The National Academy of Sciences recommends supplementation with at least 27 mg of ferrous sulphate.

2.2.5.4 Hemoglobin and Hematocrit

Due to plasma elevation, other blood components such as hemoglobin and hematocrit must decrease proportionally. For that reason, physiological anemia may appear. Physiological anemia of pregnancy takes place when hemoglobin is below 11 mg/dL, and it may be corrected.

2.2.5.5 Leukocytes

Leukocyte count may vary during pregnancy. The higher values can easily reach 12,000/L–15,000/L without pathological significance. In the puerperium, values may be close to 25,000/L. The mechanism of this process is unknown.

2.2.5.6 Platelets

In the same way as leukocytes, platelets may vary during pregnancy. A decrease in platelets may be related to gestational thrombocytopenia. Platelets under 100,000/μL could compromise childbirth.

2.2.5.7 Coagulation

In total, 50% of all coagulation factors increase during pregnancy. Especially, fibrinogen (factor I) rises by 50%. Other factors that increase are factors VII, VIII, IX, and X.

In contrast, proteins C and S reduce their values.

2.2.5.8 Repercussion of Hematological Changes

A greater amount of red blood cells allows better oxygen distribution to the fetus and stimulates the CO_2 exchange between the fetus and the mother.

However, these changes also create a state of hypercoagulability in the pregnant woman. This increases the thrombotic risk during pregnancy and puerperium.

Also, the volumetric changes create a predisposition for edema. It usually appears in the forehead, legs, ankles, and feet [4].

A summary of the hematological system can be seen in Table 2.2.

2.2.6 Immune System

The immune system of the mother needs to tolerate a "foreign body" such as the fetus. Classically, it is said that the key is in the placenta (it acts as a barrier between the mother and the fetus). Furthermore, the placenta secretes hormones such as estrogen and progestogen, which stop the immune response. The only immune molecule that can pass through the placenta is IgG, so that it can transfer passive immunization to the fetus.

The latest studies show that pregnancy is a pro-inflammatory and an anti-inflammatory con-

Table 2.2 Summary of mechanisms, changes, functions of the changes, and main problems in the hematological system

System		Mechanism	Physiological changes	Function	Main problems
Hematological system	Plasma	↑E, ↑P	Increased plasma	Meet the new metabolic demands	Hypercoagulability state
	Red blood cells	↑E, ↑P	Increased the number of red blood cells	Transport major quantity of oxygen	Hypercoagulability state Erythroid hyperplasia
	Iron	It may be supplemented	The need grows	Increasing of red blood cells, it is necessary for fetus development	It is not supplemented, anemia could appear
	Hemoglobin and hematocrit	↑E, ↑P	Decrease	Allow plasma grows	Hypercoagulability state (if they do not decrease proportionally)
	Leukocytes	Unknown	Increased	None?	Interpretation
	Platelets	Entrapment in placenta	None or decreased		Gestational thrombocytopenia
	Coagulation	↑E, ↑P	Increase: I, VII, VIII, IX, and X Decrease: protein C and S	Avoid hypercoagulability state	Bleedings

↑E: increase of estrogen levels
↑P: increase of progesterone levels

dition, depending on its stage. During trophoblastic invasion it is an inflammatory environment, while in mid-pregnancy it is anti-inflammatory. Finally, childbirth is once again an inflammatory process [6, 7].

2.2.7 Metabolism

The fast development of uterus, placenta, and particularly the fetus represent an increase in energetic demands.

The maternal metabolic rate increases by 10–20% by the end of the pregnancy when compared with a non-pregnant woman.

2.2.7.1 Weight Gain

Weight gain is normal during gestation. The average weight gain is between 12 and 18 kg. The most important part comes from the fetus, uterus, placenta, and amniotic fluid. Others components in weight gain are breast development, fat deposition, and fluid retention. This part is variable in each woman.

2.2.7.2 Carbohydrate Metabolism

Pregnancy causes changes in carbohydrate metabolism due to its diabetogenic effect: lower insulin response, hyperinsulinemia, and hyperglycemia.

These responses are due to human placental lactogen (HPL) which is secreted by the placenta. In addition, there is an effect from estrogen and progesterone.

2.2.7.3 Fat Metabolism

All the fats, such as lipids and lipoproteins, are elevated in the pregnant woman due to estrogen.

In the first month, the concentration and stocking of lipid is prevalent; in the last period of gestation, lipolysis is the main process.

2.2.7.4 Protein Metabolism

At the end of pregnancy, the fetus and placenta need more than 50% of the normal use of proteins. For that reason, the pregnant body tries to stock proteins for this stage [1].

Summary of the metabolic changes can be seen in Table 2.3.

2.2.8 Endocrine System

Many gestational hormones cause changes in maternal hormones due to their similar biochemical structure or because gestational hormones stimulate maternal ones.

2.2.8.1 Thyroid

The thyroid gland increases its size moderately, and many changes take place:

Table 2.3 Summary of metabolic changes during pregnancy

System		Mechanism	Physiological changes	Function	Main problems
Metabolic changes	Weight gain	Enlargement of the uterus, placenta, fetus and amniotic fluid	Increased between 12–18 kg	Fetus enlargement	Fluid retention Lose weight after pregnancy
	Carbohydrate metabolism	↑E, ↑P, ↑HPL	Lower insulin response Hyperinsulinemia Hyerglycemia	Nurture of the fetus	Gestational diabetes
	Fat metabolism	↑E	Lipids and lipoproteins are elevated	Neurological fetus development	Weight gain
	Protein metabolism	↑E, ↑P	Increase	Nurture of the fetus	–

↑E: increase of estrogen levels
↑P: increase of progesterone levels

In the first trimester, human chorionic gonadotropin (β-HCG) is elevated and it has a similar activity to thyrotropin (stimulating T_4 secretion), temporarily rising the levels of T_4.

Moreover, estrogens stimulate the production of TBG (thyroxine-binding protein), which in turn stimulates T_4 and T_3 secretion. In spite of that, gestation is a euthyroid state.

Other glands such as adrenal glands (there is an increase in cortisol levels) and the pituitary gland also change during pregnancy.

Hormones such as oxytocin or androgens are subject to their own changes during pregnancy [1].

2.2.9 Gastrointestinal System

The gastrointestinal system suffers the consequences of pregnancy. On the one hand, the uterine enlargement displaces the gastrointestinal viscera, and the hormones affect the mucosa and smooth muscle negatively. The symptoms could range from slight aches to severe pain.

2.2.9.1 Anatomical Changes

The most important change in this regard is the lateral and upward displacement of all the gastrointestinal organs. This may not affect their size or normal function but, in case of illnesses such as appendicitis, it could be more difficult to identify the structures involved.

The portal vein is bigger during pregnancy due to the increase of the bloodstream.

2.2.9.2 Functional Changes and Repercussion

Progesterone and estrogen have an effect on smooth muscle and mucosal hyperemia. This affects the gastrointestinal system down to the lower esophageal sphincter, relaxing it. The motility of the entire tract worsens, as does the contractility of the gallbladder.

This causes an increase in reflux and in the prevalence of biliary colic and difficult digestion.

Also, hyperemia causes gingival bleeding and, together with uterine enlargement and the increase in venous pressure, hemorrhoids are more prevalent [4].

Nausea and vomiting are common symptoms in pregnant women. The real cause is unknown, although it could be related to raised progesterone and GcH. The severe end of the spectrum is called hyperemesis gravidarum, and it can have severe implications.

Constipation is a symptom of mechanical obstruction caused by the uterus and the increased absorption of water.

Itching, usually on hands and feet, is due to the increase in biliary acid (mediated by estrogen) and cholestasis. It could be a severe condition that requires treatment or an early delivery [1].

The main gastrointestinal problems are summarized in Table 2.4.

Table 2.4 Main gastrointestinal problems

Problems of the gastrointestinal system		
Problems	Cause	Comments
Nausea and vomiting	Unknown Probably raised progesterone and GcH	Severe spectrum: Hyperemesis gravidarum
Gingival bleeding	Hyperemia (↑E and ↑P)	
Reflux	Relaxed LES (↑E and ↑P)	
Difficult digestion	Relaxation of smooth muscle (↑E and ↑P)	
Itching	↑E and cholestasis mechanism	Severe intrahepatic cholestasis
Cholestasis	Worse contractibility of gallbladder (↑E and ↑P)	
Constipation	Mechanical obstruction Increased absorption of water	
Hemorrhoids	Hyperemia (↑E and ↑P) ↑venous pressure	

↑E: increase in estrogen levels
↑P: increase in progesterone levels

2.2.10 Urinary Tract

The urinary system experiences anatomical and physiological changes in order to adapt to its new role. The changes are promoted by hormones and also due to uterine enlargement.

2.2.10.1 Anatomical Changes

The renal system has to manage a new volume and new acid–base equilibrium due to respiratory alkalosis. Therefore, the kidney cortex is swollen, and the kidneys and the collecting system are dilated. Due to these changes, the kidneys are larger than in a non-pregnant woman.

This process is mediated by hormones and also by the position of the enlarged uterus, because while it grows, it rotates to the right and affects more the right ureter than the left one.

Also, progesterone relaxes the smooth muscle of the ureters and, consequently, they could also be dilated.

The bladder is affected by the relaxation of the smooth muscle, and the uterus is compressed and becomes thinner (thus increasing residual volume), which reduces the capacity of the bladder [4].

The pregnant woman is going to suffer changes in the frequency and urge of urinating. Also, urinary tract infections are more common due to urinary stasis. Similarly, all types of bacteriuria must be treated because of the risk of pyelonephritis.

2.2.10.2 Functional Changes and Repercussion

Due to the new plasmatic volume, the kidney flow increases, causing all the functional changes in the kidney.

The kidney flow may increase by more than 75% compared with a non-pregnant woman. For instance, the glomerular filtration rate may increase by more than 50%.

The glomerular filtration is still functional, and there is no loss of proteins during pregnancy (if it appears, a disorder should be considered). However, given the increase in glomerular filtration, it could be possible to analyze whether the levels of glucose, B_{12} vitamin, or phosphate are within physiological range [4].

The entire renin-angiotensin-aldosterone system is altered during pregnancy. Renin is also produced by the placenta (as well as by the mother) and angiotensin is also produced by the mother and the fetal liver.

This elevation makes pregnant women resistant to antihypertensives that operate through this gateway.

The main urinary functional and anatomical changes are summarized in Fig. 2.6.

2.2.11 Musculoskeletal System

In contrast to other systems, alterations in the musculoskeletal system are due to anatomical changes and not hormonal fluctuation.

2.2.11.1 Diastasis Recti

In many cases, the abdominal rectus is not able to stand the tension that it is subject to. For that reason, the muscle separates at the midline in what is called diastasis recti. It may be physiological, but if it is severe, it may involve ventral hernia [1].

2.2.11.2 Lordosis

There is a compensation of the convexity of abdominal enlargement. This mechanism tries to maintain the center of gravity in its position (otherwise, the woman would fall forward). This change causes backache and numbness and fasciculation in the upper limbs [1].

2.2.11.3 Separation of Sacroiliac, Sacrococcygeal, and Pubic Joints

Progesterone and relaxin act on ligaments that are more relaxed during gestation. In addition, as a way to prepare for childbirth, the pubic symphysis separates around week 30.

2.2.11.4 Calcification

If the diet of the pregnant woman is adequate, loss of calcification should not be a problem. Although requirements increase due to the fetus and an elevated concentration of parathyroid hor-

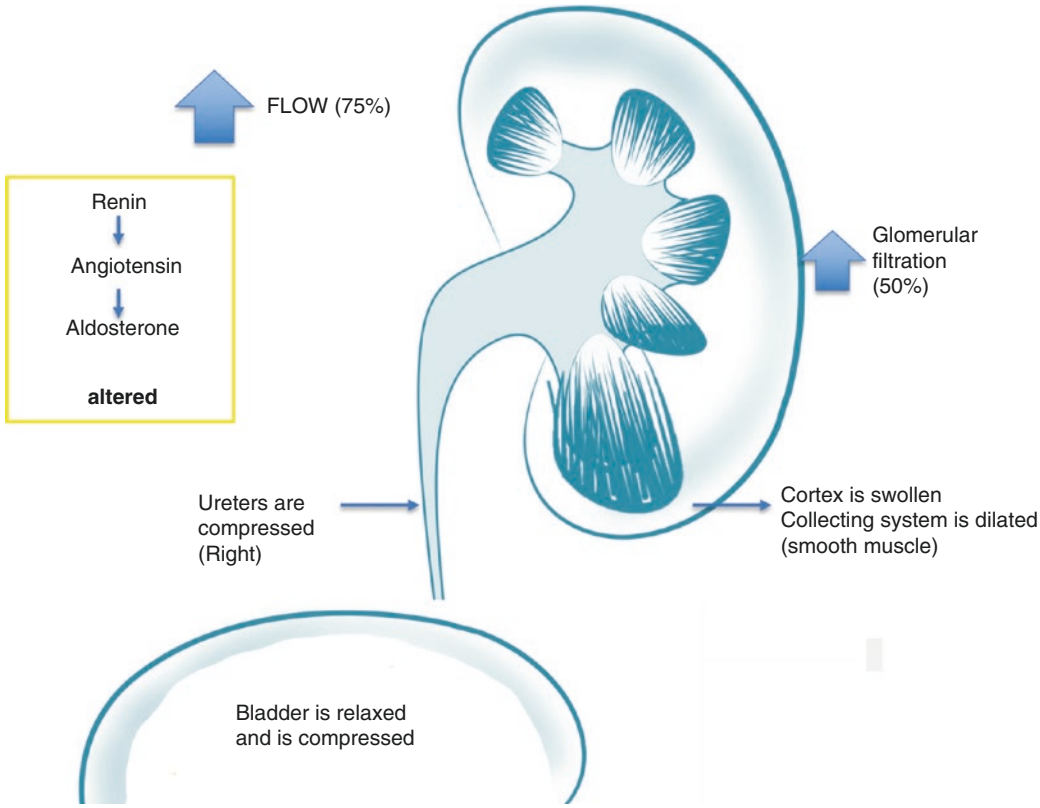

Fig. 2.6 Main urinary functional and anatomical changes

mone levels, the lower loss through the kidney and the increase in intestinal absorption should be enough [1].

2.2.11.5 Gait and Feet

The change in the gravity center, the increase of ligament relaxation, and the weight gain cause greater instability and more falls in pregnant women.

The feet suffer during pregnancy. The weight gain affects the feet considerably due to their situation and function. Castello and colleagues describe changes in the footprint during pregnancy:

The plantar pressure increases progressively in the sides and in the ankle zone, and the footprint changes. More than 38% of all pregnant women in this study reported "discomfort" or "pain," but they did not consult with a doctor. Many of them considered this "discomfort" normal. Castello and colleagues also report that many of these problems could be solved with insoles or adequate shoes [8].

Also, the weight gain can lead to fascial tension which causes pain after rest (plantar fasciitis). In addition, an increase in BMI may compound onychocryptosis.

Another equally relevant factor is flexibility lost due to an increase in abdominal volume. This may not allow pregnant women to have a proper hygienic routine and inspection of their feet.

2.2.12 Skin

The skin is one of the most damaged organs during pregnancy. Many of the changes are remarkable and noticeable for pregnant women. Rathore et al. developed a study in which they carried out a dermatological examination of 2000 pregnant women randomly selected. In 87% of them, they found physiological changes in the dermis [9].

For that reason, we should inform our patients previously [1].

The main factor in these changes seems to be hormonal changes, although there is no study on this particular topic and further research is needed.

2.2.12.1 Hyperpigmentation

Hyperpigmentation is the change in the coloration of the skin (or part of it), which becomes darker. It may happen due to estrogens that stimulate melanocytes and to human chorionic gonadotropin (GhC) being biochemically similar to melanotropin. However, there are no consistent studies on this field.

Typically, hyperpigmentation affects the skin of the middle abdominal wall (linea alba), the newly formed linea nigra, the areola, and the perineal area (Fig. 2.7).

Also, browning patches may appear on the head and neck, and they are called chloasma or melasma gravidarum (mask of pregnancy) (Fig. 2.8).

They should disappear after pregnancy and on a few occasions, retinoid treatment may be necessary [4].

2.2.12.2 Stretch Marks

They are a common problem in more than half of all pregnant women. They appear on the lower abdomen, thighs, and arms. Initially, they should be pink to purple, but over time, they become white.

Fig. 2.7 Linea alba in woman at 32 weeks pregnant

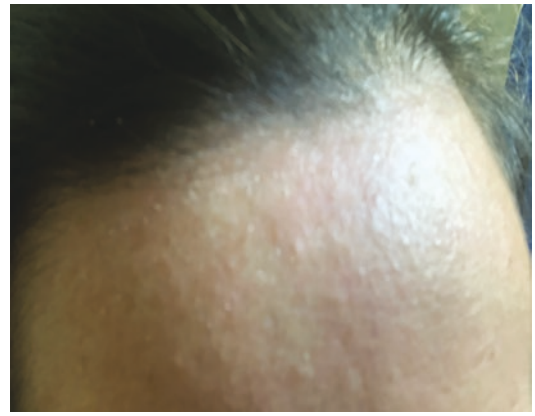

Fig. 2.8 Slight melasma on the forehead of a woman at 13 weeks pregnant

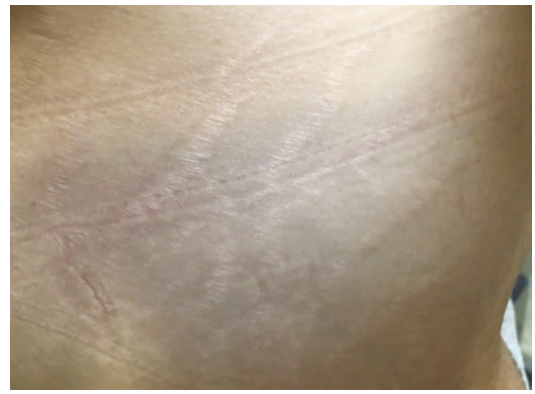

Fig. 2.9 Grey stretch marks on a thigh

The strongest factors related to stretch marks are the young age of the mother and family history (but not weight gain) [4]. There is no treatment for them (Figs. 2.9 and 2.10).

2.2.12.3 Vascular

Vascular spiders (angiomas) appear in 75% of the pregnant women. They are related to estrogen concentration and the typical zones are the thorax, forehead, and arms.

Palmar erythema appears in 50% of all pregnant women, and it is also related to estrogens.

It usually disappears spontaneously [4].

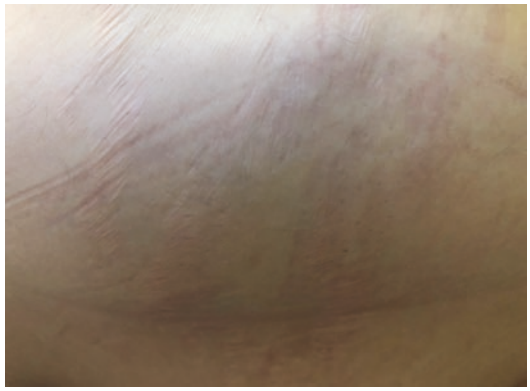

Fig. 2.10 Pink to purple stretch marks in a postpartum abdomen

2.2.12.4 Hair

During pregnancy, there is more hair in the anagen phase (growing) than in the telogen phase (resting). For that reason, at the end of pregnancy, there is transitional alopecia. We should explain that the normal loss of hair will be recovered [4].

Also, it is important to explain that it is not advisable to use depilatory methods such a laser hair removal because the skin is very sensitive during pregnancy and it can be easily burned (Figs. 2.11 and 2.12).

More information about skin changes and recovery is discussed in Chap. 10.

2.2.13 Other Systems

2.2.13.1 Vision

Blurred vision is a common symptom. Edema (fluid retention) and the decrease in intraocular pressure are the causes of this problem. It should disappear in the postpartum period.

A loss in accommodation has also been described, and it disappears on its own.

For these reasons, pregnancy is not a suitable period for vision correction adjustments [1].

2.2.13.2 Smell

There is next to no evidence about changes in the sense of smell during pregnancy. Women report increased olfactory acuity, but in contrast, Gul

Fig. 2.11 Burns in thighs after laser hair removal treatment during pregnancy

Fig. 2.12 Another case of burns in thighs after laser hair removal treatment during pregnancy

et al. describe a decreased sensitivity during the first trimester that returns to normal levels during the rest of the gestation period [10]. Further studies are necessary in this field [1].

2.2.13.3 Superior Functions

A lot of pregnant women complain about memory loss during pregnancy. The studies are few, and, at this moment, pregnancy does not seem to affect memory [1].

2.2.13.4 Psychological Functions

Hormones can affect pregnant women in various ways. It is usually associated with ambivalence and frequent mood changes, ranging from anxiety to fatigue, exhaustion, sleepiness, depressive reactions, and excitement. During pregnancy, changes include body appearance, affectivity, and sexuality, whereas the position and role of women attains a new status. We will discuss these important aspects in Chap. 4.

2.3 Conclusions

In conclusion, we should understand the main body changes that pregnancy produces in a woman. Pregnancy is a unique moment in the life of a woman, and her body goes through changes that it is not going to experience in any other situation. The complexity and integrity of the changes are crucial for a good development of the fetus and maternal well-being.

Many of the changes are physiological body adaptations for the sake of developing a new life and others are "adverse effects" that the body tries to counteract. Our mission is observing all these changes and finding the pathological ones to help the mother and the fetus in this extraordinary process.

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3 Pregnancy and Parturition: The Physical and Physiological Changes and Their Pathologies

Talla Widelock, Jeffrey Denney, and Brian Brost

Take-Home Points

- This chapter is intended to provide delivering clinicians with a succinct overview of the normal changes experienced over gestation and delivery by women and how pathologic processes may arise to guide perspective and thoughtful management of pregnancy and childbirth.
- The female anatomy undergoes mechanical and physiological adaptive changes during pregnancy.
- Endocrine- and immune-mediated processes facilitate the necessary alterations of the maternal reproductive organs and pelvic floor to accommodate and sustain gestation for the growth and development of the fetus.
- As term pregnancy is achieved, further modifications of the uterus, cervix, pelvis, and the pelvic floor in preparation for the safe passage of the fetus, ideally, without significant injury to the mother.
- Labor onset is followed by the most physically rapid and anatomically evident changes that likewise pose the greatest risk of injury to the pelvic floor and birth canal.
- Pelvic floor disorders are often rooted in the events occurring as the fetus is expulsed from the uterus and birthed.

3.1 Introduction

The maternal bio-physiological clock is set to maintain gestation until the fetus is mature enough to maintain and sustain life as a neonate ex utero. Fetal development and maturation is the core objective of pregnancy. The maternal pelvis and reproductive organs undergo significant and yet necessary changes in order to accommodate the growth and development of the fetus and later to allow for safe passage of the fetus during delivery. For example, a number of endocrine and immune-mediated mechanisms trigger histologic changes in the uterus (to allow for expansion, growth, and increased circulatory capacitance); cervix (to facilitate softening, thinning, and dilation for passage of the fetus); pelvic floor and vaginal musculature (to decrease tensile strength and enable atraumatic stretching for passage of the fetus); and, finally the maternal bony and ligamentous pelvis (to increase the circumference of the pelvic

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_3

outlet) [1–3]. Collectively, these physical and physiological changes are progressive and coordinated to culminate in the delivery of the fetus. While these processes and changes of pregnancy and childbirth are impressive in their design and result, they are however also fraught with potential for pathology and lasting maternal effects.

In general, information regarding the normal physiologic processes as they pertain to maternal alterations of anatomy are scattered throughout the obstetric literature and difficult for the busy clinician to glean a gestalt or clear understanding. The authors of this chapter hopefully have separated the *wheat from the chaff* for readers by scouring said literature and compiling these important events into a succinct and coherent chapter. We begin our chapter with a description of the anatomical and physiological changes of pregnancy and childbirth to provide a working framework and perspective for the clinician caring for women during and after pregnancy. We conclude the chapter with both a description of the associated pathologies that often result from the changes and processes of pregnancy and labor and delivery and a discussion of the implications these pathologies may have for a woman.

3.2 Clinical Anatomy of the Pelvis-Perineum

3.2.1 The Bony Pelvis

The pelvic canal is the gateway to ex utero life for the developed fetus. The pelvis is composed of four bones: the sacrum, the coccyx, and the two innominate bones (formed by the fusion of the ilium, ischium, and pubis); see Fig. 3.1.

The pelvis may be further divided into the false and true pelvis. The false pelvis lies above the linea terminalis, and the true pelvis lies below the linea terminalis; see Fig. 3.2. The true pelvis is the portion important in childbearing. The superior aspect of the true pelvis delineates the pelvic inlet. The pelvic inlet is bounded by the sacral promontory and the alae of the sacrum, the linea terminalis, and the upper margins of the pubic bones. The cavity of the true pelvis may be described as an oblique bent cylinder with the greatest height posteriorly [4]. The posterior wall of the true pelvis is the anterior surface of the sacrum. The lateral walls of the true pelvis are formed by the ilial and ischial bones and the sacrospinous and sacrotuberous ligaments and

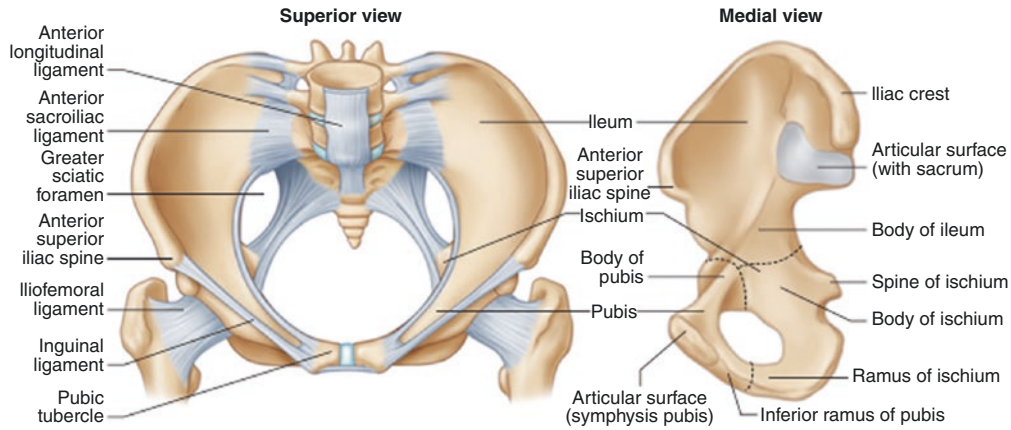


Fig. 3.1 The female bony pelvis and ligaments

corresponding sciatic foremen; see Fig. 3.3. The anterior wall is formed by the pubic bones, the ascending superior rami of the ischial bones and the obturator foramen. Inferiorly, the true pelvis is delineated by the pelvic outlet.

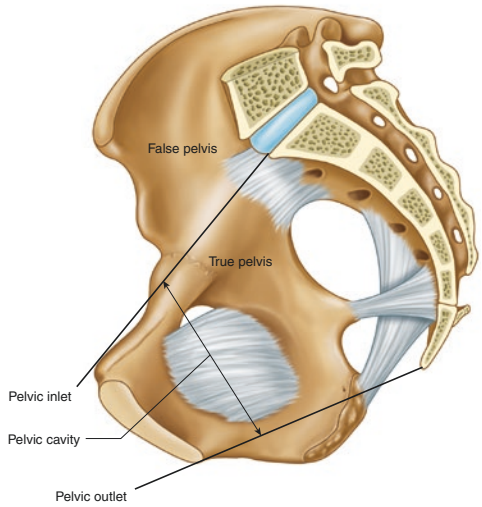


Fig. 3.2 Cross-section of the pelvic bones

The pelvic outlet is described as a diamond-shaped area constructed by (1) the confines of the tip of the coccyx and sacrotuberous ligaments laying the floor; (2) flanked laterally by the ischial tuberosities; and, (3) roofed by the left and right rami of the pubic arch joining to form the pubic symphysis; see Fig. 3.4.

3.2.2 The Pelvic Joints

There are two pelvic joints—the pubic symphysis and the sacroiliac joints—which are significant to the discussion of the anatomical adaptations of pregnancy and parturition. The pubic symphysis joins the pelvic bones anteriorly and consists of fibrocartilage and the convergence of the arcuate ligaments of the pubis. Posteriorly, the pubic bones are joined by articulations of the sacrum and the iliac portion of the innominate bones, forming the sacroiliac joints.

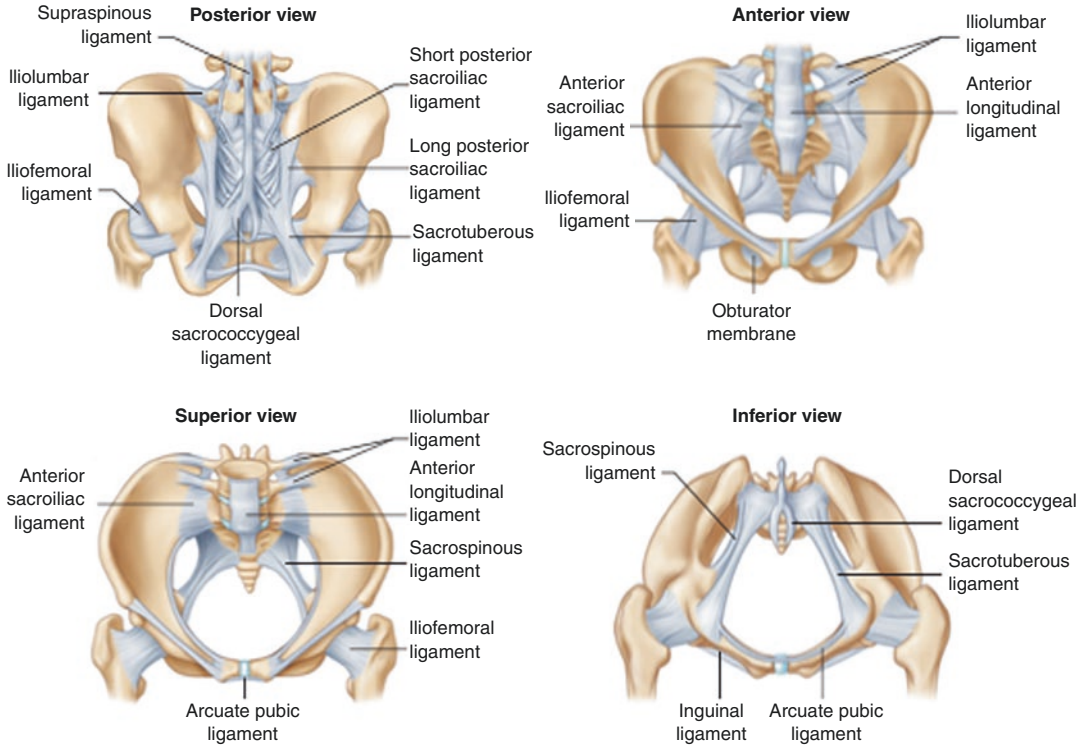
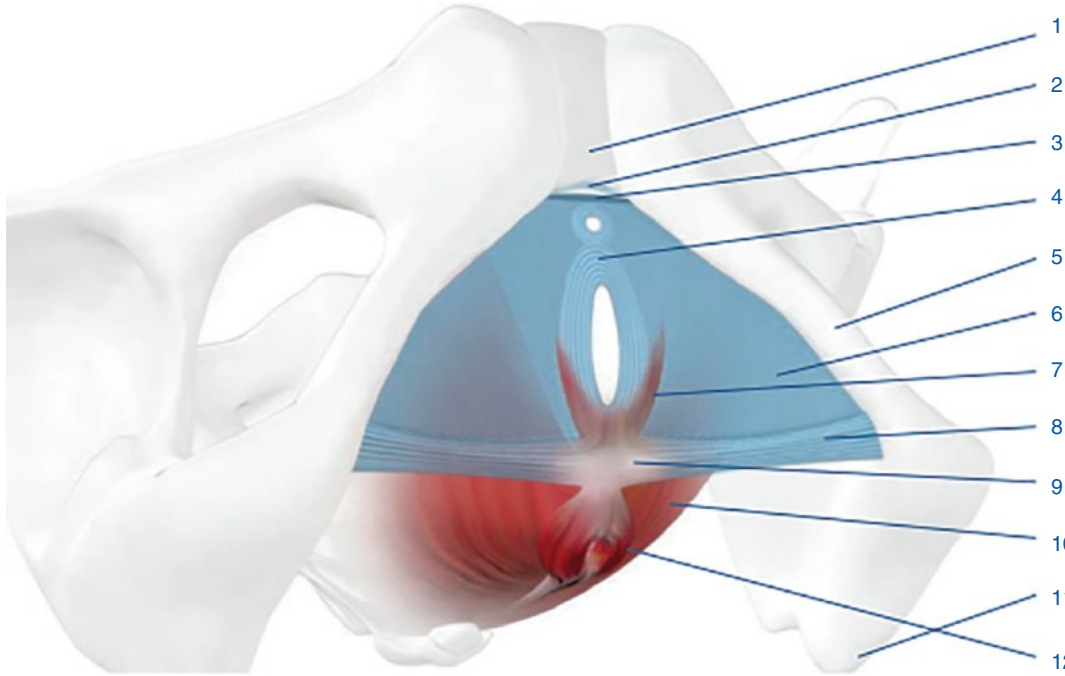


Fig. 3.3 The female pelvic cavity



1 symphysis pubis
2 inferior pubic lig. (arcuate lig.)
3 transverse perineal lig. (*Krause* lig.)
4 urethrovaginal m.
5 inferior ischio-pubic ramus
6 deep transversal perineal m. (urogenital diaphragm)
7 bulbospongiosus m.
8 superficial transversal perineal m.
9 tendinous center of the perineum (perineal body)
10 levator ani m.
11 ischial tuberosity
12 external anal sphincter m.

Fig. 3.4 Cross-section of the female pelvis

3.2.3 Obstetrical Pelvic Dimensions

Obstetricians have correlated various pelvic dimensions with obstetrical outcomes. The significant anteroposterior dimensions include the following:

1. True or anatomical conjugate: the distance between the sacral promontory and the upper edge of the pubic symphysis (mean 11 cm)
2. Obstetric conjugate (the "lesser anteroposterior diameter"): the distance between the sacral promontory and the bulge on the posterior most portion of the symphysis pubis (mean 10.5 cm)
3. Diagonal conjugate: the distance between the sacral promontory and lower edge of the pubic symphysis (mean 12.5 cm)

The obstetrical conjugate is important clinically, in that it represents the shortest distance between the promontory of the sacrum and the pubic symphysis (shortest anterioposterior diameter). This is distinct from the anterioposterior

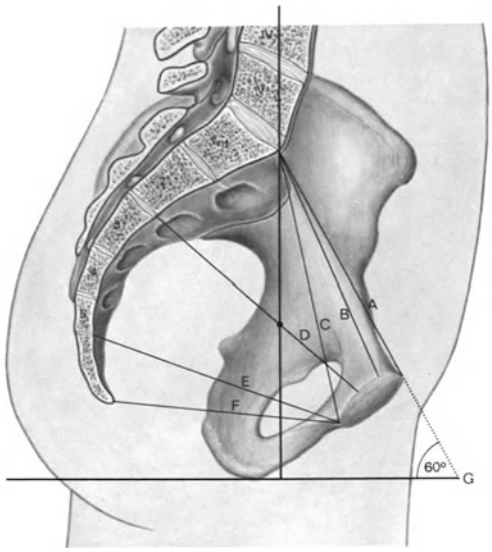


Fig. 3.5 Female pelvic outlet. (**a**) Conjugate diameter at pelvic inlet; (**b**) true conjugate; (**c**) diagonal conjugate; (**d**) pelvic cavity at its widest; (**e**) pelvic cavity at its narrowest; (**f**) pelvic outlet; (**g**) pelvic inclination (60°)

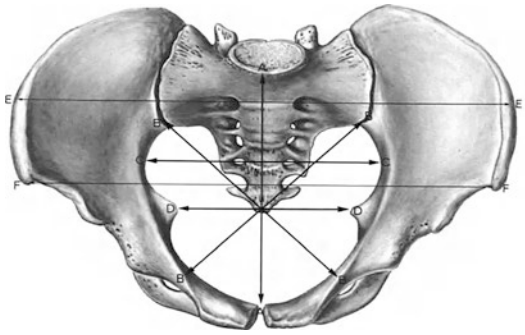


Fig. 3.6 Obstetrical dimensions. (**a**) Conjugate; (**b**) oblique; (**c**) transverse; (**d**) pelvic cavity between ischial spines; (**e**) intercristal distance; (**f**) interspinous distance

diameter of the pelvic inlet, otherwise known as the true conjugate. The obstetrical conjugate cannot be measured directly, but rather is estimated by subtracting 1.5–2 cm from the diagonal conjugate (Fig. 3.5).

The transverse diameter and the interspinous diameter are important anatomical landmarks; see Fig. 3.6. The transverse diameter is the greatest distance between the linea terminalis at the pelvic inlet, and typically averages approximately 13.5 cm. At the level of the midpelvis, the interspinous diameter is the most clinically relevant transverse diameter as it typically represents smallest transverse pelvic diameter. The interspinous diameter is typically 10 cm or slightly greater.

3.2.4 Variants in Obstetrical Pelvic Shapes

Variations in dimensions of the maternal pelvis have implications for both the success of and complications with the birthing process for both mother and fetus. These variances are manifest by hormonal and genetic influences likely evolved for the essential need for the female pelvis having varied reproductive purpose from that of the male pelvis.

The Caldwell and Moley classification of pelvic shapes is based on measurements of the greatest transverse diameter of the pelvic inlet and its division into anterior and posterior sections. The character of the posterior segment determines the type of pelvis, and the character of the anterior segment determines the tendency of the pelvis—essentially further characterizing the pelvic shape as most pelvises are actually mixed types. The four parent pelvic types of the Caldwell–Moley classification are: gynecoid, platypelloid, anthropoid, and android. Any discussion regarding maternal pelvic shape and labor discussion inherently leads to how the pelvic type impacts presentation of the fetal head through the birth canal; see Fig. 3.7.

3.2.5 The Pelvic Floor

The pelvic floor or diaphragm is elegantly designed, in that it functions to both support the

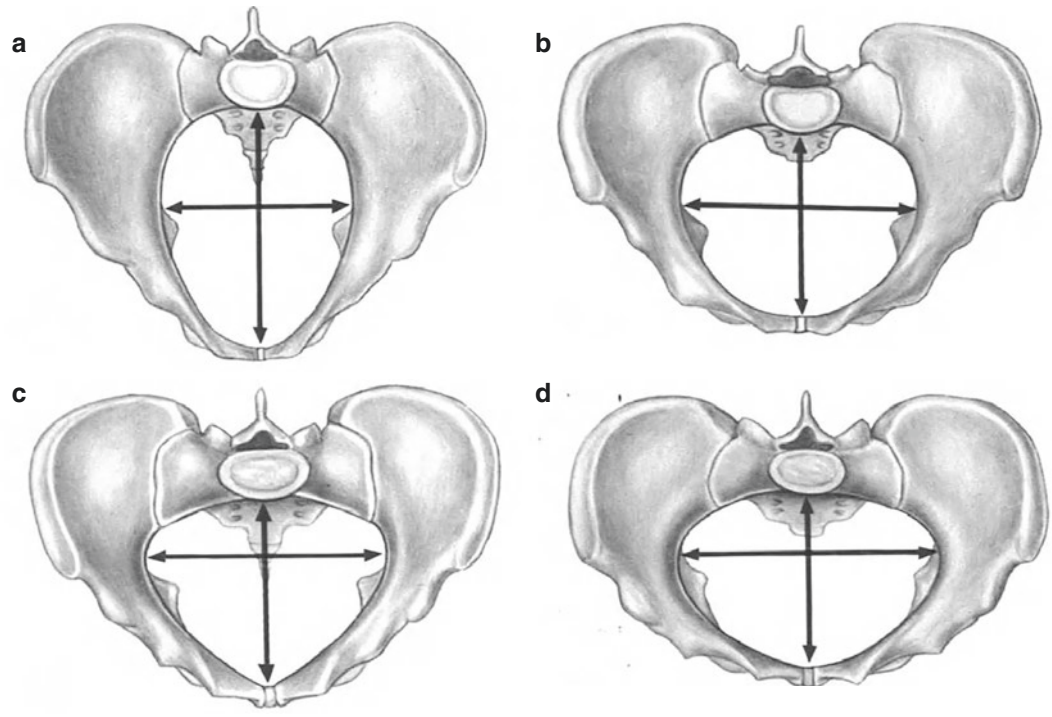


Fig. 3.7 Pelvic diameters. Caldwell-Moley classification of pelvic diameters and shapes. (**a**) Anthropoid; (**b**) Gynecoid; (**c**) Android; (**d**) Platypelloid

pelvic viscera and to also accommodate for the passage of the cranially dominant human fetus during parturition. The pelvic floor is comprised of the levator ani muscle (LAM) complex (containing the bulbocavernosus muscle, transverse perineal muscle, and ischiocavernosus muscle) and the perineal membrane [5, 6]; see Fig. 3.8. The fascial attachments of the vagina to the pelvic walls and the LAM complex comprise the mainstay support of the pelvic viscera; consequently, either direct or indirect damage to these structures may result in pelvic organ prolapse. The nerve innervation to the pelvic floor arises primarily from the pudendal nerve (S2, S3, S4) with secondary contribution of direct branches from the sacral plexus.

3.2.6 The Pelvic Viscera

The viscera of the pelvis includes the vagina, uterus, adnexal structures, and the broad ligament. For the purposes of this chapter, we will also discuss the lower urinary tract (specifically the bladder and urethra) as pregnancy and parturition notably impacts urinary function [5–7].

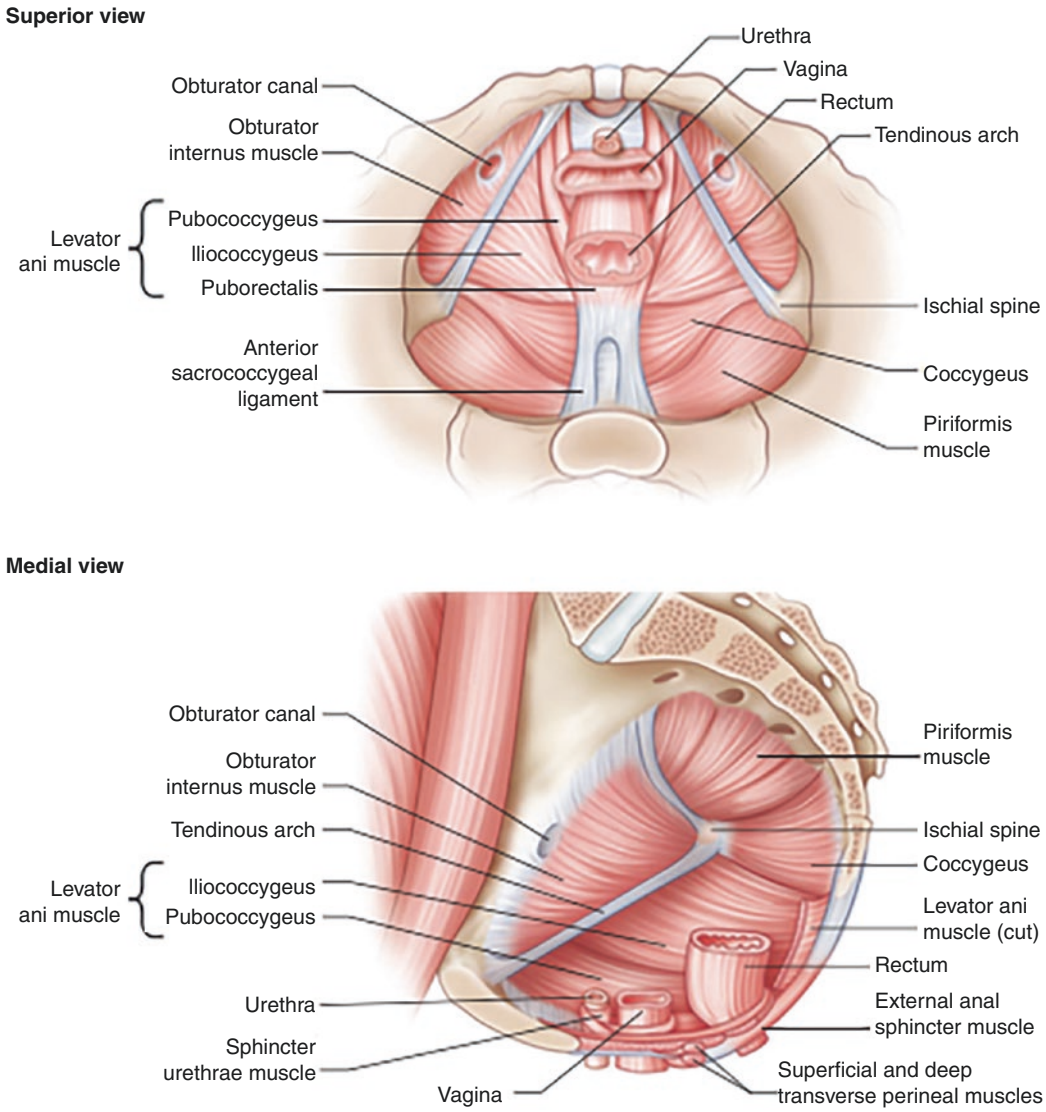


Fig. 3.8 Caldwell–Motoy pelvic types

3.3 The Adaptations of Pregnancy

Pregnancy is a remarkable time of adaptive biological processes and mechanical forces working in concert to change the maternal anatomy and physiology in order to accommodate the developing fetal life. These pregnancy changes primarily result from two key elements: the sheer mass effect from mechanical stretch and pressure and hormonal changes triggering increased tissue compliance and laxity [1, 8]. In this section, we will describe these changes in relation to the anatomy and later discuss how these changes are affected by hormonal processes.

3.3.1 The Uterus

Maternal weight gain and uterine enlargement impart mechanical force on the abdominal wall and pelvic floor. Starting in early gestation, the

growing uterus leads to a downward displacement of the pelvic floor that is evident on perineal ultrasound. Over the course of pregnancy, the uterus expands its capacity both in housing the growing fetus(es) to term size and in the ability to deliver adequate blood flow for utero-placental delivery of oxygenated blood and nutrients and capture of metabolic byproducts generated by the fetus(es) [9, 10]. To accommodate the need to increase in size, gene activation within the connective tissues of the uterus leads to a significant increase in collagen content. In fact, collagen content for a term uterus is eightfold higher than the non-gravid uterus value (60 g vs. 7 g; mean increase 53 g). Total uterine weight undergoes a tenfold increase during pregnancy. While the collagen content and uterine mass increase in parallel, percentage of collagen per gram of uterine mass decreases over pregnancy in primigravid women. Notably, this change in composition persists 5 weeks postpartum [9, 10]. After delivery, the collagen content begins diminishing and is evident by 14 hours postpartum. This process is so rapid that by postpartum day 8, the collagen content is 28% (16 g) of that seen at term prior to delivery. At 5 weeks postpartum, collagen content is only 3.9 g reflective of persistent alteration of collagen content of the uterus following the pregnancy event from delivery to the end of the puerperium. Uterine weight likewise increases from non-gravid 130 g to term 1300 g and then by 2 days postpartum more than halves to 500 g and decreases to 98 g by 4 weeks postpartum [9]. Uterine proteases and prolidases have been shown to effect the destruction in the reticular framework for pregnancy that is no longer needed following delivery; essentially, these proteases and prolidases decrease collagen content postpartum. Inflammation and endothelial disruption within the uterus occurs during this consumptive/resorptive process and leads to transient histologic edema of the uterus in the first 2 weeks postpartum [9].

During the first 2 weeks after a spontaneous vaginal delivery, the uterus involutes or exhibits a series of dynamic changes that lead to reconstitution of the nongravid state. Coordinated contractions and extrusion of blood volume lead to the restoration of the uterine body and cavity size. Breast-feeding augments this process by triggering oxytocin release leading to uterine contractions and in effect hastening the dramatic decrease in uterine size due to the nongravid state. While ultrasound data collected in the puerperium (up to day 40) have not shown significant difference in length of the uterine corpus in breast-feeding vs. bottle-feeding mothers, an inverse correlation in uterine size and breast-feeding has been demonstrated at 3-months postpartum ($r = -0.395$; $p < 0.001$) [9].

3.3.2 The Lower Uterine Segment

As the uterine cavity expands and the uterine corpus stretches to accommodate the growing conceptus, the lower uterine segment undergoes significant alterations to withstand the strain without rupture [9, 10]. Morphologic studies using both ultrasound and MRI imaging along with tissue biopsy demonstrate that the uterine myometrium hypertrophies as gestation advances [10]. While some proliferation of myocytes occurs over the course of gestation, the bulk of the changes result from hypertrophy of the existing myocytes (increased cell size) along with a complimentary accumulation of fibrous tissue of the uterine wall, especially true in the lower uterine segment.

Ultrasound data demonstrate thinning of the lower uterine segment as the uterine cavity is stretched [11]; such changes are seen earlier and more evidently in multiple gestations [12]. Interestingly, the thinner the lower uterine segment in twin gestation at increasingly early gestational age, the more likely it is for preterm labor to occur at correspondingly earlier gestational ages and earlier preterm delivery; such relationship points toward mechanical stretch and activation of labor [11]. Hormonal changes induce hypertrophy early in pregnancy as evidenced by wall thickening. Later in gestation, the lower

uterine segment thins considerably. Elastography studies demonstrate increasing compliance and decreasing density of the lower uterine segment with advancing gestational age—a biologic adaptation key to avoiding uterine rupture.

3.3.3 The Pelvic Floor and Lower Urogenital Tract

There is a decrease in the contraction of pelvic floor muscles and consequential increase in bladder and urethral mobility that is progressive and most evident in the late trimester [13, 14]. Thus, merely carrying a conceptus to the late trimester exposes the uterine, cervical, lower urogenital tract, pelvic floor, and entirety of the pelvis to macroscopic connective tissue alterations that are evident with a variety of imaging studies [13–17].

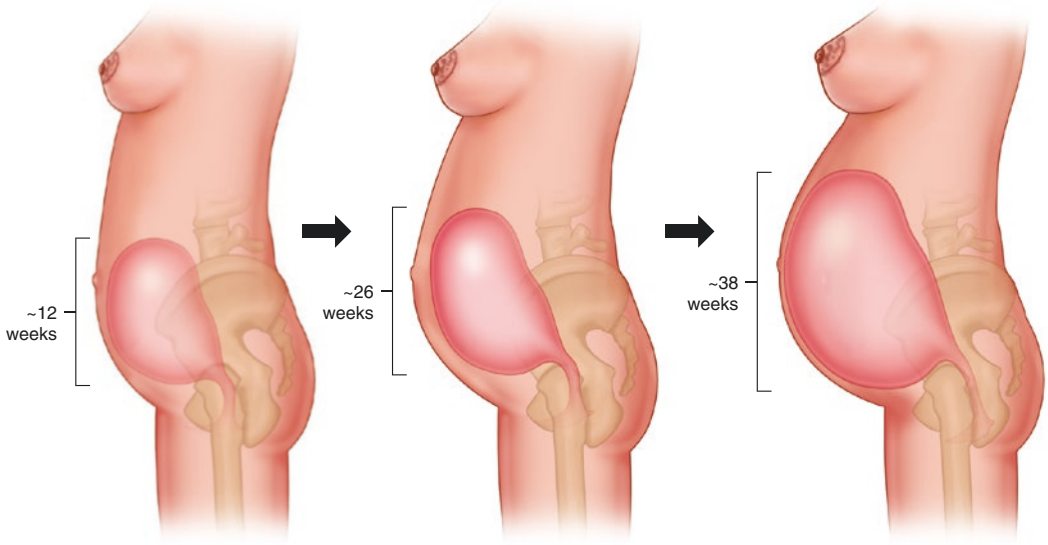
3.3.4 Hormonal Changes of Pregnancy and Parturition

Concurrent with the mechanical changes of pregnancy, hormonal alterations consisting of increased circulating levels of relaxin, estrogen, and progesterone, induce cellular and histologic modifications of the maternal tissues. Perhaps one of the most significant histological alterations of the maternal skeletal system, the ligament relaxation of the pelvis, is caused by the aforementioned increased levels of circulating estrogen, progesterone, and relaxin. The pelvic laxity of pregnancy is progressive, increasing over the course of pregnancy in concert with the hormonal changes of pregnancy [1, 18]. For example, the ovarian release of the hormone aptly named relaxin begins in the first trimester and effects joint laxity as early as the 10th week of pregnancy. These changes persist 4–12 weeks postpartum [19–23]. These hormonal alterations, such as the relaxation of the pubic symphysis and sacroiliac joints, are biologically necessary and advantageous to facilitate delivery of the fetus by widening the pelvic inlet.

It is important to note that in addition to increased skeletal and joint laxity, there is also increased soft tissue laxity during pregnancy. For example, the vagina is noted to become increasingly distensible during pregnancy. This process is believed to be mediated by hormonal changes causing increased collagen and elastic synthesis in the fibroblasts of the pelvic floor. In fact, animal models have been used to demonstrate that the vaginal wall and its supportive tissue complex are far more distensible and less stiff during pregnancy [24]. In conclusion, the gestational hormonal milieu contributes to the development of a progressive and generalized compliance and laxity.

3.3.5 Antepartum Alterations of Gross Maternal Anatomy

As a consequence of both the aforementioned mechanical and hormonal processes of pregnancy, there occurs a series of anatomical adaptive alterations of the maternal musculoskeletal system. Some of these changes are highlighted in Fig. 3.9 and include the following: (1) a shift in the axis of gravity; (2) increased force across joints; (3) postural adjustments (increased lordosis of the lower back, forward flexion of the neck, and downward movement of the shoulders); (4) joint laxity of the anterior and posterior longitudinal ligaments; (5) widening and increased mobility of the sacroiliac joints and pubic symphysis; (6) anterior tilt of the pelvis with increased use of the hip extensor, abductor, and ankle plantar flexor muscles; (7) ligamentous laxity; (8) vaginal lengthening, genital hiatal widening, and posterior vaginal relaxation [13, 25, 26].



1st trimester

- Goodell's sign: softening of the cervix and vagina
- Increased mucous secretion by endocervical glands (leukorrhea)
- Chadwick's sign: bluish-purple discoloration on the vaginal mucosa
- Desidualization occurs as the trophoblasts clears the muscular intima of the spiral arterioles and in effect increase capacitance and decrease resistance across the utero placental interface.
- Hypertrophy of the myometrium and initiation of atraumatic stretching of the uterine corpus.
- Pear shaped uterine lengthens vertically as it approaches the height of the symphysis pubis at 12 weeks.

2nd trimester

- Continued hypertrophy of the myometrium and atraumatic stretching of the uterine corpus in to more of an ovoid shape.
- Progesterone,estrogen and relaxin secretion by the maternal ovaries signal alteration in the connective tissues of the pelvis musculature, ligaments in the pelvis and uterine ligaments (ex: round, uterosacral) to relax and increase laxity
- Onset of irregular and focal contractures of the myometrium triggered by stretching and activation of myocytes
- Vascular endothelial growth factor (VEGF) and other angiogenic factors lead to increased vascularity of the uterus, vagina and perineal body

3rd trimester

- Further atraumatic stretching of the uterine corpus leads to Thinning of the lower uterine segment to 5-10 mm in thickness
- Broad, round and uterosacral ligaments continue to stretch and trigger sharp pains as the nerve fiber along the pelvic floor are triggered
- Waddle sign: complete progression of the laxity of the pelvic ligaments leads to the 15 to 50 mm separation of the symphysis pubic and sacroiliac joint leading to gait Stability
- Uterine contractions become more organized by the signalling coordinating the gap junctions between the myometrial cells this effects the uterine fundus function as a syncytium and creates coordinated albeits irregularly timed contraction prior to labor (Braxton-Hicks)
- Musculature of the pelvic floor continues to increase in laxity due to molecular signaling and alterations of collagen
- As the lower uterine segment thins as the fetus descends/engages in to the maternal pelvis, the presenting fetal part compresses the maternal bladder anteriorly reducing the volume capacity near term. Such change effectively increase urinary frequency.

Fig. 3.9 Antepartum alterations of maternal anatomy

3.4 Complications of the Anatomical and Physiological Changes of Pregnancy

As described previously, the physical and physiological adaptions and changes of pregnancy to the maternal musculoskeletal system result in a proclivity to pelvic laxity and joint mobility. The progressive lordosis, weight increase, change in the center of gravity, and increases in the laxity and mobility of the sacroiliac, sacrococcygeal, and pubic joints, all stress and alter the maternal musculoskeletal system. In addition to these mechanical changes, the hormones of pregnancy (including relaxin, progesterone, and estrogen) cause a further predisposition to pelvic laxity and joint mobility [1, 18]. For the most part, these adaptations and changes to the maternal musculoskeletal system are considered normal and necessary for childbirth. In fact, without the timely increase in laxity and skeletal flexibility, the descent of the fetal head through the birth canal would be far more disruptive to the ligaments of the pelvic ring and the surrounding soft tissue structures. However, when these changes are severe and profound, for example causing traumatic separation of the pelvic bones or ligaments, these changes may become pathologic and result in a variety of problems including arthralgia, back pain, transient osteoporosis, and tendonitis [18–22].

One such example of how a normal change during pregnancy may cause pathology for the woman is in how the mere increase in pelvic laxity and joint mobility may itself lead to pain with ambulation and pelvic instability. This unsettling sense is called symptomatic pelvic girdle relaxation. Typically, up to 4–7 cm of increased circumference of the pelvis is well tolerated and categorized as asymptomatic, but increases in excess of this distance are met with pathologic and symptomatic intolerance [22, 23, 27, 28].

Given that there are anatomical and physiological changes during pregnancy far in advance of delivery, it is ostensible to note at this time that these physiological and physical changes of gestation, from a practical standpoint, negate the potential benefit of "prophylactic cesarean." Essentially, the biomechanical stretch and hormonally induced changes of the connective tissue scaffolding of the pelvis occurs well before the fetus is delivered, and these changes may persist past the puerperal period and contribute to pelvic floor dysfunction [13–17]. Several studies have demonstrated the association between pregnancy and changes to maternal anatomy. In the Childbirth and Pelvic Symptoms study (CAPS), a contemporary human cohort study of primiparous women, the authors found that 23% of women having cesarean section without labor still reported urinary incontinence symptoms at 6 months postpartum [29]. Similarly, in a study by Rogers et al., low risk primiparous women undergoing vaginal delivery had similar rates of bothersome pelvic floor dysfunction at 6 months postpartum compared to primiparious women who underwent cesarean delivery prior to entry into the second stage of labor [30]. These studies suggest that gestation itself affects the urinary system. This effect is further elucidated in the Weidner et al. study via comparison of urethral sphincter neuromuscular function among nulligravid versus primigravid women which notes a significant and lasting decrease in the urethral sphincter neuromuscular function between the two study cohort groups. Furthermore, Weidner at al found that the decrease in neuromuscular function of the urethral striated sphincter persisted at 6 months postpartum—a finding which does not coincide with the classic temporal pattern seen with direct injuries, i.e., neurogenic or myopathic injuries of the pelvic floor occurring during childbirth [5]. These studies underscore the significant role and impact of both the normal physiological changes of pregnancy in the pathogenesis of urinary dysfunction following pregnancy.

In the next section of this chapter, we will describe the relevant anatomy and processes of labor and delivery and review the respective changes and possible pathologies that arise from parturition.

3.5 Definitions of Labor/Preterm Labor

Labor is defined as active and persistent contractions that cause cervical change and ultimately result in delivery. Term labor occurs after the achievement of 37 completed weeks' gestational age, whereas preterm labor occurs after the completion of 20 weeks but prior to the achievement of 37 completed weeks' gestational age (20–36 6/7). Contractions and cervical change leading to delivery prior to 20 weeks' gestational age constitutes a miscarriage and is not categorized as labor [28, 31].

3.6 Stages of Labor

3.6.1 Prelabor: Cervical Remodeling ("Ripening")

The uterus exhibits contractions throughout gestation. The uterine contractions in the early and midtrimesters of pregnancy are characterized by being infrequent, irregular, generally painless, discoordinated, and focal within the contractile apparatus of the uterine myometrium. This is in stark contrast to the uterine contractions experienced during labor which are typically characterized as cyclical and repetitive, coordinated, and globally effect myometrial activity across a functional uterine syncytium that occurs during the first phase of latent and active labor. Unlike the discoordinated contractions in the early and midtrimesters of pregnancy, these coordinated contractions result in significant alteration in cervical length, consistency, and ultimately in dilation [31, 32].

A number of physiologic and cellular changes occur over the course of the late trimester, especially within the month leading up to labor. Such pre-labor changes are key to setting the stage for the three phases of labor during which progressive dilation of the cervix occurs until the fetus and placenta may be delivered in succession [32, 33].

The concept of the "cervical coefficient" was coined a half-century ago when Hendricks described pre-labor changes to the cervix observed via serial cervical examinations in a cohort of 303 patients. Hendricks simplified the complex biology surrounding prelabor changes into a mathematical function generated by the product of two factors—cervical dilation and effacement. The resulting cervical coefficient demonstrated strong inverse association with duration of labor; i.e., the larger the coefficient, the shorter period of labor to effect delivery, highlighting the importance of prelabor cervical changes [34].

Similarly, Bishop generated a scoring system that is commonly used to categorize a woman's cervix as favorable or unfavorable for induction as based on cervical and obstetrical descriptors that predict successful vaginal delivery [33]; see Table 3.1.

Hormonal and cellular changes drive the aforementioned observations. Inflammatory mediators converge on the myometrial tissues to trigger downstream signaling cascades that create a syncytial milieu across the uterine fundus and thus coordinating the process of labor. Progesterone withdrawal and downregulation of progesterone receptors are key components of this process and occur in concert with upregulation of oxytocin receptors [35, 36]. Initially, the cervix undergoes softening, which is effectively the first measurable alteration evident on exami-

Table 3.1 Bishop cervical scoring system

	0	1	2	3
Dilation, cm	Closed	1–2	3–4	≥5 to 6
Effacement, %	0–30	40–50	60–70	≥80
Station[a]	−3	−2	−1, 0	+1, +2
Cervical consistency	Firm	Medium	Soft	
Position of the cervix	Posterior	Midposition	Anterior	

[a]Based on a −3 to +3 scale

nation. This measurable decline in tensile strength and increase in tissue compliance is described in both biomechanical studies in animal model studies and from clinical examination in human pregnancies by digital examination. The palpable or measured softening is due to a progressive and incremental remodeling of the cervix owing to activation of metalloproteinases in the cervical stroma that effectively decrease the density of the connective tissue in the cervix [37, 38]. This decrease in tissue density leads to both softening and thinning of the cervix [39].

Many of these changes coincide with, and are a consequence of, the metalloproteinase-mediated destruction of the collagen matrix of the cervix. Collagen is notably the most abundant protein of the cervix and as such, destruction of the fibrillar collagen matrix leads to decreased tensile strength and firmness of the cervix. Additionally, glycosaminoglycans (GAGs) increase as gestation progresses and are expressed abundantly in the cervical stroma. GAGs modulate collagen fibril size and regulate the disorganization of the collagen extracellular matrix (ECM). Such changes are mediated by inflammatory cells and pro-inflammatory cytokines that not only lead to activation of the metalloproteinase enzymes but also cell-mediated clearance of the cervical stroma by tissue monocytes, neutrophils, and leukocytes [37–39]. This clearance of the cervical stroma is what leads to the clinically evident changes Hendricks was able to first describe and reduce to the cervical coefficient as well as the more commonly used Bishop score.

As opposed to the average prelabor cervical dilation relative to parity—1.8 cm for nulliparas versus 2.2 cm for multiparas—the cervical coefficient demonstrates positive correlation irrespective of parity with predicting onset of and duration of labor. Similarly, observational studies of women undergoing induction based on "favorable" Bishop scores, defined as at least 6–8 depending on the study performed, have demonstrated success that varies significantly by parity. Hence, subsequent authors have deduced that modifying a woman's Bishop score by adding 2 points for women with prior successful vaginal birth adds prognostic quality to the Bishop score. Such variation in success is rooted in the physiologic and histologic alteration that occurs during pregnancy and delivery and persists postpartum for parous women [35–37]. Women with prior vaginal deliveries have long been described as having parous cervical os, whereby the cervical os takes on a relaxed and collapsed ovoid shape rather than the nulliparous pinhole-like appearance; see Fig. 3.10.

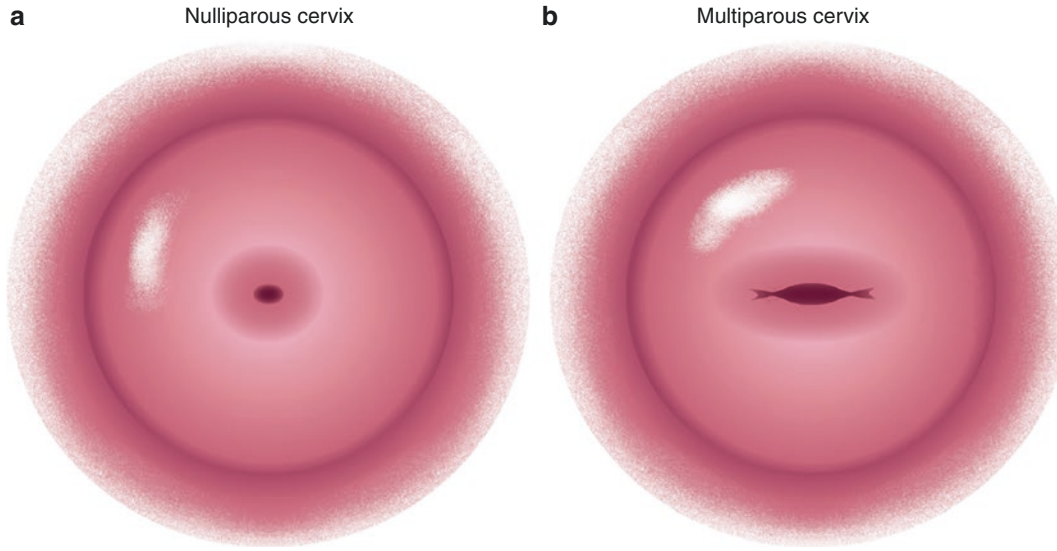


Fig. 3.10 Variation in cervical appearance by parity. Typical cervical appearance based on maternal parity

The characteristic appearance of a parous cervix is a consequence of the stretching and increased laxity in the cervical stroma that persists after a delivery even after a completely dilated and effaced cervix "closes" and reconstitutes itself postpartum. These changes are evident on elastography studies. Elastography technology enables an objective evaluation of the mechanical stamina of tissue walls as defined by a measured displacement of moving tissues in response to oscillatory pressure [40–42]. Cervical stiffness is assessed by the resistance of tissues to displacement and deformation. Nulliparous cervices demonstrate increased stiffness and resistance to displacement by elastography as compared to parous cervices. Accordingly, the mechanical strain imparted by a prior delivery has measurably created a persistent injury or deformation that is not only observable in appearance and measurable by elastography but also is functionally more efficient at effecting a vaginal delivery as demonstrated by the need to modify Bishop score to account for the positive effect of parity in childbirthing success [33, 40, 31, 42].

Following cervical remodeling are the three classic stages of labor. These stages of labor and timeline of the alterations to the maternal pelvic anatomy is highlighted in Fig. 3.11.

3.6.2 First Stage of Labor: Progressive Cervical Dilation

Following weakening and decreased tensile strength during cervical remodeling, the onset of repetitive uterine contractions leads to further widening of the cervix. Mechanical pressure from uterine contractions repeatedly and forcefully moves the presenting fetal part (e.g., fetal head in cephalic fetuses or buttocks in the breech fetus) toward and through the cervical os. This leads to progressive and active cervical dilation from the current threshold of cervical dilation of 6 cm (defining active labor) to 10 cm (complete cervical dilation) [39].

3.6.3 Second Stage of Labor: Expulsion of the Fetus(es)

Following complete cervical dilation, the fetus may be delivered through the cervix, vaginal vault, and onto the introitus. Delivery of the infant typically ensues shortly thereafter when maternal expulsive efforts are urged by the overall pressure of the presenting part being sensed in the birth canal. Given the greatly decreased tensile strength and increased compliance of the cervix, the ability of the cervix to pass the fetus without tearing or lacerations is very high. However, some women will sense the urge to push prior to the achievement of complete dilation or are urged to push prior to the achievement of complete dilation; these scenarios have a propensity for cervical laceration [31, 43].

Retrospective data indicate that in spite of such injuries, cervical lacerations are not associated with increase in cervical insufficiency (as indicated by need for cerclage) in subsequent pregnancies, cervical laceration in subsequent deliveries, labor dystocias/protracted labor in subsequent pregnancies, or with preterm delivery in subsequent pregnancies. Likewise, a history of cervical lacerations does not influence mode of delivery in subsequent pregnancies. While rare and unavoidable, the presence of fibroblasts deposition (scar) and potential for decreased compliance or integrity of the cervix for maintenance of pregnancy to term and being able to dilate and accommodate passage of the fetus, the presence of the scar tissue from prior laceration does not appear to have an adverse effect on subsequent pregnancy outcome [31, 32, 43].

The descent of the fetus through the birth canal and vaginal delivery leads to mechanical stretch that may tear and damage nerves, muscles, fascia, and ligamentous structures of the pelvic floor. Excessive stretch, tearing, and mechanical strain may lead to permanent anatomical and effectively irreversible functional alterations. The effect of the passage of the fetus

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Fig. 3.11 Is absent (Timeline of changes and alterations of maternal pelvic anatomy)

on these injuries is supported by the finding that subsequent childbirths continually expose the pelvic floor to injury and denervation and alteration of muscle tone (overstretched) that leads to decreased sensation, resting pelvic tone, and strength of the pelvic floor long term [31, 32, 43].

3.6.4 Third Phase of Labor: Placental Separation

During pregnancy, the placental site is characterized by an attachment in which the cotyledons actually extend into the decidua basalis; this interface of the placental cotyledons with the decidua is not only the exchange site during the gestation but also the functional cleavage plane during the third stage of labor [44, 45]. Placental separation occurs by a progressive shearing force of the placenta from the uterine wall. The shearing forces are created by the uterine contractions leading to a decrease in uterine size after expulsion of the fetus along with an inherent decrease in the surface area of the uterine cavity; this effectively shears or tears the placenta away from the uterine wall along the natural cleavage plane [44, 45].

During this process, the placenta is naturally thickened and decreased in overall diameter due to the constrictive forces of the uterine muscle. The ability of the placenta to decrease its surface area (given mass and density) is overcome by the force of the uterine contractions and is sheared away from the uterine wall. Upon separation, the uterine contractions result in expulsion of the placenta. Notably, the decidual vessels must be kinked/compressed by the muscle contraction since the decidualization process in pregnancy involves loss of the muscular intima of the spiral arteries. Without adequate uterine contraction and involution, obstetric hemorrhage can and will occur. As the postpartum period progresses, the associated estrogen and progesterone withdrawal lead to shedding of the thickened decidua from gestation [44–46].

3.7 Pathologies of Parturition

Previously, we have described many of the histological, physiological, and anatomical changes of parturition. For the remainder of the chapter, we begin to discuss the pathologies of labor and their implications for a woman's future health.

The mechanism of obstetrical trauma is believed to be several fold: trauma to the pelvic support system, denervation injury, ischemia, combined neurovascular injury, and defective soft-tissue remodeling have all been implicated and associated with the pathologies seen following childbirth [47].

3.7.1 Pathological Disruption of the Maternal Bony Pelvis During Childbirth

As the fetus passes through the pelvis, there is stretching and compression of the surrounding tissues and nerves. These mechanical forces of stretch and compression may result in tearing or avulsion of pelvic floor musculature, supporting ligaments, and nervous tissue. Several normal changes to the pelvic following uncomplicated term vaginal delivery have been described and include widening of the symphysis and sacroiliac joints, and also gas in the sacroiliac joints [22]. These aforementioned adaptations of gestation, while normal and necessary, also contribute to the propensity for traumatic disruption of the maternal bony pelvis during labor and delivery. Ultimately, the disruption of these tissues may in fact result in weakening the musculature and supporting ligaments and damaging the nervous tissue. For example, the sacroiliac joint exhibits marked mobility at term and this displacement functions to help increase the diameter of the pelvic outlet by 1.5–2.0 cm at delivery. When this displacement is greater than 2.5 cm, progressive injury to the posterior pelvic ring, including disruption of the sacroiliac joint or sacral fracture, may occur. This disruption of the pubic symphysis with accompanying posterior pelvic-arch

instability after natural childbirth has been previously described [22, 23, 27, 28]. Traumatic disruptions of the pubic symphysis with vaginal delivery may result in functional limitations and severe pain. Fortunately, intrapartum pubic symphysis disruption rarely occurs with an incidence ranging from 0.005 to 0.8% of live births, with an increasing incidence with advancing maternal age. When disruption does occur, women report suprapubic pain, difficulty sitting, standing, change in decubitus, and a "waddling" gait is often employed and observed [28, 34].

Abrupt intrapartum pubic symphysis separation is managed by pelvic ring stabilization with a pelvic binder if available or a sheet applied at the greater trochanter level. Injuries to this degree are ultimately surgically managed with open reduction and internal fixation with strategic placement of plates and screws to regain stability of the maternal pelvis [48–50]. Alternatively, conservative management with a pelvic binder and 4 weeks of bedrest has been described but all patients reported having severe pelvic pain, ultimately leading to open reduction internal fixation to reduce and stabilize the pelvic ring diameter to pre-pregnant state. After these procedures have been performed, hardware is typically left in situ even with intentions for future childbearing. On the contrary, some orthopedic surgeons advocate for hardware removal 1 year after the surgery when future childbearing is desired. Regardless, patients with persistent pain or hardware loosening are managed by hardware removal [48–50].

Obstetricians may perform pelvic examination, gently, to palpate diastasis of the pubic symphysis and may add pressure to the iliac crests to assess for instability of the pelvic ring. Alternatively, to avoid potential for eliciting significant patient discomfort, the clinician may order imaging studies (e.g., pelvic MRI) when cued by patient's verbal description [27, 28, 34]. Most gravidas exhibit what orthopedic surgical subspecialists refer to as an "open-book" injury in which there is partial instability—disruption of anterior ligaments with residual integrity of posterior ligaments. Such "open-book" injuries are vertically stable but rotationally unstable (Tile type B) [49]; see Table 3.2.

3.7.2 Pathological Trauma to the Pelvic Vasculature During Childbirth

During childbirth, passage of the fetus through the birth canal may also cause trauma by creating macroscopic tearing in both the symphysis pubis and venous plexus of the pelvis. Tearing and laceration of the latter (venous plexus and arterioles in the superficial fascia of the pelvic triangle) is evidenced by hematoma in the labia majora (known as the Destot sign); see Fig. 3.12.

Bleeding that is limited to the vulvar tissues superficial to the anterior urogenital diaphragm are categorized as vulvar hematomas. Vulvovaginal hematomas are likewise evident on

Table 3.2 Tile classification for fractures of the pelvis

Classification	Stability	Descriptors
A	Stable	A1: Fractures of the pelvis not involving the pelvic ring A2: Minimally displaced fractures of the pelvic ring
B	Rotational unstable, vertically stable	B1: Anteroposterior compression fracture (open book) B2: Lateral compression injury (ipsilateral) B3: Lateral compression injury (contralateral)
C	Rotationally and vertically unstable	C1: Rotationally and vertically unstable C2: Bilateral C3: Associated with acetabular fracture

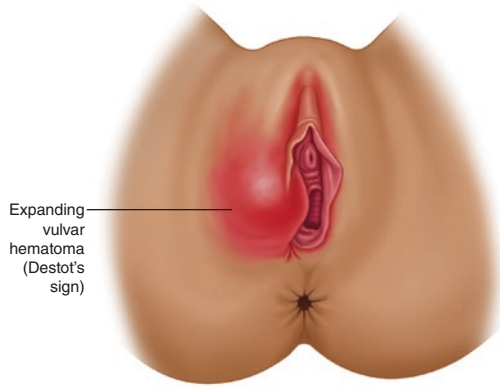

Fig. 3.12 Destot sign

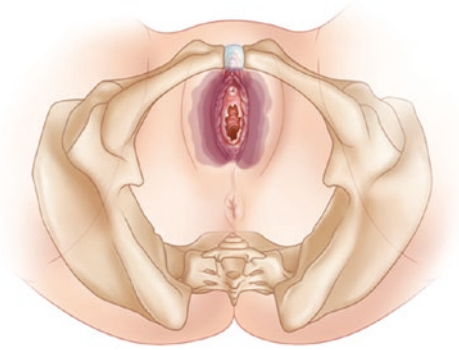

Fig. 3.13 Relationship of the urethra, vagina, perineum and anus to the maternal boney pelvis

the vulva but bleeding extends into the paravaginal tissues. In such childbirth trauma, the bleeding and apparent contusion arises from branches of the pudendal artery, namely, the posterior rectal, transverse perineal, and/or the posterior labial arteries [23, 27, 28].

3.7.3 Pathologies of the Pelvic Floor and Subsequent Development of Pelvic Floor Disorders (PFDs) Following Childbirth

As described previously, the levator ani muscle complex (LAM) is a hammock-like muscle which supports and comprises the pelvic floor [29, 51]. Levator ani muscle (LAM) injuries occur in 13–36% of women who have a vaginal delivery [52]. Vaginal delivery may compromise the integrity of the LAM complex via pathological overstretching of the muscular complex; traumatic disruption of the LAM complex via anteromedial avulsion and/or partial or complete detachment of the pubovisceral sling from the pubic bone; or denervation of the LAM complex. MRI and ultrasound data demonstrate disruptions of the LAM complex in about one-fourth to one-third of women following a normal vaginal delivery [29, 30, 51, 53]. This traumatic disruption or denervation may lead to loss of levator function and ultimately result in pelvic floor disorders [30, 53] (Fig. 3.13).

Pelvic floor disorders (PFDs) are common complications dealt with by women in the postpartum period and later in life. It is estimated that these disorders affect one-third of women in the United States and have a significant impact on a woman's overall health and quality of life [1–3]. PFD pathologies include urinary incontinence, anal incontinence, pelvic organ prolapse, nerve injury, and sexual dysfunction. While there is much controversy regarding the etiology of these pathologies as either resulting from the pregnancy itself, the delivery, or a consequence of both, a causal role of pregnancy and childbirth in causing PFDs is supported by the finding that PFDs are more prevalent among women who have delivered at least one child [2, 3, 8].

As described in the earlier section of the chapter, pregnancy itself is a risk factor for development of PFDs. However, vaginal delivery is also an independent and significant risk factor for several PFDs, including pelvic organ prolapse. It is theorized that as the fetus passes through the pelvis, there is stretching, compression, and tearing of the pelvic floor. These mechanical forces may result in damage to the integrity and function of the associated muscles, connective, and/or nervous tissue. Ultimately this may weaken the integrity of the pelvic musculature resulting in pelvic organ prolapse [54]. Similarly, with prolonged second stage of labor, there is an increased duration of possible soft tissue injury (via direct stretch, compression, tearing, or indirectly via neuromuscular damage) to the pelvic floor.

Prolonged second stage has been associated with consequential injury to the levator ani complex and pelvic floor disorders [30, 47].

The development of pelvic floor pathologies, specifically of pelvic organ prolapse, may also result from the mechanical disruption of the supporting connective tissue of the pelvic floor. Both the detachment of endopelvic fascia from its lateral attachment to the pelvic side wall, and the detachment of the arcus tendinous fascia pelvis from the ischial spine, have been implicated in the development of vaginal (paravaginal, anterior vaginal) wall defects and consequentially PFDs [51, 55]. Paravaginal defects are specifically associated with urinary incontinence and poor anterior vaginal support [55, 56].

Incontinence of stool and flatus are further complications of vaginal delivery and are more commonly experienced than was previously believed. The reported frequency of incontinence of stool in primiparous women ranges from 2 to 6% versus 17 to 62% after a severe perineal laceration [9, 10, 57]. Anal incontinence has been classically associated with both forceps delivery and anal sphincter laceration. In turn, anal sphincter laceration is strongly predicted by first vaginal birth, median episiotomy, and operative vaginal delivery. Finally, incontinence of stool is also more frequent among women who deliver vaginally and have had third- or fourth-degree perineal tears than among those who delivered vaginally and had no anal sphincter tears (7.8% v. 2.9%) [58, 59]. In conclusion, even a normal vaginal delivery (without the use of forceps or vacuum) predisposes a woman to issues related to recto-anal incontinence.

3.7.4 Pathological Disruption of the Pelvic Nervous System During Childbirth

Descent of the fetal head may cause stretching and compression of not only the pelvic floor musculature and connective tissue but also of associated pelvic nerves. For example, injuries to the lumbosacral plexus during labor and delivery may result in neuromuscular pathologies including denervation of the LAM complex and weakening of the musculature support pelvic organ prolapse. The process of demyelination and subsequent denervation as an indirect mechanism of injury to the pelvic musculature is supported by neurophysiologic tests, including concentric needle electromyography (EMG) and pudendal nerve motor latency tests [53, 60]. Stretching and compression injury to the pudendal nerve has been reported with 38–42% of vaginal deliveries [61]. Therefore, while vaginal delivery is a less described and recognized risk factor for pelvic floor neuropathy, even in the context of a normal vaginal delivery devoid of use of forceps or vacuum, there does exist risk to some degree of denervation of the pelvic floor and subsequent pelvic floor neuropathy. Other risk factors for denervation and pudendal nerve damage include operative delivery, midforceps rotation, prolonged second stage, fetal malpresentation, high birth weight, small maternal size [6, 62].

3.7.5 Pathological Disruption of the Lower Urinary Tract During Childbirth

Childbirth is associated with a high rate of stress urinary incontinence in the postpartum period. Even women who may have been continent during the pregnancy may experience significant urinary incontinence after vaginal delivery (de novo urinary incontinence). The reported incidence of de novo urinary incontinence after a first vaginal birth is 21% with spontaneous birth and 36% with forceps delivery [6, 7]. This increase in stress urinary incontinence following childbirth is believed to be the result of damage to the pelvic floor muscles, fascia, ligaments, and nerves supporting and controlling the bladder neck and urethra. Multiple studies have demonstrated that vaginal delivery may result in urinary system neuromuscular damage and bladder neck hypermobility, and pelvic floor dysfunction [47, 56, 63, 64]. It is noteworthy to mention here again that

pregnancy itself is associated with anatomical adaptations that may cause urinary incontinence and that multiple studies underscore the significant role and impact of both the normal physiological changes of pregnancy and the mechanical alterations following a normal vaginal delivery in the pathogenesis of urinary dysfunction following pregnancy [5, 29, 30].

3.7.6 Psychological Changes and Sexual Dysfunction (The Fourth Trimester)

Vaginal delivery is a risk factor for sexual morbidity. During vaginal delivery and in the postpartum period, the woman may experience lacerations, suture repair, hemorrhoids, constipation, incontinence, bleeding, and perineal or pelvic pain. These occurrences may have negative impacts on the woman and may predispose a woman to poor sexual functioning. In their study, Signorello et al. explore the relationship between obstetrical perineal lacerations and postpartum sexual functioning (including time to resuming sexual intercourse, dyspareunia, sexual satisfaction, sexual sensation, and likelihood of achieving orgasm). This study notes that the effect of spontaneous birth on postpartum sexual function is most significantly related to occurrence of perineal trauma, thus underscoring the importance of minimizing the extent of perineal damage during childbirth [65].

It is imperative to comment that in addition to the aforementioned physical factors, there are many psycho-social factors that may contribute to the risk of postpartum sexual dysfunction. Sexual health may also be impacted by mood dysphoria, sleep deprivation and fatigue, degree of partner involvement, and help with care of the infant. An awareness of both the physical and psychological changes and the consequential potential sexual difficulties following pregnancy and childbirth are paramount to providing women with vital and comprehensive postnatal care [66].

3.8 Concluding Remarks: The Fourth Trimester and Beyond

The biological processes of carrying a fetus to ideally term gestation, and then of delivery and the birth of the neonate, both entail and mandate a number of anatomic and physiologic alterations in the maternal pelvis. The endocrine and immune systems initiate and mediate these modifications to accommodate and sustain pregnancy for the growth, development, and birthing process of the fetus. The early-, mid-, and late trimesters are earmarked by a number of histologic changes of the uterus, cervix, and pelvis as summarized in this chapter. Upon achievement of term, endocrine signaling triggers the onset of labor and its inherent rapid physiologic and anatomical changes necessary to effect an atraumatic delivery for both the mother and fetus.

While childbirth occurs largely without undue trauma, pregnancy and the delivery process nonetheless may result in a myriad of physical and physiological changes with significant implications for a woman's future health. Knowledge of, and understanding of, these changes and pathologies are paramount for clinician guiding the transition from pregnancy to parenthood. In 2018, the American College of Obstetricians and Gynecologists (ACOG) recognized the many issues following pregnancy and delivery and underscored the importance of ongoing comprehensive care that should extend into the "fourth trimester" of pregnancy (the first 3 months following birth) [64, 67]. As part of a comprehensive care plan, the obstetric care provider should address with the woman the following factors: physical recovery from birth, mood and emotional well-being, infant care and feeding, sleep and fatigue, sexuality, contraction, birth spacing, chronic disease management, health maintenance [67]. Finally, the obstetric care provider should facilitate the woman's transition to on-going well-woman care to ensure that the implications of pregnancy complications is considered in the woman's future healthcare plans. In doing so, the

obstetrical provider is able to best care for the woman's physical and mental health after giving birth and enable every woman to optimize her long-term health and well-being [67].

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4 Delivery: Complicated Vaginal Deliveries and Surgical Interventions

Sarah White, Samantha Shirk, and Brian Brost

Take-Home Points

- Fetal malpresentation, such as persistent occiput posterior or occiput transverse presentations, is associated with increased maternal and neonatal complications, including prolonged labor, increased rates of third- and fourth-degree perineal lacerations, postpartum hemorrhage, chorioamnionitis, and operative deliveries.
- While rates of operative vaginal deliveries are declining, they remain an important skill set in modern obstetrics.
- Operative vaginal delivery is associated with an increased risk of levator ani injury with forceps-assisted vaginal delivery having a much stronger association with injury compared to vacuum-assisted delivery. This is thought to be due to numerous factors including rapid descent of fetal head, increased space requirements needed to place the device, and increased traction pressures.
- Routine episiotomy is not recommended due to lack of evidence demonstrating maternal or fetal benefit. Complications of episiotomy include third- or fourth-degree perineal laceration, bleeding, infection, breakdown of the episiotomy, postpartum pain, and dyspareunia.
- Median episiotomy is associated with an increased risk of anal sphincter injury, whereas mediolateral episiotomy may be protective against sphincter injury.
- Cesarean section now accounts for approximately 21% of deliveries globally.
- Studies have been unable to identify an optimal manner in which to close hysterotomy. While two-layer hysterotomy closure is generally recommended, studies have not shown a clear benefit to this technique. A preferred suture material has also not been identified.
- Pelvic floor changes are identified postpartum following both vaginal deliveries and cesarean sections.
- Postpartum tubal ligation is normally performed via the Parkland, Pomeroy, or modified Pomeroy methods.

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© Springer Nature Switzerland AG 2023
M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_4

4.1 Introduction

Labor is defined in the Merriam-Webster dictionary as the process of childbirth, especially the period from the start of uterine contractions to delivery. As presented in the previous chapter, there are specific anatomical and physiological changes of pregnancy and childbirth that allow for the normal process of labor. However, there are instances when these processes do not occur cohesively resulting in protraction of labor. During these times, operative or surgical means may be necessary to effect delivery. In this chapter, we discuss some etiologies of dysfunctional labor and management options to effect delivery along with the long-lasting anatomic and physiologic effects of these management options. Additionally, we discuss the potential anatomic and physiologic effects of permanent female sterilization.

4.2 Vaginal Delivery with Fetal Malposition

Vaginal delivery is most common when cephalic fetuses are both vertex and occiput anterior position. Fetal position describes the presenting fetal part relative to the maternal pelvis. In the setting of a vertex presentation, the fetal occiput is used to describe the fetal position, and a cephalic fetus in the occiput transverse or occiput posterior position is considered to have fetal malposition. Malpositioning of the fetus is associated with higher rates of perinatal complications, most commonly cesarean delivery.

Persistent occiput posterior position (OP) is the most common malposition at delivery with an incidence ranging between 2 and 13% [1–3]. In approximately 20% of laborers, the fetus enters the pelvis in an OP position. The right OP position is slightly more common than the left. It also appears from radiographic evidence that the OP position is more often associated with a narrow anterior pelvis or android pelvis [4].

Fetal malposition with OP position has been associated with both increased maternal and neonatal complications. There are a number of studies that have observed that the OP position is associated with prolonged labor, increased rates of third-degree or fourth-degree perineal lacerations, postpartum hemorrhage, chorioamnionitis, and operative deliveries, including both operative vaginal delivery and cesarean delivery [5, 6]. Cheng and colleagues compared outcomes of 2591 women with persistent occiput position to those of 28,801 women with occiput anterior position presentations. Data from this study found that essentially every possible delivery complication was more frequent with a persistent OP position. Additionally, only 46% of these women delivered spontaneously [5]. To date, there is no known effective intervention to minimize OP position prior to labor [7]. The nursing and midwifery literature has described a variety of maternal positions during labor to facilitate resolution of OP position, but, to date, none of these maternal positions have been examined in prospective, randomized controlled trials [8].

Early in labor, it is common for the vertex-presenting fetus to be in occiput transverse (OT) position. However, with internal rotation, a standard cardinal movement of labor, the majority of fetuses present with occiput anterior position during the active phase of the first stage of labor or the second stage of labor.

Numerous studies have studied the prevalence of OT position and found that 19–49% are in OT position at the onset of labor [9, 10], 10–20% are in OT position in the second stage of labor [10–12], and 3–8% are in OT position at delivery [9, 13]. In one study by Lieberman et al., the operative delivery rate was 87% when OT position was present at birth compared with 24% when the fetus was in occiput anterior position [9]. Furthermore, the occiput transverse position is associated with more frequent augmentation of labor, need for episiotomy, higher order perineal lacerations, febrile morbidity, prolonged second stage of labor, and low 5-min APGAR scores [14].

4.2.1 Manual Rotation

As previously mentioned, fetal malposition is associated with labor dystocia, increased cesarean delivery, and operative vaginal delivery, as well as higher risk of maternal and neonatal morbidity. Manual rotation of the fetal occiput from occiput

posterior or occiput transverse to occiput anterior was first described as a potential interventional maneuver for malposition in 1971 by Walkowiak [15]. Manual rotation prior to the second stage of labor is not recommended as the fetal head can rotate on its own during the first stage of labor [16]. Recent studies support manual rotation as a safe and effective intervention in the setting of labor arrest, particularly in the second stage. A high rate of successful rotation ranging between 74 and 93% among those who underwent a trial of rotation was observed in these studies [17, 18]. Compared with expectant management, women whose fetuses underwent successful rotation to occiput anterior position were less likely to require delivery by cesarean or operative vaginal deliveries. Outcome data on morbidity and mortality associated with manual rotation is scarce. However, maternal risks of manual rotation, namely, cervical laceration, are minimal when the procedure is performed by a skilled practitioner after completion of the first stage of labor [16].

4.2.2 Face Presentation

With this presentation, the fetal head is hyperextended so that the occiput is in contact with the fetal back and the mentum (chin) is presenting (Fig. 4.1). The fetal face may present with the mentum anterior or posterior relative to the maternal symphysis. The incidence of face presentation reported by Cruikshank and White was 0.17% [19].

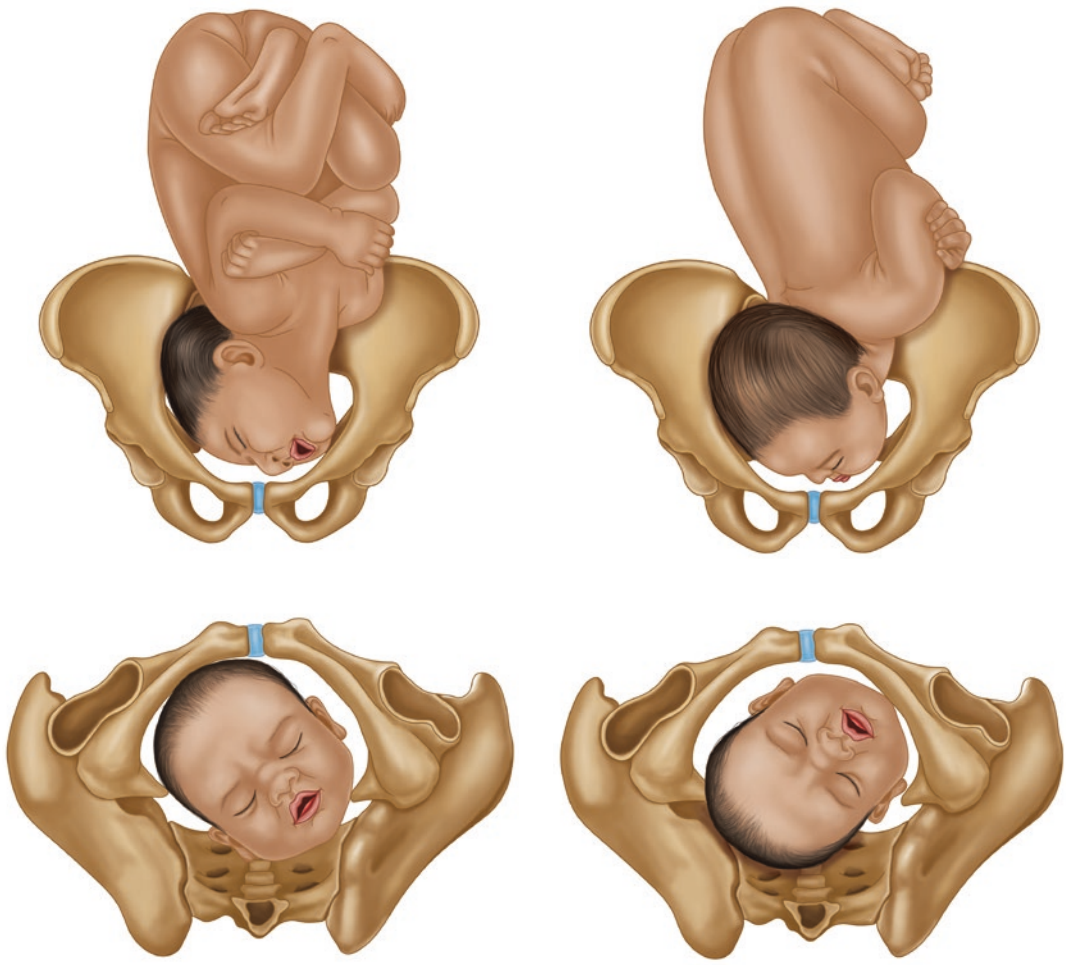


Fig. 4.1 Face presentation

Causes of face presentation are numerous and include any condition that favors fetal head extension or prevents fetal head flexion. Preterm infants with their smaller head dimensions [16] and fetal malformations such as anencephalic fetuses [20] oftentimes prevent the necessary cardinal movement of head flexion. Additionally, hyperextended positions develop more frequently when the maternal pelvis is contracted or the fetus is very large [21].

Many mentum posterior presentations convert spontaneously to anterior [22]; however, if this does not occur, this fetal malpresentation precludes the necessary fetal head flexion required to negotiate the birth canal. In term fetuses, face presentations are more common in women with some degree of pelvic inlet contraction and routinely require cesarean delivery to effect delivery. Persistent mentum posterior presentation prevents a successful vaginal delivery, and attempts to convert a face presentation with manual or forceps rotation into an alternative fetal presentation are dangerous and should not be done.

4.2.3 Brow Presentation

Brow presentation is a rare presentation that is diagnosed when the portion of the fetal head between the orbital ridge and the anterior fontanel presents at the pelvic inlet (Fig. 4.2). Except when the fetal head is small or the pelvis is unusually large, engagement of the fetal head and subsequent delivery cannot take place as long as the brow presentation persists.

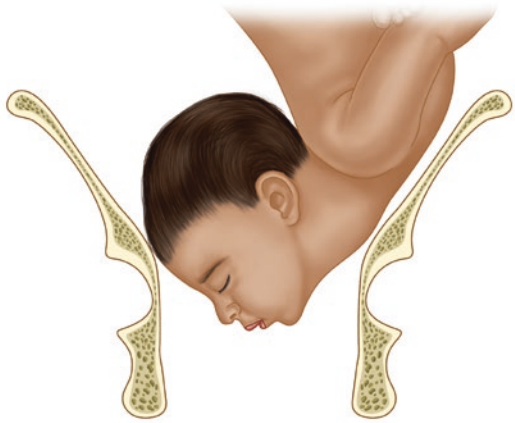


Fig. 4.2 Brow presentation

The etiologies of brow presentation are the same as face presentation. According to the study performed by Cruikshank and White, brow presentation is commonly unstable and converts to either normal occiput presentation or face presentation [19]. Principles of management are the same as those for a face presentation.

4.3 Operative Deliveries

Operative vaginal delivery, in which the second stage of labor is shortened with the use of either forceps or a vacuum device, is an important technique employed when delivery needs to be expedited. Such situations include fetal distress, maternal comorbidities necessitating a shortened second stage, or maternal exhaustion, and operative delivery offers an alternative method to cesarean section. While the use of forceps was first described in the 1600s and has been used for centuries, current trends demonstrate a decrease in use. The reported rates of operative vaginal delivery range from 3 to 5% [23, 24] and are decreasing as the rate of cesarean sections increases. Merriam et al. demonstrated a decrease in vacuum-assisted deliveries from 5.8 to 4.1% between 2005 and 2013 and a decrease in forceps-assisted deliveries from 1.4 to 0.9%. Regional trends have also been noted with higher rates in the Midwest and South, while the lowest rates are noted in the Northeast [24]. Despite the decreased use and the maternal and fetal risks associated with operative delivery, many women will choose operative delivery to avoid the longer recovery and long-term sequelae of a cesarean section. Thus, operative delivery remains an important skill set in obstetrics.

4.3.1 Forceps-Assisted Vaginal Delivery

Forceps were first described in the 1600s but became more widely used following modification of the device in the 1750s to include a pelvic curve. However, as cesarean sections have

become safer to perform, and following the introduction of the vacuum device, the rate of forceps-assisted deliveries has declined. In 1990, the rate of forceps deliveries was 5.11%, whereas by 2017, the rate had fallen to 0.5% [25].

Forceps deliveries were reclassified in 1988 into three types by the American College of Obstetricians and Gynecologists: outlet, low, and midforceps. High forceps deliveries, in which the fetal head is not yet engaged, are no longer performed in modern obstetrics. An outlet forceps delivery is one in which the scalp is visible at the introitus, the fetal skull has reached the pelvic floor, the fetal head is at or on the perineum and in right or left occiput anterior or posterior position, and rotation is less than 45°. A low forceps delivery is one in which the leading point of the fetal skull is at +2 or more but not yet reaching the pelvic floor, and there is no restriction on rotational degrees. A midforceps delivery is one in which the fetal head is not yet at +2 but is engaged in the maternal pelvis.

4.3.2 Types of Forceps (Table 4.1)

4.3.2.1 Simpson

Simpson forceps were introduced in 1848 and are the most commonly used type of obstetric forceps (Fig. 4.3). These forceps are characterized by an elongated cephalic curve to allow to use with a molded fetal head most commonly seen in a nulliparous patient.

4.3.2.2 Tucker-McLane

Tucker-McLane forceps were introduced in 1868 and have a smooth blade without fenestrations (Fig. 4.4). These forceps are used when delivering a non-molded fetal head most commonly seen in a multiparous patient.

Table 4.1 Types of forceps

Forceps	Description	Indication	Advantages	Disadvantages
Simpson	Fenestrated blade with elongated cephalic curve; parallel shank; Luikart modification of blade available	Molded hold	Can be used in nulliparous females and in fetuses with caput	Risk of neonatal injury or facial nerve palsy; risk of maternal perineal laceration
Tucker-McLane	Smooth blade; overlapping shank	Unmolded head; rotation	Can be used in multiparous females or those with rapid cervical dilation/minimal molding; overlapping shanks cause less perineal stretching	Risk of neonatal injury or facial nerve palsy; risk of maternal perineal laceration
Kielland	Slight pelvic curve; overlapping shank; sliding lock	Rotational maneuvers	Can be used for rotational maneuvers	Due to minimal pelvic curve, more likely to cause sulcal tears once fetal head is at the level of pelvic floor
Barton	Anterior hinged blade; posterior blade with deep cephalic curve; sliding lock	Deep transverse arrest in platypelloid pelvis	Can be used for deep transverse arrest	Limited use outside of deep transverse arrest
Piper	Long shank with backward curve; no pelvic curve	Delivery of after-coming head in breech deliveries	Long shanks and lack of pelvic curve allow direct application to after-coming head	Limited use outside breech deliveries
Spatula	Two independent levers that do not articulate; smooth blade	Delivery of fetal head	Decreased risk of neonatal cerebral hemorrhage	Limited use outside of Europe; possible increased risk of lacerations

Fig. 4.3 Simpson forceps

Fig. 4.4 Tucker-McLane forceps

4.3.2.3 Kielland

Kielland forceps were first introduced in 1915 by Dr. Christian Kielland. These blades have a slight pelvic curve with an overlapping shank and a sliding lock (Fig. 4.5). Due to the minimal pelvic curve, these forceps are used to correct rotational defects.

4.3.2.4 Barton

Barton forceps were introduced in 1925 to aid in the delivery of fetuses with deep transverse arrest in a platypelloid pelvis (Fig. 4.6). In this situation, the Kielland forceps cannot be used as the fetus must be delivered in the OT position, and the anterior blade of the Kielland forceps could damage the symphysis or the bladder. The Barton forceps have an anterior hinged blade, a posterior blade with a deep cephalic curve, and shanks attached to anterior and posterior blades at a 50° angle to form a pelvic curve when held with the shanks perpendicular to the horizontal.

4.3.2.5 Piper

Piper forceps were introduced in 1924 to aid in the delivery of the after-coming head in vaginal breech deliveries (Fig. 4.7). Piper forceps have long shanks with a backward curve, which drops the handles below the level of the blades. Additionally, there is no pelvic curve allowing for application to a fetal head at high station.

4.3.2.6 Spatula

The Thierry and Teissier spatulas consist of two independent and symmetric branches, which include a shank, handle, and wide solid blade. Teissier spatulas are shorter and preferred for preterm deliveries. The shanks do not articulate

Fig. 4.5 Kielland rotational forceps

preventing compression of fetal head between the blades, leading to the main advantage of spatulas, to lower the risk of cerebral hemorrhage and cranial injury.

Fig. 4.6 Barton forceps

4.3.2.7 Vacuum

Vacuum-assisted vaginal delivery was first described in 1705 by Yonge with the use of a glass cup vacuum device. Multiple iterations of vacuum devices have been described including an air tractor vacuum described by Simpson in 1848 and a metal cup vacuum device by Malstrom in 1953. Currently, bell-shaped and hemispheric vacuum devices are used. The past 20 years have seen an increase in vacuum-assisted vaginal deliveries, and 5% of vaginal deliveries in the United States are now assisted via vacuum devices. The indications and contraindications for use of vacuum are the same as those for forceps. While forceps are thought to cause more maternal morbidity, vacuum devices are thought to cause more neonatal morbidity. A meta-analysis of ten clinical trials demonstrated a lower risk of severe perineal laceration with the vacuum as compared to forceps. However, the same study demonstrated a high rate of scalp injury and cephalohematoma with vacuum as compared to forceps [26].

There are two main types of vacuum devices: a soft cup and a rigid cup. Soft cups are pliable and funnel or bell shaped, whereas rigid cups are mushroom shaped and firm. The cups are attached to a pliable or freely rotating stem to prevent the torque of the cup and subsequent scalp injury. A meta-analysis of 1375 women demonstrated that soft cups are more likely to fail due to detachment as compared to rigid cups, but they are less

Fig. 4.7 Piper forceps

likely to cause fetal scalp injury. In addition, there was no increased risk of perineal trauma [26]. Other studies have not shown increased failure rates when using soft cups. It is generally recommended to use a soft cup for straightforward vacuum extractions and rigid cups for occipitoposterior presentation, significant caput succedaneum, larger infants, or asynclitism.

In order to effect a successful vacuum-assisted delivery, the vacuum device must be placed symmetrically over the sagittal suture approximately 2 cm anterior to the posterior fontanelle. Vacuum pressure is then applied to create a chignon, and with each contraction, vacuum pressure is increased to 0.8 kg/cm^2. There is no difference in neonatal outcomes if the pressure is maintained or reduced between contractions. The traction force needed to ensure a vaginal delivery is unknown. However, an observational study of 119 deliveries demonstrated that a pressure of 450 mmHg was adequate for delivery in most cases, and all patients were delivered with pressures of 500–600 mmHg [26]. Higher pressures are associated with increased risk of neonatal injury.

4.4 Pelvic Floor Following Operative Delivery

The use of forceps to effect vaginal delivery is a known risk factor for the development of pelvic floor dysfunction. In his meta-analysis, Friedman et al. described an odds ratio of 6.94 for levator ani avulsion when comparing forceps-assisted vaginal delivery to spontaneous vaginal delivery. The odds ratio for avulsion when comparing forceps-assisted vaginal delivery to vacuum-assisted vaginal delivery was 4.57, placing a patient who has undergone a forceps-assisted vaginal delivery at highest risk for pelvic floor dysfunction in the future. In a longitudinal study of women 16–24 years following vaginal delivery, women who had a forceps delivery were more likely to have stage 2 prolapse or have undergone surgery for prolapse compared to those who had spontaneous vaginal deliveries or vacuum-assisted deliveries. Hiatal area was also larger in women who had undergone forceps delivery [27].

Vacuum-assisted delivery, like forceps-assisted vaginal delivery, is associated with an increased risk of levator ani injury, though it is thought to be a weak risk factor. In a large meta-analysis, Friedman et al. found an OR 1.27 for vacuum-assisted delivery compared to a spontaneous vaginal delivery [27]. This risk may be due to rapid descent of the fetal head associated with the use of vacuum devices, increased space requirements needed to place the device, and increased traction pressures. Similarly, Garcia-Mejido demonstrated an increased risk of levator ani injury with an avulsion rate of 34.2% compared to 9.6% in spontaneous vaginal deliveries [28]. When rigid and soft cups were compared to determine the risk of levator ani injury as seen on 3D sonography at 6 months postpartum, no difference in risk was discovered. In this study, levator ani muscle avulsion was seen in 33% of

deliveries with a rigid cup as compared to 29.4% of deliveries with a soft cup [29]. The same group of investigators showed that the number of traction pulls was not associated with the risk of levator ani avulsion [30].

The effects of these forces directly on the cervix and vaginal musculature are not described in literature, making this a potential area for future research.

4.5 Episiotomy (Table 4.2)

An episiotomy, surgical enlargement of the vaginal introitus by an incision of the perineum, was first described in the 1740s but did not become widely used until the twentieth century. At that time, it was believed that childbirth was a pathologic process and could be shortened with the use of an episiotomy. From the 1970s to 1990s, episiotomies were commonly performed on all females during the second stage of labor as it was thought to decrease perineal trauma, pelvic floor dysfunction and prolapse, urinary and fecal incontinence, and sexual dysfunction. In 2006, the American College of Obstetricians and Gynecologists published a recommendation against the use of routine episiotomy due to lack of evidence showing maternal or fetal benefit. To date, there is still insufficient objective evidence-based criteria to define the indications for use of episiotomy in obstetric practice, and the recommendation remains to practice restricted use of episiotomy based on clinical judgment [31]. In 2012, the rate of episiotomy in childbirth was 12%, decreased from 33% in 2000. While the rate of episiotomy decreased, the rates of obstetric anal sphincter injury (OASI) decreased 1.5%, but there was a 7.6% increase in OASI in the setting of operative vaginal delivery [26]. In a review of 2,226,170 deliveries between 2006 and 2012 at over 5000 hospitals, Friedman et al. demonstrated that white race and commercial insurance were associated with higher rates of episiotomy while delivery in a rural or academic center was associated with lower rates of episiotomy use [27]. Additional studies on episiotomy use have revealed that private practitioners have a two- to fourfold increased use as opposed to trainees, academic faculty, and midwives [27, 32, 33].

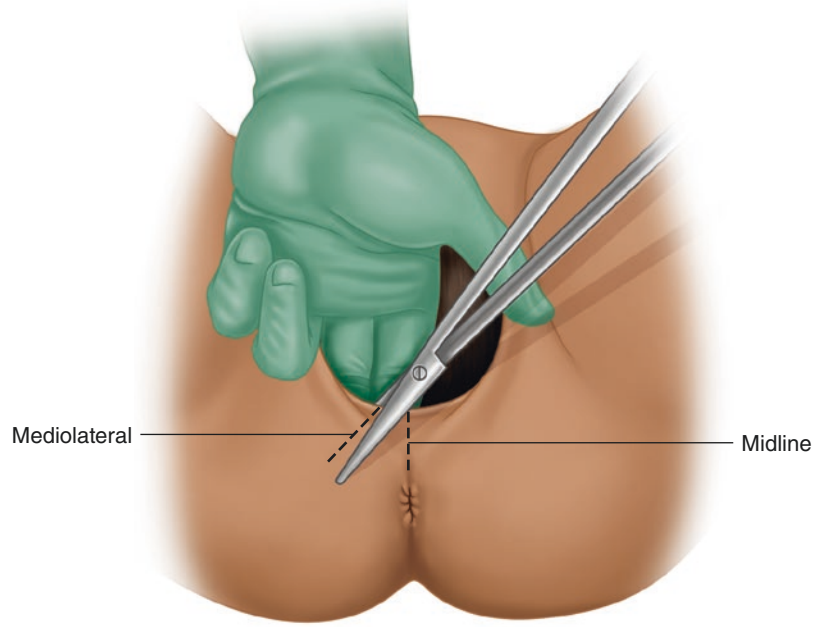
4.5.1 Mediolateral Episiotomy

Mediolateral episiotomy, one in which the incision extends from the introitus down at a 45° angle, is the preferred type of episiotomy performed in Europe and is recommended over the midline episiotomy in "Intrapartum care for a positive childbirth experience" published by the World Health Organization (Fig. 4.8). In 2008, the first large cohort study investigating the rate of obstetric anal sphincter injuries in operative deliveries was published using the Dutch National Obstetric Database. This study which included 21,254 women delivered via vacuum extraction and 7478 women delivered with forceps demonstrated a 0.11 OR for OASI with mediolateral episiotomy in vacuum extraction and 0.08 in forceps deliveries [34]. A similar result was found in a study by Gurol-Urganci, which included 1.2 million women and demonstrated a three times lower incidence of OASIS with the use of mediolateral episiotomy in nulliparous women undergoing operative vaginal delivery (OR 1.89 for vacuum extraction without episiotomy; OR 6.53

Table 4.2 Types of episiotomies

Episiotomy	Description	Advantages	Disadvantages
Midline	Incision extends downward at 0–25° angle	In select situations may facilitate delivery of fetal head	Independent risk factor for third- or fourth-degree laceration; increased risk of bleeding, infection, extension of incision, postpartum pain, and dyspareunia compared to no episiotomy
Mediolateral	Incision extends from introitus at 45° angle	Questionable lower rate of OASIS	Increased risk of bleeding, infection, extension of incision, postpartum pain, and dyspareunia compared to no episiotomy

Fig. 4.8 Episiotomies



for forceps delivery without episiotomy) [35]. Another Dutch cohort study in 2018 demonstrated a 14.0% rate of OASI in women who underwent a vacuum extraction without an episiotomy compared to a 2.5% rate in women who did receive an episiotomy. In this study, the rate of mediolateral episiotomy was 87.3%, which suggests a protective effect of episiotomy. Similar findings were demonstrated in women who had forceps deliveries (26.7% rate of OASI without episiotomy compared to 3.4% with episiotomy) and in multiparous women [36]. To date, no randomized control trials have been performed to validate these findings.

Angle of the episiotomy is also an important consideration and factor in OASI. The mediolateral episiotomy ideally starts at the 6 o'clock position on the posterior fourchette and angles away from the midline. However, due to significant distortion of the perineum during childbirth, the correct starting location and angle can be difficult to estimate. A study performed by Kalis et al. investigated the difference between the angle of episiotomy cut during crowning of the fetal head and the suture angle of the episiotomy after childbirth. A 40° angle pre-marked episiotomy resulted in a 22° suture angle, while a 60° pre-marked episiotomy resulted in a 45° suture angle [37]. An Irish study looking at mediolateral episiotomies revealed that the rate of OASI was 10% with a 25° suture angle but that the risk reduced by 50% for every 6° that the episiotomy was angled away from midline; this rate ultimately decreased to 0.5% with a 45° suture angle [38]. A Norwegian study revealed similar findings but did show that a 90° suture angle was associated with a ninefold increased incidence of OASIS [39]. Based on these findings, the Royal College of Obstetricians and Gynecologists as well as the society of Obstetricians and Gynecologists of Canada now recommend a 60° cutting angle when making mediolateral episiotomies.

When performing a mediolateral episiotomy, the direction of the incision depends on the handedness of the provider; a right-handed provider will incise from the posterior fourchette towards the patient's left ischial tuberosity. The incision involves the vaginal epithelium, transverse perineal and bulbocavernosus muscles, and perineal skin. A large incision may also expose the adipose tissue within the ischiorectal fossa. If

needed, the incision can be extended through the levator ani to provide additional space needed during delivery [40].

Following delivery, a rectal exam should be performed to evaluate for potential anal sphincter injury. Repair of a mediolateral episiotomy otherwise occurs in a fashion similar to the repair of other vaginal lacerations. Prior to re-approximation of the vaginal epithelium, the bulbocavernosus and the transverse perineal muscles must be re-approximated. Due to more surface area on the lateral aspect of the incision, larger lateral suture bites must be taken. The remainder of the repair occurs in a standard fashion. While interrupted sutures have been described in episiotomy repair, continuous repairs are associated with less pain postpartum, less analgesia use, and a lower risk of needing suture material removed postpartum and are therefore recommend by the American College of Obstetricians and Gynecologists. Care should be taken not to place excessive tension on the tissue, which can lead to tissue strangulation. Synthetic absorbable sutures are recommended for repair and are associated with less pain up to 3 days postpartum and less analgesia use up to 10 days postpartum. However, women with absorbable synthetic suture are more likely to require removal of unabsorbed suture material postpartum (RR 1.81; 95% CI, 1.46–2.24) [31]. Nonabsorbable sutures should be avoided for episiotomy repair.

4.5.2 Midline Episiotomy

Midline episiotomy, one in which the episiotomy extends downwards at 0–25° of the sagittal plane, is the most commonly used episiotomy in the United States (Fig. 4.8). Despite this, it is known that midline episiotomies are an independent risk factor for third- or fourth-degree perineal lacerations. Shiono et al. studied 24,114 women and found that women with midline episiotomies were almost 50 times more likely to have a third- or fourth-degree perineal laceration compared to those who did not undergo episiotomy. After adjusting for use of forceps, occiput posterior and occiput transverse presentations, small pelvic outlet measurements, lower maternal prepregnancy weights, and fetal weight, midline episiotomy was associated with a 4.2-fold increased risk of laceration in primiparous women and a 12.8-fold increased risk in multiparous women [41]. Though this study was performed in 1990, additional more contemporary studies have demonstrated similar findings. A study performed by Kudish et al. investigated 33,842 vaginal deliveries between 1996 and 2003 and demonstrated that nulliparous women who had a midline episiotomy were 4.5 times more likely to have OASI compared to those who did not have an episiotomy. Meanwhile, multiparous females were 14.6 times more likely to have OASI with midline episiotomy. Similarly, operative vaginal delivery with episiotomy was associated with a greater likelihood of having OASI in both nulliparous and multiparous females, with multiparous females at a greater risk than nulliparous females [42]. Even if the laceration spares the anal sphincter, midline episiotomy was found to increase the length of perineal lacerations by an average of 3 cm in a study performed by Nager et al. [43].

To perform a midline episiotomy, the perineum is incised vertically at the 6 o'clock position starting at the introitus. The incision is directed internally with the intent to minimize the amount of perineal skin incised. The length of the incision varies depending on the clinical situation with the goal to release any tissue that may be restricting the delivery of the fetal head. The layers of tissue incised in a midline episiotomy include vaginal epithelium, perineal body, and junction of the perineal body with the bulbocavernosus muscle.

Repair of a midline episiotomy is performed in a similar fashion to a second-degree perineal laceration repair.

4.5.3 Complications

Complications of episiotomy have been reported to include extension of the perineal incision, bleeding, infection, breakdown of the episiotomy, postpartum pain, and dyspareunia. However, with the exception of perineal laceration exten-

sion, data is conflicting regarding these long-term complications. In a meta-analysis of 22 studies, women with a third- or fourth-degree perineal laceration were 3.69 times more likely to have had an episiotomy performed during delivery [44]. In a randomized control trial in Colombia in 2008, nulliparous females who received routine midline episiotomy were more likely to have a third-degree laceration compared to females who did not have an episiotomy [45]. In contrast, severe perineal lacerations may be decreased with mediolateral episiotomies compared to midline episiotomies. The Collaborative Perinatal Project demonstrated a decreased adjusted odds ratio for OASI with mediolateral episiotomies in primiparous females [41]. A Cochrane review in 2017 did not find any increased risk in blood loss at delivery, perineal infection, moderate or severe perineal pain, long-term dyspareunia, urinary incontinence, or genital prolapse in women who received routine episiotomy versus those who received selective episiotomy [46]. However, House et al. demonstrated a statistically significant increase in pain of postpartum day 3 with routine use of episiotomy compared to restricted use [47], and likewise, a prospective cohort study involving 519 females found significantly higher rates of perineal pain and dyspareunia at 3 months postpartum in those who received a mediolateral episiotomy compared to those who did not [48]. In a study focused only on midline episiotomies, no increased postpartum pain was found in women who received episiotomy versus those who did not [49].

4.6 Pelvic Floor in Relation to Episiotomy

While vaginal delivery is a known risk factor for pelvic floor dysfunction, the relation of episiotomy to this dysfunction is not well known. Multiple studies performed in the early 1990s demonstrated that there is a general decline in perineal function regardless of the degree of perineal damage obtained during childbirth and that this decline in function was most notable following a primigravid birth. Similarly, Rockner et al. demonstrated that women who had a mediolateral episiotomy had a 33% loss in muscle function compared to a 20% loss in women who did not receive an episiotomy [50]. Fleming et al. investigated the effects of midline episiotomy on perineal muscle strength. In the study, pregnant females had their perineal muscle strength and endurance tested both antepartum and postpartum. Antenatally, women who eventually received an episiotomy were found to have the highest peak muscle strength and endurance. When comparing women who had intact perinea, episiotomies, first-degree lacerations, second-degree lacerations, and cesarean sections, women who had episiotomies had the worst perineal muscle performance postpartum and were the only group of women who had a decline in postpartum muscle strength when compared to antepartum muscle strength [51]. Contrasting these findings, a secondary analysis of the Mothers' Outcomes After Delivery study found that history of episiotomy was not associated with pelvic floor disorders 5–10 years following delivery; the relative odds of prolapse was the same among women with a history of no episiotomies, one episiotomy, or multiple episiotomies. Women with a history of multiple spontaneous lacerations were significantly more likely to have stage 2 or greater prolapse when compared with those who had none or one spontaneous laceration. This analysis was supportive of newer evidence that levator ani avulsion plays a role in the development of pelvic floor dysfunction and that spontaneous laceration is a proxy for excessive levator ani stretch and avulsion during childbirth. With this theory, episiotomy would relieve this stretch and therefore potentially preserve levator ani anatomy and function later in life [52]. Furthering this theory, Oliveira and colleagues created a biomechanical model to assess the distribution of stress and damage on the pelvic floor muscles that occurs in various obstetrical situations. The model included the levator ani and coccygeus muscles, the surrounding support structures, the pubic bone, and the fetal head in the occiput anterior position with initial head flexion to present and maintain the smallest head diameter during the simulated delivery. An intact perineum was compared to

three lengths of episiotomy (10, 20, and 30 mm) performed at three angles (30, 45, and 60°). In this model, the pelvic floor muscles, specifically the pubovisceral component of the levator ani, were subject to significant stretch and strain and episiotomy was found to be protective against such damage. In all simulated deliveries, the maximum value of stress on the muscle was where the opening of the episiotomy ended, and in the intact perineum, the stress was distributed at the insertion points of the rectal area of the levator ani. In the model, the angle of the episiotomy was found to affect the amount of force experienced by the tissue with the 30° angle producing the least amount of tissue damage. Similarly, the length of the episiotomy was also found to be inversely proportional to the amount of force the muscle experienced with the 30 mm incision having the least amount of force needed for delivery. Taken altogether, a 30 mm episiotomy at 30° was found to be most protective to the pelvic floor musculature. The peak force needed for delivery with this episiotomy was found to be 100.9 N, while the peak force needed for delivery without episiotomy was 211.0 N. This is suggestive that the force needed for delivery in the setting of an episiotomy is less likely to cause avulsion of the levator ani from the pubic bone when compared to a delivery without an episiotomy [53]. To confirm and expand these findings, Oliveira and colleagues created additional models to evaluate the effects of vaginal delivery and episiotomy on the pelvic floor musculature and the development of pelvic organ prolapse. In these models, the same angles and lengths of episiotomy were tested as in previous models. Again, a 30 mm episiotomy cut at a 30° angle was found to be protective against pelvic floor muscle damage when compared to a vaginal delivery without episiotomy and the other episiotomies evaluated. Furthermore, damaged pelvic floor musculature was more like to be associated with a larger levator hiatus and inability to contract the pelvic openings, decreased ability to elevate the pelvic floor musculature with voluntary contraction, and increased mobility between the bladder neck and pubic symphysis, suggestive of increased risk of stress urinary incontinence [54]. These results stand in direct contrast to those found by Fleming et al., which demonstrated weaker pelvic floor musculature in the setting of episiotomy. However, Oliveira's models demonstrated tissue strength immediately postpartum, and it is possible that the tissue strength is lost after healing of the episiotomy repair.

4.7 Cesarean Delivery

Cesarean section, first described in ancient Rome, is now performed for approximately 32% of births in North America. While the rate varies greatly among countries due to available resources, the global rate of cesarean sections is approximately 21%. However, in countries such as Brazil, the rate is between 80 and 90% due to requests for elective cesarean sections. In the United States, it is estimated that the elective cesarean rate due to maternal request is 2.5%. Indications for cesarean section include fetal distress, fetal malpresentation, failed progression of labor, failed induction of labor, history of prior cesarean sections, and fetal or maternal contraindications to labor. The American College of Obstetricians and Gynecologists recommends proceeding with cesarean based on maternal request only after counseling about the risks of cesarean section and the increased risks of placenta previa, placenta accreta, and need for hysterectomy with subsequent cesareans.

4.7.1 Transverse Skin Incisions

A Pfannenstiel incision is the incision most commonly used in contemporary cesarean sections (Fig. 4.9). This incision is made 2–3 cm above the pubic symphysis in a curvilinear fashion to follow the lines of Langerhans along the abdomen. Care should be taken when extending this incision into the subcutaneous tissue to avoid lateral extension, which may transect the superficial epigastric arteries. Following dissection through the skin and subcutaneous tissue, the anterior rectus fascia is sharply incised with a scalpel, and

the incision is extended laterally with curved Mayo scissors or a scalpel. The fascia is then dissected off the underlying rectus muscle with a combination of sharp and blunt dissection, taking care to ligate any perforating vessels. The peritoneum can then be entered between the rectus muscle bellies, offering access to the anterior uterine surface. Pfannenstiel incisions are associated with better cosmesis and less postoperative pain when compared to midline vertical incisions but, due to more dissection to reach the uterus, are associated with a slightly longer operative time [55, 56].

The Joel-Cohen incision is a transverse incision made 2–3 cm above where a Pfannenstiel incision would traditionally be made; this incision is linear rather than curvilinear in nature. When performing a cesarean with a Joel-Cohen incision, blunt dissection can be used once the fascia is transected, resulting in a faster operating time. However, there are no other maternal or fetal benefits other than speed, and the surgical steps performed are similar to those taken with a Pfannenstiel incision [56].

4.7.2 Vertical Skin Incision

The midline vertical incision was the skin incision historically used secondary to speed and ease of entry into the peritoneal cavity (Fig. 4.9). With this incision, a vertical skin incision is made from below the umbilicus to just above the pubic symphysis; if needed, the incision can be extended cephalad around the umbilicus. The incision is carried down sharply to the level of the rectus muscle sheath, which is then incised sharply and extended both cephalad and caudad. The fascial edge closest to midline is then grasped and dissected bluntly and sharply off the underlying rectus muscle. The peritoneal cavity can then be entered to expose the uterus.

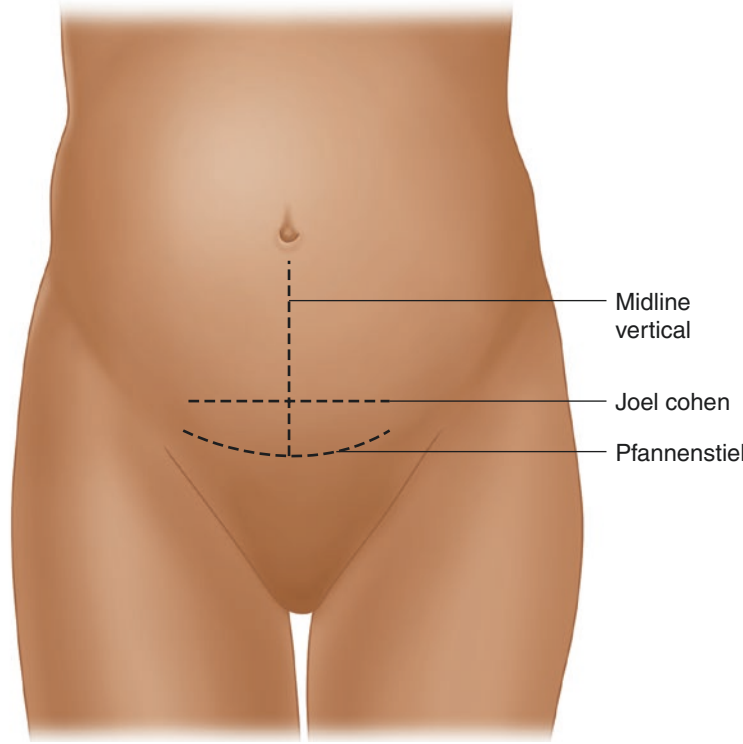


Fig. 4.9 Cesarean skin incisions

While the primary skin incision is no longer used, a midline vertical incision is associated with decreased blood loss as the superficial epigastric arteries and superficial circumflex iliac veins are out of the operative field. This incision also allows for increased access to the uterus in situations where a technically difficult surgery is anticipated. However, midline vertical incisions are also associated with poorer cosmesis, increased postoperative pain, infection, wound dehiscence, and hernia formation [55, 56].

4.7.3 Uterine Entry

There are three types of hysterotomy that are traditionally used during cesarean section: low transverse, low vertical, and classical (Fig. 4.10). The type of incision used is determined by gestational age at delivery, width of the lower uterine segment, lie of the fetus, uterine anomalies, and placental location in the event of a morbidly adherent placenta. Furthermore, low transverse uterine incisions can also be extended by the operator to make a "J" or "T" incision if needed for delivery of the fetus [55, 56].

The low transverse hysterotomy is made in the lower uterine segment and is used in 90% of all cesarean sections. The incision is made approximately 2–3 cm above the upper edge of the vesicouterine fold in the noncontractile portion of the uterus. When making the hysterotomy, it is advisable to leave the membranes intact to avoid lacerating the fetus. Extending of the hysterotomy can be done either bluntly or sharply with scissors. If sharply extended, bandage scissors are used to extend the hysterotomy laterally and then slightly upward. If performed bluntly, the hysterotomy can be extended either in a transverse or in a cephalad-caudad fashion [55, 56]. A study performed by Magann et al. showed that sharp extension of hysterotomy was associated with increased estimated blood loss, change in hematocrit, postpartum hemorrhage, and inadvertent lateral extension of the hysterotomy as compared to blunt extension [57]. In a study of 800 women, Cromi et al. demonstrated that a transverse extension of the hysterotomy was associated with higher rate of unintended lateral extension and increased risk of blood loss >1500 mL when compared to a cephalad-caudad extension [58].

In approximately 1–2% of cesarean sections, the incision is extended vertically by the surgeon to make a "J" or "T" incision. A T extension is made in the midline of the hysterotomy, whereas a J extension is made at the lateral aspect. These intentional extensions are typically needed for fetal malpresentation, difficult fetal extraction, or a poorly developed lower uterine segment and are associated with increased blood loss, broad ligament hematoma formation, and uterine artery laceration when compared to low transverse hysterotomy without extensions [56]. Furthermore, if the vertical extension involves the contractile portion of the uterus, future attempts at labor may be contraindicated. In a review of patients who

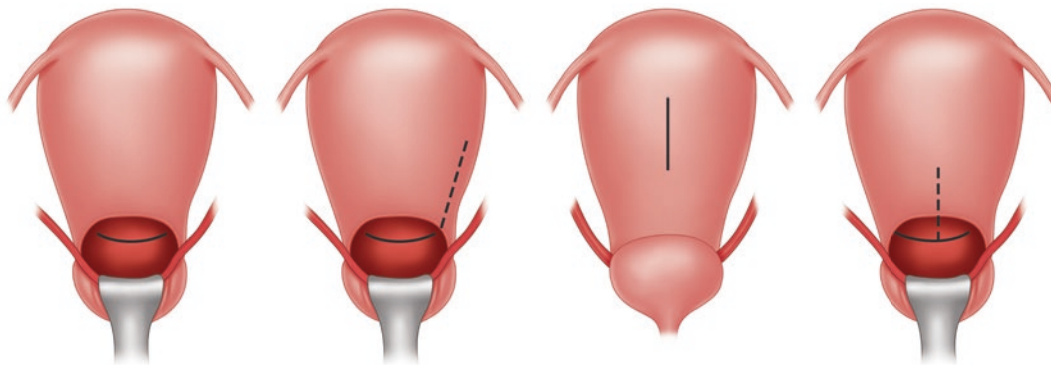


Fig. 4.10 Uterine cesarean incisions. Depicted left to right: low transverse incision, J incision, classical incision, T incision

delivered between 1988 and 1994 at the Ohio State University that required one of these extensions, these deliveries were associated with increased blood loss, uterine extension, broad ligament hematoma, cervical laceration, uterine artery laceration, and longer hospital stay [59].

The low vertical hysterotomy is made parallel to the long axis of the uterus but remains in the noncontractile portion of the uterus. Technical aspects of making the hysterotomy remain the same as a low transverse hysterotomy.

A classical hysterotomy is one in which the incision is made parallel to the long axis of the uterus through the contractile portion of the myometrium. This incision is used when the lower uterine segment has not fully developed, in cases of fetal malpresentation such as transverse back down lie, and in the setting of uterine anomalies, such as uterine fibroids, which preclude a low transverse hysterotomy [55, 56]. In an analysis of the Maternal-Fetal Medicine Network database of women delivered via cesarean with a known hysterotomy, 4.3% received a classical hysterotomy. The incidence of a classical hysterectomy peaked between 24 0/7 days and 25 6/7 days, and the likelihood of classical hysterectomy also increased with small for gestational age and noncephalic presentation [60].

While a classical hysterectomy must be closed in multiple layers to ensure adequate tensile strength and hemostasis, there has been debate as to the optimal manner to close a low transverse hysterotomy. A Cochrane review performed in 2014 looked at the material and technique used for hysterotomy closure as well as single- versus double-layer closure with the primary outcome of febrile morbidity and secondary outcomes that included postoperative pain, blood loss, need for transfusion, wound complication or infection, duration of surgery, thromboembolic event, and complications with future pregnancies or surgery. A single trial was identified in which chromic catgut was compared to polyglactin-910, and closure with catgut was associated with reduction in the need for blood transfusion and complications requiring re-laparotomy. Nineteen studies compared single- versus double-layer closure of the hysterotomy. There was no significant difference in both primary and secondary outcomes with either closure technique [61]. A second large meta-analysis was also performed in 2014 reviewing single- versus double-layer closure. This review found that both types of closure had similar short-term maternal outcomes, but single-layer closure was associated with shorter operative time. Single-layer closure and locked first-layer closure were also associated with less residual myometrial thickness on future ultrasound studies. However, there was no significant difference in the risk of uterine rupture between single- and double-layer closure. Based on the findings, the authors stated that there was not a preferable manner in which to close the hysterotomy [62]. A more recent meta-analysis performed in 2017 also found that single- versus double-layer closures had similar risks of uterine scar defects, including dehiscence and rupture [63]. However, in a randomized trial of 81 women, double-layer closure with an unlocked first layer was associated with a significantly thicker residual myometrial thickness when compared to a single-layer closure. A double-layer closure with a locked first layer was not significantly different than a single-layer closure [64].

4.7.4 Fascial Closure

Adequate fascial closure is crucial to prevent the development of hernias and ensure proper postoperative healing. Ideally, the fascia would be closed in a manner that would provide elastic and tensile strength similar to that of fascia itself and would allow for or promote healing without increasing the risk of infection. Synthetic monofilament sutures were designed with this in mind but still are associated with an infection rate of 9–14% and lose at least 75% of their tensile strength by 6 weeks. Synthetic fast absorbable sutures, such as Vicryl, are commonly used for fascial closure but only provide tensile strength for 3–4 weeks, leaving the wound at risk for incision, hernia formation, or dehiscence, and indeed this finding was seen in the INSECT trial. The hernia formation rate was 16% with the use of Vicryl compared to 8% with the use of PDS [65].

However, this finding was not seen in other reviews. In a large meta-analysis of 55 studies, Patel et al. found no difference in hernia formation when looking at absorbable vs. nonabsorbable suture, slow versus fast absorbable suture, mass versus layered closure, and interrupted versus continuous closure. Similarly, there was no difference found in the rate of wound infection or wound dehiscence when these measures were investigated. Absorbable sutures may decrease the risk of postoperative fistula formation, but this is an issue infrequently seen in the obstetric population [66]. The MATCH review, another meta-analysis of 23 studies, also found that suture material did not affect the rate of hernia formation following laparotomy incision [67]. Patel did find that the use of monofilament suture may decrease the risk of hernia formation following a laparotomy incision and that absorbable sutures may decrease the risk of postoperative fistula formation, but this is an issue infrequently seen in the obstetric population [66]. As infection has also been linked to the development of incisional hernias, research has been done to determine if using antibiotic-impregnated suture may decrease hernia formation. A study by Justinger et al. did demonstrate a decrease in wound infections with the use of triclosan-coated Vicryl compared to PDS suture in elective laparotomy but did not find a difference in hernia formation [68]. Multiple other studies in general surgery and colorectal literature have confirmed a decrease in surgical site infections with the use of triclosan-soaked suture, but none have commented on the formation of hernias. As data remains limited on the use of antibiotic-coated suture in obstetric literature, it is unclear if the additional costs associated with the suture are warranted in all patients; however, these could be considered in patients deemed high risk for hernia formation or infection.

Traditionally, when closing fascia, sutures are placed 10–15 mm apart and 10–15 mm from the fascial edge as described by Descoux et al. in 1993 [69]. However, the STITCH trial found that small bites, defined as 5 mm apart and 5 mm from the edge of the fascia, were associated with significantly fewer incisional hernias when compared to traditional spacing. This technique, as it contradicts traditional teaching, does warrant further investigation before becoming used in a widespread manner [70].

4.7.5 Skin Closure

When it comes to skin closure following cesarean delivery, there have been many studies comparing options for skin closure, including sutures, staples, and glue. Most randomized controlled trials have compared absorbable sutures with nonabsorbable metal staple closure. A meta-analysis of 12 randomized controlled trials, including 3112 women, reported fewer wound complications, particularly wound separation with suture closure [71]. In addition, suture was associated with improved cosmesis and increased patient satisfaction [72]. Based on this large volume of level 1 data, the absorbable suture is currently considered the gold standard for skin closure at the time of cesarean delivery [73].

4.8 Uterine Changes Postdelivery

Following delivery, the uterus involutes to return to a nonpregnant size. In a prospective study by Mulic-Lutvica using ultrasound to evaluate postpartum uterine changes, the maximum anteroposterior diameter of the uterus decreased from 92.0 mm on postpartum day 1 to 38.9 mm on postpartum day 56. Similarly, the maximum anteroposterior diameter of the uterine cavity decreased from 15.8 mm on postpartum day 1 to 4.0 mm on day 56. The anteroposterior diameter did, however, increase between days 7 and 14 postpartum [74]. Likewise, a study performed by Negishi et al. also demonstrated decreasing uterine sizes during the puerperium. In this study, the length of the uterus 1 month postpartum was found to be 79.3 and 70.3 mm at 3 months postpartum. These measurements were larger in women who had had cesarean sections compared to those who had undergone vaginal delivery. Increased maternal parity was also associated

with increased uterine size, while breastfeeding 80% or more per day was associated with a smaller uterine length and width compared to women who breastfed 20% or less [75]. Cesarean section also appears to affect the position of the uterus postpartum. A study by Kaelin Agten et al. demonstrated that patients who had undergone cesarean section were more likely to have an increased flexion angle compared to those who had undergone vaginal delivery, placing the uterus in a more retroflexed position [76]. Furthermore, according to Ryo et al., uterine flexion increases with the number of cesarean deliveries, and flexion was found to change after cesarean delivery in 41.6% of patients. This study also found that changes in uterine flexion were more frequently seen in women who had cesarean scar defects compared to those who did not have such defects. Based on their findings, these authors believe that the uterine flexion occurs as a result of poor healing of the scar and subsequent failure of restoration of the anterior uterine segment [77].

Following cesarean deliveries, some patients develop a niche or cesarean scar defect, which can be detected on ultrasound. It is described as a triangular anechoic area at the presumed location of the hysterotomy. However, the exact sonographic characteristics needed to define a niche are currently unclear with multiple definitions or findings used. A meta-analysis by Bij de Vaate found a prevalence of a niche in 24–70% of patients with a history of one or more cesareans when using transvaginal ultrasonography; using sonohysterography, the prevalence varied from 56 to 84%. Suspected risk factors for the development of niches include single-layer myometrial closure, history of multiple cesareans, and a retroflexed uterus; however, the included studies did not investigate identical risk factors and some risk factors are known to be related. Therefore, the determination of exact risk factors was inconclusive, and it remains unclear how niches develop [78]. A study from the Czech Republic found that when comparing females who had a single-layer closure of the hysterotomy versus double-layer closure, a higher proportion of niches were seen with single-layer closure. Furthermore, the defects in the single-layer closure were wider, and the residual myometrial thickness was thinner [79]. Bij et al. hypothesized based on the meta-analysis that a thinner myometrium, such as that in the lower uterine segment, is less vascularized and that other factors, such as uterine flexion, may obstruct blood flow to the uterine segment, impede healing, and lead to the formation of a niche [78]. However, as mentioned earlier, other studies suggest that perhaps the niche itself leads to retroflexion [77]. Despite being a visible finding on ultrasound, the exact implications of a niche on future pregnancies are unknown.

4.9 Pelvic Floor Following Cesarean Delivery

Both pregnancy and delivery are known to cause alterations to the pelvic floor, some of which may lead to pelvic floor dysfunction. Vaginal delivery may cause nerve, muscle, and connective tissue damage, but the effects of planned cesarean delivery remain unclear. Using 3D sonography, studies have demonstrated that pelvic floor muscles undergo distension during crowning, and this distension has been implicated in levator ani avulsion. This distension and the force that the fetal head exerts during pushing may also lead to nerve compression and subsequent muscle atrophy. In a review of six publications on 3D sonography of levator ani muscles both antepartum and postpartum, Carvalho de Araujo found that across all studies, vaginal deliveries were associated with a larger genital hiatus size compared to cesarean deliveries. These studies also found no major levator ani injury in women who underwent cesarean delivery, including those who underwent second-stage cesarean. Furthermore, a smaller hiatal area antepartum was associated with a higher risk of levator injury during delivery; however, no threshold for prediction of injury could be established [80]. In a similar study by Falkert, 3D ultrasonography was performed 2 days postpartum to evaluate the levator ani anatomy. Women who had undergone vaginal delivery of any type, including operative delivery,

were found to have larger levator hiatus measurements in all planes as compared to women who underwent cesarean delivery. There was no difference between subgroups of women who had spontaneous versus operative delivery and primary versus repeat cesarean [81]. These findings suggest that while cesarean delivery is not completely protective from pelvic floor dysfunction, the pressure exerted on the levator ani during expulsive efforts increases the overall risk of muscle injury and therefore subsequent pelvic floor dysfunction. However, continued research is needed to confirm this.

In a study investigating short-term pelvic floor dysfunction based on delivery mode, Colla et al. found that mode of delivery did not play a role in the development of pelvic floor dysfunction at 3 months postpartum. There was a recovery in pelvic floor muscle functionality as measured by maximum voluntary contraction strength during the first 3 months after delivery, but during that same time period, patients reported a worsening impact of urinary incontinence of their quality of life. This impact was not significantly different between women who delivered vaginally versus cesarean [82]. In a study investigating pelvic floor strength 6 months postpartum, Afshari et al. used perineometers to objectively measure muscle strength. In this, women who underwent vaginal delivery with mediolateral episiotomy had the lowest pelvic muscle strength, whereas there was no difference in strength between nulliparous females, females who underwent vaginal delivery without episiotomy, and any type of cesarean delivery [83].

Looking specifically at muscles potentially affected during delivery, DeLancey et al. performed pelvic MRI on both nulliparous and vaginally primiparous females. No muscle defects were identified in the nulliparous females. However, 20% of the primiparous females had defects found in the levator ani muscle with the majority of the defects found specifically in the pubovisceral portion. Seventy-one percent of the women identified to have defects reported having stress incontinence [84]. This data is supported by prior studies that demonstrated an increase in the genital hiatus of 20–30% following levator injury. Vaginal delivery also appears to have some effect on the muscle fibers themselves. In a histopathological study on female cadavers, changes in the pelvic floor muscle cells were identified, including increased centrally located nuclei, fibrosis, and variation in fiber diameter, when parous females were compared to nulliparous females [85]. While the underlying cause of these changes was not elucidated in the study, these findings suggest a pathologic response of the muscle cells themselves to vaginal delivery and subsequent impaired functioning.

Despite these changes to the pelvic floor following vaginal delivery, most females recover function by 1 year postpartum.

4.10 Sterilization

Female sterilization is defined by the American College of Obstetrics and Gynecology as the occlusion or division of the fallopian tubes to prevent ovum passage and avoid fertilization [86]. The timing of the procedure influences both the surgical approach and the method of occlusion used. In the United States, more than one half of all tubal occlusions are performed in the early postpartum period with 8–9% of all hospital deliveries currently followed by immediate postpartum tubal occlusion [87]. Postpartum sterilization can be completed at the time of cesarean delivery or after a vaginal delivery [88]. There are currently many methods for occlusion, including mechanical methods, electrocoagulation, ligation with removal of tubal portion, and most recently salpingectomy. For most practitioners, ligation of fallopian tubes via the Pomeroy, modified Pomeroy, and Parkland techniques is most commonly performed (Figs. 4.11 and 4.12) [89].

Similar to all other forms of sterilization, postpartum sterilization requires counseling and informed consent before labor and delivery. Data from the US Collaborative Review of Sterilization (CREST) demonstrate a relationship between regret and timing of procedure with a diminished probability of regret with increased interval between delivery and sterilization [90]. CREST data has also illustrated that postpartum partial

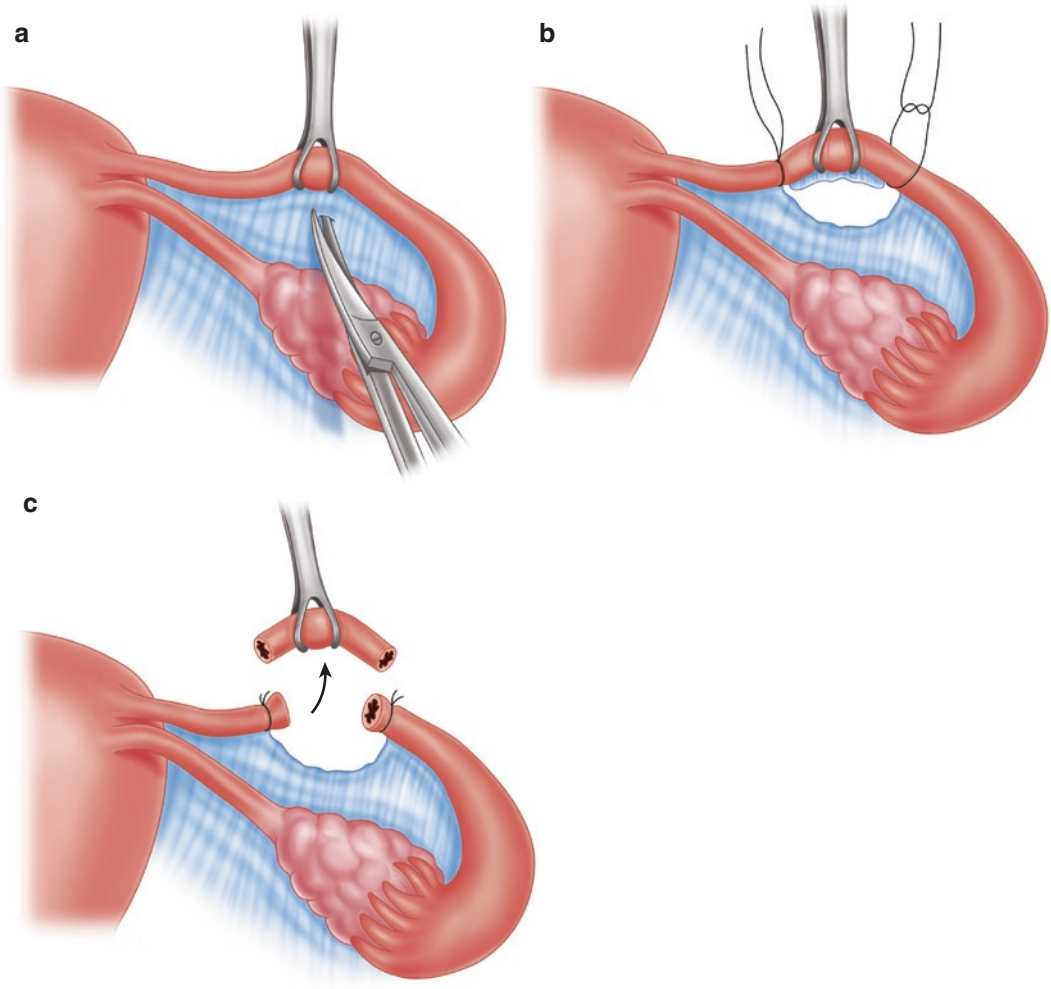


Fig. 4.11 Parkland method. (**a**) A midisthmic portion of the oviduct is grasped with a Babcock tissue forceps in an avascular portion of the mesosalpinx, an avascular portion of the mesosalpinx is identified, and then opened using blunt or sharp dissection freeing up about 2.5 cm of the oviduct. (**b**) The proximal and distal portion of the freed oviduct is ligated using O-chromic suture. (**c**) An approximately 2 cm intervening segment of the oviduct is divided and the remaining distal and proximal stumps inspected for hemostasis. The removed segment is also assessed to assure complete transection of the tubal lumen at both ends of the tubal segment

salpingectomy is associated with lower failure rates than interval tubal occlusions completed via laparoscopic methods. Postpartum partial salpingectomy has the lowest 10-year cumulative probability of pregnancy with a rate of 7.5/1000 women [91]. Additionally, data from CREST demonstrates no difference between postpartum tubal occlusion and other methods of female sterilization in regard to menstrual irregularities, risk of ectopic pregnancy, or risk of subsequent hysterectomy [92–94]. In regard to risk of salpingitis, one study by Todd et al. evaluating women 2 weeks postpartum from delivery and tubal ligation that tested positive for Chlamydia did demonstrate an increased risk of febrile postoperative complications after ligation in these women [95]. However, cumulative data evaluating all forms of contraception demonstrate that ligation may reduce the spread of organisms from the lower genital tract to the peritoneal cavity [96]. When evaluating postpartum ligation effects on breast milk production, the data is mixed. One study by

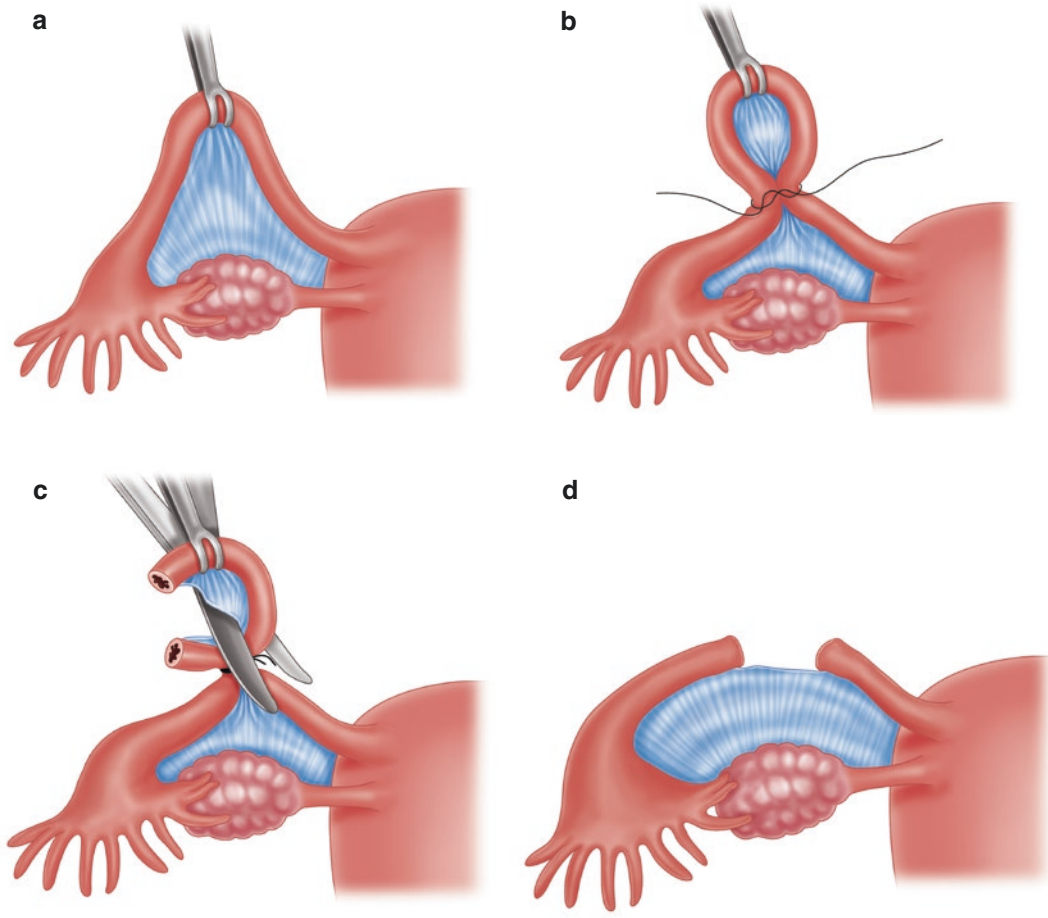


Fig. 4.12 Pomeroy method. (**a**) A midisthmic portion of the oviduct is grasped with a Babcock tissue forceps in an avascular portion of the mesosalpinx. (**b**) A 2.5–3 cm "knuckle" of fallopian tube is developed by ligation of the tubal segment using O-plain gut suture. (**c**) An avascular portion of the mesosalpinx is identified, and then opened using blunt or sharp dissection and an approximately 2 cm intervening segment of the oviduct is divided and the remaining distal and proximal stumps inspected for hemostasis. The removed segment is also assessed to assure complete transection of the tubal lumen at both ends of the tubal segment. (**d**) The suture will initially occlude the tubal ends and then rapidly resorb allowing the occluded proximal and distal tubal stumps to fall away from eachother

Vytiska-Binstorfer found that breast milk quantity following postpartum tubal ligation on days 6–7 was associated with significantly lower quantity than the antecedent pregnancy [97]. However, a more recent study in Thailand comparing breastfeeding initiation and breast milk production did not demonstrate a difference between mothers undergoing postpartum ligation and those not [98]. Finally, when investigating the effects on maternal weight gain, a study by Lu evaluating the long-term follow-up of more than 1000 women did not demonstrate a significant effect on body weight from postpartum ligation [97].

4.11 Summary

While labor and delivery often unfold in an uncomplicated process, there are situations in which the typical physiologic changes do not occur, resulting in a protracted labor course. In such cases, operative deliveries, including forceps-assisted deliveries, vacuum-assisted deliv-

eries, and cesarean sections, are frequently relied on to effect the safe delivery of the neonate; however, these are not without their inherent risks and implications on the healing process. Episiotomy, once used heavily to shorten labor and decrease the risks of vaginal delivery to the pelvic floor, is no longer recommended for routine use due to increased risks of OASIS and pelvic floor damage. Lastly, postpartum sterilization remains a safe and viable option for contraception with minimal deleterious side effects.

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Psychological Changes During and After Pregnancy

5

Nathan Wilson and Jin Joo Lee

Take-Home Points

- Depressive symptoms are just as likely during pregnancy as during the post-partum period.
- Fatigue is the most common experience for women in the last trimester and in the months after birth and can be a distressing, sustained, negative experience.
- Fatigue is closely associated with higher depressive symptoms, and differential diagnosis is required.
- There are reliable, valid, and brief measures for assessing fatigue in the post-partum period.
- Treatments for post-partum fatigue show some promise, especially those that focus on helping women manage unsettled infant behaviours, while mild exercise might be useful in pregnancy.

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5.1 Introduction

Pregnancy is characterised by major physiological and psychological changes [1]. In particular, fatigue and mood and sleep disturbances are frequently reported symptoms [2, 3], which have significant impact on maternal well-being. However, such changes often go unrecognised, being overlooked as pregnancy-related discomfort. Understanding the common psychological challenges may assist healthcare professionals identify early symptoms and provide appropriate support or treatment [4], improving the individual's quality of life [5].

5.1.1 Sleep Disturbance

During pregnancy, the majority of night-time awakenings and restless sleep can be accounted for by pregnancy-specific factors [6]. Nocturia (frequent urination at night) is a major cause of night-time awakenings, leading to fragmented sleep [6–8]. A large study with 2427 pregnant women found nocturia (83%) and uncomfortable sleeping positions (79%) to be the most commonly reported contributors to sleep disturbance [9]. Uncomfortable sleeping positions are due to various physical changes and discomfort. Additionally, hormonal changes (oestrogen and progestogen) during late pregnancy have also

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_5

been associated with heightened arousal at night and excessive daytime fatigue [10].

As women enter their first trimester, night-time sleep gradually becomes shorter and more fragmented [8]. While daytime naps typically increase at the same time [11], it does not have the equivalent restorative value of night-time sleep [12]. This is consistent with self-reported reductions in sleep quality in the first trimester as compared to preconception [13]. Although some have suggested that there is an improvement in sleep during the second trimester of pregnancy [8], there is little empirical support. Instead, a large longitudinal study found sleep progressively deteriorated even in the second trimester, and factors causing sleep fragmentation (i.e. uncomfortable position and foetal movement) were more regularly reported than the first trimester [14]. Additionally, the reduction of rapid eye movement (REM) sleep during the second trimester suggests that there are alternations from pre-conception sleep architecture [7].

Closer to parturition, sleep duration and quality are subject to significant changes [15]. The third trimester is characterised by frequent night-time awakenings, with, on average, women reporting 2–5 nocturnal awakenings each night [9]. Although an increase in daytime naps may help to compensate for night-time sleep loss, the total amount of sleep remains low (<6 h) [14]. Compared to the first and second trimesters, women experience longer sleep-onset latency [14] and obtain shorter sleep [16]. Typically, in the weeks before delivery, women experience the highest sleep disturbance and poorest sleep quality [17].

Furthermore, sleep disorders commonly emerge in this last trimester [18] and may persist into the post-partum period. Obstructive sleep apnoea, restless legs syndrome, and insomnia are frequently reported disorders [19–21]. Insomnia is one of the most frequently diagnosed sleep disorders worldwide [22], with a prevalence rate of 11.9% in the general population [23]. It is characterised by difficulties in sleep initiation, maintenance, and non-refreshed sleep even with an adequate opportunity and environment to sleep [24]. This is coupled with daytime impairments such as decrements in cognitive functioning, changes in mood, and increased fatigue and physical discomfort [25]. Crucially, insomnia is often co-morbid in nature and thus interacts with various other disorders to reduce overall physical and mental well-being [22].

Following the delivery, sleep patterns continue to be challenged as mothers adapt to the needs of the infants. Although total sleep time (TST) increases during the post-partum period, women experience high sleep fragmentation due to infant behaviour during night-time [26, 27]. This may include multiple awakenings to feed and settle the infant [27, 28], decreasing overall sleep quality. One study showed that the frequency of attending to the infant at night-time was associated with the mothers' subjective sleep quality [29]. Due to the significant sleep disruptions, women are likely to compensate this by increasing daytime napping [30]. While sleep improves with time, there is evidence suggesting that even at 15 weeks post-partum, sleep patterns did not return to the same level of nonpregnant women [31].

5.1.2 Mood Disturbance

Perinatal depression, which includes minor and major depression occurring during pregnancy or within the first 12 months post-delivery, can significantly impair functioning [32]. Not only does it impact the individual's quality of life, but also the baby and family [33–36]. Approximately up to 11% of women may experience perinatal depression [32]. The World Health Organization (WHO) has recognised depression to be one of the leading contributors to global burden of disease [37]. Given that women are more likely to experience depression during their lifetime, perinatal depression requires greater clinical attention [5].

Various factors may contribute to the onset of perinatal depression. As discussed previously, there are significant physical and hormonal changes during pregnancy that may affect the overall mood [38]. Another is the significance and stress it places on one's life, which past stud-

ies have shown to be associated with mood disorders [39]. Furthermore, 43% of women who had a history of depression experienced a relapse during their pregnancy [40], which suggests that previous mental health history in combination with other factors could increase the women's vulnerability to perinatal depression [41].

There is the common misconception that pregnancy is a "protective" factor for mood disorders; however, recent research has suggested that rates of antenatal depression are similar to those of post-partum depression [5]. The prevalence rate of depression during pregnancy is 10–20% [42, 43], highlighting that women are equally as vulnerable during the antenatal period. Similarly, around 12–16% of women experience post-partum depression, most likely during the first 6 months of post-partum. Furthermore, up to 84% of mothers have experienced transient mood disturbances or post-partum blues [44]. Although milder forms of mood disturbance do not usually persist longer than 2 weeks [45], it may be a predictor for later onset of post-partum depression [46].

There is now strong evidence that various factors are linked with perinatal depression, including sleep and fatigue [2, 3]. Studies have shown that poor sleep is associated with low mood and may increase the risk for development of mood disturbances during the perinatal period [2]. In addition to sleep, sustained fatigue is a highly prevalent experience that can also make women more vulnerable to psychological distress.

5.2 Psychological Changes During Pregnancy

Given that pregnancy involves rapid shifts in both body weight and size, as well as major adjustment to upcoming parenthood, it is not surprising that several psychological changes have been documented. The most well documented is that of increased depressive symptoms, as noted above, which has a prevalence of approximately 10–20% [42]. Several risk factors have been identified for perinatal depression including sleep disturbance, anxiety, fatigue, past history of depression, lack of social supports, lower education, lower socio-economic status, poor partner relationship, and body image concerns [47–49]. Body image concerns about weight gain and shape tend to be relatively stable across pregnancy and increase in the post-partum period [48].

Although depression is the most studied psychological issue in pregnancy, it is not the most prevalent; fatigue occurs in up to 60% of pregnant women in the last trimester [50, 51]. Fatigue is a subjective psycho-physical experience of sustained reduced energy (see detailed definition in Sect. 5.3 below), and it seems to increase across pregnancy and peak in the third trimester [51]. There is some overlap in the symptoms of perinatal fatigue and depression, and they likely have a bidirectional relationship [50]. Despite the high prevalence of fatigue symptoms which ranges between 35 and 60% depending on the study, and findings that a substantial percentage of pregnant women seek medical support (34%) or complementary or alternative medicine support (28% of women) for its symptoms [50, 52], there has been relatively little research interest in developing assessment tools and effective interventions for fatigue during pregnancy. Currently, only one scale, the Multidimensional Assessment of Fatigue, has been specifically validated during pregnancy [53, 54]. There are also no well-developed psychological treatments that exist specifically for fatigue during pregnancy. However, resistance-based exercise programmes have shown some success in helping pregnant women temporarily reduce subjective fatigue and increase their energy levels [55]. Given that much more information is available on the assessment and treatment of fatigue after pregnancy, this will be the focus of this chapter.

5.3 Fatigue After Pregnancy

The most prevalent psychological experience after pregnancy is the experience of fatigue. Many parents of new babies feel more than what

could be normal tiredness; they feel fatigued. In the weeks and months after the arrival of their new child, many but not all parents describe high levels of physical and mental exhaustion and a sustained lack of energy. These subjective symptoms of fatigue add unwanted difficulty to the already challenging task of caring for a new baby [56, 57]. This fatigue can also make parents more vulnerable to other forms of psychological distress, such as depression [58] and impacts upon their ability to function as parents and participate in society [59, 60].

This chapter aims to provide an overview of the research on post-partum fatigue. This chapter provides an overview of current models of post-partum fatigue, its measurement, and its treatment. The first task in doing this is to define what will be calling the post-partum period. Frequently, the first 6 weeks after birth is referred to as the post-partum period, with this 6 weeks made up of two distinct phases. The first initial "acute post-partum period" is the first 12 h after birth, a time of risk for acute medical complications for mothers (e.g. haemorrhage). Next is the "subacute post-partum period" that lasts up to 6 weeks, involving less immediate but numerous physiological and psychological adjustments following the birth [61].

While 6 weeks is the standard definition of post-partum, there is awareness of the need to broaden the definition of post-partum, beyond 6 weeks into the "delayed post-partum period", which involves more gradual physical and psychological processes that continue for many months after birth [61]. We use this broader definition of the post-partum period in this chapter, similar to many other studies of this period [62]. In this chapter, we have settled on using the term "post-partum fatigue" to describe the subjective psychologically based feelings and symptoms of fatigue experienced by parents in the first 18 months after childbirth.

Although fatigue is a commonly recognised response to childbirth, the detailed scientific study of the experience of post-partum fatigue did not occur before the early 1990s. From this period, there was a surge in research interest which set the foundation for the understanding of post-partum fatigue as it is understood today [63–70]. Research may have been slow to start in this area for several reasons. Firstly, there has been a view that parent's feelings of tiredness and fatigue were universal, uniform, and necessary normative experiences [65, 66]. Secondly, research viewed fatigue symptoms as a subset of maternal post-partum depression symptoms, rather than as a related but separate experience [71]. Also, given that in society the role of caring for an infant within the home can be devalued in comparison to other work [72], the "occupational fatigue" associated with raising an infant [73] may not have received as much research attention as other contexts.

It is also necessary to address the concern that investigating fatigue in this period may lead to the typical experience of parenting being even further over-pathologised [74]. While this is a valid concern, we believe that post-partum fatigue is worthy of research attention for several reasons. There is sufficient evidence from the research over the last three decades to suggest that post-partum fatigue is more than a transient state of normal tiredness and is an overwhelmingly negative and distressing experience that makes coping with everyday tasks more difficult for some but not all parents [56]. The following section will now focus on summarising the current understanding of post-partum fatigue and how it differs from other related constructs.

Our first step here is to define what is meant by fatigue, which is not a simple task. There is no single symptom that defines the experience of fatigue, and there is no gold standard measure nor any formal diagnostic criteria [75, 76]. However, there is a consensus that fatigue (1) is an unpleasant subjective physical and mental experience, (2) involves an overwhelming and sustained subjective experience of exhaustion or tiredness, and (3) reduces an individual's ability to function both physically and mentally to their own expectations [56, 65, 75–79]. Part of the task of defining what fatigue is clarifying what is not fatigue.

▶ **Important** Fatigue is a subjective unpleasant physical and mental experience that reduces an individual's ability to function to their own expectations. Fatigue is not normal tiredness, sleepiness, or drowsiness.

Fatigue is frequently confused with related terms such as tiredness, sleepiness, and drowsiness [75, 76, 80]. However, each of these constructs differs from fatigue. Unlike fatigue, tiredness is a universally experienced feeling of reduced energy that is rapidly relieved by adequate rest and renewal of energy supplies [75, 76]. Sleepiness, in contrast to fatigue, refers strictly to the likelihood of falling asleep when intending to stay awake [76]. Daytime sleepiness is a problem when it occurs too often or at inappropriate times, for example, while driving a car [76, 81]. Sleepiness is measured by asking individuals how likely they are to fall asleep in scenarios such as sitting in a stationary motor vehicle [82] or is objectively measured by timing how long it takes someone to fall asleep in a controlled dark environment [75]. Drowsiness refers specifically to physiological changes occurring between the behavioural states of wakefulness and sleep. These changes include more extended eye blinks, diminished muscle tone, and well-understood variations in brain-wave patterns [75, 76, 83, 84].

As both fatigue and depression can include subjective feelings of low energy and impaired physical and mental performance, they can be difficult to distinguish at times [85, 86]. Historically, there was also debate about whether fatigue and depression may be the same phenomena in post-partum women [65, 85]. However, the post-partum literature now recognises them as separate but related constructs [87]. Depression refers to a combination of sustained reduction in mood, loss of interest or pleasure in activities, physical changes (change in weight and sleep patterns, feelings of fatigue or loss of energy), psychomotor agitation or retardation, feelings of worthlessness, difficulties with concentration, and recurrent thoughts of death or suicide [88]. Fatigue is also one of the diagnostic criteria for depressive disorders [88], which makes some degree of overlap between these two constructs inevitable. A section below will address the bidirectional nature of their relationship.

5.4 Prevalence and Trajectory of Post-partum Fatigue

Although not universal, fatigue appears to be prevalent and persistent for many parents in the months after childbirth. Although this review aims to cover the literature for both women and men, most findings relate only to women. Overall estimates of the prevalence of post-partum fatigue vary widely between studies. As many as 20–70% of post-partum women in the community experience post-partum fatigue during the first 12 months post-partum [58, 89–91]. The reported prevalence of fatigue among women in the community at 12–18 months ranges from 18 to 52% [67, 89]. Also, approximately 65% of parents with children aged between 0 and 4 years report at least occasional problems with fatigue [92].

Fatigue appears to be more prevalent in clinical post-partum samples. Fisher and Feekery [93] found that 92% of women (the mean age of infants in their study was 22 weeks) attending a mother-baby unit reported clinically elevated fatigue symptoms. Overall, it seems that levels of fatigue also appear to differ between women dimensionally. A community sample of post-partum women with infants of a mean age of 5 months identified that 30% of women reported high levels of fatigue, 22% reported moderate fatigue, and 21% relatively little fatigue [94].

Some studies have attempted to plot the course of parents' experience of fatigue over time. A pattern does tend to emerge across these studies, where fatigue levels for both parents increase sharply after birth for both parents and then continue to steadily increase over the next 4–6 weeks [30, 70, 95, 96]. For both women and men parents, average fatigue levels then tend to plateau and stabilise from around 6 weeks until around 6 months post-partum. From this point onwards, they may remain relatively stable even up until

18 months post-partum [67, 68, 95]. Overall, women reported slightly more fatigue at 1 and 6 months post-partum than men, but average fatigue levels were equivalent at 3 months post-partum [95]. Several studies have also demonstrated moderate to strong positive correlations between earlier and later post-partum fatigue symptoms [58, 95, 97, 98], showing that earlier fatigue tends to predict later fatigue in parents.

5.5 Correlates of Post-partum Fatigue

There are many different correlates of post-partum fatigue; this following section aims to provide an overview of the many identified to date in the literature. These have been organised into three categories, biological, psychological, and social, although the distinction between these categories for some phenomena is rather arbitrary (e.g. subjectively reported sleep). A summary table is provided in Table 5.1.

5.5.1 Biological Correlates

Initial post-partum fatigue is closely associated with the experience of childbirth. The greater the pain, the greater complications of labour, and the more the blood loss during labour, the more fatigued women feel during the first 8 weeks post-partum [66, 70, 96, 99]. The older women are, the more fatigued they feel during the first 8 weeks post-partum [70, 91, 96]. During the first year after birth, mothers who are less physically healthy, have had previous caesarean sections, or have older partners, all have higher odds of feeling fatigued [89]. At up to 5 years post-partum, the less physically healthy parents feel, the more fatigued they feel [92].

One arm of the research has focused on linking subjectively reported fatigue symptoms with biomarkers. Overall, these studies have tended to be small and have reported mixed findings. In the first weeks after birth, fatigue can share moderate positive associations with cytokine interleukin-1-beta [100], breast milk melatonin [101], and cortisol levels [102]. Fatigue and elevated haemoglobin levels also correlate for the first week post-partum but not after this period [103]. Fatigue negatively correlates with cortisol levels in teenage mothers [102] and with breast milk secretory immunoglobulin A [104]. However, within the first weeks post-birth, fatigue was not associated with cytokine interleukin-1-beta [100], blood serum prolactin [101], haemoglobin [103], cortisol [101, 103, 105], breast milk secretory immunoglobulin A [101, 105], interleukin (IL-1, IL-5, and IL-78), granulocyte-macrophage colony-stimulating factor, monocyte chemotactic protein, and macrophage inflammatory protein 1-beta [106]. To our understanding, there has been no exploration of these relationships between fatigue and biomarkers beyond the first few weeks after birth. At this stage, there are no

Table 5.1 Correlates of post-partum fatigue

Biological	Psychological	Social
Pain during childbirth	Depression	Multipara
Labour complications	Anxiety	Infant crying, fussing, and settling difficulties
Blood loss during labour	Perceived stress	Shorter infant sleep cycles
Maternal age (older)	Confusion	Greater daily hassles
Reduced physical health	Bewilderment	Conservative household division of labour
Caesarean section		Increased daily hassles
Partner age (older)		Reduced efficacy in parenting ability
Cytokine interleukin-1-beta level		
Breast milk melatonin level		
Maternal cortisol level		
Immunoglobin A level		
Shorter sleep duration (biomarker)		
Increased time in bed awake		
Reduced subjective sleep quality		

precise biomarkers for post-partum fatigue, and we are reliant on subjective measures discussed later in this chapter.

Another factor that is often related to fatigue is sleep. Greater fatigue is related to reduction in both sleep duration and quality. During the first 2 weeks post-partum, the shorter the duration of a woman's sleep, the more fatigued they feel [107]. At 7 weeks post-partum, the more time women spend in bed awake (the lower their sleep efficiency), the more fatigued they feel [107]. Also, in the first 6 weeks post-partum, the fewer hours that women subjectively recall sleeping, the more fatigued they feel [66, 96]. In the first 6 months post-partum, the more that women report their sleep as being disturbed, the more fatigued they feel [30, 53, 95, 99, 108]. Beyond 6 months post-partum, the more women report their sleep quality as being low, also the more fatigued they feel [109]. Also, across the entire extended post-partum period, the fewer hours that women expect to sleep or the less rested they feel, the more fatigued they report feeling [89, 92]. Women who report that they feel higher subjective daytime sleepiness also report feeling more fatigued [108].

5.5.2 Psychological Correlates

Fatigue is also closely related to the experience of psychological distress, in the form of depression, anxiety, or stress. Overall, the more depressed mothers feel during the first 8 weeks, 6 months, or 2 years post-partum, the more fatigued they feel [3]. This association between post-partum women's depressive and fatigue symptoms is consistent and bidirectional in nature; that is, fatigue leads to greater depression and depression leads to greater fatigue [3, 58]. A recent systematic review found that fatigue and depression share a summary correlation in the first 2 years post-partum of 0.05 [3]. The following section of models of fatigue and depression discusses in detail the differences between fatigue and depression.

There is less research available on the relationship between fatigue and other forms of psychological disturbance. However, it is known that during the first 8 weeks and 6 months post-partum, the more anxious mothers feel, the more fatigued they feel [96, 99, 110]. Similarly, during the first 6 months post-partum, the more stress mothers perceive, the more fatigued they feel [95, 98, 108, 110], but studies do not consistently find a relationship between stress and post-partum fatigue. Additionally, the more confusion or bewilderment that mothers experience, the higher their reported feelings of fatigue [110].

5.5.3 Social Correlates

Many other psychosocial factors have also been found to be associated with higher fatigue in post-partum parents. During the first 6 weeks post-partum, having more than one child increases the likelihood of a woman feeling fatigued [66, 96]. Also, during both the first 8 weeks and 6 months post-partum, the more that babies cry, fuss, and are difficult to settle, the more fatigued women feel [66, 96]. The shorter that infant sleep cycles are, the more fatigued women feel [47]. Furthermore, women that experience more daily hassles, have more passive reaction styles to events, and are more conservative in their views of household divisions of labour, all have higher odds of feeling fatigued [89]. For parents of children aged up to 5, the more stressed they are about their parenting, the more fatigued they feel [92]. Also, the more parents feel irritable or are less warm towards their child, the more fatigued they feel [92, 111]. The more parents rate themselves as being less competent in their parenting abilities, having less parental self-efficacy, and less involved with their child, the more fatigued they feel [92, 111].

During the first 6 months, the more social support that mothers feel they need, the more fatigued they feel [109]. The less maternity leave a mother has access to, the less their partners earn, the less access they have to social support, and the more difficulties they have getting on with their partner, the more fatigued they feel [47, 96, 109]. Mothers who work more than 44 h a week and also have problems with their super-

visor have increased odds of being fatigued during the first year post-partum [89].

5.5.4 Non-significant Relationships

Although many bio-psycho-social factors have been found to be associated with post-partum fatigue, many non-significant correlations have also been reported in the literature. Some of these factors are associated with fatigue at some points in time and not at others (e.g. maternal age), while some have not been found at all to be associated with fatigue (e.g. paternal age). Non-significant correlates reported with fatigue include paternal age, cortisol levels, prolactin levels, interleukin-1-beta levels, bloodstream cytokines, lactogenesis, type of delivery, parental age, actigraphic total sleep time, actigraphic number of awakenings, actigraphic total nocturnal wake time, actigraphic sleep efficiency, subjective number of awakenings, subjective nocturnal wake time, subjective sleep duration, subjective sleep quality, subjective sleep supplementation (napping), infant sleep duration, stress, anxiety, confusion-bewilderment, parity, infant mood/difficulty, maternal social readjustment, gratification, paternal parenting warmth, socio-economic status, social support, relationship length, family income, and household type [53, 66, 68, 92, 95, 96, 98–100, 106–109, 111]. Further research is required to determine if these relationships are due to the limited size of many studies or if they are found to consistently have no relationship with fatigue levels.

5.6 Post-partum Fatigue Models

Given that post-partum fatigue appears to be prevalent and dimensional and is not easily explained by physical biomarkers, researchers have developed models to try to explain why fatigue occurs and persists. Over the last two decades, researchers have published several different models, which differ in their complexity and focus. Overall, these models can form two groups. The first group is general models of post-partum fatigue that aim to explore the various roles of physical, psychological, and environmental factors, as well as their antecedents and consequences. The second group is nested within the first group and zero in on the specific relationship between fatigue and depression.

5.6.1 General Models of Post-partum Fatigue

The first model developed was the Framework for the Study of Childbearing Fatigue (FSCF) [112]. Based on the widely used biopsychosocial model [113], the FSCF brings together the physiological, psychological, and situational factors that could influence a woman's fatigue levels in the days and weeks after birth. Each of these three factors can act in parallel and lead to fatigue, which then leads to performance deficits. For example, maternal hormonal changes (physiological), feelings of anxiety (psychological), and infant sleep difficulties (situational) could all contribute to a woman experiencing fatigue. Once feeling fatigued, this woman would experience fatigue-related performance deficits as she is less able to sustain physical or mental effort [112].

The FSCF was the first theory of post-partum fatigue and broke new ground. However, it has acknowledged weaknesses, in that it represents fatigue as a single uniform experience, and it is unable to incorporate the bidirectional relationships between the different parts of the model. For example, it cannot incorporate the established bidirectional relationship between fatigue and depression [65, 85].

The next model to gain prominence was the Theory of Unpleasant Symptoms (TOUS) [64], which has been widely used to explain the origins, experience, and factors that maintain post-partum fatigue [57, 58, 64, 99, 114, 115]. The TOUS was adapted from the nursing literature by the authors of the FSCF to rectify the acknowledged weaknesses with the FSCF [64, 116]. The TOUS comprises three interacting lev-

els. In the first level, like the FSCF, the TOUS states that physiological, psychological, and situational factors can lead to a parent's experience of fatigue. In the second level, these above factors all act to cause fatigue and other related unpleasant symptoms. Each of these unpleasant symptoms can vary in its level of intensity, quality, timing, and amount of distress they cause. In the third level of the TOUS model, the unpleasant symptoms combine to impair everyday functioning [64]. An advantage of TOUS over FSCF is that the three different levels of the model can all interact with each other. The TOUS can also incorporate another unpleasant symptom such as anxiety or depression acting on fatigue in a bidirectional manner [58]. Support for the TOUS model date comes from the many studies identifying correlates of post-partum fatigue [3, 117]. These correlates serve as either factors, symptoms, impairments, or related unpleasant symptoms in the various levels of the TOUS model (Fig. 5.1).

A third general model of post-partum fatigue emerged from qualitative research called the Persevering Through Post-partum Fatigue (PTPF) model [56]. The PTPF was developed using grounded theory with a small group of women recruited in the community in the United States. Fatigue is a cluster of mental and physical fatigue symptoms that combine with experiences of "stress-worry" and "frustration". The extent of fatigue experienced by a woman is dependent upon maternal-infant sleep conflict, the infant's temperament, and the ability of mothers to limit their fatigue through coping strategies (e.g. settling strategies). Under the PTPF, women can limit their fatigue by establishing more realistic expectations given their infant's sleep and feeding patterns and using social supports [56]. A distinguishing feature of the PTPF model is its focus on coping strategies to deal with their feelings of fatigue. Another unique feature is its focus on the role of stress and worries in influencing parents' ability to cope with fatigue [56, 114]. However, the PTPF model has received little recognition since its publication and not been used to inform the development of any interventions for post-partum fatigue [114], which may be due to its lack of any further quantitative validation.

One other model is the Explanatory Model of Postpartum Fatigue (EMPF) that aimed to explain post-partum fatigue among primiparous women in South Korea [118]. This structural equation model (SEM) is explicitly built upon the TOUS model by including various physiological, psychological, and situational factors and culturally specific components of care in Korea called sanhujori [118]. In the EMPF, social support, infant temperament, satisfaction with sanhujori care, childcare stress, and feeding difficulties were all hypothesised as impacting upon either depression or maternal sleep quality. The reduced sleep quality and depression were hypothesised to increase fatigue [118] (Song et al., 2010).

Song and Chang [118] found an excellent statistical fit for the model within South Korean women during the first 8 weeks post-partum. They identified a small significant negative association between maternal sleep quality and fatigue and a large positive association between depressive symptoms and fatigue, providing empirical support for reduced sleep quality and

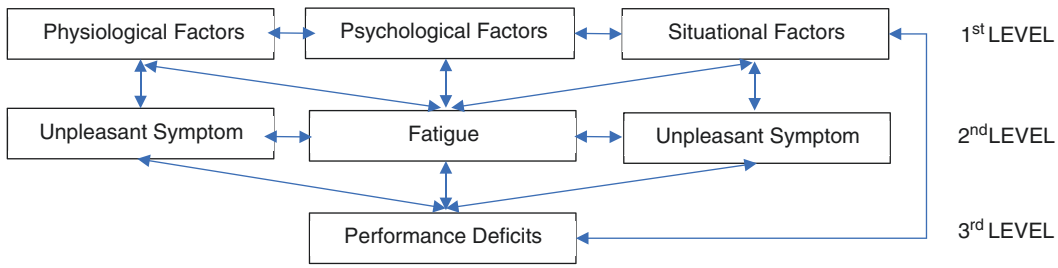

Fig. 5.1 Theory of Unpleasant Symptoms (TOUS) model of post-partum fatigue

depressive symptoms playing a role in post-partum fatigue. However, despite the good statistical fit for the EMPF model, there may be issues with the model. Firstly, by specifying fatigue as an outcome of depression, the authors discount the often-cited possibility of fatigue being a likely precipitant of later post-partum depression symptoms [97, 98]. The model also does not consider past findings that show that many women can experience post-partum fatigue without increased depressive symptoms [93, 94]. Furthermore, by linking sleep quality and fatigue but not linking sleep quality and depression, the EMPF ignores the substantial literature linking post-partum sleep disturbance and reduced mood [2, 119, 120].

5.6.2 Fatigue and Depression Models

The next group of models focuses specifically on the fatigue and depression relationship. The first of these is the Depressive Symptoms Responsiveness Model (DSRM) [86]. The DSRM highlights the issue that many women in the weeks after birth may be experiencing non-depression-related fatigue symptoms, while some women may be experiencing depression-related fatigue symptoms, and these two presentations may be difficult to distinguish. Overall, in the DSRM, post-partum fatigue is seen as a dynamic experience that can be reduced by increased sleep and rest, while post-partum depressive symptoms are static and resistant to change across time [86]. The DSRM suggests that depression-related post-partum fatigue is identified by whether depressive symptoms persist after the short-term granting of relief for fatigue [86]. This conceptualisation of fatigue in the DSRM as a dynamic "state" experience differs somewhat from the other definitions of fatigue discussed in this section, which all define fatigue as a persistent more "trait"-like experience. However, Runquist [86] argues that the non-psychological medical literature highlights that fatigue in hospital patients can be a dynamic phenomenon, which fluctuates in response to many different factors and the DSRM can explain the relationship between fatigue and depression in the first few weeks after birth only.

Runquist [86] acknowledges that the DSRM may have limited usefulness in situations where the fatigue of parents cannot be quickly relieved. Such a situation could occur for single parents or parents that have infants with difficult temperaments, ongoing frequent night-time awakenings, or medical difficulties. There has also been no empirical validation of the DSRM or follow-up in the literature during the last decade since its publication that either supports or rejects the model [114]. Furthermore, findings from an intervention study for women with unsettled infants found that depressive rather than fatigue symptoms were more quickly relieved after 1 week [121], the opposite of what is suggested in the DSRM. Although the DSRM model has not been adopted more broadly in studies exploring the relationship between post-partum fatigue and depression, some of the qualitative work used by Runquist [86] that informed the model may still serve as useful in understanding the relationship between fatigue and depressive symptoms.

Runquist [86] identified two separate categories of depressive symptoms: (1) those experienced by women who were fatigued but not depressed and (2) symptoms experienced only by women who were experiencing fatigue and depression. This analysis highlights that depressive symptoms such as feelings of emptiness, guilt, and thoughts of self-harm or suicide are not usually shared with women only experiencing post-partum fatigue. Other depressive symptoms (e.g. difficulty concentrating) can be shared by those experiencing either fatigue, depression, or both. This is supported by the loading of factors on fatigue and depressive scale items in other studies [122]. These findings are helpful for clinicians to help make a differential diagnosis between the treatment options that may be required for a woman with fatigue versus women with more severe co-morbid post-partum depression and fatigue (Table 5.2).

Table 5.2 Differential diagnosis between fatigued (and not depressed) and fatigued and depressed post-partum women[a]

Symptoms for women with fatigue and non-elevated depression	Additional depressive symptoms for women with both fatigue and depression
Reduced motivation Irritability Sleep disturbance Insomnia (difficulty initiating sleep) Concentration difficulties Feeling of a loss of control Feeling overwhelmed Feeling like the situation is not normal Feeling like a failure as a parent Feeling anxious about returning to normal	Emptiness of life and sense of nothing to look forward to or be enthusiastic about Confusion Agitation Depersonalisation Guilt over intrusive thoughts of harming the infant Intrusive thoughts of suicide or self-harm Intense perfectionism A sense of a lack of any positive feelings at all

[a]Based on findings of Runquist [86] and Wilson, Wynter [122]

Pearls and Pitfalls

Women who experience fatigue and depression have additional symptoms of emptiness, agitation, depersonalisation, intense perfectionism, and guilt that are not seen in women experiencing only elevated fatigue.

In addition to the qualitative DSRM model of fatigue and depression, researchers have developed quantitative models of the fatigue-depression relationship. These models support the concept that both post-partum fatigue and depression are distinct but overlapping experiences. These findings have come from three studies using confirmatory factor analysis (CFA). Two initial studies that recruited women in the community at 6–7 months post-partum (with relatively mild mean levels of depressive symptoms) found a better fit for a two-factor model of strongly correlated but distinct fatigue and depression factors than a single-factor model of combined fatigue and depression [71, 85]. A later study by one of the authors of this chapter recruited women with clinical levels of fatigue and depression symptoms admitted to specialist care [122]. We also found that with clinical levels of fatigue and depressive symptoms, a two-factor model of fatigue and depression was a better fit than a single-factor model of combined fatigue and depression [122].

5.6.3 Best Current Model for Post-partum Fatigue

The findings from these three studies support the theory that the experience of fatigue and depression during the post-partum period overlaps but is distinct. The results also fit well within the TOUS model discussed above. The TOUS's broader conceptualisation of fatigue allows fatigue to have close and complicated relationships with other unpleasant symptoms such as depression. Overall, (1) since the FSCF has been made redundant by the TOUS and due to (2) the lack of further validation of the EMPF and PTPF models and (3) the ability of the TOUS to integrate many aspects of the EMPF, PTPF, and more specific models such as the DSRM with empirical support from the CFA studies of the two-factor model of depression and fatigue, the TOUS is probably the best available model to currently explain the phenomenon of post-partum fatigue. Furthermore, the TOUS's flexibility and adaptability as a model would also likely make it a useful framework for which to understand fatigue through the different stages of pregnancy, as well as the post-partum period.

5.7 Assessing Post-partum Fatigue

Given that we can understand post-partum fatigue with models such as the TOUS, the next challenge for clinicians and researchers is reliably identifying and measuring fatigue. Currently, there are many challenges for researchers or clinicians to measure fatigue. In a clinical setting, differential diagnosis is required to identify if women are experiencing fatigue or other psychological difficulties that may have contributed to the initiation and/or maintenance of the fatigue as per the TOUS. This is summarised in Table 5.3.

Table 5.3 Differential psychological diagnoses for post-partum fatigue

Post-partum fatigue—potential presenting symptoms	Other potential psychological differential diagnoses to be considered
Sustained reduced energy levels even with sleep opportunities Reduced concentration Reduced motivation Feeling overwhelmed Less able to complete everyday tasks Reduced activity levels	Unipolar depression Bipolar depression Generalised anxiety disorder Obsessive compulsive disorder Post-traumatic stress disorder Post-partum psychosis

Based on findings of Runquist [56], Runquist [86] and Wilson, Wynter [122]

Firstly, as fatigue is a subjective experience, no reliable objective measure is available [76]. There is also no consensus on what constitutes a gold standard measure of fatigue [75]. Furthermore, different fatigue scales vary considerably in content and focus, and their comparative ability to measure fatigue is poorly understood. There is also little consensus or consistent use of fatigue scales in either post-partum or other clinical settings [123, 124]. Post-partum or pregnancy fatigue is also not included in current psychiatric diagnostic systems such as the DSM-5 or ICD-11.

These problems contrast with the measurement of other psychological constructs such as depression or anxiety. For example, while there is no objective measure of depression, there is a relatively strong consensus of what constitutes a gold standard measure [125]. Also, while many different self-report measures of depression exist, in practice, a handful of measures tend to be used relatively consistently (such as the Edinburgh Postnatal Depression Scale [126] or Depression Anxiety Stress Scale [127]). The performance of each of these scales relative to each other is understood, and the norms of these scales are well established in general adult populations in many countries [128, 129]. In contrast, comparisons among fatigue scales are rare, and the few available comparisons suggest that the overlap between fatigue scales is only moderate at best [53, 75, 76, 130]. Population norms for fatigue scales for either post-partum populations or general adult populations are also not readily available. Finally, while depression scales share many similarities in their style and content and conceptualisation of depression, this is not the case for fatigue scales.

Fatigue scales can vary substantially in their conceptualisation of fatigue as either a unidimensional or a multidimensional construct. They also vary in their length, the specific symptoms they focus on, and the extent to which they focus on the experience of fatigue symptoms or the impairments caused by the symptoms [53, 123, 124, 131]. Overall, we estimate the use of as many as 20 different scales of fatigue in the post-partum literature in the last three decades [30, 107, 110, 130, 132–134]. However, to our knowledge, only four of these scales have been validated with post-partum populations [66, 135–137]. There is no clear evidence that post-partum fatigue differs from other forms of fatigue, so general fatigue scales have served as useful starting points for post-partum fatigue scales [53, 76, 124, 138].

Another issue to consider with these fatigue scales is that they do not identify the causes of fatigue, but only tend to measure the severity of symptoms. Other scales and assessment tools such as a sleep diary [139], the Breastfeeding Experience Scale [140], the Pittsburgh Sleep Quality Index [141], the Brief Infant Sleep Questionnaire [142], and the Edinburgh Postnatal Depression scale [126] will likely be required to help clinicians conceptualise the actual precipitants and perpetuating factors of the post-partum fatigue. The following section focuses on the four scales that have been specifically validated for the post-partum period and seem to be the best candidates for both clinical and research use in the future.

5.7.1 Fatigue Assessment Scale

The Fatigue Assessment Scale (FAS) [137] is a widely used scale of fatigue in clinical settings. The FAS consists of ten items on a 5-point scale (1 = “Never”, 5 = “Always”) that ask about the fatigue symptoms respondents currently feel. Half of the items assess cognitive aspects of

fatigue, while half of the items assess physical aspects. Two studies have assessed the psychometric properties of the FAS in post-partum women recruited from the community, one during the first week post-partum [143] and the other among women with children aged from 0 to 5 years [138]. Both studies found that the FAS had adequate reliability and validity. Giallo and Wade [138] found the best fit for a shortened five-item version of the scale and no difference in the structure of responses given by parents of infants compared to parents of older children. Both studies found that although the FAS measures both mental and physical fatigue, the scale was unidimensional [138, 143].

5.7.2 Multidimensional Assessment of Fatigue

Another validated scale is the Multidimensional Assessment of Fatigue (MAF) scale [135]. The MAF is a 16-item state measure of fatigue that assesses the severity and timing of fatigue symptoms during the last week, as well as associated distress and degree of interference with daily living. The first 15 items form a Global Fatigue Index (GFI) score ranging from 1 (no fatigue) to 50 (severe fatigue). Fairbrother and Hutton [53] found that GFI scores in post-partum women from the community were in the range typically found in samples with chronic medical issues and that the MAF had excellent reliability and validity among both pregnant and post-partum women up to 6 months post-partum. Given the MAF's name, it is somewhat ironic that the measure was found to be a unidimensional measure of fatigue among post-partum women [53].

5.7.3 Post-partum Fatigue Scale

One of the other few validated scales is the Postpartum Fatigue Scale (PFS), a ten-item scale of post-partum fatigue symptoms adapted by Milligan and Parks [66] from the 30-item Fatigue Symptom Checklist (FSC) [144]. The PFS consists of ten items on a 4-point scale that ranges from 1 (not at all) to 4 (all the time) and assesses fatigue during the last week. Milligan and Parks [66] found it to be a reliable and valid measure of post-partum fatigue. Like the FAS and MAF, the PFS is a unidimensional measure of fatigue [66]. A disadvantage of the PFS is that it has been rarely used in recent years.

5.7.4 Fatigue Severity Scale

The Fatigue Severity Scale (FSS) [136] is another scale validated among post-partum women. The FSS in its original form is a very widely used measure of fatigue severity and interference in clinical populations [75]; it consists of nine items rated on a 7-point scale ranging from 1 ("completely disagree") to 7 ("completely agree") that assess fatigue during the last week. The nine items are summed to create a total score of fatigue severity ranging from 7 to 63 (or 1 to 9, if averaged). Unlike the other measures, the FSS primarily focuses on assessing the severity of the interference and impact of fatigue on functioning rather than fatigue symptoms [136]. This focus is an advantage given the lack of consensus on what symptoms make up the experience of fatigue [131].

Wilson and Wynter [145] used Rasch analysis to assess the psychometric properties of the FSS among post-partum women. They found that reducing the scale down to five of the nine items and simplifying the response items [146–148] led to the revised FSS (FSS-5R) being a brief, reliable, and valid scale for post-partum fatigue. Overall, it seems that the modified FSS, the revised FAS, and MFI have good psychometric properties and have enjoyed recent use in the literature. The authors of this chapter have relied on the modified FSS-5R and would recommend it for future use. However, all three scales seem to be good contenders for future use in research or clinical settings.

Pearls and Pitfalls

The FSS-5R has recently been validated in a post-partum sample and has the advantages of being a very short measure (five items) to admin-

ister. The focus of the scale on the severity of the impact of fatigue symptoms on functioning also means that it avoids ongoing debates about the definition of fatigue.

5.8 Treatment of Post-partum Fatigue

Despite the high prevalence of fatigue symptoms, there are few specifically developed options available to clinicians wanting to treat post-partum fatigue [149–151]. To date, only a handful of interventions have been trialled and have had mixed results with relieving fatigue skills. The interventions trialled to date fall into three classes: (1) psycho-behavioural interventions, (2) exercise and complementary medicine interventions, and (3) interventions designed to help parents manage distress and fatigue symptoms in the context of infant-settling difficulties. Below, the efficacy of each class of intervention is briefly reviewed, but pharmaceutical and medical treatments for clearly identifiable medical causes of fatigue such as anaemia, infection, and thyroid dysfunction are excluded [152].

5.8.1 Psycho-Behavioural Interventions for Maternal Fatigue

Overall, there has been little success of treatments using psychological and behavioural principles in managing fatigue. The first intervention ever trialled for post-partum fatigue was a self-help intervention for parents called the Tiredness Management Guide (TMG), adapted from treatment guidelines for cancer-related fatigue [69, 153], that aimed to help promote self-care and communication that would assist with increasing support. A trial of the TMG found no differences in fatigue compared to a control group between 2 and 6 weeks post-partum [153]. The TMG may be ineffective due to its long format and reliance on its users to implement the techniques without any guidance [153, 154]. A subsequent review of the TMG's written content found that women rated a majority of the suggested techniques as irrelevant to their needs in the post-partum context [154]. Subsequently, the more comprehensive Wide-Awake Parenting (WAP) intervention was developed and trialled in Australia.

The WAP protocol involved women with infants aged 0–7 months in the community receiving a telephone-based treatment, a written version of the treatment, or being part of a wait-list control group [149, 151]. The telephone and written treatments used a specially developed model of energy conservation and restoration drawn from cognitive behavioural and self-regulation theory to reduce fatigue and help women to develop strategies to renew their energy levels [149, 151]. In the WAP trial, women assigned to the telephone group reported more intention to engage in healthy behaviours and higher self-efficacy compared to women in the written intervention or control groups. However, there was no difference in fatigue levels after 6 weeks of participation [151]. The authors of WAP hypothesised that the relatively short duration of the intervention, the persistent nature of fatigue, and moderate levels of fatigue in their sample could explain the lack of efficacy of the WAP protocol in the trial [151].

Doering and Dogan [155] piloted another intervention called the Helping U Get Sleep (HUGS). The HUGS intervention is specifically designed to address sleep and fatigue difficulties in the first 2–3 weeks after birth by using self-management to reduce fatigue. The intervention involved a professional nurse facilitating participants' ability to engage in self-management through a repeated process of evaluating participant-initiated goals that helped them manage fatigue and the steps taken to achieve those goals [155]. An initial pilot has shown some promising results, with women from a socio-economically disadvantaged background in the HUGS intervention reporting substantial reductions in fatigue between 2 and 9 weeks post-partum. Furthermore, women participating in the HUGS intervention reported fatigue levels approximately 50% lower at 9 weeks post-partum than women in an active control group, despite the women in the HUGS group having higher levels of fatigue at baseline

measurement [155]. Further research is still required to determine if the HUGS intervention pilot results are replicable and can be applied later than the first few weeks post-partum, and to determine if the changes last longer than a few weeks.

More recently, Gholami and Mohammadirizi [156] compared the efficacy of face-to-face and electronic delivery of an intervention that focused on helping women with managing fatigue, compared to a control condition in the first 6 weeks post-partum. Both versions of their intervention focused on providing relaxation techniques, developing realistic expectations about maternal sleep, energy conservation techniques, and planning opportunities for rest. They reported similar significant reductions in fatigue for women in both the face-to-face and e-learning conditions at 4 and 9 weeks post-partum compared to women in the control group [156]. However, while these differences were statistically significant, the magnitude of the change reported was quite small and may not be reliable or clinically meaningful.

5.8.2 Exercise and Complementary Medicine Interventions

Like the psychologically based treatments, non-psychological and non-pharmacological therapies have also had mixed results in treating post-partum fatigue. Exercise programmes for women in the early post-partum period showed significant reductions in both physical and mental fatigue compared to control conditions in one community study [157], reductions in physical but not mental fatigue among post-partum women with elevated depressive symptoms in a second study [158], and no differences in a third community study [159].

Other interventions in the form of laughter therapy and drinking herbal teas have also reported mixed results. Participation in group laughter therapy sessions led to lower average fatigue levels in the laughter therapy group compared to a control group after four sessions [160]. Studies in Taiwan have investigated the efficacy of herbal teas in reducing post-partum fatigue between 6 and 10 weeks after birth. One study found a reduction in fatigue within a group assigned to drink lavender tea compared to the control group after controlling for baseline differences in fatigue [161], while another study found no effect of drinking chamomile tea [162]. Young and Gryder [163] explored the impact of the increasingly popular practice of human maternal placentophagy on fatigue levels. In their trial, they found no difference between fatigue scores at 4 days, 1 week, and 3 weeks post-partum among women consuming processed encapsulated placenta compared to women in the placebo condition.

5.8.3 Management of Unsettled Infant Behaviour

Another form of intervention that has shown some efficacy in reducing maternal fatigue is through the management of unsettled infant behaviour (UIB). UIB is a technical term used to describe the behaviour of babies that (1) parents are concerned about; (2) parents find difficult to live with; and (3) clinicians find hard to treat, as there is no identifiable cause [73, 164]. UIB is common, occurring among up to one in five infants, and usually involves some combination of persistent and inconsolable crying, sleep difficulties, short sleep periods, and frequent night waking [73, 164, 165].

Thome and Alder [166] trialled a telephone-based cognitive behavioural therapy (CBT) treatment for both post-partum fatigue and distress for women in Iceland between 4 and 6 months post-partum reporting UIB and experiencing elevated depressive symptoms. In their trial, women in the telephone intervention group received five telephone calls on managing fatigue, distress, and UIB. After the calls, these mothers reported less fatigue and depression at the end of the study compared with the mothers receiving standard care [166].

In Australia, admission to specialist residential services dedicated to helping parents is available for parents and their infants when parents are having difficulty managing UIB and experi-

encing fatigue and psychological distress [73]. These programmes provide respite opportunities, group psychoeducational training on managing infant settling, and multidisciplinary care in an intensive short-term residential programme [73]. Through the admission, the aim is to help parents establish more sustainable infant "feed-play-sleep" routines upon discharge that lead to less infant and parental fatigue and distress [73]. Fisher and Feekery [167] found that women with infants ranging from 4 to 12 months attending one of these specialist programmes in Australia experienced a significant reduction in fatigue levels 1 month after admission, and at 6 months post-admission. Fisher and Feekery [167] also found similar significant reductions in depressive, anxiety, anger, and confusion symptoms. Other studies at the same or other sites in Australia (these programmes are available in most major cities) have also found significant improvements in infant's sleep behaviour, maternal-infant bonding, and other mental health symptoms that are often co-morbid with post-partum fatigue and may perpetuate problems with fatigue. These include objective psychomotor performance, demoralisation, daytime sleepiness, depression, anxiety, and stress symptoms [121, 167–169].

5.8.4 Best Current Options for Treatment

Currently, there are no readily available resources (e.g. a treatment manual) for clinicians (psychologists, psychiatrists, nurses, midwifes, etc.) to implement an evidence-based treatment for post-partum fatigue, with demonstrated effectiveness from a randomised control trial. This is a contrast where there are well-developed protocols for the treatment of post-partum depression. Based on the research findings to date, it seems that interventions that focus on helping women with unsettled infant behaviour may have the most efficacy in improving fatigue, compared to the lower intensity self-help guides and psycho-behavioural interventions. There is also limited evidence for the effectiveness of the complementary medicine approaches. A summary table is given below of the current treatments for post-partum fatigue. It is also possible that some of these forms of treatment (e.g. nurse-guided psychoeducation on fatigue management) may also be effective in reducing treatment during pregnancy, but there is currently insufficient evidence to draw any strong conclusions yet (Table 5.4).

Key Points

Current evidence suggests that clinician-guided treatments that help women improve their infant-settling abilities and/or manage their own fatigue appear to have the most efficacy in reducing post-partum fatigue.

5.8.5 Interactions with Other Forms of Surgical Treatment

Given that this volume is about post-maternity body changes, including potential surgical reshaping procedures post-pregnancy, the interaction between the treatment of fatigue and other treatments such as abdominoplasty or mastopexy can be considered. This area is yet to be considered specifically in the post-partum fatigue research. Furthermore, the relationship between perinatal fatigue and body image has yet to be researched. However, we do know that the corre-

Table 5.4 Currently effective treatments for post-partum fatigue

Evidence of effectiveness	Mixed evidence of effectiveness	No evidence of effectiveness
Nurse-guided psychoeducation on fatigue management (face-to-face, online, or telephone) Telephone-based infant settling programmes Residential infant settling programmes Laughter group participation	Exercise programmes Herbal tea consumption	Self-study psychoeducation on fatigue management Maternal placentophagy

lational relationship between perinatal depressive symptoms and increased body image concerns appears to be at its strongest at 6 months post-partum, a time that also tends to involve elevated post-partum fatigue [48].

Given the high prevalence of fatigue in the first 12 months post-partum, the authors consider that in the absence of any current findings, it seems that at least several months take place after the birth before any surgery is scheduled; this will likely allow fatigue levels to have a chance to reduce prior to the commitment to surgery. Additionally, prior to conducting any surgery, clinicians would also be wise to use one of the brief measures of fatigue (e.g. FSS or FAS) mentioned above in Sect. 5.7. A thorough assessment of fatigue and depressive symptoms can allow a clinician to consider if fatigue and/or depressive symptom interventions (e.g. infant settling, cognitive behavioural therapy) should be considered first prior to undertaking surgery.

5.9 Conclusion

The perinatal period is a challenging period for many women, as they adapt to the many physical changes. The disruption to sleep and ongoing fatigue from caregiving and adjustment to childbirth leave women vulnerable to more serious mental health difficulties such as depression, which can also then worsen both fatigue and sleep disturbance. This chapter has focused on the widespread but somewhat overlooked psychological phenomenon of prenatal and post-partum fatigue. While prenatal fatigue is less well understood, there is a growing body of evidence that post-partum fatigue is highly prevalent and, for a minority of women, persists and has a substantial impact on their ability to adjust following childbirth.

This chapter has identified that there are bio-psycho-social models that provide a good explanation of how post-partum fatigue is triggered and then persists. The research has also clearly differentiated post-partum fatigue from depression and identified that while there is some overlap, they are distinct experiences, with distinct symptoms that can be clarified in clinical settings. There are also some widely available reliable and valid measures that can be used in clinical and research settings to measure post-partum fatigue. These post-partum measures of fatigue may also prove to be useful for measuring fatigue during pregnancy with additional future validation.

Finally, while there are not specific treatments available, there is a small but growing body of evidence that suggests that infant settling-focused interventions may be one of the most effective ways to assist women reduce their post-partum fatigue symptoms during this period. Overall, while there is much to do in this area, we hope that this chapter provides a useful stepping stone for professional working in this area to better understand this phenomenon.

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6 Sexuality During and After Pregnancy

Hatice Yıldız

Take-Home Points

- Pregnancy and postpartum processes, which play a temporary but also very specific role in the life of women and couples, cause significant changes in the sexual life of women and couples.
- Women's sexual functions are being highly affected, particularly during the third trimester of pregnancy.
- Multiple sexual dysfunctions may occur during pregnancy and postpartum period.
- Sexuality during pregnancy can be beneficial in maintaining healthy sexual functions and a good relationship between couples after birth.
- Prepregnancy sexuality should not be overlooked while approaching the sexual functions during pregnancy and postpartum, because the couples' background on this issue is important.
- Sexuality during pregnancy is safe in general, and in fact, more evidence is needed to claim that sexual function should be avoided in order not to jeopardize high-risk pregnancies.
- Especially perineal traumas related to assisted vaginal deliveries and episiotomy are cause to play a critical role in postpartum sexual dysfunction.
- Women and couples have many concerns and questions about their sexuality and changes regarding pregnancy and postpartum periods, but couples generally do not share their problems on this issue. On the other hand, pregnancy and postpartum sexuality is generally neglected in healthcare services.
- Sexual functions and sexual health counseling are outstandingly important in preconceptional, pregnancy, and postpartum processes in relation to these issues discussed above.

6.1 Introduction

Sexuality is an important component of health and well-being, and it is fundamental for the protection and maintenance of them [1–3]. According to the World Health Organization, "Sexual health is a state of physical, emotional, mental and social well-being related to sexuality; it is not merely the absence of disease, dysfunction or infirmity" [4].

Sexuality is a natural part of human life and is a multidimensional phenomenon [5–9]. Human sexuality is a complex subject, because it encompasses a broad range of issues such as behaviors and processes, including sexual identity and sexual behavior, and the physiological, psychological, social, cultural, political, and spiritual or religious aspects of sex [10–13].

Women's sexual function is also a complex and dynamic interplay of many variables [14].

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_6

Throughout history, the subject of female sexuality has been expressed in several writings and depicted in numerous Venus figurines and fertility goddesses [10]. The earliest surveys about sexuality behavior started in the 1890s [15]. However, research on sexuality began in the 1950s when Masters and Johnson described the anatomy and physiology of the human sexual response [10, 16]. Sexual health in pregnancy and after childbirth is also a relatively new research interest [10, 17–19].

Sexual function has a complex etiology for any couple, and sexuality may be adversely affected by biological, psychological, social, cultural, ethical, interpersonal, organic, and neuroendocrinological factors. However, the sexuality of each person or couple is intensely private and individual [2, 5–7, 9, 20].

Sexual function that is being affected by many factors may change at various stages of human life; pregnancy, childbirth, and postpartum periods are temporary, but they are very special and important processes in women's and couples' life [5–9]. These periods are genuinely emotional, unique, and difficult experiences with a great impact on the woman's life and health, including sexual health and relationship with her partner [10, 11, 21].

Pregnancy, labor, and postpartum periods constitute an extremely significant, indeed exclusive, time in every woman's life; on the other hand these events affect their health, along with other aspects of their lives, including sexual activity, which is undeniably a significant aspect of human life [10, 11, 19, 21–29]. These changes associated with these periods affect not only the sexuality of the woman but also the health of a couple's sexual relationship [5, 9, 10, 19, 22, 25, 30–34]. Although it is stated that female sexual problems during pregnancy and postpartum are generally related to changing conditions in those periods, it is stated that the prepregnancy sexuality of women or couples should not be overlooked in order to make an assessment on sexuality during pregnancy and postpartum [8, 35].

Although pregnancy and postpartum are just temporary periods in the life of women, healthy sexual activity during pregnancy and after delivery is one of the main features in maintaining a good relationship for couples [5–7, 9], because sexual function is an important part of each human being's personality and a keystone in the general couple relationship, with an obvious impact on the quality of life [36]. It is stated that sexual problems that cannot be solved during pregnancy and after birth can trigger ongoing dispute patterns with harmful consequences for men, women, couples, children, and society [37]. On the other hand, pregnancy and postpartum sexuality shows a significant linear correlation with prepregnancy sexuality [8]. So, in addition to the importance of solving sexual problems during pregnancy and postpartum periods, which are temporary processes in the life of a woman and/or couple, the resolution of the existing prepregnancy sexual problems especially during the prepregnancy period is extremely important for the couples to sustain their healthy sexual function and relationships.

It is recommended that appropriate care strategies should be developed to increase knowledge and reduce worries related to the sexuality of women who are pregnant or gave birth, and hence their partners [38]. Pregnancy and postpartum sexuality, which has not received sufficient attention from healthcare providers in the past, has recently started to attract attention. And sexual health during these periods is increasingly being recognized as an important component of women's and couples' life and a notable area of maternity service provision and postpartum care [30, 39].

In this chapter, pregnancy and postpartum sexuality is investigated in a wide frame with literature data.

6.2 Sexual Function During Pregnancy

Pregnancy is one of the very specific, complex, exciting, and temporary periods in a woman's life where many physical, hormonal, and psychological changes occur [1, 2, 30, 37, 40, 41]. Sometimes depending on changes or serious problems, pregnancy may not be a desired experience for all

women [2, 37], because changes during pregnancy often affect women's physical well-being, mood, relationships, and sexuality [20, 30, 40, 42–44]. There are numerous factors that may justify the change in sexual functions during pregnancy [2, 45, 46].

6.2.1 Factors Affecting Sexuality During Pregnancy

Many factors may affect sexual functions during pregnancy. Factors related to sexual problems in pregnancy according to von Sydow are shown in Table 6.1 [29].

6.2.1.1 Hormones

Women's hormonal changes in pregnancy may provoke and promote a decline in sexual activities [30]. Hormonal changes (increased estrogen, progesterone, and prolactin) cause nausea and breast tenderness, which together with fatigue, weakness, and anxiety can reduce sexual desire and arousal or in other ways determine the difficulty of sexual life [2, 30, 47]. It is indicated that serum androgen levels have the highest levels at the beginning of pregnancy and then they fall in the third trimester, which theoretically may lead to a decrease in sexual desire [48]. Thorne and Stuckey suggested that in the relationship between decreased sexual desire and hormones in late pregnancy, increased progestin hormone negatively affected sexual behavior rather than decreased androgen levels [49]. Relaxin relaxes the ligaments in the pelvis, softens and widens the cervix, and causes epithelial cells in the vagina to enlarge and vaginal circumference lumen to increase, and this subsequently might cause a decrease in vaginal sensitivity [50]. Hormonal changes can also cause emotional changes, and these may affect the sexual desire and sexual behavior [51]. There are also studies reporting that there is no significant relationship between hormones and sexual behavior [52].

Studies suggest that hormones cause symptoms of diminished clitoral sensation, orgasmic disorders that may last up to 6 months postpartum, and lack of libido [30]. On the other hand, although men may not experience the hormonal changes that occur within their partners' bodies, they may often have emotional and visceral reactions to pregnancy [32].

Table 6.1 Factors related to sexual problems during pregnancy

Biomedical factors
Tiredness
Worry that the fetus could be hurt during intercourse
Dyspareunia
Backache
Woman's low physical attractiveness (self and partner evaluation)
Psychosocial factors
Mental symptoms (depressed mood, emotional lability)
Prepregnancy sexual history and sexual symptoms (e.g., dyspareunia)
Negative or ambivalent feelings about the pregnancy
Couple/relationship factors
Low relationship satisfaction

Von Sydow K. Sexuality in pregnancy and the postpartum period. In: Reece EA, Hobbins JC, eds. Clinical obstetrics: the fetus and mother. John Wiley & Sons; 2007: 1016–1021

6.2.1.2 Worry About Damaging the Fetus or Pregnancy

Both the woman and her partner may be worried about those complications that may occur as a result of sexual activity during pregnancy [53–56], and the sexual interest of both partners may be reduced due to their concerns [51, 57]. Although during pregnancy one-third or half of the expectant parents were reported to be afraid of harming their babies [26, 53, 58], in a prospective study, this rate was indicated as 80% [59]. It is stated that one-quarter of women reported that they experienced fear of sexual intercourse during pregnancy [2, 60, 61]. Also, males are afraid of hurting a female, and females are afraid of dissatisfaction of a male partner [26, 31, 53]. One study reported that the majority of their participants stopped engaging in sexual activity during pregnancy, one reason for which being the fear of harming the fetus [1]. It is stated that sexual problems and dysfunction during pregnancy often arise from the worry that the fetus will be damaged [31], and these fears indicate the major influence on male sexual activity [51, 57]. Some

people believe that sexual activity or orgasms might harm the baby, increase the chances of a miscarriage, or induce early labor [30]. However, in a healthy pregnancy, none of these are true and it is said that as long as no health issues are involved, sexual intercourse during pregnancy is safe [30, 62].

6.2.1.3 Nausea, Vomiting, and Fatigue

Nausea, vomiting, and fatigues are some of the most common problems and reasons for loss of sexual desire during pregnancy. Nausea and vomiting, which many women experience during the first trimester, may diminish their feelings of eroticism, and fatigue may lead to insufficient energy to participate or enjoy in sexual intercourse [30].

6.2.1.4 Abdominal Growth, Weight Gain, Breast Tenderness, Body Image, and Discomfort

As pregnancy progresses, the abdomen of the woman grows, body gains weight and changes physically, breasts grow and become sensitive, and therefore the woman's perception of body image also changes. Discomforts due to changes in pregnancy may affect the sexual satisfaction of both men and women [63]. Women might feel less attractive due to the increased size of their body and abdomen [32, 36], and increasingly large abdomen of a woman causes physical limitations and gradual changes in fulfilling some sexual positions during pregnancy [2, 32, 36, 47]. It is stated that some couples may be distracted by the idea that a third person is in bed during lovemaking [32]. Physical appearance is a prominent preoccupation during pregnancy [30, 48]. Moreover, the presence of uterus that grows day by day during pregnancy and the gradual change in a pregnant woman's self-image that influences her self-confidence affect sexual functions [2, 47]. Studies show that there is a relationship between body image and sexual satisfaction and between dissatisfaction with the body and sexual distress [64]. In relation to the change in breasts mentioned above, while a male partner may find larger breasts exciting, the female partner may find any breast or nipple stimulation to be painful rather than erotic [30, 65]. On the other hand, fetal movements and Braxton-Hicks contractions may serve to diminish feelings of intimacy [32].

6.2.1.5 Traditional

Social and cultural factors and related myths can influence the sexual life of a pregnant couple, and they may also be associated with a decrease in sexual interest [30, 66]. As reported in a study conducted in Nigeria, a total of 44.3% of the respondents believed that sexual intercourse during pregnancy widens the vagina and facilitates labor and 30.2% believed that it caused abortion in early pregnancy [67]. In one study in Iran, it was found that women fear about sexual activity during pregnancy because of the possibility of causing rupture of the hymen of the female fetus or possible fetal blindness. Women also believed that sexual intercourse might be an act of adultery while carrying a female fetus [68]. It is emphasized that traditional Chinese medicine has many prohibitions on sexual activities during pregnancy and places great emphasis on dietary and behavioral restrictions to restore physical and emotional harmony [1]. According to the study by Malewitz et al., sexuality in pregnancy for Polish couples means a stimulus to search for new ways of pleasing each other in love play. In addition, in this study, it was stated that experience of sexual satisfaction by pregnant women improves their self-esteem, facilitates the mutual relationship between partners, and strengthens the bond of marriage [69]. In case of another study conducted in Nigeria, 34.8% of women believed that sexual intercourse during pregnancy improves fetal well-being. It has been reported that demographic factors also, such as education level, full-time employment, marriage duration, and ethnic group, affect sexual function during pregnancy [30, 66].

6.2.1.6 Partner Approach

The partner approach plays an important role in pregnancy, and the mutual understanding between partners during pregnancy is important for them to seek new ways of sexual satisfaction [70]. That is, this reinforces the role of pregnancy as a stimulus for partners to search for new ways

to enhance mutual emotional connection, intimacy, and close physical affinity, in order to share physical sexual pleasure and satisfy each other's sexual needs [2, 41, 70]. One study investigated that women reported more of a decrease in communication about sex when compared with their partners and that significant difference was seen in mean avoidance of sex between women and men, and non-sensuality [71]. In a different study, it was reported that the level of intimacy and passion were higher at the beginning of pregnancy between couples; the commitment score in women was, in general, higher than men; and the commitment score in men increased at the beginning of the third trimester [72].

The sexual relationship seems to be the most vulnerable area in the relationship of expectant and young parents [26], and sexual function during pregnancy is one of the keystones for couples to go forward from partners to parents [73]. Pregnancy can also affect the sexual functions of a pregnant woman's partner, because there is a strong correlation between male and female sexual function [42].

6.2.2 Sexual Dysfunction in Pregnancy

Pregnancy affects people's sex drives in different ways, so there is no typical response. The majority of studies on the subject reported that pregnancy has a negative effect on the quality of sexual intercourse between couples [10, 19, 20] and that there is a relationship between pregnancy and sexual dysfunction [74]. Contrarily, there are also studies showing that pregnancy has no negative effect on sexuality [60].

In studies, rate of sexual dysfunction in pregnant women is stated as high. This rate was indicated as 91.08% by Aydın et al. [75], 92% by Erbil [76], and 72% by Mobasher et al. [77]. A study that evaluated sexual functions of pregnant women stated sexual desire disorder rate as 88.9%, sexual arousal disorder as 86.9%, lubrication disorder as 42.8%, orgasm disorder as 69.6%, and sexual satisfaction disorder as 48% [78]. In another study, the most common sexual dysfunctions in pregnant women were reported to be diminished clitoral sensation 94.2%, lack of libido 92.6%, and orgasmic disorder 81% [52].

Sexual desire and arousal influence sexual satisfaction and intercourse frequency [2, 47, 79], so sexual activity decreases during pregnancy [2, 7, 47, 53, 55, 61]. A prospective cross-sectional study revealed that Chinese pregnant women had less sexual activity and desire during pregnancy [59]. In one study, it was reported that one-third of women reported a decrease in sexual desire, and they expressed that vaginal, oral, and anal sex and masturbation had been performed by them during pregnancy [2, 61]. In some literature, it is stated that desire, arousal, lubrication, orgasm, and satisfaction decreased significantly with the progression of pregnancy (especially in third trimester) [75, 79, 80], and Erbil's study results support these studies' results (except sexual desire) [76].

In the studies comparing sexuality between pregnancy and prepregnancy, it has been found that frequency of sexual intercourse, orgasm, libido [8, 81], desire, arousal, lubrication, and satisfaction during pregnancy significantly decreased according to prepregnancy period [8]. Moreover, the duration of intercourse and the ability to experience orgasm decrease during the later phases of pregnancy compared with prepregnancy, and dyspareunia increases significantly throughout pregnancy [26].

Sexual pain disorders, including vaginismus and dyspareunia, are quite prevalent in pregnancy. Results suggest that about half of women may develop genito-pelvic pain during pregnancy, which will persist for about a third, and that pain will also develop after birth in this group [82]. In a small percentage of pregnant women, an increase in libido and orgasm has been reported. Arousal and increased orgasm ability due to the disappearance of contraception requirements and increased genital blood supply are shown as the possible reasons [37]. One study found that overall sexual function and satisfaction were not problematic for couples during pregnancy [71].

It is emphasized that healthy sexuality during pregnancy is necessary and it may play a key role

for a couple towards becoming parents [2, 30, 41]. It is even stated that prenatal sexuality may be a predictor of postpartum sexuality [10, 19, 37]. Yıldız reported that there was no relation between pregnancy and postpartum sexuality. In addition, she stated that all of the participants who had prepregnancy sexual dysfunction continued to also experience it during pregnancy, and the majority of them had a significant level of sexual dysfunction by 6 months postpartum [8]. Pauls et al. reported that sexual practices changed during pregnancy but returned to early pregnancy levels in the postpartum period and stated that sexual functions that worsened during pregnancy did not recover by 6 months postpartum [83]. Trutnovsky et al. indicated significant decrease in perceived "importance of sexuality," "importance of sexual intercourse," and "contentment with present sex life" from over early pregnancy to late pregnancy, which was followed by a slight increase in the postpartum period [84]. Each individual and couple have a background of sexuality. So, it is important not to ignore the prepregnancy sexual relations of women or couples, because the prepregnancy sexual relations of couples also have a decisive role in pregnancy and especially postpartum sexuality [8].

6.2.3 Sexuality in Pregnancy According to Trimesters

Most women are sexually active during the pregnancy [26, 60, 70, 85, 86], but sexual activity during pregnancy is decreased over time compared to prepregnancy [70, 83, 87], and also one study reported that the majority of women stopped engaging in coital activities during pregnancy [1]. This is because sexual activity, which is influenced by biological, psychological, and social factors, modifies as pregnancy progresses [1, 2, 58, 70, 80].

In the first 3 months of pregnancy, women's sexuality may be affected by drowsiness, breast pain, nausea, vomiting, mood disorder, and fear of damage to the embryo or fear of occurrence of miscarriage as a result of sexual contact [70]. In the second trimester of pregnancy, there is a significant increase in the number of sexual intercourse and experiences of sexual fantasies in the majority of women due to the genital congestion and more intensive and faster wetting of the walls of the vagina in relation to physiological and hormonal changes. During this period, the increase of achieving a sexual satisfaction is also noted [70]. In terms of sexuality, the most affected process during pregnancy is third trimester, and in this trimester of pregnancy, a woman may experience problem and pain during sexual intercourse [69, 70].

Specific changes that occur in each trimester of pregnancy have significant influences on sexual behavior [2, 54, 55, 59, 83]. A meta-analysis study showed that 90% of women were sexually active during pregnancy [26, 85], but this rate decreased to 30% in the ninth month and women's sexual interest and coital activity declined slightly in the first trimester, showed variable patterns in the second trimester, and decreased sharply in the third trimester [26]. Some studies reported mean sexual function scores to be similar in the first and second trimesters [52, 58]; in another study, it was reported that women were most active sexually also in the first trimester of pregnancy [70]. Some studies demonstrated that the frequency of coitus does not change or changes only minimally during the first and second trimesters of pregnancy [2, 3, 29]. One study showed that 90% of pregnant women had no sexual intercourse in the past 4 weeks [68].

As pregnancy progresses, the frequency and length of sexual intercourse decrease as well as the achievement of orgasm, sexual satisfaction, and stimulation [7, 31, 62]. Most studies indicated that the sexual function (like frequency of sexual intercourse, desire, arousal, orgasm, satisfaction) decreases during pregnancy and significantly declines in the third trimester [1, 7, 8, 31, 42, 52–55, 58, 62, 87, 88], they were reluctant to enjoy sexual satisfaction [70], and dyspareunia increases significantly throughout pregnancy [7, 31, 55, 62]. But Masters and Johnson stated that many women who have never had an orgasm during their intercourse can experience their first orgasm during pregnancy and that women who have been previously orgasmic may have the experience of multiple orgasms [89]. von Sydow stated in the third trimester that 54% of sexually

active women report having an orgasm with the last coitus [29]. Prevalence of reduced sexual interest, desire, and enjoyment during pregnancy could be over 50–60% [30, 58, 80]. von Sydow stated that women's enjoyment of sexual intercourse in the first trimester decreases to 59%; in the second trimester, it increases to 75–84%; and in the last trimester, it decreases again to 40–41% [29].

One study indicated that the prevalence of sexual dysfunction is high during pregnancy and reaches higher levels in the third trimester [68]. Pauls et al. reported that overall sexual function declined throughout pregnancy and did not return to baseline by the 6-month postpartum assessment although sexual activity and variety of practices had returned to prepregnancy levels [83].

The results of the studies that examined sexual function during pregnancy according to the prepregnancy sexuality showed that reduction occurred in sexual function as pregnancy progressed, and particularly during the third trimester, significant decrease occurred in many women compared with prepregnancy [2, 8, 54, 55, 59, 70, 83]. Some studies stated that this typically occurs in nulliparous women, while in multiparous women, usually changes are not observed in sexual activity compared with the prepregnancy period [70]. Although sexual activity during pregnancy decreases over time, there is also study indicating that sexual satisfaction in pregnancy does not change compared to prepregnancy period [2]. Another study reported no differences in the prevalence and indices of sexual function between pregnant and nonpregnant women [77].

Possible changes in pregnancy according to trimesters and their possible effects on sexual functions, and the sexual dysfunction states that can be seen, are summarized in Table 6.2.

Table 6.2 Changes in pregnancy according to trimesters and their possible effects on sexual functions

Changes according to trimesters	Possible effects on sexuality
First trimester *Drowsiness, breast pain, nausea, vomiting, fatigue, mood disorder, fear of occurrence of miscarriage,* etc.	Decrease in sexual activities Decrease in sexual intercourse (*coital activity decline slightly*) Decrease in sexual desire Decrease in eroticism feelings Insufficient energy for sexual intercourse
Second trimester *Hormonal and physiological changes, increase in genital congestion and vaginal sensitivity, good physiological adaptation to pregnancy,* etc.	Increase in libido Increase in sexual intercourse Increase in sexual arousal Increase in sexual fantasies Increase in sexual satisfaction Increase in achievement of orgasm (*may be experience of multiple orgasms*)
Third trimester *Abdominal growth, weight gain, breast tenderness, body image, discomfort, worry about damaging the fetus, genito-pelvic pain,* etc.	Sexual absence Decrease in sexual intercourse (*coital activity decrease sharply*) Loss of sexual desire Decrease in sexual frequency Sexual distress Orgasmic and sexual dissatisfaction Decrease in intimacy feelings Decrease in clitoral sensation Pain during sexual intercourse Difficulty in sexual positions *(There are generally decrease in frequency of sexual intercourse, desire, arousal, orgasm, and satisfaction in the third trimester)*
Sexual dysfunctions that can be seen during pregnancy	
Sexual desire disorders, lack of libido Sexual arousal disorder, lubrication disorders Orgasmic disorders Sexual satisfaction disorders Sexual pain disorders (including vaginismus and dyspareunia)	

6.2.4 Conditions Affected by Sexuality During Pregnancy

There are some conditions in pregnancy where sexuality may be contraindicated. But there is limited evidence about situations where it is advisable to limit sexual activity during preg-

nancy [30, 80]. In the 1990s and early 2000s, large representative studies observed no overall association between perinatal complications and either coital activity or orgasmic frequency. In general, most of the studies could not find any relationship between frequency of intercourse and preterm labor [26, 90, 91].

One study showed that 29.4% of women believe that sexual intercourse during pregnancy has a negative effect [85]; another study reported that many women believe that having sexual intercourse at term will expedite the onset of labor [92]. It is estimated that nipple stimulation, clitoral stimulation, and orgasm-related uterine activity may help trigger the onset of labor. The physiological basis of this is the production of oxytocin and prostaglandin. Prostaglandin (PG) E and F play an important role in ripening the cervix and contribute to the contractibility of the uterus (*prostaglandins in pregnancy are produced by the cervix, the fetal membrane, and the decidua, and there is presence of prostaglandin E in human semen*) [30, 80]. It is stated that sexual activity may have an effect on the onset of labor, and this effect may be due to the role of prostaglandin E, that is present in human semen, in the maturation of the cervix and the onset of uterine contractions [80]. It was found that the concentration of prostaglandin E and F in the cervical mucus of women was similar in the first and second trimesters of pregnancy, but that the PGF level was 10–20 times higher in the third trimester. In addition, 2–4 h after intercourse, prostaglandin concentrations in the cervical mucus were found to be about 10–50 times higher than normal [93]. Therefore, there is a biological probability regarding the effect of sexual intercourse on the onset of labor from this point of view [30]. In three different studies conducted by Tan et al., a variety of parameters were examined in terms of the relationship between coitus and onset of labor, but they generally could not find a relationship. It was reported that the rate of spontaneous onset of labor was similar in term pregnant women who are advised and not advised to have sex in order to induce labor [94–96]. It was stated that sexual intercourse did not show a significant relationship with cervical maturation and initiation of labor [64, 92], but Faumane et al. indicated that the women who had active sexual intercourse before and after 28 weeks in pregnancy significantly had a shorter active phase and a shorter second stage, higher rate of spontaneous deliveries, and a lower rate of cesarean sections and needed less oxytocin usage before expulsion [64]. One study found that coitus in early pregnancy did not associate with increased preterm birth risk, but there is an association between an increasing number of sexual partners in a woman's lifetime and recurrent preterm delivery [97]. On the other hand, some literatures state that intercourse just before the expected date of birth or woman's orgasm may lead to the start of the birth due to the prostaglandins contained in the semen of male [70, 98]. Also, it is stated that an orgasm or sexual penetration in the late period of pregnancy is possible to initiate Braxton-Hicks contractions [30]. As is seen, most of the studies date back to several years. And there is limited evidence to guide recommendations on sexual activity in women who are at increased risk of preterm labor. Therefore, restriction of sexual intercourse is often recommended for prevention and management of threatened preterm labor.

Although it is thought that there will be an increase in the risk of preterm labor in twin or multiple pregnancies as a result of sexual activity, studies have not confirmed this [99, 100]. In some studies investigating the effect of coitus on premature rupture of membrane, it was stated that there is no relationship between membrane rupture and sexual intercourse, coital frequency, frequency of orgasmic coitus, or sexual position [30, 91].

In contrast to common belief, sexual intercourse is stated to be not associated with vaginal bleeding in the first trimester of pregnancy. However, placenta previa, placental abruption, and prenatal hemorrhages in the second and third trimesters are reported to be associated with increased frequency of sexual intercourse [62]. Despite inadequate evidence, it is thought that advising women with placenta previa to avoid sexual intercourse will be the safest way in terms of prenatal bleeding risks [62]. And it is theoretically accepted that penile contact during intercourse could result in a similar risk of hemorrhage [80].

On the other hand, vaginal vascularization increases during pregnancy. Although there are few reported cases, it is expressed that the high-pressure rough sexual intercourse during pregnancy may create a risk of venous air embolism due to the increased vaginal vascularization [101]. Also, it is stated that the uterine orgasm-induced contractions during pregnancy may increase the risk of uterine rupture in women with uterine scar after sexual intercourse in the last weeks of pregnancy, and dangerous infection can more often occur [98]. Therefore from 6 weeks before the expected date of birth, especially if there is a risk of premature rupture of the membrane, it may be recommended that the woman avoid sexual intercourse because of the increased risk of infection [69].

In the late 1990s to early 2000s, von Sydow and Leeners et al. made the following description: "for the majority of healthy pregnant women and their partners, there is no reason to forbid sex, even in the last weeks before birth" [26, 90].

Table 6.3 shows some situations in which women with pregnancy complications should avoid sexual intercourse and/or orgasm. But these situations have not been exactly validated with the studies [25, 29, 80]. However, there is also a lack of substantial evidence about the safety of having sexual intercourse during pregnancy in high-risk pregnant women. So, a woman's experience of having a negative pregnancy risk as a result of sexual intercourse should be evaluated separately for each individual [30].

Sexual activity in pregnancy is a topic insufficiently addressed in clinical practice and in the literature. Many studies evaluating sexual activity during pregnancy and in high-risk pregnancies have been conducted decades ago, and there is even less scientific evidence and insufficient data to provide proven recommendations in high-risk pregnancies [102].

Clinicians need to engage in conversations regarding sexual activity for patients experiencing complications in pregnancy [30, 80, 102]. But it is important to provide validated recommendations. So, recommendations for or against restricting sexual activity should be based on evidence-based guidelines [102]. Sexual activity recommendations in high-risk pregnancies are presented in Table 6.4.

Table 6.3 Most common risks to sexual intercourse during pregnancy

Serious risks:
• Unexplained vaginal bleeding • Placenta previa • Premature dilatation of cervix • Premature rupture of membranes
Increased risks:
• History of premature delivery • Multiple gestation • Repetitive bacterial vaginosis

Jones C, Chan C, Farine D. Sex in pregnancy. CMAJ. 2011;183(7):815–818

Table 6.4 Sexual activity recommendations in high-risk pregnancies

For history of preterm birth (PTB)
*Level II-2: Sexual activity of any type should not be discouraged in women with a history of PTB *Level III: Sexual activity of any type should not be discouraged in women with a history of PTB until they have an episode of preterm labor (PTL). After this, sexual activity of any type that causes an increase in frequency or intensity of uterine contractions should be avoided *Author's opinion*: Women with a history of PTB in the absence of a short cervix or other obstetrical risks need not be discouraged from sexual activity of any type
For both a prior PTB and a short cervix
*Level III: Women with both a prior PTB and a short cervix should avoid coitus *Level III: Limited data suggest that women with a short cervix need not be discouraged from sexual activity of any type *Author's opinion*: Women with a short cervix need not be discouraged from sexual activity of any type unless experiencing bleeding, increase in baseline uterine contraction frequency/intensity, or worsening in cervical length (CL). After this, vaginal penetration and any non-penetrative sexual activity with or without orgasm that causes patient perceived uterine contractions or painful contractions should be avoided

(continued)

Table 6.4 (continued)

For cervix with a cerclage
*Level III: Vaginal penetration should be avoided *Level III: After prophylactic cerclage placement, pelvic rest for 1 week and use condoms with coitus thereafter. After rescue cerclage, abstain from coitus until 32–34 weeks of gestation
For preterm premature rupture of membrane (PPROM)
*****Level III: Patients with PPROM, regardless of gestational age, should adhere to strict pelvic rest *Author's opinion*: Vaginal penetration may increase the risk of infection and thus should be avoided
For placenta previa
*Level III: Until placenta previa is confirmed in the second trimester, typically after 28 weeks, the need for sexual activity restrictions is usually not indicated *Level III: Abstain from any sexual activity that may lead to orgasm after 20 weeks of gestation (earlier if they have experienced vaginal bleeding) *Author's opinion*: Sexual activity of any type need not be restricted until the CL is <3 cm, after the sentinel bleeding episode, or the baseline uterine contraction frequency/intensity increases. If the CL is between 3 cm and 2.5 cm, recommendations for sexual activity of any type need to be individualized. After the sentinel bleeding episode, penetrative sexual acts and any sexual activity leading to patient perceived uterine contractions or painful contractions should be avoided. Non-penetrative sexual activity that does not result in patient perceived uterine contractions or painful contractions need not be restricted after the sentinel bleeding episode
For placental abruption
The literature did not provide any data or expert opinion on sexual activity recommendations with an existing placental abruption *Author's opinion*: Sexual activity recommendations in women with a chronic placental abruption stable enough for home monitoring need to be individualized. In women with a stable, chronic abruption, any sexual activity that results in bleeding should be avoided
For twin gestation
*Level II-2: Sexual activity of any type should not be discouraged in twin gestation The literature does not provide any data or expert opinion on sexual activity recommendations in higher order multiple gestations *Author's opinion*: In the absence of other obstetric risk factors, sexual activity of any type need not be restricted in twin or higher order multiple gestations
For history of classical cesarean section
The literature does not provide any data or expert opinion on sexual activity recommendations with a history of classical cesarean section *Author's opinion*: In the absence of other obstetric risk factors, a history of a classical cesarean section alone would not necessitate sexual activity restrictions of any type. Women who experience very painful or intense, prolonged uterine contractions following any sexual activity should limit that specific sexual activity
For all
*The evidence to support or refute the safety of penetrative or non-penetrative sexual activity with or without orgasm is limited *Individualize recommendations based on consideration of obstetric history and comorbidities as well as patient and partner fears and emotional needs *Further research is needed to make validated recommendations

MacPhedran SE. Sexual activity recommendations in high-risk pregnancies: What is the evidence? Sexual Medicine Reviews. 2018;6(3):343–357

6.3 Sexual Function After Delivery: Postpartum Sexuality

6.3.1 Definition and Characteristics of Postpartum

Postpartum period, which includes a short and transient period in the life of a family and an important milestone in the protection and promotion of the health of the mother, baby, and family, is a developmental transition period covering the 6-week period after the birth. Although the days following childbirth are generally considered a period of intense happiness, this period is a critical phase in the lives of mothers and newborn babies, family life, and couple relationship [103, 104].

Physiological changes during pregnancy subside in the postpartum period. But all new mothers need time to heal and recover after giving birth and for the body to recover, cervix to close, postpartum bleeding to stop, and, if applicable, their C-section incisions or vaginal tears to heal. The sudden disappearance of placental hormones after delivery and the start of lactation cause drastic endocrinological changes in the first weeks, but after 6 weeks, a steady state is reached. The psychosocial adaptation of the mother, the baby, and the family to the new situation usually attains a new balance. However, this does not mean that the pre-pregnant state has completely returned, because lactation usually continues, often the menstrual cycle has not yet normalized, and sexual activity may not have been resumed yet. Contraception is an important need in that period, and it may be problematic for many couples. Therefore, it is important to support women in this process, because the lack of social support of the postpartum woman directly affects the spouse/marriage relationship and the postpartum psychology of the woman [103, 104]. Transition to parenthood can be both extremely pleasurable and stressful. The relationship within the partners changes, especially after the birth of a first child [37]. After childbirth, numerous physical, psychological, and sociocultural factors may affect both sexual activity of women and quality of their lives [10, 11, 105, 106]. In one study, 68% of women expressed the need for help on postpartum sexual issues [18]. In the WHO's recommendations, it is emphasized that postpartum male and female sexuality is as important as many other conditions that are important in maintaining and improving postpartum health [103, 104].

6.3.2 Resumption of Sexual Intercourse After Childbirth

The most frequent question in postnatal period is "when can I restart my sex life?" [62]. Women can return to sexual activity after birth whenever they feel they are ready to do so. There is no prescription for the time required to resume sexual intercourse after birth, because the time required for resuming sexual intercourse after childbirth varies from woman to woman and is influenced by many factors [27].

In the postpartum period, new parents are concerned about when to resume sexual intercourse, when to restart birth control, whether or not they will suffer during sexual intercourse, effect on sexual activity due to changes between couples, effect on sexual activity due to body changes, becoming pregnant again, and similar issues [86, 107]. Many mothers and fathers are afraid to resume intercourse [29, 108]. One study reported that 89% of new mothers and 82% of new fathers had at least one concern related to postpartum sexuality and approximately 50% of all new parents had multiple postpartum sexual concerns [107]. Resumption of sexual intercourse after childbirth is usually possible 6 or 8 weeks postpartum [103, 104]. Some studies report that approximately half (52%) of women resume sexual activity by 5–6 weeks postpartum [17, 109], and this rate is 90% by 3 months postpartum [5, 110]. A longitudinal prospective study found that 57% of women at 6 weeks, 82% at 12 weeks, and 90% at 24 weeks resumed intercourse after birth [111]. One study investigated the time required to resume sexual intercourse following childbirth in women with laceration; it was found that women

with lower grades of laceration (grades I, II) resumed sexual intercourse on average 7.1 weeks postpartum while women with higher grades of laceration (grades III, IV) resumed sexual intercourse on average 9.3 weeks postpartum, and after 6 months all women who participated in the study resumed sexual intercourse regardless of the level of laceration [108]. In another study, the percentage of women who resumed having sexual intercourse at 6 months postpartum was approximately 90%, and the resumption of sexual intercourse took slightly longer for women with third- and fourth-degree perineal tears [110].

As it is seen in the results of the studies, there is no standard regarding the time of resumption of sexual intercourse after birth. The time of resumption of sexual intercourse after childbirth varies from individual to individual, from culture to culture, with the level of experienced changes, etc.

6.3.3 Factors Affecting Sexuality During Postpartum

The resumption of postpartum sexual activity is affected by the numerous changes that occur in a woman's anatomy, hormonal status, type of birth, perineal trauma, episiotomy, breastfeeding, depression status, partner relationships, family structure and family dynamics, etc. [86]. In a study conducted on the factors affecting the sexual activity of women after childbirth, it was reported that the factors affecting sexual activity in the first and second half of the year after childbirth include the concern about pain during intercourse, fatigue, fear of subsequent pregnancy, tenderness of breasts [11], disinterest, feeling tired, bleeding, mother diseases, neonate problems, etc. [112]. Lurie et al. mentioned about three mechanisms that may contribute to postpartum sexual dysfunction: dyspareunia, birth canal injury, and general maternal health [113].

6.3.3.1 Mode of Delivery

There are many studies in the literature investigating the effect of mode of delivery on postpartum sexual functions. However, some studies showed no differences in sexual outcomes between vaginal delivery and cesarean section [114], while some studies showed that there are indirect effects of mode of delivery on sexual function and sexual satisfaction [115, 116]. According to Saleh's study, although postnatal sexual function showed a significant difference according to the type of birth, it was reported that this was not clinically significant within 1 year after birth [117]. There is no clear evidence in the literature to support the claim that vaginal births are harmful and cesarean delivery is protective to one's future sexual life [118, 119].

Several studies have shown that primiparity has a negative impact on subsequent sexual function [120, 121]. However, another study reported that having more than one child increases the tendency for female sexual dysfunction [122]. According to the study by Makki and Yazdi, dyspareunia decreased in both multipara and primipara, libido decreased in multipara, and vaginal loosening increased in multipara [123].

It is emphasized that birth (*especially vaginal delivery*) itself is a risk factor for the development of genito-pelvic dyspareunia in the postpartum period [124]. Following normal spontaneous delivery, the vagina is wider and can be swollen and bruised and the vaginal wall is poorly lubricated because of hormonal causes, especially lower levels of estrogen [30]. The mode of vaginal delivery has been reported to be associated with dyspareunia due to perineal tears, episiotomy, and operative vaginal delivery [19, 116, 124–126]. One study related in terms of postpartum sexual desire loss states that the type of delivery or episiotomy is not the only factor responsible for the loss of desire and that other factors may also play a role such as lack of interest in one's partner, fear of getting pregnant again, and fear of feeling genital discomfort [127].

Safarinejad et al. investigated the relationship between mode of delivery and subsequent incidence of sexual dysfunction, and they found that the rate of resumed sexual intercourse within 8 weeks after delivery was highest in women who gave birth by planned cesarean section as 64%; this rate was 42.6% in women who had a sponta-

neous vaginal delivery (*without injuries*), and the lowest rate of 32% was found in those who had operative vaginal delivery. Also, it is stated that women who experienced a planned cesarean section had the lowest pain scores, and women who had operative vaginal delivery had the highest pain scores at the first sexual intercourse [128]. In the same study, it was reported that partners of women who underwent instrumental delivery suffered from erectile dysfunction more frequently than partners of women who delivered vaginally or by cesarean section, but orgasm, sexual arousal, and sexual satisfaction were not affected by women's mode of delivery [128]. One meta-analysis study indicated that cesarean and spontaneous vaginal delivery did not affect postpartum sexual satisfaction (*short term and long term*) and appeared to have minimal effect on the long-term resumed intercourse and sexual pain in primiparous women [129]. One study reported that resumption of sexual intercourse did not show a significant difference according to the type of birth [19].

The Events Related to Vaginal Deliveries

Postpartum sexual behaviors are usually affected by vaginal delivery events such as assisted vaginal delivery, episiotomy, and perineal damage.

The pelvic floor muscles and disorders: The pelvic floor is a dynamic unit that allows the physiology of continence, emptying, sexual function, and delivery [130]. The pelvic floor muscles play an active part in a woman's sexual function [131], and they are also active in both male and female genital arousal and orgasm [131]. So, pelvic floor disorders are associated with female sexual disorders, especially also sexual pain disorders [27, 131]. Pelvic floor traumas causing pelvic floor disorders are especially associated with advanced maternal age, operative vaginal delivery, prolonged second stage of labor, fetal head circumference, position of fetus, episiotomy, nulliparity, use of oxytocin, birth weight >4 kg, etc. [27, 132]. Perineal trauma is a common event in the first labor, affecting up to 90% of primigravidas; despite adequate primary sphincter repair, sexual dysfunction may develop in most of these patients [132]. Vaginal delivery is a complex phenomenon involving the activation of several muscles [133]. Episiotomy and third- and fourth-degree lacerations, which are effective in perineal floor disorders, may follow any type of vaginal delivery [132]. Many studies have found that episiotomy is the factor with the strongest association with a third- or fourth-degree laceration. As a result, in many studies, it was indicated that the impaired pelvic floor muscles after birth had negative effects on sexual functions. One systematic review study reported that postnatal pelvic floor muscle exercises (PFME) were effective in improving sexual function [134].

Assisted vaginal deliveries: Assisted vaginal delivery is sometimes called "*instrumental delivery*" or "*operative vaginal delivery*." Evidence suggests a strong link between assisted vaginal deliveries and impaired sexuality during postpartum [135–138]. Assisted deliveries such as forceps or vacuum are associated with an increased risk of perineal and anal sphincter trauma, intrapartum pudendal nerve injury resulting in pelvic floor dysfunction, and sexual health morbidity [25, 139–141]. Injuries to pelvic floor muscles during childbirth, and subsequent repair, can provoke dyspareunia and have effects both on the time and quality of the reinitiation of postpartum sexual activity [31, 86, 131, 142–144]. In a systematic review by Hicks et al., it was reported that increased risks of delay in the resumption of intercourse, dyspareunia, sexual problems, or perineal pain were associated with assisted vaginal deliveries [145]. It is stated that long-term maternal and paternal sexual dysfunction is associated with the highest rate of assisted vaginal deliveries and the lowest rate of planned cesarean section [30].

Perineal trauma (lacerations, tears, and such): Perineal trauma is a common event especially at the assisted vaginal deliveries (*forceps, vacuum and vaginal breech delivery, and episiotomy*) [132]. Anatomically, perineal trauma contributes to perineal pain, and perineal pain is the most common cause of dyspareunia. These are the most important conditions affecting postpartum sexual function [10, 26, 31, 73, 86, 108, 146–149], affecting both the timing and quality

of the resumption of sexual relations during the initial months after delivery [10, 86]. The orgasmic disorders are also influenced by the presence of perineal trauma [10, 108]. This is a sequence of events that affect each other (*perineal trauma causes perineal pain and dyspareunia, and dyspareunia causes postpartum sexual problems and thus sexual dysfunction*).

It is reported that perineal pain occurs in 42% of women immediately after delivery and reduces to 22% and 10% at 8 and 12 weeks, respectively [10]. A retrospective cohort study found that compared to women with an intact perineum, women with second-degree perineal trauma were 80% more likely to report dyspareunia at 3 months postpartum [108]. Studies indicate that women who delivered with intact perineum were significantly more likely to report enhanced sexual functions (*sexual sensation, sexual satisfaction, and likelihood of orgasm*) [147, 148]. Odar et al. stated that 22.2% of women had sexual problems due to vaginal pain (*regarding laceration*) at a 6-month postpartum follow-up [150].

There are also very few studies that advocate the opposite. In one of these studies that compared women with minor or major perineal trauma after birth, it was reported that both groups were equally likely to be sexually active [149]. In another study, there was no relationship between the postpartum second-degree perineal lacerations with complaints of urinary or anal incontinence, sexual inactivity, or sexual function [146].

Episiotomy: During childbirth, some women suffer spontaneous perineal trauma while others require episiotomy to facilitate birth. Although these injuries can be repaired with sutures, such repairs are frequently associated with perineal pain and discomfort [151]. It is well known that episiotomy and repair may have a negative effect on postpartum sexual activity and may cause dyspareunia [152], and episiotomy is associated with a higher prevalence of postpartum dyspareunia [31]. In one study, it was concluded that dyspareunia 3 months after childbirth was common among first-time mothers who underwent episiotomy and seemed to be associated with slower reinitiation of sexual activity [153]. Studies have shown that women who underwent episiotomy [110, 154] and women with third- and fourth-grade vaginal tears [108] reported feeling more pain at 3 and 6 months in the postpartum periods. In addition, some studies reported that not only pain but also other important aspects of sexual functions such as arousal, lubrication, orgasm, and satisfaction were affected [154, 155]. These results were recently confirmed by Rathfish et al.; moreover, it is reported that women with episiotomy or a second-degree perineal tear had lower arousal, orgasm, and sexual satisfaction and more dyspareunia at 3 months after birth [156].

The results of the studies comparing women with episiotomy and without episiotomy reported that women with episiotomy had more complaints of perineal pain, dyspareunia, decreased sexual satisfaction, and delayed resumption and restoring of sexuality after birth. Based on these results, it can be said that the restriction of perineal traumas and episiotomy during childbirth is important for the resumption of subsequent sexual activity.

Cesarean Section

One of the perceived benefits of cesarean delivery is sparing the pelvic floor from mechanical damage. Since the risks of episiotomy or assisted vaginal birth are eliminated, it will be less likely to report perineal pain or dyspareunia at cesarean delivery [19, 136, 141, 145], and thereby, sexual function will be protected. In addition, it is stated that the somewhat protective role of cesarean delivery contributes to an early resumption of postpartum sexuality [25, 26, 108]. But a systematic review showed no differences in sexual function between women with cesarean delivery and those with spontaneous vaginal delivery [111, 145].

There are limited studies that specifically evaluate sexual dysfunction in women delivered by cesarean section. According to the results of these studies, the rate of postpartum dyspareunia is low in cesarean deliveries. But it would be wrong to think that cesarean birth is a precaution to reduce postpartum dyspareunia. The fact that it is a major operation with possible serious side effects should not be ignored.

6.3.3.2 Breastfeeding

Breastfeeding is also effective on postpartum sexual activity [103, 104, 157–159]. The physical as well as psychological aspect of a woman's sexuality is altered by breastfeeding [160]. During the first months (at months 1–4 postpartum), breastfeeding women show less sexual desire than those who use artificial feeding, and they experience more dyspareunia [26, 103, 104, 161]. Breastfeeding may alter sexual function as a result of vaginal dryness produced by the high levels of prolactin and lowered estrogen and androgen levels [30, 37, 86, 103, 104]. Signorello et al. stated that women who breastfeed were four times as likely to report dyspareunia as those who did not breastfeed [108]. Breastfeeding is linked to a low coital activity, low sexual desires [26, 31, 157, 161], and low sexual satisfaction of females and their partners [26, 29, 31, 161, 162]. Resumption of sexuality after birth in breastfeeding women is much later; they more often suffer from dyspareunia from the sexual intercourse [31]. One study stated that especially breastfeeding and low partnership quality were revealed as significant risk factors for sexual dysfunctional problems postpartum [163]. On the other hand, after birth, breasts ceased to be an erotic symbol, and it became milk-producing and secreting machines [37]. For both partners, this changed "meaning" of the breasts may adversely affect postpartum sexual activities and lower satisfaction. Besides, breastfeeding is tiring and time consuming with a lot of skin contact, and this can also reduce the woman's need for skin contact with her partner [37].

6.3.3.3 Family Structure, Changing Sleep Patterns, Fatigue

Although postpartum is a period in which different excitements are experienced, it also has a tiring and stressful side, which changes the family dynamics, roles, and needs and increases responsibilities. The birth of a baby could disrupt a couple's balance [27]. Family structure, changing sleep patterns, and fatigue decrease the likelihood of a woman and her sexual partner having the time and privacy to re-establish intimacy [86]. Fatigue and sleeplessness are among the most commonly reported characteristics of the postpartum period [103, 104]. They play a destructive role in satisfying the sexual needs [37] and inevitably have a negative effect on the libido [103, 104]. One study indicated that the fatigue, stress, and perineal pain during the first few postpartum months are associated with dyspareunia [164].

6.3.3.4 Postpartum Depression

Most female sexual dysfunctions are multifactorial, and depression is one of these factors. After delivery, women suffer physical, emotional, social, financial, and relational problems that can worsen over time [27]. Depression and sexual dysfunction are bidirectional [5, 37]; it begins generally 2–4 weeks after delivery [165]. In a population-based study, 40% of depressed women reported desire, arousal, and orgasm disorders [37].

Although postpartum depression has been researched extensively, there are limited studies examining the relationship between sexual health and depression [166]. One study showed that cesarean delivery was associated with an increased prevalence of depressive symptoms at 3 months and no differences in the trends related to depressive symptoms or sexual functions (except desire) within 1 year postpartum [166]. One study found that sexual dysfunction is common in women with postpartum depression and they are late to resume sexual intercourse after childbirth [158]. In a cross-sectional study, it was stated that depressed women were less likely to have resumed sexual intercourse within 6 months after birth, that their diversity of sexual activities was low, and that they reported sexual health problems more than non-depressive women [158, 167]. The psychological condition itself and antidepressants used for treatment also affect postpartum sexual functions negatively [168]. Postpartum depression accompanied by loss of sexual desire or secondary loss of desire, and loss of arousal or ability to achieve orgasm resulting from antidepressant medications, may also contribute to postpartum sexual dysfunction [86]. Although postpartum depression resolves, it sometimes may not improve [165].

Some factors that may affect female sexual functions in the postpartum period and their possible effects, and sexual dysfunctions that can be seen in the postpartum period, are summarized in Table 6.5.

6.3.4 Postpartum Sexual Dysfunctions

It is almost impossible to say what optimal sexual function after birth is [30]. Many women experience sexual problems in the postpartum period [10], and this is often overlooked [11, 86]. Given the data that only 12–14% of couples deny sexual problems after birth [29, 31], it will give us an important clue to the extent of the problem.

There are differences in the results of the studies on the prevalence of postpartum female sexual dysfunction. As well as the literature data indicating that the prevalence of female sexual dysfunction after birth is generally reported as being between 10 and 40% [169–171], there are also generally results indicating that the prevalence of postpartum sexual dysfunction ranges between 22% and 50% [27]. In the 2000s, postpartum sexual dysfunction (*including dyspareunia*) was reported in 41–83% of women at 2–3 months postpartum [19, 108]. In a different study, the prevalence of female sexual dysfunction after childbirth has been reported to be 5–35% after the cesarean section and 40–80% after normal vaginal delivery [172]. In another study of the same researcher, it was stated that 64.3% of women experienced sexual dysfunction and 70.5% sexual dissatisfaction during the first year after childbirth [120]. More than one-half of women enjoy sexual intimacy with their partner in the first year after giving birth, with 18–20% partially enjoying it and 24–30% not enjoying it at all. In addition, their partners have also reported the same result [29].

It is stated that women reported more than one sexual disorder in the postpartum period [86]. Most postpartum women may suffer from certain sexual dysfunctions such as loss of sexual desire [163], loss of excitation, dyspareunia, vaginal pain, loss of lubrication, and painful orgasm or orgasmic disorder [27, 151, 171].

von Sydow stated that postpartum sexual dysfunction is a complex interaction between possible biomedical, psychosocial, and couple relationship factors as well as the qualities of the infant and mother-child relationship (Table 6.6) [29]. Salvatore et al. reported that little is known about postpartum sexual dysfunction related to birth, that postpartum sexual dysfunctions are frequently occurring, and that it is related to various aspects of sexuality. They listed postpartum female sexual disorders according to their causes as given in Table 6.7 [27].

Table 6.5 Some factors and their possible effects on female sexual functions in the postpartum period

Some factors	Possible effects on sexuality
Mode of delivery • *Assisted-operative vaginal delivery, episiotomy, perineal trauma* • *Cesarean section*	Genital discomfort, perineal pain Sexual desire loss Dyspareunia Delay in the resumption of intercourse Sexual problems Sexual dysfunctions (*sexual pain, arousal and lubrication,* desire, *orgasm, and sexual satisfaction disorders*) Early resumption of postpartum sexuality Less perineal pain or dyspareunia Sexual problem reporting is not much
Breastfeeding	Less sexual desire Decrease in coital activity Dyspareunia Less satisfaction Sexual dysfunctional problems
Changing sleep patterns, fatigue	Negative effect on the libido Dyspareunia
Postpartum depression	Delay in the resumption of intercourse Decrease in sexual activity Sexual dysfunctions (desire, arousal, and orgasm disorders)
Sexual dysfunctions that can be seen during postpartum period	
Sexual pain disorders (*dyspareunia)* Sexual desire disorders Arousal and lubrication disorders Painful orgasm or orgasmic disorder Sexual satisfaction disorders	

Table 6.6 Factors associated with postpartum sexual dysfunction

Biomedical factors
Degree of perineal birth trauma (tears, episiotomy)
Assisted vaginal delivery
Tiredness
Kegel exercises not performed
No reliable method of contraception
Psychosocial factors
Mental symptoms (depressed mood, emotional lability)
Prepregnancy sexual history and sexual symptoms (e.g., dyspareunia)
Poor childhood relationship with father (e.g., good relationship only with mother)
Couple/relationship factors
Low relationship satisfaction (in women and men)
Attributes of the baby and the mother-child relationship
Male babies: mothers of boys are perceived by their partners as being less tender during the postpartum months than mothers of girls
Mothers with a rigid and overprotective relationship to their baby
Breastfeeding

Von Sydow K. Sexuality in pregnancy and the postpartum period. In: Reece EA, Hobbins JC, eds. Clinical obstetrics: the fetus and mother. John Wiley & Sons; 2007: 1016–1021

Table 6.7 Postpartum female sexual dysfunction disorders

• *Sexual desire disorders* that are often related to the hypoefficiency of the pelvic floor, which occurs postpartum
• *Sexual arousal disorders* due to the vaginal dryness and poor lubrication typical of breastfeeding women
• *Orgasmic disorders* related to hypotonia due to childbirth, which causes pain and inability to reach orgasm
• *Superficial dyspareunia (pain during penetration)*

Salvatore S, Redaelli A, Baini I, Candiani M. Sexual Function After Delivery. In: Childbirth-Related Pelvic Floor Dysfunction. Springer; 2016:101–104

A very important determinant of postpartum sexual function is perineal pain and resultant dyspareunia (*painful sexual intercourse*) [146, 162, 173]. Sexual pain disorder is the most common category affecting women in the postpartum period [47, 173]. More than 50% of all women experience pain during their first intercourse after birth [29, 108]. Dyspareunia, which is one of the most common sexual problems after birth [10, 27], is quite common in the first 3–6 months after birth [86]. In studies published in the early 2000s, dyspareunia is reported to be, respectively, 41% and 22% at 3 and 6 months postpartum [108]. Barrett et al. also stated that 62% experienced dyspareunia in the first 3 months postpartum, and it decreased to 31% at 6 months [19]. In a study carried out by Odar et al., approximately 62% of women who resumed having sexual intercourse 6 months after childbirth reported pain [150]. Recently, in one article, dyspareunia was reported by 41–67% of women in 2–3 months of postpartum [30]. Dyspareunia is reduced to 22% at 6 months postpartum, and it may remain at this level until 13 months postpartum. On the other hand, postpartum pain has a significant effect on sexual satisfaction [29, 108].

It is known that sexual desire is still reduced 1 year after giving birth and that the frequency of sexual intercourse is less [19, 158]. There are limited studies that specifically evaluate sexual desire disorder in the postpartum period [10]. One study reported that sexual desire disorder in the perinatal period was the most common form of female sexual dysfunction [163]. In a cross-sectional study, postpartum loss of sexual desire was reported to occur in 53% at 3 months and 37% at 6 months after birth, which is 9% in the year prior to pregnancy [19].

Sexual arousal, orgasm, and lubrication also undergo some changes after delivery [27]. The postpartum period is often associated with a decline in the couple's sexual satisfaction [174]. Decreased sexual satisfaction in postpartum women is not related to the type of birth and is reported to improve over time [128]. On average, it is stated that the first postpartum orgasm may occur 7 weeks after birth, rising to 75% (*about the same as before pregnancy*) 3–6 months after the birth [29]. In a cross-sectional study, it was reported that 33% and 23% of women experienced difficulty in reaching orgasm at 3 and 6 months postpartum, and 14% of them experienced this problem in the year prior to pregnancy [19]. It is stated that sexual satisfaction may continue as low in couples also within the first

Table 6.8 Clinical approach in prevention, evaluation, and treatment of postpartum sexual concerns

Prenatal care
• Determine whether dysfunction was present before pregnancy • Discuss changes in anatomy, physiology, and sexual function that commonly occur during pregnancy • Discuss the likely safety of continuing sexual activity through pregnancy for most women • Evaluate for the presence of depression during pregnancy • Discuss the option of perineal massage to minimize perineal trauma and postpartum pain
Intrapartum
• Judicious use of operative vaginal delivery and selection of vacuum rather than forceps will decrease the incidence of anal sphincter lacerations • Limit the use of episiotomy • Careful postpartum examination to increase the detection and repair of anal sphincter lacerations • Repair perineal lacerations with synthetic absorbable suture • Discuss perineal pain, dyspareunia, and initiation of postpartum sexual activity before hospital discharge
Postpartum
• Assess sexual function and address concerns, including considering the use of a brief sexual function screening questionnaire • Assess perineal repair if dyspareunia is present • Assess for the presence of urinary and anal incontinence symptoms • Encourage vaginal lubricants, particularly in breastfeeding women with a physiologic hypoestrogenic state • Consider alternative positions • Assess for postpartum mood changes, adequate rest, and time for intimacy

Leeman, L.M. and R.G. Rogers, Sex after childbirth: postpartum sexual function. Obstetrics & Gynecology, 2012. 119(3): p. 647–655

3 years after birth [143, 158]. On the other hand, in one study, it was reported that the mode of delivery, breastfeeding, intimacy, and spouse's contribution to household chores did not affect sexual dysfunction [171].

According to Leeman, postpartum sexual dysfunction may be either primary which may indicate lifelong sexual dysfunction or secondary which indicates a change in function [86]. It is said that experiencing discomfort with sexual intercourse is likely to discourage women from desiring sexual intercourse in subsequent situations and reduce their sexual satisfaction [5]. Suffering from sexual problems can have a detrimental effect on a woman's quality of life, also impacting her social, physical, and emotional well-being [10]. On the other hand, sexual dysfunctions do not involve only women, because this situation also affects women's partners [27]. That is why it is important to know the postpartum sexual dysfunctions, assess women and couples in this context, and give counseling.

Maintaining healthy sexual functions of couples during postpartum period will positively affect their marital relationships, healthy transition to parenting roles, and quality of life. Leeman and Rogers' recommendations on the clinical approach for preventing, evaluating, and treating postpartum sexual concerns are given in Table 6.8 [86].

6.4 Conclusions

Sexual functions in which multifactorial agents play a role change at some stages of life. Pregnancy and postpartum periods are two of them. The evolution of women's and couples' sexuality from the pre-pregnant state and pregnancy to postpartum period is a life-changing event with complex physical, psychological, and sociocultural agents. Pregnancy and postpartum processes, which play a temporary but also very important role in the life of women and couples, cause significant changes in the sexual life of women and couples. Therefore, sexual health counseling is important in preconceptional, pregnancy, and postpartum processes.

6.5 Recommendations

Pregnancy and postpartum sexual health is a common concern that is often not discussed and overlooked during prenatal or postpartum care, and it has received little attention from healthcare providers. However, preserving healthy sexual functions during pregnancy and the postpartum period is crucial, not only for improving the quality of sexual life of women but also for healthy sex life of couples. Therefore, care in preconcep-

tional, prenatal, and postnatal follow-ups should also be structured to include sexual health assessment, sex education, and counseling. In the evaluation of sexual functions, it must be determined whether the sexual problem is a situational problem due to changes in the current periods, or it is a continuing sexual problem that has existed in the past. An elaborated sexual history is a cornerstone of all sexual problem assessments and sexual dysfunction diagnoses. The use of scales or questionnaires can play a key role in the diagnostic evaluation of sexual dysfunctions. Also, the scales may help in providing coherent and evidence-based management for sexual dysfunctions. There are many scales or questionnaires that can be beneficial in the evaluation of female sexual functions. For example, "Female Sexual Function Index (FSFI)," "Sexual Function Questionnaire (SFQ)," "Female Sexual Distress Scale-Revised (FSDS-R)," "The Brief Sexual Symptom Checklist (BSSC)," Golombok Rust Inventory of Sexual Satisfaction (GRISS), Index of Female Sexual Function (IFSF), and the Carol Postpartum Sexual Function and Dyspareunia Assessment Scale are some of such scales and questionnaires that can be used for the diagnostic evaluation of sexual dysfunction, sexual problems, or sexual function status in women. Moreover, women and couples should be encouraged to talk and discuss about sex-related issues during pregnancy and postpartum periods. Sexual health counseling should be done. Sexual function needs to be addressed as part of holistic care of the pregnant and postpartum woman and couple, and offered care should be evidence based, qualitative, and sensitive. In order for these to be implemented, health professionals should have the awareness, knowledge, and skills to deal with these sexual problems.

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Changes and Potential Complications During Puerperium

7

Filipe Cordeiro and Mónica Gomes-Ferreira

Take-Home Points

- The puerperium is defined as the period of 6–8 weeks after delivery, in which the reversion of anatomical and physiological changes seen during pregnancy happens.
- The important physiological events that occur during the postpartum period include, among others, the return of the reproductive organs and the levels of the female hormones to their pre-pregnant state.
- It is important that mothers are informed of what normally happens during this period, and about the danger signs which can compromise the health of the mother or the newborn.

7.1 Introduction

The puerperium corresponds to a variable period of time in which there are several phenomena of a hormonal, psychic, and metabolic nature that characterize the readaptation of the female organism (altered by pregnancy and childbirth) to the nonpregnant state [1].

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7.2 Definition of the Postpartum Period

The puerperium is defined as the period of 6–8 weeks that begins after delivery, in which the regression of anatomical and physiological changes seen during pregnancy occurs. However, this definition is purely conceptual, as it is known that not all systems return to their basal state within this range [1].

In a practical way, three periods can be considered:

– Immediate puerperium: first 24 h
– Early puerperium: from the first to the seventh day
– Late puerperium: after the seventh day

7.3 Postpartum Findings and Changes

7.3.1 Uterus

The uterus is an organ that shows expressive growth during pregnancy, so after the discharge, it gradually returns to its normal size. This process, known as uterine involution, is mediated by a set of strong and rhythmic contractions in which the muscle fibers undergo a progressive shortening Myometrial retraction (brachystasis) [2]. These can often be perceived by the puerperal

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_7

woman as painful, being more frequent in the first days, and intensified by breastfeeding, a consequence resulting from the production of oxytocin (Fig. 7.1).

The contraction of muscle fibers around the existing vessels in the myometrium, as well as the thrombosis of the placental vessels, also promotes a blood transfusion process, which thus limits the hemorrhage of the uterine scar where the placenta was located.

After delivery, the uterus is at the level of the umbilical scar, assuming a reduction of approximately 1 cm/day. It is completely intrapelvic in about 2 weeks and will reach its prepregnancy status in 6 weeks [2].

In parallel with the reduction in volume, there is also a reduction in weight. After delivery, the uterus weighs approximately 1000 g; at the end of the first week, it is halved, and it returns to its basal state (60–100 g) after 6 weeks [2].

The uterine involution process can be affected by several factors, such as uterine overextension (e.g., twin pregnancy), multiparity, cesarean delivery (uterus is slightly larger), and breastfeeding (uterus is smaller in those who breastfeed) [2].

On physical examination, a well-involuted uterus is considered if it assumes the characteristics referring to the size mentioned above for the determined time interval, as well as when it

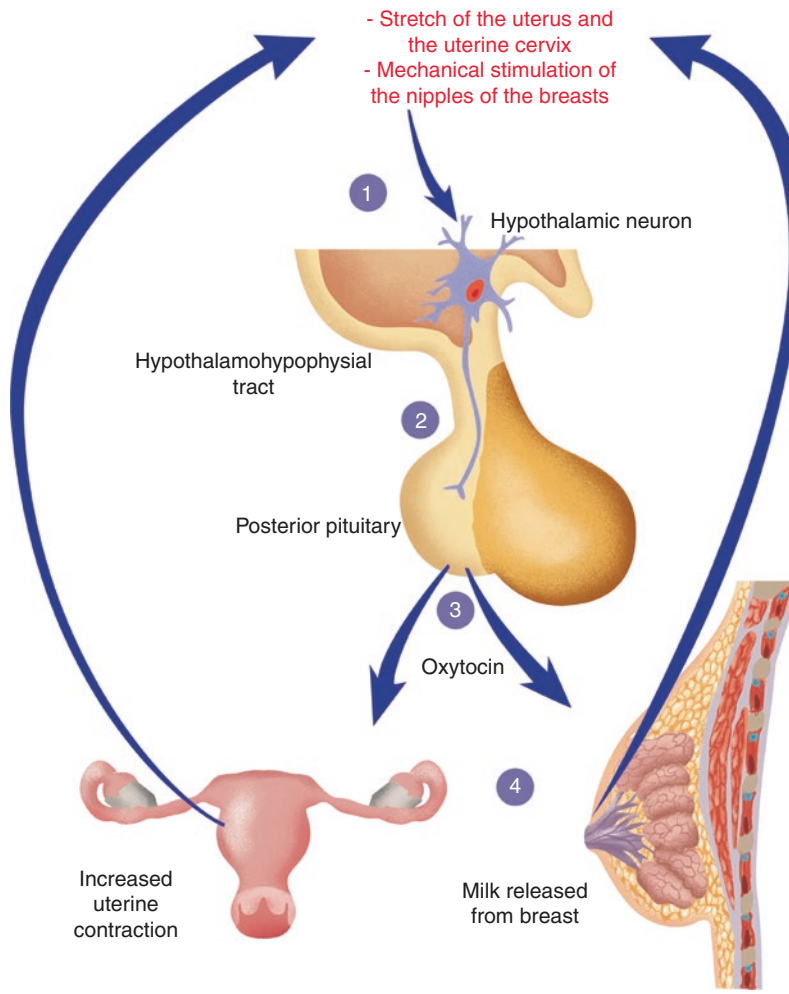

Fig. 7.1 Uterus-mammary reflex

acquires a firm consistency. When it combines these characteristics, it is often called a safety globe (by Pinard).

Ultrasound assessment is not routinely recommended, as it is common to see hyperechogenic material inside, which has no indication for removal, except in situations where fever or heavy bleeding occurs [2].

Take a Note
Uterine involution is faster in breastfeeding women. The suction performed by newborns stimulates the release of oxytocin by the neurohypophysis, which in turn promotes milk ejection and uterine contractility. This process is usually referred to as the uterus-mammary reflex.

7.3.2 Lochia

After placental separation, there is exposure of the decidua.

The decidua is divided into two layers: superficial (which flakes) and deep (regenerates new endometrium). The most superficial layer is weakened and becomes irregular, suffering necrosis, being eliminated in the form of lochia [2].

According to the temporal evolution and in a schematic way, we can consider [2]:

- Hematic lochia (lochia rubra): until the fifth day (fragments of decidua and erythrocytes)
- Sero-hematic lochia (lochia serosa): from the fifth to the tenth day
- Serous lochia (lochia alba): after the tenth day (leukocytes)

The total volume of lochia is estimated at approximately 200–500 mL over a period of 1 month.

The duration of discharge is variable, and in a small percentage of cases (15%), it can exceed 6–8 weeks of puerperium [2].

Changes in volume and duration can often be seen in women with changes in hemostasis. Hormonal contraceptives containing estrogen and/or progesterone do not appear to influence the characteristics of lochia.

Take a Note
Microscopically, lochia is formed by deciduous fragments, epithelial cells, erythrocytes, leukocytes, and bacteria. If the patient has had a c-sectio, is more likely to have less abundant lochia.

Persistent hematic lochia >2 weeks accompanied by uterine subinvolution should raise the hypothesis of placental retention.

7.3.3 Cervix

Similarly to the uterine body, the cervix also loses its pregnancy characteristics.

After delivery, the cervix is thin and soft in consistency, but as a result of contractions, it becomes thicker, allowing the restoration of the cervical canal. The diameter of the cervical canal also undergoes a significant reduction, and after 2 days, it will only be permeable to two fingers, and after a week, it will no longer allow digital exploration [2].

The external orifice never takes on the same punctiform configuration typical of the prepregnancy state, adopting the aspect of transverse slit from birth (Fig. 7.2) [2].

Stroma edema and cell infiltration are changes found histologically for up to 3 months. For this reason, the evaluation in the context of fetal losses only makes sense after the third month.

7.3.4 Vagina

In the immediate postpartum period, the vagina loses its soft consistency and undergoes a reduction in its diameter, acquiring its usual characteristics around the third week. Mucosa folding and mucus production are later restored in lactating

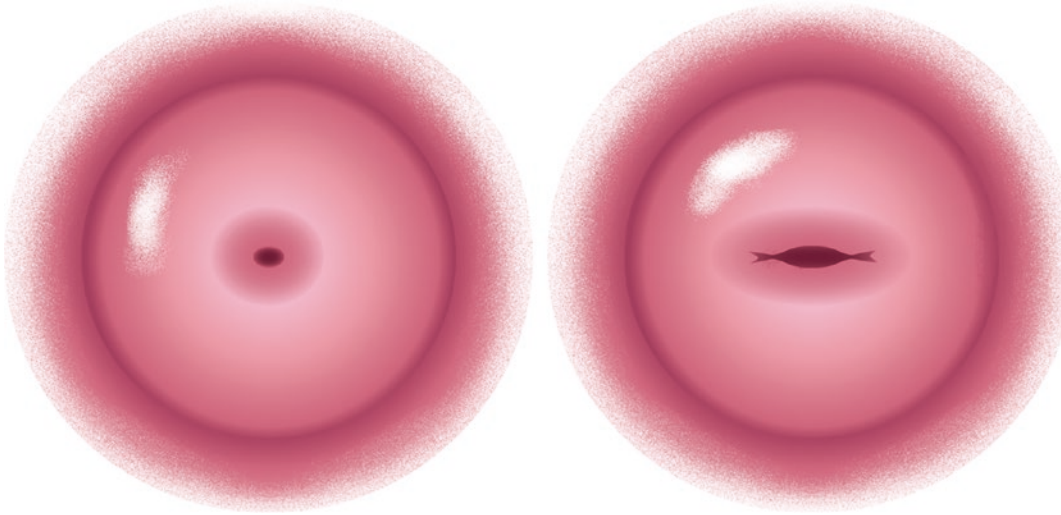

Fig. 7.2 Cervical changes after pregnancy

women, since they depend on the action of estrogens, whose production is reduced during breastfeeding [2].

7.3.5 Vulva

The remaining fragments of the hymen give rise to small protrusions, known as myrtiform caruncles.

The trauma and stretching of the fascia induced by vaginal delivery cause a relaxation of the pelvic muscles, which can acquire a persistent character in the postpartum period, giving rise to dysfunctions of the pelvic floor [2].

7.3.6 Abdominal Wall

Abdominal distension seen during pregnancy, particularly if accompanied by excessive weight gain, leads to a marked reduction in the tone of abdominal muscles, which may not be fully restored several months after delivery. The weakening and removal of the rectus abdominis are the most obvious pathological alteration, which is known as diastasis. In addition to the resulting aesthetic problems, pain should not be underestimated, which is a frequent manifestation of this process [2].

7.3.7 Breast Engorgement

After delivery of the placenta, there is an important decrease in the production of steroid hormones that reduce the blockage of the mammary gland to the action of prolactin. As a consequence of this process, milk secretion begins, which gives the breast greater volume and consistency (breast engorgement) that is often associated with edema and pain [2].

Primary breast engorgement occurs between the first 24 and 72 h after delivery, due to the occurrence of interstitial edema and the increase in milk production. The painful symptoms seem to be more intense between the third and fifth days after delivery.

Secondary breast engorgement occurs when the emptying of the breast is lower than the rate of milk production (Fig. 7.3). For this reason, frequent breast emptying is important, usually never longer than an interval of 4 h, in order to minimize the discomfort generated by increased milk production (Fig. 7.4) [2].

During milk production that occurs after childbirth, it is common to notice a slight transient hyperthermia that is usually self-limiting and can be relieved with supportive therapy (local heat, massage, or even painkillers).

Suppression of lactation, whether indicated by medical pathology (e.g., maternal HIV infection)

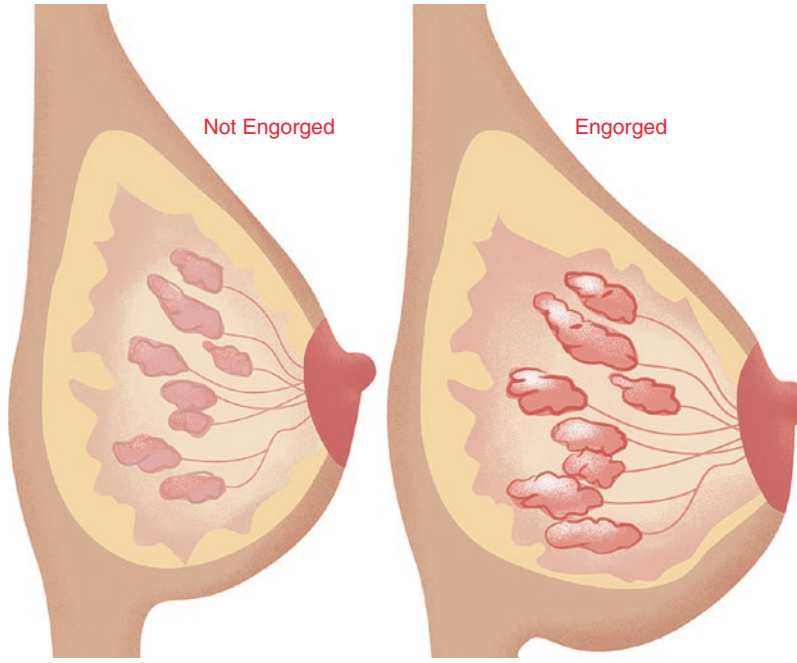

Fig. 7.3 Breastmilk engorgement

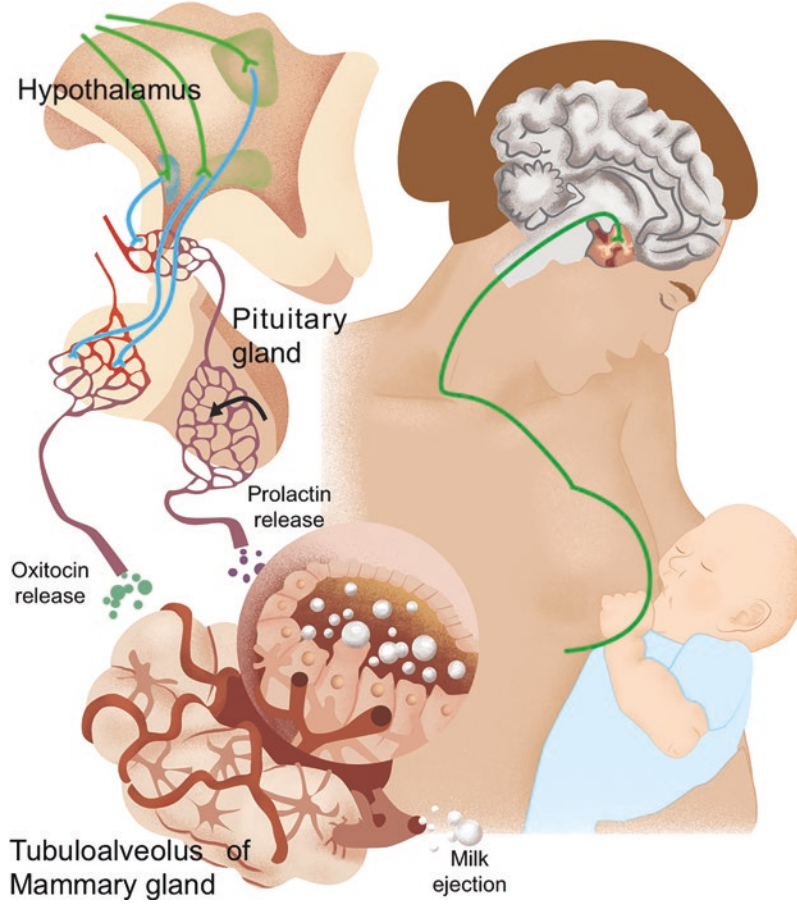

Fig. 7.4 Milk ejection reflex

or by the patient's expressed desire not to breastfeed, can be achieved by the absence of breast stimulation and the use of a tight bra and eventually the use of medical therapy (dopamine analogues) [2].

7.3.8 Skin and Skin Attachments

Skin hyperpigmentation is frequent in pregnancy, being more evident in certain regions of the body, such as the face (chloasma), mammary areolas, white line, and vulva. The mechanism by which it occurs is poorly understood; however, it is believed to be related to the increase in the production of melanocyte-stimulating hormone (MSH) [2]. The higher the phototype, the greater the likelihood of hyperpigmentation. This darker color completely disappears a few months after delivery.

Stretch marks are other skin changes that occur in pregnancy and correspond to solutions of continuity of the dermis, which are formed after rupture of the collagen fibers that have suffered excessive water retention. They are preferably located on the breasts, abdomen, and thighs. Initially, they are reddish in color, but in the puerperium, they become clear and bright. The appearance of skin streaks has a strong association with genetic predisposition, in which estrogens are believed to play an important role [2, 3]. The incidence of stretch marks is higher in women of young age, with a family history and who have an excessive weight gain.

Peripheral vasodilation secondary to the state of hyperestrogenism is responsible for the appearance of other manifestations, such as palmar erythema and vascular spiders.

There are also important changes at the capillary level. It is known that about 5–10% of hair follicles are in the telogenic phase (resting phase) at the end of pregnancy and that this rate quadruples in the puerperium, which causes a significant hair loss (telogenic effluvium) that it is only restored about 6–15 months after delivery (Fig. 7.5). This appears to be due to the high levels of circulating estrogen.

7.3.9 Physiological Weight Loss

After delivery, an average weight loss of about 6 kg occurs, corresponding to the sum of the weights of the fetus, placenta, and amniotic fluid. However, this weight loss is even more significant due to the reduction in the volume of intravascular and interstitial fluid, as well as resulting from uterine contraction, which corresponds to an additional loss that varies between 3 and 7 kg [2].

It is believed that there is a loss of about half of the weight acquired during pregnancy in the

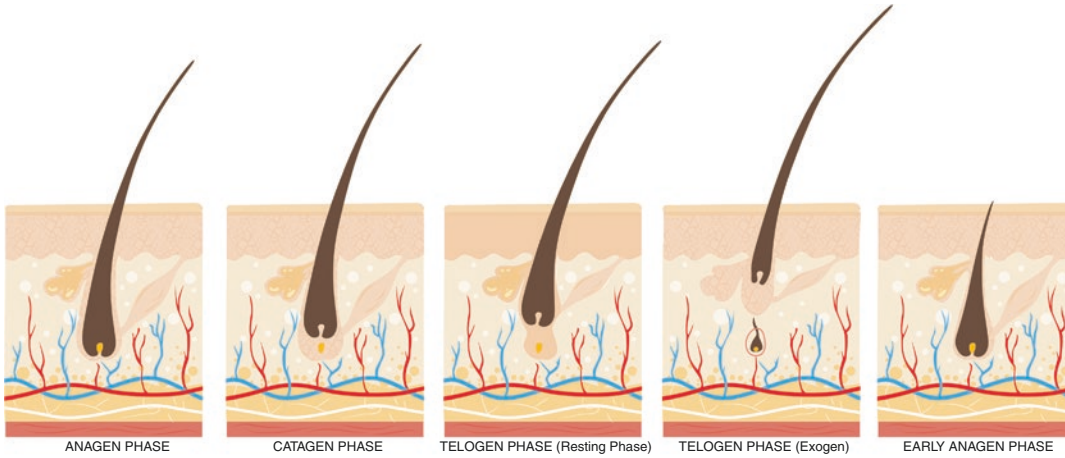

Fig. 7.5 Pregnancy changes at the capillary level

first 6 weeks after delivery and that this rate occurs at a lower rate in the following 6 months, by which time you should have returned to your prepregnancy weight.

7.3.10 System Cardiovascular

The peripartum is a period in which sudden hemodynamic changes occur, which imposes on the maternal organism an ability to adapt, which is dependent on the existence or not of previous cardiac pathology. In the presence of this, the volume and/or pressure overload can lead to situations as serious as acute lung edema [2].

- Cardiac output: At the time of delivery, there is an increase in cardiac output of about 60%, mainly at the expense of increased stroke volume. Consequently, there will also be an increase in blood pressure.
- Plasma volume: In the immediate postpartum period, the increase in plasma volume (blood volume) is even greater due to the return to the blood circulation present in the uterine circulation, the increased venous return to the right heart (sudden decompression of the inferior vena cava), and the mobilization of extravascular fluid. The increase in blood volume thus seems to counterbalance blood loss at delivery (about 500 mL at vaginal delivery and 1000 mL at cesarean section).

As a general rule, cardiac output and plasma volume return to the prepregnancy level in about 2 weeks.

7.3.11 System Hematological

- Erythrocytes: There are no significant differences, unless the delivery has been accompanied by increased blood loss. Hemoglobin concentration returns to prepregnancy levels in approximately 6 weeks [2].
- Leukocytes: During labor, leukocytosis occurs which persists or increases in the first week of puerperium. Values up to 25,000 leuc/mL are considered normal, mainly at the expense of granulocytes and without deviation to the left. Lymphopenia is also frequently seen [2].
- Hemostasis: The coagulation system is activated at the time of delivery. From the first hours, there is a consumption of platelets and clotting factors, which aims to promote the buffering of uterine hemorrhage. In about 48 h, the clotting factors are practically normal [2].

7.4 Risk Factors for Postpartum Complications

The main complications in the puerperium are essentially related to maternal comorbidities, previous or acquired during the pregnancy, as well as aspects associated with childbirth and delivery.

Briefly, they can be organized into antepartum and intrapartum/postpartum factors (Table 7.1) [2, 3].

Particularly in relation to the mode of delivery, cesarean section alone is the main risk factor for puerperal complication. In this procedure, there is a higher rate of maternal morbidity and mortality compared to vaginal delivery and there are several complications that result from it, which include endometritis, postpartum hemorrhage, pelvic thrombophlebitis, septic shock, etc.

Table 7.1 Antepartum and intrapartum and postpartum risk factors

Risk factors for puerperal complications	
Antepartum	Intra- and postpartum
Low socioeconomic and educational level	Premature rupture of membranes
Absence or poor prenatal surveillance	Chorioamnionitis
Poor nutrition	Cesarean
Immunosuppressive therapy	Dystocic childbirth
Obesity	Prolonged labor
Hypertension is a risk factor too	Multiple vaginal touches
Anemia	Internal fetal monitoring
Poor personal hygiene	Postpartum hemorrhage
Lower genital tract infections	Birth canal trauma
	Breast fissures

In several studies, a relative risk of 5–30 times for some complications is described.

7.5 Life-Threatening Postpartum Complications

7.5.1 Headache

Most puerperal headaches do not reflect severe pathology, since they are the result of a combination of factors, which include hormonal and psychological changes, fatigue, sleep deprivation, and irregular dietary habits. In those submitted to neuro-axis anesthesia, headache may be secondary to several vasoactive drugs previously used [2–4].

However, other entities, although rarer, are given.

Table 7.2 Puerperal headache conditions

Conditions	Association
Preeclampsia of late onset	Particularly if hypertension and in the first 48 h after delivery. It is also possible to appear a few weeks after delivery
Stroke	Associated with focal neurological deficits de novo
Headache after dura mater puncture	In normotensive women and with neuro-axis analgesia. Usually in the first 48 h after the procedure, which worsens with the orthostatic position and with the elevation of the head of the bed. Relief with decubitus and rest
Primary headache	Women with previous headache, with exactly the same characteristics

Alarm signs in headaches
Sudden-onset headache ("worst headache in life")
Headache de novo, especially "migraine type"
Modification of the usual headache characteristics (e.g., pain, pattern, intensity)
Headache in anticoagulated patient or with hemorrhagic dyscrasia
Headache in an immunocompromised patient or with neoplasia
Headache associated with fever or manifestations suggestive of CNS pathology
Headache that does not respond to analgesic medication

7.5.2 Seizure

7.5.2.1 Preeclampsia/Eclampsia

In most cases, seizures in pregnancy, childbirth, and puerperium arise in the context of preeclampsia/eclampsia. In the postpartum period, seizures usually appear in the first 48 h, although they may appear later. Prevention and treatment (Table 7.3) involve performing therapy with magnesium sulfate [2, 3].

Severe hypertension of recent-onset, underlying cases of preeclampsia/eclampsia, particularly wherein BP ≥160 and/or 110 mmHg, is indicated to be treated immediately (Table 7.4), under penalty of serious maternal cardiovascular complications, such as AMI and stroke.

The goal in the puerperium is to obtain a BP ≤140 and/or 90 mmHg. Alpha-methyldopa, in view of its association with postpartum depression, should be passed over to other drugs, namely inhibitors of the renin-angiotensin-aldosterone system and calcium channel antagonists.

Table 7.3 Prevention and treatment of seizures in eclampsia

1ª Line: Magnesium sulfate		
Loading dose	4 g EV in 20–30 min (bolus)	*Therapeutic levels*: 4–8 mEq/L *Toxicity* if >8 mEq/L +/− abolition of the rotulian reflex, depression, awareness, diplopia, muscle paralysis, respiratory arrest, prolongation of the QRS on the ECG *Antidote*: 1 g 10% calcium gluconate (10 mL EV in 3–4 min)
Manutention dose	2–3 g/h (rhythm 50–75 mL/h)	
Booster dose	2 g EV during 10–15 min (additional bolus)	
2ª Line: Diazepam		
Loading dose	5 mg EV	
Manutention dose	5 mg each 5 min (max. 20 mg)	

Table 7.4 Blood pressure control in severe preeclampsia and eclampsia

Acute treatment	Manutention treatment	Contraindications
Labetalol: 20 mg (bolus EV) and duplicate the dose at each 20 min (max. 200 mg)	50–400 mg/6 h (max. 600 mg/day)	Congestive heart failure, maternal bradycardia, coronary heart disease, aortic stenosis, and asthma
Nifedipine: 10 mg (repeat 10 mg after 30 min)	10–20 mg 6 h (max. 60 mg/day)	Congestive heart failure, severe asthma, and intestinal obstruction
Hydralazine: 5 mg (bolus EV) and repeating the dose at each 20 min (max. 20 mg)	3–7 mg/h (max. 200 mg/day)	Heart disease, coronary disease, and tachycardia
Nitroglycerin: 5 mcg/min and repeating the dose at each 5 min (max. 100 mcg)		Hypertensive encephalopathy
Sodium nitroprusside: 0.25 mcg/kg/min and duplicate the dose at each 5 min (max. 10 mcg/kg/min)	<4 h (fetotoxicity due to cyanide accumulation)	

At 6 weeks postpartum, all women with hypertension during pregnancy and preeclampsia/eclampsia should collect urine for proteinuria and measure the TA to be able to reclassify the situation. Approximately 12% of women with hypertension in pregnancy can develop chronic hypertension.

7.5.2.2 Epilepsy

The incidence of seizures in the puerperium does not appear to be higher in women with a history of epilepsy. However, it is important to recognize significant changes in the pharmacokinetics of antiepileptics in the postpartum period, which potentiates phenomena of toxicity to these agents. Serum monitoring of the concentration of these drugs assumes an important role at this stage [2–4].

7.5.3 Dyspnea and Chest Pain

Dyspnea and chest pain appear in the context of heart and/or lung diseases. Although there are several possible causes (Table 7.5) in the postpartum period, the two most clinically relevant are pulmonary thromboembolism and peripartum cardiomyopathy.

Table 7.5 Causes of dyspnea and/or chest pain

Pathology	Other clinical manifestations
Pulmonary thromboembolism	Hemoptysis
Peripartum cardiomyopathy	Cough, orthopnea, paroxysmal nocturnal dyspnea, hemoptysis, and MI edema
Panic disorder	Palpitations, trembling, feeling of imminent death
Musculoskeletal pathology	Pain with movement and breathing (more in inspiration)

7.5.4 Vulvar Edema

Vulvar edema is a consequence of trauma existing during childbirth, which is associated with dystocic births (suction cup and forceps) and episiotomy [2, 4]. Usually, there is talk of a vulvar painful syndrome, which is accompanied by edema and erythema and which analytically leads to leukocytosis. If complicated by infection by group A streptococcus or necrotizing fasciitis, broad-spectrum antibiotic therapy is mandatory. In the case of necrosis, surgical debridement may even be necessary.

7.6 Non-Life-Threatening Postpartum Complications

7.6.1 Difficulty in Urination and Urinary Retention

Urinary retention in the postpartum period is defined by the inability to have urination for more than 6 h, either spontaneously or after removal of the bladder catheter (placed in the cesarean section) [2, 4]. In this definition, it is also assumed that the residual post-voiding volume is at least

150 mL after spontaneous voiding. The cause seems to be related to the pudendal nerve injury.

The risk factors involved include epidural analgesia, primiparity, dystocic delivery, and episiotomy [2–4].

Clinical manifestations are variable. The patient may be asymptomatic, as she may have pain, burning, pollakiuria, urinary urgency or hesitation, hypogastric pain, weak or intermittent urinary stream, and/or incomplete bladder emptying.

Treatment involves intermittent bladder catheterization. Prophylactic antibiotic therapy is not necessary. The role of anticholinergics such as physostigmine and rivastigmine is limited.

The prognosis is usually good, since it is a self-limited condition, which resolves within 1 week.

7.6.2 Incontinence

Urinary and/or fecal incontinence are relatively common conditions in the immediate postpartum period. These are of multifactorial etiology, although the most frequently described causes are lacerations of the respective sphincters at the time of delivery [2, 4]. Pelvic floor ultrasound plays an important role in the assessment of this type of dysfunction. Early pelvic paviment physiotherapy is determinant as a incontinence recovery.

In most cases, a progressive improvement is noted in subsequent weeks. If complaints persist, it will be necessary to discuss the various options for diagnosis and treatment that are most appropriate for each case.

7.6.3 Hemorrhoids

Hemorrhoids are frequent in pregnancy and in the puerperium, and it seems that in this last phase they become more symptomatic. This problem affects approximately one-third of women. The treatment of symptomatic hemorrhoids (pruritus, pain, hemorrhage, or prolapse) involves the use of topical anesthetics, corticosteroids, oral laxatives, fecal emollients, and vasoactive agents [2, 4].

7.6.4 Foul-Smelling Lochia

A strong and unpleasant odor in the postpartum period is more often related to deficient intimate hygiene, which may be underlying bacterial vaginosis. Do not forget to review the birth canal, regarding a possible compress forgotten at the time of suturing the laceration or episiotomy [2, 4].

Strong and unpleasant odor accompanied by fever and brownish lochia (chocolate brown) should make you think of endometritis.

7.6.5 Symptomatic Venous Insufficiency of the Lower Limbs

In pregnancy, there are several factors that promote venous distension and occurrence of edema, namely the increase in venous pressure due to the mechanical pressure of the pregnant uterus on the lower pelvic and vena cava, the myorelaxant effect of progesterone when contributing to the decreased venous vascular resistance, as well as the hydrodynamic obstruction caused by the high pressure of the venous flow of the uterine circulation. Here, stasis and endothelial injury may predispose to the appearance of superficial thrombophlebitis or even deep venous thrombosis.

After delivery, with a reduction in pressure below the diaphragm, there is an adjustment that may involve only partial improvement of venous insufficiency, since the vascular structural alteration has already occurred.

The improvement of symptoms involves elevation of the lower limbs, physical exercise, compression stockings, and bioflavonoids.

7.6.6 Thromboembolism

Thromboembolism is an important cause of postpartum mortality and morbidity in the Western world. This term refers to all phenomena of vas-

cular occlusion at the venous level, which will include deep vein thrombosis, pulmonary embolism, superficial thrombophlebitis, and septic pelvic thrombophlebitis [2, 4].

Risk factors for thrombotic events can be organized schematically into three groups, which are part of the so-called Virchow triad (Fig. 7.6). Hypercoagulability, one of the elements of this triad and which has been present since pregnancy, is even more pronounced in the puerperium due to the release of thromboplastin with the discharge. Thus, in the puerperium, we speak of a 6–8 times higher risk for thrombotic events.

The diagnosis of thrombotic events is suspected, often inferred from the following clinical manifestations (Table 7.6) [2]:

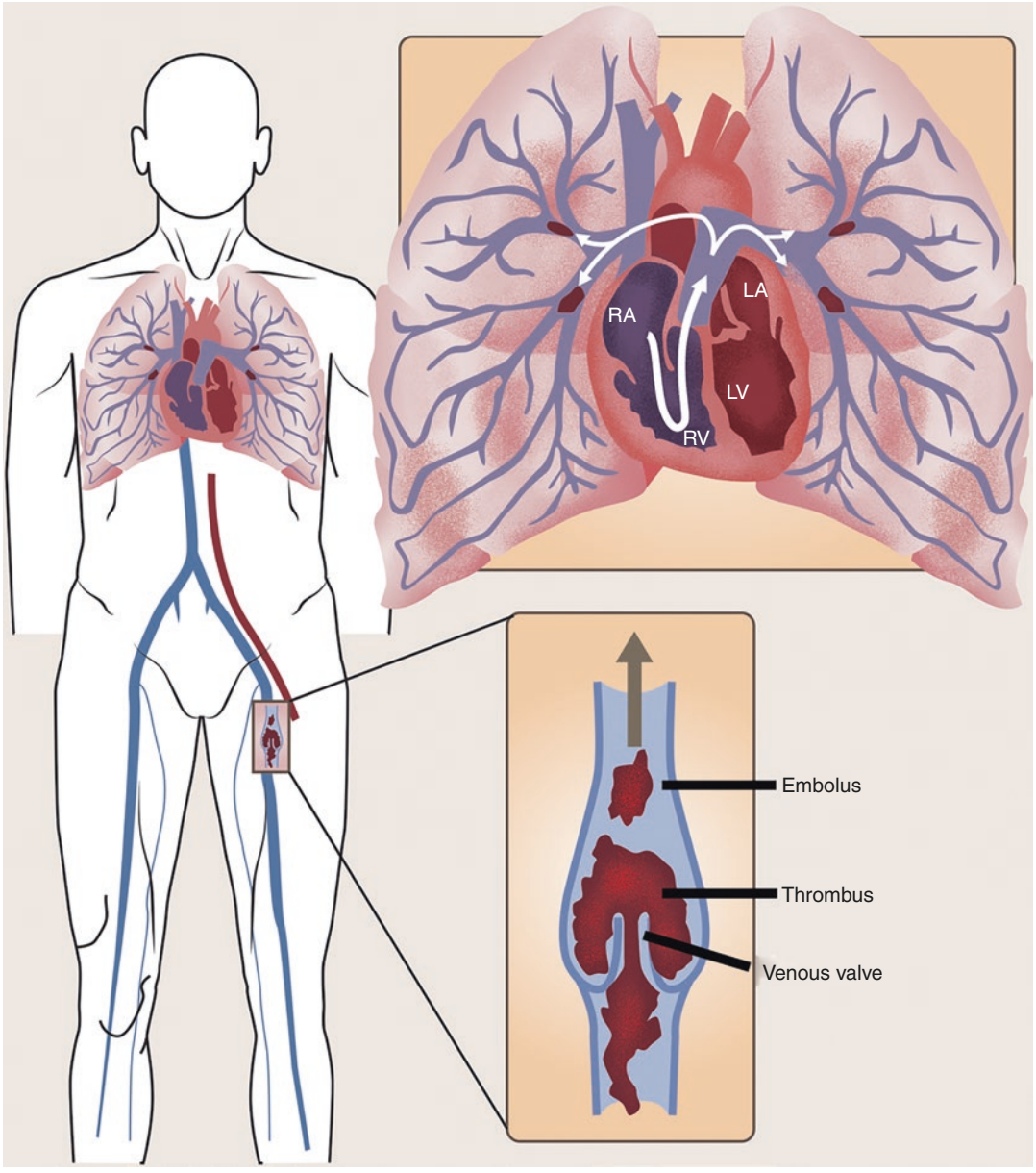

Fig. 7.6 Virchow triad

Table 7.6 Clinical manifestations of thrombotic events

Thrombotic events	Clinical manifestations	Treatment
Superficial thrombophlebitis	– Inflammatory signs (heat, flushing, edema, and pain) in a vascular area of the limb	– Rest, elevation of the limb, and application of local heat – Nonsteroidal anti-inflammatory drugs (topical or systemic) and analgesics – Elastic compression stockings – Low-molecular-weight unfractionated heparin in prophylactic dose – Surgery (if no response to previous)
Pelvic septic thrombophlebitis	Isolated fever or associated abdominal pain, which does not yield to antibiotic therapy – Abdominal pain (more frequent in FID, related to thrombosis of the right ovarian vein)	Low molecular weight unfractionated heparin in therapeutic dose – Surgery (if no response to previous)
Deep venous thrombosis	Pain, redness, edema, and swelling of the limb – Pain on palpation and sensation of "hardened" cord in the affected vascular path – Positive Homans sign (pain in the twin region with limb dorsiflexion)	– Unfractionated and low molecular weight heparin in therapeutic dose – Surgery (if no response to previous)
Pulmonary embolism	– Sudden-onset dyspnea – Chest pain, of a pleuritic nature, and hemoptysis (in small and peripheral pulmonary infarcts) – Syncope, seizures, and other changes in the state of consciousness – Tachypnea, tachycardia, hypotension – Signs of right-heart failure	

The prophylaxis and treatment of thromboembolism in the situations described above are summarized in Table 7.7 [2].

7.6.7 Fever and Puerperal Infections

The increase in body temperature in the first 24 h of the puerperium is a normal finding. The cause is not fully known, although the most plausible hypothesis is related to the woman's endocrine-metabolic response to the stress of childbirth. It usually has spontaneous resolution [2, 4].

A feverish condition, on the other hand, can be defined as a body temperature above 38°, lasting more than 48 h, in the first 10 days of the puerperium, excluding the first 24 h [2].

Take a Note

The absence of fever does not mean the absence of infection. Likewise, a feverish spike, especially in the first 24 h, is not a sign of infection.

Fever is not a single parameter of infection and should be carefully evaluated in order to understand whether or not it deserves investigation.

The rate of infection in the puerperium is approximately 5–7%, with higher rates in those undergoing cesarean section [4]. However, it is believed that the actual prevalence remains underestimated, given the various limitations of epidemiological surveillance systems.

Table 7.7 Prophylaxis and treatment of thromboembolism [2]

Unfractionated heparin				
80 UI/kg bolus, followed by the continuous infusion 18 UI/kg/h				
Low-molecular-weight heparin				
Weight in early pregnancy	<50 kg	50–90 kg	> 90 kg	high risk
Enoxaparin	40 mg 2×/day	60 mg 2×/day	80 mg 2×/day	1 UI/day × weigh (Kg)
Dalteparin	5.000 UI 2×/day	6.000 UI 2×/day	8.000 UI 2×/day	10.000 UI 2×/day
Tinzaparin	175 UI/kg 1×/day	175 UI/kg 1×/day	175 UI/kg 1×/day	175 UI/kg 1×/day

Unfractionated heparin				
5.000 UI 2×/day				
Low-molecular-weight heparin				
Weight in early pregnancy	< 50 Kg	50-90 Kg	> 90 Kg	high risk
Enoxaparin	20 mg 1×/day	40 mg 2×/day	40 mg 2×/day	0.5–1 mg/kg 2×/day
Dalteparin	2.500 UI 1×/day	5.000 UI 2×/day	5.000 UI 2×/day	50–100 UI/kg 2×/day
Tinzaparin	3.500 UI 1×/day	4.500 UI 1×/day	4.500 UI 2×/day	4.500 UI 2×/day

Most febrile infectious processes in the puerperium are caused by infection of the lower genital tract [2]. In a schematic way, we can consider:

1. Uterus infections and appendages
2. Surgical wound infections (abdominal or perineal)
3. Breast infections (mastitis and breast abscesses)
4. Infections from other locations (e.g., urinary infections)

7.6.7.1 Infection of the Uterus and Adnexa

Endometritis seems to be the precursor event in all infectious processes involving the uterus and the appendages, so it is important to recognize the diagnosis early in this phase [2].

Endometritis refers to the infection of the decidua, which can extend to the myometrium (endomyometritis) or affect the parametrium (parametritis) [2].

It is currently the most frequent cause of fever in the first 10 days postpartum.

The etiology of endometritis is polymicrobial, with an ascending pathway of infection [4].

It often appears between the fourth and the fifth day. Symptoms include high fever, underinvolved uterus, and painful on palpation and mobilization, with soft consistency and purulent discharge and a foul smell [2].

Take a Note

Etiology of endometritis: polymicrobial (Gram positive, negative, anaerobic, and Mycoplasma). Chlamydia is related to late endometritis (more than 1 week postpartum).

Brumm triad: uterus with three characteristics (underinvolved + soft + painful).

The complications of endometritis are related to the extension of the infectious process to the pelvic and peritoneal cavities, which include parametritis, salpingitis, peritonitis, abscess, necrotizing fasciitis, and septic shock. Pelvic thrombophlebitis can also be one of the complications.

The diagnosis can be complemented with an analytical evaluation, blood cultures, urine culture, and pelvic ultrasound.

The indicated treatment (Table 7.8) [2] is to carry out IV antibiotics that must be maintained until at least 48 h after the patient becomes apyretic and asymptomatic.

7.6.7.2 Surgical Wound Infections (Abdominal or Perineal)

Surgical Wound Infections

They usually result from injuries and bruises that are contaminated by skin microorganisms [2] (vaginal flora in the case of episiorrhaphy).

Table 7.8 Antibiotic scheme recommended in endometritis

Clindamycin 900 mg 8/8 h EV + Gentamicin 1.5 mg/kg 8/8 h EV **Or** **Ceftriaxone 1 g 12/12 h EV + Metronidazole 500 mg 12/12 h EV** + Azithromycin 500 mg/day EV (2 days) or doxycycline 100 mg 12/12 h PO (7 days) (suspected Chlamydia infection and/or late endometritis) + Ampicillin 2 g 6/6 h EV (sepsis or *Enterococcus* infection suspected) After apyrexia and clinical improvement, the patient can be discharged with amoxicillin + clavulanic acid 875/125 mg 12/12 h PO, for 10 days In refractory cases, add ampicillin (diagram above)

Table 7.9 Antibiotic recommended for surgical wound infections

Superficial infection Clindamycin 300 mg 8/8 h PO or cefuroxime 500 mg 12/12 h PO or amoxicillin + Ac. Clavulanic 875/125 mg 12/12 h PO **Deep infection** Opening, cleaning, debridement, and antibiotic therapy **Hospitalization criteria:** deep infection, immunosuppression, diabetes mellitus, severe anemia, non-patent oral route, inability to comply or therapeutic failure with the oral regimen, and sepsis It will be indicated: clindamycin 900 mg 8/8 h EV + gentamicin 3–5 mg/kg/day EV or amoxicillin + Ac. Clavulanic 875/125 mg 6/6 h EV Apyrexia and clinical improvement, possibility of discharge with oral antibiotic indicated for superficial infection

The infection can occur in the first month after delivery and is classified as superficial (skin and/or subcutaneous tissue involvement) or deep (involvement of the fasciae and muscle planes).

The agents involved are B-hemolytic Streptococcus group A and B, *S. aureus*, *S. epidermidis*, *E. coli*, and *Proteus mirabilis* [2].

Clinical manifestations can be fever, local pain, heat, redness, edema, abscess formation, and drainage of purulent exudate.

The wound should be washed, preferably with 0.9% SF drained, opened, or even debrided in the presence of foreign or necrotic material.

Treatment involves antibiotics (see Table 7.9) [2]. Whenever possible, collect purulent exudate for direct and cultural microbiological examination.

The wound that is complicated by a bruise or infection may suffer dehiscence. The approach involves cleaning, drainage, disinfection, and antibiotics. Second intention healing or need for resuscitation may be considered.

7.6.7.3 Breast Infections (Mastitis and Breast Abscess)

Mastitis is an infectious process, acute or chronic, which can affect breast tissues (skin, subcutaneous, or glandular tissue) [2].

Acute puerperal mastitis is the most common form of mastitis [2]. Most often, it appears in the first 6 weeks postpartum and is caused by saprophytic microorganisms in the skin: *S. aureus*, *S. epidermidis*, B-hemolytic group B Streptococcus [2, 4].

These microorganisms enter the breast parenchyma from fissures around the nipples, most of the time resulting from the inadequate grip of the newborn and/or breast engorgement.

The risk factors described [2, 4] include primiparity, age under 25 years, breast engorgement, nipple fissure, previous episode of mastitis, direct trauma to the breasts, infant's rhinopharynx infection, poor hygiene, and nipple abnormalities.

The clinical manifestations are fever and other classic signs of inflammation, associated with breast engorgement and with the possibility of adenopathies.

The treatment of patients involves the use of analgesics, antipyretics, adequate breast suspension (suitable bra), frequent and complete breast emptying, and antibiotic therapy (Table 7.10) [2]. For severe infection, culture material should be collected.

Breastfeeding must be maintained in both breasts, and the infant must start with the unaffected one. If difficult, emptying should be done by manual or mechanical expression.

The breast abscess corresponds to a purulent collection in the breast parenchyma.

Table 7.10 Recommended treatment for mastitis

Conservative measures (symptomatic relief)
Analgesic/antipyretic
Antipyretics
Local ice
Complete breast emptying at <4-h intervals
Oral antibiotics (10–14 days)
Flucloxacillin 500 mg 6/6 h
Dicloxacillin 500 mg 6/6 h
Cephalexin 500 mg 6/6 h
Clindamycin 300 mg 6/6 h (if allergic to penicillin)
Abscess drainage
If fluctuation is present, otherwise adopt previous measures
It will be indicated: clindamycin 900 mg 8/8 h EV + gentamicin 3–5 mg/kg/day EV or amoxicillin + Ac. Clavulanic 875/125 mg 6/6 h EV
Apyrexia and clinical improvement, possibility of discharge with oral antibiotic indicated for superficial infection

The treatment of abscess involves the institution of antibiotics (see Table 7.10) and surgical drainage in the presence of fluctuation. Drainage is done using a radial incision and as far away as possible from the areola in order to preserve the galactophorous ducts and consequently lactation.

7.6.8 Postpartum Psychiatric Disorders

Changes in mood in the puerperium [2, 4] are frequent and of a transitory nature. Psychological support for women thus becomes extremely important in this phase, which is known to be highly vulnerable in order to avoid the negative consequences of some psychiatric pathologies, namely postpartum blues, postpartum depression, and psychosis puerperal.

7.6.9 Postpartum Blues

Postpartum blues affect about 60% of women depending on the criteria used, appear in the first 10 days after delivery, and are characterized by depressed mood, emotional lability, easy crying, insomnia, and irritability [2]. In contrast to depression, it appears to be more benign, transient, and self-limiting. However, in a small percentage, it can progress to depression. At this stage, the woman demonstrates liking the newborn and seems motivated to maintain breastfeeding. Psychotherapy is the main weapon in preventing the evolution of this pathology to something more serious.

7.6.10 Postpartum Depression

About 10% of women develop symptoms of depression within 4–8 weeks after delivery [2]. The diagnosis is made according to the DSM-V criteria.

The main risk factors appear to be a history of depression or anxiety disorder during pregnancy, a family history of depression, teenage pregnancy, poor social and family support, and traumatic events during pregnancy [2, 4].

In major depression, there is interference with personal functioning, that is, the woman becomes unable to carry out her usual tasks.

Five or more of the following symptoms should be present daily for most of the day for at least 2 weeks [5]:

1. At least one symptom is either depressed mood or anhedonia
2. Changes in appetite or weight
3. Insomnia or hypersomnia
4. Psychomotor agitation or retardation
5. Fatigue or loss of energy
6. Feeling of guilt or worthlessness
7. Difficulty with thinking, concentration, or making decisions
8. Suicidal ideation or suicidal attempts

In women with a history of postpartum depression, there is a 25% risk of recurrence in subsequent pregnancy.

7.6.11 Postpartum Psychosis

This is a serious delusional condition, often accompanied by hallucinatory activity in the second to third months of puerperium [2].

Table 7.11 Drugs and their risk of excretion in breast milk

Risk	Very low	Low	High
Antidepressants	Sertraline, paroxetine, duloxetine, citalopram, escitalopram, venlafaxine mirtazapine, fluvoxamine nortriptyline	Fluoxetine, bupropion	Reboxetine
Benzodiazepines	Lorazepam Midazolam Oxazepam	Diazepam Alprazolam Clonazepam Triazolam Estazolam Flumazenil	Bromazepam Flurazepam
Mood stabilizers	Carbamazepine Valproate	Lamotrigine Asenapine	Lithium
Antiepileptics	Carbamazepine Valproate	Lamotrigine	
Antipsychotics	Quetiapine Risperidone Olanzapine Paliperidone	Haloperidol Droperidol Promethazine Chlorpromazine Aripiprazole Asenapine	Ziprasidone

APILAM (Association for the Promotion of and Scientific and Cultural Research into Breastfeeding) [6]

The prodrome includes previously described symptoms present in major depression. In the disease phase itself, delusional thinking arises, almost always dominated by the belief that the child has a malformation or is dead, or that they are not married and that the newborn does not belong to them [2, 5]. Hallucinations, predominantly visual and auditory, are also present in 25% [2].

In this pathology, due to the risk for the mother as well as the child, hospitalization is often indicated. It is considered a psychiatric emergency, in which treatment with antidepressants and eventually antipsychotics should be started. Psychotherapy has its role essentially after the acute phase and is directed to the conflict areas identified in the assessment.

Regarding the prognosis, it is known that women who present this clinical picture have a higher risk of developing depression and bipolar affective disorder [5].

7.6.12 Treatment of Psychiatric Disorders

The choice of treatment will depend on several factors, including history of psychiatric illness, singularity of the symptoms and signs, severity and functional impact, and the patient's preference. Among the various treatment options, we have cognitive behavioral therapy, interpersonal therapy, and pharmacological therapy [4].

The main concerns with pharmacological treatment are related to the possibility of drugs and/or their metabolites being excreted in breast milk and thus having consequences in the newborn. In addition to the possibility of inducing short-term toxicity, they can also have an effect on neurodevelopment.

Table 7.11 lists the drugs and their risk of excretion in breast milk, so that a safer choice can be made.

7.7 Neuropathy

It affects about 1% of postpartum women [2].

The most frequent condition is mononeuropathy, and the nerves frequently affected are the femoral skin, femoral nerve, peroneal nerve, lumbosacral plexus, sciatic nerve, and obturator nerve [2]. Nerve damage occurs by compression, stretching, transection, or vascular injury. Neuropathic symptoms rarely occur following neuraxial anesthesia, as in hematoma or epidural abscess.

Table 7.12 Indications for CT and/or MRI in suspected neuropathy

Fever
Neurological symptoms with worsening pattern
Immunosuppression
Coagulopathy
Symptoms localized to the spinal cord

Clinical manifestations include sensory and motor changes in the affected nerve territories.

Risk factors for neuropathy include macrosomia, non-cephalic fetal presentation, sensory block, prolonged lithotomy position, second stage of prolonged labor, extremes of maternal weight, and inappropriate use of leg retractors [2, 4].

The diagnosis is usually clinical and can be complemented with an imaging study in the situations listed in Table 7.12.

The treatment is essentially based on painkillers [4]. The first-line treatments are anti-inflammatory drugs. All drugs administered should be assessed for compatibility with breastfeeding. Physiotherapy may be indicated in selected cases.

The prognosis of most neuropathies is good, with resolution in days to weeks, in which the average recovery time is about 8 weeks [2].

7.8 Postpartum Hemorrhage

Postpartum hemorrhage occurs if blood loss from the genital tract is very abundant and/or is associated with hemodynamic impairment. In developed countries, it complicates 3% of births and is an important cause of maternal mortality [2]. This number increases especially in underdeveloped countries.

The most frequent causes are uterine atony (80% cases), partial or complete retention of the placenta, and lesions of the genital tract. Less frequent causes are uterine rupture, maternal coagulopathy, placental accretism, and uterine inversion [2].

The proposed approach varies according to the protocol of different countries.

You should think that in a woman with hemodynamic instability without visible bleeding, blood will be accumulating in the abdominal and pelvic cavity, particularly after a cesarean section.

7.9 Routine Postpartum Care

7.9.1 Joint Accommodation

Rooming-in is a practice that allows the healthy newborn to stay with the mother right after birth, 24 h a day in the same environment before discharge from hospital [2]. This is even one of the prerequisites required for the Baby Friendly Hospital certification promoted by the World Health Organization and the UNICEF. It seems that close contact between mother and child plays a crucial role in bonding from an early stage, still allowing for a positive reinforcement of breastfeeding.

Some studies have already shown that children separated from their mother at an early stage were more susceptible to abandonment, abuse, and being victims of violence [4].

7.9.2 Maternal Clinical Surveillance

In a puerperal woman, the following should be evaluated [2]:

- Vital parameters (temperature, blood pressure, and pulse)
- Lochia (in abundance should motivate investigation of causes of postpartum hemorrhage)
- State of uterine contraction or Pinard safety globe
- Perineum (edema, dehiscence, purulent exudate, or other signs of infection)

7.9.3 Laboratory Evaluation

- Blood count
  - Indications: pre-delivery anemia, postpartum hemorrhage, or anemia symptoms
  - No indication to be asked for a routine, that is, an uncomplicated delivery

- Leukogram
  - Indications: clinical suspicion of infection
  - At birth, a leukocytosis of 10,000–15,000 cells/microL may be present

7.9.4 Breastfeeding

Breast milk is a living, complete, and suitable food for practically all newborns. It should ideally be given exclusively until at least the sixth month, given the numerous advantages, both in the short and long term.

Regarding some practical aspects about breastfeeding, we have to consider the following [3]:

- The newborn must be breastfed freely, that is, whenever requested.
- It is important to understand the amount of milk the newborn is getting from the feed, so the duration should not be considered a determining factor. Most breastfeed about 90% of what they need in 4 min. Prolonged breastfeeding (>30 min) means that the newborn uses the nipple as a pacifier, which increases the risk of breast fissures and eventually mastitis.
- One breast should be emptied, and then the second should be offered, thus maintaining the pace of milk production.
- The milk obtained in the first days is called colostrum, which has a greater amount of water and lactose. In the subsequent days, the amount of fat present increases.
- The proper growth of the newborn must be monitored by weight, a function that is the responsibility of the health professional.
- The environment must be peaceful in order to stimulate milk production.

Breastfeeding has a lot of well-known benefits (Fig. 7.7) [3].

Fig. 7.7 Breastfeeding benefits

It is also necessary to pay attention to some contraindications (Table 7.13) [2]:

In the presence of temporary contraindications, the administration of artificial milk per cup, spoon, or syringe and breast stimulation and emptying are indicated.

If there are absolute contraindications, the mother should receive therapy to suppress lactation and feeding of the newborn should be made with artificial milk by teat.

Table 7.13 Breastfeeding contraindications

Temporary contraindications	Definitive contraindications
– Chickenpox or herpes virus infection – Untreated tuberculosis – Temporary incompatible medication	– HIV – Newborns with rare metabolic disorders (e.g., phenylketonuria and galactosemia) – Chronic incompatible medication

7.9.5 Prevention of Venous Thromboembolism

Venous thromboembolism (VTE) was the main cause of direct maternal mortality in developed countries. It is known that the risk is about five times higher during pregnancy, compared to a nonpregnant woman, and that this risk can be about ten times higher in the puerperium. The early puerperium is the period associated with the greatest risk [4].

In a schematic way, we can arrange the risk factors in three risk categories: low, moderate, and high (see Table 7.14).

The existence of some factors, as well as a combination of these, may determine the indication for thromboprophylaxis [2]. However, some may have only a transitory character, as well as new complications may arise, which require a frequent reassessment of risk.

Table 7.14 Venous thromboembolism risk categories [2]

Categories	High risk	Intermediate risk	Low risk
Risk factors	– Previous VTE – Any woman who has undergone thromboprophylaxis during pregnancy	– Hereditary or acquired thrombophilia (asymptomatic) – Medical pathology with thrombotic risk (SLE, heart disease, nephrotic syndrome, sickle cell disease, inflammatory bowel diseases) – Morbid obesity – Prolonged hospital stay (>3 days)	– Cesarean – Age >35 years – Obesity – Multiparity (≥3) – Venous insufficiency of the lower limbs – Smoking (<10 cigarettes/day) – Active infectious process – Preeclampsia – Prolonged labor (>24 h) – Severe postpartum hemorrhage – Blood transfusion – Postpartum surgery
Indicated therapy	≥1RF: HBPM during 6 weeks of puerperium	≥1RF: HBPM at least till discharge, but may extend to 6 weeks of puerperium	≥2RF: HBPM at least till discharge 1 RF: Prevent dehydration, stimulate early walking

Low-molecular-weight heparins (LMWHs) are the drugs of choice for prophylaxis and venous thromboembolism in pregnancy and puerperium. Unfractionated heparin can also be used, although it is dependent on aPTT monitoring. Doses are adjusted to weight.

For the small number of women who underwent coumarin therapy during pregnancy, HBPM in therapeutic dose should be instituted in the puerperium, and can be restarted later, since they are safe in breastfeeding.

Postpartum approach:

– How long does it take to introduce LMWH after removing the epidural catheter?
  - Prophylactic dose 6 h after
  - Therapeutic dose 12 h after

The contraindications or need to suspend anticoagulation is described in Table 7.16 [2].

7.9.6 Prophylaxis of RhD Alloimmunization in the Puerperium

Prophylaxis with anti-D immunoglobulin is indicated in the immediate postpartum period (<72 h), if mother is RhD negative and the newborn RhD positive.

Table 7.15 Low-molecular-weight heparin doses [2]

Weight (Kg)	Enoxaparin	Dalteparin
<50	20 mg/day	2.500 UI/day
50–89	40 mg/day	5.000 UI/day
90–130	60 mg/day	7.500 UI/day
131–170	80 mg/day	10.000 UI/day
>170	0.6 mg/kg/day	75 UI/kg/day

Table 7.16 Contraindications or need to suspend anticoagulation

Active bleeding
Heparin-induced allergy or thrombocytopenia
Uncontrolled arterial hypertension (≥180 and/or 110 mmHg)
Thrombocytopenia (<70,000 pL/μL) or coagulopathy (INR >1.5)
Renal impairment (creatinine >1.5 mg/dL)

7.9.7 Pelvic Floor Exercises

A randomized study showed that pelvic muscle exercises at an early stage of the puerperium do not have a protective role against urinary incontinence and that they can even be harmful to the levator ani muscle complex.

7.10 Discharge Planning

7.10.1 Length of Stay

There is low-quality evidence on the main studies associated with the ideal length of stay after delivery.

According to ACOG recommendations, discharge should happen 48 h after a vaginal delivery or 72 h after a cesarean delivery (excluding the day of delivery). Obviously, evaluation is a dynamic process, and several aspects should be reviewed. The parameters include maternal vital signs, mucous membranes' color, uterine contraction, lochia, ability to tolerate diet and walking, pain control, and ability to care for herself and the newborn. All puerperal complications listed in the previous topics should be excluded.

7.10.2 Health Education

All women need to be informed about what to expect during puerperium, namely the postpartum changes that occur on a physiological basis.

Warning signs will help mothers to distinguish from pathological changes. The main warning signs include [4]:

– Fever
– New or worsening perineal or uterine pain
– Purulent exudate from the C-scar or perineum
– Excessive vaginal bleeding
– Breast inflammatory signs
– Urinary tract infection symptoms
– Dyspnea or chest pain
– Leg pain or swelling
– Mood disturbance

7.10.3 Physical Activity

Unfortunately, there are no data to strain the recommendations on postpartum physical activity. The return to routine activities is something individually decided and is essentially conditioned by postpartum pain.

The most recommended approach suggests telling the mother to do the normal activities [2] (exercise, housework, driving, sexual intercourse) when she is comfortable, in order to prevent the pain and/or excessive fatigue.

The most asked issue is about sexual intercourse. A woman should wait at least 2 weeks till the perineum is completely healed and contraception is prescribed. She needs to feel comfortable about it, and this question should be discussed by the couple.

7.10.4 Contraception

Most women initiate sexual relations between 4 and 6 weeks postpartum, which is the most common time for a postpartum medical visit. But the contraception issue should be discussed before discharge.

The contraception is recommended to be initiated 21 days after delivery. In women not exclusively breastfeeding, ovulation can occur on the first month, and even in those who breastfeed exclusively, the risk of pregnancy is <5%. The combined contraceptives should be avoided, once the estrogens pass through the blood-milk barrier.

Family planning needs to be discussed. Adverse outcomes in pregnancy could occur in short (<6 months) and long (>5 years) interpregnancy intervals [2]. Optimal interval is approximately 18–59 months. In case of older women or a family history of early menopause, these recommendations may not be applied.

7.10.5 Follow-Up Visits [2]

The timing of the postpartum visit should be individualized and woman centered.

The initial assessment in pregnancy and puerperium with no risk should be followed up with ongoing care as needed, and no later than 6 weeks after birth.

Women with chronic medical conditions, such as hypertensive disorders, diabetes, thyroid disorders, renal disease, mood disorders, and substance use disorders, should be counseled to book a follow-up appointment with their obstetrician-gynecologists or primary care providers earlier.

All the potential problems should be searched and addressed. Past problems are important to be reviewed.

7.11 Conclusion

The puerperium is a variable period of time that marks the transition from a pregnant to a non-pregnant state, in which various involutive and recovery processes of the maternal organism occur. From a clinical point of view, it is relatively complex, which requires the doctor to have detailed knowledge about the existing changes. Only by understanding the physiological changes of this period is it possible to understand what is pathological and to provide a correct approach that allows the resolution of any possible complication.

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Part III

Preoperative Consultation

8 Informed Consent and Medicolegal Aspects

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Take-Home Points

- Prevention is often the best approach to litigation. Seek legal counsel from an experienced attorney/solicitor when setting up your practice and before undergoing significant changes.
- Patients' expectations about the results achievable by surgery may also be a source of liability. Take time to explore and correct them.
- Patients seeking post-maternity surgery should be explained in detail the risks or consequences associated with combined procedures, future pregnancies, and lactation when appropriate.
- The content of your advertisements, of the informed consent, and of what you explain in your practice are often understood as terms of the contract between you and the patient, and therefore binding.

8.1 Introduction

Patient care is a heavily regulated interaction, no matter the legal system nor the medical subspecialty considered. It is affected by both general regulations concerning trade and specific regulations that protect the privacy of the patient or state the boundaries of the doctor-patient relationship.

Although both medicine and law are liberal professions, the practice of medicine is far more informal than the practice of law, which is more reliant on the written word. In aesthetic surgery, the nuances and uncertainty of the medical assessment are magnified, as it focuses on subjective matters such as beauty and self-image. This chapter provides an overview of the different types of criminal and civil liability a plastic surgeon can face when practicing aesthetic surgery, the possible pitfalls when treating a post-maternity patient, and which points to address when writing and implementing a proper informed consent [1].

8.1.1 Sources of Litigation

Far from the image of doctors standing trial depicted in television, the most common interaction with the legal system is when it is required from us that we provide an official narrative about a patient under our care or a deposition to characterize an injury and its scarring or the disability caused by it. It is also fairly common to be summoned to court to provide live testimony about the appropriateness of a diagnosis or procedure performed by a colleague.

In aesthetic surgery, a growing trend among patients is believing themselves blameless while expecting a perfect result, without regard for the

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© Springer Nature Switzerland AG 2023

M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_8

instructions nor the possible complications explained in the interview. This discrepancy between the patient's expectations and their willingness to understand the uncertainty of medicine or to take responsibility in their care is often a source of disappointment, anger, and eventually a lawsuit against the plastic surgeon.

However, it is our responsibility to explore the motives underlying the patient's request, to be able to shed some light on the preconceptions that she brought to the interview. Those patients who after a detailed explanation of the limits of surgery and the extent of the result that can be expected with a procedure keep demanding unrealistic results, hint distrust towards the surgeon, or seem to not grasp the importance of the complications explained are patients that should not be subjected to surgery. In a nutshell, if the risks of a procedure outweigh its results, it should not be performed, as it occurs with non-aesthetic procedures [2].

8.1.1.1 Preventing Litigation

It is difficult to imagine someone reasonable who has been treated with care, dignity, and respect seeking a way to get back at you or your practice, even if something goes wrong. On the other hand, if a patient feels that she is not listened to, that she has been abandoned by you, or that you are not trustworthy, she is likely to be disgruntled and willing to complain or sue. In order to prevent patient complaints and therefore litigation, the best policy is treating patients with the dignity and respect they deserve, making them feel that they are listened to and that you are available for them, and when things take a wrong turn, own your mistakes and look after them throughout their complications.

No matter with how much care you treat your patients, there will always be some that complain. It is nonetheless important to reduce their number, so the only left complaining are those with unreasonable claims [3].

8.1.2 Issues with Post-maternity Patients

The post-maternity patient poses a significant challenge, as she often demands aesthetic procedures combined with gynecologic procedures—i.e., abdominoplasty after C-section—with the increased risk of complications that it entails. Furthermore, a prolonged stay in the hospital or a complication due to a combined procedure can affect the ability of the patient to breastfeed or take care of her child. As this is a sensitive issue, it is best discussed beforehand with the patient, so she can understand the risks associated with her particular postoperative status and the effect that complications of her surgery could have on her child.

Another possible scenario is that of a patient seeking contour improvement surgery well after having her child. The main risk of this kind of patient is that she is less likely to identify the changes after her pregnancy as the source of her desire for contour-improving surgery, thus not prompting a question about previous pregnancies or further desire of pregnancy/motherhood. Failing to address the possible desire of pregnancy when assessing the suitability for contour-improving surgery is a mistake that can have serious consequences, as it is the case with abdominoplasty and/or transverse rectus sheath plication. Both these procedures involve a decrease in abdominal capacity, limiting the available space for the fetus to grow, were the patient to become pregnant again. Further unfavorable outcomes such as contour irregularities or deformities can also be produced as a result of the changes associated with pregnancy after a contour-improving surgery. Asking about the desire of pregnancy/motherhood of the patient and previous pregnancies is crucial when assessing the suitability for abdominal contour improvement surgery in a patient.

A third scenario where a post-maternity patient should be evaluated with special care is when she requests breast reduction or breast lift surgery. Both these surgeries shape the breast

parenchyma, damaging the lactiferous ducts and the breast lobules. This can impair future lactogenesis and milk excretion, affecting both the child, by difficulty in breastfeeding, and the mother, causing lacteal cysts to appear in the breast where the parenchyma was altered.

Lastly, the post-maternity patient can present with underlying personality disorders or mental illnesses, some of which can arise after childbirth or during pregnancy. The greatest risk with such kind of patients is that the informed consent may be nullified if the patient is deemed not able to understand its content or its implications for her health when it was obtained, generating in turn a range of civil and/or criminal liabilities. Therefore, it is not advisable, be it a post-maternity patient or not, to operate on a patient currently suffering from a mental illness or personality disorder without having him or her assessed by an experienced psychiatrist. Then can it be determined if the underlying disorder affects the decision-making ability of the patient, and whether this disorder is expected to be permanent or transient.

As both postpartum and lactation are sensitive periods for both parents, the possible complications affecting them should be discussed in depth in the interview and written down in the informed consent, along with the current desire for future pregnancies and the past gynecologic history of the patient.

Pearls and Pitfalls
Always assess the social environment of the patient, her desire for pregnancy, if she intends to breastfeed her children, and if there has been any significant change of mood or any seemingly unfounded worry that could conceal an underlying psychiatric disorder.

8.2 Criminal Offenses in Aesthetic Surgery

A crime or a criminal offense is often defined as an unlawful act such as assault or tax evasion that is harmful not only to an individual but also to society as a whole. It is the state that prosecutes and punishes these kind of acts, either by producing a criminal code or by setting legal precedents through judicial decisions of courts in common law countries.

Due to the nature of the acts performed in aesthetic surgery, which are the cause of differences between professionals and conflict with the public administration, the activity of aesthetic surgery has both legal and economic ramifications. Aesthetic surgery is without any doubt a legitimate part of medicine, as it does improve the health of the individuals that are subject to it. However, as it is performed voluntarily and due to the absence in most cases of physical illnesses, the assessment of its indications and therefore its legal classification remains difficult. It is our objective to promote the culture of compliance regarding the practice of aesthetic surgery and to allow the description of procedures and best practice guidelines to identify and classify the legal and operative risks that aesthetic surgeons face on a daily basis.

8.2.1 Sources of Criminal Liability

As the specific crimes may vary in its punishment or definition in the different legal systems, we present the following broad concepts that have an analogousness in most of them, although the precise characteristics may vary. It is to be noted that in civil law systems, analogy is not allowed in criminal law, and only the typified crimes do constitute a crime; therefore, the crimes of this section may not be considered as such where you practice. We advise consulting with an experienced attorney in your region to conduct a risk assessment or to provide legal defense if you so require.

8.2.1.1 Injuries
As it has been stated before, aesthetic surgery is performed voluntarily, on patients who do not have a physical disease and seek gratification through a better self-image. It is in this field in which it is understandable that negligence or lack of ability can find their place in the commission of these crimes, a topic which is often studied as

a part of legal and forensic medicine. The usage of modern imaging tools to manipulate an image to present the desired result of the patient can generate a contractual liability in the form of a warranty of a result, moreover when that image is printed and given to the patient without further clarification. If in such a case the result is not the promised, or if during the surgery an injury is produced, or, even worse, if the patient dies, the doctor can face criminal charges, and as the contract between the surgeon and the patient warranted a result instead of merely warranting the best ability of the surgeon, the informed consent may be only considered an attenuation or even completely void.

! Attention
Every surgical act is an aggression by itself. Do not perform an aesthetic surgery procedure without a valid signed informed consent.

8.2.1.2 Breach of Privacy

This relates specifically to the duty of secrecy that we owe to our patients. Depending on the jurisdiction, the punishment is only due to the diffusion, or due to both the diffusion of secrets that are entrusted to us and the acquisition of private information that we do not have consent or permission to access. In the particular case of aesthetic surgery, it is common to take images of the patients to observe and compare the preoperative and postoperative results. Usually, an informed consent document allowing those photographs is passed, but it is not rare that the patients only consent to have their photographs preserved in their electronic medical history. Frequently, the photographs are taken with smartphones or similar devices, and even when the surgeon performs his or her due diligence and transfers the images to the EMH, a copy of the photograph remains on the phone, which is a known vulnerability to breach of privacy. Even more concerning is the fact that those images, even though some surgeons do not have the specific permission to do it, are shown in congresses or courses. Another instance of breach of privacy is sharing those pictures in direct messaging groups with other surgeons when none of them needs to know the existence of those photos.

8.2.1.3 Fraud

In the field of aesthetic surgery and cosmetic medicine, there are several devices and drugs that anyone with a bare minimum understanding of the trade knows that they do not have any effect, being equally effective as placebo. Such devices or drugs, although they can be eventually approved by the government or by one of its institutions, have seldom any clinical trial that supports the claims made by their marketers. In Europe, the more loose legislation of some member countries has been the gateway for some cosmetic products under the classification of medical devices. Eventually, these products have been recalled, but the damage to the patients is already done. The usage of such products knowingly deceiving the patient about the reach of their effectiveness can end with a criminal charge of fraud. Another instance of fraud is the off-label use of a product with the intent to deceive the patient, i.e., by providing a service of less value or quality than it was advertised. It is to be noted that off-label usage of a product or drug when properly explained to the patient and with their consent does not generate criminal nor civil liability.

8.2.1.4 False Advertising

Although the doctor-patient relationship aims to establish a warranty for the best ability of the surgeon and due diligence, there are also partial warranties of result that relate to some procedures that a doctor must perform when having a patient under their care; in the field of aesthetic surgery, one of such partial warranties of result relates to the informed consent (and its verbal clarification to the patient). Furthermore, the warranty for the best ability of the surgeon can turn into a warranty of result if the clarification is performed without care. The competitive pressure to attract patients can make a surgeon give into publishing his or her best results, hiding the cases that had complications, or not publishing their complications' rate. There have been instances of postop-

erative photographies altered with imaging software to show an unrealistic result, descriptions of miraculous procedures, or descriptions of products that do not show their possible adverse reactions. Another instance of false advertising is the publication of false entries of one's curriculum vitae, with internships in institutions or other titles that the person does not own. It is to be noted that the duty to inform should extend not only to the description of the foreseeable and frequent complications but also to clarify those complications that could have an impact on each patient based on their situation.

! Attention
Be aware that even disclaimers under the pre-op and post-op images stating that the result displayed may not be applicable to the case of the reader are not enough to extinguish liability in some jurisdictions.

8.2.1.5 Bribery

Bribery is defined as the offering, giving, receiving, or soliciting of any item of value to influence the actions of an official or other people in charge of public or legal duty. Depending on the jurisdiction in which this crime occurs, it will or will not need the existence of an agreement between the parties. In Europe, the crime of bribery between individuals was introduced in 2003. The prosecution of this crime in Europe has the objective to protect the adequate proceeding of the market, by guaranteeing the implementation of the penal code in those cases that a position of dominance is attained through bribery instead of fair competence. It is to be noted though that in Europe the crime of bribery between individuals is punished in a harsher way than the bribery of a civil servant.

In the field of aesthetic surgery, it is not unheard of someone to accept a gift to code an aesthetic treatment as a reconstructive one, so it can be billed to the insurer of the patient. Other instances of bribery between individuals are the assistance to congresses and courses paid by the pharmaceutical industry, which can influence the doctor to prescribe more loosely one drug or use one device over others of similar quality.

8.2.1.6 Money Laundering

In the field of aesthetic surgery, the most common form of money laundering is self-laundering, in which the perpetrator of the crime of money laundering is the same person that earned by any criminal activity the money being laundered. Instances of this crime can be found in aesthetic surgeons that give speeches or conferences in a foreign country, being paid in cash, or more frequently aesthetic surgeons that fly overseas to perform procedures off the books, receiving cash for their service. This cash crosses our borders and is laundered through limited liability companies (or their equivalent in different jurisdictions).

8.2.1.7 Tax Crimes

Related to the practice of aesthetic surgery, it consists mainly of tax fraud, as some surgeons do not code aesthetic procedures as such, so they do not have to pay the VAT (or its equivalent). This is applicable in the jurisdictions where those procedures deemed "curative" are VAT-exempt. If both "curative" and "aesthetic" procedures are equally taxed in a given jurisdiction, this kind of exploit poses no benefit for a surgeon.

There are other tax crimes, but they do not relate specifically to aesthetic surgery. There is a growing doctrine in Europe that favors the interpretation that "aesthetic" procedures are a form of patient care and should also be exempt from VAT, but this controversy exceeds the scope of this chapter.

8.2.1.8 Crimes Against Public Health

The strategies and policies of the public health departments and institutions are based on the most advanced scientific knowledge available through all the known disciplines. Public health is a primarily social endeavor, whose objective is the improvement of the global health of the population. Through the protection of public health, the government tries to preserve the safety of its citizens when they acquire products or services in the market. The need for government intervention is due to the unfeasibility for the citizens to know the risks or dangers of a product by themselves, given the extremely complex circum-

stances in which they are produced and distributed. There is the widespread notion that some products that can be found in the market, even though they are well past their expiring date, can be administered to a patient. This course of action, no matter whether it is followed knowingly or not, can be the basis for a criminal charge. Other crimes against public health are the usage of products that are not approved in a country by the corresponding public health institution.

8.2.1.9 Forgery

The motive for the prosecution of forgery is the preservation of the trustworthiness and the safety of the judicial proceedings. This kind of criminal offense has a special consideration because it damages judicial collective goods, although the main affected is an individual.

In the practice of aesthetic surgery, the commission of this crime could have the objective of performing tax fraud or attracting more patients, by producing false reports stating that a procedure is reconstructive in nature in order to not have to charge the VAT to the patient or vice versa, forging the reports so a patient that is to receive a reconstructive procedure is coded as an aesthetic one, so you can turn this patient into a private patient, earning more from the same service. Again, this kind of crime is only profitable for an aesthetic surgeon in legal systems in which aesthetic surgery is taxed differently.

8.2.1.10 Concealment or Failure to Disclose

In the Spanish legal system, the citizens must report the commission of crimes that are public in nature to the corresponding public authority or its agents. The matter of interest in the prosecution of this crime is the preservation of the functions of the administration of justice.

An aesthetic surgeon can face a criminal charge for such a crime when they help, without benefit to oneself, the perpetrators or accomplices of a crime to benefit from the result of said crime. In other legal systems, the reception of benefit by the concealing surgeon might not alter the criminal charge. For instance, a surgeon can lie knowingly about the lesions that a patient presents, and by doing so is concealing the effects of the crime that took place on the patient. It is considered a crime both in its active course of action (concealment) and in its passive course of action (failure to disclose).

The concealment of a criminal by altering his or her distinctive facial features is a feat only seen in movies and thus falls outside the scope of this chapter.

! Attention

Whenever you are served a judicial citation against you or your practice, contact immediately your insurance provider (when appropriate) and your attorney/solicitor, and let them guide you through the process.

8.3 Civil Wrongs and Informed Consent

Civil law is the body of law that relates to civil wrongs, property disputes, and rights and duties of persons (be them legal or natural) in a society. How civil law is articulated depends on the legal system to which it belongs. The most widespread systems in which some type of civil law is identifiable are the Common Law system (as are the legal systems of the United States or the United Kingdom) and the Civil Law system derived from the Corpus Juris Civilis, or "Coded Law" (as are the legal systems of Spain, France, or Germany). The various laws under the civil law of the Common Law system and the topics that concern the civil law of the Coded Law system can be summarized in two kinds of civil liability: contractual liability, or the liability that one assumes on behalf of another party as a result of a valid contract, and extra-contractual liability, or the damage for which a person is responsible and for which there is not a signed agreement between the parties, such as damages suffered by someone due to negligence.

Contractual liability emerges from a contract, and the violation of such a contract is the civil

wrong known as "breach of contract," whereas extra-contractual liability emerges from a person's actions or omissions, and when those are wrongful, they are known as "torts" [4].

8.3.1 Tort and Breach of Contract

The torts or extra-contractual civil wrongs that most directly concern the practice of aesthetic surgery are negligence, be it in the form of negligent infliction of emotional distress, negligent infliction of personal injury, or cases of product liability, for instance, due to products marketed or sold by you in your office.

Regardless of the type of injury, for a negligence case to hold water, it should prove first that the plaintiff was owed a duty of care (as a doctor owes a patient under his or her responsibility); second that there was a breach of that duty, i.e., when the action performed is under the standards of the profession in that particular case, against the "lex artis ad hoc"; third that the plaintiff suffered damage as a result of that breach; and fourth that the damage was immediate to the negligent act, which means that it was caused by it.

There are other types of torts, but they do not relate specifically to the practice of aesthetic surgery, and therefore it is not the place to discuss them.

On the other hand, breach of contract is a civil wrong that does relate to the practice of aesthetic surgery, particularly the understanding of the terms of the contract reached between the surgeon and the patient that is going to be the subject of surgery. The main controversy in contract law that should concern us is the kind of warranty that the patient understands from what one explains during the interview, from the images that are shown to them, from what is stated in the informed consent or the interview transcript, or from the advertising of your practice. These are usually considered sources of contractual liability in most legal systems, and a wary surgeon should avoid generating an express warranty of a result through them, as it may be enforceable in their jurisdiction [5].

Pearls and Pitfalls

Providing due diligence, a conservative marketing strategy, and a balanced informed consent are crucial to prevent civil liability lawsuits.

8.3.2 The Informed Consent

The modern concept of "informed consent" was born in the mid-twentieth century, but some practices associated with it predate the concept name in medical history, such as seeking that the patient understands the proposed therapeutic course, that their permission to initiate such therapeutic course is requested, and that more than one option is presented to the patient, letting them choose without compelling them to pick one over another.

These practices have been integrated into a document that is usually presented to patients and that they are instructed to read. Nevertheless, written informed consent is not always necessary, such is the case in emergencies or in minor procedures and physical exploration, where implied consent or verbal consent may suffice, respectively. When written consent is needed though, one must not neglect the content of the interview with the patient. It is an opportunity to build a good rapport and a trusting relationship, as well as clarify the most obscure complications of the proposed operation.

The informed consent is the expression of the ethical principle of autonomy, by which the patient is given both responsibility and agency over his or her treatment. Although patient collaboration is to be pursued, an individual can only provide a valid informed consent when all the following four criteria are fulfilled:

- She has the information necessary to make an autonomous decision.
- She is able to understand the information presented.
- She is able to form a reasonable opinion based on the possible consequences presented during the interview.

- She can reach a decision without being subjected to coercion or other types of manipulation.

Depending on the location of your practice, you will be subject to one or another code of law or legal precedents. It is advisable to give your informed consent forms to an experienced attorney to have them proofread before handing them to patients to avoid undesired liabilities or litigation. The following parts, as depicted in Fig. 8.1, should be included in a balanced informed consent.

! Attention
Any informed consent signed by a patient that does not meet any of these criteria is likely to be nullified, with grievous consequences for your practice and your personal life.

8.3.2.1 Instructions
Under this heading, one should explain the general objective of informed consent and ask the patient to read carefully the whole document before signing. It should be made clear if she needs to sign all the pages or only the last one, and it should include a brief overview of the contents of the consent; that is, it should state that there are complications associated with the procedure, that the patient compliance with the instructions of the medic is indispensable for a good outcome, or that there is a disclaimer at the end of the text.

8.3.2.2 General Information
A brief description of the pathology is given, which we intend to treat with the procedure. Known etiologies, pathophysiology, and a description of how the procedure corrects the deformity of the patient written in an understandable way constitute this section's objective. Schematic images of the steps of the procedure can be added in this section. However, these images should be carefully selected in order to avoid generating an express warranty of result based on the images depicted. If images are used, document accurately what it is said about them, and emphasize their objective in the disclaimer section, to prevent the generation of such warranty.

8.3.2.3 Other Options for Treatment
This section is vital to achieving informed consent, independently of the legal system considered. Explaining to the patient in detail the available therapeutic pathways in a manner that she can understand is fundamental to enable them to take responsibility for their healing process.

8.3.2.4 Inherent Risks to the Technique Proposed
Every surgery has some risks associated with the tissues that are manipulated or the complexity of the technique performed. Some instances of inherent risks are breastfeeding difficulties for breast reduction or breast lift, contour deformity or belly-button loss for abdominoplasty, flap loss

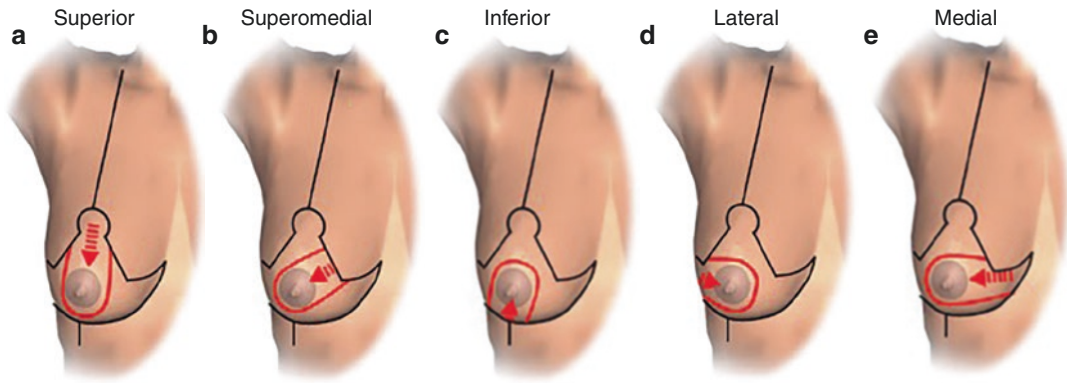

Fig. 8.1 Outline of the contents of an adequate informed consent document. The informed consent should be designed as a reminder for the patient of the conversation held in the interview, not as the primary source of information

for breast reconstruction with autologous tissues, capsular contracture or implant rupture for breast augmentation, and breast reconstruction with implants.

8.3.2.5 General Risks Associated with Surgery

Surgery and anesthesia, although considered safe nowadays, still carry some uncertainty concerning the occurrence of complications. Wound healing delay and/or scarring, serum buildup, bleeding and hematoma formation, and surgical site infection should always be discussed. Fat necrosis, deep venous thrombosis, and chronic postoperative pain are to be explained if the risk for the patient is higher than usual or if the patient shows concern about them. Alcohol and tobacco consumption should also be discussed, and it is mandatory asking the patient to stop smoking approximately 7 days before surgery and not resuming smoking again until well after the wounds have closed (if at all). Concerning tobacco, the patient must know the associated wound healing risks and complications, such as scar widening, altered pigmentation, wound dehiscence, and wound infection.

8.3.2.6 Secondary Operations

The possible need for a secondary operation, should one of the stated complications occur, has to be discussed in the interview and written down in the informed consent, as it can alter significantly the decision of the patient. Moreover, if she is a post-maternity patient, a secondary operation can entail more time apart from her children, which may be unacceptable for her.

8.3.2.7 Patient Compliance

It is advisable to include in the informed consent all the instructions that have to be followed by the patient to avoid complications and undesired results, as well as the indications for wound care and stitch removal after discharge from the ward.

8.3.2.8 Communication and Follow-Up

The follow-up plan after discharge from the ward and your practice contact information can be included in the informed consent, to improve your availability to the patient. Several communication lines can be provided. Email contact allows for photographic and video follow-up, while phone contact data is easier to use. Instructions to be followed before and after each follow-up interview can also be detailed in this section.

8.3.2.9 Disclaimer

Here is to be disclosed the intent of the material given to the patient, usually by summarizing the content of informed consent. The reach of the informed consent presented is to be discussed, as it is not nor should be meant to be an all-inclusive document. It is advisable to state that some information that you have given verbally in your interview may differ from what is stated in the informed consent document, based on the facts of the particular case of the patient or the current medical knowledge.

8.3.2.10 Acquisition and Use of Patient Images

Patient images are often acquired for a number of reasons, mainly maintaining an adequate patient record, preventing liability, for academic purposes, and for patient education. With the uprise of the demand for aesthetic surgery, one new use for patient images is advertising, be it by means of physical billboards, newspapers, or magazines or through websites or social networks. In any case, whenever patient images are to be taken, it is advisable to explain to the patient all the intended uses for those pictures, accompanying the explanation with a specific informed consent form, which is to be signed by the patient before taking the pictures. This informed consent should include all the possible uses of the pictures of the patient's record, the measures that are going to be taken to ensure her privacy, and it should also explain the patient the extent of the rights over those images that she forfeits and give her the chance of rejecting some of the uses of her images.

Pearls and Pitfalls

Having an opt-out form for each of the uses of patient images can be the difference between having unusable images and images that you just cannot use for advertising.

8.4 Conclusion

As marketing trends evolve and new legal precedents or laws that are passed increase the complexity of the regulations underlying the doctor-patient relationship, it is not feasible anymore to keep up with the latest changes in the law affecting our trade while maintaining a busy practice. Having a working knowledge of the applicable law can prevent the most common legal issues when setting your practice, while experienced legal counsel is advisable to get around the more complex pitfalls and to remain ahead of the changing legal environment.

It is also critical to maintain appropriate patient selection criteria and not giving in to competitive pressures. No economic factor should substitute your clinical judgment when deciding if a surgical technique is suitable for a patient or even if that patient is to receive any kind of treatment. Treat patients with whom you can establish a good rapport and refuse to treat those with whom communication is ineffective or whose expectations are unrealistic. Use the interview to explore the extent of the concern of the patient about her deformity and her desire for further pregnancies or breastfeeding. If the proposed surgery is to be performed soon after childbirth, discuss the expected recovery time and the possibility of secondary surgeries and document these in the informed consent.

Accurate documentation, careful patient selection, appropriateness of procedure, and proper informed consent are the keys to running a successful practice while reducing the likelihood of the unpleasantness of a legal proceeding.

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9 Establishing a Post-maternity Strategy

Alan Matarasso and Darren M. Smith

Take-Home Points

- Combining an abdominoplasty with breast surgery is becoming increasingly popular, and the term "mommy makeover" has entered mainstream parlance.
- It is critical to ensure that each individual procedure is as safe and successful in a combined operation as if it were to be performed individually.
- The primary safety concerns for combined procedures are systemic problems, especially VTE, rather than local surgical issues, as the individual procedures are for the most part operatively isolated from one another.
- It is reasonable to perform combined aesthetic surgery procedures as long as rigorous planning and execution criteria are met in the preoperative, intraoperative, and postoperative periods.

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9.1 Introduction

Various aesthetic and breast surgery procedures may reasonably be combined with abdominoplasty. Careful consideration is essential at all stages of the process for these combined procedures, from preoperative planning to intraoperative technique, and postoperative regimen. There are several advantages to combined procedures including reduced cost, convenience, a single recovery period, and expedited patient gratification (Figs. 9.1, 9.2, and 9.3) [1, 2]. Goldwyn wrote that these advantages must be weighed carefully in view of "the patient's wants, needs, and understanding" and "the surgeon's ability, stamina, and philosophy" [3]. He further advised that a sufficient number of experienced staff must be available and "the patient's place of residence (the pressure of doing more to save the patient travel time and expense)" and locally accepted practices must be accounted for [3]. Goldwyn further warned, "It is far preferable for the patient and the surgeon to be successful in each operation on two or, if necessary, three occasions than to have only partial success in a combined venture" [3]. Byrd also commented on this issue: "any monetary savings or time advantage is quickly lost if complications related to the combination are incurred. Consequently, any presumed advantage must be weighed against the potential for adverse events" [4, 5]. The surgeon

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_9

Fig. 9.1 Above, 31-year-old gravida 2 para 2 prior to breast augmentation and abdominoplasty. Below, shortly postoperatively after breast augmentation and abdominoplasty

must also remember that the opportunity to perform any unexpected or planned revisions is lost by combining procedures.

To reasonably combine abdominoplasty with breast surgery, it must be ensured that the entire operation is as safe as each component procedure if performed individually. Moreover, the quality of each individual procedure cannot be compromised. This chapter is intended to explore the issues facing surgeons as they undertake procedures combining abdominoplasty with breast surgery in the postpartum setting. We will report findings from the literature as well as our experience.

Fig. 9.2 Above, 33-year-old gravida 3 para 3 before vertical breast reduction, abdominoplasty, and suction lipectomy of flanks. Below, result over 1 year after vertical breast reduction, abdominoplasty, and suction lipectomy of flanks

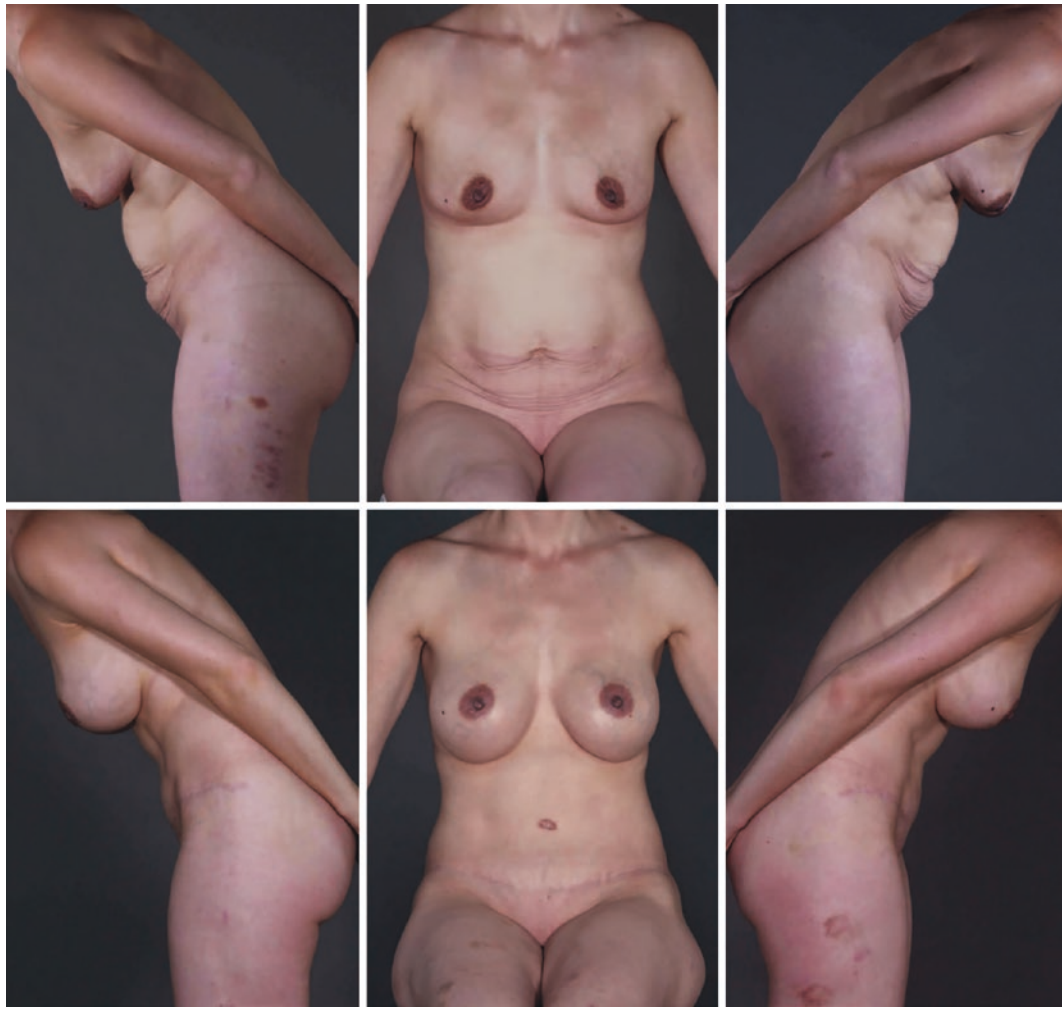

Fig. 9.3 Above, 35-year-old gravida 4 para 4 before abdominoplasty, suction lipectomy of the arms, back rolls, and breast augmentation. Below, result greater than 1 year after abdominoplasty (highlighting changes of the flexed abdomen), suction lipectomy of the arms, back rolls, and breast augmentation

9.2 Methods

We begin by reviewing the literature to elucidate the state of the art in combined abdominoplasty and breast surgery. We then consider the senior author's (AM's) experience with combined abdominoplasty and breast surgery in the context of our findings from the literature. We then offer recommendations for the successful and safe execution of combined abdominoplasty and breast surgery in the postpartum patient.

9.3 Findings from the Literature

9.3.1 Intra-abdominal or Pelvic Surgery with Concomitant Abdominal Contouring: The Origins of Combined Abdominoplasty and Breast Surgery

The practice of performing abdominal reshaping in conjunction with anatomically proximate operations such as gynecologic or intra-

abdominal surgery marked the beginning of efforts to combine abdominoplasty with other procedures. One of the first favorable reports on combing abdominoplasty with intra-abdominal, pelvic, or other aesthetic procedures came from Hester, who noted comparable complication rates and cited only obesity as a risk factor for unfavorable outcomes [6]. Other early reports were less encouraging. Voss reported higher morbidity, longer operative times, and protracted hospital stays when abdominoplasty was combined with common gynecologic operations [7]. Specifically, his data indicated that while no patients undergoing a single procedure had a pulmonary embolism (PE), 6.6% of patients undergoing combined procedures did have a PE. While initially alarming, these data are tempered by the realization that significant practice modifications have been enacted since these studies were performed. In the words of Beran, "comparison of DVT [deep venous thrombosis]/PE rates in these combined procedures before and after the adoption of these [venous thromboembolism prophylaxis] modalities is like comparing infection rates before and after the time of Fleming" [1].

The literature also informs our understanding of local complication rates related to adjacent combined procedures. Ali demonstrated, for example, that combining abdominoplasty with cesarean section leads to higher complication rates and inferior aesthetic results due to distorted local anatomy and compromised healing secondary to contamination [8]. More recent studies have reiterated that combining obstetrical procedures with aesthetic operations of the abdomen is ill-advised. For example, one group specifically recommends waiting at least 6 months after an obstetric procedure to perform a cosmetic abdominal procedure [9]. Fortunately, local problems that may arise during adjacent combined procedures, such as wound contamination and excess tension, are fairly easy to avoid as they are straightforward to conceptualize. According to Rubin's group, in the massive weight loss population, performing multiple procedures in the same operative setting increases the total number of complications for a given number of trips to the operating room. However, the absolute number of complications is the same as would be expected if all procedures had been performed individually [10].

We and others have discussed the concept of combining abdominoplasty with liposuction for flap suctioning or contouring of adjacent areas. Strategies for perioperative decision-making and approaches to intraoperative technical details to ensure synergistic aesthetic benefits from this combination have been addressed and are continuing to evolve [5, 11–14]. Dillerud showed that neither obesity nor suction lipectomy increased flap necrosis in abdominoplasty [15], and Ousterhout demonstrated the feasibility of combining abdominoplasty and high-volume liposuction in the obese patient [16]. It should be noted, however, that obesity is widely thought to be an independent risk factor for systemic morbidity and local wound healing complications [17–19].

9.3.2 Combining Abdominoplasty with Anatomically Distant Procedures, Including Breast Surgery

Combining abdominoplasty with proximate procedures such as liposuction, umbilical herniorrhaphy [20], and ventral hernia repair is now a regularly accepted practice. Present concern focuses on whether combining abdominoplasty with anatomically distant procedures increases risk, especially DVT/PE. Abdominoplasty and breast surgery are anatomically distinct. The procedure performed on one site does not necessarily impact the other (i.e., we have not seen any impact on inframammary fold location from tension on the abdominoplasty flap). Therefore, the issues in combined abdominoplasty and breast surgery—and for most examples of combined aesthetic procedures involving separate anatomical regions—often focus on systemic instead of local complications and the logistics of lengthy combined procedures rather than on the individual techniques themselves.

Although it does not seem to be clinically significant, the increased systemic risk, such as of

cardiac, pulmonary, blood loss, and anesthesia-related complications, is important to consider. The need for blood transfusions, for example, increases most in relation to larger volumes of liposuction, but is usually not related to the combination of abdominal and breast surgery. The literature supports these findings [2, 21–24]. Stevens reports no increase in complications when comparing abdominoplasty combined with breast surgery or facial rejuvenation to isolated abdominoplasty [2, 22]. He reports a revision rate of 13% for these combined procedures, noting that while a 13% revision rate is not insignificant, all of these patients would have required a second operation should their procedures have been staged from the outset [23].

While the breasts and the abdomen are anatomically distinct with regard to operative intervention, they are physiologically linked. Possible respiratory compromise after combined breast surgery and abdominoplasty with concomitant compressive surgi-bra and abdominal binder use was reported by De Castro [25]. No difference in complication rates between combined and isolated abdominoplasty was ultimately reported by this author. In our experience, performing combined aesthetic procedures on anatomically distinct areas such as the breasts and abdomen generally does not lead to an increase in systemic morbidity when instituting proper safety measures.

9.3.3 VTE Risk in Combined Abdominoplasty and Breast Surgery

VTE is the universally feared complication—the "elephant in the room"—that must be addressed during any discussion of combined, lengthy procedures in plastic surgery [26–29]. VTEs can be life-threatening, devastating events that occur as frequently as in 1.1% of abdominoplasties [5, 6, 30, 31]. DVTs are, in fact, evolving from random events to ostensibly preventable complications ("never events") for which government and insurance companies are making surgeons directly accountable in the modern healthcare environment.

Abdominoplasty is not a benign procedure in this regard. VTE was found to occur most frequently with abdominoplasty and abdominoplasty combined with another procedure (there was no significant difference in frequency between the two) in a survey of more than 1100 plastic surgeons on VTE occurrence and prevention in their practices [32]. The American Society of Plastic Surgeons (ASPS) VTE Task Force considers VTE risk in abdominoplasty high enough to warrant specific consideration [33]. Abdominoplasty was found to be the procedure most frequently associated with death and with death secondary to PE in the American Association for Accreditation of Ambulatory Surgery Facilities (AAAASF) data on 411,670 cases [34]. This study included 12 abdominoplasties resulting in death; 9 were performed in combination with another procedure. As this study was conducted as a retrospective multi-surgeon database review and no information about the patients' genetic predisposition to VTE was included, it is difficult to comment on the significance of this finding.

It is difficult to interpret data comparing the risk of VTE, PE, and death in abdominoplasty combined with other procedures to that in abdominoplasty alone. Broughton, for example, reported an increased VTE rate in a group of patients undergoing combined abdominoplasty and liposuction; however, these findings do not comment on the relative risk of VTE in abdominoplasty versus that in abdominoplasty plus liposuction as the only groups compared to abdominoplasty and liposuction in this study are face-lift and liposuction in isolation [35]. Alternatively, Simon reported findings consistent with those of the authors. That report demonstrates that VTE risk is not increased by combining abdominoplasty with other procedures including mastopexy, breast reduction, colostomy revisions, hysterectomy, and ventral hernia repairs. It also stresses the importance of careful patient selection and vigilant VTE prophylaxis [21].

The data surrounding this issue is quite complex, as highlighted by recent AAAASF data implying, counterintuitively, that combining abdominoplasty with three procedures is safer than combining abdominoplasty with two procedures [36]. Intuition, in contrast, would have us believe that additional procedures would increase risk depending on multiple factors (e.g., length, nature, and sequence of procedures). This dataset does not define or address these variables. This series does demonstrate, however, that combining abdominoplasty with one additional procedure has comparable VTE risk to performing abdominoplasty alone [36].

In addition to complexities within a given dataset, differences between datasets with their inherent biases (e.g., which cases they capture and what data they collect) should also be considered. For example, CosmetAssure data will not include metrics on complications dealt with in an outpatient office because its coverage does not extend to these situations. Alternatively, TOPS™ (Tracking Operations and Outcomes for Plastic Surgery) surveys and data are limited by the fact that they are dependent on self-reporting. AAASF data is skewed as it includes only data from accredited outpatient surgical centers.

Abdominoplasty is particularly prone to VTE for several reasons. Third spacing, increased intra-abdominal pressure [37, 38], tight external compression garments, and flexed positioning that decreases venous return from the lower extremities may exacerbate venous stasis [24]. Other predisposing VTE risk factors include decreased peripheral vascular resistance associated with general anesthesia, vessel injury incurred secondary to intense dissection of superficial veins, and decreased postoperative mobility [39].

Many recommendation schemes exist for VTE risk reduction in surgical patients. The Seventh American College of Chest Physicians Consensus Conference on Antithrombotic Therapy stratified patients into four VTE risk categories (low, moderate, high, and highest) defined by age, type of surgery, and additional risk factors [40]. While an important theoretical step in the direction of appropriate risk-based VTE prophylaxis in plastic surgery and its schema is often considered by plastic surgeons, there are limitations to applying this system to our patients. It is not clear, for example, if plastic surgery procedures qualify as "minor," "non-major," or "major," and the system is therefore not necessarily directly generalizable to our field [39].

The Davison-Caprini model is a widely accepted framework for VTE risk stratification and prophylaxis in plastic surgery despite its development for inpatients undergoing nonplastic surgery procedures [41, 42]. Typically, an otherwise uncomplicated abdominoplasty in a healthy patient is rated at four points (two for "major surgery" and two for a patient over age 40), immediately classifying the operation as high risk [42]. Others consider the operation itself to be worth five points [43].

Hatef retrospectively reviewed several hundred body-contouring procedures to assess the validity of the Davison-Caprini framework in an effort to provide VTE prophylaxis recommendations specific to body-contouring procedures [39]. This group found that the Davison-Caprini model effectively stratifies body-contouring patients. All patients in the Hatef study experiencing VTE were in the highest risk group as defined by the Davison-Caprini model [41, 42]. Enoxaparin (Sanofi-Aventis U.S. LLC, Bridgewater, NJ) use in the highest risk group demonstrated a trend towards VTE risk reduction [39]. In other groups, the VTE rate was too low to assess the effect. Higher hematoma rates, bleeding requiring transfusion, and increased intraoperative blood loss were also associated with enoxaparin use [39]. The timing of enoxaparin administration did not affect VTE rate, intraoperative bleeding levels, or transfusion requirements [39]. Prolonged enoxaparin administration (3 days or longer) did lead to greater transfusion requirements, but hematoma rate was not increased [39]. This group ultimately recommended starting enoxaparin, 40 mg daily, on the first morning after abdominoplasty [39]. Other guidelines are based on the mode of anesthesia and operative modality: one report, for example, suggests mechanical VTE prophylaxis with the administration of systemic anesthesia, along with

frequent assisted postoperative walks, and administration of low-molecular-weight heparin if operative time exceeds 4 h [1].

The role of pharmacologic intervention for VTE prophylaxis is controversial and remains an active conversation [35, 39, 41, 42, 44–59]. Swanson maintains that there is presently "no evidence of a benefit from anticoagulation in reducing the rate of VTE in plastic surgery patients" [60]. He cites Pannucci's VTEP study [52] as the only large-scale controlled trial of VTE chemoprophylaxis in plastic surgery patients. While the authors of that study conclude that enoxaparin is protective against VTE in high-risk plastic surgery patients, Swanson maintains that his review of the data presented in the Pannucci paper does *not* offer evidence of VTE protection with enoxaparin [45, 47, 60]. Instead, Swanson advocates for other forms of VTE prophylaxis including total intravenous anesthesia, avoidance of prone positioning, and avoidance of paralysis [45, 60]. Alternative chemoprophylaxis agents have been investigated as well. For example, Dini attempted to investigate the efficacy of the oral VTE prophylactic agent rivaroxaban. Unfortunately, this study was terminated early due to high hematoma rates in the treatment group [61]. It is also interesting, for context, to consider findings from a *New England Journal of Medicine* study funded by Sanofi (manufacturer of Lovenox) of over 8000 acutely ill medical patients showing that Lovenox administration conferred no benefit with regard to mortality rate [62].

This debate is fraught with conflicting data that has yet to be clearly parsed. Particularly interesting is an ongoing randomized, double-blind trial evaluating the role of weight-based versus fixed-dose chemoprophylaxis [63]. Therefore, decisions about the use of chemoprophylaxis should be made by the individual surgeon on a case-by-case basis depending on the unique characteristics of each situation. Pannucci et al. put it well when they recommended "using the 2005 Caprini score as a 'jumping-off'" point for surgeons to consider and conceptualize VTE risk among the aesthetic population [44]. A maximally informed decision can then be made for each patient.

9.3.4 The Significance of Operative Procedure Length

Combined aesthetic procedures can be very long operations. A variety of "moving parts" must be optimized to successfully complete a single-stage abdominoplasty and breast procedure. These can be broadly categorized as patient selection, perioperative preparation, procedural nuance, and postoperative protocol.

Operative time is the variable that is most readily quantified across studies investigating the safety of combining multiple procedures. The exact significance of operative duration is not completely understood: it is not clear if one 4-h procedure is preferable to two 2-h procedures from an outcome standpoint. We do know, however, that prolonged exposure to general anesthesia and other potentially deleterious intraoperative conditions (blood loss, hypothermia, hypotension, exposure to infection, etc.) interfere with the body's maintenance of physiologic homeostasis. Of course, every effort must be made to maintain homeostasis during anesthesia regardless of procedure length. Meticulous hemostasis should be ensured to minimize the physiologic effects of continued blood loss over extended operative procedures [1, 25, 64]. Maintaining normotension and vigilance in recognizing and treating postoperative hypertension may reduce postoperative hematomas [65]. Attention must be paid to maintaining normothermia: intraoperative hypothermia has been associated with increased blood loss, greater transfusion requirements, more frequent infections, higher cardiac morbidity rates, and more seroma formation [66, 67].

It is logical that minimizing operative time is paramount in reducing complication rates since factors contributing to deleterious outcomes increase in significance over time as homeostasis is progressively challenged [22, 68, 69]. De Castro emphasizes the importance of careful preoperative planning and marking, possible pres-

ence of assistants to close the breast incisions when the surgeon turns his or her attention to the abdomen, and well-trained surgical team (anesthesiologists, nurses, technicians) to streamline the operative workflow and minimize operative time in combined abdominoplasty/breast cases [70]. De Castro completed all combined abdominoplasties and breast procedures in his series in less than 3 h with these measures in place.

While it is intuitively clear that shorter operative times are desirable to minimize destabilization of homeostasis, precise guidelines regarding the upper limits of operative duration are elusive. Howland noted that after 6 h, an increase in cardiovascular, pulmonary, and renal complications occurred [68]. An association between operative times exceeding 140 min and occurrence of pulmonary embolism in a series of liposuction procedures was reported by Gravante [71].

It is difficult, however, to document causal relationships between the length of an operation and the risk of adverse outcomes due to abundant confounding factors. For example, Gravante attributed the increased PE rate he recorded after 140 min to the volume of fat that was suctioned. He noted that although these longer cases had higher rates of PE, there was only an 8.8% increase in patients with surgery exceeding 140 min. Moreover, he reported that only those with large volumes of liposuction (1500 g or more) experienced this complication. Similarly, in a comparison between patients undergoing head and neck, limb, and breast reconstruction, Fogarty concluded that it was the nature of the operation itself, rather than the actual length of the operation, that accounted for higher complication rates in long procedures [72]. Dr. Kim's group completed a 5-year study of over 15,000 plastic surgery procedures and demonstrated an association between operative duration and surgical, medical, and overall complication rates. This series demonstrated a sharp increase in complications in procedures that exceeded four-and-a-half hours in length [73]. Kenkel's group recently demonstrated that operative time is an independently significant predictor of morbidity in plastic surgery, with an increase in complications after 3 h [74]. As indicated by the extent of the discussion inspired by this topic [75–77], we cannot reach an absolute conclusion about the relationship between operative time and morbidity in this chapter.

VTE risk is widely believed to be impacted by operative time [41, 42, 78, 79]. The time added to an abdominoplasty by concomitantly performing a breast procedure therefore might increase VTE risk; this risk, moreover, may vary with the complexity of the breast procedure (i.e., it takes less time to perform a breast augmentation than an augmentation/mastopexy). In our experience, however, in appropriate low-risk patients (ASA category I), we have not observed increased VTE occurrence while limiting combined procedure length to less than 4 h and following our protocols for technique and prophylaxis. We ultimately use 4 h and the volume of any planned concomitant liposuction as approximate and arbitrary benchmarks when designing our operative plans. The decision to combine multiple procedures must be made on a case-by-case basis and account for the nature of the procedures to be combined as well as for patient-specific factors.

9.4 Impressions and Recommendations from Our Experience

The senior author published his initial experience with combined abdominoplasty and distant liposuction in 1995 [13]. In that series, 50% of the patients had concurrent procedures. Distant liposuction was the most common secondary procedure. Breast surgery and dermatolipectomy were among the other secondary procedures included in this series. There were no complications related to undergoing a concurrent procedure. In a more recent random analysis of the senior author's practice, 59 abdominoplasties were performed and evaluated over a 1-year period. All were performed in combination with other aesthetic procedures including breast reductions, mastopexies, augmentations, face-lifts, blepharoplasties, and rhinoplasties except for 16 cases. Again, no systemic complications occurred in this series.

It is, therefore, more common than not for us to combine abdominoplasty with an additional procedure, and the most frequently associated procedure is liposuction. We have found it feasible to combine breast surgery with abdominoplasty as long as appropriate logistical precautions are taken, and operative time is minimized. This course is consistent with the majority of the literature on the topic of combining abdominoplasty with additional procedures (Table 9.1), including recent AAAASF data [36]. This analysis showed abdominoplasty plus one additional procedure to be performed slightly more frequently than abdominoplasty alone (187,847 versus 176,092 cases, respectively), but abdominoplasty plus one, two, or three procedures is performed over 1.5 times more frequently than abdominoplasty alone (286,742 versus 176,092 cases, respectively). Critical elements in avoiding pitfalls with combined aesthetic procedures include careful patient selection, efficient and meticulous operative planning and technique, a carefully designed operative sequence including necessary changes in patient position, diligent fluid management, and a well-thought-out postoperative care plan including early ambulation and blood pressure management. Following are our

Table 9.1 Review of studies evaluating risk in combined abdominoplasty procedures

Reference	Procedures performed with abdominoplasty	Increased complications?	Additional comments
Cardoso de Castro and Daher (1978) [65]	Breast reduction	No	Avoid simultaneous compressive bras and abdominal binders
Pitanguy and Ceravolo (1983) [72]	Multiple	No	"Quadrangle" model: surgeon, patient, anesthesiologist, and surgical team must be optimized
Voss et al. (1986) [7]	Gynecologic procedures	Yes	
Hester et al. (1989) [6]	Assorted intra-abdominal and aesthetic procedures	No	
Dillerud (1990) [15]	Liposuction	No	Obesity noted not to predispose to wound healing problems
Cardoso de Castro and Cupello (1990) [23]	Breast reduction	No	
Ousterhout (1990) [14]	Liposuction	No	Obesity noted not to predispose to wound healing problems
Matarasso (1995) [12]	Liposuction	No	
Matarasso (2000) [13]	Liposuction	No	
Stevens et al. (2004) [2]	Breast surgery and facial surgery	No	
Simon et al. (2006) [19]	Breast surgery, assorted intra-abdominal procedures	No	Obesity associated with increased complications
Stevens et al. (2006) [20]	Breast surgery	No	
Stokes and Williams (2007) [22]	Breast surgery	No	
Stevens et al. (2009) [21]	Breast surgery	No	
Ali and Essam (2011) [8]	Cesarean delivery	Yes	

recommendations for the pre-, intra-, and postoperative periods to facilitate the practical and safe execution of combined abdominoplasty and breast surgery.

We do not find that combining aesthetic procedures necessitates any specific changes in the abdominoplasty markings, incision design, or postoperative plan of care. Moreover, the breast procedure (augmentation, reduction, mastopexy, or augmentation/mastopexy) that is indicated is not altered by the combined abdominoplasty.

9.4.1 Preoperative Practices

Several "red flag" patient characteristics emerged from our experience that apply to combining abdominoplasty with any procedure. Pulmonary conditions, smoking, exposure to secondhand smoke, clotting disorders, history of or increased risk for VTE, cardiac insufficiency, peripheral vascular disease, hypertension, obesity, bleeding diathesis, and diseases affecting microcirculation (diabetes, lupus, chronic fatigue syndrome) should warrant special consideration prior to undertaking combined abdominoplasty and breast surgery. If the patient's history is concerning for VTE (Rubin's group offers an excellent historical battery, Table 9.2) [80], screening should be performed for hereditary thrombophilias such as protein S deficiency, factor V Leiden mutation, protein C deficiency, or prothrombin 20210 A mutation. Fifteen percent of the Western population has some form of hereditary thrombophilia, and these conditions can dramatically increase the risk of VTE. Those homozygous for factor V Leiden mutations, for instance, have a relative risk for VTE of 79. This value increases to 100 with oral contraceptive use [80].

History of previous infection, as noted by Beran, is another potential warning sign for adverse outcomes [1]. We routinely utilize nostril mupirocin ointment (GlaxoSmithKline, Research Triangle Park, NC) in the perioperative period, as well as oral and intravenous antibiotics and antimicrobial body scrubs. At the time of surgery, alcohol-based prep solutions are used.

Table 9.2 Risk factors to consider in routine screening for thrombophilia. Reproduced with permission from Friedman et al. [80]

Personal history of VTE (including during pregnancy or while taking oral contraceptives). Unusual site of thrombosis (mesenteric, splenic, portal, hepatic, cerebral) also increases suspicion.
Personal history of idiopathic, migratory, or recurrent SVT in the absence of varicose veins.
Personal or family history of skin necrosis when receiving warfarin. Warfarin decreases the level of natural anticoagulants, rendering the patient temporarily hypercoagulable. Development of skin necrosis is suggestive of preexisting protein C or S deficiency.
Personal history of adverse pregnancy outcomes, including consecutive spontaneous abortions later than 10 weeks of gestation, three nonconsecutive spontaneous abortions, severe unexplained intrauterine growth restriction, intrauterine fetal death, placental abruption, or severe preeclampsia.
First-degree relative who had a VTE, especially at a young age.
First-degree relative with known hereditary coagulopathy.
First-degree relative of a neonate with purpura fulminans without sepsis. This suggests a homozygous state of protein C and S deficiencies.

VTE Venous thromboembolism, *SVT* superficial venous thrombosis

An important concern of combining breast surgery and abdominoplasty is an increased risk of systemic morbidity. VTE is extremely dangerous and occurs at a significant rate. While the data is still open to interpretation with regard to VTE prophylaxis, the operating surgeon should be well versed with the available literature so as to be able to make patient-specific decisions using metrics such as the Davison-Caprini model or equivalent systems prior to any surgery [41, 42, 48, 49]. Our patients discontinue the use of all female hormones (including drug-eluting patches, intravaginal devices [81], and intrauterine contraceptive devices) in the preoperative period. Nicotine usage, from any source [82], is also stopped. We offer our patients prothrombogenic blood test screening and postoperative venous Doppler testing. Capella has found evidence of VTE on ultrasound the morning after circumferential body lifts in up to 2% of cases [83]. Additionally, we liberally hydrate our

patients and use compressive stockings and sequential pneumatic compression devices prior to the induction of anesthesia.

To be a medically appropriate candidate for a combined procedure, medical "clearance" for each individual procedure must be obtained. Aesthetic surgery patients (especially those undergoing a combined procedure) should be healthy, low-risk (e.g., ASA I) patients. Precautions must also be taken to maximize the safety of each individual procedure. For example, if indicated prior to breast surgery, a mammogram must be obtained. Similarly, if clinical concern exists prior to implant cases, a screen for autoimmune issues is obtained. After all, the entire case may be compromised if there is a problem with one portion of a combined procedure. Preoperative planning for the massive weight loss patient demands special vigilance. The importance of patient selection, management of expectations, maintenance of intraoperative normothermia, and VTE prophylaxis in this population is highlighted by Rubin's group [84].

9.4.2 Intraoperative Considerations

The foundation of a complex combined procedure is an experienced, coordinated operative team. This includes perioperative personnel, nurses, scrub techs, assistants, and anesthesiologists. A 1903 *Wall Street Journal* editorial expresses the long-recognized importance of a cohesive, skilled group dedicated to the successful achievement of a common goal quite effectively: "A 'scrub' team which has thoroughly mastered the theory of co-operation will at football or baseball frequently beat a team of men who are far better players, individually, but do not understand how to work together" [85]. A team that has "mastered the theory of co-operation" may not, unfortunately, be the default in an operating room.

The surgeon must design a precise operative plan and convey that plan clearly to the surgical team. We regularly work with an anesthesiologist familiar with the logistics of combined cases. We inject superwet solution sequentially, beginning in the supine position. We continue injecting in the prone position when indicated and then perform any prone procedures (e.g., back and flank liposuction) so that the patient does not have to be flipped to the prone position after other procedures. We next perform any facial and breast procedures. This allows for extended monitoring for any signs of hematoma. Consequently, the abdominoplasty is done last as the "Miami Beach Chair Position" places the patient in extreme flexion that makes other procedures awkward.

While as mentioned earlier there is no "absolute cutoff" for safe operative time, we aim to limit total operative time in combined procedures to approximately 4 h. According to the Davison-Caprini model, VTE risk increases after only 45 min [41, 42]. We have found that in appropriately selected patients, this framework provides a reasonable amount of time in which to complete combination abdominoplasty and breast surgery or other procedures.

9.4.3 Postoperative Management

A "tectonic shift" has occurred in inpatient hospital admissions over the past decade. While in the past one-third of our patients were admitted for an overnight stay, we now perform all cases as outpatient procedures. The patients are then observed overnight by an experienced nurse. While the ultimate responsibility for safety rests with the surgeon, this new model has shared the burden of detecting postoperative problems with the patient and caregiver. This change has made patient and caregiver education even more critical so that they are adequately prepared to recognize problems. We additionally advise checking key areas several hours after completion of all procedures and prior to discharge (e.g., assessing the nipple-areola complex after breast reduction and the suprapubic region after abdominoplasty for ischemia). Liberal fluid intake is encouraged if medically appropriate, and a Foley catheter is used to assist with close tracking of fluid status. An abdominal binder is placed on postoperative day 3. We occasionally screen for DVT and offer patients a venous Doppler study postoperatively.

While it is true that most VTEs are subclinical, any cardiopulmonary symptoms or leg pain or swelling warrant a prompt evaluation. After suture removal, patient follow-up continues weekly to surveil for seroma or pseudobursa formation and to assess the overall quality of healing.

9.5 Conclusion

Abdominoplasty is a frequently performed procedure, and requests to combine this operation with other aesthetic procedures are becoming more popular. The tendency towards multiple births, later pregnancies, patients' desires to retain their youthful prepregnancy appearance, and the fact that nonsurgical alternatives do not provide the same degree of benefit have driven increasing demand for these procedures. Combined abdominal and breast procedures have become so popular—these body areas are often subject to the most recognizable alterations following pregnancy—that the term "mommy makeover" has been born.

When planning a combined procedure, local factors, systemic factors, and perioperative issues should be optimized so as to ensure that the safety and success of the combined procedure are comparable to those metrics for the individual procedures. The primary concern in combined procedures is systemic risk, particularly VTE.

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Combining Plastic Surgery with Vaginal Delivery or C-Section

10

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10.1 Introduction

The most frequent plastic surgeries combined with obstetrical procedures are abdominoplasty and liposuction. Considering the studies done in our population and medical evidence, we cannot recommend to combine this procedure during the obstetrical procedure. Maternity death is a serious problem and consequence found in this kind of procedures as well important number of complication as seroma, necrosis and unsatisfactory results that cannot make a recommendation to consider this kind of combination.

10.2 Scientific Evidence

The current interest in having a youthful figure and for proper nutrition and exercise has an influence on all women; sometimes, it can be considered that pregnant women can have a plastic surgery during delivery to regain as soon as possible the figure that was in the past or desired.

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The famous "mommy makeover" that transforms both the abdomen and the breasts (since they are the two regions with the most visible changes in the postpartum) leads many women to request for a tummy tuck; the conflict arises when that request is done at the same time of cesarean section or natural birth. Then the question arises: Is it safe to perform a tummy tuck in the immediate postpartum period?

The proposal to reduce surgical time with both procedures comes as a possibility. Although the normal physiological and hormonal changes are present, some surgeons may consider this procedure as possible. We decided to analyze the evidence in our population: first to know if plastic surgeons have experiences with this procedure and second to know the results with this type of combination.

A survey is a way of obtaining relevant data by asking questions to understand the issue, create a hypothesis, and develop solutions and recommendations.

We executed a survey, validated in content and consensus, and sent it to the members of the Mexican Association of Plastic Surgery in the months of May and June 2016.

We found that 61 surgeons performed a combination of abdominoplasty and cesarean section or natural delivery. The total number of procedures reported was 808, with an average of 13.24 procedures per surgeon, varying between 1 and 41 procedures per surgeon [1].

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_10

The plastic surgery procedures were as follows: abdominoplasty (242 cases, 29.95%), abdominoplasty plus liposuction (210 cases, 25.99%), mini-lipectomy (18 cases, 2.22%), mini-lipectomy plus liposuction (121 cases, 14.97%), and liposuction (217 cases, 26.85%). In 783 cases (96.9%), the combination was with cesarean section and in 25 cases (3.13%) with vaginal delivery (Table 10.1).

The following complications occurred, in order of prevalence: seroma (255 cases, 31.57%), thrombosis (212 cases, 26.23%), infection (170 cases, 21.03%), skin necrosis (127 cases, 15.71%), and hematoma (42 cases, 5.19%). There were three deaths due to thrombosis (0.4%). There were redundant skin abdominal wall defects in 336 cases (41.66%), unaesthetic scars in 291 cases (36.11%), abdominal wall defects in 134 cases (16.58%), unpleasant contours in 22 cases (2.72%), and rotational folds in 22 cases (2.72%) (Table 10.2).

Fifty-five surgeons (90.16%) decided to stop delivering with these practices.

Table 10.1 Types of procedures

Type of aesthetic procedure	
Abdominoplasty	242 (29.95%)
Abdominoplasty plus liposuction	210 (25.99%)
Mini-lipectomy	18 (2.22%)
Mini-lipectomy plus liposuction	121 (14.97%)
Liposuction	217 (26.85%)

Type of obstetric procedure	
C-section	783 (96.9%)
Vaginal delivery	25 (3.13%)

Table 10.2 Types of complications

Seroma	255 (31.57%)
Thrombosis	212 (26.23%)
Infection	170 (21.031%)
Skin necrosis	127 (15.71%)
Hematoma	42 (5.19%)
Abdominal wall redundancy	336 (41.66%)
Unaesthetic scars	291 (36.11%)
Abdominal wall defects	134 (36.11%)
Unpleasant contour	22 (2.72%)
Rotational folds	22 (2.72%)
Mortality	3 (0.4%)

During pregnancy, women go through physiological changes in all of their organs and functions; breathing changes occur starting at the fourth week of gestation, and edema may occur in the upper respiratory tract, which favors infectious processes. The mucous epithelium becomes friable and can be easily damaged when placing an orotracheal tube for general anesthesia [2]. Additionally, a pregnant uterus elevates the diaphragm and the heart and can lead to changes in the electrocardiogram, arrhythmias, and functional murmurs. In extreme situations, it can also lead to pericardial effusion: circulatory volume increases from 30 to 50% with a dilution of hemoglobin to supply for the metabolic processes of the fetus and to compensate for the blood lost during delivery [3]. Progesterone induces changes in the digestive tract; increases salivation; changes the pH in the oral cavity; increases cavity formation, pyrosis, and gastric acids; and stimulates the formation of gallstones and cholecystitis. Changes in the position and function of the stomach and esophagus are present, which leads to regurgitation and increases the risk of bronchial aspiration. Fibrinogen and factors VII, VIII, X, and XII prevent hemorrhage during delivery but can simultaneously increase the risk of thrombosis [4, 5].

Not only cardiovascular or respiratory system changes, but also in the kidney, renal blood flow and glomerular filtration rate rise 50–60%, creatinine clearance rises, and colloid osmotic pressure decreases. In the skin, the patient may experience increased extracellular fluid and hyperpigmentation of the face, neck, areolas, abdominal midline, and perineum, which greatly increases the laxity of the skin that occasionally causes stretch marks [2].

It is important to note that all these changes return to normal in several weeks [6].

The knowledge of the physiological changes related to the obstetric patient is an element of great value to make decisions when combining procedures with a normal delivery or cesarean section.

Before our report, we found that Ali and Essam compared two groups of patients: one group of 50 females that underwent both abdomi-

noplasty and cesarean section and another group of 80 women who underwent only abdominoplasty [7]. Among the first group, 36% had complications, and in the second group, 11.3% of the patients had complications. Abdominoplasty is an aesthetic procedure with the highest incidence of complications, which increases when combined with other procedures [8, 9]. The incidence of complications that we found was 11.75%, and it increased when combined with other surgeries.

Benn and Spera allude to the physiological changes that occur during pregnancy and right after postpartum; these changes include physiological anemia, hypercoagulability, and loss of blood during the postpartum period [10]. Patients with these changes are not ideal candidates to undergo combined procedures.

Matarasso and Smith indicate that the best time to realize a body-contouring procedure is when the patient has returned to her normal physiological status, which is reached around the sixth week after delivery [6]. Jackson mentions that the risk for thrombosis increases 21.5–84 times postpartum and then decreases rapidly [3]. In hospitalized and surgical patients, symptomatic thrombosis is present in 1.4–1.8% of patients and mortal thrombosis is present in 0.8% [5, 11].

The most significant cause of death in patients who undergo combined abdominoplasty or liposuction is pulmonary thromboembolism [12, 13]. When both procedures are combined, the risk is higher [8, 9]. We found a high incidence of thrombosis (26.31%) in patients with combined procedures. Other authors found that the combination of abdominoplasty with cesarean section or natural delivery leads to a high incidence of postsurgery complications and poor aesthetic results [14]. Surgeons that were part of this research reported cutaneous redundancy, unaesthetic scars, defects of the abdominal wall, and an unpleasant contour.

For some surgeons, the increase in uterus volume and the secondary effects of a cesarean section caused skin flaccidity with crease formation and a loose abdominal wall. These are the most common reasons to proceed with both an abdominoplasty and a cesarean section; additionally, the authors consider this to avoid a new surgery meaning another anesthetic procedure. Usually, during the immediate postpartum period, it is common to observe persistent abdominal bulges, lack of a defined waistline, and redundant skin in the lower abdomen; these body disturbances are due to the persistent uterus growth that stretches the abdominal skin and hinders the surgeon's ability to estimate the adequate cutaneous resection. A few months later, the uterus involutes, the skin loosens out, and the abdominal flaccidity becomes more obvious. Infections, wound dehiscence, and necrosis are frequent complications that are usually attributed to contamination of vaginal exudates and disturbances in abdominal tissue irrigation [3, 15]. Time in the operating room should also be considered a risk factor for complications. Combining obstetrical procedures with plastic surgery results in a longer time in the operating room. The obstetrical procedure is not free of complications, as we have mentioned. If combined with other procedures, such as any plastic surgery, there are greater possibilities of risk due to a longer procedure time.

We should not forget that there is a strong association between pathological scars and pregnancy. If patients have a predisposition to this type of condition, there is a greater chance of having an unsatisfactory result. In addition, patients with keloid or hypertrophic scars can have a recurrence of these problems [16].

10.3 Home Points and Conclusion

Therefore, due to the current evidence and as long as no additional information suggests a different approach for this clinical situation, we firmly recommend avoiding the combination of obstetrical procedures with abdominoplasty or any other corporal contour surgery.

Legislation in every country is different. In our case, authority considers maternal death during the first year after delivery. Risk must be balanced with assistance of the patient with care of baby, and it is suggested to wait for 6 months to recover and evaluate the final size of the abdomen and uterus.

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Part IV

Skin

Dermatological Changes During and After Pregnancy

11

Ana Mª. González-Pérez, Daniel Bancalari-Díaz, and Javier Cañueto

Take-Home Points

- The endocrine, metabolic, and immunological changes occurring during pregnancy are associated with many alterations of the skin and its appendages that are generally considered physiological.
- Hyperpigmentation is the most common skin alteration during pregnancy and generally affects previously pigmented areas such as the areola, the axilla, or the genitals. It usually improves during puerperium.
- Although nevi tend to become hyperpigmented and increase their size symmetrically during pregnancy, there is no evidence of an increased risk of malignancy development. No clinical or histopathological atypical condition of the skin may be attributed to pregnancy.
- Pruritus is one of the most common symptoms during pregnancy (up to 20%) as well as the main symptom of the four dermatoses associated with pregnancy.
- A pregnant woman with intense pruritus and skin lesions requires a complete clinical-pathological assessment in order to correctly diagnose a dermatosis with potential associated maternofetal risks such as intrahepatic cholestasis of pregnancy or pustular psoriasis of pregnancy.
- Atopic eruption of pregnancy is the most common pruritic disorder during pregnancy, and it generally appears before any other specific dermatosis of pregnancy. It has no associated maternal or fetal risks.

11.1 Introduction

The skin is the largest organ of the body. It performs many vital functions, including protection against external agents, thermoregulation, evaporation control, and sensory functions. It is composed of three layers (Fig. 11.1):

- The epidermis is the outermost layer which serves as a protective barrier. Its main component is cells known as keratinocytes, which synthesize keratin.

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© Springer Nature Switzerland AG 2023
M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_11

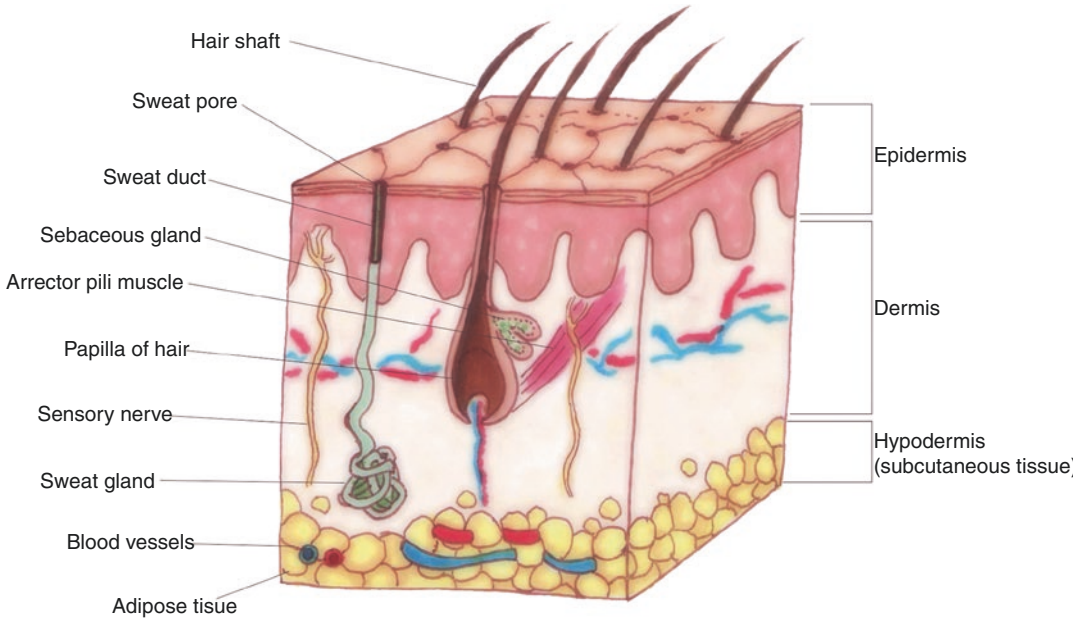


Fig. 11.1 Anatomy of the skin

- The dermis is the middle layer and is made up of collagen. It contains hair follicles and sweat glands.
- The hypodermis or subcutaneous tissue contains fat cells (lipocytes).

Puerperium is the period after childbirth required for the reproductive organs to return to the state before pregnancy. It usually lasts 6 weeks [1, 2]. The endocrine, metabolic, and immunological changes that take place during pregnancy are associated with many alterations of the skin and its appendages [3, 4]. These changes are generally considered physiological, in view of their high prevalence [5]. Many of these alterations resolve during puerperium, but others can extend beyond childbirth or are exclusive to the postpartum period [6, 7]. In this context, we can establish three categories into which dermatosis may be classified during pregnancy and puerperium:

- Preexisting dermatoses affected by pregnancy
- Specific dermatoses of pregnancy
- Dermatoses that are actually physiological changes caused by pregnancy and largely induced by hormonal and immunological alterations

11.2 Preexisting Dermatoses

Pearls and Pitfalls
During pregnancy, diseases associated with a Th1 immune response like psoriasis tend to improve, while those associated with a Th2 response like atopic dermatitis generally worsen.

Pregnancy may have positive or negative effects on the state of some preexisting skin conditions. Diseases associated with a predominantly Th1 immune response tend to improve during pregnancy, while those associated with a Th2 response generally worsen [8].

Psoriasis usually improves during pregnancy and flares up 6–12 weeks after childbirth [9], whereas psoriatic arthritis tends to become worse. Atopic dermatitis, lupus ery-

thematosus, and pemphigus vulgaris tend to worsen during pregnancy and improve after labor [9, 10].

11.3 Pregnancy-Specific Dermatoses

Dermatoses of pregnancy are a heterogeneous group of inflammatory and pruritic dermatoses that appear exclusively during pregnancy and the immediate postpartum period [7, 10].

Holmes and Black (1983)	Shornick (1998)
Prurigo of pregnancy	Herpes gestationis
Herpes gestationis *(pemphigoid gestationis)*	Pruritic urticarial papules and plaques of pregnancy (PUPPP)
Polymorphic eruption of pregnancy	Cholestasis of pregnancy
Pruritic folliculitis of pregnancy	Prurigo of pregnancy

For many years, pregnancy-specific dermatoses were a diffuse group of overlapping conditions mostly known from sporadic cases and series of clinical cases. The first classification, which distinguished four conditions, was made by Holmes and Black in 1983 [11]. The second was proposed by Shornick in 1998 [12], which added intrahepatic cholestasis of pregnancy to the previous list [13]. The most recent classification, proposed by Ambros-Rudolph et al. (2006) [14], introduces a further entity, known as atopic eruption of pregnancy [10, 13]. Therefore, five categories of dermatosis of pregnancy are currently recognized [9, 10]:

- Pemphigoid gestationis
- Polymorphic eruption of pregnancy
- Atopic eruption of pregnancy
- Intrahepatic cholestasis of pregnancy
- Pustular psoriasis of pregnancy (formerly known as impetigo herpetiformis, but now considered a variant of pustular psoriasis that is probably related to relative hypocalcemia of pregnancy)

11.3.1 Atopic Eruption of Pregnancy (AEP)

- ***Synonyms:*** Prurigo of pregnancy, prurigo gestationis, early-onset prurigo of pregnancy, pruritic folliculitis of pregnancy, linear IgM dermatosis of pregnancy, eczema of pregnancy

Pearls and Pitfalls

AEP is the most common and the one with an earlier onset of all pregnancy-specific dermatoses. Up to 80% cases do not have a previous history of atopy. Diagnosis is eminently clinical; no further studies are needed unless diagnostic doubts arise. Treatment is based on topical corticoids, emollients, and humectants associated or not with systemic antihistamines. Although it is not associated with an increase in maternofetal risk, recurrences are common in subsequent pregnancies.

AEP is the most common pruritic disorder during pregnancy, occurring in approximately 50% of cases of dermatosis of pregnancy [9, 15], and it generally appears before any other specific dermatosis of pregnancy (around 75% before the third trimester; generally, in the first or second trimester) [16].

11.3.1.1 Signs

AEP is described as a flare-up or as the first episode of skin changes with eczema and/or papules during pregnancy in patients with atopic diathesis in which other specific dermatoses have been ruled out [10, 17]. The association with atopy goes unnoticed in many patients because most of them (up to 80%) were previously unaware that they had atopic skin [17]. It sometimes may appear as pruritic folliculitis (perifollicular papulopustular eruption, also known as pruritic folliculitis of pregnancy) [18].

Two-thirds of patients present eczematous lesions that generally affect typical regions of atopic dermatitis such as the face, neck, and flexor surfaces of extremities (Fig. 11.2). One-third of patients present a papular eruption on the

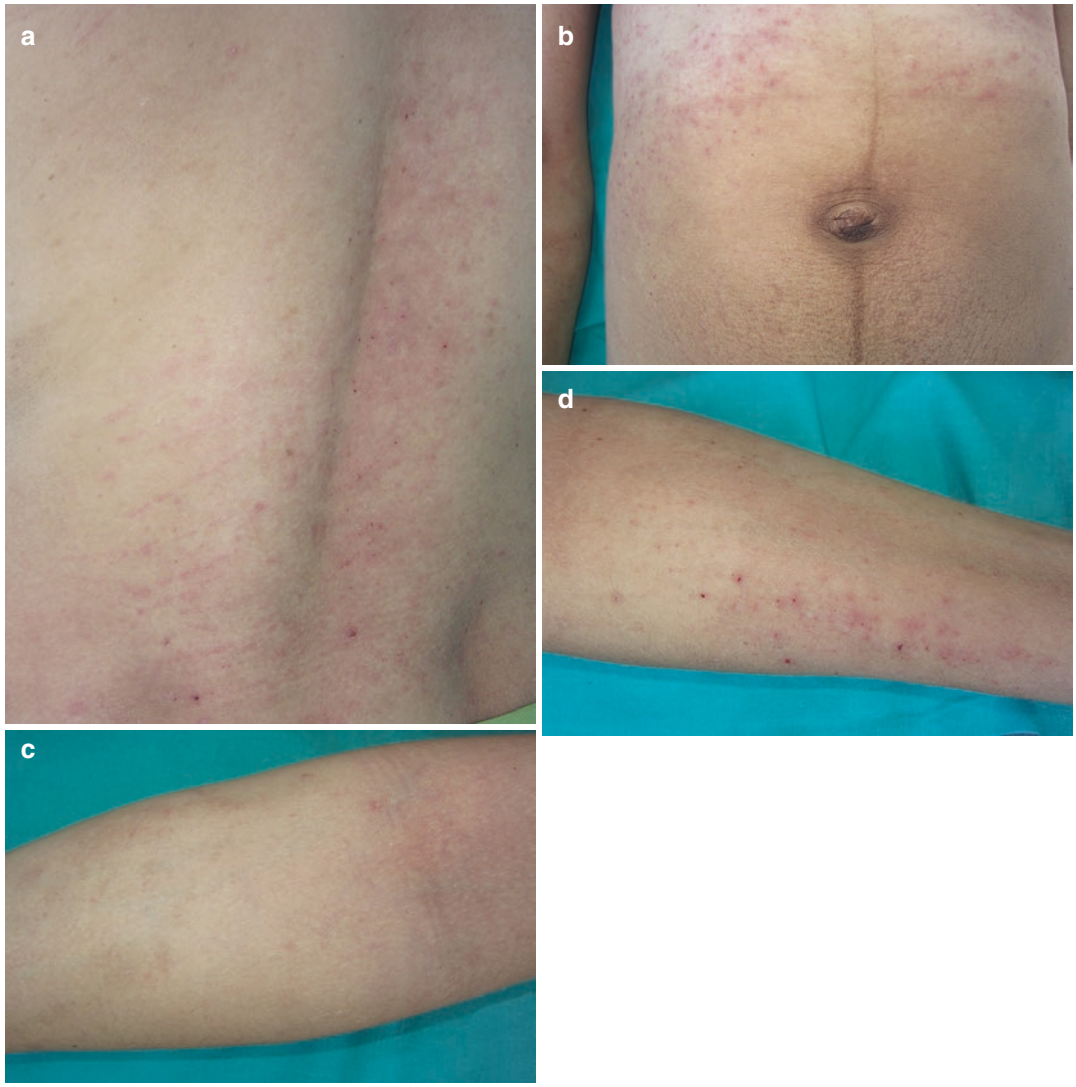


Fig. 11.2 Diffuse generalized eczema lesions in a pregnant patient with atopic eruption of pregnancy **(images a–c)**. The skin appears dry and lichenified, especially in flexural areas like the crease of the elbow **(image d)**

torso and extremities, with prurigo-like lesions or small erythematous papules [10]. Xerosis is a common occurrence.

11.3.1.2 Complementary Tests

The histology of this condition is unspecific, and direct immunofluorescence is negative. Serum IgE is elevated in up to 70% of cases [9].

11.3.1.3 Prognosis

No risk to the mother or fetus. Common recurrence in subsequent pregnancies [15].

11.3.1.4 Treatment

Treatment is based on topical corticoids, associated or not with systemic antihistamines [5]. Emollients and humectants are also useful (topical 10% urea, polidocanol, pramocaine, and menthol are safe during pregnancy) [10]. UVB radiation is very useful in severe cases. Secondary bacterial infection may require systemic antibiotics.

11.3.2 Pemphigoid Gestationis (PG)

- ***Synonyms:*** Herpes gestationis

Pearls and Pitfalls
PG is an autoimmune disease caused by antibodies against collagen XVII. Its diagnosis is based on a combination of clinical findings, skin biopsy of perilesional skin, and determination of serum antibodies. Treatment is based on topical corticosteroids, although the more severe cases may require prednisone 0.5 mg/kg. Due to the maternofetal antibodies' transmission, up to 10% of newborns might experience mild symptoms. Furthermore, it is associated with an increased risk of premature labor and with small-for-gestational-age newborns. Recurrence is common in subsequent pregnancies.

This is a rare, blistering, bullous, pruritic, and self-limiting rash that appears towards the end of pregnancy (second or third trimester) or in the immediate postpartum period, although it can appear at any point during pregnancy [17]. It is an autoimmune disease and is the only pregnancy-specific dermatosis that can also affect the skin of the newborn, as occurs in up to 10% of the cases of dermatosis of pregnancy due to the transfer of antibodies through the placenta, although the effect is generally mild [9]. Its estimated incidence is 1:20,000 to 1:50,000 pregnancies. On rare occasions, it is associated with trophoblastic tumors such as hydatidiform mole or choriocarcinoma [10].

11.3.2.1 Pathogenesis

It is caused by circulating IgG1 antibodies against the bullous pemphigoid antigen of 180 kDa, also known as collagen XVII, a transmembrane glycoprotein of hemidesmosomes expressed in the basal membrane of the skin. The primary site in which autoimmunity originates seems to be the placenta, because the autoantibodies attach not only to the basal membrane of the epidermis, but also to the membrane of the chorionic and amniotic epithelium (both of which have an ectodermal origin) [15, 17].

Currently, the stimulus that triggers the production of antibodies is unknown, but the focus has been put on immunogenetics and a potential cross-reactivity between the placental tissue and the skin, because autoantibodies also attach to the amniotic basal membrane. Some authors have suggested that it is triggered by an anomalous expression of anti-MHC class II DR3/DR4 antibodies (paternal haplotype) that start an allogeneic response to the placental basal membrane, which, in turn, presents cross-reactivity with the skin [9]. The incidence of anti-HLA antibodies is almost 100% in patients with a history of PG. Since the only source of different human leukocyte antigens is generally the placenta (which usually comes from the father), the universal finding of anti-HLA antibodies implies a high frequency of immunity attacks during gestation. Women with PG also exhibit an elevated expression of class II MHC antigens (DR, DP, DQ) in their chorionic villi [9, 10].

11.3.2.2 Signs

PG is clinically characterized by a sudden onset of skin lesions on the torso, particularly on the abdomen and often inside the navel or in the surrounding area (Fig. 11.3) [5]. Pruritus may precede the appearance of visible lesions. The rash generally starts on the torso as urticarial plaques or papules surrounding the navel. Vesicles may also appear. It then rapidly evolves to a generalized pemphigoid-like rash with papules and urticarial pruritic plaques followed by clustered herpetiform vesicles or tense blisters on erythematous plaques. This eruption may affect the entire body including palms and soles (Fig. 11.4) [15], but the face and mucosal areas are only rarely involved [17].

11.3.2.3 Diagnosis

Its diagnosis is based on a combination of clinical findings, the biopsy of perilesional skin, and the determination of serum antibodies against the NC16A domain of protein BP180 [19]. Levels of autoantibodies are not related to the severity of this condition and do not offer clues to its prognosis [16]. These levels may remain elevated up to 1 year after pregnancy and persist in subsequent pregnancies without any other signs of pemphigus [9].

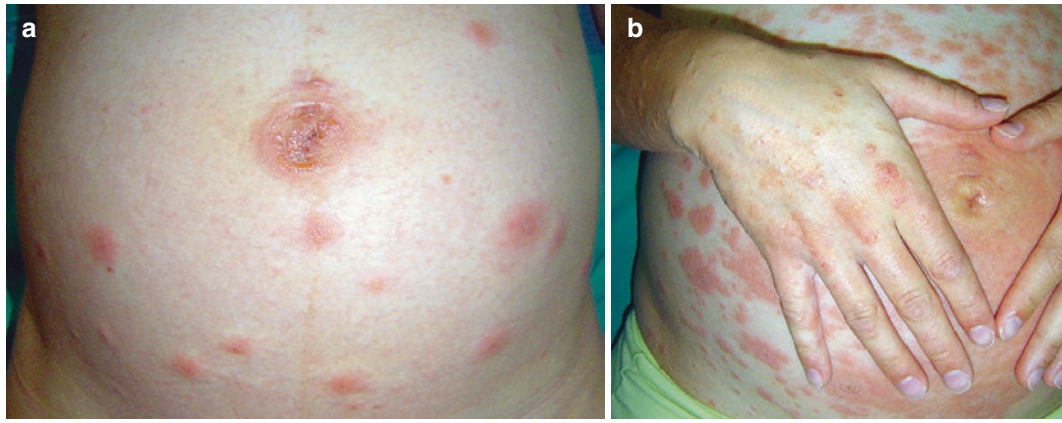


Fig. 11.3 Blistering urticarial papules and plaques in a pregnant woman **(image a)**, which are rapidly evolved to a generalized rash with urticarial papules and plaques **(image b)**. Notice the navel involvement, which is an unlikely finding in polymorphic eruption of pregnancy

Fig. 11.4 The lesions may affect palms and soles, but rarely involve face or mucosal areas

The classic histological finding of a subepidermal vesicle is present in a minority of patients, and it is more common to find unspecific mixed cellular infiltrate with a variable amount of eosinophils at the dermoepidermal junction [15]. The presence of eosinophils is the most constant histological finding in PG [18]. Direct immunofluorescence makes it possible to observe a linear deposition of C3 throughout the area of the basal membrane [9].

11.3.2.4 Differential Diagnosis

It is important to distinguish PG from polymorphic eruption of pregnancy, because both conditions may present urticarial lesions and drug-induced eruptions or multiform erythema. It is also important to appreciate how it differs from dermatitis herpetiformis, which is associated with gluten sensitivity, lesions that generally appear on the elbows, the knees, the back of the forearms, the back, the buttocks, and the scalp, with granular IgA deposits visible under direct immunofluorescence [9].

11.3.2.5 Treatment

The objectives of the treatment are to sooth the itchy skin and prevent the appearance of blisters. In mild cases, powerful topical corticoids associated with emollients and systemic antihistamines may suffice [5]. In more severe cases, or cases that do not respond to topical drugs, prednisone 0.5 mg/kg may be used, although the dose must be progressively reduced as soon as blisters stop appearing [15]. Flare-ups associated with childbirth require a temporary increase in the dose [10]. Women with severe and persistent PG after childbirth may require higher doses of oral corticoids (up to 2 g/kg/day), or even other immunosuppressant agents such as cyclosporin or rituximab [9].

11.3.2.6 Prognosis

Although its presentation and clinical evolution may vary considerably, spontaneous improvement is common in the final stages of pregnancy. It is associated with an increased risk of premature labor and with the newborn being small for its gestational age, the risk being related to the severity of the disease [18]. There is no increased risk of abortion [9]. Recurrence is common in subsequent pregnancies (up to 75%), although recurrence and/or flare-ups are also associated with menstruation and oral contraceptives. Women with a history of PG may have an increased risk of developing Graves' disease [10].

PG may resolve before labor, but it flares up after childbirth in 75% of patients and reappears in at least 2% of patients as a result of contraceptive use or during menstruation. In most cases, it resolves spontaneously within the first weeks/months after labor. It generally reappears in subsequent pregnancies, at greater intensity, although it may also skip pregnancies [15, 18].

11.3.3 Polymorphic Eruption of Pregnancy (PEP)

- ***Synonyms:*** Pruritic urticarial papules and plaques of pregnancy (PUPPP), Bourne's toxemic rash of pregnancy, late-onset prurigo of pregnancy, toxemic rash of pregnancy

Pearls and Pitfalls

PEP is a common gestational dermatosis characterized by papules and urticarial plaques that usually start inside pregnancy stretch marks during the last stages of the third trimester. Unlike PG, it does not affect the periumbilical region. Diagnosis is clinical, and most patients respond to topical corticoid therapy and oral antihistamines. There is no risk to the mother or fetus. Recurrences are rare.

PEP is a common gestational dermatosis, with an incidence of 1:200 pregnancies [9], characterized by a typical clinical presentation, with normal results in the analysis and negative immunofluorescence or ELISA. It is more common in primigravida women in the final weeks of their pregnancy and/or in the immediate postpartum period. Its etiopathogenesis is unknown. The risk factors for its development include multiple pregnancies and weight gain by the mother [17].

11.3.3.1 Signs

Signs include papules and urticarial plaques that usually start inside pregnancy stretch marks during the last stages of the third trimester or in the immediate postpartum period, and which generally do not affect the periumbilical region (Fig. 11.5). Its onset is more frequent in the last stage of the third trimester (85%) or in the immediate postpartum period (15%) [15, 17]. The eruption generally spreads over several days, although it does not usually affect the face, palms, or soles. As the disease progresses, polymorphic lesions appear (vesicles, erythema, targets, and eczematous lesions) (Fig. 11.6) [5, 10].

11.3.3.2 Diagnosis

Its diagnosis is clinical, based on the history of the patients and the findings of a physical examination. Its histological characteristics are unspecific (superficial and deep perivascular infiltrate, interstitial lymphocytic infiltrate that may be accompanied by eosinophils), with negative immunofluorescence [9]. The ordinary analytical assessment is normal.

The differential diagnosis must take into account erythema multiforme, viral exanthem, and scabies [9].

11.3.3.3 Treatment

Most of the patients improve with topical corticoid therapy and oral antihistamines. The most severe cases and/or cases with intense itching may require the use of systemic corticoids [5, 15].

11.3.3.4 Prognosis

There is no risk to the mother or fetus, and recurrence is rare. Its evolution is self-limiting, and it disappears 2 weeks after labor [10].

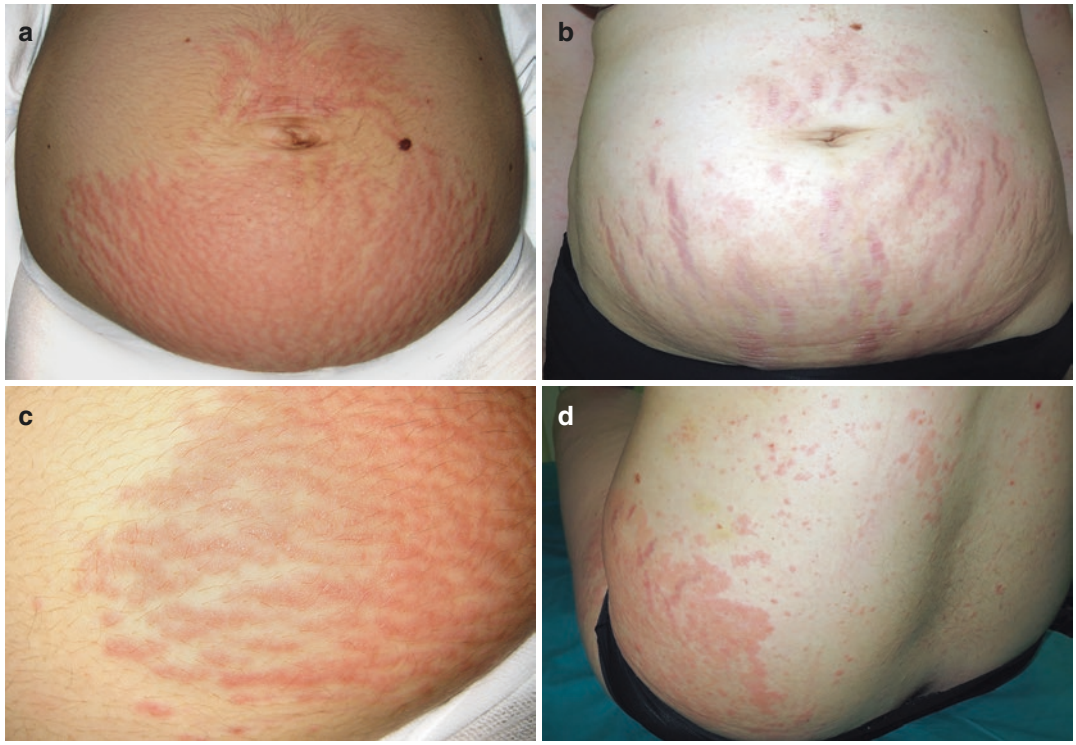


Fig. 11.5 PEP rash usually begins in the stretch marks of the abdomen, without affecting periumbilical area **(images a and b)**. The urticarial papules may grow together forming larger wheal-like plaques on the abdomen or thighs **(images c and d)**

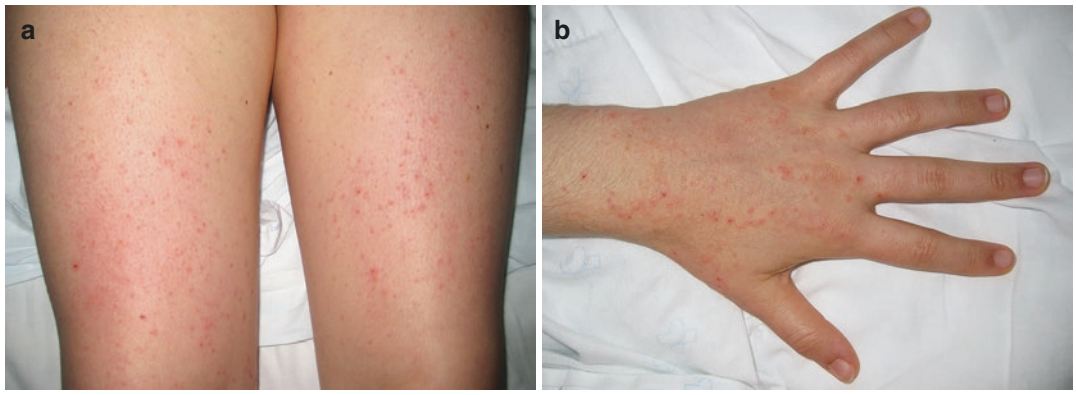


Fig. 11.6 PEP lesions are polymorphous and sometimes may adopt a vesicle-like appearance (**a**). The intense pruritus may also induce the apparition of excoriations (**b**)

11.3.4 Intrahepatic Cholestasis of Pregnancy (ICP)

- **Synonyms:** Cholestasis of pregnancy, obstetric cholestasis, cholestatic jaundice of pregnancy, prurigo gestationis

Pearls and Pitfalls
ICP is a hormone-dependent cholestasis that appears in the last stages of pregnancy. Usually, it presents as pruritus followed by scratching lesions. Diagnosis is made upon finding an elevated total serum concentration. The total serum concentration of bile acid can predict adverse fetal effects, and it is associated with an increase of fetal death when it exceeds 100 μmol/L. Treatment is based on oral ursodeoxycholic acid and usually requires close monitoring.

Warning Box
Although the prognosis for the mother is good, there are increased risks of premature birth, intrapartum fetal distress, and fetal death. Therefore, maintaining a high level of suspicion might allow early diagnosis and treatment, which in turn may prevent fetal damage.

It is a rare form of cholestasis that is reversible, hormone dependent, and associated with genetics. It generally appears in the last stages of pregnancy (mainly in the third trimester) as pruritus without primary skin lesions [5]. Thus, the usual presentation of this condition is the absence of clinically evident lesions. Secondary skin changes are correlated with the duration of the disease, and they range from tiny excoriations to severe nodular prurigo [10]. Its incidence is greater in multiple pregnancies [9, 10]. It is the most common hepatic condition that appears exclusively during pregnancy [15].

11.3.4.1 Signs
Prurigo generally starts on the palms and soles. The most commonly affected areas are the extensor regions of extremities, buttocks, and abdomen [15]. Jaundice is only present in 10% of patients and is usually a complication in the most severe and prolonged cases (in these cases, it may be associated with steatorrhea, with the subsequent vitamin K deficiency and the increased risk of intra- and postpartum hemorrhage) [9, 10]. The prurigo is maintained until delivery and then spontaneously resolves within days [20]. Prolonged evolution is rare, and this makes it necessary to rule out other pathologies (mainly primary biliary cirrhosis) [9, 17].

11.3.4.2 Pathogenesis
A decrease in the bile acid excretion rate causes an increase in serum concentration, which leads to intense pruritus for the mother and harmful effects for the fetus (the bile acid that enters the placenta may cause acute fetal anoxia) [9]. Some of the known predisposing factors include mutations in the genes encoding the bile transport proteins. Therefore, a mild dysfunction that is asymptomatic in nonpregnant women may become symptomatic when the capacity of the transporters to segregate substrates is exceeded [14, 18].

11.3.4.3 Diagnosis
An elevated total serum concentration of bile acid is a diagnostic factor (>11 μmol/L in pregnant women; normal range in nonpregnant women: 0–6 μmol/L) [15, 20]. Levels of transaminases may be elevated. In women with jaundice, the level of conjugated (direct) bilirubin is elevated and prothrombin time may be high [20]. The liver ultrasound is generally normal, although in women with jaundice, calculi may be observed. Its histology is unspecific, and immunofluorescence is negative [10].

The total serum concentration of bile acid can predict adverse fetal effects. When it exceeds 100 μmol/L, it is associated with an increased risk of fetal death [20].

11.3.4.4 Treatment
The treatment is based on oral ursodeoxycholic acid [20].

11.3.4.5 Prognosis
Although the prognosis for the mother is good, there are increased risks of premature birth (20–60%), intrapartum fetal distress (20–30%), and

fetal death (1–2%) [9, 20]. Fetal risk is associated with the serum concentration of bile acid, particularly when it is over 40 μmol/L [10, 20]. Therefore, this is the most important gestational pruritic disorder, and it must be diagnosed and treated from an early stage in order to prevent fetal damage. Recurrence is observed in 45–70% of subsequent pregnancies [20].

11.3.5 Pustular Psoriasis of Pregnancy (PPP)

- ***Synonyms:*** Impetigo herpetiformis

Pearls and Pitfalls

PPP is a rare variant of psoriasis that usually appears in the third trimester. While not a pregnancy-specific dermatosis per se, given the relevance of its rapid recognition and treatment, it is still included in this category. The most severe cases may require hospitalization and close monitoring of both mother and fetus. Systemic corticoids are often the first-line therapy with low-dose cyclosporine as an alternative. PPP is associated with placental insufficiency, miscarriage, fetal growth restriction, and stillbirth. It has a high risk of recurrence in subsequent pregnancies.

PPP is a very rare variant of generalized pustular psoriasis that appears during pregnancy or is triggered by it. This condition generally appears in the third trimester, but it may appear before that stage or in the immediate postpartum period [21]. In the past, it was known as impetigo herpetiformis, but it is not associated with bacterial colonization or with the herpes virus. There is controversy regarding its inclusion in the list of specific dermatoses of pregnancy, since it is not a type of dermatosis as such, but rather a variant of psoriasis. However, given the relevance of its rapid recognition and treatment, it is still included in this category [9, 10]. Hypoparathyroidism, hypocalcemia, stress, and infections have been suggested as potential triggers of pustular psoriasis [21].

11.3.5.1 Signs

Symmetrical erythematous plaques with peripheral sterile pustules in a circinate pattern [21]. The plaques evolve and expand across the peripheral area, whereas the center erodes and crusts over. The eruption starts in the flexural areas and spreads centrifugally [9]. The torso and extremities are usually affected, while the hands, feet, and face are not. There may be oral and esophageal lesions as well as nail involvement. In severe cases, the rash may develop into erythroderma. There is generally no itching, although the general condition is affected (malaise, fever, anorexia, nausea, vomiting, diarrhea, tetany) [10, 21].

11.3.5.2 Complementary Tests

The diagnosis can be clinical, although a biopsy is usually recommended for histological confirmation, given the potentially severe consequences of the disease and its treatment on the fetus [21]. Leukocytosis and increased ESR are common [9]. Hypocalcemia leading to tetany may also occur.

The differential diagnosis distinguishes PPP from infections, such as candidiasis, impetigo, and tinea corporis, which may be ruled out through the examination of cultures and reactions to drugs [9, 10].

11.3.5.3 Treatment

Treatment includes hospitalization and close monitoring of mother and fetus, correction of hypocalcemia if it is present, and maintenance of hydroelectrolytic balance [21].

Systemic corticoids are the initial therapy (moderate cases, approximately 30 mg/day; severe cases, up to 60–80 mg/day for several days, with progressive reduction when the symptoms improve, and close monitoring in case of flare-ups) [21]. Low doses of cyclosporin (2–3 mg/kg/day) may be an alternative to systemic corticoids during pregnancy. It is classified as category C, with low teratogenic effects, although there is a risk of preterm labor and of

the newborn being small for its gestational age [21]. Other treatments, such as anti-TNFα (infliximab), have been used satisfactorily in isolated cases [9]. Phototherapy with narrowband UVB is safe during pregnancy, and PUVA is recommended during breastfeeding. Some experts recommend a combination with antibiotics (cephalosporin), even though the pustules are sterile [9].

In severe and recalcitrant cases and in cases that do not respond to treatment, labor may be induced as an alternative, because the eruption generally resolves after birth [9].

11.3.5.4 Prognosis

PPP generally resolves in the postpartum period, but there is a high risk of recurrence in subsequent pregnancies. It may be associated with placental insufficiency, miscarriage, fetal growth restriction, or stillbirth [21].

11.4 Skin Changes During and After Pregnancy

Pearls and Pitfalls

- Hyperpigmentation is the most common skin alteration during pregnancy and generally affects previously pigmented areas such as the areola, the axilla, or the genitals. It usually improves during puerperium.
- Melasma is more common among patients with darker phototypes (IV to VI) in whom it tends to persist after puerperium.
- Epulis is the most common vascular tumoral lesion during pregnancy and usually resolves spontaneously during puerperium.
- Diffuse hair loss during puerperium (postpartum telogen effluvium) has a high prevalence. It generally starts 3–6 months after labor, with an average duration of 2–5 months.

	Post-maternity changes in skin			
	Hyperpigmentation	Vascular changes	Striae	Hair loss
Treatment	– Topical solution with 4% hydroquinone – Superficial dermabrasion – Laser therapies	– May resolve spontaneously postpartum – Intralesional corticoid injection – Surgical excision – Laser therapies	– Retinoid creams – Non-ablative fractional laser	– Topical 2% minoxidil solution

11.4.1 Pigmentation

11.4.1.1 Hyperpigmentation

Between 85 and 90% of all pregnant women present some degree of skin hyperpigmentation, which is the most common skin alteration [4, 22]. Hyperpigmentation may be mild or moderate and generally affects previously pigmented areas such as the areola, the axilla, or the genitals [4]. Pigmentation of the linea alba, giving rise to what is known as the linea nigra, and of scars is also relatively common [3].

Changes in pigmentation are usually considered to be conditioned by the increase in melanin production induced by the elevation of MSH, estrogen, and progesterone levels [22].

11.4.1.2 Melasma

Melasma is the appearance of dark macules and patches, mainly on the neck and face. The most frequently affected anatomical regions are the nose and the cheeks (Fig. 11.7) [23]. It appears in 50–70% of pregnant women [4], generally starting during the first trimester. It is more common among patients with darker phototypes (III to VI) [24, 25], in whom it tends to persist after puerperium [3]. Its pathogenesis involves hormonal factors and the action of UVA radiation [24], making it particularly important for patients to use sunscreen with UV filters [24].

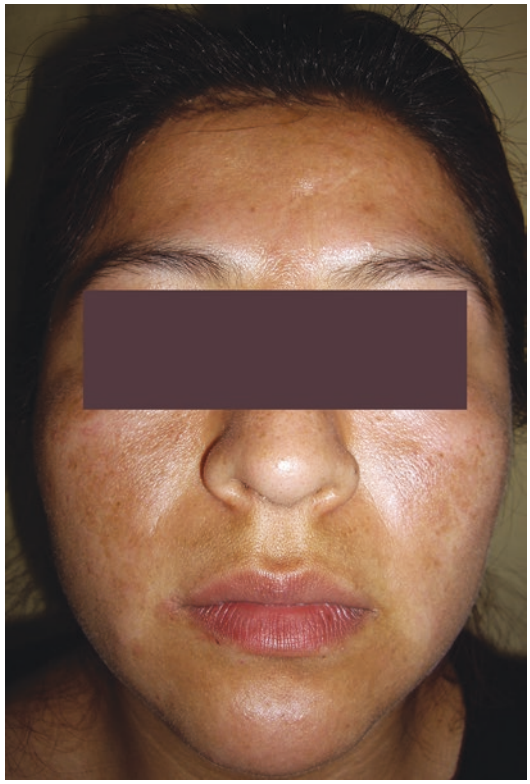


Fig. 11.7 Blotchy flat brown patches on both cheeks and above the upper lip in a puerperal woman. Melasma is more common in people with darker phototypes (specially III and IV)

11.4.1.3 Nevi and Melanoma

Warning Box

Although nevi tend to become hyperpigmented and increase their size symmetrically during pregnancy, there is no evidence of an increased risk of malignancy development. Despite this fact, no clinical or histopathological atypical condition of the skin may be attributed to pregnancy.

Although nevi tend to become hyperpigmented and to increase their size symmetrically during pregnancy, they generally do so in areas that are particularly prone to expansion, such as the torso, and they usually return to their normal state during puerperium [4, 26]. There is no evidence of an increased risk of malignancy of the nevi during pregnancy [27]. No clinical or histopathological atypical condition of the skin may be attributed to pregnancy (Fig. 11.8) [3, 27]. In addition, in the case of melanomas, some studies have reported that even though melanomas that appear during pregnancy are generally thicker, on average, this does not mean that the melanomas themselves are associated with a worse prognosis [28, 29]. Therefore, it is important to remain alert to any suspicious clinical or dermatoscopic changes, and biopsies of suspicious lesions are indicated, just as in any other patient [26, 27].

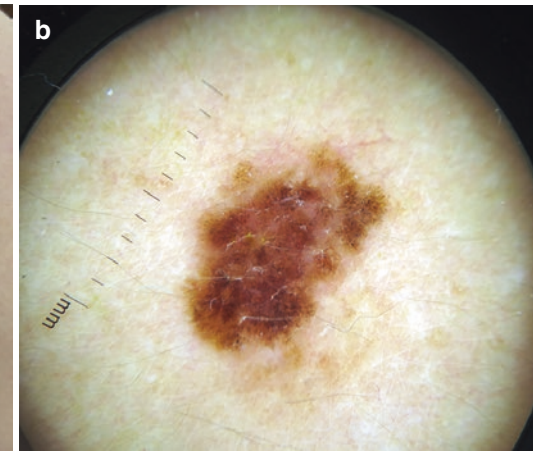


Fig. 11.8 Dysplastic nevi on the back. Notice the ill-defined borders and variable pigmentation. No clinical atypia may be attributed to pregnancy. Thus, biopsies of suspicious lesions are indicated just as in any other patient **(image a)**. Dermoscopy. Homogeneous pattern with patchy distribution of hyperpigmented areas **(image b)**

11.4.2 Vascular Changes

Hormonal changes during pregnancy increase the production of angiogenic factors such as vascular endothelial growth factor (VEGF) or fibroblast growth factor (FGF) [27], which cause an increase in vascular distension, instability, and proliferation [4]. In this regard, spider nevi and varices are a common occurrence (Fig. 11.9), as well as the appearance of *cutis marmorata*, palmar erythema, and gingival hyperplasia [5].

On the other hand, the increase in venous hydrostatic pressure may promote the appearance of edema, generally on the lower limbs [16], although it has also been described on the face and hands [22]. Varices may also occur on the lower limbs and the perianal region (hemorrhoids) [4, 30]. Varices tend to improve during puerperium, but they do not achieve complete remission [8].

Gingival pyogenic granuloma, or epulis, is the most common vascular tumoral lesion during pregnancy (Fig. 11.10) [27], and it usually resolves spontaneously during puerperium, although in some cases, particularly those accompanied by intense hemorrhaging, surgical treatment may be required [27, 30].

11.4.3 Striae Gravidarum

Stretch marks are linear lesions that initially have an erythematous or purplish color and that evolve to become atrophic whitish scar-like lesions [31]. They are often symptomatic and accompanied by itching and a burning sensation and may have a profound emotional impact on patients [31, 32]. They are the second most common skin change during pregnancy, with a prevalence that ranges from 70 to 90%, depending on the series [3, 4], and they are the most common alteration of the connective tissue. They generally appear on the breasts, abdomen, hips, buttocks, and thighs (Fig. 11.11) [22, 31].

Their origin is unknown, although some authors have suggested that they may be triggered by the combination of several elements, including genetic factors, weight gain and/or periods of rapid growth, or hormonal changes [31, 33]. The risk factors for the appearance of stretch marks include age (higher risk at younger ages), a maternal history of stretch marks, and being overweight before pregnancy and before delivery [32].

The most effective treatments include creams with retinoids (e.g., tretinoin 0.05%) and non-

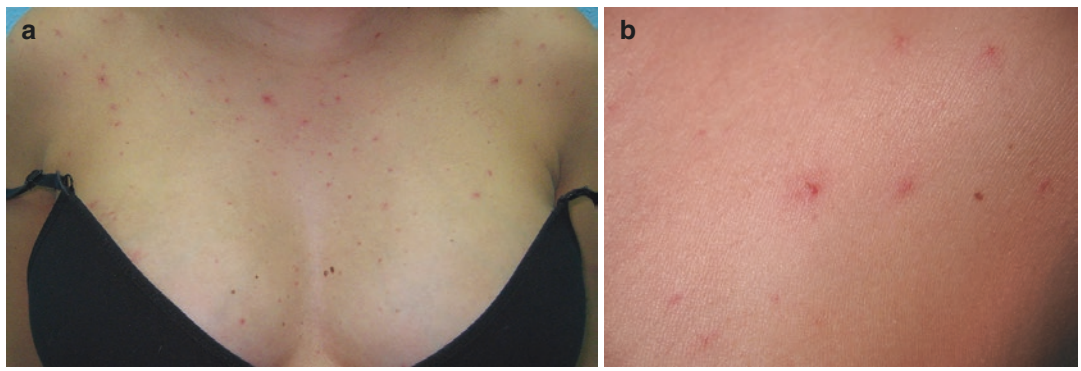


Fig. 11.9 Multiple spider angiomas in a pregnant woman's chest **(image a)**. The spider angioma, also known as spider nevus or spider telangiectasia, is a vascular lesion characterized by the dilatation of the skin vasculature. It usually appears as a bright red dot surrounded by reddish extensions with a weblike appearance **(image b)**. They may appear as solitary or multiple lesions

Fig. 11.10 Ulcerated vascular lesion on the maxillary gingiva and interdental papilla of a pregnant patient. The patient also had a venous lake on the upper lip

Fig. 11.11 Whitish swollen lines following the skin tension lines of both breasts

ablative fractional laser [32]. For prevention, creams with extract of *Centella asiatica* and daily massages are the most strongly evidence-based therapeutic approaches, although further research into this topic is required [32].

11.4.4 Glands

The activity of eccrine and sebaceous glands increases, whereas the activity of apocrine glands decreases during puerperium [4]. The increased activity of sebaceous glands promotes the growth of Montgomery tubercles, which are papules located on the areolas that revert to their pregestational state after labor [22, 23]. The effects of the sebaceous activity on the potential worsening of acne during pregnancy and puerperium are not definitively established [22]. On the other hand, the activity of eccrine sweat glands increases during pregnancy, with the possible appearance of hyperhidrosis and miliaria [16].

11.4.5 Hair

11.4.5.1 Postpartum Telogen Effluvium

Diffuse hair loss during puerperium is a well-known condition because of its prevalence and the psychological impact it has on patients.

During pregnancy, the anagen phase becomes longer, causing a degree of hirsutism and hypertrichosis [34, 35] that is affected by the increase in levels of estrogens and progesterone (Fig. 11.12) [36, 37]. After childbirth, the levels of both hormones decrease, and the alterations in the hair cycle revert to their original state [38]. Therefore, the hair rapidly switches to the telogen phase, which, in turn, manifests itself as diffuse hair loss (>150 hairs per day) [36, 39]. The latency period from childbirth to the onset of hair loss varies among patients. It generally starts 3–6 months after labor, with an average duration of 2–5 months [1, 34], although in some cases it may last over a year [35].

11.4.5.2 Androgenetic Alopecia

Just as the rapid shedding of hairs under the influence of estrogens to the telogen phase leads to the appearance of telogen effluvium, it may also reveal androgenetic alopecia, which leads to the superimposition of the two conditions [36, 38]. In most cases, this scenario follows the female pattern proposed by Ludwig, although in others it may exhibit Hamilton's male pattern (Fig. 11.13) [36]. Since it generally appears during puerperium, topical minoxidil may be used as treatment without the risk of secondary effects for the newborn [36].

11.4.6 Nails

Although there are no known pathognomonic changes that affect the nails during pregnancy

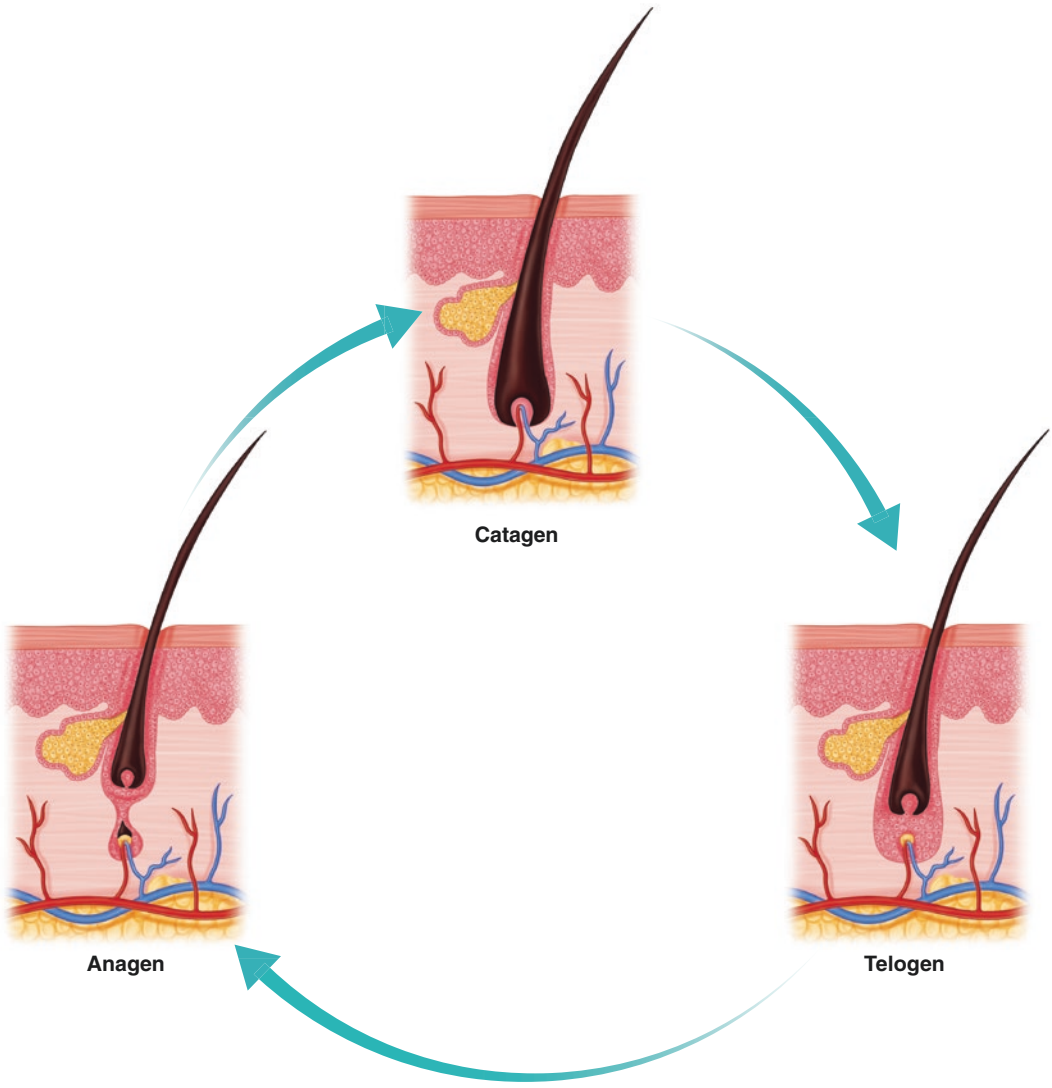


Fig. 11.12 Hair growth cycle has three stages: anagen, catagen, and telogen. Anagen is the growing phase of the hair and determines the length of hair. The catagen phase is a transitional stage in which growth stops; the hair follicle shrinks and detaches from the dermal papilla. Finally, the hair enters the resting phase or telogen. When telogen phase ends, the resting hairs fall out allowing the new hair to grow and restarting the cycle. Each single hair can be at a different stage of the growth cycle. A healthy scalp has around 100,000 hair follicles of which 85–90% are in anagen, around 3% in catagen, and 5–10% in telogen phase. During pregnancy, the increase in levels of estrogen and progesterone extends the anagen phase. After childbirth, the levels of both hormones decrease, and the alterations in the hair cycle revert to their original state. Therefore, the hair rapidly switches to the telogen phase manifesting as a diffuse hair loss

[3], alterations on the nails appear in 2–40% of pregnant women [22]. The most common disorders are leukonychia, subungual hyperkeratosis, distal onycholysis, longitudinal melanonychia, and transverse bands [5].

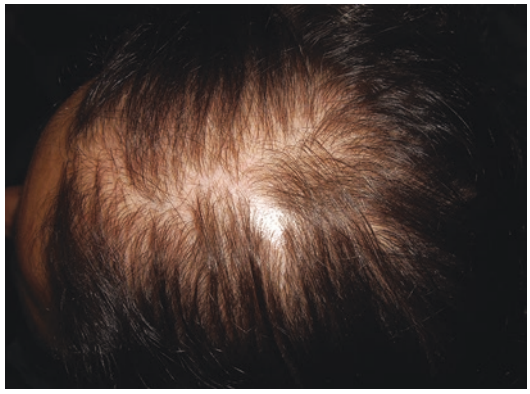
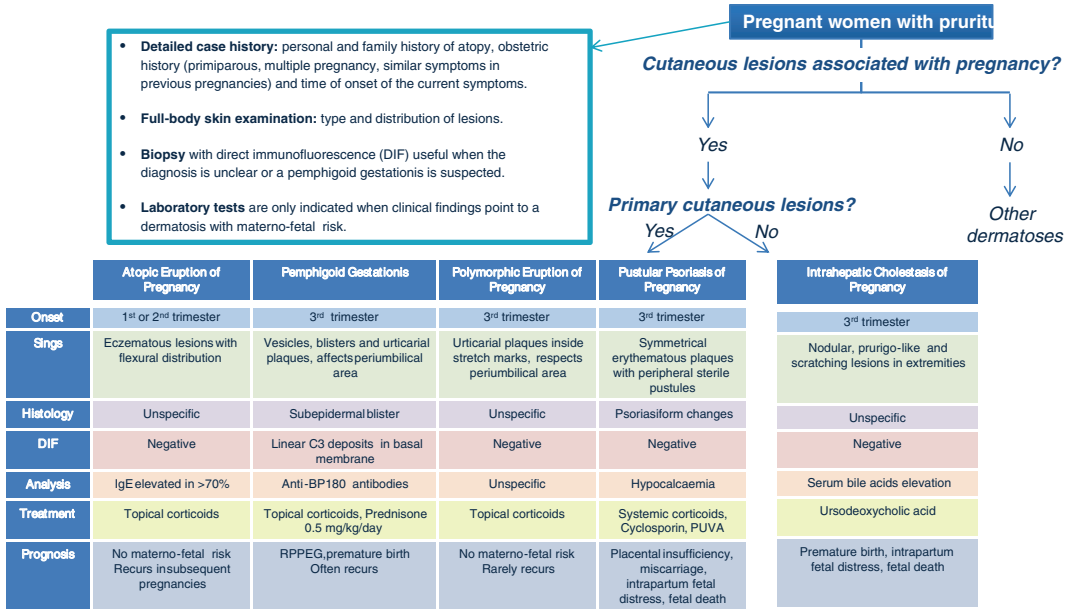


Fig. 11.13 Female pattern hair loss (androgenetic alopecia) in a puerperal woman. The telogen effluvium aggravated her condition

11.5 Assessment of Pregnant Women with Pruritus

Pruritus is one of the most common symptoms during pregnancy (it appears in up to 20% of all pregnancies) [15]. It is also the main symptom of the four dermatoses associated with pregnancy, although it may also be associated with casual dermatoses that are concurrent during pregnancy (e.g., scabies, urticaria, and pityriasis rosea) [9].

A pregnant woman with intense pruritus and skin lesions requires an emergency clinical-pathological assessment of the possibility of associated fetal risks (Fig. 11.14). The assessment includes the following steps [10, 15]:



	Atopic Eruption of Pregnancy	Pemphigoid Gestationis	Polymorphic Eruption of Pregnancy	Pustular Psoriasis of Pregnancy	Intrahepatic Cholestasis of Pregnancy
Onset	1st or 2nd trimester	3rd trimester	3rd trimester	3rd trimester	3rd trimester
Sings	Eczematous lesions with flexural distribution	Vesicles, blisters and urticarial plaques, affects periumbilical area	Urticarial plaques inside stretch marks, respects periumbilical area	Symmetrical erythematous plaques with peripheral sterile pustules	Nodular, prurigo-like and scratching lesions in extremities
Histology	Unspecific	Subepidermal blister	Unspecific	Psoriasiform changes	Unspecific
DIF	Negative	Linear C3 deposits in basal membrane	Negative	Negative	Negative
Analysis	IgE elevated in >70%	Anti-BP180 antibodies	Unspecific	Hypocalcaemia	Serum bile acids elevation
Treatment	Topical corticoids	Topical corticoids, Prednisone 0.5 mg/kg/day	Topical corticoids	Systemic corticoids, Cyclosporin, PUVA	Ursodeoxycholic acid
Prognosis	No materno-fetal risk Recurs in subsequent pregnancies	RPPEG, premature birth Often recurs	No materno-fetal risk Rarely recurs	Placental insufficiency, miscarriage, intrapartum fetal distress, fetal death	Premature birth, intrapartum fetal distress, fetal death

Fig. 11.14 Algorithm: Assessment of pregnant women with pruritus

- A detailed case history, including a personal and family history of atopy, obstetric history (primigravida, multiple pregnancy, similar clinical events in previous pregnancies), and the time from the start of the current signs (early or late pregnancy).
- A full-body skin examination to determine the type and distribution of the lesions.
- A biopsy with direct immunofluorescence when the diagnosis is not clear and there is a suspicion of PG. A biopsy is also recommended to confirm the diagnosis of pustular psoriasis of pregnancy [21].
- Laboratory tests (bile acid, metabolic panel, antibodies against antigen 180 of bullous pemphigoid) are only indicated when the clinical findings raise suspicion of a dermatosis with risk to the mother and/or fetus, such as PG, ICP, and generalized pustular psoriasis [20, 21].

Being primigravida and having multiple pregnancies are closely associated with polymorphic eruption [15], whereas a history of identical skin findings in previous pregnancies (recurrence) indicates intrahepatic cholestasis [20]. An early presentation (75% before the third trimester) is typical of atopic eruption [9, 10], while other disorders appear later during pregnancy or after childbirth. The abdominal location of the skin lesions is characteristic of PG and polymorphic eruption, and involvement of the torso and extremities is typical of atopic eruption, while a predominant involvement of the extremities suggests intrahepatic cholestasis [20]. The combination of pruritus as the only presenting symptom (particularly when it is predominant on the palms and soles) followed by lesions that are exclusively secondary to scratching is only observed in intrahepatic cholestasis [9, 10].

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Wound Care and Treatment of Scars

12

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Take-Home Points

- Prevention, based on proper surgical technique and judicious postoperative care, is the best treatment for scars.
- Recent research suggests that hypertrophic scars and keloids are caused by the same fibroproliferative pathology and that their different clinical and pathological features largely reflect the degree of inflammation in the healing wound.
- Treatment combinations are typically the best option when treating hypertrophic scars and keloids.
- Every scar should be considered unique, and each scar may require a customized approach.
- An early diagnosis and adequate treatment of surgical wound complications are part of the prophylactic treatment of scars.

12.1 Introduction

Cutaneous scarring following surgical procedures is unavoidable, and increasingly patients request specialists to avoid visible scars whenever possible. What patients do not usually imagine is that the management of scars is a therapeutic challenge.

This chapter discusses the techniques used to prevent and treat scars, specifically those associated with pregnancy (episiotomy and cesarean section) and elective post-pregnancy surgeries (mastopexy, abdominoplasty, liposuction, etc.).

Consequences associated with scars are not only cosmetic; abnormal scarring may also cause the patient to have functional disabilities or symptoms of pain, tightness, and pruritus. Moreover, scars may induce distress and decreased quality of life because of their aesthetically unpleasant appearance.

12.1.1 Skin Anatomy

The skin is the largest organ of the body. It receives 1/3 of the body's blood volume. The human skin consists of cells and extracellular matrices, and its thickness varies from 0.5 to 6.0 mm.

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© Springer Nature Switzerland AG 2023
M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_12

Our skin layer has many crucial functions [1]:

- Protective barrier: physical, mechanical, and immunological
- Social function (appearance)
- Synthesis of vitamin D
- Thermoregulation
- Touch, proprioception, pain

The skin is composed of three layers that, from outer to inner, are epidermis, dermis, and hypodermis (Fig. 12.1).

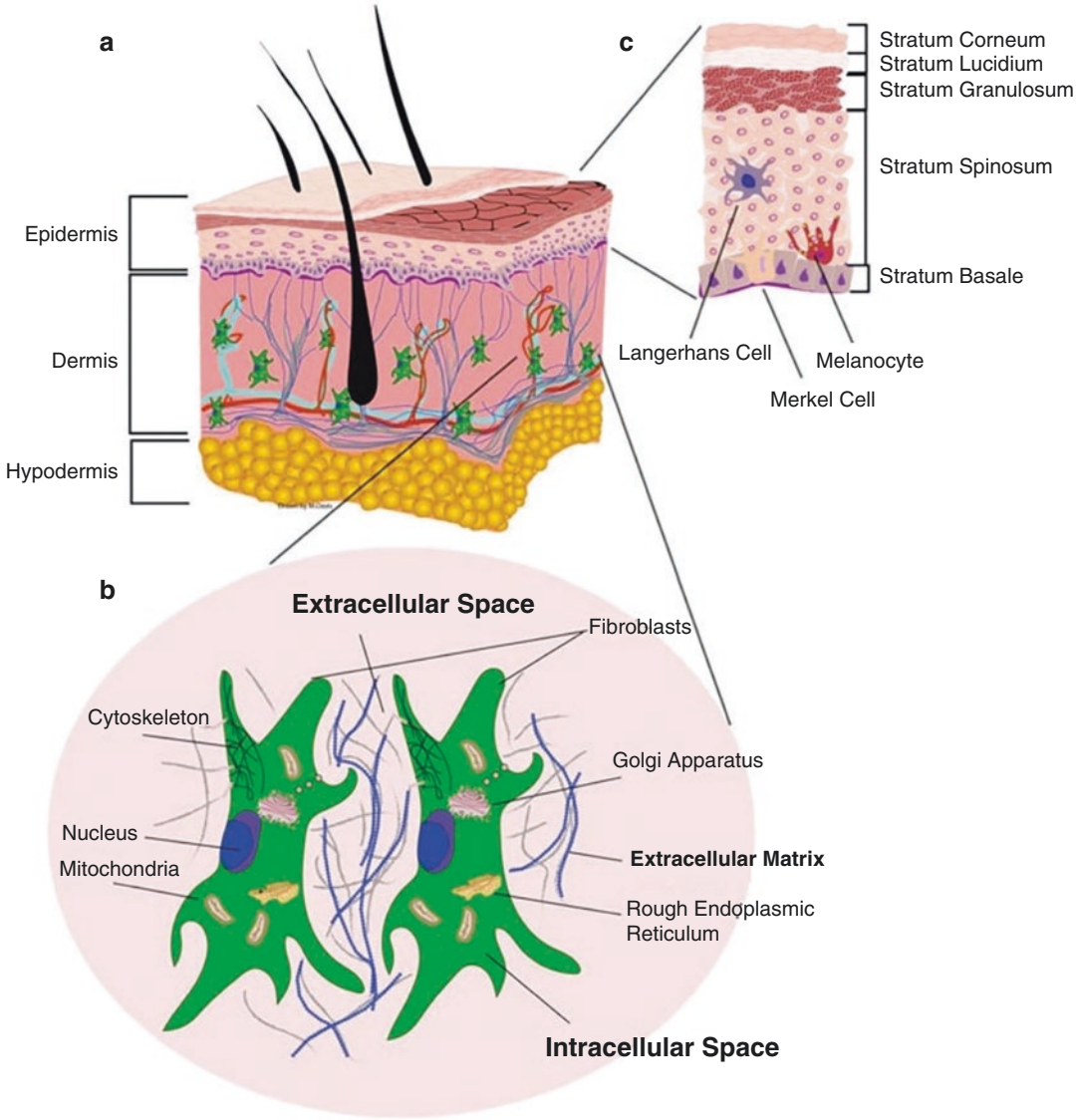

Fig. 12.1 Skin anatomy. (**a**) Human skin is composed of three layers: epidermis, dermis, and hypodermis. (**b**) The major cellular components of the dermis are fibroblasts, which interact with the external extracellular matrix of collagen, fibronectin, and elastic fibers. (**c**) The epidermis layer is composed of five layers: basal, spinous, granular, lucid, and corneum layer. Reprinted from Limbert G. Skin Biophysics. From Experimental Characterisation to Advanced Modelling. Switzerland: Springer; 2019

12.1.1.1 Epidermis

The epidermis is a stratified squamous keratinized epithelium. It is an avascular layer, receiving blood supply from the dermis across the semipermeable basement membrane. The thickness of the epidermis varies in different types of skin. It is the thinnest on the eyelids at 0.05 mm and the thickest on the palms and soles at 1.5 mm.

Epidermis contains four layers, described according to the morphological aspect of the keratinocytes, although plants and soles contain five layers. The layers are named, from bottom to top, as stratum basale, stratum spinosum, stratum granulosum, stratum lucidum, and stratum corneum [1, 2].

- The stratum basale (basal layer) is the deepest layer and consists of a single layer of epidermal cells (keratinocytes). It forms the dermal-epidermal junction (basement membrane zone), which separates the epidermis from the dermis. It is the only layer of the epidermis in which cells undergo mitosis.
- The stratum spinosum (spinous layer) consists of several rows of more mature keratinocytes.
- The stratum granulosum (granular layer) contains 3–5 flattened cell rows comprising a higher concentration of keratin.
- The stratum lucidum (lucid layer) is only present in palms and soles. It is a thin and clear layer of dead skin cells.
- The stratum corneum (corneum layer) is the most superficial layer and consists of dead keratinocytes (corneocytes) and keratin.

Several types of cells can be found in epidermis:

- Keratinocytes: They are major cells of the epidermis, making up approximately 90% of epidermal cells. They originate at the basal layer, mature, lose their nucleus, and flatten as they move upward. They produce keratin and form the basic component of hair, skin, and nails.
- Melanocytes: They represent 1–8% of epidermal cells. They are responsible for melanogenesis, and they are found only in the basal layer. Variation in normal skin color is not determined by the number or density of melanocytes but the number, size, and distribution of melanosomes (organelles that produce melanin pigment). Melanin is transferred from melanocytes to keratinocytes, where they form a protective cap over the keratinocyte nucleus, protecting the nuclear DNA from the effects of ultraviolet radiation.

Pearls and Pitfalls

- Although melanin is principally responsible for skin color, it is also influenced by hemoglobin, elastin, dermic collagen, and some components of the diet, such as carotenes.
- Langerhans cells: They represent 2–8% of epidermal cells. They are antigen-presenting cells that protect the body against infection.
- Merkel cells: They represent approximately 1% of epidermal cells. They are neuroendocrine cells. They are high-sensitivity mechanoreceptors that provide information on light touch sensation.

12.1.1.2 Dermis

The dermis is a thick layer of connective tissue, composed of many cells and blood and lymph vessels. Its main functions are structural support and nourishment of the epidermis.

Dermis is composed of two layers; the upper layer is named papillary dermis and the lower one is named reticular dermis [1, 2].

- Papillary dermis: It represents 20% of dermis, and most of the cells of the dermis are located in this layer. It is named for its fingerlike projections called papillae, wherein fibers of collagen (predominantly type III) and elastin prevail. It contains capillaries for skin nourishment and pain touch receptors, such as Meissner and Pacinian corpuscles.
- Reticular dermis: It represents 80% of dermis. In this layer prevail fibers of collagen (predominantly type I), and glycosaminoglycans. It is thicker than papillary dermis, so its main function is supportive. Epidermal appendages can be found in this layer, including sebaceous glands, eccrine and apocrine sweat glands, hair, and nails.

Important
Hair follicles are a source of multipotent stem cells, which have the capacity to restore epidermis [3, 4].

Principal cells that can be found in dermis are the following:

- Fibroblasts: They are the main cells of the dermis, which produce collagen, elastin, granulation tissue, and cytokines (including growth factors). They are more numerous and larger in the papillary dermis.
- Macrophages and white blood cells: Their function is defensive, helping fight infection.
- Mast cells: They are immune cells that help initiate inflammation through secretion of histamine, enzymes, and chemical mediators.

12.1.1.3 Hypodermis

It is also named subcutis or subcutaneous tissue. Hypodermis is composed of adipocytes, which are grouped together in lobules of fat, and connective tissue, and contains larger blood vessels and nerves. Its functions are thermoregulation, structural support, energy storage, and mechanic absorption (as in soles). It represents about 10% of the body weight, although the size of this layer varies widely from person to person [1, 2].

12.2 Wound Healing

A wound is a disruption of the normal structure and function of the skin and underlying soft tissue, though the severity and depth may vary widely. This chapter focuses on surgical wounds, which are a controlled form of acute wounds that are created in the operating room environment.

Types of wound healing:

- Primary healing (first intention): It consists of direct apposition of skin edges of acute surgical or traumatic wounds after appropriate wound preparation with sutures and/or staples.
- Secondary healing (second intention): A wound is deliberately left open and fills in with granulation tissue, and eventually epithelization occurs over a period of time.
- Delayed primary closure (tertiary): A wound is initially left open and, following an interval of wound management, the skin edge apposition is performed.

12.2.1 Phases of Wound Healing

The wound healing process is a complex process. The progressive knowledge of the pathophysiological events that occur in each type of scars will help us to better understand and treat abnormal scarring.

Classically, four phases have been described in the wound healing process, which are hemostasis, inflammation, proliferation, and maturation and remodeling [3–8].

12.2.1.1 Hemostasis

The hemostasis phase starts immediately after skin injury. Damaged small vessels contract for 5–10 min after injury. Fibrin and platelets form blood clots, which minimize blood loss, act as a physiologic barrier against bacterial infection and dehydration, serve as a provisional scaffold, and trigger clotting cascade.

The alpha granules of platelets contain essential growth factors and cytokines, such as platelet-derived growth factor (PDGF), transforming growth factor beta (TGF-β), fibroblast growth factor (FGF), or epidermal growth factor (EGF). These substances activate fibroblasts, vascular endothelial cells, and macrophages and allow the initiation of the wound healing process.

Key Point
Platelets are more than just a passive coagulation factor. They are the first responders to a wound site, actively secreting molecules that regulate and control the healing process.

12.2.1.2 Inflammation

After hemostasis, inflammatory phase starts, which is completed within the first 48–72 h. Main factors of inflammatory phase are secondary vasodilation, with an increase in vascular permeability, and cellular recruitment.

Neutrophils are the first leukocytes to arrive at the wound site, attracted by chemotactic agents (bacterial proteins containing C5a, *N*-formyl-methionyl-leucyl-phenylalanine (FMLP), leukotriene B4, etc.), and reach their peak number at 24 h. Chemotactic agents increase neutrophil adherence to vascular endothelial cells, where they cause acute inflammation. Neutrophils prevent infection from local resident bacteria, secrete proteases (elastase, collagenase, …), and remove damaged or degenerated extracellular matrices and dead tissue.

Within a few days, monocytes are attracted to the wound by bacterial products and fibronectin. Circulating monocytes are activated as they enter the wound site and are eventually converted into macrophages, becoming the dominant cell type about 48–72 h after injury. Macrophages phagocytize foreign bodies and bacteria, as well as secrete additional cytokines and growth factors that promote fibroblast proliferation, angiogenesis, and keratinocyte migration.

Key Point
Macrophages have the most important role in the inflammatory phase, because they release cytokines and growth factors that are essential for the development of the wound healing process.

12.2.1.3 Proliferation

The proliferative phase of wound healing is estimated to begin 3 days after injury and last for a few weeks. It is the stage when the wound actually closes, and this happens through different processes that occur simultaneously: collagen deposition, granulation tissue formation, angiogenesis, epithelialization, and wound contraction.

In this phase, the provisional matrix is dissolved by proteases and is converted into granulation tissue, which consists of a vascularized extracellular matrix formed of fibrin, fibronectin, collagens, proteoglycans, glycosaminoglycans (GAGs), and other glycoproteins.

Collagen synthesis and accumulation are directly associated with fibroblast migration into the wound, starting around 2–3 days after injury and gradually increasing for 2–3 weeks. Among the many growth factors involved in collagen synthesis, TGF-β has the strongest influence. Non-collagen proteins are also included in the extracellular matrix, including elastin that gives skin the physiologic property of pliability.

Angiogenesis, the formation of new vessels from the existing ones, is the basis for all wound healing, as new vessels supply oxygen and nutrients to the regenerated tissue.

▶ **Important** Angiogenesis and vasculogenesis are not the same process. Angiogenesis is the formation of new blood vessels from existing ones, whereas vasculogenesis is the process of blood vessel formation de novo.

The formation of granulation tissue facilitates epithelization, which is stimulated by EGF, FGF, TGF-β, and multiple cytokines. Epithelialization is initiated a few hours after injury, by keratinocytes present on the wound edge as well as from dermal appendages. It has several stages, including formation of epithelial cells, cell migration, proliferation, and cell differentiation.

Lastly, wound contraction normally stars 5 days after injury. Wound contraction is a dynamic phenomenon in which the surface area of the open wound gradually decreases and contracts toward its center. The amount of dermis influences wound contraction; for example, there is more wound contraction when less dermis is present.

Key Point
Epithelialization and wound contraction also play an important role in scar formation. Earlier epithelialization and controlled wound contraction result in less scarring.

12.2.1.4 Maturation and Remodeling

The last and longest phase of wound healing is the maturation phase, which begins about 3 weeks after injury. The basic processes of the maturation phase are collagen restructuring and formation of a mature scar.

During this phase, the cellular components of the healed wound do not increase. There is a deli-

cate balance between apoptosis of existing cells and production of new cells. In addition, the granulation tissue previously produced is rearranged, and type III collagen is replaced by type I. These structural changes of the newly accumulated collagen gradually increase the tensile strength of the wound.

The decrease in metabolic demand during this phase initiates the regression of immature vessels created during the proliferation phase.

Although fibroblasts have a primary role in the synthesis of extracellular matrix components, such as collagen, elastin, and proteoglycans, they are also an important source of matrix-dissolving matrix metalloproteinases (MMPs). Therefore, fibroblasts are the major contributors to not only quantitative but also qualitative changes in the extracellular matrix.

Unfortunately, healed and regenerated tissue can never fully recover the highly organized structure displayed by uninjured normal dermis.

12.2.2 Factors Affecting Wound Healing

Acute wounds in healthy individuals heal through the orderly sequence of phases related previously. Nevertheless, some individuals may have one or more factors that contribute to impaired wound healing and complicate the regular surgical course.

Some of the more important risk factors [8] associated with impaired wound healing are the following:

- **Ischemia and hypoxia**: Wound healing is a complex process that represents a high energetic demand, requiring glucose and oxygen. Moreover, low oxygen levels increase the risk of development of wound infection because it decreases the functioning of neutrophils and fibroblasts. Finally, collagen deposition is directly related to wound oxygen tension and tissue perfusion [4].

Pearls and Pitfalls

While tissue perfusion is vital to wound healing, normal hemoglobin levels are not. Low hemoglobin levels do not necessarily diminish oxygen supply. Oxygen supply is related to arterial partial pressure of oxygen, which can be maintained by modifications in vasodilation, cardiac output, and capillary permeability.

- **Infection**: The presence of infection impairs several steps of the wound healing process. Among other actions, it decreases oxygen tension, retards epithelialization and angiogenesis, and prolongs inflammation and edema [9].
- **Smoking**: The detrimental effect of smoking on wound healing is multifactorial, and it is not only due to nicotine. There are other constituents of tobacco (carbon monoxide, hydrogen cyanide, nitrogen oxides, *N*-nitrosamines, …) that have a greater impact too. Some of the effects of smoking on wound healing are vasoconstriction, a reduced inflammatory response, impaired bactericidal mechanisms, and alterations of collagen metabolism [4, 9, 10].

Attention

Postoperative healing complications occur significantly more often in former smokers compared with those who never smoked.

- **Aging:** Some physiologic changes associated with aging contribute to slowed or impaired wound healing in older adults, such as loss of collagen, diminished ability to produce more collagen, and decrease of blood supply [9, 11].
- **Diabetes:** Numerous factors contribute to impaired wound healing in patients with diabetes. Among other factors, diabetes produces microvascular and macrovascular disease, as well as disorders in growth factor production, macrophage function, collagen accumulation, or keratinocyte and fibroblast migration and proliferation [4, 9, 12].
- **Nutritional deficiencies**: Surgery increases metabolic demand, so it can increase borderline deficiencies. Protein malnutrition and deficiency in the amino acids arginine and glutamine are of particular importance in wound healing. Vitamins most closely associated with wound healing are vitamins C and A. Of the micronutrients, the key players in wound healing are zinc and magnesium. Zinc is a cofactor for RNA and DNA polymerase, and its deficiency decreases wound strength

and epithelialization. Magnesium also functions as a cofactor in enzymes required for protein and collagen synthesis [4, 13].

Tip

Benefits of supplementation of arginine and vitamin A have been demonstrated in wound healing. Specifically, vitamin A is used to reverse the detrimental effects of corticosteroids on wound healing.

- **Drugs:** Many drugs can interfere in the wound healing process. The most frequently associated are corticosteroids, antineoplastic agents, and anti-inflammatories. Steroids decrease inflammation, inhibit epithelialization, and decrease collagen production. Antineoplastic agents specially affect vascular endothelial growth factor (VEGF) and increase the risk of development of wound infection. Lastly, anti-inflammatories may decrease collagen synthesis [9].
- **Radiation therapy**: Surgical incisions located in radiated areas are more likely to develop a wound complication. Chronic damage, fibrosis, atrophy, and occlusion of small vessels generate bad perfusion in radiated tissues [4, 14].
- **Genetics:** Recent research indicates that the formation and growth of hypertrophic scars and keloids are clearly associated with genetics [15].

12.2.3 Scarring

Human tissue is repaired either by scar formation or by regeneration of the original tissue. Scar formation consists of the substitution of a different cellular matrix as a patch to immediately re-establish a physical and physiological continuity to the injured organ, whereas regeneration is a recapitulation of the developmental processes that initially created the injured organ. Ideally, all defects made by wounds should be restored by regeneration, but the skin is an organ that repairs itself through scarring rather than regeneration.

Furthermore, wound repair and scar formation are a dynamic process, and if the normal wound healing response is altered, the result may be an undesirable scar. Abnormal scarring is usually classified into hypertrophic, keloid, or atrophic scars.

12.2.3.1 Hypertrophic Scars and Keloids

Recent research suggests that hypertrophic scars (Figs. 12.2 and 12.3) and keloids (Fig. 12.4) are caused by the same fibroproliferative pathology and that their different clinical and pathological features largely reflect the degree of inflammation in the healing wound [16].

The diagnosis of hypertrophic scars and keloids is usually clinical, based upon history, scar shape, size, and growth pattern (Table 12.1). Firstly,

Fig. 12.2 Hypertrophic scar after cesarean section

Fig. 12.3 Hypertrophic scar in the leg, secondary to primary closure of a traumatic wound

Fig. 12.4 Keloid in the back, secondary to surgical extirpation of a benign skin tumor

Table 12.1 Clinical differences between hypertrophic scars and keloids

Hypertrophic scars	Keloids
Usually remain restricted to the original wound	Extend beyond the margins of the original wound
Development in the first months (up to 6 m)	Beginning of development variable
Possible regression	No regression

hypertrophic scars usually respect borders of the original scar, while keloids grow outside original borders. Secondly, hypertrophic scars usually present a rapid growth phase, followed by possible regression over the following 12–18 months. On the other hand, the beginning of development of keloids is very variable (from months to years) and they do not regress spontaneously (even they enlarge progressively over time) [16, 17].

Hypertrophic scars and keloids also differ in their histology characteristics. Hypertrophic scars present dermal nodules only, and keloids present hypocellular dermal nodules plus multiple thick eosinophilic collagen bundles called keloidal collagen.

The risk of formation of keloids and hypertrophic scars has been associated with genetic, epigenetic, and systemic and local risk factors (particularly skin tension around scars, delayed wound healing [17], and deep wounds). A genetic predisposition is suggested by the fact that keloids are more common in dark Africans, Americans, and Asians, and patients often have a family history of these scars. They also present endocrine influences, as their growth increases in puberty and pregnancy.

Hypertrophic scars affect 5–15% of wounds. They can be classified as linear or widespread. Linear scars usually result from surgery or trauma and widely spread from burn injuries or extensive soft-tissue trauma or infections (for example necrotizing fasciitis).

Keloids are less frequent than hypertrophic scars, and they occur predominantly on the upper chest, shoulders, upper back, and head and neck (especially on the ear). Pain and pruritus are frequently associated symptoms. Keloids can be classified according to their size: minor or major (with the latter being more than 0.5 cm).

12.2.3.2 Atrophic Scars

Atrophic scars usually develop after an inflammatory process and can be the result of collagen loss and dermal atrophy. These tend to develop after insults to the skin such as acne, varicella, or trauma; therefore, they are not common consequences of cesarean section (C-section), episiotomy, or elective surgeries.

12.2.3.3 Other Scarring Disorders

- **Widened scars:** They look wide and depressed from wound tension perpendicular to wound and mobility during maturation phase. For example, periareolar and medial horizontal inframammary fold scars, associated to mastopexy, are proper to wide (Fig. 12.5).

▶ **Important** One of the principal reasons for patient dissatisfaction after mastopexy, associated or not with breast reduction surgery, is unaesthetic scars.

Fig. 12.5 Widened periareolar and vertical scars after mastopexy

- **Depressed scars:** They are the consequence of fibrosis and adherence to deep planes. As a result, the scar function may be impaired, and patients may suffer from scar stiffness and limited range of motion. For example, depressed and adherent scars can be observed associated with C-section (Fig. 12.6).
- **Pigmented scars**: Pigmented scars are not only caused by sun exposure; they are usually caused by post-inflammatory hyperpigmentation and neovascularization. In fact, post-inflammatory hyperpigmentation can appear on sun-exposed skin or sun-protected skin, although it is proved that ultraviolet (UV) exposure usually worsens post-inflammatory hyperpigmentation.

Fig. 12.6 Depressed scar after cesarean section. Frontal view (left) and lateral view (right)

12.3 Surgical Technique

12.3.1 Physiology and Biomechanics of Skin Flaps

A flap is a tissue with its own vascular supply, unlike for skin grafts, which does not have its own vascular supply.

This chapter focuses on skin flaps that are typically composed of skin and subcutaneous tissue, because they are the ones involved in abdominoplasty and mastopexy. However, flaps can also be composed of other types of tissues, such as fascia (fasciocutaneous flaps), muscle (myocutaneous flaps), or even bone (bone flaps).

According to their vascularization (Figs. 12.7 and 12.8), flaps can be classified into random pattern flaps (based on unnamed smaller vessels) and axial pattern flaps (based on an identified pedicle) [18, 19]. Flaps in abdominoplasty and

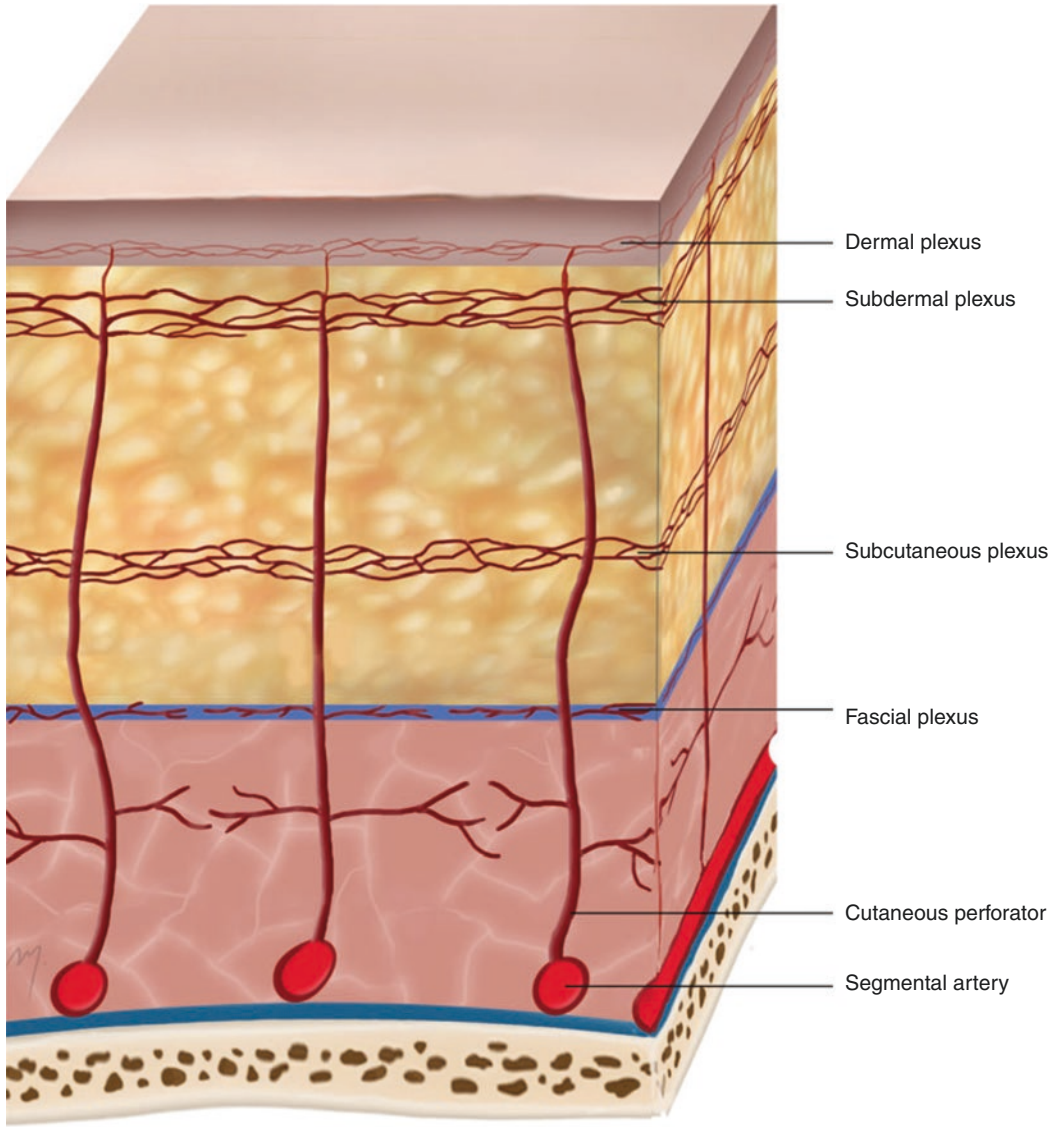

Fig. 12.7 The cutaneous vascularization. Reprinted from Thomaidis VK. Cutaneous Flaps in Head and Neck Reconstruction: From Anatomy to Surgery. Berlin: Springer; 2014

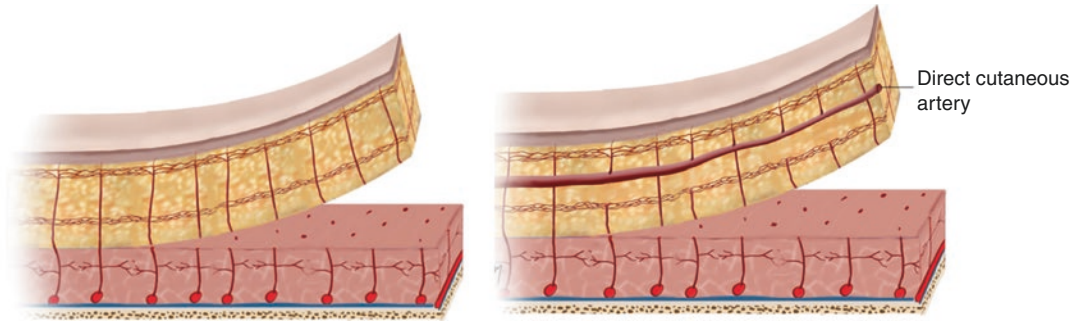

Fig. 12.8 Random pattern flap (left) and axial pattern flap (right). Reprinted from Thomaidis VK. Cutaneous Flaps in Head and Neck Reconstruction: From Anatomy to Surgery. Berlin: Springer; 2014

mastopexy are random pattern flaps, so their vascularization is based on the longitudinal dermal-subdermal plexus. For example, at mastopexy, the thickness of the skin flaps, preserving some subcutaneous tissue and respecting the dermal-subdermal plexus, is essential to avoid flap necrosis.

12.3.1.1 Flap Physiology

When a flap is raised, the normal vessels supplying that skin are cut and the flap depends on decreased circulation from the collateral vessels. At that moment, flap survival is dependent on various factors [20, 21]:

- Blood flow: Sufficient blood flow through the base of the flap is essential in the first 24–48 h. In random pattern flaps, the flow recovery is progressive for up to 4 weeks, and it happens from proximal to distal.
- Angiogenesis and vascularization: The flap receives blood supply not only from its base, but also from the wound bed.
- Edema: It affects flap blood supply.
- Wound healing tension: Suturing wounds under excessive tension produces vascular stress on the tip of the flap and risk of necrosis and dehiscence (Fig. 12.9).
- Postoperative complications (hematoma, seroma, infection): Hematoma and seroma increase tension and impair adhesion to the wound bed; in addition, infection produces important edema, vessel thrombosis, and releasing of toxic free radicals, which can facilitate flap necrosis.

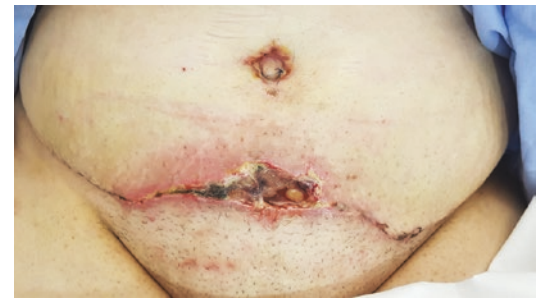

Fig. 12.9 Abdominoplasty closure done under excessive tension, resulting in vascular stress on the tip of the flap, necrosis, and dehiscence

12.3.1.2 Flap Biomechanics

Understanding the biomechanical properties of the skin is essential when managing skin flaps.

Biomechanical properties [18]

- Stress: It is the force applied per cross-sectional area.
- Strain: It is the change in length divided by the original length of the tissue on which a given force is applied.
- Creep: It is the increase in strain seen when the skin is under constant stress.
- Stress relaxation: It is related to creep, and it means that the amount of stress required to maintain the tension decreases with time when the skin is held under constant tension.

Although skin is considered an elastic structure, the stress-strain relationship of skin shows that it is not totally true. If a small amount of stress is applied, the skin length changes; however, it has a limit, and at certain point, even a large amount of applied stress will not result in further incremental skin length. This is caused by the relationship between collagen and elastin. In relaxed skin, collagen is randomly oriented and elastin is loosely wrapped around, but when a force is applied, the fibers stretch and there is a point when they cannot distend more.

If a constant force is applied for several minutes (approximately 5–10 min) to the skin, the reorganization of collagen and elastic fibers enables to exceed the stretch limit (creep), and some days later, the skin is able to relax (stress relaxation).

Therefore, it is important to know that there is a limit for skin elasticity and that it is necessary to avoid excessive stress on the flap edges and minimize tension on the wound closure. High tension may lead to wound edge necrosis, wound dehiscence, and unaesthetic scars.

▶ **Important** Aging and sun exposure decrease the capacity of stretching of skin because of collagen and elastic fiber damage.

Fig. 12.10 Left: Cesarean section sutured with 3-0 silk suture. Right: Cesarean section closed with staples. We do not recommend these types of suture because of the risk of skin marks

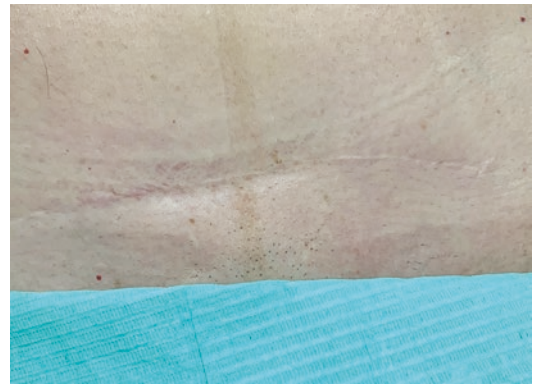

Fig. 12.11 A proper surgical technique can lead to obtaining good aesthetic results after a cesarean section, as we see in the picture

12.3.2 Suture Techniques

Proper surgical technique has been found to reduce scar width and hypertrophy, so surgeons have to know how the surgical technique, the suture techniques, and the suture material influence scarring (Figs. 12.10 and 12.11). Furthermore, the position and length of the incision line should be carefully considered, and if possible, it should always be parallel to the relaxed skin tension lines.

12.3.2.1 Wound Apposition

It is proved that contributing factors to pathological scarring are tension, melanin, and inflammation. Some factors are not modifiable, such as melanin; in contrast, inflammation and tension are more controllable.

Inflammation can be reduced by gentle tissue handling, debridement of dead tissue, reducing the risk of infection through rinsing and disinfection, decreasing thermal energy spread, and proper suture selection.

Tension can be reduced by undermining (dissecting under the flaps and its surrounding area to allow tissue movement), but the possible detrimental consequences must be estimated. Undermining may compromise vascularization and increase dead space, which can lead to surgical complications.

12.3.2.2 Suture Material

Sutures can present different physical characteristics (elasticity, memory, knot security, tissue reactivity, visibility, etc.) that provide them different properties. Some of the most essential

classifications are according to the suture configuration, monofilament, or multifilament (Table 12.2), and its absorption, absorbable or nonabsorbable (Table 12.3). In addition, the caliber of the suture is important, which is related to the strength of the suture [13]

The surgeon should choose the suture according to the tension of the wound. The smallest caliber suture that provides sufficient strength should be chosen, and if an absorbable suture is used, it has to lose strength comparable to the timing of wound strength recovery.

Finally, the alternative to sutures is stainless steel staples (Fig. 12.12). Although it is a time-saver closure method and there are some locations where they are recommended (for example hair-bearing scalp), we do not recommend it in C-section, episiotomy, or post-pregnancy surgeries. However, staples can be useful to position a skin closure temporarily before suturing. Some of the disadvantages of this skin closure technique are that they are inelastic, produce imprecise epidermal approximation, and pose the risk of skin marks if they are not removed early.

Table 12.2 Differences between monofilament and multifilament sutures

	Definition	Characteristics
Monofilament	Single strand	– Less friction → less trauma – Less risk of harboring infective organisms
Multifilament	Made of several strands that can be braided or twisted	– More friction – More tensile strength – Handle easily

Table 12.3 Differences between absorbable and nonabsorbable sutures

	Definition	Characteristics
Absorbable	Degradation by proteolysis (natural materials) or hydrolysis (synthetic sutures)	Lose tensile strength
Nonabsorbable	No degradation	Sutures induce a cell-mediated reaction until the suture becomes encapsulated

▶ **Important** When using staples, wound edges must be everted with forceps to prevent inverted skin edges.

12.3.2.3 Common Suture Techniques

The choice of closure technique should be based on wound and patient characteristics, but it should always be directed to the minimization of tension on the closure and meticulous closure with wound edge eversion.

Wound eversion is more likely to achieve a fine and flat scar than planar repair, which tends to result in a depressed scar. It is best achieved using deep dermal sutures.

Key Point

Deep dermal sutures relieve tension off the epidermis and produce skin edge eversion, whereas subcuticular sutures do not support much tension and their main function is approximating epidermis.

Suture techniques most used in C-section, episiotomy (Fig. 12.13), and post-maternity surgeries are the following:

– Simple interrupted suture (Fig. 12.14): It is the most commonly employed suture. The suture must be placed at the same depth on each side of the incision; otherwise, the edges will overlap. Their main advantages are that it provides wound eversion and allows high-low correction and individual sutures may be removed without disturbing others. The disadvantages are the risk of skin marks, and it may increase closure time (in comparison with continuous sutures).
– Simple continuous suture (Fig. 12.15): It is a time-saver closure technique, but it is not early as precise as interrupted sutures, there is a risk of leaving skin marks if they are not removed early, and integrity depends only on knots on either end.
– Deep dermal suture (Fig. 12.16): They are essential to decrease wound tension. Sutures

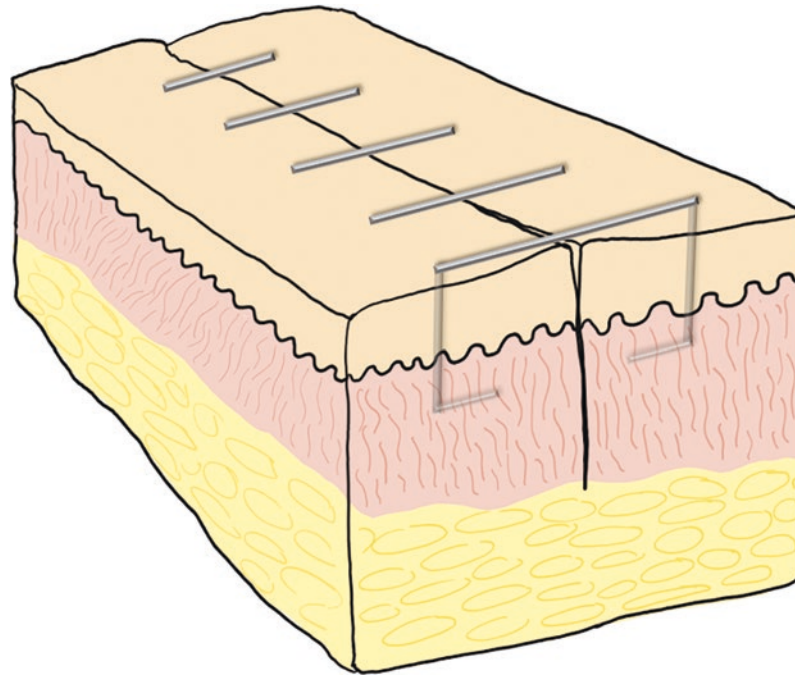

Fig. 12.12 Staples

Fig. 12.13 Episiotomy sutured with simple interrupted stitches. An absorbable multifilament suture was used

must also be placed at the same depth on each side of the incision.

- Vertical mattress suture (Fig. 12.17): They are indicated in high-tension areas, and it helps in eversion of the skin edges. However, there is a risk of leaving skin marks if they are not removed early.
- Horizontal mattress suture (Fig. 12.18): It has the same indications as vertical mattress suture, and it is used in tight situations when vertical mattress suture is not possible. In addition, although it may help in hemostasis, it increases tissue ischemia.
- Subcuticular continuous suture (Fig. 12.19): This suture is used to approximate epidermis, but it is not able to support wound tension. Its principal benefit is that there is no risk of skin marks. It is usually the chosen technique for epidermis layer closure in elective surgeries.
- Three-point-U suture (Fig. 12.20): This suture is especially important in "T" area at mastopexy (the point when vertical and horizontal scars join), but could also be necessary if the

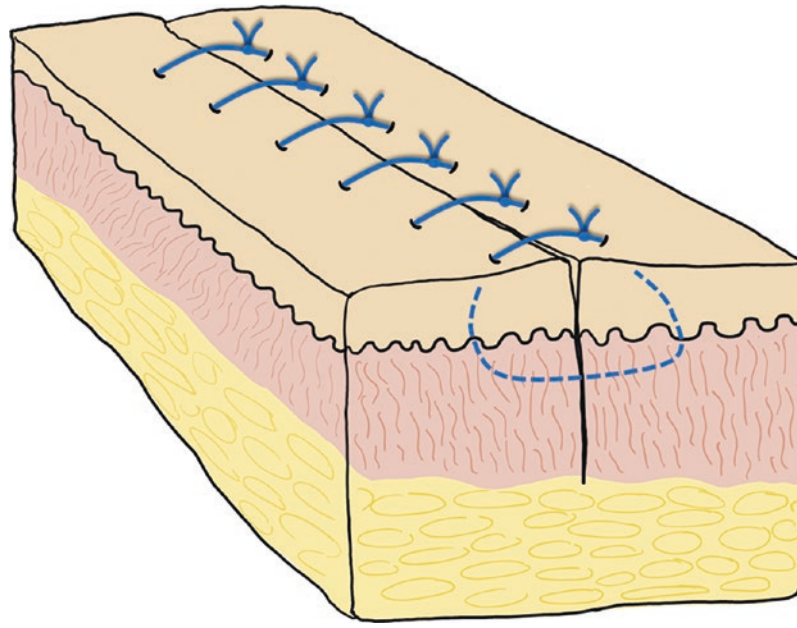

Fig. 12.14 Simple interrupted suture

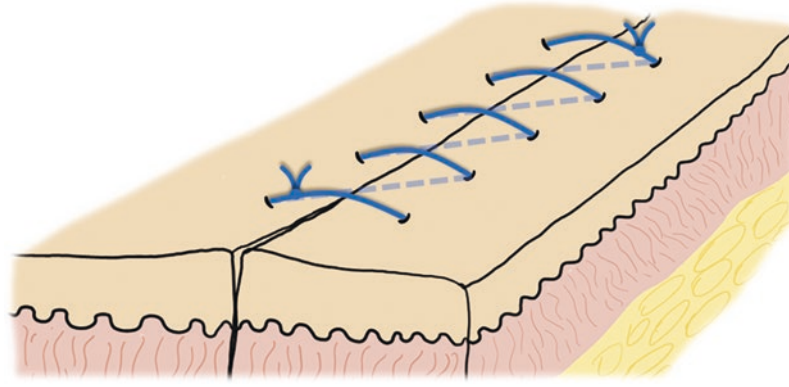

Fig. 12.15 Simple continuous suture

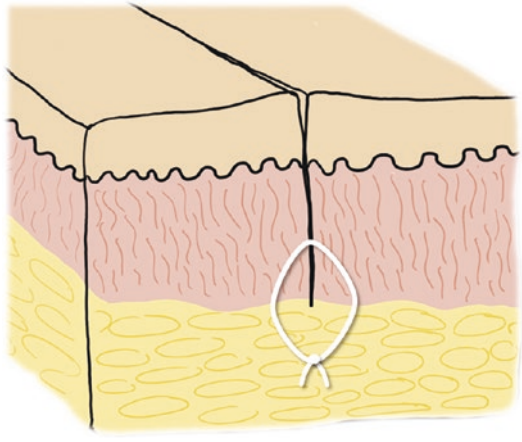

Fig. 12.16 Deep dermal suture

horizontal suprapubic scar of abdominoplasty has to be prolonged with a small vertical scar at midline. It approximates and relieves tension from the different flaps.

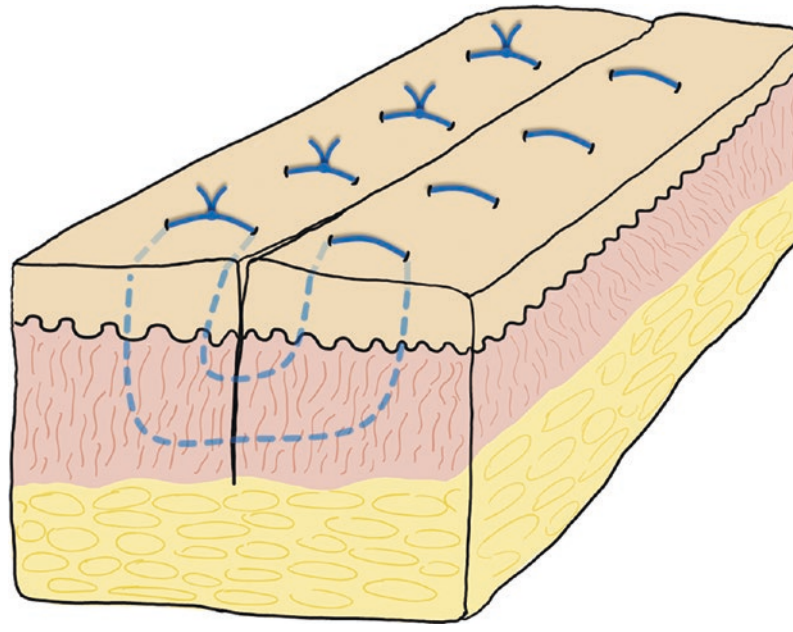

Fig. 12.17 Horizontal mattress suture

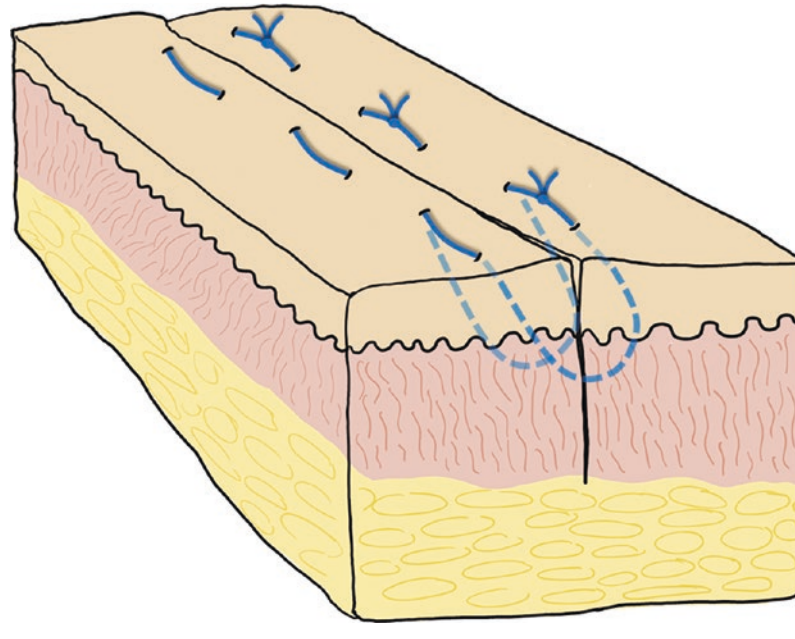

Fig. 12.18 Vertical mattress suture

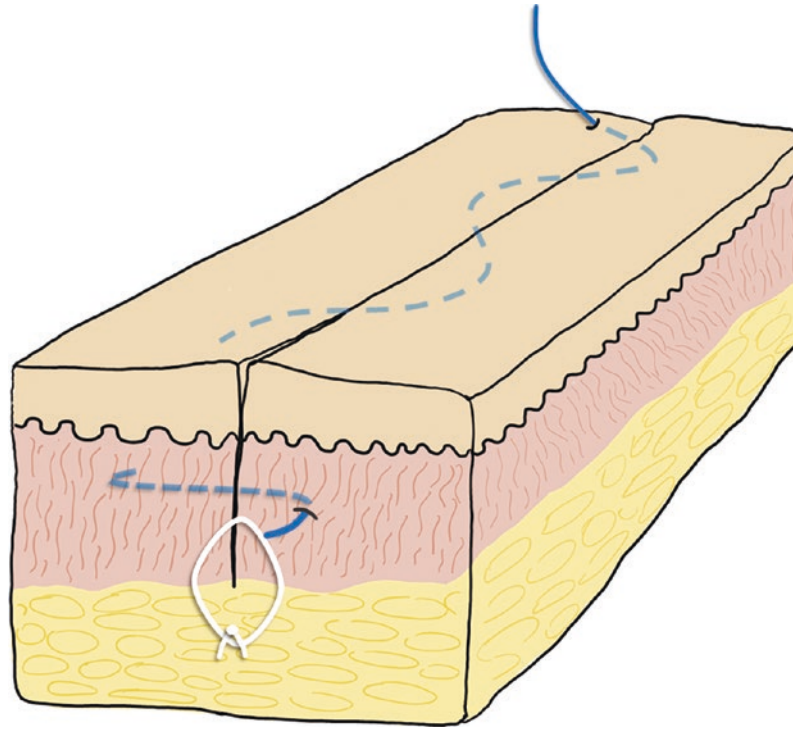

Fig. 12.19 Subcuticular continuous suture

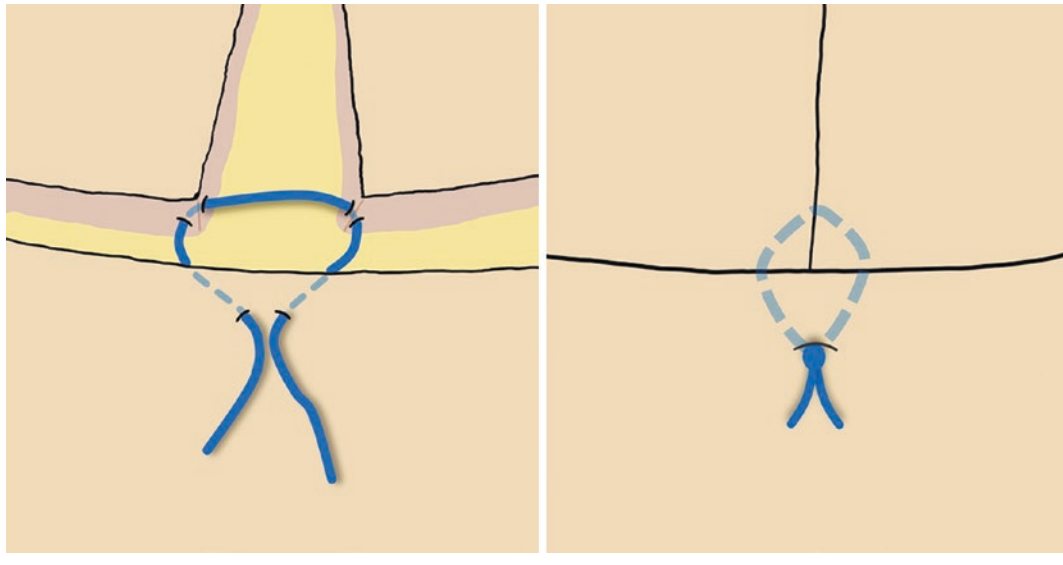

Fig. 12.20 Three-point-U suture

12.4 Postoperative Care: Scar Management and Prevention of Pathological Scarring

Although scars can never be completely removed, appropriate surgical technique and judicious postoperative care can minimize their appearance. With patients demanding less and less visible scars, prevention and improvement of scars should be one of the main goals in any surgical procedure.

Key Point
The best treatment of scars is prevention.

12.4.1 Scar Management

Prevention of pathological scarring should start as soon as surgery begins. Two important components of scar prevention, immediately after wound closure, are tension relief and taping [22]. There is a large list of surgical dressings that have been designed to provide coverage of sutured wounds. The most commonly used traditional dressing materials are gauze and adhesive dressings. However, in our opinion, there are dressings that provide greater benefits. Two dressings that should be highlighted are adhesive strips and paper tape (Fig. 12.21). Adhesive strips may be applied immediately after wound closure to provide wound coverage and relieve tension, but also after removal of the suture to help keep the wound edges approximated. Paper tape (Fig. 12.22) is a basic, hypoallergenic, breathable, and economic dressing, and additionally, it usually contains zinc oxide that contributes to supporting wound healing and preventing infection.

In high-tension wound or high-risk patients, there are some more sophisticated devices that can be used, such as negative pressure therapy (NPT) [23]. NPT dressings are typically applied in an operating room under sterile conditions.

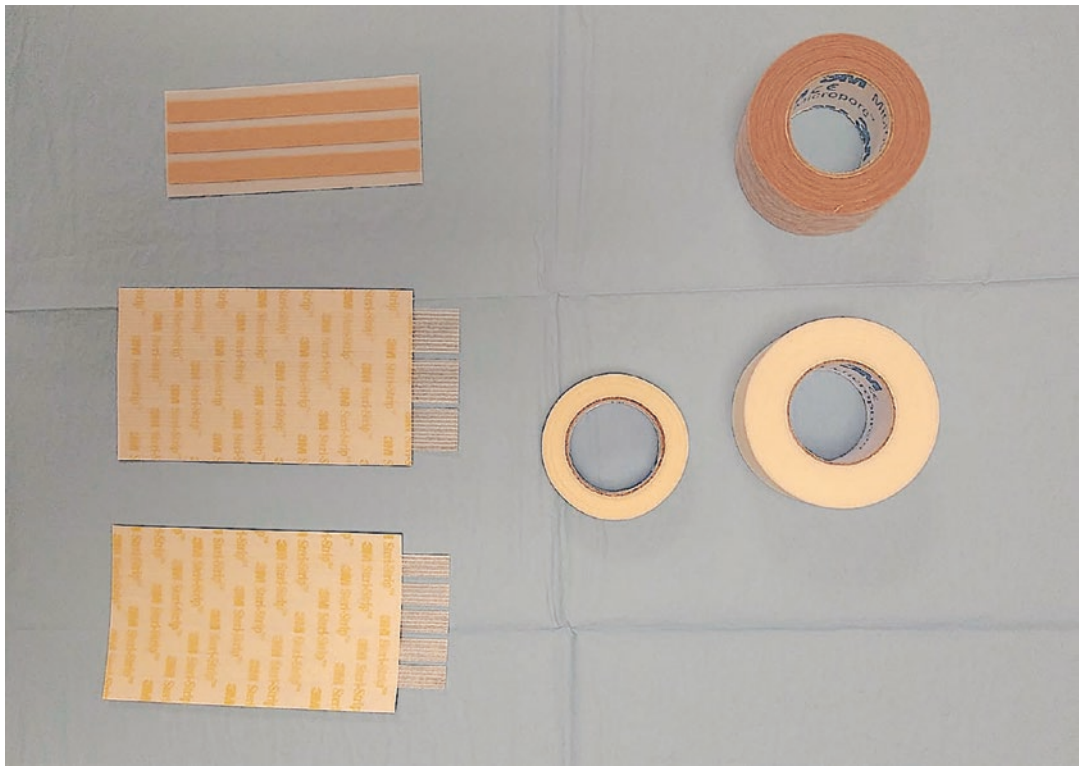

Fig. 12.21 Different color and sizes of adhesive strips (left) and paper tape (right)

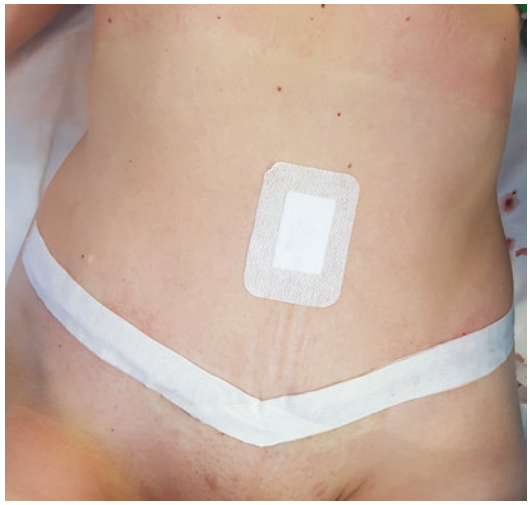

Fig. 12.22 Horizontal scar at abdominoplasty covered with paper tape, immediately after wound closure

They ideally remain intact over the suture line for 5–7 days postoperatively. It can be beneficial in procedures such as abdominoplasty and breast reduction.

As soon as the suture is removed and the wound is completely epithelialized, the most basic principles are massage, moisturizing, and sun protection until the scar has matured. Studies have shown that, after wound healing, water still evaporates more rapidly through scar tissue and may take over a year to recover to pre-wound levels [22]. Moreover, avoiding exposure to sunlight and continued use of sunscreens with a high sun protection factor (>50 SPF) reduce the risk of hyperpigmentation of the scars. Finally, scar massage is an innocuous procedure that may be effective in decreasing pain and increasing a sense of well-being.

12.4.2 Prevention of Pathological Scarring

Basic procedures that are compulsory in postoperative care have already been described. However, many over-the-counter topical products and dressings have been marketed as tools to prevent scars or to improve their appearance or symptoms. Specialists should know their properties and indications in order to recommend them to their patients, according to the appearance of the scar and the risk of development of a pathological or unaesthetic scar.

Attention
Patient's expectations should be discussed and managed prior to the initiation of any treatment.

12.4.2.1 Topical Products and Dressings

Silicone is universally considered as the first-line prophylactic and treatment option for hypertrophic scars and keloids [24]. It can be applied to scars in the form of sheets or gel. Gel can be preferred because of ease of application, and its use is compatible with other topical agents, for example sunscreen. It is a noninvasive and safe therapy, which may produce minimal side effects such as pruritus, contact dermatitis, or dry skin. Its effectiveness is believed to be based on occlusion and subsequent hydration of the scar tissue. Silicone therapy is recommended in high-risk scars or when patients are concerned about the outcome of their scars. The treatment should start once the wound is healed and at least for 3 months; however, if there is further scar maturation once that period of time has passed, it should be continued for as long as necessary.

Recent data has also shown that silicone sheeting can be used in combination with pressure therapy producing better improvements in hypertrophic scars than either therapy alone. The two treatments have complementary modes of action, with the silicone therapy acting on the erythema and pliability of the scar, whereas the pressure therapy prevents scar thickening. In this respect, some mechanomodulatory therapies have been developed to use on high-tension wounds, such us embrace Advanced Scar Therapy device® (Neodyne Biosciences, Inc., Menlo Park, Calif.) [25]. The device includes a simple disposable applicator that transfers a predetermined level of strain to a single-use adhesive silicone sheet, which is then adhered over the closed scar. This mechanism of action provides a uniform compressive strain, or a stress shield around a closed scar, which can minimize collagen proliferation and formation of scar tissue. This therapy has

demonstrated to significantly reduce scarring following abdominoplasty surgery.

Steroid tape is recommended as a prophylactic treatment for patients at high risk of scar hypertrophy [26]. The application can start once the surgical wound is completely healed, approximately 1 month after epithelialization, and it should be changed every 24–48 h. Nevertheless, it is not an innocuous treatment, and it has to be strictly controlled to avoid overuse. In addition, it is important to cut the tape to the size and shape of the scar to decrease the risk of atrophy in the surrounding skin.

Other products described in the literature for the treatment of scars are onion extract and vitamin E [27]. However, though onion extract may have beneficial molecular effects on scars, its clinical efficacy in scar prevention and treatment has not been demonstrated. In the same way, the efficacy of vitamin E remains unproven.

12.4.2.2 Pressure Therapy

Pressure therapy, usually performed with pressure garments, bandages, or special devices for certain locations, has been a commonly used treatment modality for hypertrophic scars and keloids. Specifically, it is widely used for the prevention of pathological scarring in burn victims. However, its benefit has not been proved in uncomplicated surgical scar as a preventive treatment [28].

On the other hand, although its function is not specifically prevention of pathological scarring, specific pressure garments are recommended after abdominoplasty or liposuction to prevent some complications, such as seroma.

12.4.2.3 Light and Laser Therapies

Light and laser therapies are able to modify the different wound healing phases; therefore, they potentially affect scar formation and can be used both as a prophylactic measure or as a treatment in established scars [29].

Laser treatment is based on the principle of selective thermolysis. This means that the targeted tissue may be modified by chromophore absorption of laser light without significant thermal damage to surrounding normal tissues. The chromophores of skin used frequently as target are hemoglobin, melanin, and water.

The underlying mechanism for laser therapy as a prophylaxis for excessive scar formation is based on several facts. First, early use of vascular lasers produces scar tissue hypoxia, which leads to cell catabolism, prevention of abnormal collagen deposition, shortening of the duration of acute inflammatory response, and acceleration of scar maturation. There is not an established consensus regarding the timing of the treatment, the number of sessions, and the energy used. However, it is clear that it should be an early treatment, even starting on the day of suture removal.

In the last decades, the most common laser therapy used in the early treatment of scars has been pulsed dye laser (PDL). PDL laser selectively targets hemoglobin; therefore, it coagulates the microvasculature and decreases inflammation of neovascularized tissue [24]. The main effect is an improvement in erythema, although it may also improve texture and pliability and reduce scar volume. Wavelengths usually used to treat scars are 585 and 595 nm [30]. Common complications of PDL therapy include transient purpura, and mild-to-moderate erythema or edema that resolves in some days. More infrequent adverse effects are skin blistering or crusting, pigmentation disorders, or ulceration.

More recently, fractional non-ablative and ablative lasers have also been introduced as prophylactic and therapeutic treatment for scars. They are able to influence and modify the development, deposition, quality, and distribution of collagen, aiming toward that found in normal skin. Some of the most common adverse effects found in ablative laser treatment include prolonged erythema, delayed wound healing, ulceration, and post-inflammatory hyperpigmentation. Hypopigmentation, pain, or herpes simplex virus infection are infrequent side effects. Most common fractional ablative lasers used in the treatment of scars are carbon dioxide (CO_2) laser (10,600 nm) and erbium:yttrium aluminum garnet (Er-YAG) laser (2940 nm). In relation to fractional non-ablative lasers, some of the most used are neodymium:yttrium aluminum garnet (Nd:

YAG) laser (1064 nm, 1320 nm, 1340 nm, …) and diode laser (1455 nm) [31, 32].

▶ **Important** According to the wavelength, the same type of laser can be used as ablative or non-ablative treatment.

Finally, light devices can also be used as a prophylactic treatment for scars, including intense pulsed light (IPL), light-emitting diodes (LEDs), or photodynamic therapy (PDT). Most frequent light therapy used is IPL [32, 33]. (remove 36). This light differs from the laser because it is polychromatic, which means that the emitted radiation includes multiple wavelengths (ranging from 400 to 1800 nm), so it can act over different chromophores. IPL treatment may improve scar erythema, texture, and overall appearance of scars. It is a safe therapy, which has not been associated to long-term side effects. However, its learning curve is longer and is very user dependent.

12.4.2.4 New Treatments

As in other areas of medicine, nowadays research is focused on molecular therapies. Although some molecules have shown promising results in preclinical and clinical trials in animals, such as TGF-β_3, human clinical trials have failed to produce effective results. In the same way, some preclinical experiments have demonstrated the therapeutic potential of mesenchymal stem cell-conditioned medium (MSC-CM) in wound healing and inhibition of hypertrophic scar formation [4, 20].

▶ **Important** Generally, all scars should be re-evaluated 4–8 weeks after surgery to determine whether additional scar management interventions are required or whether preventive therapy can be finished.

12.5 Treatment of Pathological Scarring

Hypertrophic and keloid scars can significantly affect the patient's quality of life due to the appearance, the functional alterations, or the symptoms associated. However, these two scarring disorders are not the only cause of patient's complaints. Specialists should know how to treat some other minor alterations, such as pigmentation disorders, widened scars, or depressed scars.

Therefore, the goals when scars are treated may include one or more of the following:

- Relief of symptoms
- Reduction of the scar volume
- Functional improvement
- Cosmetic improvement

Nowadays, most current clinical treatment strategies continue to focus on decreasing inflammatory processes. However, recent research suggests that molecular and cellular approaches may be promising scar therapies. Further research into genetics, epigenetics, and mechanobiology is needed, in order to find more effective prophylactic and clinical treatments.

12.5.1 Hypertrophic Scars

Silicone is universally considered as the first-line treatment option for hypertrophic scars, whereas pressure therapy may be an alternative first-line treatment. Pressure therapy can also provide benefits as symptomatic treatment, such as alleviation of edema, itchiness, and pain [34].

Second-line therapies include intralesional injections, light and laser therapies, botulinum toxin, and surgical excision [35]. Usually, silicone or pressure therapy is used as adjunctive therapies to second-line treatments. Steroid tape can also be applied as adjunctive therapy.

12.5.1.1 Intralesional Injections

Most frequent injected substances are corticosteroids and 5-fluorouracil.

- Corticosteroids: They are the most frequently used drugs in hypertrophic scars (Fig. 12.23). The corticosteroid most commonly used is triamcinolone acetonide 10^{e40}mg/mL. It should be injected into the papillary dermis every 2–4 weeks until the scar is flattened. Corticosteroids decrease collagen synthesis

Fig. 12.23 Hypertrophic scar. The right area has been treated with intralesional injection of corticosteroids

and limit fibroblast proliferation. Common adverse effects are subcutaneous atrophy, telangiectasias, and pigment changes [24].

– 5-Fluorouracil (5-FU): 5-FU is an antimetabolite that inhibits fibroblast proliferation. It is usually used when the treatment with corticosteroids is insufficient, as monotherapy or in combination with them. Some studies have proved that the combination of 5-fluorouracil and triamcinolone acetonide may be more effective in treating scars than the individual treatments. Some of the possible adverse effects are wound ulceration, hyperpigmentation, and pain [36].

Some more infrequent substances, usually reserved for resistant hypertrophic scars, are bleomycin and verapamil. Bleomycin is an antitumor agent that induces cell apoptosis and reduces fibroblast activity, whereas verapamil is a calcium channel antagonist that decreases collagen synthesis and increases collagen breakdown.

12.5.1.2 Light and Laser Therapies

Laser and light therapies are also interesting therapeutic tools used in the treatment of linear hypertrophic surgical scars. However, it is important to adapt the device to the stage of scar maturation.

PDL is more effective in immature hypertrophic scars (usually erythematous and younger than 1 year), because it only penetrates 1 mm and thick hypertrophic scars may not respond. The application of PDL in the early stages of the hypertrophic scars may decrease inflammation, erythema, and pruritus. Frequently, the treatment with PDL is supplemented with intralesional injections of corticosteroids, combined or not with intralesional 5-FU [37]. Immature hypertrophic scars refractory to PDL can be treated with fractional laser therapies. The combination of lasers, indeed, may also function in a synergistic manner. Firstly, PDL can be applied to reduce vascularization; later, fractional CO_2 laser can be used to prevent the scar's continued growth as this laser deals primarily with inhibiting proliferating fibroblasts and the deposition of abnormal collagen.

Moreover, immature scars can also be treated with IPL. Its application may reduce height and erythema and produces an overall clinical improvement in the appearance of hypertrophic scars. The treatment with IPL is also supplemented with intralesional injections of corticosteroids, combined or not with intralesional 5-FU.

In matured hypertrophic scars, fractional ablative lasers are frequently used to remodel irregular scar contour and improve stiffness and pliability. In addition to the effect of decreasing and remodeling of the scars, fractional ablative systems have allowed what is called the "laser-assisted drug delivery." These lasers open channels through the epidermis, which can be used as a system of direct communication with the dermis. Therefore, when ablative lasers are used, it is recommended to apply topical corticosteroids (combined or not with intralesional 5-FU) instead of intralesional injection [38].

12.5.1.3 Botulinum Toxin

Botulinum toxin type A is a potent neurotoxin, derived from *Clostridium botulinum*, which indi-

rectly blocks neuromuscular transmission. Therefore, it can be used as a prophylactic treatment for hypertrophic scars, by preventing muscle and skin contraction during wound healing. Moreover, it is also a therapeutic tool in the management of hypertrophic scars and keloids, because it has been demonstrated that the administration of botulinum toxin type A inhibits the proliferation of fibroblasts. And finally, it can be used to treat symptoms associated with scars, such as pruritus and pain [39–41].

12.5.1.4 Surgical Excision

If the patient develops a permanent hypertrophic scar (approximately 1 year), surgical scar revision may be considered. Aesthetic correction of linear hypertrophic scars is usually done by simple resection and primary closure, being necessary sometimes to apply some type of tension-releasing technique. After that, postoperative care will be essential to prevent the recurrence of a new hypertrophic scar.0

12.5.2 Keloids

Many treatments, such as steroid injections, topical dressings (silicone, steroids, …), pressure therapy, or laser treatment, have been shown to be successful treatment modalities for keloids. The problem is that they have high rate of recurrence rates when they are used as monotherapy, so the basis of the treatment of keloids lies in the combination therapy [42]. Furthermore, keloids manifest themselves in a wide variety of forms and etiologies and thus require tailored therapies.

First-line therapy could be intralesional corticosteroids, which can be combined with intralesional 5-FU and other adjunctive therapies (for example occlusion dressings and pressure therapy). Ablative laser could also be used in keloids, but it must be combined with intralesional injections of corticosteroids or 5-FU because laser-induced injury can often start the process of keloid recurrence [43].

Second-line therapy could be surgical excision, which must always be combined with post-excision adjuvant therapies. In addition to those previously commented, more specific adjuvant therapies that are reserved for aggressive keloids are the following:

- Radiation therapy: The effectiveness of post-excision radiation therapy in reducing keloid size has been demonstrated by multiple studies [44, 45]. Radiation inhibits new vessel formation and proliferation of fibroblasts, which results in decreased collagen production. The most commonly used forms of radiation therapy for keloids are brachytherapy and electron beam radiation. Although radiation therapy can be associated with some adverse effects, such as carcinogenesis, it is regarded as a safe option when carefully applied in selected patients. In fact, it has been applied immediately after cesarean section in postpartum patients, with confirmed keloids resulting from previous C-sections, with good cosmetic results [46].
- Cryotherapy: It produces cellular injury and necrosis of the keloidal tissue. It can be administered as spray or intralesional. Some adverse effects may be hypopigmentation, hyperpigmentation, blisters, and local pain.

Other emergent therapies, such as interferon (IFN), imiquimod, bleomycin [47], TGF-β, or tacrolimus, still need further studies to evaluate their role in the prevention and treatment of keloid scars [48].

Attention

All patients with keloids should be aware of the risks of recurrence with procedures. Nevertheless, the best treatment is prevention, avoiding nonessential surgeries or procedures.

12.5.3 Other Unaesthetic Scars

- **Depressed scars**: Treatment consists of releasing the scar from the underlying tissues (subcision) and subsequently filling with fat grafting or other filler substances (for example hyaluronic acid). Moreover, neoangiogenesis induced by adipose-derived stem cells con-

Fig. 12.24 Left: Widened scar after abdominoplasty. Right: Immediate result after debridement of the scar and direct closure, 13 months after the first surgery

tained within the fat graft may play a role in scar improvement [49, 50].

- **Widened scars**: The best treatment is debridement of the scar and direct closure. Scar revisions can be performed about 1 year after initial surgery, when the final result of the scar is usually visible and there would be less tension in the surrounding tissues (Fig. 12.24).
- **Pigmented scars:** Hyperpigmentation can be treated essentially with depigmented creams (hydroquinone, kojic acid, retinoic acid, topical steroids, azelaic acid, tranexamic acid, …), laser therapies, or IPL. Topical hydroquinone, 2–5% concentration, is regarded as the gold standard treatment for hyperpigmentation in the last 50 years. Some of the adverse effects of hydroquinone are rebound hyperpigmentation, photosensitivity or phototoxicity, tolerance, resistance, and exogenous ochronosis. Furthermore, some creams based on the combination of depigmented agents, such as Kligman cream or modified Kligman cream, can lead to good results too.
- **Hypopigmented scars**: Hypopigmentation is generally treated with non-ablative fractional lasers with positive outcomes, although good results in treatments with ablative fractional lasers have been proved too [51]. In addition, micropigmentation is also a good therapeutic tool to treat hypopigmentation.

Finally, some minor alterations may also be treated with laser too. For example, telangiectasias can be treated with any laser or light source that targets hemoglobin (PDL, Nd: YAG, IPL, …), whereas some small textural alterations are mostly treated with fractional ablative lasers.

Key Point

Treatment combinations are typically the best option when treating hypertrophic scars and keloids.

12.6 Treatment of Wound Healing Complications

During the early postoperative period, wounds are susceptible to suffer some complications, such as necrosis of surrounding tissues, dehiscence, or surgical site infection.

Not all surgeries commented in this chapter have the same risk of developing wound healing

complications [52, 53]. While minimal liposuction scars rarely suffer any complication, mastopexy and abdominal surgery scars are more prone to necrosis and dehiscence, in most cases because of excessive tension. If surgical technique and postoperative care are adequate, surgical wound infections are rare in these procedures.

Attention
If a wound suffers a dehiscence without an excess of tension or another known cause, infection should always be considered.

In mastopexy, wound healing complications are more frequent in inverted T-procedures. T-zone is the most vulnerable region because of excess of tension, and it may suffer necrosis and dehiscence (Fig. 12.25). Another complication associated with mastopexy is necrosis of skin flaps. A proper surgical technique is essential to prevent this complication, as well as making sure to respect the subdermal plexus. And finally, another possible complication is partial or total necrosis of nipple-areola complex (Fig. 12.26).

Likewise, horizontal scar at abdominoplasty is also susceptible to skin necrosis and dehiscence, especially in midline because it is the area that supports most tension (Fig. 12.27). On the contrary, this kind of complications are infrequent at cesarean delivery, in which surgical site infection

Fig. 12.26 Total nipple-areola complex necrosis after mastopexy

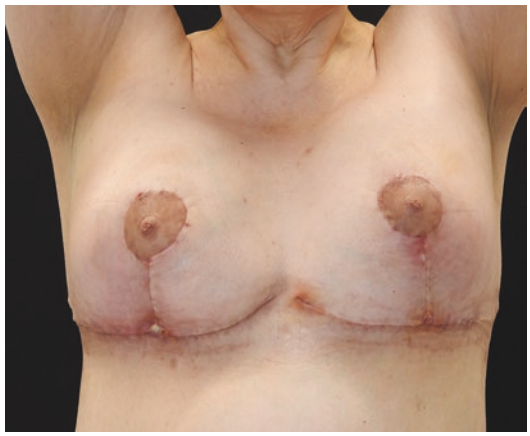

Fig. 12.25 Dehiscence in "T" area after mastopexy

Fig. 12.27 Initial stage of skin necrosis, affecting midline, after abdominoplasty

is more common. Unscheduled cesarean delivery is a major risk factor for wound infection.

Finally, episiotomy is the surgery with the highest risk of infection of all these commented. The area is heavily colonized by bacteria and frequently is contaminated by stool during the delivery process. However, infection is unusual because of the patient's immune system action. Furthermore, to prevent infection, obstetricians should insist on irrigation of the treated area. If infection does occur, the risk of necrosis and dehiscence increases.

12.6.1 Treatment of Skin Necrosis

Treatment should be based on the debridement of wound edges, the debridement of damaged or necrotic tissue from wound bed if it is present, and healing by first or second intention. The risk of a first wound healing is that if the cause of necrosis (frequently excessive tension) is still present, the wound can suffer some tissue necrosis again. On the other hand, some disadvantages for second healing are that it is a longer process, it may worsen the esthetic result, and it increases the risk of infection.

One special case is the reconstruction of nipple-areola complex after a necrosis. Although second intention healing is possible (Fig. 12.28), especially in partial necrosis, reconstruction is often performed using more sophisticated techniques, such as grafts and flaps.

Fig. 12.28 Outcome of total nipple-areola complex necrosis treated by second healing

Tip

Micropigmentation is a good treatment to conceal scars and pigmentation alterations after surgeries that involve nipple-areola complex.

12.6.1.1 Debridement

Debridement consists of removing necrotic, damaged, or infected tissue to improve the healing potential of the remaining healthy tissue. The presence of necrotic tissue obstructs the new tissue growth and serves as a nidus for bacterial proliferation.

Debridement may be sharp, surgical, mechanical, enzymatic (Fig. 12.29), autolytic, or biological (larval). In this type of surgical acute wounds, the chosen techniques are usually sharp or surgical debridement. Nevertheless, autolytic debridement, through enzymatic debridement agents (collagenase, trypsin, …), may also be applied to remove fibrin and sloughs from the wound bed during the process of second healing [54, 55].

Tip

If autolytic debridement is indicated, a moisture-retentive dressing should be selected because it will become a high exudate wound. In addition, it is important to protect peri-wound skin to avoid maceration.

12.6.1.2 Principles of Second Healing

Successful wound healing is most likely to be achieved if the underlying cause of failure to heal is identified and treated. An easy way of understanding and treating wounds by second healing is using the TIME acronym. The TIME acronym, developed by a group of wound care experts, was first published in 2003 [56, 57]. It is a practical guide to wound management that relates clinical observations and interventions to the underlying wound pathology in each of the four areas:

Fig. 12.29 Some examples of enzymatic debridement agents. At the top of the picture, a barrier film spray can be seen that is used to protect intact or damaged peri-wound skin (Cavilon, 3M ®)

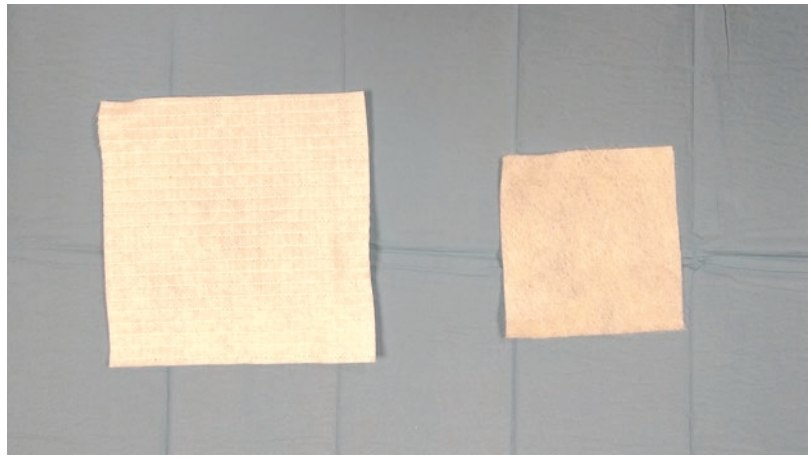

Fig. 12.30 Alginate (left) and hydrofiber (right)

- T for tissue: nonviable or deficient
- I for infection/inflammation
- M for moisture imbalance
- E for edge of wound, nonadvancing or undermined

Therefore, according to TIME acronym, firstly it is necessary to remove all damaged or necrotic tissue and foreign bodies on the surface of the wound. Debridement is the quickest and most efficient method of removing these materials. The second point refers to control infection and management of inappropriate inflammation unrelated to infection. Infection should be prevented or, in case it is present, treated. The best way to avoid infection is wound cleansing and shielding the wound from bacterial invasion. Thirdly, the wound should not be desiccate, neither can have excess of exudate. The relevance of moisture balance has led to the development and use of a wide range of dressings [7]. A draining wound requires a dressing with the ability to absorb moisture and protect the surrounding wound from maceration, such as hydrofibers, alginates (Figs. 12.30 and 12.31), or foam dressings (Fig. 12.32). A nondraining wound requires a dressing that provides moisture or prevents evaporative

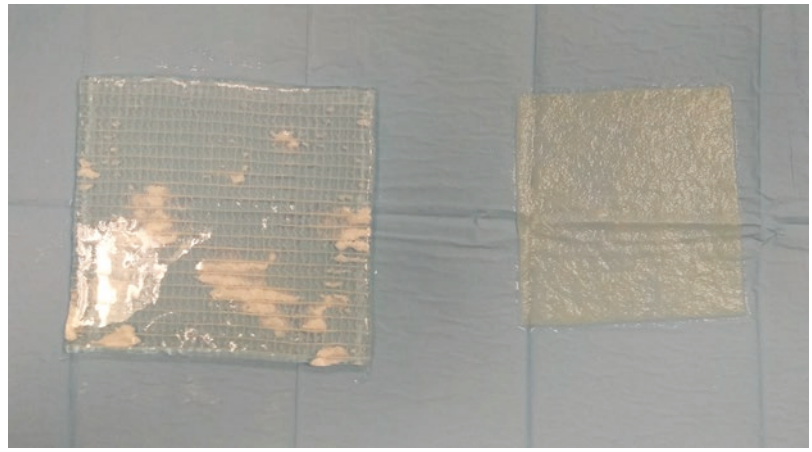

Fig. 12.31 Alginate (left) and hydrofiber (right) after absorbing exudates

Fig. 12.32 Different foam dressings

fluid loss, such as hydrogels or hydrocolloids (Fig. 12.33). Even in highly exuding wounds, negative-pressure wound therapy can be applied. NPWT provides a closed moist wound healing environment and regulates the quantity of exudate. Finally, it is advisable to use creams or dressings that facilitate the process of healing and epithelialization, but also that protect the surrounding skin. Dressings should be adapted to the wound bed, and the progress of the wound changes over time. During the phase of epithelialization, wounds require a dressing that will protect from trauma and promote a moist environment, for example films of polyurethane (Fig. 12.34).

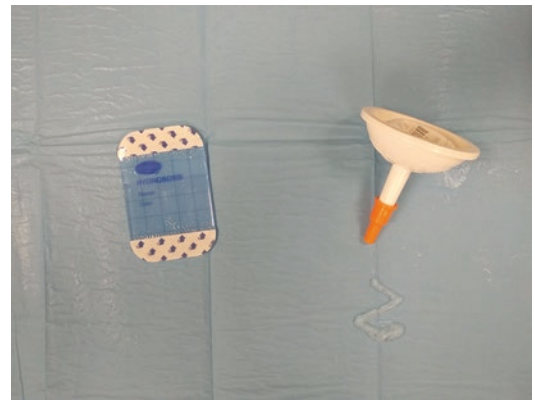

Fig. 12.33 Hydrocolloid (left) and hydrogel (right)

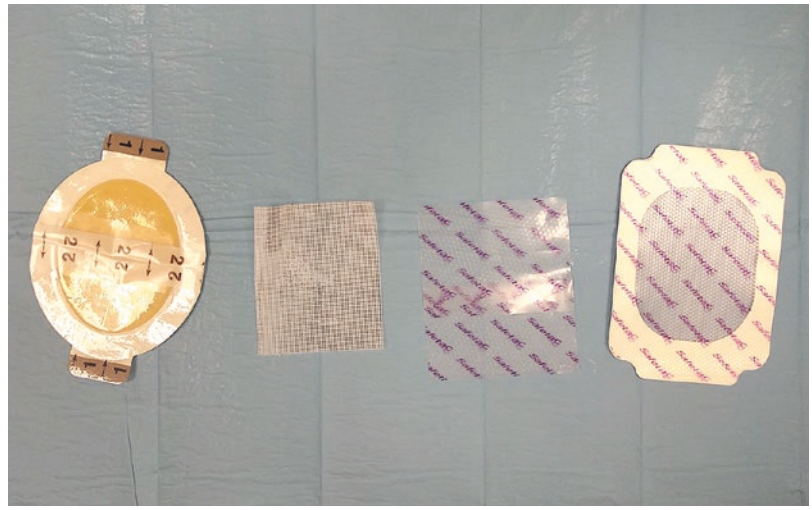

Fig. 12.34 Dressings recommended in the epithelialization phase. From left to right: hydrocolloid, paraffin gauze, non-perforated film, and perforated film

Many studies have verified the fact that a moisturized environment promotes wound healing better than a dry one. A moist wound environment facilitates all three phases of wound healing by trapping endogenously produced enzymes to facilitate autolytic debridement, preserve endogenously produced growth factors, and reduce patient pain complaints. Furthermore, a moist wound usually results in a more cosmetically appealing scar.

Principles at second healing:

- T (tissue) → Early excision of nonviable tissue
- I (infection) → Microbial control
- M (moisture) → Control exudate/avoid desiccation
- E (edge of wound) → Advanced wound healing techniques

There are no fixed principles in choosing the dressing material. Dressings should be selected based on the information obtained from the wound examination, preferences of the patient or medical team, economic impact, frequency of dressing changes, location, etc [55]. Some characteristics of the ideal wound dressing would be the following:

- Provide a barrier to microorganisms.
- Create a moist wound environment.
- Manage quantity of exudate.
- Provide adequate gas exchange.
- Provide thermal insulation.
- Protect exposed nerves (decrease pain).
- Eliminate dead space.
- Remove debris, necrotic tissue, and foreign material.
- Allow dressing changes painlessly and atraumatically.
- Protect peri-wound skin.

12.6.2 Treatment of Dehiscence

Treatment should be based on the debridement of wound edges, and the debridement of s damaged or necrotic tissue from wound bed if it is present, and healing by first or second intention. As in skin necrosis, the chosen technique in this kind of acute wounds after surgery is usually sharp or surgical debridement and primary closure with sutures, although it depends on the preferences of the patient and the medical team. If the area of dehiscence is reduced, second healing (following

the same principles as seen above) is also a good option.

12.6.3 Treatment of Infection

Skin is naturally colonized by many microorganisms, which are named skin microbiota. Most are nonpathogenic microorganisms; some of them are commensal (meaning they coexist without harming their host) and some are mutualistic (meaning they coexist and also offer a benefit to their host). They are found principally in the superficial layers of the epidermis and the upper parts of hair follicles.

Attention
Contamination (microorganisms are present, but do not result in signs or symptoms) and infection (there are signs or symptoms) are not the same.

When there is a wound, skin integrity is lost and microorganisms are allowed to enter the human body, where they can proliferate and grow at the expense of damaged or necrotic tissue.

Risk factors for developing a surgical wound infection are the following:

- Patient factors: smoking, aging, obesity, diabetes, weakened immune system, chronic steroid use, malnutrition, …
- Local factors: necrotic tissue, bad perfusion, foreign bodies, hematomas, dead space, …
- Surgery factors: emergency surgeries, long period of surgery (>2 h), …

The basic treatment for surgical wound infection can be summarized in a three-step process [55, 58].

1. Irrigation: It is important for diminishing the bacterial load and removing loose material. Open wounds should be irrigated on initial examination and with each dressing change. The most frequently used irrigation solution is normal saline. However, it has been proved that potable tap is as safe as sterile water or saline. Nonetheless, tap water must be used with caution in immunosuppressed patients, particularly if the water might be non-potable. Other cytotoxic antiseptic irrigation solutions (dilute iodine, chlorhexidine, hydrogen peroxide, …) are also frequently used, although the evidence of benefits for their use is weak and may have negative influence on tissue regeneration due to toxicity to host cells.

2. Debridement: All damaged and died tissues should be removed, as well as purulent collections. Debridement plays a vital role in the management of wound infections. Debridement of necrotic tissue and exudate helps to reduce wound bioburden and may also increase the effectiveness of topical antimicrobials.

3. Topical antimicrobial treatment: The term antimicrobial is used broadly to describe disinfectants, antiseptics, and antibiotics. It can be applied in the form of impregnated dressings or irrigants. Most frequently used antimicrobials are silver, iodine, and polyhexamethylene biguanide, while some antibiotics often used in infected surgical wounds are silver sulfadiazine, nitrofurazone, or mupirocin. Infected wounds should not be occluded and should be rebandaged at least once a day. Antimicrobial therapy is not indicated for all wounds and should be reserved for the following:
   - Prevention of infection in patients who are considered to be at an increased risk
   - Treatment of localized wound with clinical signs of infection
   - Local treatment of wound infection in cases of local spreading or systemic wound infection, in conjunction with systemic antibiotics

Systemic antimicrobial treatment would only be needed if there are systemic symptoms, for example fever.

Tip

Infection signs are similar to the cardinal signs of inflammation (redness, heat, swelling, and pain), but these signs are typically excessive or disproportionate to the size and extent of the wound. Some other signs of infection are delayed healing, presence of pus, or foul smell.

12.7 Conclusion

Management of scars is a therapeutic challenge. The progressive knowledge of the wound healing process and the physiological events that take place in each type of scar have allowed the development of new treatments for hypertrophic scars and keloids, as well as the development of multiple techniques for minimizing scar formation and correcting unaesthetic scars. Nevertheless, there is still much to know and to advance in this field of research, and we hope that the dream of being able to erase the scars will become true in the future.

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Striae Gravidarum and Its Treatments

13

E. Moreno-Artero and L. Aguado

Take-Home Points

- *Striae distensae* are atrophic linear scars that generally develop in the connective tissue due to various physiological states, such as pregnancy.
- *Striae gravidarum* are a subtype of *striae distensae* that develop in pregnant women. Mechanical stress, pregnancy hormonal environment, younger maternal age, primigravidas, higher maternal body mass index, and higher weight gain in pregnancy have been described as risk factors.
- *Striae gravidarum* are initially seen as dark-pink or bright-red atrophic linear scars. This initial stage is known as *striae rubra*. Later on, they become paler or lightly brown, being renamed as *striae alba*.
- Treatment is difficult. Topical tretinoin and pulsed dye laser may improve the clinical aspect of *striae rubra*, while the fractional ablative lasers (CO_2 and Er:YAG) are superior when treating *striae alba*.

13.1 Introduction

Striae distensae (SD) are atrophic linear scars that generally develop in the connective tissue due to various physiological states, such as pregnancy and growth spurt during puberty, or rapid changes in body mass, such as in weightlifters, obese, or weight loss. *Striae gravidarum* (SG) are a subtype of SD, which develop in pregnant women [1, 2].

13.2 Epidemiological and Clinical Aspects

SG usually develop between the end of the second trimester or the beginning of the third trimester of pregnancy. The prevalence is estimated to be around 55–90% of pregnant women. SG affect mostly the abdomen and breasts, but they can also affect the hips, thigh, groins, and armpits [2].

Clinically, SG are initially seen as dark-pink or bright-red atrophic linear scars. This initial stage is known as *striae rubra* (SR; Fig. 13.1). Later, SR become paler or lightly brown, being renamed as *striae alba* (SA; Fig. 13.2). SA are less perceptible, but they never have spontaneous resolution, and treatment remains, especially in this chronic phase, difficult [3, 4].

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_13

Fig. 13.1 Red or pinkish atrophic linear scars in the abdomen of a pregnant woman. This initial stage is known as *striae rubra*

Fig. 13.2 Chronic atrophic white linear scars in the abdomen. SG in this chronic phase are known as *striae alba* (SA)

13.3 Etiopathogenesis

The etiopathogenesis is multifactorial. The extracellular matrix of the dermis is a framework of different structural proteins such as fibrillin, elastin, fibronectin, and collagen. In the pathogenesis of SD, there is a rigid cross-linked collagen network, low expression of collagen and fibronectin genes, and elastolysis. Thus, genetic predisposition is critical, but there are other factors that may be involved [3].

Among maternal risk factors, mechanical stress, pregnancy hormonal environment, younger maternal age, primigravidas, higher maternal body mass index (BMI), and higher weight gain in pregnancy, as well as a history of striae in the mother and/or sister, have been described [1, 2]. Fitzpatrick V–VI skin types and ethnicities have also been documented as risk factors; in fact, Chinese women seem to have a lower risk than Indian or Malay [1]. Additionally, it seems that the absence of social security increases the risk two times, probably by affecting the nutritional state of pregnant women [2]. Interestingly, it seems that a sleep duration of 9 h and more rises the risk of developing SG by approximately two times when compared with pregnant women who sleep 7–8 h a day [2]. However, there are some inconsistences between different studies; in fact, a recent study has shown that younger age and parity have no association with the prevalence of SD [1]. In parallel, higher birth weight has also been related to SD (Table 13.1) [1].

! Attention

"Higher maternal body mass index (BMI) and higher weight gain in pregnancy have been described as risk factors of SG."

Table 13.1 Risk factors of SD

Maternal risk factors	Fetal risk factors	Risk factors associated with pregnancy	Socioeconomic and lifestyle risk factors
Younger maternal age	High birth weight	Mechanical stress	Absence of social security
Primigravids		Pregnancy hormonal environment	Sleep duration of 9 h and more
Higher maternal BMI and higher weight gain in pregnancy			
Familial history of striae			
Fitzpatrick V and VI			

13.4 Histology

In the normal skin, the epidermis shows quite regular projections toward the dermis, called rete ridges. The papillary dermis is composed of a mix of collagen bundles and elastin fibers, randomly arranged. In the reticular dermis, collagen, which is organized in thick dermal bundles, predominates [3].

In the initial stage of SR, the epidermis is almost normal; dermis is edematous with a perivascular lymphocytic inflammatory infiltrate, and there is an increase of the dermal microvasculature, contributing to its red color. Normal elastin fibers predominate in the papillary dermis, while collagen bundles become small and thin [3].

In the chronic phase, an atrophic epidermis with loss of rete ridges and absence of skin appendages characterizes SA. In the papillary dermis, elastic fibers are scant, and collagen fibers, densely packed, are disposed in parallel to the epidermis [3].

13.5 Prevention

SG can affect women, as they may be a cause of stress during pregnancy or become an aesthetic or cosmetic problem later. In this sense, prevention is the first concern, and many women use diverse commercially available products for preventing their development during pregnancy [5]. There is not a consensus and high-quality evidence to support their use. In 2012, Brennan et al. searched the Cochrane Pregnancy and Childbirth Group's Trials Register and included all the randomized or quasi-randomized controlled trials comparing different topical preparations, comparing topical preparations with placebo or topical preparations with no treatment. Six trials with 800 women were included, with no statistically significant differences in the development and severity of SG when comparing the different topical preparations with active ingredients. In the same way, there were no statistically significant differences in the development and severity of SG when comparing the application of topical preparations with placebo or no treatment. Topical preparations with active ingredients included Alphastria, Trofolastin, Verum, olive oil, and cocoa butter, all of them containing vitamin E; Alphastria and Verum also contain hyaluronic acid (HA) [6].

In 2015, Korvagkar et al. supported the anterior hypothesis by affirming that there is limited evidence that *Centella asiatica*, cocoa butter, olive oil, and HA, and massage with bitter almond oil, may prevent SG and/or reduce their severity, due to the lack of strong evidence from rigorous, well-designed, randomized controlled trials with a sufficient number of subjects [7].

Two small randomized controlled trials have demonstrated the efficacy of HA in the prevention of SD [8, 9], but some limitations were the lack of follow-up and a subjective measure of the clinical improvement [3]. Another trial showed a mild improvement when compared with the topical application of HA by massage with no massage or no application; however, limitations were poor randomization and lack of placebo control [7, 10]. When evaluating the efficacy of HA, the

fact that creams containing HA also include allantoin, vitamins A and E, and calcium pantothenate, among others, needs to be taken into consideration, and a superimposed effect of massage needs to be also considered [7]. Thus, there is a lack of evidence that creams containing HA have a benefit in SD [7].

Despite this, a substantial number of women employ different commercially available products for prevention of SG. Brennan et al. have recently conducted a cross-sectional, descriptive study in which among 753 pregnant women at 36 weeks' gestation or more, 589 employed different topical products to prevent SD during the current pregnancy. The 78.2% indicated that they used a product to prevent or reduce the development of SG, and 36.5% used two or more products. Bio-oil was the most frequently used product [11].

! Attention
"There is a lack of evidence that the commercially available products today for prevention of SG have a benefit in SD."

13.6 Treatment

The three main mechanisms to improve SD are enhancing the collagen production, reducing vascularity, and increasing melanin [3].

13.6.1 Topical Treatments

In this section, we review the three most employed topical drugs in the treatment of SD, tretinoin, *Centella asiatica*, and some chemical peel agents, such as glycolic acid, trichloroacetic acid, and L-ascorbic acid. Since most of the women who have SG are in the breastfeeding period, it is important to take into consideration if these therapeutic options could be indicated in this situation. Regarding the safety of *Centella asiatica*, glycolic acid, and topical tretinoin, there is little or no information about transfer into breast milk because they have not been studied during breastfeeding, but topical preparations are poorly absorbed into systemic circulation after topical application (Table 13.2).

Table 13.2 Review of topical and procedural therapies

Topical treatments	Procedural therapies
Topical tretinoin	Aluminum oxide microdermabrasion
Centella asiatica	Percutaneous collagen induction therapy
Chemical peel agents	Galvanopuncture
Glycolic acid	Platelet-rich plasma
L-Ascorbic acid (vitamin C)	
Trichloroacetic acid	

13.6.1.1 Topical Tretinoin

Tretinoin, a topical retinoic acid, is the most employed therapeutic option in daily practice so far. It stimulates collagen production by activating fibroblasts. Many studies have demonstrated that SR can be improved by topical tretinoin at high doses (0′05% to 0′1%), with minimal or no effects in SA. Tretinoin has a proved efficacity and a high level of evidence in the treatment of SD [3, 4, 12, 13].

13.6.1.2 *Centella asiatica*

Centella asiatica is a plant used in Asian herbal medicine for diverse dermatosis such as leprosy, lupus, eczema, and venous stasis ulcers; it contains triterpenoids (asiaticoside and related compounds), which stimulate fibroblasts to produce collagen. *Centella asiatica* is often combined with other components, such as α-tocopherol, collagen and elastin hydrolysates, hydroxyprolisilane-C, rosehip oil, and vitamin E [3].

Mallol et al. demonstrated in a randomized, double-blind, placebo-controlled trial involving 80 women that daily massage with Trofolastin, a cream which contains *Centella asiatica*, to the abdomen, breasts, buttocks, and hips from the 12th week of pregnancy until delivery was associated with decreased SG incidence compared with placebo (56% vs. 34%). The cream was effective for preventing SG in subjects with a history of puberty-associated SD, but not in subjects with a history of SG from preceding preg-

nancies. In subjects who developed SG, the cream reduced the severity of lesions, compared with placebo [14].

In another randomized, double-blind, placebo-controlled trial, García Hernández et al. showed no differences in the prevention of SG in 183 women who applied a cream containing triterpenoids from *Centella asiatica* twice a day to the abdomen, thighs, hips, buttocks, and breasts from the 12th week of pregnancy until delivery. However, if there was not a history of SD, only 6% of women developed SG compared with 35% in women with a history of SD. If lesions appeared, the severity of lesions was decreased in the intervention group. As the authors concluded, it seems that the cream reduced the severity of SG developing during pregnancy in all women and prevents its incidence only in women without a history of SD [15].

Finally, Martelli et al. proved its efficacy in the prevention of wrinkles and striae in a double-blind trial conducted in 20 female volunteers aged between 20 and 25, which applied twice a day for 1 month a combination of *Centella asiatica* and boswellic acid. A clinical noninvasive evaluation (temperature, humidity, skin hydration, and biomechanical properties of the skin, as extensibility, elasticity, and firmness) was performed. Boswellic acid blocks LTB4 and human leucocyte elastase (HLE). LTB4 stimulates chemotaxis, cell adhesion, superoxide production, and hydrolysis, while HLE degrades elastin, fibronectin, laminin, collagen, and proteoglycans of the extracellular matrix in the dermis [16].

13.6.1.3 Chemical Peel Agents

Chemical peel agents, such as glycolic acid, L-ascorbic acid (vitamin C), and trichloroacetic acid (TCA), induce collagen production through the creation of an inflammatory state in the dermis [3].

A double-blind controlled trial on a total of 40 patients ranging from 16 to 35 years evaluated the efficacity of 70% **glycolic acid** lotion in SR and SA, with light modifications, but without totally disappearing [17]. Combination of 20% glycolic acid with 0.05% tretinoin is more effective than a preparation of 20% glycolic acid with 10% L-ascorbic acid in the treatment of SA, both applied once a day for 12 weeks [18].

In a recent study, the efficacity of platelet-rich plasma (PRP) with microneedling and **trichloroacetic acid** peel for treatment of striae distensae has been evaluated. Under topical anesthesia, PRP was injected over the SD with an insulin 31-gauge syringe followed by microneedling with a 1 mm dermaroller over the striae and extended 2–4 mm beyond the margins. Finally, TCA peel (35%) was applied for 1 min. Three sessions are done 3 weeks apart, with an important clinical improvement at week 9 [19].

l**-Ascorbic acid** derivative sodium L-ascorbate is a potent stimulator of collagen and elastin production in cultures of fibroblasts derived from normal human skin and dermal fat, being an interesting option, especially in combination with other collagen stimulators, in the treatment of wrinkled and stretch-marked skin [3, 18].

Karia et al. evaluated various therapeutic measures in SR through a prospective cohort study performed in 50 patients that were randomly divided into five groups receiving topical tretinoin 0.1% applied once a day, microdermabrasion (MDA) combined with TCA 30% peel, mesotherapy, Q-switched Nd:YAG laser, and a combination treatment of microdermabrasion, salicylic acid peel, and retinol yellow peel, respectively. Patients were each 2 weeks for 2 months and then at monthly intervals. Combination treatment with microdermabrasion, salicylic acid, and retinol yellow peel showed the best results compared to other therapeutic options, followed by Nd:YAG laser, mesotherapy, MDA + TCA, and topical tretinoin [20].

Pearls and Pitfalls

"Many studies have demonstrated that SR can be improved by topical tretinoin at high doses (0′05% to 0′1%), with minimal or no effects in SA."

"Even if results are discordant regarding the prevention of SG, it seems that *Centella asiatica* prevents its incidence only in women without a history of SD; in addition, when SG appear, it reduces the severity of lesions."

"Chemical peel agents, such as glycolic acid, L-ascorbic acid, and TCA, induce collagen production and improve the aspect of SD, especially when combined with other therapeutic options, such as tretinoin, microdermabrasion, and microneedling."

13.6.2 Procedural Therapies

Procedural therapies include aluminum oxide microdermabrasion, percutaneous collagen induction therapy, and galvanopuncture. All of them increase collagen production by fibroblasts (Table 13.2).

13.6.2.1 Microdermabrasion

Microdermabrasion is used for cosmetic purposes as SD, scars, acne scars, melasma, photoaging, or fine wrinkles. Devices may be crystal or crystal-free. Among the first group, the most common crystal used is aluminum oxide. Aluminum oxide induces mechanical dermabrasion of damaged skin, increasing collagen production by fibroblasts. Using negative pressure, the device pulls the skin into the handpiece and releases the abrasive crystals. Three passes over the treated per sessions and 4–6 weekly sessions are needed to achieve results [13].

13.6.2.2 Percutaneous Collagen Induction Therapy

Percutaneous collagen induction therapy, or needling therapy, creates microclefts in the papillary dermis, leading to thickening of the epidermal layers and collagen production. Aust et al. conducted a single percutaneous collagen induction therapy in 22 female patients with SD, under local tumescence anesthesia. After 6 months, skin texture and tightening had improved, and on histology, augmentation in elastin and collagen I content was seen. Post-inflammatory hyperpigmentation was not noticed [21].

Recently, percutaneous collagen induction therapy has been demonstrated to be superior to microdermabrasion combined with sonophoresis and to carbon dioxide laser [22, 23].

13.6.2.3 Galvanopuncture

Galvanopuncture is another needling therapy that applies a continuous microcurrent in the dermis. Bitencourt et al. demonstrated in a prospective single-center study the efficacy and safety of galvanopuncture for the treatment of **SA** in 32 female patients with SA in the buttocks; 10 sessions 7 days apart were performed. All patients showed clinical improvement [24].

13.6.2.4 Platelet-Rich Plasma

Platelet-rich plasma (PRP) is a concentrated solution of plasma containing various autologous growth factors, especially epidermal growth factor, platelet-derived growth factor, transforming growth factor, and vascular endothelial growth factor, and proteins that are injected intradermally. PRP increases dermal elasticity by inducing neocollagenesis through the fibroblasts of the extracellular matrix [3].

PRP has been used in combination with fractional radiofrequency, which was expected to enhance the penetration of PRP. Eighteen patients were treated with four sessions every 2 weeks. After treatment, subjective and objective clinical improvement was remarkable, and the average width of the widest striae had decreased from 0.75 to 0.27 mm. Biopsies were obtained from three patients, showing a significant increase of both collagen and elastic fibers in papillary and reticular dermis, accompanying increase of subepidermal collagen density. The only reported side effect was post-inflammatory hyperpigmentation (11.1%) [25].

As commented above, PRP has been employed for the treatment of SD in combination with TCA and microneedling, with synergistic effects [19].

There is a study comparing PRP vs. microdermabrasion vs. combination of PRP and microdermabrasion in the treatment of SD. It was done in 68 patients that were randomly assigned to those three groups. Each patient underwent a maximum of six sessions at 2-week interval. There was significant clinical improvement of SD in patients treated with PRP and the combination of PRP and microdermabrasion when compared with patients treated only with micro-

dermabrasion. Besides, combination of PRP and microdermabrasion showed faster results. An increase in collagen and elastic fibers in the dermis was observed in cutaneous biopsies [26].

Another study compared PRP (monthly intralesional injections for 3 months) versus topical tretinoin 0.05% (daily application for 3 months) in the treatment of SD, showing that, even if both treatments showed statistically significant improvement of SD, PRP is more effective than tretinoin [27].

Pearls and Pitfalls

"Microdermabrasion with aluminum oxide induces mechanical dermabrasion of damaged skin, increasing collagen production by fibroblasts, improving SD."

"Percutaneous collagen induction therapy, or needling therapy, creates microclefts in the papillary dermis, leading to thickening of the epidermal layers and collagen production."

"Galvanopuncture has demonstrated efficacy for the treatment of SA."

"PRP, alone or in combination with radiofrequency, TCA, microneedling, or microdermabrasion, has demonstrated subjective and objective clinical improvement of SD by inducing neocollagenesis."

13.6.3 Energy-Based Methods

This group includes radiofrequency, lasers, intense pulsed light, and infrared light. All of these therapeutic options, often used in combination, have been shown to offer clinical improvement due to reorganization of the collagen and dermal remodeling (Table 13.3) [28].

Table 13.3 Energy-based methods

Energy-based methods	Efficacy
Radiofrequency	SR and SA
Lasers	
Fractional carbon dioxide laser 10,600 nm	SA > SR
Erbium:yttrium-aluminum-garnet laser	SR and SA
Pulsed dye laser	SR
Nd:YAG 1064 nm laser	SR and SA
Erbium glass 1540 nm laser	SR
Copper-bromide laser	SR
Diode laser	Controverted
Intense pulsed light	SR > SA
Infrared light	SA
UV light	SA
Excimer laser	SA

SR striae rubra, *SA* striae alba

13.6.3.1 Radiofrequency

Radiofrequency (RF) devices induce a thermal damage in the dermis caused by a high-frequency oscillating electrical current, causing collagen denaturation and subsequent collagen production by fibroblasts. Fractional RF is the most effective system, especially in SR and if it is combined with topical tretinoin or PRP. Bipolar RF, in combination with IL or fractional RF and IL, seems to be effective on both SA and SR [28].

Recently, Ahmed et al. compared the efficacy between carboxytherapy, PRP, and tripolar radiofrequency; all three proved to be effective clinically and histopathologically in treating both types of striae, which were well tolerated by the patients with minimal, transient side effects and our study results gave us guidelines for their clinical application [29].

13.6.3.2 Lasers

The term laser is an acronym for "light amplification by stimulated emission of radiation." Lasers deliver monochromatic (only one longwave), coherent (waves are in phase with respect to space and time), collimated (beam diameter does not increase with distance), and high-intensity beams of light, which represents a part of the electromagnetic spectrum. This light acts on different skin chromophores (hemoglobin, melanin, or water) [30].

The term "ablative" refers to the capacity of some lasers to vaporize skin structures, whereas "non-ablative lasers" leave the skin intact [30].

The energy of ablative lasers is capable of heating water in the skin. This chromophore, when turned into gas, vaporizes skin cells with two main consequences: a skin-peeling effect and

a collagen formation with subsequent retraction of the dermis and epidermis, tightening the skin. Ablative lasers can be non-fractionated lasers, which are devices that act on the entire projected area of the skin surface, or the most recent fractional lasers, which target an equally disseminated portion of the projected area. The group of ablative lasers comprises the fractional carbon dioxide laser 10,064 nm (CO_2 laser) and the fractional Er:YAG laser [30].

Non-ablative lasers include the erbium glass 1540 nm laser, the pulsed dye laser (PDL), the 308 nm excimer laser, the Nd:YAG 1064 nm, the copper-bromide laser, and the diode laser [30].

Fractional Carbon Dioxide Laser 10,600 nm

The CO_2 laser is a fractional ablative laser that emits light at a wavelength of 10,600 nm in the infrared spectrum. It delivers high peak fluences (>5–7 J/cm^2) in a very short pulse duration (1 ms). It is largely utilized for facial skin resurfacing, to vaporize cutaneous lesions, and to improve the clinical aspect of scars, including SD [30]. Recently, Crocco et al. published a two-arm, prospective, self-control open-label study to evaluate clinically and histologically the changes in SG after treatment with the CO_2 fractional laser. Thirteen females with SG were recruited and treated with four monthly sessions of increasing pulse energy levels (80, 90, 100, and 110 mJ/microscopic treatment zone). A statistically significant increase in the thickness of the epidermal cell layer and in the amount of collagen fibers was seen in skin biopsies. Clinically, there was a remarkable diminution in the width of SG [31].

Lee et al. confirmed its efficacy in 27 women with SA after one session (pulse energy of 10 mJ) [32]. In 2012, Naeini et al. carried out a randomized clinical trial in female patients with SA comparing the CO_2 laser every 2–4 weeks with a topical treatment based on a 10% glycolic acid +0.05% tretinoin cream once a day. Striae surface area was significantly decreased after treatment in the CO_2 laser group in comparison with the topical treatment [33]. Another study conducted by Naeini et al. compared the clinical efficacy of a fractional CO_2 laser as well as a combination of fractional CO_2 laser and pulsed dye laser (PDL) in the treatment of SA. Eighty-eight SA lesions in three female patients were included; half of the lesions were treated with the fractional CO_2 laser and half with the combination of fractional CO_2 laser and PDL. Three sessions with 4-week intervals were performed with each therapeutic option. Results showed that the combined laser treatment was more effective than fractional CO_2 alone [34]. Thus, the efficacy of the CO_2 laser has been better proved in late-stage SA as compared to SR. Among the adverse effects, post-inflammatory hyperpigmentation may be a great problem in the darker skin types IV to VI.

Erbium:Yttrium-Aluminum-Garnet Laser

The Er:YAG laser is a fractional ablative laser that emits light at a shorter wavelength (2940 nm) than the CO_2 laser. Its light is 16 times more strongly absorbed by water within the skin cells, and it has a very short pulse duration, limiting damage to surrounding areas. In addition to finer ablation and shortened healing time, pigmentary changes are also less common, making it beneficial for highly pigmented individuals. However, hemostasis is not complete, causing pinpoint bleeding at the dermal-epidermal junction, which leads to a lower degree of skin tightening in comparison with the CO_2 laser [30]. Wanitphakdeedecha R et al. conducted a study to determine the efficacy and safety of the Er:YAG laser for the treatment of SD in skin phototypes III–IV. They recruited 21 women with **late-stage SD** (the mean stria age was 131 months) and treated them monthly for 2 months. Each stria was divided into two parts; one part was treated with one pass of 400 mJ in short pulse mode with 50% overlapping and one pass of 2.2 J/cm^2 in smooth mode without overlapping, while the other half of the stria was treated with two passes of 400 mJ in short pulse mode with 50% overlapping. Most of the patients showed improvement in skin roughness, skin smoothness, and width, but there were no statistical differences between the two modalities of use. However, post-inflammatory hyperpigmentation persisting for more than 6 months was more frequent in darker phototypes and the areas of SD treated by only the

short pulse mode, maybe because the smooth mode penetration of heat is slower, minimizing the thermal damage [35].

Recently, Shen et al. evaluated the clinical and histopathologic efficacy and safety of this laser with recombinant bovine basic fibroblast growth factor (rb-bFGF) and light-emitting diode-red light (LED-RL) for the treatment of **SA**. Thirty patients were treated with 6 monthly sessions of Er:YAG. Once completed, the subjects were required to spray rb-bFGF for 1 week at home. They then received LED-three weekly sessions of RL. All 30 patients demonstrated clinical improvement, and an increase in epidermal thickness, dermal thickness, and collagen and elastin density was demonstrated in skin biopsies [36].

There is a French study which combines the conventional Er:YAG 2940 nm laser with a specially designed spatially modulated ablation (SMA) nozzle in the treatment of both SR and SA. The RecoSMA technology is a non-fractional, nonthermal, and micro-ablative method (skin temperature remains stable at 36.68 °C, minimizing thermal effect); thus, the skin's barrier function is not compromised, which limits side effects, especially hyperpigmentation, and reduces recovery time. Patients with late-stage SA (maturity of SA between 20 and 32 years) responded poorly in comparison with SR or early SA [37]. In another study of Güngör et al., SR responded well to the Er:YAG laser, while mature SA had a poorer response [38].

Pulsed Dye Laser

The PDL uses the liquid medium rhodamine and emits short pulses of light flashes with a wavelength between 585 and 595 nm [30]. The 585 nm PDL has been largely employed for the treatment of SD. This laser has demonstrated to improve the erythema of SR because of its high affinity for its chromophore hemoglobin, but also to increase collagen in the extracellular matrix of the dermis when it is utilized at low fluences (2.0–4.0 J/cm^2). Other authors support that there is no effect in collagen and elastin production, or minimal. Thus, it seems largely accepted that its efficacy in treating SR relies on reducing vascularity and, subsequently, on the erythema of SR, with a controverted effect on elastin and collagen production [6]. Thus, it seems reasonable to expect that PDL has more efficacy in SR than in SA (Figs. 13.3 and 13.4).

Jiménez et al. piloted a trial to conclude whether the 585 nm pulsed dye laser was effective in both SR and SA after two treatments. Twenty patients with SR and SA were treated twice, at baseline and 6 weeks apart. A moderate improvement of erythema in SR was seen, and an increase in total collagen amount was demonstrated histologically both in SR and in SA [39]. However, PDL is not superior to fractional ablative lasers (CO_2 and Er:YAG) when treating SA [40].

Regarding SR, there is no consensus whether PDL is superior to the Er:YAG laser or not [13, 41].

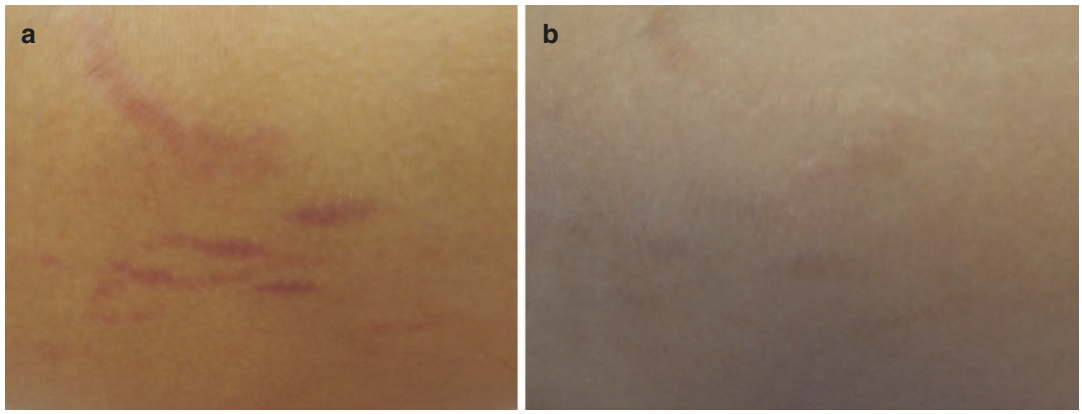

Fig. 13.3 A 31-year-old woman with red *striae gravidarum* on the abdomen (**a**) treated with PDL (2 sessions 2 months apart; energy 8.5 J/cm^2, pulses 0.5 ms, spot 7 mm). Clinical aspect after the second PDL session 2 months apart (**b**)

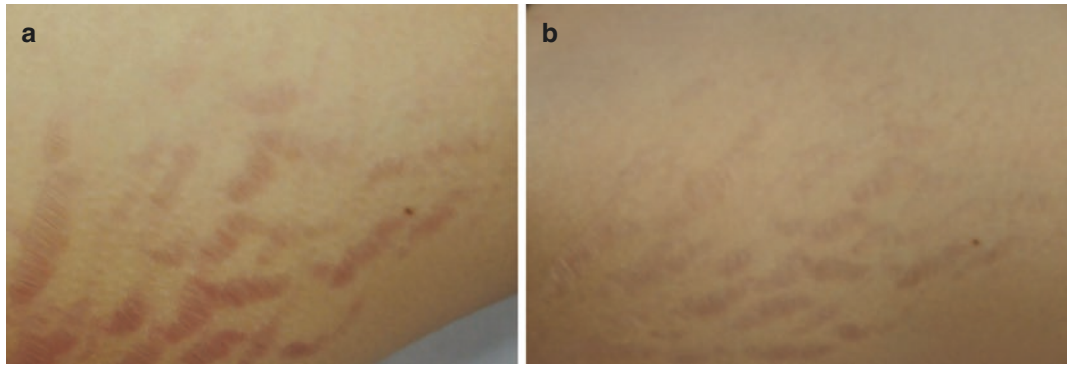

Fig. 13.4 A 26-year-old woman with red *striae distensae* on the hips developed because of a rapid weight gain (**a**). Aspect after 2 sessions of PDL 3 months apart; energy 8.5 J/cm^2, pulses 0.5 ms, spot 7 mm (**b**)

As seen above, the combination of the fractional CO_2 laser and the PDL has been demonstrated to be superior to their use alone [34].

Because the absorption spectrum of melanin includes visible and infrared light, at the wavelengths used by vascular lasers, absorption also occurs by melanocytes, with the subsequent risk of hypopigmentation and scarring. Furthermore, although permanent hyperpigmentation has not been reported, post-inflammatory hyperpigmentation is not infrequent, especially in patients with a dark skin type (III–VI) [30].

Nd:YAG 1064 nm Laser

The Nd:YAG 1064 nm laser is a fractional non-ablative laser that has been used to treat SD. In 2016, Elsaie et al. compared the efficacy of two fluences (75 and 100 J/cm^2) of long-pulsed Nd:YAG in 45 subjects with **SR and SA**. Each stria was divided into three equal sections, two areas treated with long-pulsed 1064 nm Nd:YAG laser, with fluences of 75 or 100 J/cm^2, and one non-treated, as a control section. All patients received four treatments at 3 weeks' interval. SA showed better improvement with 100 J/cm^2 fluence, while SR improved more with 75 J/cm^2. Histologically, collagen and elastin fibers were increased in both cases [42].

Zaleski-Larsen et al. evaluated the efficacy of the non-ablative fractional 1565 nm Er:glass and the picosecond fractional 1064/532 nm Nd:YAG lasers in 20 patients with SA on the abdomen. Three sessions were conducted with a 3-week interval. It was showed that they were equally efficacious in improving texture and atrophy in **SA**, with no changes in the number of lesions. The picosecond laser was, however, less painful and had a shorter healing time [43].

Erbium Glass 1540 nm Laser

The erbium glass 1540 nm laser is a fractional non-ablative laser with the ability to create microscopic columns of coagulated tissue on the skin tissues, leading to neocollagenesis. Because it is a non-ablative laser, there is a preservation of the stratum corneum, diminishing the risk of post-inflammatory hyperpigmentation and allowing faster recovering. It has also a lower risk of hyperpigmentation when compared to vascular lasers. Oliveira et al. reported the efficacy of this laser on four patients with **SR**. All of them had skin type IV, making the treatment of SD challenging, due to the risk of hyperpigmentation with ablative laser modalities and vascular lasers. They showed that the erbium glass 1540 nm laser is a safe option in those cases, with good cosmetic results [44].

Copper-Bromide Laser

Longo et al. tested the 577 nm copper bromide non-ablative laser in the treatment of **SD**, which has higher rates of absorption by hemoglobin than its PDL counterpart does, with a 33% of total response and the rest of the lesions showing diminution of size [45].

Diode Laser

The non-ablative 1450 nm diode laser has been used to improve cutaneous atrophic scars; thus, it was expected to be effective in SD. However, Tay et al. published a study to evaluate the efficacy of the 1450 nm diode laser in the treatment of **SR and SA** in Asian patients with skin types IV–VI, but no improvement was confirmed [46].

13.6.3.3 Intense Pulsed Light

Intense pulsed light (515–1200 nm) seems to cause collagen denaturation by emitting energy pulses with various durations and intervals, followed by neocollagenesis. Hernández-Pérez et al. evidenced the efficacy of IPL by a prospective study conducted in 15 women with SD on the abdomen, treated with five sessions of IPL performed every 2 weeks. All of them showed statistically significative improvement, clinically and histologically. The 590 nm is the most effective modality [47].

To compare the difference between the treatment efficacy of PDL and IPL, Shokeir et al. treated 20 patients with SD with PDL on one side of their bodies and with IPL on the other side once a month, for five sessions. SD width was reduced, texture was improved, and collagen expression was increased with both PDL and IPL, with a higher improvement in collagen I expression with PDL compared to IPL in a significant manner. The degree of improvement was **higher in SR than in SA** [48].

13.6.3.4 Infrared Light

Infrared light (IL) comprises a spectrum of broadband light emitted by a xenon lamp. It has been largely used in the treatment of atrophic facial scars and fine wrinkles. One study including ten patients was performed by Trelles et al. to evaluate the non-fractional broadband IL for the treatment of **SA**; four sessions were given 15 days apart. The parameters selected for the treatment of stretchmarks were an 800–1800 nm bandwidth and a fluency of 31 J/cm^2. Subjective patient satisfaction, measured by a subjective graded score, was poor for all patients, but some degree of improvement was shown in the 3D skin surface analysis and histological organization of SD [49].

13.6.3.5 UV Light

Because repigmentation is a major goal in the treatment of **SA**, UV light has been employed due to its potential of improving **SA** color by increasing the amount of melanin [13]. Sadick et al. showed that the combination of UVB (296–315 nm) and UVA1 (360–370 nm) in nine patients was efficient in 50% of patients, although it was only temporary; side effects included transient hyperpigmentation [50].

13.6.3.6 Excimer Laser

The xenon chloride excimer laser delivers narrow-band (308 nm) UVB radiation quicker and with increased precision compared to standard UV therapy. Different studies have reported improvements in **SA** with excimer laser, while others do not [13].

Pearls and Pitfalls

"RF seems to be effective on both SA and SR, especially when combined with topical tretinoin (SR), PRP (SR, SA), or IL (SA)."

"The CO_2 laser is a fractional ablative laser. The efficacy of the CO_2 laser has been better proved in late-stage SA as compared to SR, especially when combined with PDL."

"The Er:YAG laser is a fractional ablative laser that has proved efficacy in late-stage SD; it has also demonstrated clinical improvement and an increase in epidermal thickness, dermal thickness, and collagen and elastin density in SA."

"PDL has demonstrated to improve the erythema of SR because of its high affinity for hemoglobin; thus, it seems reasonable to expect that PDL is more efficient in SR than in SA. Its effect in collagen and elastin production is controverted, but it is not superior to fractional ablative lasers (CO_2 and Er:YAG) when treating SA."

13.7 Conclusions

SD are atrophic linear scars that may affect pregnant women, as a source of stress during pregnancy or as an aesthetic concern later on. There are many risk factors, as mechanical stress, pregnancy hormonal environment, younger maternal

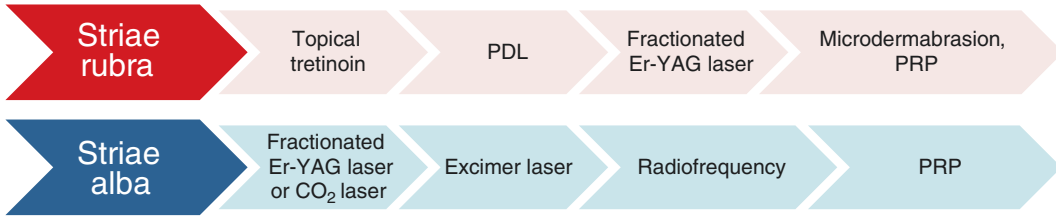

Fig. 13.5 Algorithm for management of SR and SA. Based on the article of Lokhande et al. (2019)

age, primigravidas, higher maternal body mass index, and higher weight gain in pregnancy. Topical tretinoin and pulsed dye laser may improve the clinical aspect of SR, while the fractional ablative lasers (CO_2 and Er:YAG) are superior when treating striae alba (Fig. 13.5).

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Part V

Breast

Mammary Tissue Changes During Pregnancy and Breastfeeding

14

Tatiana Costas, Mónica Gomes-Ferreira, and Jesús Olivas-Menayo

Take-Home Points

- We should consider breasts not only as a breastfeeding organ but also as an aesthetic one. The second function is as important as the first, and it must not be overlooked.
- Breasts are dynamic organs that change during a woman's life. Hormone variations during pregnancy and breastfeeding cause changes in the physiology, shape, size, and vascularization of these organs.
- There are particular conditions in this period such as mastitis or nipple fissure. Moreover, changes in breast tissue make it difficult to diagnose breast pathology.
- These changes may revert over time or require surgical procedures to recover the aesthetic function of the breasts.

14.1 Introduction

Breasts are an important organ in the woman's body, not only for breastfeeding but also because of their important aesthetic function. Both of them are crucial, and the latter must not be overlooked.

During pregnancy and breastfeeding, the mammary tissue is exposed to critical changes due to hormonal activity. Depending on multiple factors, these changes may persist over time or disappear after the breastfeeding period.

There are also typical pathologies in this stage, such as mastitis in the puerperium. Also, there may be other common lesions, such as fibroadenoma, which are more difficult to detect and diagnose due to changes in the mammary tissue.

14.2 The Breasts

14.2.1 Anatomy

The breasts are a bilateral organ in the thoracic area. They are usually close to the sternum, between the second and sixth ribs. In addition, there is mammary tissue in a triangular extension close to the axilla called axillary process or tail of Spence, which has several implications in breast cancer.

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_14

The breasts are affixed to the chest through the Cooper's ligament, which joins the breasts to the pectoral fascia.

They are made up of glands, fat tissue, fascia, and skin. The mammary tissue composition changes during the different stages of life due to hormonal mechanisms [1] (Fig. 14.1).

14.2.2 Tissues

14.2.2.1 Glands

The gland is formed by gland lobules (between 15 and 20) that are connected to the lactiferous sinus through the lactiferous ducts.

The milk is produced in the glands by secretory cells, and it is carried through the lactiferous ducts to the sinus. When the nipple is stimulated or the sinus completely filled, the milk comes out from the breast through the nipple.

The mammary gland is extremely exposed to hormonal changes. During pregnancy and breastfeeding, the glands are stimulated and their structure changes. This concept will be explained below [2].

14.2.2.2 Fatty Tissue

The mammary fat tissue is different from other body fat tissue, such as the one in the thighs, for example, due to its inherent characteristics.

In the breasts, fat is essential for the development of mammary glands and their changes during pregnancy and breastfeeding, since fat creates the structure in which glands may develop [3].

Moreover, it plays a crucial role in carcinogenesis due to the special microenvironment that fatty tissue creates. Adipocytes have aromatase activity, which increases the effect of estrogen (also important in pregnancy) [4], and these cells secrete many other factors such as adipokines, involved in cancer development [5]. On the other hand, the latest research shows that the growth of these tissues (not only mammary tissue) has an inflammatory component, and it could also be connected to cancer [6].

From an aesthetic perspective, the mammary fat tissue is the one most affected by weight changes and weight loss, because breasts only have fatty tissue (with no muscle or bones), and they have an elevated amount of estrogen receptors (Fig. 14.1).

14.2.2.3 Vascularization and Lymph Drainage

Irrigation of the anteromedial zone is provided by branches of the internal thoracic artery (specially, the branches of the second to fourth intercostal spaces), which perforate the chest wall close to the sternum. In the lateral external zone, irrigation is provided by axillary vessels [1] (Fig. 14.2).

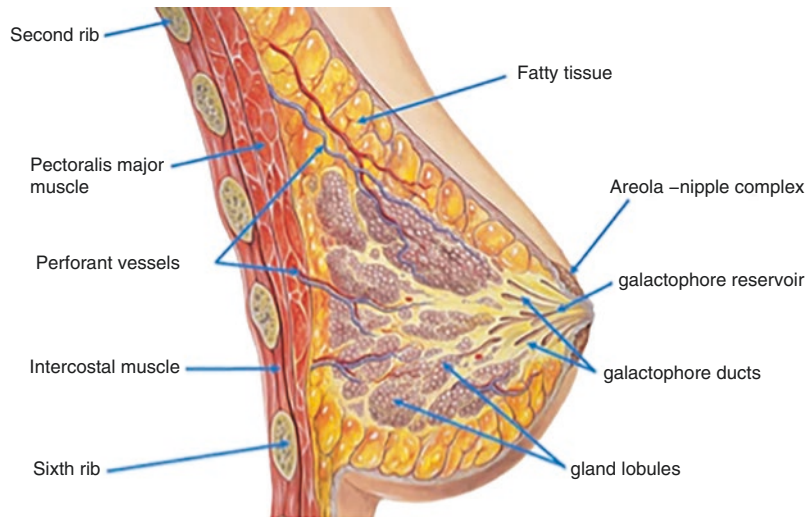


Fig. 14.1 Basic breast anatomy. Redrawn with permission of Olivas Menayo J. Available at https://www.cirugiasdelamama.com/anatomia-de-la-mama

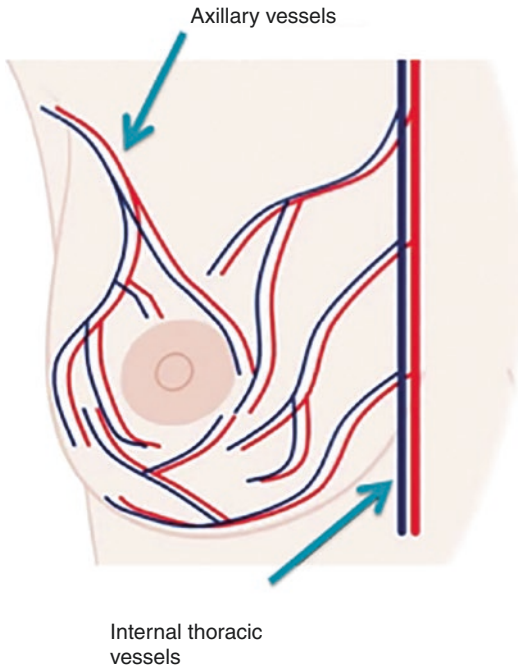


Fig. 14.2 Vascularization of the breast. Redrawn with permission of Olivas Menayo J. Available at https://www.cirugiasdelamama.com/anatomia-de-la-mama

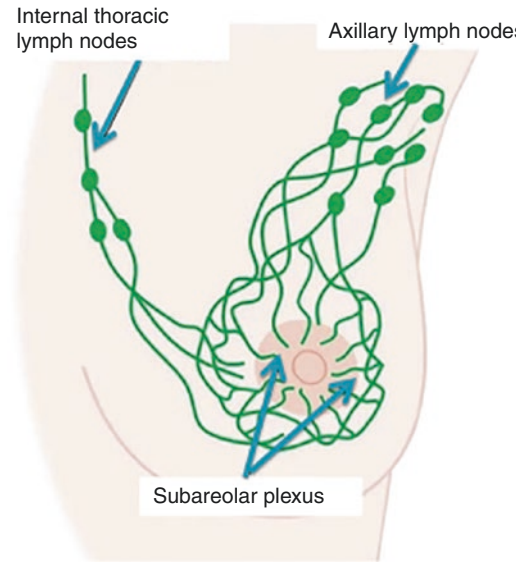


Fig. 14.3 Lymph drainage of the breast. Redrawn with permission of Olivas Menayo J. Available at https://www.cirugiasdelamama.com/anatomia-de-la-mama

The lymph vessels drain the medial zone to internal thoracic lymph nodes and the lateral zones to axillary lymph nodes. The union of both of them is located in the area of the nipple, and it is called subareolar plexus (Fig. 14.3).

The skin sensitivity is provided by intercostal nerves, specially fourth to sixth, in their lateral and anterior branch.

14.2.3 Physiological Changes and Breast Development: Hormone Function

Breast continues to change since prenatal life to menopause.

In this section, changes in breast (and the hormones involved in that) during all women life are going to be explained, since prenatal life, menarche, puberty and adult life, pregnancy, and breastfeeding and the end of that.

Breasts are an ectodermal derivative (specialized skin). They are exocrine glands that are able to secrete milk thanks to a differentiation process. Hormones and protein factors such as prolactin, aldosterone (responsible for duct differentiation), and placental lactogen are involved in the fetal breast development, and progesterone and estrogens also participate.

At the end of the fetal life, the breast is completely formed with a minimum size (no fatty components, and lactiferous ducts at their minimum). During infancy, breast development takes a rest due to a reduction of placental hormones and lack of hormones from the body itself.

Before menarche, the levels of ovarian estrogen increase in response to gonadotropin levels. Due to this, thelarche appears: an increase in the fat and gland differentiation due to hyperplasia and hypertrophy. Before that (more or less 2 years prior), the nipple-areola complex starts to grow.

During puberty and adult life, the breasts develop without interruption until reaching complete structural and functional development. It is well known that during the menstrual cycle, the mammary tissue changes due to the hormonal differences that are registered during this cycle.

During pregnancy, the breasts have to be prepared for their function: breastfeeding.

Nowadays, the inherent mechanism involved is still a mystery.

It is known that the increased levels of estrogens, progesterone, and placental lactogen induced by pregnancy (due to the corpus luteum and placenta) are involved in breast changes due to their mammotropic effects.

During the first weeks of pregnancy, there is simply growth of ducts and lobules. In the third trimester, due to an increase in the level of hormones, the breast undergoes remarkable changes: it grows further, with proliferation of the duct epithelium and creation of new lobules, and the lumen of the ducts dilates due to an accumulation of secretions. The involution of fatty and connective tissue to allow this enlargement is mediated by progesterone. The first colostrum is formed. Also, the nipple-areola complex grows.

After childbirth, the levels of estrogens, progesterone, and placental lactogen decrease dramatically and, for that reason, prolactin can carry out its function: lactogenesis. During pregnancy, levels of prolactin are similar to those of the puerperium stage, but the other hormones were previously inhibiting it.

Lactogenesis has two phases:

The first one is called lactogenesis I or galactogenesis, and it is the first milk production promoted by prolactin.

Lactogenesis II or galactopoiesis is the second one. Its function is the maintenance of breastfeeding. In this stage, not only prolactin is important (every time that milk is evacuated, prolactin is stimulated), but also the suction and pressure of the baby, which maintains prolactin and milk ejection reflex (an autonomous reflex that acts on the smooth muscle).

There are also other hormones such as insulin, oxytocin, or thyroid hormones, as well as local and microenvironmental factors, which allow the epithelium to secrete milk and which also modify its properties.

At the end of breastfeeding, the spacing of baby breastfeeding intake stops the stimulation of prolactin and breasts gradually come back to normal.

In menopause, the hormonal decrease also causes changes in the mammary tissue, which involutes and loses firmness. However, there are other anatomical factors, such as changes in the connective tissue or in ligaments, which also have an influence on this process [7].

14.3 Changes During Pregnancy and Breastfeeding in Mammary Tissue

In order to prepare the body for lactation, the breasts undergo significant changes during pregnancy and breastfeeding afterwards.

Anatomical changes are due to tissue modifications: gland tissue should proliferate. In return, the rest of the tissues, such as a fatty tissue or connective tissue, have to allow this change through involution. The mammary glands grow significantly.

During breastfeeding, ducts should be completely filled with milk, and changes similar to those of pregnancy may be observed.

This change may be observed with ultrasounds. During pregnancy, mammary tissues are usually hypoechoic. In the lactating woman, breasts are generally hyperechoic, with more vascularity and bigger ducts [8] (Figs. 14.4 and 14.5).

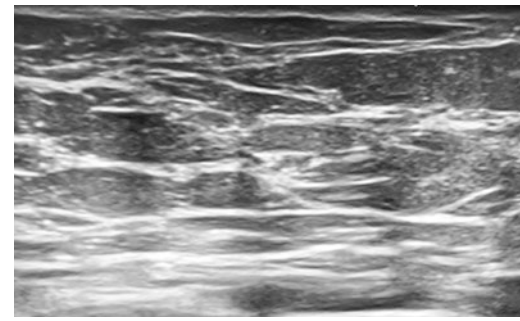


Fig. 14.4 This image shows pregnancy in a primigravida woman at week 26. It should be noted that the hypoechoic area is due to proliferation of breast tissue and disruption of the layered architecture. Image courtesy of Dr. Martín Esquilas (Salamanca)

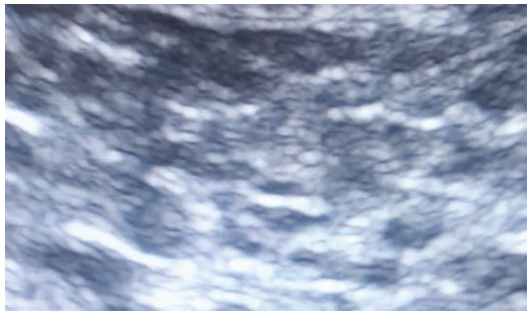


Fig. 14.5 This image shows a lactating woman on her 15th day after labor. Differences should be seen with an increased hyperechoic area (with many vessels and ducts). Image courtesy of Dr. Martín Esquilas (Salamanca)

14.3.1 Changes in Volume, Position, and Density: Symmetry

14.3.1.1 Volume and Density

Tissue changes modify the shape of the breast during pregnancy and lactation.

The breasts grow and become less stiff due to the increase in gland tissue and the decrease in connective and fatty tissue during pregnancy (they grow by one to two sizes). During breastfeeding, the breasts may feel heavy due to milk content and the volume could also increase. After breastfeeding, the breasts may be bigger or smaller than before pregnancy. It depends on the breast tissue recovery or fatty and connective tissue after glandular involution.

There is no clear factor involved in the change of size of breasts:

Bayer et al. carried out a study in Germany in which they assessed breast volume during pregnancy using a three-dimensional surface technique. They discovered that the average increase in volume was 96 mL, regardless of the initial size. Factors such as age, previous pregnancies, and BMI did not seem to have substantial effects. However, during pregnancy and breastfeeding, breast changes are related to progesterone, which is involved in carcinogenesis. There could be a relation between breast enlargement during pregnancy and cancer development [9].

In contrast, Rauh et al. described in 2012 [10] several factors that could have an influence on breast stiffness and size after pregnancy and breastfeeding. A decrease in breast volume was reported in 21.8% of the women, and an increase in 35.1% of them (no changes were reported by the remaining women). The following variables were predictive factors for an increase in breast size: a younger age at first pregnancy at term, time elapsed from that pregnancy (more time was a better predictive factor), weight before pregnancy, and weight gain. In addition, predictive factors of greater breast stiffness were age at first pregnancy at term, time from that pregnancy, weight before pregnancy, breastfeeding status, and number of pregnancies [10].

Moreover, some studies reported that women with a larger increase during pregnancy are more likely to carry inside a male fetus [11]. There is not enough evidence on this aspect, and further studies are needed.

Finally, no correlation was found between breast size during pregnancy and milk volume [12].

Figure 14.6 summarizes the main changes.

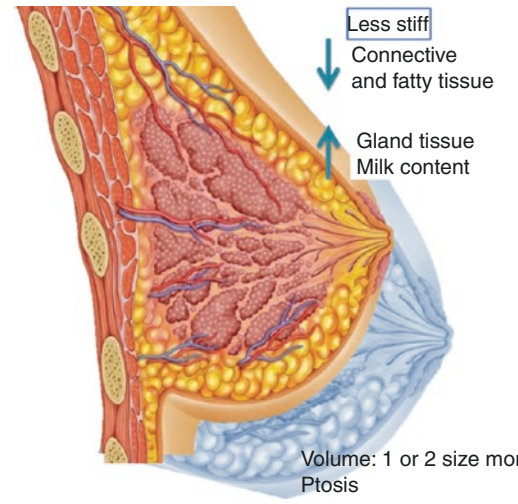


Fig. 14.6 Main changes in volume and density in breast during pregnancy. Redrawn with permission of Olivas Menayo J. Available at https://www.cirugiasdelamama.com/anatomia-de-la-mama

14.3.1.2 Ptosis: Position of the Nipple-Areola Complex

The position of the breasts is influenced not only by tissue changes, but also by alterations from gravity induced by this extra weight.

Breast ptosis occurs when the supportive breast tissue cannot attach to glands and fatty tissue, causing a stretch of breast skin that allows descent of the parenchymal mass and changes in the shape and position of the nipple-areola complex. Hormonal changes during pregnancy and breastfeeding, together with the fast change in volume, may cause sagging breasts after this period in a woman's life [13].

This situation may be classified as ptosis when the nipple-areola complex is more than 21 cm away from the suprasternal notch.

In the 1970s, Regnault proposed a ptosis classification that is still useful nowadays. Although there is a subjective component, it is the best tool for ptosis classification for surgery (mastopexy) [14] (Fig. 14.7):

- Grade 1: Slight ptosis: nipple-areola complex just below inframammary fold and above breast contour
- Grade 2: Moderate ptosis: nipple-areola complex further below inframammary fold and above breast contour
- Grade 3: Severe ptosis: nipple-areola complex below inframammary fold and no tissue below the inferior pole
- Pseudoptosis: Inferior pole ptosis with nipple in correct position

There is no correlation between lactation and ptosis. In fact, the main factors that affect ptosis are being overweight, weight changes, number of pregnancies, breast size before pregnancy, age, and smoking habits [15].

Ptosis can be treated surgically (*see reshaping after breastfeeding*).

14.3.1.3 Symmetry

As a double organ, breasts can show differences between them. The volume could be different if the amount of estrogen and progesterone receptors is different. The mechanism behind this is unknown.

Different studies have tried to correlate symmetry with the fetus' sex without results [16], as well as with the child's weight, head, or chest circumference, without success [11].

14.3.2 Changes in the Nipple-Areola Complex: Skin and Pigmentation

14.3.2.1 Nipple-Areola Complex

Allowing suction will be the function of the nipple-areola complex during breastfeeding. In order to achieve this, it may change.

The width and depth of the nipple increase in order to become adequate for the newborn's mouth. Similarly, the areola undergoes the same process.

Montgomery glands appear. They are hypertrophic sebaceous glands scattered on the areola [17]. Their function is not completely known.

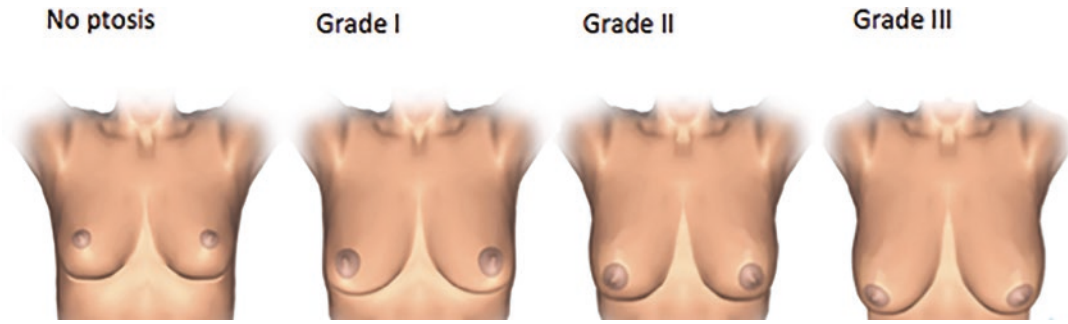


Fig. 14.7 Ptosis classification. Redrawn with permission of Olivas Menayo J. Available at https://www.cirugiasdelamama.com/elevacion-de-la-mama

They may emit a smell that could attract the newborn to lactation (Fig. 14.8).

14.3.2.2 Pigmentation

Hyperpigmentation is the change in the coloration of the skin (or part of it), which becomes darker. It may happen due to the facts that estrogens are melanocyte stimulating and human chorionic gonadotropin (HCG) is biochemically similar to melanotropin. However, there are no consistent studies in this field.

More than 90% of all pregnant women reported some type of hyperpigmentation during gestation. The most common one is enhancement of normally dark areas [18]. Typically, hyperpigmentation affects the middle abdominal wall skin (linea alba), which forms the linea nigra, and also the areola and nipple on the breast.

The areola and nipple are darker during pregnancy than in nonpregnant states (Figs. 14.9 and 14.10).

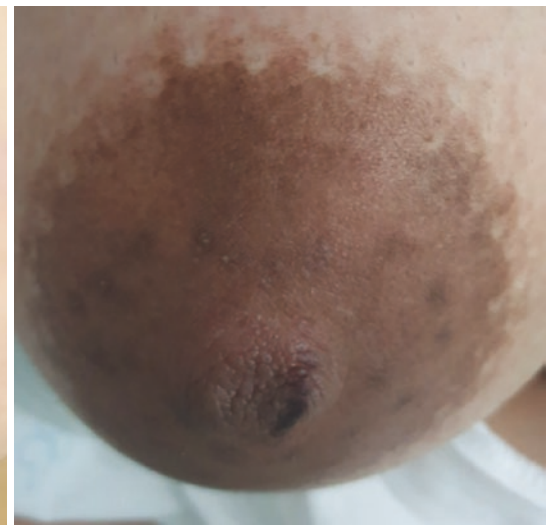
Darkening of the region surrounding the areola is called secondary areola. The mechanism behind this process is unknown (Fig. 14.11).

Fig. 14.8 Montgomery glands on the areolar surface. Black arrowheads signal Montgomery glands

14.3.2.3 Skin

The breasts go through the same process as the rest of body skin regarding weight changes during pregnancy. It may be even worse in these organs due to their dramatic changes.

If the increase in breast size is extensive during pregnancy, stretch marks may appear. They usually turn up after breastfeeding due to the quick breast weight change (Fig. 14.12).



Figs. 14.9 and 14.10 (Left) and (right): The image on the left one is a nonpregnant woman with a pink areola. The image on the right is a pregnant woman at week 29 (not the same patient). The hyperpigmentation and darkness on the right image can be seen

Fig. 14.11 Secondary areola in breastfeeding patient

Fig. 14.12 Stretch marks after 6 months of breastfeeding in a 29-year-old primigravida woman. Her breasts increased two sizes during pregnancy and breastfeeding. White arrowheads show two stretch marks

14.3.3 Vascularization

Increasing blood volume is necessary for breast gland development. Breast blood vessels are full due to the hormonal effect. In sum, the fullness of the vessels and the fact that the skin is thinner due to breast enlargement may make little veins slightly noticeable on the breast surface during pregnancy.

Ogawa et al. tried to measure the tissue concentrations of oxyhemoglobin, deoxyhemoglobin, and total hemoglobin and their saturation in the breasts. Values were higher during pregnancy, but in the breastfeeding period, they decreased during the newborn suction time. This could be because during suction, oxytocin not only binds to lactiferous epithelial cells but also affects the vessels of smooth muscles. There is also a compression mechanism of multiple ducts above the blood vessels that can explain this situation.

There are not many factors that affect the volume of breast vessels. The only one with which they found a negative correlation was BMI [19].

14.3.4 Paresthesia and Pain

Tenderness and paresthesia appear in breast tissue from very early stages of pregnancy.

This could be explained by two causes:

The first of them is breast enlargement. Mammary tissue grows into the skin and the breast is perceived as full and stimulated, which causes tenderness.

Also, changes in estrogens and progesterone could stimulate neurological receptors that may explain the paresthesia in the first weeks of pregnancy. Moreover, anatomical changes can have an influence on the receptors by applying pressure or crushing them.

Breast tissue may feel painful during pregnancy but also during breastfeeding. It is important to take care of the breasts and try to alleviate pain by applying heat or cold, for example.

14.3.5 Secretions

From the midpregnancy, the first "milk products" are prepared. Colostrum (also known as "first milk") is a yellow fluid that may be secreted after the first months of pregnancy with a slight nipple massage that discharges oxytocin over the lactiferous ducts.

After childbirth, the suction reflex stimulates the production of new colostrum and milk.

Colostrum is less dense than milk, and it provides different immune qualities. It is the perfect nurture product for the newborn in its first days.

Milk is ejected in the third or fourth days postpartum. The breast mechanism by which colostrum switches to milk is unknown.

Main breast changes during pregnancy are summarized in Table 14.1:

Table 14.1 Main breast changes during pregnancy

	Change	Physiology
Volume and density	Breasts grow and become less stiff	Increasing in gland tissue and decreasing in connective and fatty tissue
Ptosis	Nipple-areola complex is more than 21 cm away from the suprasternal notch	Hormonal changes during pregnancy and breastfeeding, together with the fast change in volume
Symmetry	Change in volume between both breasts	Estrogen and progesterone receptors are different in each breast
Nipple-areola complex	Montgomery glands appear	Unknown
	Hyperpigmentation	Estrogens are melanocyte stimulating, and human chorionic gonadotropin (HCG) is biochemically similar to melanotropin
Skin	Stretch marks	Quick breast weight change
Vascularization	Increase blood volume Little veins slightly noticeable on the breast surface	Estrogen and oxytocin
Paresthesia and pain	Tenderness and paresthesia	Breast enlargement Estrogen and progesterone could stimulate neurological receptors
Secretions	Colostrum and milk secretion	See the description on lactogenesis

14.4 Breastfeeding and Pregnancy Breast Illnesses: Diagnostic Challenges

The mammary tissue changes and the presence of new fluid, such as colostrum and milk, make identifying breast conditions during pregnancy and breastfeeding a cumbersome challenge.

There are also some typical benign conditions in this stage.

14.4.1 Galactocele

It is milk accumulation outside the lactiferous ducts in breast tissue due to extravasation. It is the most prevalent pathology during pregnancy and breastfeeding. Milk accumulation forms a firm mass inside the breast that is palpable. Women should not have other local or systemic symptoms such as erythematous breasts, fever, or malaise. In ultrasounds, it appears as a cystic mass without Doppler flow. Galactocele does not require treatment: it does not interfere with breastfeeding, and it may be resolved on its own. If it is very painful, it may be drained [20].

14.4.2 Mastitis in Breastfeeding

This is an inflammation and infection of lactiferous glands due to breastfeeding (there may also be mastitis with no associated breastfeeding, but it is less common). Mastitis is produced by milk accumulation in lactiferous glands. The most common isolated organism is *Staphylococcus aureus* followed by *Streptococcus*. Symptoms are tender, edematous, and erythematous breasts. There may be thickening of the breast skin, and systemic symptoms are fever and malaise.

It should be treated with antibiotics, and breastfeeding should be maintained (it promotes breast emptying).

The severe spectrum of mastitis is an abscess: infection causes an abscess in the breast tissue. It should be confirmed by ultrasounds (cystic mass with increasing vascularity). Treatment is also antibiotics, but this is often not enough, and aspiration drainage may be necessary. Breastfeeding should also be maintained in this case.

14.4.3 Lactating Adenoma

The etiology and composition of lactating adenoma are not clear. Some theories claim that it is a "de novo" lesion that appears due to hormonal changes. On the other hand, other theories argue that it is a variation of fibroadenoma.

It is a benign mass that is often palpable and bilateral. It is painless and soft, and it may be compressive. In an ultrasound, it generally shows benign characteristics: solid, well-defined margins and longitudinal diameter larger than the transversal one. But in some cases, they may present malignant characteristics such as irregular margins or mixed echogenicity. In case of doubt, it should be biopsied [20].

Lactating adenoma usually disappears after the breastfeeding period.

There are other benign and malign pathologies that can change their appearance during pregnancy and breastfeeding:

14.4.4 Fibroadenoma

It is mass proliferation of stromal and epithelial component. It is the most common breast mass in women. Many times, fibroadenomas exist before pregnancy, but with breast enlargement, they become more evident at this time. It should be a palpable mass, painless, and mobile. Ultrasound images are usually a solid circumscribed mass. Breastfeeding could change echogenicity. It should be biopsied if there is any doubt [20].

14.4.5 Malignant Mass

Breast cancer has an incidence of 1 case out of every 1000–3000 pregnant women. The most common type is poorly differentiated, with nega-

Table 14.2 Basic characteristics of breast pathologies during breastfeeding and pregnancy

Pathology	Physiopathology	Symptoms	Ultrasound appearance	Biopsy	Treatment
Galactocele	Milk accumulation inside breast	Painless mass	Cyst mass without Doppler	No	None. If severe, it could be drained
Lactating adenoma	Unknown	Bilateral, painless, and compressible mass	Hypoechoic mass with benign characteristics (in some cases, malignant appearance)	May be needed	None. Biopsy
Fibroadenoma	Hypertrophy	Painless and firm mass	Variable Solid mass	May be needed	Monitoring
Malignant mass	Depends on cancer histology	Painless, firm, and irregular mass	Malignant appearance	Always	Oncologic treatment
Mastitis	Infection and inflammation	Tender, erythematous breast. Fever and malaise	Edema in tissue	No	Antibiotics
Abscess	Infection and inflammation	Mass and same symptoms as mastitis	Cyst mass with Doppler surrounding caption	No	Antibiotics, drainage

tive receptors. The symptoms and ultrasound images are similar to those of nonpregnant women. But it is more difficult to identify due to changes in the surrounding tissue.

The basic characteristics of these pathologies are summarized in Table 14.2.

There are also typical pathologies of the nipple-areola complex:

14.4.6 Mammary Fissures

They are injuries in the nipple area that are caused by an incorrect suction technique during breastfeeding. Fissures may be very painful, and the most important element is prevention with an adequate technique.

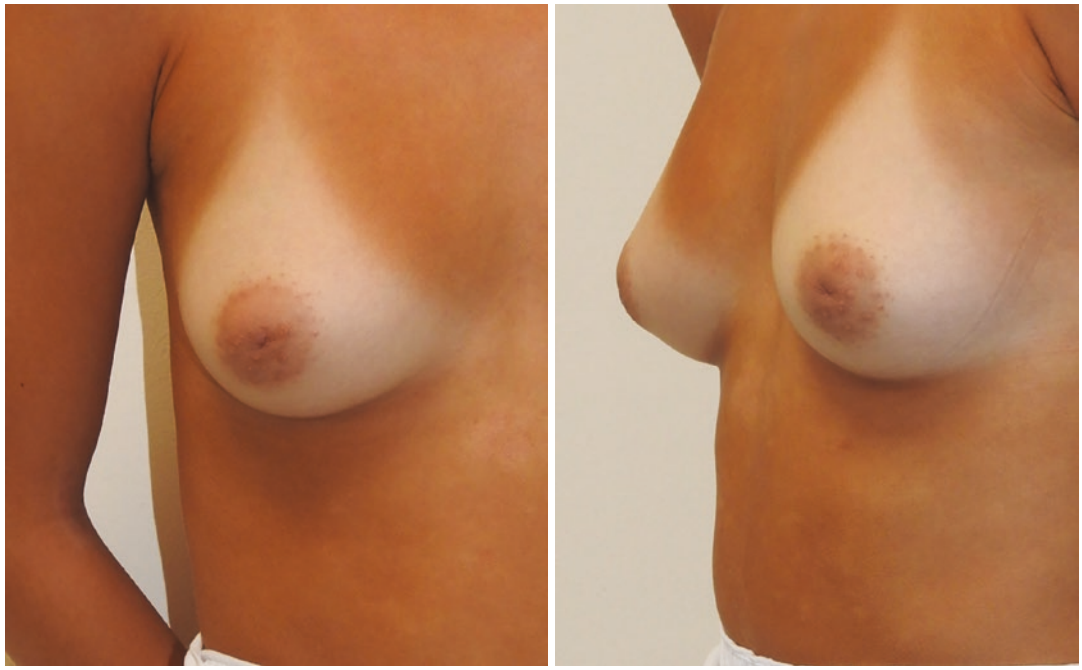
There is not a wide range of treatment options: many experts recommend spreading the mother's own milk before suction or applying massages with olive oil (Fig. 14.13).

Fig. 14.13 Nipple fissure in breastfeeding breast. The fissure may be seen below the white arrowhead

14.4.7 Inverted Nipple

Inverted nipple is an intussusception of the nipple (Figs. 14.14 and 14.15). It could be a genetic problem or caused by breastfeeding. It is caused by the failure of the mechanisms that support the nipple.

It causes breastfeeding failure (in these cases, a breast pump may be useful) and aesthetic changes.



Figs. 14.14 and 14.15 Inverted nipple in front (left) and left side (right) views. This may be seen below the white arrowhead. Image courtesy of Dr. Olivas-Menayo (Madrid)

It can be classified into different grades:

- Grade I: nipple may be pulled manually.
- Grade II: nipple may be pulled manually but it reverts to its original position.
- Grade III: surgery is the only method to pull the nipple because it is fixed by fibrous tissue.

There are different surgical and nonsurgical procedures than can resolve this problem (*see reshaping after breastfeeding*).

14.4.8 Nipple Hyperkeratosis

This is a condition called pregnancy-associated hyperkeratosis of the nipple. In addition to physiological skin changes during pregnancy, there are other changes such as seborrheic keratosis or skin tags that may be developed in the nipple (Fig. 14.16). Furthermore, diseases such as nipple hyperkeratosis may appear.

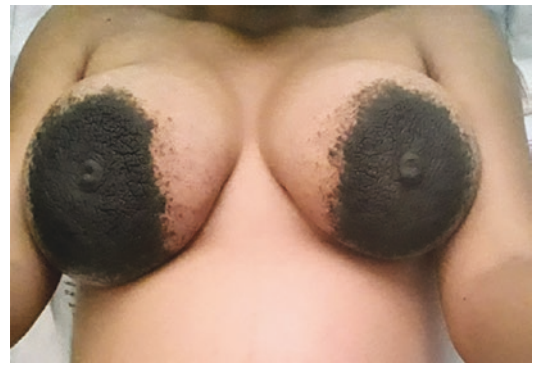


Fig. 14.16 Nipple hyperkeratosis is indicated with white arrowhead. Image courtesy of Dr. Olivas-Menayo (Madrid)

It is composed by verrucous and confluent lesions in both nipples. Its mechanism is unclear, although it seems to be caused by exposure to estrogens. It usually resolves spontaneously [21].

14.5 Reshaping After Breastfeeding

After pregnancy and breastfeeding, the breasts suffer dramatically. Sometimes, breast recovery is satisfactory, or the woman simply accepts the changes. In other cases, the alteration requires surgical correction.

The most common problems are changes in size or volume, empty breasts, or ptosis.

There are many surgical interventions that may solve the main problems:

14.5.1 Mastopexy for Ptosis

The correction of ptosis is called mastopexy. There are different types of surgery depending on the grade of ptosis and the woman's condition.

It is important to determine volume problems apart from ptosis:

If there are empty or slightly empty glands, we should practice mastopexy with prostheses (mastopexy plus mammoplasty) in order to increase breast volume.

If, in contrast, the pregnancy has caused gigantomastia, the correct surgery would be a reduction mammoplasty and mastopexy [22].

Types of mastopexy (Fig. 14.17):

Periareolar scar: When ptosis is Regnault grade I and we only have to elevate the breast tissue 2 cm or less, it is a suitable option. It also makes it possible to reduce the size of the areola.

Upright scar: It is indicated in grades I and II. It makes it possible not only to reduce the breast size, but also to reduce the areolar and periareolar size.

"Y shape": It is indicated in pseudoptosis because it does not make it possible to elevate the nipple-areola complex. It is only indicated to correct the excess of mammary tissue in the inferior mammary pole.

"T shape": This is indicated when ptosis is severe (grades IV or III) and preferably in cases of gigantomastia. This type of operation could affect breastfeeding.

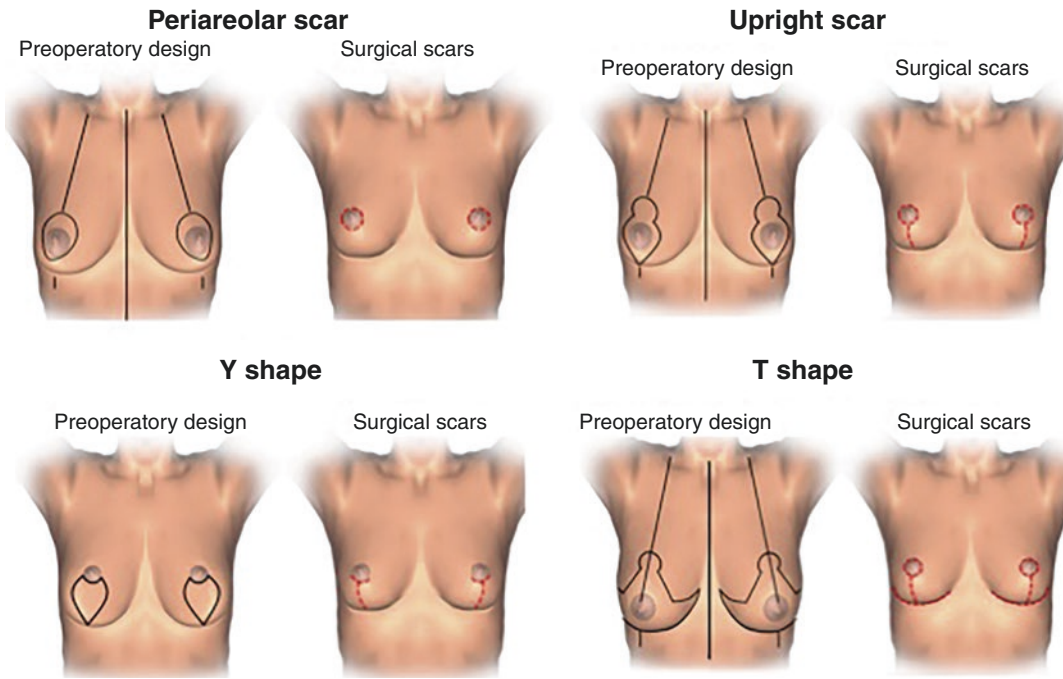


Fig. 14.17 Surgical procedures for ptosis. Redrawn with permission of Olivas Menayo J. Available at https://www.cirugiasdelamama.com/elevacion-de-la-mama

There are other surgical procedures for extreme cases.

Complications could range from numbness to paresthesia. Also, the nipple-areola complex could be affected if the irrigation is not correct.

14.5.2 Breast Reduction or Augmentation

Empty breasts are one of the most common problems after breastfeeding. They are often accompanied by size problems.

When the size after pregnancy and breastfeeding is too big, reduction techniques may be applied.

When there is no ptosis, breast liposuction could be enough, but in many occasions, gigantomastia is accompanied by ptosis. In these cases, techniques similar to those used for ptosis should be applied.

In other cases, fat tissue is reduced by gland expansion in pregnancy and breastfeeding. The subsequent gland regression may make the breasts feel lighter and sagging. Augmentation mammoplasty surgery could be useful for this problem.

There are different mammoplasty types depending on the type of prosthesis, surgical incision, or location of the prosthesis [22].

14.5.2.1 Prostheses

Choosing the correct prosthesis is crucial for surgical success. On the one hand, big prostheses cause deformation and back pain; and on the other hand, smaller ones may not meet the woman's expectations.

Implants may be saline or silicone based. Both of them are useful. Silicone implants may create a more physiological aspect, but their rupture could cause several problems (the latest generation minimizes this risk).

In addition, their shape may be round or anatomical. Anatomical implants usually create a more physiological shape. Round implants are useful in case of rotation, because they maintain the shape of the breast.

The surface of the implant may be smooth or rough. Rough ones have less migration capacity, and they usually cause less encapsulation than smooth ones [22].

14.5.2.2 Surgical Incisions

There are different incision approaches: inframammary fold, axillary, navel, or periareolar. All of them have advantages and disadvantages. Nowadays, the inframammary fold is the most widely used due to its practicality and versatility and the low risk of encapsulation [15].

14.5.2.3 Location

There are different planes in the breast in which the implants may be placed.

Submuscular pocket: The prosthesis rests below the pectoral muscle. This is indicated in cases of scant breast tissue. It causes less encapsulation than others. However, prostheses can rotate easily.

Subglandular pocket: When the breast has enough tissue, this is the standard choice. If the gland has not enough tissue, the woman may perceive roughness.

There is an intermediate plane called "dual" in which prostheses are placed below the muscle in the upper pole and below the gland in the lower pole. It tries to take advantage of both planes.

The most important factor in augmentation mammoplasty is to have an individualized plan for each patient and case. Each prosthesis, plane, and surgical incision has its own benefits [15].

14.5.3 Nipple-Areola Complex Surgeries

The most common problems after breastfeeding and pregnancy are macrothelia and inverted nipple.

Macrothelia is the enlargement of the nipple-areola complex compared to the rest of the breast.

The surgical procedure is a circular reduction of the area. Wound healing is good due to the changes of pigmentation in this zone [22].

14.5.3.1 Inverted Nipple

There are different surgical and nonsurgical procedures that could help:

In the less serious grades: nipple massages (Hoffman massage) could help after pregnancy (it should never be applied during pregnancy because it could trigger premature childbirth). In addition, rubber bands or a different suction process could be useful. However, all these techniques have a high recurrence rate.

In the more serious cases, surgical procedures are needed. There are different types: On the one hand, there are techniques that preserve the lactiferous ducts but are less effective (such as differently shaped sutures); on the other hand, there are more damaging but effective surgical procedures (transfixion suture) [22].

14.6 Conclusions

Breasts are a dynamic tissue affected by hormonal changes. Their shape and physiology are perfect for their breastfeeding and aesthetic functions.

Throughout a woman's life, breasts are constantly changing and suffering alterations, but it is during pregnancy and breastfeeding that these changes are deeper. Our goal as physicians should be to take care of the woman's breasts during this part of her life and help her in her recovery if she needs it.

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Reduction of the Postpartum Breast

15

Cristina Gómez Martínez de Lecea, Bernardo Hontanilla, Julia Sanz Irigoyen, and Jesús Olivas-Menayo

Take-Home Points

- Anatomical considerations for ensuring breast blood supply.
- The moment recommended for undergoing a breast reduction is at least 3–6 months after stopping breastfeeding or after the last pregnancy.
- Pedicles for the nipple-areola complex (NAC) may be superior, medial, lateral, inferior, central, and superomedial.
- The breast reduction approaches include inverted T, vertical, horizontal, periareolar, and liposuction-only reduction mammoplasty patterns.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/978-3-030-43840-1_15.

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15.1 Introduction

The aim of breast reduction after pregnancy is to reshape the breast by removing the excess of parenchyma, repositioning the NAC, and tailoring the lax leftover skin.

15.1.1 History

Since the 1920s and 1930s, many surgeons started to publish about the procedures to reduce and reshape pendulous and hypertrophic breasts, as well as to preserve their function. Surgeons such as Biesenberger (1931) or Gillies and McIndoe (1939) first based their mammoplasty reductions on a one-pedicle method. The former performed the breast reduction supported mainly in the internal mammary network supply [1, 2]. Postoperative complications in wound healing were described frequently in their procedures [3]. For this reason, later on, other surgeons such as Ragnell (1946), Maliniac (1950), Strombeck (1960), or McKissock (1972) started to employ bipedicle methods in an attempt to preserve breast vascularization as well as decrease the risk of skin necrosis [2, 4]. In 1963, Skoog described a technique for breast reduction which transpositioned the nipple based on a dermal-glandular pedicle coming from the lateral side [5]. In 1967, Pitanguy introduced the superior pedicle breast reduction, which allowed the avoidance of flat-

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_15

tening the superior breast pole as well as the nipple vertical rotation upward maintaining the breast blood supply [1]. A decade later, Robbins (1977) introduced the inferior pedicle which also demonstrated to have a reliable blood supply for the NAC [6].

Meanwhile, in 1956, Robert Wise described a skin resection pattern for the treatment of the leftover skin of patients with moderate-to-large breasts [3]. His design pattern was made from the shape of a brasserie called "Cordelia of Hollywood" [1, 2]. The resultant scars laid on the periareolar, vertical breast axis and horizontally on the inframammary fold and became known as the inverted T pattern. Marchac and de Olarte (1982) [7], Lassus (1987) [8], and Lejour (1990) [9] popularized the vertical technique with a superior pedicle in an attempt to eliminate the horizontal scar in smaller breast reductions.

Nowadays, all the different pedicles are adapted to the inverted T and vertical patterns depending on the surgeon's preference and experience.

Since the 1980s, breast liposuction started to be performed. It has become a new method to reduce slight amounts of volume and avoid scars from direct skin and parenchyma resection approaches.

15.1.2 Breast Anatomy

Breast reduction surgery involves a thorough breast anatomy understanding to encompass both functional and aesthetic goals. The NAC standard position lies approximately 19–21 cm from the sternal notch. Therefore, its successful repositioning into the corresponding position requires the maintenance of its blood supply as well as, if possible, its sensation and breastfeeding potential. At the same time, this procedure accomplishes a combination of different skin and breast parenchymal resection patterns, which need an optimal breast neurovascular supply for ensuring good outcomes and minimizing possible postoperative complications.

The breast is predominantly vascularized from four main vascular systems [10]: the internal mammary artery for the parasternal medial region, the lateral thoracic artery and some perforators from the posterior intercostal arteries for the lateral area, and the thoracoacromial system for nourishing the superior edges. These vessels travel deeply around the breast periphery and become more superficial as they reach the nipple [11].

The mammoplasty reduction can be performed based on different pedicles depending on the patient's physical examination and breast functional desire (Fig. 15.1).

- The superior pedicle comes from the descending branch of the internal mammary artery and travels superficially in the subcutaneous layer through the second and third rib interspaces. The NAC viability may be compromised if a big rotation of this pedicle is needed. For this reason, some surgeons are currently more confident employing the superomedial pedicle. An adequate vascularity of the NAC can be ensured by incorporating some more medial parenchyma to the pedicle. Moreover, adding the medial pedicle improves the fullness of the upper and medial poles with a superior cosmetic appearance of the cleavage.
- The inferior pedicle is supplied by deep branches of the anterior intercostal vessels, which come from the internal mammary system along the 4th–6th interspaces. Their close and deep pathway along the inframammary fold is the reason for leaving undisturbed the attachment of the breast tissue to the chest wall when using this pedicle.
- The central pedicle is based on deep branches that come from the thoracic lateral artery and from the internal mammary artery, as well as from pectoralis major perforators coming from the intercostal and the thoracoacromial vessels [12].
- The lateral pedicle receives blood from a superficial branch of the lateral thoracic artery that lays in the subcutaneous tissue.

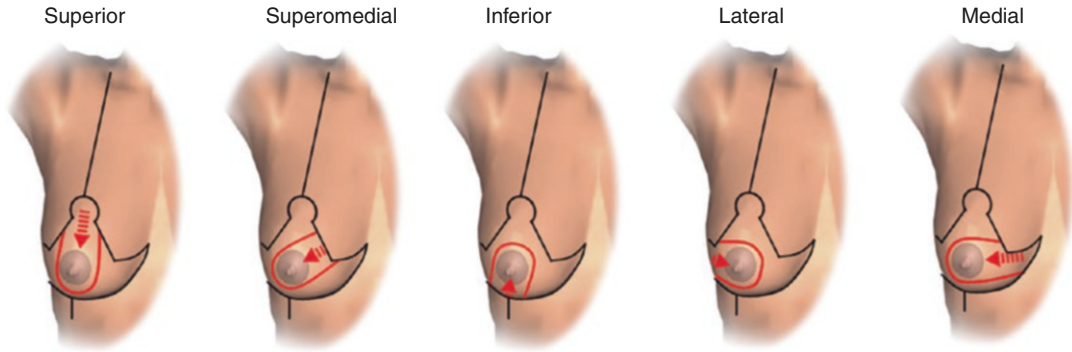


Fig. 15.1 Pedicle designs for NAC. (**a**) Superior. (**b**) Superomedial. (**c**) Inferior. (**d**) Lateral. (**e**) Medial

- The medial pedicle is based mainly on the internal mammary artery branches coming from the 3rd–4th rib interspaces and runs superficially toward the nipple.

Tip

Almost all the veins travel alone superficially and can easily be identified through the skin. However, the veins running deeply at the 4th–5th rib interspaces accompany the corresponding arteries.

Only the inferior and the central pedicles have concomitant veins travelling along their deep arteries.

The inferior and central pedicles must be a full-thickness dermoglandular pedicle to survive. In contrast, the superior, medial, and lateral pedicles can all be thinned because both their venous and arterial blood supply are superficial.

Regarding the main innervation to the nipple-areola, it comes from the anterolateral fourth intercostal nerve. It gives a superficial and a deep branch. The former travels around the periphery of the breast, whereas the latter curves up and enriches the NAC at the breast meridian. The lateral and inferior pedicles preserve the deep branch of the lateral fourth intercostal as it runs just above the pectoralis fascia. It is important to leave tissue on the fascia to preserve this nerve and protect sensation. On the other hand, several other nerves such as the anteromedial intercostal branches or the supraclavicular branch from the cervical plexus are also important in breast sensation.

Tip

The inferior pedicle has become the workhorse for maintaining blood supply, sensation, and breastfeeding potential for the nipple-areola complex [13].

The breast is an organ that undergoes dramatic changes in size, shape, and function through the different phases of life. The full development and differentiation of the female breast are completed after the first full-term pregnancy [14]. The structural breast changes during pregnancy and lactation are mediated by a complex interplay between multiple hormones (placental hormones, estrogen, progesterone, prolactin, glucocorticoids, and oxytocin) [15]. The formation of new lobules and the differentiation of the alveoli into milk secretory units are the main reasons for the breast to enlarge during pregnancy [14]. In addition, during pregnancy and breastfeeding, there are skin and breast tissue changes related to the variations in weight and in water retention. After the cessation of breastfeeding, withdrawal of prolactin and oxytocin leads to involution of the gland. These breast volume changes are responsible for the stretching and relaxing forces on Cooper's breast suspensory ligaments, as well as on the skin. The loss of the skin and Cooper's ligament elasticity with age, as well as the gravity effect on the body, makes the

return into the initial breast shape and position even more difficult after pregnancy. Consequently, it is frequent to have postmaternity patients complaining about loss of the breast upper pole fullness and also some grade of ptosis.

15.2 Patient Selection

Patient candidates need to have the indications, as well as be interested in breast reduction, NAC repositioning, or breast lift separately or in combination.

Breast reduction surgery is better performed once the skin and breast tissue have stabilized. Experienced plastic surgeons recommend to wait for at least 6 months after stopping breastfeeding to undergo a breast reduction. It is believed that within 6–12 months, the body may readjust to the changes related to pregnancy. If further pregnancies are contemplated, it would be important to consider this surgery after the last pregnancy.

The American Society for Aesthetic Plastic Surgery (ASAPS) and the American Society of Plastic Surgeons (ASPS) recommend at least 3–6 months after breastfeeding or delivery for undergoing breast surgery.

15.3 Preoperative Evaluation

15.3.1 Patient Considerations

The patients' desires and expectations related to breast reduction must be clarified from the first medical consult. The surgeon would have to select the best surgical planning in accordance to the patient's anatomy and considerations, as well as explain what can be or cannot be achieved.

Smoking, patient's preoperative body mass index (BMI), medical history of hematological diseases, and medication or herbal therapies' use also have to be taken into consideration. All these factors may influence the outcomes and the risk of complications associated with a breast reduction surgery.

15.3.2 Physical Examination

As in any aesthetic and reconstructive breast procedure, a thorough preoperative assessment of the breast footprint on the thorax, the glandular tissue (cone), and the skin (the envelope) is mandatory [16, 17]. These three aspects allow the surgeon to evaluate the breast size or hypertrophy, shape, ptosis grade, changes in the inframammary fold position or asymmetries, masses, or breast consistency, as well as the skin quality and elasticity. Once these factors have been defined, the surgeon is able to plan and perform a systematic breast improvement with aesthetically pleasing and reproducible results.

The possible symptoms associated with breast hypertrophy should also be collected in the first medical visit. Some surgeons talk about a syndrome defined as persistent neck and shoulder pain with a tendency toward dorsal kyphosis, shoulder growing from the brassiere straps, intertrigo rash on the inframammary fold, or even episodes of headache, back pain, and upper extremity neuropathies. Others also refer psychosocial impairment in terms of low self-esteem, body image dissatisfaction, or sexual harassment. Patients should be informed that even though there has been no correlation between the breast volume resection and the symptom relief, it is well known that reduction mammoplasty has shown improvement in general symptoms and in quality of life [18].

The body mass index may be another important factor to be registered. Several studies have demonstrated that the higher the body mass index, the higher the risk of complications, mainly those related to wound healing [19–22]. Nonetheless, the ASPS did not find any conclusive evidence in the association between BMI greater than 25 and higher risk of complications [18]. Therefore, the surgeon must decide whether patients on high BMI should be encouraged to undergo a strict nutritional control before being operated.

15.3.3 Screening Imaging

Preoperative screening mammography in healthy and asymptomatic women undergoing breast reduction is generally accepted. The American College of Surgeons, the American Cancer Society [23–25], and the American College of Radiology recommend screening starting at 40 years of age. Scientific evidence supports mammography among women younger than 40 only for those who have a high risk for breast cancer [23]. Nevertheless, the U.S. Preventive Service Task Force recommends biennial mammograms between 50 and 74 years of age [26].

MRI is recommended as an adjunct to mammography in the case of a known BRCA mutation, if the first-degree relative is known to have the BRCA mutation but the patient is untested, or if there is a lifetime risk of 20–25% of breast cancer [24].

Ultrasonography is also used as an adjunct to screening mammography if needed.

15.3.4 Markings

The surgeons must keep the ideal breast measurements in mind while marking the breast reduction patterns (Fig. 15.2).

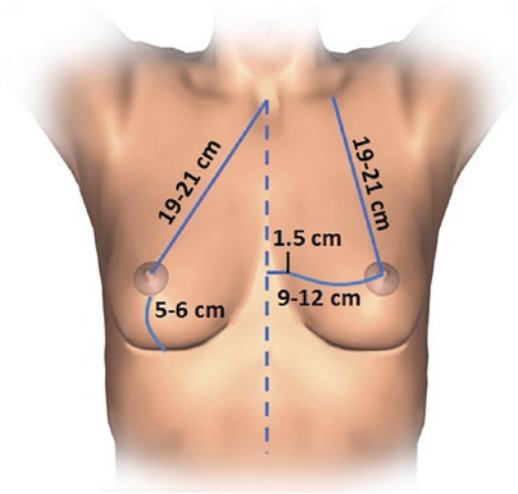


Fig. 15.2 Ideal breast measurements

Distance from the sternal notch to the nipple and the meridian breast line should be equal and range between 19 and 21 cm. The lower areola border-inframammary fold distance should measure 5–6 cm or up to 7–8 cm for big breasts. Distance between the nipple and the middle line should be around 9–12 cm. Finally, the distance between the middle line and the medial inframammary fold border should maintain a distance of 0.5–1.5 cm to avoid symmastia (intermammary distance of at least 1–3 cm).

Afterwards, the preoperative marks can be systematically drawn beginning with the standard measure lines and then continuing with the specific surgical pattern markings.

Standard Measure Lines

First: The middle line is drawn from the sternal notch to the upper border of the umbilicus.

Second: The inframammary fold is drawn and then a line that connects both lower portions of the inframammary folds.

Third: The ideal new nipple position is generally marked at Pitanguy's point (Fig. 15.3). The

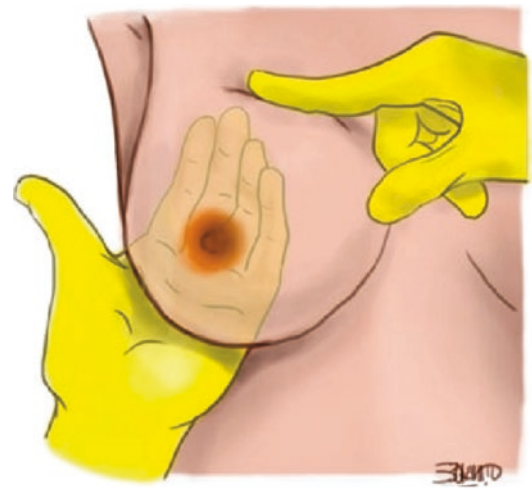


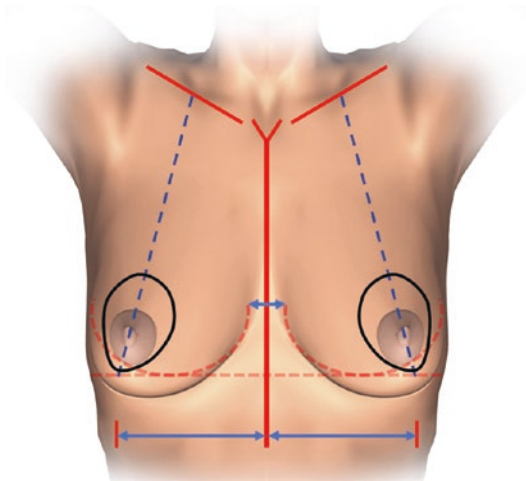
Fig. 15.3 Pitanguy's point. This point is measured by palpating the inframammary fold with the finger pointing to the breast meridian line and then, with the other hand, transposing it to the overlaying breast (Reproduced from the book "Breast Surgery. Aesthetic Approaches". Editor Juarez Avelar M. Springer. 2018. ISBN 978-3-319-54115-0)

new nipple position is expected to descend slightly with time. The surgeon should keep in mind that the standard nipple position is slightly below the middle line of the breast mound and it points a bit lateral and downwards to make the marking readjustments as needed if in doubt.

Fourth: Then the breast meridian is marked bilaterally through the ideal new nipple position and it is continued through the abdomen. It starts at 7 cm from the clavicular medial edge.

Specific Surgical Pattern Markings

- **Periareolar (Fig. 15.4):**
  - First: Following the procedure explained above, the new nipple position is marked.
  - Second: The new upper areola border is drawn 2 cm above the new nipple position along the breast meridian line.
  - Third: The lower areola border should be 7–8 cm above the inframammary fold along the breast meridian line.
  - Fourth: Then a peripheral outline circumference is marked depending on the skin excess. The medial point is designed by gently displacing the breast laterally and marking the medial point where the breast meridian is transposed.
  - Fifth: The same approach but with the breast moved to the medial side is performed for designing the lateral point.
  - Sixth: The four points are then connected.
- **Vertical pattern (Fig. 15.5):**
  - First: Following the procedure explained above, the new nipple position is marked.
  - Second: Then the new areola is drawn in accordance with the total new areola diameter. A total circumference of 16 cm matches a 5 cm diameter, and a 14 cm circumference matches a 4.5 cm diameter.
  - Third: Afterwards, both vertical lines are drawn regarding the breast vertical pinch test and in a "U" shape.



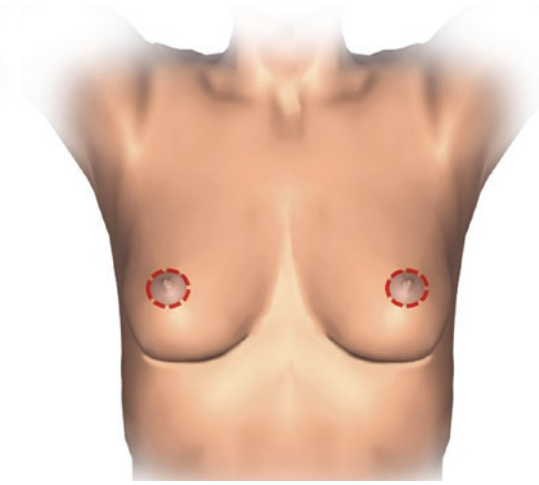
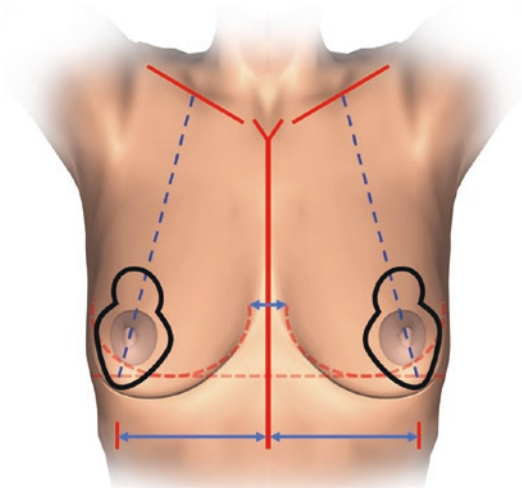


Fig. 15.4 Markings of a periareolar pattern. (**a**) Preoperative markings. The red lines delimit the clavicle figure, middle line, inframammary folds, bilateral connection, and abdominal continuation of the breast meridian line. The blue lines highlight the breast meridian line in which the new nipple position is located; the intermammary distance (which has to measure between 1 and 3 cm) and the distance between the abdominal breast meridian and the middle line should range between 11 and 13 cm. The black lines refer to the periareolar markings. (**b**) Postoperative scars. The periareolar pattern results in only periareolar scars



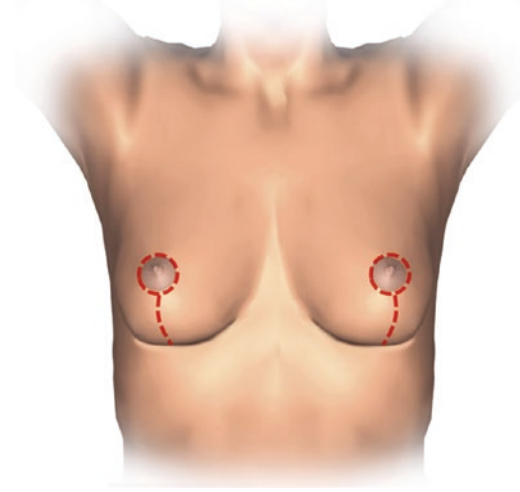
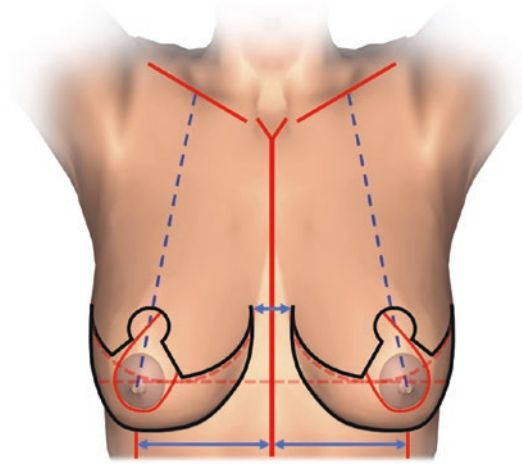


Fig. 15.5 Markings of a vertical pattern. (**a**) Preoperative markings. The red lines delimit the clavicle figure, middle line, inframammary folds, bilateral connection, and abdominal continuation of the breast meridian line. The blue lines remark the breast meridian line in which the new nipple position is located; the intermammary distance (which has to measure between 1 and 3 cm) and the distance between the abdominal breast meridian and the middle line should range between 11 and 13 cm. The black lines refer to the vertical pattern. (**b**) Postoperative scars. The vertical pattern results in periareolar and vertical scars



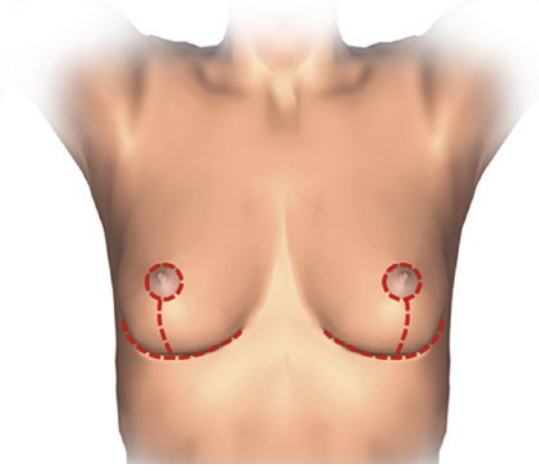


Fig. 15.6 Markings of an inverted T pattern with a superomedial pedicle. (**a**) Preoperative markings. Red lines delimit the clavicle figure, middle line, inframammary folds, bilateral connection, and abdominal continuation of the breast meridian line and the superomedial pedicle. Blue lines remark the breast meridian line in which the new nipple position is located; the intermammary distance (which has to measure between 1 and 3 cm) and the distance between the abdominal breast meridian and the middle line should range between 11 and 13 cm. The black lines correspond to the new nipple-areola complex, the vertical and horizontal lines of both the medial and lateral pillars, and the inferior incision. (**b**) Postoperative scars. The inverted T pattern results in periareolar, vertical, and horizontal scars

- **Inverted T pattern (Video 15.1; Fig. 15.6)**:
  - First: Following the procedure explained above, the new nipple position is marked.
  - Second: The new upper areola border is drawn in accordance with the total new areola diameter, which usually encompasses between 38 and 45 mm.

- Third: The vertical incisions of both skin flaps are marked following a line from the new upper areola border and the breast meridian line. These vertical lines are the sum-up of the areola diameter and the new distance between the inferior areola border and the inframammary fold. Their length usually varies from 9 to 12 cm. Their angle ranges from 60° to 120° degrees depending on the size of the breasts.
- Fourth: Finally, the horizontal limbs of both skin flaps are marked. They must match the total horizontal length of the inframammary fold. It is recommended to pinch both vertical limbs together and make sure that the closure will not have much tension.

General Key Points

All patients should be marked preoperatively in the standing and anterior facing position with both upper limbs relaxed and adducted.

The intermammary distance should be in between 1 and 3 cm to avoid symmastia.

Due to gravity and time-related changes, the new nipple-areola position should be 1 cm lower to the inframammary fold if there is an empty upper breast pole and may be 1 cm elevated if there is a full upper pole.

Key Point for Inverted T Pattern

Smaller and more ptotic breasts would benefit from a smaller angle between the vertical lines to avoid excessive skin removal.

It is important to match the horizontal length of the medial and lateral skin flaps to the incision in the inframammary fold. The sum of both horizontal sides should be equal or a bit less than the inframammary incision to avoid the medial and lateral dog-ear.

Key Point for Vertical Pattern

The lower edge of the vertical marking must rest at a minimum of 2 cm above the inframammary fold, to avoid the scar from falling below it.

Key Point for Periareolar Pattern

This technique should be considered in pseudoptosis, grade 1 breast ptosis, and small breast reductions with a good skin quality.

15.4 Anesthetic Considerations

15.4.1 Outpatient Versus Inpatient Procedure

It was around the 1990s when some plastic surgeons started to perform outpatient reduction mammaplasties in an attempt to decrease the complication rate and the costs of the surgical procedure [22, 27–29]. Carpelan or Stevens demonstrated a saving between 18 and 50% in comparison to inpatient-based reduction mammaplasties, from a total average cost of 5039 euros to 4114 euros, respectively [30]. Moreover, no significant differences existed in complication rates between inpatient and outpatient groups [22, 29]. Nowadays, both surgical options are available but should always be performed in well-accredited facilities.

15.4.2 Antibiotic Prophylaxis

Currently, evidence supports the use of perioperative antibiotics to reduce the infection associated with breast reduction mammoplasty [18, 31–33]. Some studies advocate for a single preoperative antibiotic dose [31]. However, due to the lack of evidence findings, a recommendation cannot be made on antibiotic prophylaxis timing or duration [18, 32].

15.5 Surgical Technique

15.5.1 Patient Positioning

The patient must be prepared to an intraoperative seating position for optimizing and comparing

bilateral breast results after glandular and skin resections. The patient can be prepared both with the upper limbs abducted or adducted, but the former positioning allows a better view and approach of the lateral border of the breast. An accurate symmetry in the position of the arms and shoulders must also be maintained during the surgery.

15.5.2 Approaches

The surgical approaches depend mainly on the amount and quality of the excess skin. There are five main patterns:

- **Liposuction-only reduction mammaplasty:**
  This technique approach involves minimal skin incisions through which to perform the liposuction. This standard liposuction does not involve the use of a pedicle for nipple blood supply, and it also leaves intact the breast nerves. For similar reasons, breastfeeding potential is not typically compromised. In addition, this technique permits a slight elevation of the nipple and tightening of the skin. The recovery from liposuction-only reduction mammaplasty can be quite significant, and it can take about 6 weeks for bruising and swelling to decrease and about 6 months for the breast to soften and for lumpiness to settle. Liposuction-only reduction mammaplasty works well when breast tissue is mostly fat and thus has limited usefulness in those patients in whom breast is more glandular, such as teenagers [34–36].
- **Horizontal pattern:**
  This procedure is also known as the no-vertical scar breast reduction. Similar to an abdominoplasty, a large skin horizontal resection is made, followed by a periareolar incision to detach the nipple-areola complex and then gather the superior skin flap to the inframammary fold. Afterwards, a new circumferential incision is made on the skin flap to expose again the nipple-areola complex. This technique involves the use of an inferior pedicle and the absence of vertical breast parenchyma or skin resections.
- **Periareolar pattern:**
  This is only indicated in small breasts, Regnault breast ptosis classification grade I, and patients with elastic skin. Its dissection allows the maintenance of the breast and nipple-areola complex vascular nervous supply and the breastfeeding function. However, it involves the release of the skin from the glandular tissue, reduces and readapts the breast gland depending on the pedicle employed, and then sutures the skin back to the areola under tension.
- **Vertical pattern:**
  It is mainly employed in small-to-moderate breast hypertrophies with a good skin quality. Any pedicle can be adjusted to this skin reduction approach, but the most common are the superior, medial, and lateral.
- **Inverted T pattern:**
  It is the most common technique for big-sized breast reductions and in patients with nonelastic redundant skin in those who are not possible to readjust the breast shape without further skin resection. The different pedicles can be adjusted to this pattern.

Tip
Periareolar and liposuction-only procedures have specific indications.

15.5.3 Procedure Step-by-Step of the Inverted T and the Vertical Procedures

- **Vertical pattern:**
  - First: The areola is marked with a 38–45-mm-diameter nipple marker.
  - Second: The pedicle is de-epithelized, and 0.5–1 cm of tissue around the areola is left. The pedicle is created full thickness down to the breast meridian.
  - Third: The vertical incisions are then made. The skin cover is released from the gland with a 0.5–1 cm thickness all around the

inferior breast pole up to the mid-horizontal nipple axis.
  - Fourth: Then a wedge of breast is resected in the inferior breast pole.
  - Fifth: The medial and lateral pillars are sutured together in the midline without tension and with interrupted 3-0 Novosyn stitches.
  - Sixth: The skin is closed without tension with interrupted 3-0 Novosyn for deep planes and with intradermal 3-0 Monocryl stitches.
- **Inverted T pattern (Video 15.2):**
  - First: The areola is marked with a 38–45-mm-diameter nipple marker.
  - Second: The pedicle is de-epithelized around the new areola and the vertical incision. In our institution, the superomedial pedicle is the most performed.
  - Third: Afterwards, both vertical incisions are made and the intervening superior and lateral periareolar breast tissue is dissected down to the pectoralis major fascia.
  - Fourth: Then the inferior and both horizontal incisions are performed. The excess breast is removed along the pectoralis major fascia to the superior incisions.
  - Fifth: Both the medial and lateral breast pillars are brought together to the midline and sutured with interrupted 2-0 and 3-0 Novosyn to reduce tension on the vertical closure.
  - Sixth: A 38–45-mm-diameter areola marker is used to mark the final placement of the areola after the rotation of its pedicle (Fig. 15.7), and the periareolar tissue is then de-epithelialized.
  - Seventh: The areola is uncovered and inset with interrupted 3-0 Novosyn and intradermal 3-0 Monocryl sutures.
  - Eighth: The rest of the skin defects are closed in two layers with interrupted 2-0 and 3-0 Novosyn and intradermal Monocryl 3-0 sutures.

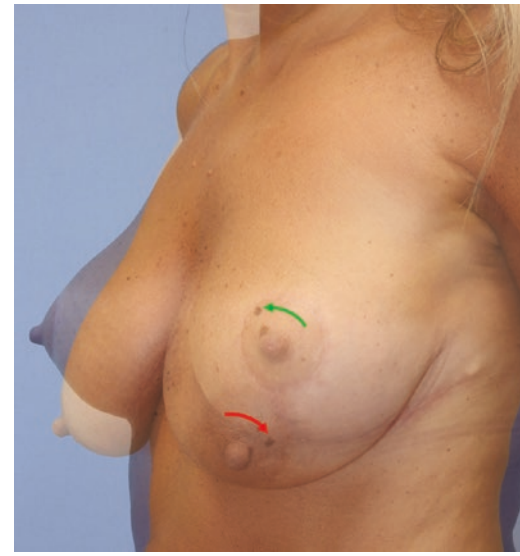


Fig. 15.7 This figure shows a superimposed image of a preoperative and postoperative case. Note the rotation of the pedicle demonstrated by the new position of the mole (green arrow)

15.5.4 Surgical Modifications

15.5.4.1 Combined Breast Reduction Augmentation

A common problem shared by the different breast reduction techniques is that with time and due to gravity effect the breast gland tends to fall into the lower pole resulting in a bottoming-out sign. This means a loss of the upper pole fullness which becomes a non-projecting breast with pseudoptosis. The breast reduction augmentation is a technique which combines both the breast reduction and the use of breast implant in an attempt to maintain the breast shape in the late postoperative period [37]. This procedure combines either the inverted T or the vertical patterns with a total subpectoral implantation of a round silicone breast prosthesis. This surgery seems to provide a natural and lasting upper pole fullness with complication and revision rates similar to the conventional breast reduction techniques.

15.5.4.2 Internal Breast Fixation

Internal breast devices for avoiding or preventing recurrent ptosis after mammoplasty have been described [38, 39]. These devices are commonly made of silicone sheets or absorbable mesh [39]. The GalaFLEX scaffold is an example of a Food and Drug Administration-approved mesh, composed of resorbable poly-4-hydroxybutyrate (P4HB) monofilaments, that is usually placed on a subpectoral breast implant [38]. It allows tissue ingrowth into its pores toward the implant and permits the formation of a strong and pliable capsule that supports the elevated breast profile over time [38]. Even though it has demonstrated economical and better integration advantages compared with acellular dermal matrixes, only 24 months of follow-up have been recorded following ptosis correction.

The internal bra system is also a 3D preshaped woven polyester mesh that has demonstrated to be a strong, stretchable, and non-palpable mesh [39]. It is placed under the breast skin and fixed high up to the second rib junction and to the pectoral fascia with nonabsorbable sutures or staples, preventing its dislocation, curling up, or migration [39]. It has demonstrated good outcomes in a 4.5-year-follow-up study. It also seems not to interfere in X-ray or physical examinations. However, its use during pregnancy, lactation, local infections, irradiation, and previous subglandular augmentation has been considered absolute contraindications [39].

Even though these devices seem to be promising in breast surgery, complications such as infection or abscess formation, rippling, small partial extrusion, or interference in sentinel node diagnosis have to be considered when using them.

Further investigation and longer term follow-up studies are needed to recommend these devices and prove that their results are stable over time.

15.5.5 Technical Tips to Improve Outcomes and Avoid Complications

- **Vertical pattern:**

  The vertical pattern should never be closed with tension, to avoid wound healing problems.

  The vertical dog-ear can be matched in two manners. Conservative treatment is the best option for small skin excess, as the incision stretches out with time. Larger puckers can be corrected intraoperatively by adding a further small skin resection horizontally, becoming a small inverted T pattern.
- **Inverted T pattern:**

  A free nipple graft is usually used when the sternal notch distance exceeds 35–37 cm.

  An oblique dissection of the breast tissue along each horizontal incision is recommended to fulfill a rounder and fullness inferior pole. This dissection achieves an attractive and anatomic breast profile (Fig. 15.8).

  Sometimes, medial and lateral wedge resection are performed to diminish the breast width.

  Since the inverted T pattern relies on the skin as a brasserie, skin closure under some tension is acceptable.

15.5.6 Anatomopathological Examination

All breast tissue removed from women older than 40 years or from those with personal or family history of breast cancer at any age should be sent to pathology for microscopic analysis [23, 40]. The incidence of occult breast cancer in reduction mammoplasty specimens most closely approximates 1% [23, 41]. Invasive ductal carcinoma is the most common malignant lesion iden-

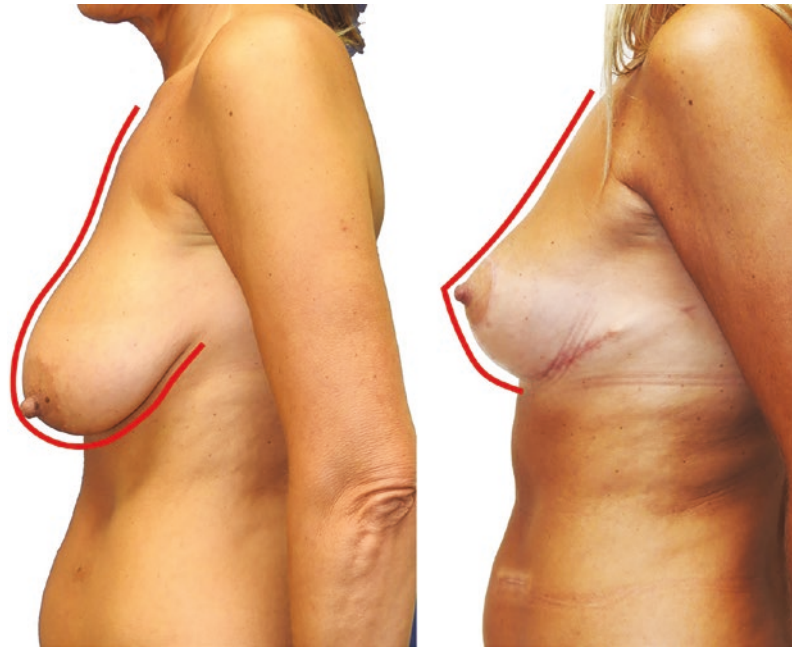


Fig. 15.8 Preoperative (left) and postoperative (right) pictures of a case operated by using an inverted T pattern. An oblique dissection of the breast tissue along each horizontal incision was done to fulfill a rounder and fullness inferior pole, achieving an attractive and anatomic breast profile

tified, but DCIS, lobular carcinoma in situ, Paget's disease, and fibrosarcoma have also been reported less frequently [23, 41–43].

15.6 Postoperative Care

15.6.1 Drains

The main usefulness of drains remains in the avoidance of fluid and blood accumulation in the dead space from tissue removal. Drains are generally removed when the output is less than 50 cc in a 24- to 72-h period. However, several studies have reported that the use of surgical drains after breast reduction does not result in any significant difference in wound healing nor hematoma rates [44–47]. Moreover, drains may increase postoperative patient discomfort and anxiety due to the "pinching" pain at the drain exit side, the ache with the drain removal, and the scar left on the drain exit [18].

15.6.2 Wound Care

Surgeons may cover the skin incisions with different wound dressings such as sterile tape. The wounds should be kept dry at least during the first 24–72 h to allow the wound seal. Afterwards, the patients are allowed to shower and are explained to perform a simple wound care based on a proper drying of the incision, followed by the application of an aseptic solution and then a new cover with a simple wound dressing. This wound care should be maintained until the stitch removal in 2 weeks.

15.6.3 Surgical Brasserie and Adjustable Stretch Chest Band

Most surgeons use surgical brassieres during 2–4 weeks postoperatively. The aim is to provide some type of support while also avoiding excessive compression that may compromise the nipple blood supply. Other surgeons also employ orthopedic bands laying over both inframammary folds to keep them in place until its healing fixation to skin occurs.

15.6.4 Venous Thrombosis

In accordance with the American Society of Breast Surgeons consensus guideline, the aggre-

gate DVT risk for breast surgery is less than 0.4% in more than 100,000 patients [48]. The risk is highest in patients undergoing mastectomy with immediate autologous reconstruction and also in patients older than 65 years, in obese patients, in surgeries longer than 3 h under general anesthesia, when it is a cancerous etiology, if it implicates a long hospital stay, and if the patient has undergone a previous surgery within the last 30 days. Chemoprophylaxis should be considered in this type of patients. On the other hand, the American Society of Breast Surgeons recommends no specific VTE prophylaxis in patients undergoing breast operations under local or regional anesthesia. However, preventive standard algorithm with compression devices and early ambulation regimen should be started since the first night after surgery in cases undergoing a breast operation with general anesthesia without immediate reconstruction [22, 48].

In our institution, when it is indicated, patients below 70 kg are administered 2500 U of subcutaneous heparin and those who weigh more than 70 kg are given 3500 U of subcutaneous heparin daily during the first 2 postoperative weeks.

15.7 Outcomes and Prognosis

15.7.1 Smoking

Even though smoking is related to higher risk of wound complications in general, there are studies which have not found statistical significance in breast reduction outcomes [22, 49]. On the other side, some studies suggest to quick smoking before undergoing a breast reduction surgery because it is an independent risk factor for complications, specially those associated with infection [50].

15.7.2 Wound Care

Once the stitches are removed, patients are encouraged to hydrate their wounds and protect them from sun exposure during the first postoperative year to avoid wound hyperpigmentation complications.

15.7.3 Follow-Up

Patients are followed up in the clinics at 15 days and 1, 3 (Fig. 15.9), 6, and 12 months postoperatively. The most reliable outcomes are noticed 3 months after surgery (Figs. 15.10 and 15.11). Further patient considerations and surgeon reviews are then evaluated and recorded with the patient physical examination and standard follow-up photographs.

15.7.4 Breast Postsurgical Changes

Postsurgical changes in the breast after reduction mammaplasty encompass a variety of physical and radiographic manifestations [51–53]. Fat necrosis, oil cysts, fibrosis, organizing hematoma, calcifications, and, rarely, concurrent malignancy should be considered in this type of patient [51]. On presentation of a breast mass after reduction mammaplasty, a diagnostic protocol is used to determine whether operative intervention is appropriate, to avert unnecessary biopsy and to avoid overlooking breast malig-

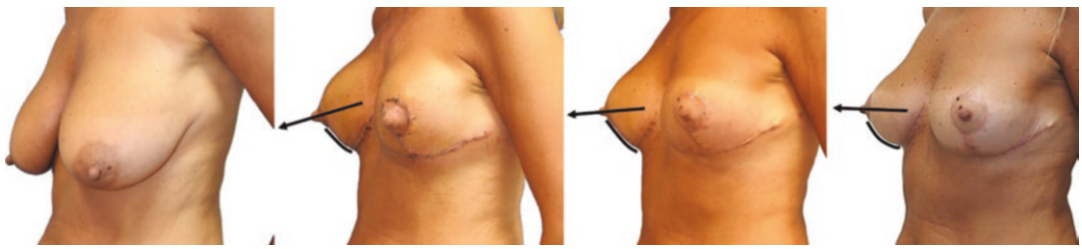


Fig. 15.9 From left to right, preoperative picture and 15 days, 1 month, and 3 months after the procedure. Note how the lower pole is rounder and rounder and the change in the orientation of the nipple-areola complex

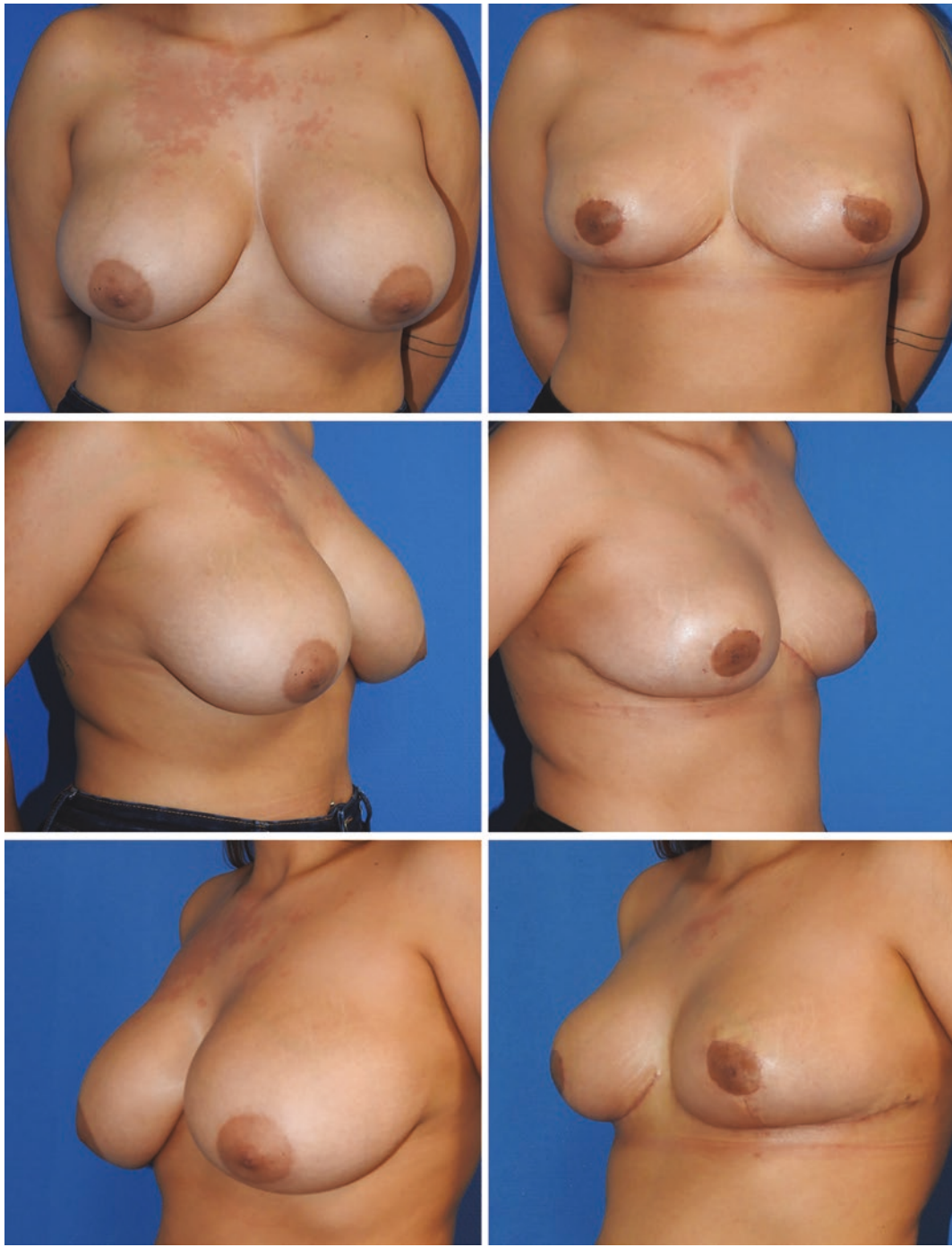


Fig. 15.10 Preoperative (left) and postoperative (right) pictures of a 45-year-old woman after inverted T breast reduction. A total of 1.8 kg was resected

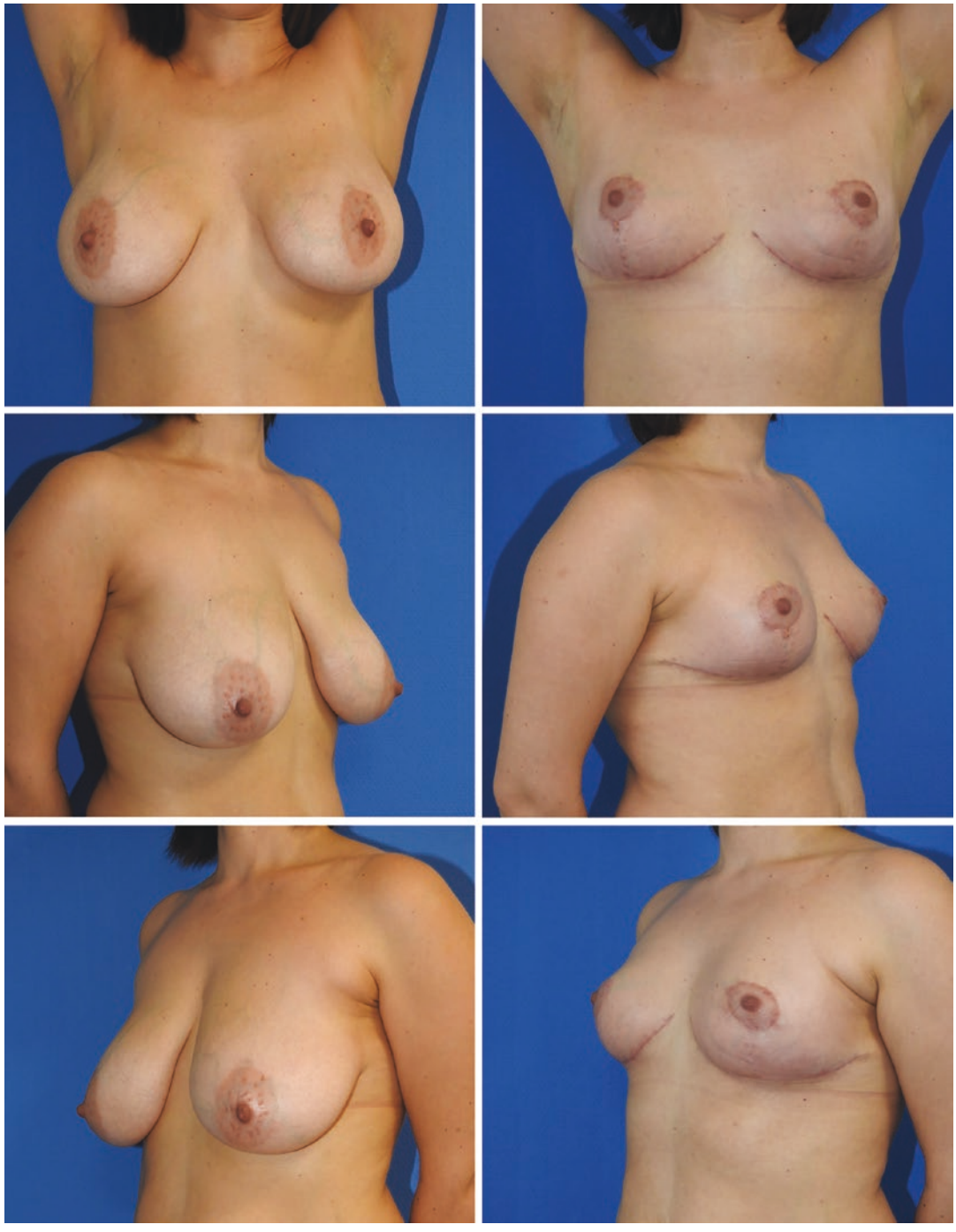


Fig. 15.11 Preoperative (left) and postoperative (right) pictures of a 38-year-old woman after inverted T breast reduction. A total of 860 g was resected

nancy [53]. After a physical examination and in the absence of an acute phenomenon such as a wound infection, evaluation should consist of mammography and ultrasonography of the affected breast. Combining the radiographic findings with echographic appearance of the mass will help to differentiate fat necrosis and other benign conditions from the more ominous malignant etiology. The mammographic appearance of fat necrosis ranges from completely undetectable to a spiculated density and clustered microcalcifications. Many authors believe that the calcifications of fat necrosis can be distinguished from those seen with breast malignancies [54]. Ultrasonographic findings include a solitary cyst, heterogenous echogenicity, and microcalcifications. Any remaining doubt as to the biologic nature of the mass should then be pursued with needle or open biopsy of the mass. Injection of any agent into the mass before it is definitively diagnosed is contraindicated, as is surgical removal or observation without obtaining a confident exclusion of malignancy. Referral to an oncologist would be premature in this instance and would provoke an unnecessary level of patient anxiety.

15.8 Complications

The average complication rate derived from the literature runs within 14–53% [22, 49–51]. The most common complications include seroma, hematoma, nipple necrosis, fat necrosis, infection, and wound healing problems (Table 15.1).

Table 15.1

Postoperative complications	Risk factors	Treatment
1. Delayed wound healing (most common)		
Dehiscence	Big preoperative breast volume	**A. Conservative**
Skin loss	Large breast resection weight	Wound care
Hypertrophic scars	Active smoking	Infection avoidance
	Older patients	**B. Surgical:** Debridement and closure
2. Fat necrosis (2–10%)		
	High BMI	A. Conservative (if asymptomatic)
	Large breast resection weight	B. Surgical (if pain/big size)
	Suprasternal notch to the nipple >37 cm	
3. Nipple-areola necrosis		
	Pedicle compression	**A. Intraoperatively:**
	Tight sutures	Suture withdrawal
	Internal hematoma	Nipple-areola graft
		B. Postoperatively:
		Partial loss: wound care
		Total/subtotal loss: debridement and reconstruction
4. Hematoma/seroma		
	Hematological diseases	A. Conservative (if stable or small)
	Drugs/herbal therapies BMI >35 Kg/m^2	B. Surgical (if unstable or big)
5. Infection (4–26%)		
	Smoking	Conservative

15.8.1 Delayed Wound Healing

Delayed wound healing is the most common complication in breast reduction surgery. It contemplates wound partial or complete dehiscence (Fig. 15.12), skin loss, and hypertrophic scars. It is correlated directly with the average preoperative breast volume, average resection weight per breast [18, 50], and active smoking [52] and inversely with patient age [22, 49]. The typical areas affected are the points of greater skin tension or the most remote from blood supply.

Patients with delayed wound healing should be followed up closely in the office to ensure the most appropriate wound care and to avoid the development of infection. Wet wound care is frequently used in our institution, except for very contaminated and exudative lesions which may be benefited from dry dressings or even from negative-pressure wound healing.

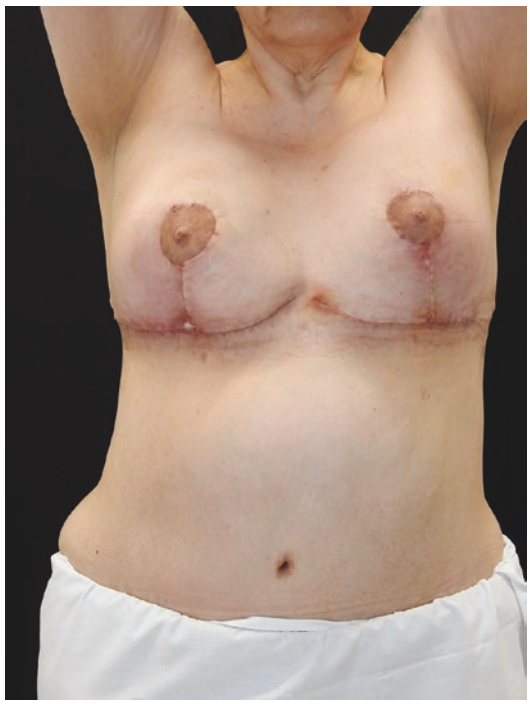


Fig. 15.12 Skin dehiscence in the union of the vertical and the horizontal incisions of an inverted T pattern

15.8.2 Fat Necrosis

Fat necrosis is one of the most common complications associated with reduction mammoplasty. Regardless of the technique, the rates of fat necrosis have been reported in the 2–10% range [50]. Its main etiology is the lack of blood supply secondary to large suture bites in the breast parenchyma or a diminished blood supply at the distal end of the pedicle [11]. Fat necrosis commonly presents as a firm, soft-tissue mass that usually resolves spontaneously. It can be associated with redness and mild discomfort and may be confused with an infectious process. The literature is inconsistent with respect to detailed cause and effect or definitive correlations between fat necrosis and risk factors. However, some of these risk factors include greater BMI [11, 22, 55–57], larger resection weights (greater than 1300 g) [23, 49], and long suprasternal notch-to-nipple distance (especially over 37 cm) [58]. Conservative treatment is the best approach in asymptomatic patients, whereas a second review surgery must be recommended in painful or in large fat necrosis.

15.8.3 Nipple-Areolar Necrosis

Nipple necrosis can occur when there is constriction, kinking, or compression of the pedicle obstructing venous return. The main reasons for this venous compression may come from a too tight closure of the skin incisions or from an internal hematoma.

If a nipple and areola look congested, removal of sutures and release of compression are first indicated. If there is still no improvement of the nipple-areola venous drainage intraoperatively, an immediate nipple-areola complex graft should be performed.

A conservative treatment with wound care should be followed if the nipple-areola congestion has developed during the immediate postoperative period. Sometimes, some early blistering

Fig. 15.13 A partial nipple-areola complex loss in an inverted T pattern, treated conservatively, healing by secondary intention and with a subsequent loss of pigmentation and slight deformity

Fig. 15.14 Picture after complete debridement of a total nipple-areola complex necrosis in an inverted T pattern breast reduction mammoplasty

can occur with complete recovery or with some irregular pigmentation. Other times, only a partial loss occurs, and it is often best to leave this to heal by secondary intention because the outcome can be excellent or acceptable (Fig. 15.13). However, a total or subtotal well-delimited nipple necrosis should undergo debridement and a second-stage reconstruction (Fig. 15.14).

15.8.4 Hematoma and Seroma

Hematoma risk increases with patients with hematological pathologies as well as patients under some medications or herbal therapies (acetylsalicylic acid, nonsteroidal anti-inflammatory drugs, ginger, garlic, among others). Higher risk of developing seroma has been associated with higher BMI or equal to 35 kg/m^2 [57]. Hemodynamically stable patients with small liquid accumulation must be treated conservatively. An acute active hematoma should be urgently ruled out and treated surgically if the patient starts with sudden changes in breast volume, pain, consistency, and vital constants.

15.8.5 Infection

The rate of infection after breast surgery ranges from 4 to 26% [33]. The microorganism most commonly found comes from the skin microbiota. Culture specimens should be taken if there is any type of wound discharge to optimize the antibiotic therapy in accordance with the sensitivity of the microorganism involved and the hospital's infection disease protocols.

15.9 Conclusions

Breast reduction is a reliable surgery in postmaternity patients. Considerations on further pregnancies or patients' expectations should always be clarified in the first medical consultation for the optimization of the surgical preparation. Different skin approaches, glandular resections, and breast remolding may be assessed depending on the patients' breast morphology, desires, and surgeon's preferences. Finally, patients must be explained and aware of the possible complications and the surgical outcomes before undergoing breast reduction.

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Postpartum Breast Lift with and Without Implants

16

Richard J. Zienowicz and Ercan Karacaoglu

Take-Home Points

- The discussion of breast rejuvenation should include whether breast implants should be recommended. Most experienced aesthetic breast surgeons feel that the addition of an implant to the sagging breast results in a more predictable breast mound elevation and longer lasting result.
- The patient is marked in the standing position. The lower pole tissues are gently pinched, and marks are made on both sides of the pinched skin. Depending on the size of the implant chosen (or not), the markings can be adjusted accordingly.
- These markings are only provisional and serve as a guide to begin the tailor-tack method of reshaping the gland.
- The base of the NAC marking is incised on the junction of circular and vertical marking, and a single 3-0 Monocryl is subcuticularly placed to secure this important landmark.
- Circumvertical mastopexy by design re-creates an ideal breast shape. The technique involves tightening in a vertical direction that maximally elevates the glandular tissues and restores projection more than any other method.
- Limitations of this technique are seen with massive ptosis and where Weiss pattern excision of redundant lower pole tissues is sometimes a preferable option.

16.1 Introduction

The postpartum patient after dealing with the exigencies of childcare is left to deal with an often drastically altered physique. Fortunate individuals will lose their pregnancy weight expeditiously, and this is often hastened by the act of nursing with the enormous calorie expenditure that it involves. The maternal infant bonding that results as well as enhanced immune competence and intelligence seen in infants nursed for a significant time frame suggests that most physicians including plastic surgeons should recommend breastfeeding to their prospective patients. A few months of discontinuation of nursing is generally recommended before entertaining breast surgery. The discussion of breast rejuvenation should include whether breast implants should be recommended. Most experienced aesthetic breast surgeons feel that the addition of an implant to the sagging breast results in a more predictable breast mound elevation and longer lasting result due to the inherent structure of the implants, which confer immediate shape enhancement to the breast.

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_16

Regnault published a classification of breast ptosis in 1976 that continues to be a common system of classifying ptosis [1]. Although variations of this classification exist, key elements from Regnault's classification predominate when surgeons discuss and describe degrees of breast ptosis:

Grade 1: Mild ptosis—nipple just below the inframammary fold but still above the lower pole of the breast

Grade 2: Moderate ptosis—nipple further below the inframammary fold but still with some lower pole tissue below the nipple

Grade 3: Severe ptosis—Nipple well below the inframammary fold and no lower pole tissue below nipple

Pseudoptosis—Inferior pole ptosis with nipple at or above the inframammary fold.

Circumvertical mastopexy (CVM) by design re-creates an ideal breast shape. It is the author's preferred technique because of the limited scarring that results. Indeed, compared to Wise pattern techniques, scarring is generally halved. The CVM technique involves tightening in a vertical direction that maximally elevates the glandular tissues and restores projection more than any other method. Limitations of this technique are seen with massive ptosis and where Weiss pattern excision of redundant lower pole tissues is sometimes a preferable option. The decision of whether it is safe to perform augmentation concurrent with mastopexy has been addressed by several large studies [2, 3] and has been safely practiced by the authors for over 25 years.

16.2 Patient Selection

All grade 3 and most grade 2 ptotic patients require mastopexy for proper breast rejuvenation. Occasionally, a circumareolar (Benelli, donut) mastopexy will suffice for some grade 2 patients, and very large implants can sometimes adequately correct intermediate ptosis. For discussion of the nuances of these scenarios, the reader is encouraged to refer to more comprehensive sources.

Contraindications

- Active galactorrhea
- Active breast acne
- Previous trauma or surgery that may have compromised nipple-areolar complex vascularity

16.3 Preoperative Evaluation

16.3.1 Physical Examination

The patient should be able to give the surgeon an estimate of her expectations with respect to the size of the resulting breasts, degree of lifting, size of areolae, and scarring. Her body habitus, i.e., natural breast size, shoulders, hips, derriere, and ectomorphic, endomorphic, or mesomorphic build, should be considered in recommending a size that complements her frame ideally and coincides with her individual preferences. We typically then place the patient in an appropriate sized bra and choose silicone sizers (Allergan, Inc., Mentor, Inc.) to place within each cup and have the patient put on her blouse or shirt to view in a full-length mirror. We can upsize or downsize until she is comfortable with a particular size. We then perform three-dimensional imaging with VECTRA imaging system to demonstrate landmarks, symmetry, or lack of CVM markings and implant type and size and utilize morphing software to simulate post-op result. If the patient wishes to see a variety of sizes, these can be visually compared side to side facilitating accurate choices that have been validated in several studies.

16.3.2 Preoperative Markings

The patient is marked in the standing position. A vertical line is drawn with a methylene blue marker from the apex of the nipple upwards in a direction that corresponds to the desired direction of glandular correction. A breast that hangs in a medial to lateral direction will require obliquity of the line in a lateral to medial direction to move the displaced tissues from lateral to medial. Next, the lower pole tissues are gently pinched with the

surgeon's index and thumb until they are touching together and marks are made on both sides of the pinched skin along the lower pole stopping a few centimeters short of the inframammary fold (IMF). The skin of the lower pole of an individual's breast can vary enormously. If the skin thickness and quality are optimal, then the markings should be immediately adjacent to the surgeon's fingers. If the skin is thin and stretchable, then the markings should be commensurately wider. Depending on the size of the implant chosen (or not), the markings can also be adjusted accordingly. These are only provisional and serve as a guide to begin the tailor-tack method of reshaping the gland described below.

16.4 Anesthetic Considerations

This operation can be performed comfortably with general endotracheal (GET), laryngeal mask airway (LMA), or deep monitored anesthesia care (MAC). My preference having done it for many years with MAC, which required intercostal nerve blocks to accomplish satisfactorily, is for general anesthesia with LMA. The operation should take on average 2 h for a single surgeon and only half with a competent assistant who can suture adequately. This is within the safety window of time for LMA anesthesia. My strong preference is to avoid epinephrine anywhere near the nipple-areolar complex (NAC) to prevent unintentional restriction of blood flow to that structure, which is the most concerning complication of this combined procedure.

16.5 Surgical Technique

16.5.1 Patient Positioning

The patient is placed supine on the OR table with arm boards superiorly positioned at right angles and arms fixed to the arm boards with Webril and Velcro to permit a full sitting position to assess breast shape and properly judge intraoperative NAC markings. Additionally, the head should be secured with tape to the headrest in a straight neutral position.

16.5.2 Approaches

Occasionally, in a narrow breast with marked ptosis and planned large implant placement during which it is anticipated that there will be strain on the NAC closure due to increased tension from the indwelling implant, I will opt to place the implants through a transaxillary approach. This portal maximally preserves vascularity to the NAC but adds another step and incision. The resulting axillary scar is invariably of little cosmetic concern to the patient for the added safety it provides.

16.5.3 Procedure Step-by-Step

Prior to prepping, xylocaine 1% with epinephrine is injected into the central lower pole (where the implant insertion will be performed) in the center of the zone that has been marked for excision. For postoperative comfort, 0.25% Marcaine and 0.5% xylocaine intercostal nerve blocks may be performed from T2–T7 as well. The patient is prepped with ChloraPrep and Tegaderm applied to the NAC bilaterally until implants are placed. Depending on the chosen implant size, a vertical incision is made in the lower pole between 3.5 and 5 cm in length and carried down through breast parenchyma until the pectoralis major muscle is encountered (Fig. 16.1). A narrow Deaver retractor is then inserted, and traction in the direction of the ceiling is applied which pulls

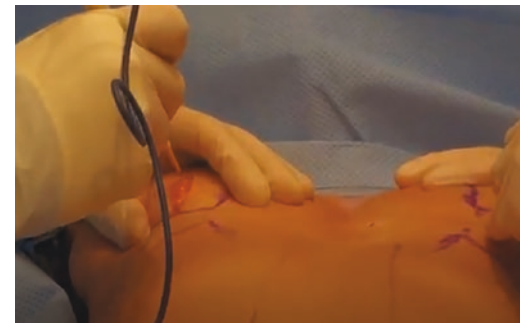

Fig. 16.1 Depending on the chosen implant size, a vertical incision is made in the lower pole between 3.5 and 5 cm in length and carried down through breast parenchyma until the pectoralis major muscle is encountered

the pectoralis major away from the rib cage, allowing safe division of the muscle in the direction of the fibers. The surgeon can then insert a finger and sweep the loose tissues between the muscle and chest wall until the retractor can be inserted completely, and then the pectoralis major is divided along the medial lower edge and inferiorly at its origin creating a dual-plane pocket that permits lower pole expansion by the implant. The degree of muscle division is according to the need for lower pole expansion to accommodate the implant. A larger implant will require more muscle release. The pockets are inspected for optimal hemostasis, and once achieved, Betadine 10 cc is instilled into the pocket and the opposite breast is prepared in the same fashion. Once both breast pockets are completed, the surgeon's gloves are changed and an implant is loaded into a Keller Funnel (or similar device which allows atraumatic implant insertion) along with triple-antibiotic solution that the implant has been immersed in (cephalexin, gentamicin, and clindamycin) and then the implant is instilled into one side followed by the other and the implant positional symmetry is assessed by downward displacement in a caudal direction by the surgeon's hand. Both implants should readily descend to the lower pole area symmetrically (Fig. 16.2). The surgical opening is then closed with 2-0 Monocryl and temporary staples.

Fig. 16.2 A subpectoral pocket is created. Both implants should readily descend to the lower pole area symmetrically. The surgical opening is then closed with 2-0 Monocryl and temporary staples

Fig. 16.3 The NAC is then marked with a cookie cutter (38–42 mm) and the north, south, east, and west meridians are marked with methylene blue and a 25 G needle to facilitate correct orientation of the NAC later

The NAC is then marked with a cookie cutter (38–42 mm), and the north, south, east, and west meridians are marked with methylene blue and a 25 G needle to facilitate correct orientation of the NAC later (Fig. 16.3). Placement of a double mark at the north (12 o'clock) position will discourage twisting of this structure, which could compromise circulation to the NAC. The NAC is incised with a 10 blade, and further freeing of the edges from the surrounding skin is performed with a needlepoint cautery. Tailor-tack stapling of the previously marked edges is performed in a cephalic to caudal direction, and the new IMF is secured temporarily with a single Size 0 Maxon suture (Fig. 16.4). This tailor tacking will transform the typically flattened breast into a conical shape. The apex of the cone which has been created will then be flattened by the use of a temporary purse-string suture (2-0 Monocryl) that when tied transforms the cone into a globular structure resembling the final desired shape. Additional staples may be applied until the lower pole is flat rather than curved. This flattened lower pole will round out over the ensuing post-op weeks. Small breasts and thick-skinned individuals require less flattening because the tissues will not be as likely to "bottom out" postoperatively due to the smaller volumes and/or less distensible, stronger lower pole tissues. Once the surgeon is comfortable with the symmetrical shape of the breasts, the NACs can be marked for inset. The patient is placed in the fully seated

Fig. 16.4 The NAC is incised with a 10 blade and further freeing of the edges from the surrounding skin performed with a needle-point cautery. Tailor-tack stapling of the previously marked edges is performed in a cephalad-to-caudad direction, and the new IMF is secured temporarily with a single 0- Maxon suture. This tailor tacking will transform the typically flattened breast into a conical shape

Fig. 16.5 The NACs are marked with a cookie cutter coated with methylene blue. The size utilized depends on the chosen size of the NAC previously marked and whether greater or less skin excision is required in the central breast area. Once the team agrees that these markings are ideal in placement, then the patient is reclined to the mostly supine position. The base of the NAC marking is incised on the circular and the vertical marking at the apex of the vertical tailor-tacked closure, and a single 3-0 Monocryl is subcuticularly placed to secure this important landmark

upright position. I typically request that several OR personnel weigh in on the shape, and then the NAC markings as several sets of eyes will help achieve more accuracy. The NACs are marked with a cookie cutter coated with methylene blue. The size utilized depends on the chosen size of the NACs previously marked and whether greater or less skin excision is required in the central breast area. Once the team agrees that these markings are ideal in placement, then the patient is reclined to the mostly supine position. The base of the NAC marking is incised on the circular and the vertical marking at the apex of the vertical tailor-tacked closure and a single 3-0 Monocryl is subcuticularly placed to secure this important landmark (Fig. 16.5). Next, the purse-string suture is removed and the marked area is adjusted under tension applied by the assistant in a circular fashion by pressure applied with both hands using methylene blue until the area is a proper circular shape. It is then de-epithelialized, and optimal hemostasis is achieved with the electrocautery. Extreme care must be taken to assure that the patient's NAC that is buried below is safely remote to the cautery and not injured during this excision. It is then sewn with a deep subcuticular 3-0 Gore-Tex suture, which is tied down to a smaller cookie cutter, i.e., 34–38 mm with

Fig. 16.6 Next, the purse-string suture is removed, and the marked area is adjusted under tension applied by the assistant in a circular fashion by pressure applied with both hands using methylene blue until the area is a proper circular shape

multiple knots (Fig. 16.6). The north, south, east, and west markings are then united between the areola and the breast skin with 5-0 nylon interrupted sutures. 5-0 Monocryl is placed between those points and then subcuticular 4-0 Stratafix barbed suture to complete the NAC closure. The center of the stapled vertical closure is carefully marked with methylene blue and crosshatch markings as well to ensure eventual accurate clo-

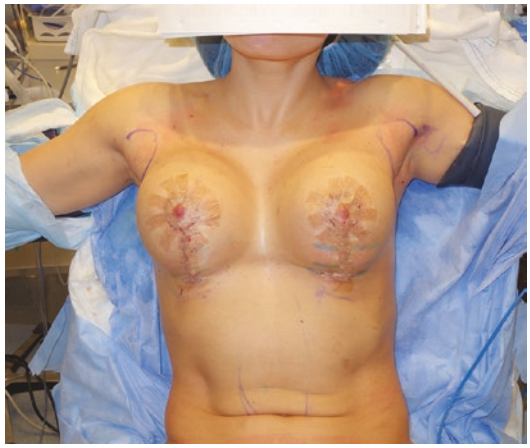

Fig. 16.7 The pillars of breast tissue as they are referred to are then plicated with 0- Maxon buried sutures followed by 2-0 Monocryl to skin and parenchyma and then 3-0 Monocryl to dermis and running 5-0 nylon to skin

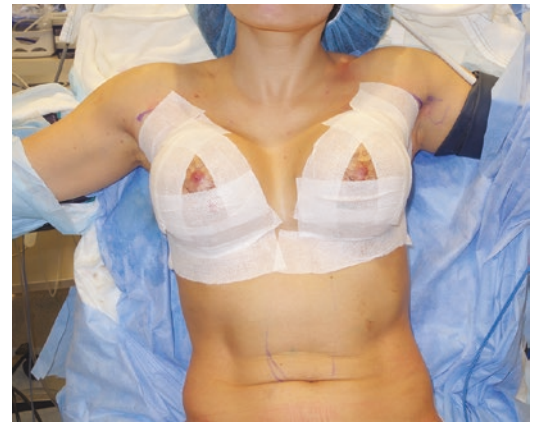

Fig. 16.8 The NACs are glued with Dermabond, Mastisol, and Steri-Strips applied to the vertical and small horizontal incisions. Medipore tape is applied for support and shaping in lieu of a surgical bra

sure. Staples are removed leaving the IMF securely buttressed by the 0- Maxon, the marked area is excised by tandem parallel vertical cuts, and redundant skin is finally excised with pinpoint cautery. The pillars of breast tissue as they are referred to are then plicated with 0- Maxon buried sutures followed by 2-0 Monocryl to skin and parenchyma and then 3-0 Monocryl to dermis and running 5-0 nylon to skin. The IMF is marked; the 0- Maxon is removed; if necessary, a short transverse incision is made 3–5 cm; and the redundant soft tissue and skin are excised and closed with 2-0 and 3-0 Monocryl and finally 5-0 nylon to skin. If indicated, liposuction to the IMF and lateral axillary areas is performed to refine the contours in those areas. Tumescent solution with epinephrine is instilled 10 min before anticipated liposculpture (Fig. 16.7).

16.5.3.1 Dressings

The NACs are glued with Dermabond, Mastisol, and Steri-Strips applied to the vertical and small horizontal incisions. Medipore tape is applied for support and shaping in lieu of a surgical bra (Fig. 16.8).

16.6 Postoperative Care

Patients are seen at 1 week, and dressings are changed. At week 2, vertical sutures are removed unless there is a history of severe hypertrophic scarring for which sutures are removed after 7 days. Any IMF sutures are removed at 3 weeks post-op. Taping with Medipore is done across all suture lines for 3 months. Medipore tape is used for shaping and support on the lateral breast and fold until underwire bra wear is initiated after week 3.

16.7 Outcomes and Prognosis

Early scar maturation is seen at 3 months, but scar coloration may take many months to years to fully mature in some ethnicities.

Prognosis is typically highly satisfactory though asymmetries will persist to varying degrees as in nature. Patient satisfaction is high in those with realistic expectations. The surgeon should prepare their patients for the possibility of revisions if indicated (Figs. 16.9, 16.10, 16.11, and 16.12).

Fig. 16.9 A 56-year-old woman with a history of breast ptosis and two prior pregnancies presenting with lower abdominal skin laxity. Procedure: This patient underwent abdominoplasty, and CVM with subpectoral placement of implants bilaterally. (Left) Preoperative images. (Right) Postoperative result at a follow-up appointment at 22nd month

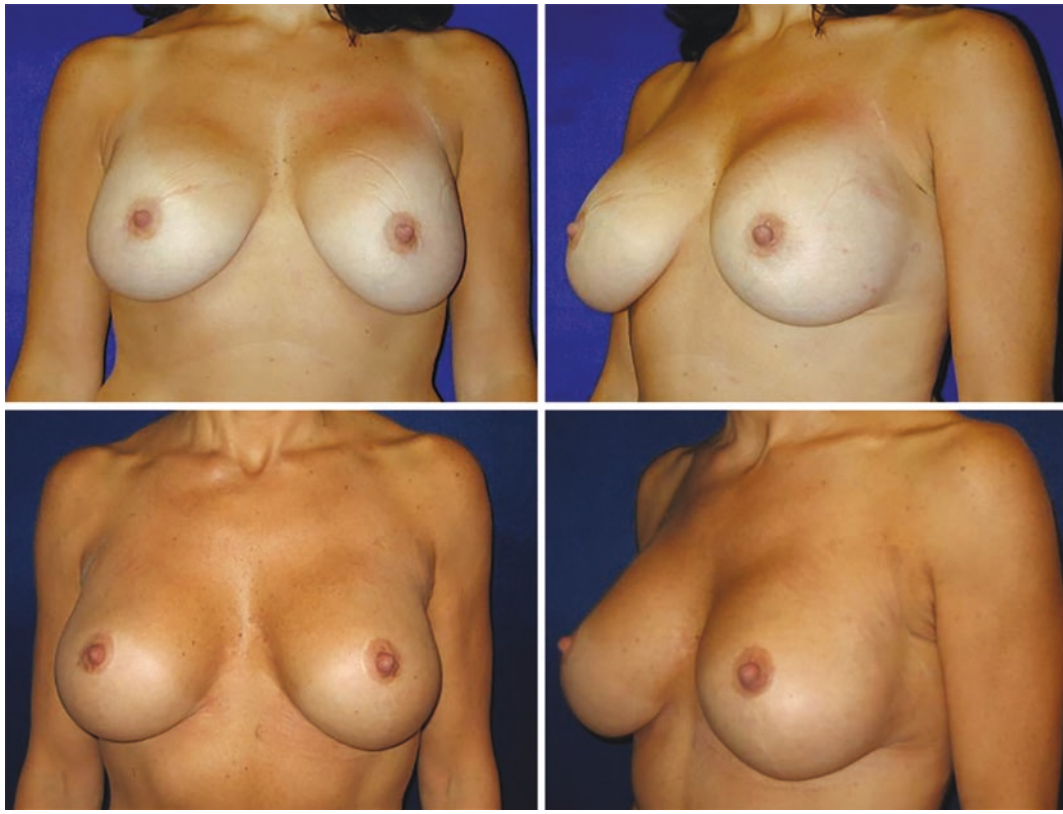

Fig. 16.10 A 48-year-old woman with a history of breast ptosis and breast augmentation almost 5 years ago. Procedure: This patient underwent CVM with subpectoral placement of implants bilaterally. (Above) Preoperative images. (Below) Postoperative result at a follow-up appointment at 18th month

Fig. 16.11 A 42-year-old woman with a history of grade 3 breast ptosis. Procedure: This patient underwent CVM with subpectoral placement of implants bilaterally. (Left) Preoperative images. (Below) Postoperative result at a follow-up appointment at 12th month

Fig. 16.12 A 38-year-old woman with a history of breast ptosis and breast augmentation almost 9 years ago. Procedure: This patient underwent CVM with subpectoral placement of implants bilaterally. (Left) Preoperative images. (Right) Postoperative result at a follow-up appointment at ninth month

16.8 Complications

Asymmetry due to:

(a) Implant malposition
(b) NAC position and size discrepancies
(c) Glandular/implant size discrepancies

16.8.1 Implant Malposition

As in breast augmentation, it is imperative that the surgeon be certain that implant position be assessed in the sitting position during mastopexy. Unlike simple augmentation, the entire premise of mastopexy is to tighten the flaccid lower pole tissues to restore a youthful configuration, and most surgeons tighten the lower pole tissues slightly more than is aesthetically ideal to accommodate the anticipated lower pole stretch that occurs in the weeks to months postoperatively. These tissues must heal, and hence the implants within are concomitantly higher in the pocket than they will be after a few months of settling. This settling can unfortunately occur at different rates resulting in visual asymmetry that can be unsettling to the patient. Asymmetric bandeau wear should be employed as soon as this is identified. The application of upper pole force with an asymmetric bandeau over several weeks can restore symmetry in most patients. This needs to be done by the surgeon or trained staff on a weekly basis to be sure that the process is being carried out effectively at home. The breasts are taped with Medipore across the incisions to support the scars and then to support the lower pole

of the breast with proper implant position including the IMF. The breast with the superior fullness due to higher pocket position is also taped across the incisions for scar support. The bandeau will apply force exclusively to the upper pole of that breast and will via tissue expansion lead to descent of the implant if sufficient force is applied and if the process is initiated prior to the development of unyielding scar tissue in the lower pocket dissection site (Fig. 16.13). If this intervention has not resulted in the restoration of symmetry over a 1–2-month period, then operative release of the lower pole capsule must be considered. If this is done, it can typically be accomplished through a small IMF incision with rapid healing time and minimal impact on the patient with respect to discomfort and restriction of activities. Alternatively, some breasts will require IMF repositioning with pexy sutures to maintain that position. In the case of bottoming out, this may be adequately done in mild cases with strong suture fixation to the chest wall fascia and periosteum while more severe cases may require the use of an ADM or absorbable devices like GalaFLEX (Figs. 16.14, 16.15, and 16.16).

Fig. 16.13 Unlike simple augmentation, the entire premise of mastopexy is to tighten the flaccid lower pole tissues to restore a youthful configuration, and most surgeons tighten the lower pole tissues slightly more than is aesthetically ideal to accommodate the anticipated lower pole stretch that occurs in the weeks to months postoperatively. These tissues must heal, and hence the implants within are concomitantly higher in the pocket than they will be after a few months of settling. This settling can unfortunately occur at different rates resulting in visual asymmetry that can be unsettling to the patient. Asymmetric bandeau wear should be employed as soon as this is identified

16.8.2 NAC Position and Size Discrepancies

Once final healing has occurred in 3–6 months, any obvious irregularities will be best dealt with by corrective surgery which may involve simple NAC elevation maneuvers with crescent excisions to elevate an NAC or more elaborate revisions requiring central lower pole skin excision to concurrently reshape the lower pole and elevate the NAC.

16.8.3 Glandular/Implant Size Discrepancies

Once postoperative swelling has subsided after the first 2–3 months, any persistent size difference will have to be dealt with by either implant size changes or fat grafting or excision. Those adjustments may require secondary mastopexy as well.

Fig. 16.14 A 46-year-old woman with a history of breast ptosis and mastopexy augmentation with periareolar approach 8 years ago. Procedure: This patient underwent CVM with subpectoral placement of implants bilaterally. (Left) Preoperative images. (Right) Postoperative result at a follow-up appointment at 24th month

Fig. 16.15 A 37-year-old woman with a history of tuberous breast deformity that underwent augmentation mastopexy 5 years ago. She had her implants removed 6 months ago. Procedure: This patient underwent CVM with subpectoral placement of implants bilaterally. (Left) Preoperative images. (Right) Postoperative result at a follow-up appointment at tenth month

Fig. 16.16 A 40-year-old woman with a history of breast deformity that underwent augmentation mastopexy 5 years ago. She had periareolar type mastopexy, and her implants were placed in subglandular pocket. She had significant breast deformity, with areola widening. This patient underwent CVM with subpectoral placement of implants bilaterally. (Left) Preoperative images. (Right) Postoperative result at a follow-up appointment at 14th month

16.9 Conclusion

Mastopexy is possibly the most challenging aesthetic operation that endeavors to achieve an ideal long-standing outcome. It is highly litigated because of a widespread significant lack of success and subsequent patient disappointment. Preoperative size assessment for symmetry restoration and achievement of ultimate patient satisfaction are imperative. Three-dimensional imaging for implant sizing—important in simple augmentation—is just as important during breast lift. Implant sizers confer similar predictability and should always be employed.

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Postpartum Breast Augmentation with Implants

17

Jorge Aso and Ismael González

Take-Home Points

- Postpartum breast augmentation without mastopexy is indicated in patients with good skin quality and absence of ptosis.
- The surgeon has to deeply explore the patient's expectations and clearly transmit the possible outcomes and limitations of her case.
- The selection of the size is probably the single most important item for the patient in the whole decision-making process.
- Dual-plane technique is extremely useful in post-maternity patients, since it combines the advantages of both subglandular (glandular lift) and submuscular (better coverage in the upper pole).

17.1 Introduction

Beauty has been pursued since ancient times but had its maximal evolution during the last century. The progress of medicine and surgery and influence of modern society extended the pursuit of beauty to a lifelong moment; interestingly, we can identify two concepts of beauty: one linked to the classical beauty standards (typical of youth) and the other linked to the research of youth itself (typical of second and third age).

Pregnancy in particular is a moment in which a combination of hormonal and mechanical factors may alter the female body shape.

Breastfeeding has erroneously been considered the main cause of breast changing after pregnancy, and despite its proved importance for the newborn's health, many women avoid lactation fearing that it will affect their breast shape and attractiveness.

It has to be clarified that breast changes may occur in different degrees or not occur at all after pregnancy. The main risk factors for breast ptosis are age, cigarette smoking (both of which are associated with a loss of skin elasticity), larger prepregnancy bra cup size, and number of pregnancies. While breast ptosis appears to increase with each additional pregnancy, breastfeeding does not seem to worsen these effects [1, 2].

Women willing to improve their breast shape or volume after pregnancy have to be accurately evaluated, and ptosis as well as tissue quality should be correctly addressed before surgery in order to avoid suboptimal results.

Breast augmentation without mastopexy is indicated, as described in this chapter, in case of good skin quality and absence of ptosis.

17.1.1 Available Breast Implants

Breast implant design has continuously evolved since the first creation, and use of a silicone gel-

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_17

based prosthesis was reported in 1963. Progressive understanding of implants' biodynamic and technology evolution has brought us to fifth- and sixth-generation breast implants. Three fundamental characteristics help in the understanding of the majority of the devices: shape, shell characteristics (surface design, surface material), and filling material. Slightly more difficult is understanding the biodynamic and the long-term interaction of each one of the variables [3, 4].

17.1.1.1 Shape

With implant shape, we primarily define the sagittal section of the implant shell. The two options are "round" and "anatomical" (Fig. 17.1).

Round-Shaped Implants

These implants were the first one to be invented and exclusively used for many years. The term "round" is somehow improper, and it refers to the equal convexity of the anterior surface of the implant. The convexity increases proportionally with the projection of the implant (but never exceeds the diameter of the basis). The maximal projection point is always at the center of the implant. As a consequence of these characteristics, the base of the implant is round.

Anatomically Shaped Implants

The anatomical or "teardrop" implant is an evolution of the shape concept characterized by an asymmetrical sagittal section in which the point

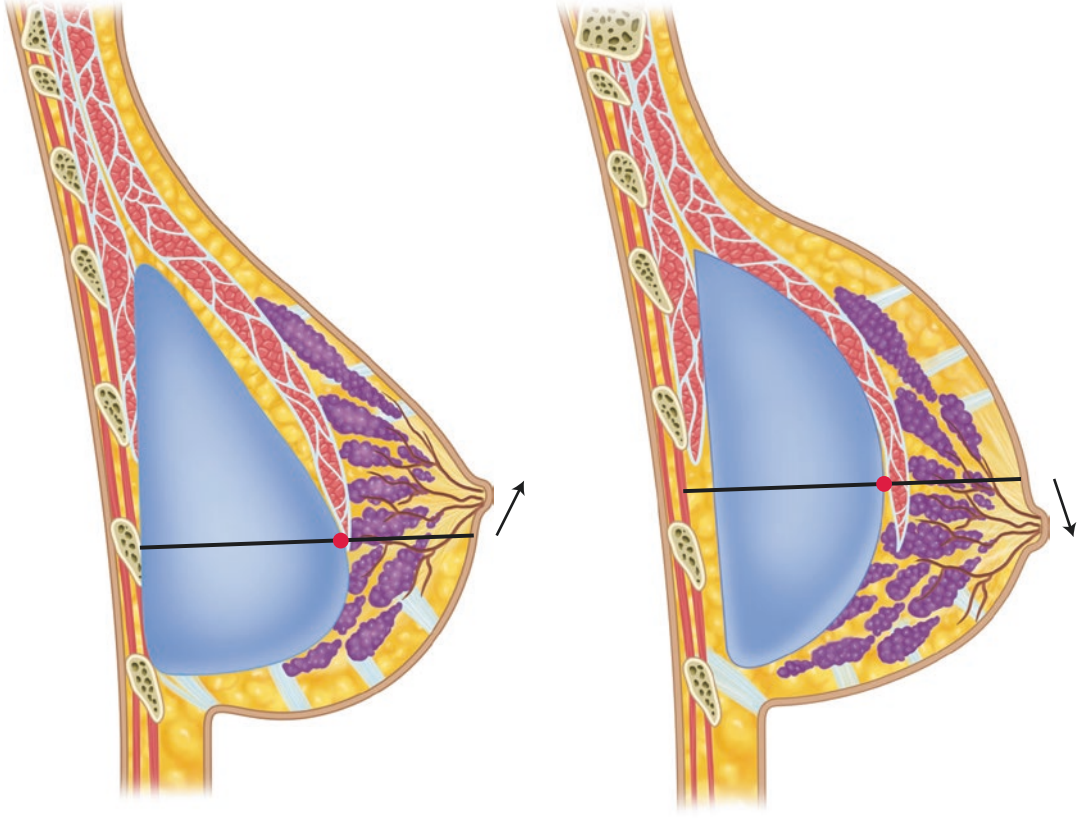

Fig. 17.1 Different effects on a post-maternity breast of anatomical implants (left) and round (right). Note how the anatomical implant has a maximum projection point in a much lower position compared to the round one. This helps when trying to align a slightly low-positioned NAC and still getting a nice and natural result without the need of a mastopexy

of maximal projection is located in the lower half of the device. The teardrop shape figuratively indicates the gradual increasing of projection from the apex to the lower third of the implant; this shape is more representative of a natural breast in the upright position. The horizontal and vertical dimensions are not important in the "anatomic" definition; any type of ratio is possible between these two variants. The main drawback of these implants is the possibility of rotation, creating an abnormal shape.

17.1.1.2 Shell Characteristics

Surface Design

The importance of shell surface has progressively increased during the years, and the implants of first generation were only smooth; however, in the 1970s, it was observed that the newly introduced polyurethane-coated implant had a dramatically lower incidence of capsular contraction. Even if the use of polyurethane was temporarily dismissed for suspected cancer risk, the idea of recreating a textured "polyurethane-like" surface on silicone's shell was implemented with the second generation of breast implants [5, 6].

There are several methods of texturization of a silicone shell (salt loss, imprinting, etc.) and different grades of texturization. Producers have independently developed and commercially branded their own texturized products (Allergan-Biocell, Mentor-Siltex, Motiva-Velvet, Polytech, POLYtxt, etc.).

Texturization characteristics have recently been reevaluated in the investigation of late-onset complications such as breast implant-associated anaplastic large-cell lymphoma (BIA-ALCL) and late-onset seroma.

In order to carry out objective studies, several standardized scientific nomenclatures have been proposed. The three-dimensional surface area ratio could ultimately clarify the nano, micro, and macro-texturization concept defining four roughness grades [7]. Other studies have focused on the capacity of the implant surface to promote bacterial proliferation [8].

Surface Material

The multilayer silicone shell has evolved during the years thanks to experience and technology, reducing the overall thickness of the shell and increasing impermeability to avoid leakage problems.

Independently of the filling, texturization, and additional coating, all the breast implants are made of silicone (laboratory product derived from silicium, a likely inert, nonmetallic, chemical element widely diffuse in nature). After the 1995 FDA's disclaim over polyurethane carcinogenicity, some producers started to reintroduce additional polyurethane coating to their texturized models. The main advantage of polyurethane is the ingrowth of the capsule in the polyurethane foam, which has been proven to significantly diminish capsular contraction rates [9].

17.1.1.3 Filling

After various attempts to find an inert filling material which closely resembles the consistency of breast tissue, two filling materials have lately been selected for their safety.

Silicone Gel

The silicone gel implant was the first one to be used, and gel production standards and characteristics have been improved during the years. Gel-filled implants have a more natural feeling if compared to saline ones, and their cost is also considerably higher. Fundamental feature of a silicone gel is its grade of cross-linking, which determines the cohesivity (attractive force between the particles of a determined substance) and viscoelasticity. These two factors determine the capacity of maintaining a given shape and the grade of resistance to temporary modifications. Cohesivity also avoids the spillage of the gel in case of shell rupture.

Gel-filled implants are produced independently of the shape with different grades of silicone cross-linking. Specific anatomical implants are filled with two gels with different cohesivity (Polytech Diagon-gel, Allergan 510).

Also related to the key concepts of viscoelasticity, the relatively new idea of "ergonomic" prosthesis was recently introduced. A particular viscoelastic gel in a round implant temporarily changes its shape during the upright position resembling a more natural anatomic implant without the risks of a rotation.

Saline

Saline-filled implants are implants which contain a saline solution; they are either pre-filled or equipped of an inflation valve (Baker implant); they had an oscillating popularity during the years. Despite the several drawbacks due to the low cohesivity of the saline solution (rippling, deflation, somehow unnatural feel …), it was the only available option in the United States during the 1990s after the FDA moratorium on gel-filled implants. The most effective strategy in order to overcome the low density is to slightly overfill, giving in case of round implant even a fuller appearance of the upper pole. After the withdrawal of the FDA moratorium in 2006, saline implants have been used in a descending trend. The main advantages of these implants other than the absolute harmlessness of the saline solution are the easy insertion even from a small incision and the possibility of overcoming asymmetries or patient's higher volume desires with simple inflation [4].

17.2 Patient Selection

A breast augmentation is a simple, low-risk procedure. Nevertheless, one has to keep in mind that, as any other cosmetic procedure, only healthy, adult patients should be considered for the operation.

In very special circumstances, patients below the age of 18 could also be considered (tuberous or great breast asymmetries that produce psychological disorders), always with the clear consent of the parents or legal tutors and a positive recommendation of a psychiatrist or a psychologist.

Patients should be warned that smoking can greatly increase the possibilities of complications after the procedure.

The surgeon has to deeply explore the patient's expectations and clearly transmit the possible outcomes and limitations of her case. Every case has a limitation (usually subtle), but this has to be explained in a clear way to her. Failure to meet expectations is undoubtedly the main source of problems after the surgery.

The perfect patient is an adult, well-informed, intelligent woman with reasonable and clear expectations.

Anatomical requirements: The nipple has to be at least at the same level as the IMF (preferably above). If the nipple stands in a ptotic position (lower than the IMF), an augmentation-mastopexy should be considered instead.

Key Points

Every case has a limitation (usually subtle), but this has to be explained in a clear way to the patient.

17.3 First Consultation and Patient Selection

17.3.1 Measurements

The first step when assessing a new case is measuring the most important elements of the breast (Fig. 17.2):

- BBW: breast base width
- SN-N: sternal notch-to-nipple distance
- N-IMF: nipple-to-inframammary fold distance
- Nipple-to-nipple distance
- Diameter of areolas
- NS: nipple-to-sternum distance
- BP: breast projection
- Nipple positioning in relationship to the IMF height: above, same level, and below

17.3.2 Preoperative Planning and Simulations

Some systems use the base width, skin stretch, and nipple-inframammary fold distance to determine the implant size [10]. These considerations

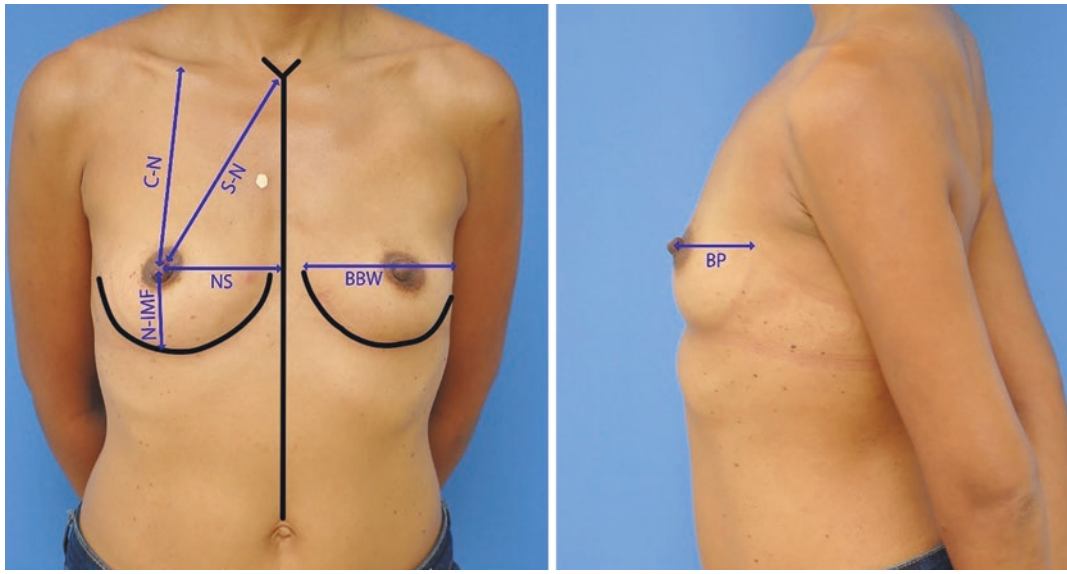

Fig. 17.2 Main measurements in breast augmentation

provide a safe and highly reproducible method that minimizes complications. On the other side, patient's wishes and expectations are important and they are to be considered in the implant selection process, allowing patients to cultivate ownership of the final results [11]. The selection of the size is probably the single most important item for the patient in the whole decision-making process. We always invest at least 20 min in our first consultation on this particular matter.

During the first consultation, the patient undergoes both bra sizing and a 3D simulation. The parameters of sizers and 3D simulator are adjusted by the surgeon based on previously determined breast measurements of the patient. With this approach, the surgeon is able to provide a range of acceptable implant volumes and projections, based on the patient's measurements, and then, eventually, choose the best one depending on the desire of the patient [12, 13].

Key Points

The selection of the size is probably the single most important item for the patient in the whole decision-making process. We always invest at least 20 min in our first consultation on this particular matter.

17.3.2.1 Bra Sizers

This is the most commonly used sizing method in breast augmentation. The process consists of using external silicone sizers under the bra. The patient is able to check the result in the mirror, even with her favorite clothes on.

The surgeon changes the different volumes of the size simulators to simulate the different projections within the width range of the patient's breast base.

We usually start by trying out the implant that has the same breast width as the patient's (minus pinch divided by two) and full projection, since this is the most commonly used implant used in our practice.

The width of the breast limits the size of the implants that we can use in a patient. In cases where the patient wants more volume, we simulate extra-high projections superimposing two sizers in one breast.

On the other hand, if a full projection implant is considered too large by the patient, a moderate one is simulated.

Some studies showed that the patients that underwent bra sizing felt that the final breast size was smaller than predicted by the sizer process [14]. This is mainly caused by two factors:

1. The patient is not used to having a bigger breast. First impression causes the patient to feel that "maybe this is too much."
2. Over time, some breast gland atrophy is expected, and the swelling will fade away, creating the perception of a smaller breast than before.

Thus, we always try to convince the patient to choose the largest implant volume with which they feel comfortable.

Key Points
We always try to convince the patient to choose the largest implant volume with which they feel comfortable.

17.3.2.2 3D Imaging Simulator

The 3D simulator is a very useful tool to calculate the size and shape [15–17]. One study showed that 90% of patients agreed (66% absolutely agreed, and 24% partially agreed) in that the final product after breast augmentations was similar to the 3D simulation. The majority of patients felt that the simulated images were accurate in predicting their actual results and shape [18].

In our experience, it is very useful not only in calculating the size, but also in showing the difference between round and anatomic implants in the patient. Thus, the patient can decide what type of implant she prefers, being aware of the advantages and disadvantages of each type of implant (especially the risk of rotation in the anatomical ones).

However, we have to be very careful with the use of this 3D simulation. Final result may diverge from the simulated image, and patients may be disappointed or may lodge a complaint. We always stress the fact that medicine is not an exact science and that a 3D simulation is a tool to show where the efforts are directed and never, ever, shows guaranteed results. No image or file of the simulation is sent to the patients, since this could be legally considered a guaranteed result.

17.4 Anesthetic Considerations

17.4.1 Surgical Technique

17.4.1.1 Patient Positioning

The patient is placed in decubitus supine. The upper limbs can be adduced (and secured to each side by sheets placed under the body) or abducted (90°). Both positions are possible, our preference being the adduced one, since it gives a more natural and real effect of the augmentation once the implant is in place.

17.4.1.2 Implant/Pocket Plane

A good and safe result in implant breast augmentation is a combination of two factors (other than a proper indication!).

- Election of the right implant based on patient's anatomy and desires
- Right plane to position the implant, which is still influenced by patient's anatomy but not driven by a standard algorithm and still based on surgeon's preference and experience

There are basically three possible implant positions: submuscular, subglandular/subfascial, and partial submuscular.

Submuscular

The conventional called "submuscular position" consists of a pocket dissected between the thoracic wall and the posterior surface of the pectoral major muscle. As a matter of fact, this pocket is not completely submuscular since about one-fourth of the implant will extend beyond the lower lateral margin of the pectoralis major due to its normal anatomy. Complete submuscular procedures are described and involve the additional dissection of the serratus and lateral oblique muscles. Advocates of the submuscular positioning believe that especially in skinny patients with scarce glandular tissue and thin subcutaneous coverage, the muscle gives an extra soft tissue protection, thereby a more natural

feeling and lower rippling and capsular contracture incidence. Dynamic breast and early waterfall deformity are the considerable disadvantages of this procedure. Our preference is to use the total submuscular plane only for breast reconstruction.

Subglandular

The subglandular/prepectoral position consists of a pocket dissected between the posterior surface of the breast's gland and the anterior surface of the pectoral's muscle. The subfascial variant involves the positioning of the implant between the pectoralis fascia and muscle fibers. The main benefit of the subglandular position is a favorable prosthesis glandular interface for low-grade ptosis correction (especially when using anatomic, full, and extra-projected implants). The subglandular placement allows the implant to be in close contact with the gland, tightening the lower pole of the latter, and, thus, correcting partly a low nipple-areola complex (NAC) without the need of a mastopexy. Moreover, a prepectoral implant will drop over time with the gland, as opposite to the submuscular plane, in which the gland will drop and the implant will stay high (waterfall deformity).

Other advantages of this plane are:

- Absence of dynamic breast
- Lower surgical site morbidity
- Faster recovery (less pain) and complete preservation of muscular function

The more natural shape advocated by some surgeons is for us a relative concept being strongly influenced by implant and patient characteristic. Equally, we do not believe that the subfascial plane guarantees a consistent improvement in implant coverage but may play a protective role for implant contamination.

Apparent higher capsular contraction rate, palpable implant's edges (or even visible upper pole of the implant in thin patients), and rippling are the main drawbacks of this technique [19].

We recommend the subglandular implant position only in case of really good soft-tissue coverage (pinch test at medial and upper pole >4 cm). This is mandatory in young women with desires of a future pregnancy, since the soft-tissue thickness would likely undergo a significant or at least unpredictable thinning.

Partial Submuscular/Biplanar

The partial submuscular implant placement was developed in order to combine advantages of both submuscular and subglandular placement: implant coverage in the upper and medial quadrants, favorable lower pole implant-soft tissue interface for mild ptosis and/or constricted lower pole correction, reduced dynamic breast, and capsular contraction.

Dual Plane

In this technique, the interface between muscle and breast is variably dissected until the upper border of the areola is proportional to the grade of ptosis tendency/lower pole constriction. The pectoral muscle is completely divided along the rib insertions along the inframammary fold, and a subpectoral pocket is prepared. The inferior release of the muscle and the additional breast-muscle interface dissection allow the muscle to shift cranially leaving the inferior portion of the implant directly under the glandular parenchyma (Fig. 17.3).

According to Dr. Tebbetts [20], any breast augmentation should meet the following criteria:

1. The implant lies partially behind the pectoralis major muscle and partially behind the breast parenchyma (in dual planes simultaneously).
2. A specific group of pectoralis major muscle origins is totally divided in a specific area to alter implant-soft tissue dynamics by anatomically repositioning pectoralis major portions relative to the implant (this criterion distinguishes dual-plane from partial retropectoral augmentation).
3. The parenchyma-muscle interface is specifically altered to change the soft-tissue relationship between the pectoralis major and parenchyma and to change the implant-parenchyma dynamics.

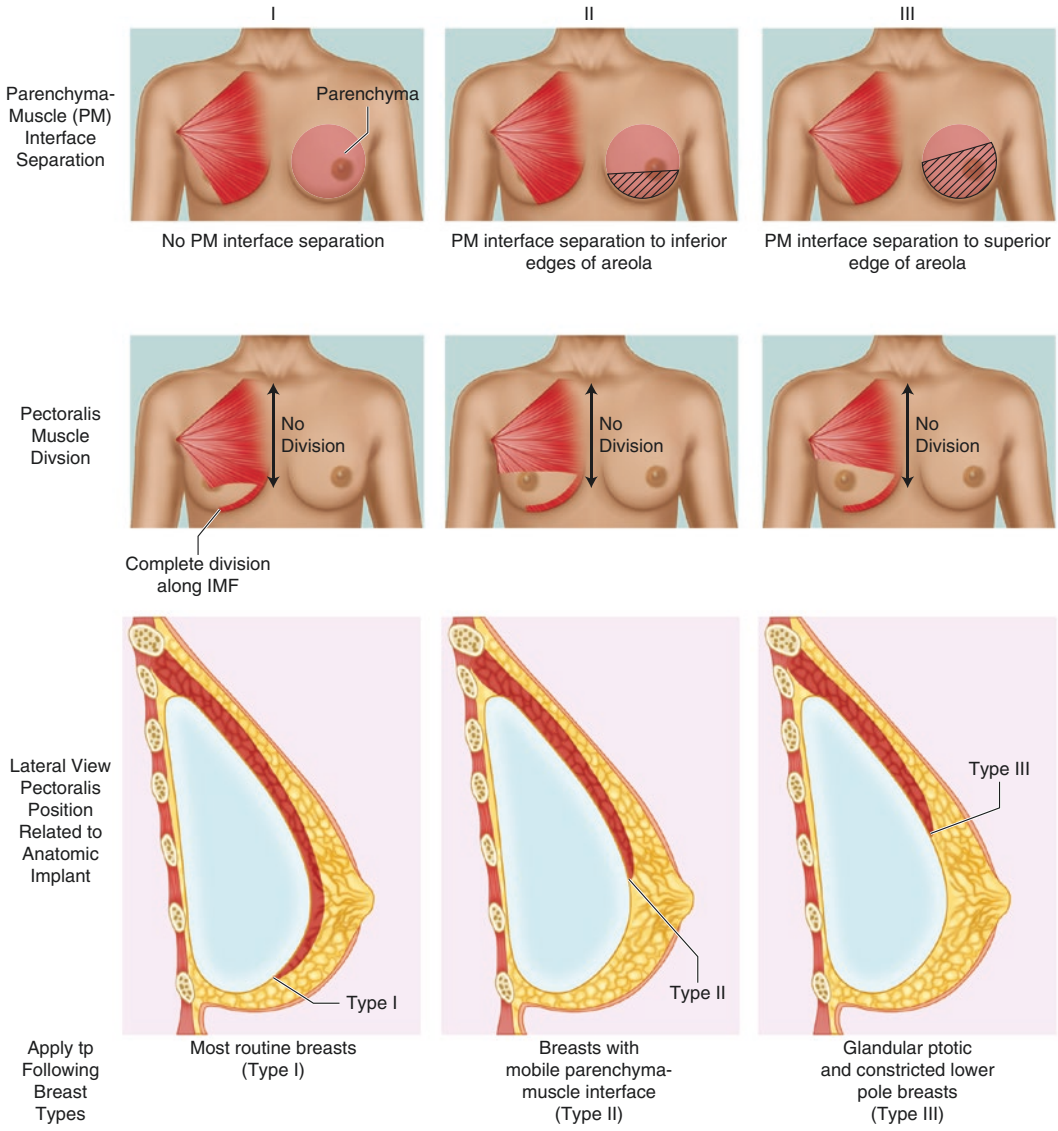

Fig. 17.3 Different types of dual-plane levels. Left column: dual plane I; center column: dual plane II; right column: dual plane III

This technique is extremely useful in post-maternity patients, since it combines the advantages of both subglandular (glandular lift) and submuscular (better coverage in the upper pole).

Muscle Splitting

Muscle splitting augmentation is a procedure in which a pocket is created simultaneously in the subglandular and submuscular planes, with the implants lying behind and in front of the pectoralis muscle at the same time, without pectoralis division along the costal margin. It is basically a variant of the dual-plane technique in which the pectoral muscle is directly incised at the nipple-areola complex leaving the inferior part of the muscle attached to the rib cage. Submuscular dissection is limited to the upper part of the split pectoralis major. The advocated advantages compared to the dual-plane technique are the lower risk of dynamic breast and faster recovery due to limited submuscular dissection (Table 17.1) [21, 22].

Table 17.1 Implant location: benefits and trade-offs. More + = longer time

	Implant coverage ↑ upper poles ↓ lower poles	Capsular contraction rate[a]	Animation and implant displacement	Operative time	Recovery time	Risk of waterfall deformity	Other considerations
Subglandular	↑ – ↓ –	May be higher, especially with smooth implants	–	+	+	–	Palpability/visibility of implant, especially in the upper pole Higher risk of visible rippling Direct effect on the gland (more NAC "lift")
Total submuscular	↑ ++ ↓ ++	May be lower, especially with smooth implants	+++	+	+++	+++	Good implant coverage Less control of the IMF Higher risk of waterfall deformity Less effect on nipple-areola "lift"
Partial submuscular (dual plane)	↑ ++ ↓ –	May be lower, especially with smooth implants	+/++	+	++	++	Good implant coverage (except in the lower pole) Good control of the IMF The implant "lifts" more than total submuscular due to direct effect on lower pole
Combined (fat graft + subglandular implant)	↑ +/++ ↓ –/+ Depending on grafted volumes and treated zones	Not enough data available but may be same as subglandular	–	+++	++	–	Subglandular placement advantages and trade-offs with better tissue coverage Variability in fat graft survival may lead to suboptimal results Possible donor-site complications

[a]Capsular contraction related to implant location is somehow controversial due to heterogeneity of past studies and lack of up-to-date evidence-based reports on last-generation breast implants

Key Points
Dual-plane technique is extremely useful in post-maternity patients, since it combines the advantages of both subglandular (glandular lift) and submuscular (better coverage in the upper pole).

17.4.2 Composite Fat and Implant Techniques

It is evident that soft-tissue coverage is a key factor in breast augmentation for long-lasting and satisfactory results. Moreover, the presence of adequate subcutaneous fat in a well-developed breast will allow a safe subglandular implant placement with its relative advantages. Unfortunately, the majority of the patients seeking breast augmentation do not meet these criteria since they are very thin.

The composite breast augmentation is a relatively new concept, which combines fat grafting and implants. Concerns about breast fat grafting have currently been rejected both by oncological and radiological long-term studies. Extra parenchymal graft is however recommended. The key principle is that the prosthesis is used for core volume augmentation while fat grafting is used for global reshaping and camouflaging of implant edges (mainly in the medial-upper poles). It is possible to use fat grafting for potentially any variant of implant position with benefits in terms of softness and better shaping of the breast and cleavage area.

However, we believe that the real advantages are extending the indication of the subglandular implant placement with less rippling and palpability risk and facilitating round implant use avoiding malposition. If it is true that fat grafting is not meant to significantly increase volume and projection, it still allows smaller implant selection, which is correlated with fewer long-term complications.

On the other hand, very skinny patients are not good candidates (no available donor sites) and the technique requires adequate surgeon's confidence with fat grafting. The unpredictability of the result is one of the principal issues; in fact, part of the adipose graft will be reabsorbed, and this amount would not generally exceed 50% if lipofilling is properly performed. In addition, donor-site morbidity has to be adequately discussed with the patient [23, 24].

Fat grafting is extremely useful in revision surgeries for rippling and palpability correction.

Patients with mild ptotic breast are less likely to benefit from this procedure since the primary need is to enhance the implant-gland interaction in a push-up fashion. Adding significative fat volume (additional soft-tissue weight) in the upper poles is in our opinion not recommendable. A partial subpectoral position will allow adequate implant-gland interface in the lower poles while covering the upper poles with muscle, which is not a gravity-susceptible structure.

17.4.3 Surgical Marking

17.4.3.1 Placement of the IMF and Footprint

The placement of the IMF is the most important decision in the surgical marking. Incorrect IMF placement may lead to bad aesthetic outcomes or even very visible deformities.

The patient is marked in the standing upward position with her shoulders in a relaxed position. First, we mark her actual IMF (if there is one) and the midline.

Since we have already chosen the implant, based on the width and shape of it, we know the exact measurements of it. We first check the width of the implant, and we add the measurement of the pinch test. The pinch test is performed checking the fullness of the upper pole as shown in the image. This measurement is usually 0.8–1.2 cm in thin patients.

If the implant's width is, for example, 12 cm, we will measure 12 cm + 1 = 13 cm. This is the width we mark on the patient.

Placement of IMF
First, we check the ARC of the implant. The ARC is the measurement of the length of the arc defined between the point of maximum projec-

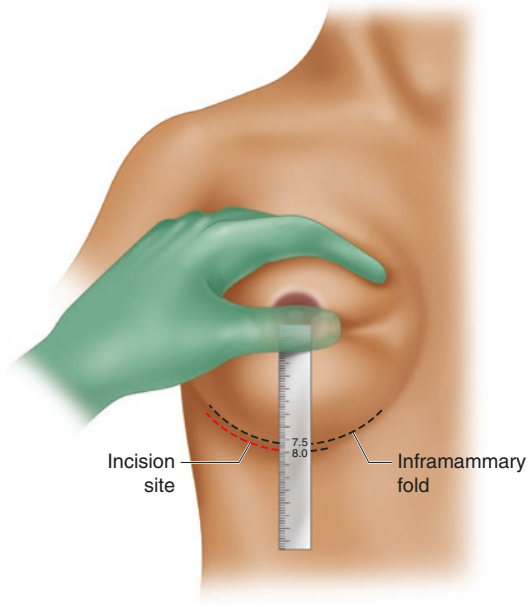

Fig. 17.4 Positioning of the incision site: one hand lifts the breast, stretching the lower pole to the point where the IMF starts moving upwards. This is the correct stretching tension to measure where the incision will be placed

tion of the implant and the lowest point of it (see Fig. 17.4). Considering that the implant will be covered by one layer of soft tissue, we add half of the pinch test. In this example, if the arc of the implant is 7 cm, we will measure 7.5 cm.

We then hold the nipple between the index and thumb fingers and start stretching it upwards until the previous IMF starts moving. In this point, we measure the ARC ½ pinch test, from the nipple down, and check whether we have to lower the IMF or not.

Never try to lower a very-well-defined IMF with a gland hanging over it, since a double-fold deformity will be created. If the measure for the length of the lower pole exceeds the patient's IMF fold and her fold cannot be lowered, a smaller or more anatomical implant should be used. In other cases, a mastopexy should be considered.

Once the new IMF has been marked, the height is calculated in the same fashion as the width, and the upper limit of the implant is also marked.

Attention
Never try to lower a very-well-defined IMF with a gland hanging over it, since a double-fold deformity will be created.

17.4.4 Incision Placement

Multiple surgical approaches have been described for breast augmentation. The experience with the inframammary, periareolar, and axillary groove is the most studied.

17.4.4.1 Inframammary Fold

The incision in the inframammary fold should be placed in the new fold leaving a scar hidden by it. Its location depends on the patient's tissues and the size of the prosthesis.

It allows the visualization of the entire pocket where the breast implant will be housed and allows to place all types of implants in a simple way. The size of the incision is 3–5.5 cm depending on the type of breast implant.

As a disadvantage, if the new groove is not calculated correctly, it may be visible and requires future refinements.

On the other hand, it is the approach that presents a lower incidence of capsular contracture [25, 26], greater ease of radiological follow-up of breast cancer since the glandular anatomy is not altered, and less alteration of the sensitivity of the nipple-areola complex in most of the studies, although the presence of hypoesthesia and paresthesia is frequent in the lower pole of the breast.

17.4.4.2 Hemiareolar/Periareolar Incision

The periareolar approach is also very popular: the incision is placed at the junction between the areola and the skin. If the NAC is not to be changed, an inferior hemiareolar incision is carried out. This approach allows direct access to the gland, so it is very useful when you have to make modifications of the mammary gland. It also allows the surgeon to reduce the size of the areola if necessary. This technique has shown higher rate of capsular contracture, changes the anatomy

of the gland, and lengthens the operative time. We tend to restrict the use of the periareolar incision for the following cases:

1. Tuberous breast.
2. Difficult IMF placement: when the placement of the future IMF is not a straightforward decision, the periareolar incision gives the possibility of deciding that intraoperatively.
3. NACs requiring reduction.
4. Periareolar mastopexy

Possible disadvantages include an alteration of the anatomy of the mammary gland because of the need to section it in order to reach the muscular plane, the potential bacterial contamination of the implant (contact with the glandular ducts), and a visible scar in case of poor healing. Its use is not advised in cases of areolas smaller than 4 cm in diameter, especially if the implant to be used is bigger than 300 cc.

Most studies on the subject show a greater incidence of capsular contracture [25, 26] than the inframammary fold, theoretically due to a greater contamination of the implant when it comes into contact with the glandular ducts that present bacterial colonization.

Also, a higher incidence of loss of sensation in the nipple-areola complex with respect to the use of the inframammary fold has been reported.

17.4.4.3 Transaxillary Incision

Transaxillary breast augmentation is frequently used in the Asian population [27], as they are prone to hypertrophic and prolonged hyperemic scarring of the inframammary scar. It can be performed directly or through the use of an endoscope, which allows for greater visibility and control of the structures. The main disadvantages of this approach are the difficulty for the treatment of glandular alterations and the need for a different approach in case of postoperative complications.

The transaxillary approach has shown greater satisfaction in comparison with other approaches. The incision is far from the breast and less visible in patients with no visible IMF prior to surgery.

On the contrary, it is the approach that traditionally presents the highest incidence of capsular contracture compared to the other two [25]. However, a recent 2019 publication shows that there are no differences between this approach and the inframammary fold [27].

Another drawback of this approach is the difficulty in correctly positioning the new IMF, which lies distant to the site of incision. Since the patient is positioned with her arms abducted in 90° to access the axilla, it is quite frequent to place the implants too high (superior malposition), especially if the surgeon is less experienced.

Regarding the alteration of the sensitivity, there are not many studies that collect the alterations in the sensitivity after the transaxillary increase. Some authors such as Tebbetts describe the appearance of paresthesia on the inner side of the arm during the first 3–4 months and attribute it to damage during dissection in their first patients, but with the modification of the surgical technique, future injuries were avoided.

17.4.5 Our Preferred Technique

The author's preferred technique for breast augmentation is through an inframammary fold (IMF) approach and the placement of the implant in a dual plane using a technique similar to that described by Tebbetts [28].

17.4.5.1 Preoperative Care

Prior to surgery, a preoperative study with blood count, coagulation tests for liver and renal function, as well as an EKG should be performed on all patients. A pre-anesthetic consultation is also performed.

17.4.5.2 Technique

General anesthesia was performed in all patients. The use of muscle relaxants is mandatory, with the submuscular dissection being more difficult otherwise.

The patient is placed supine with arms attached to the body. They place four sterile cloths having painted the entire thorax of the patient (including neck and umbilicus) with povidone-iodine.

In a systematic way, two adherent films are placed in the nipple-areola complex to avoid con-

tamination of the implants with colonizing bacteria of the nipple ducts [29, 30].

An incision is performed in the inframammary fold previously designed, and dissection of the subpectoral pocket with electrocautery is done being very careful with hemostasis. The direction of this dissection is oblique (upwards), not perpendicular to the skin, in order to minimize the risk of bottoming out (inferior malposition of the implant) (Fig. 17.5a and b).

The pectoralis major is sectioned in its lower and medial portion leaving a small muscle remnant of the caudal insert of approximately 1 cm. This muscle cuff also prevents caudal malposition of the implant.

Depending on the height of the nipple-areola complex (NAC), prepectoral dissection is carried out prior to the subpectoral pocket dissection (Fig. 17.3):

- NAC in place: no prepectoral plane dissection (dual plane I)
- NAC slightly low but clearly in a higher position in comparison with the IMF: prepectoral dissection of the lower pole without reaching the NAC (dual plane II) (Fig. 17.6)

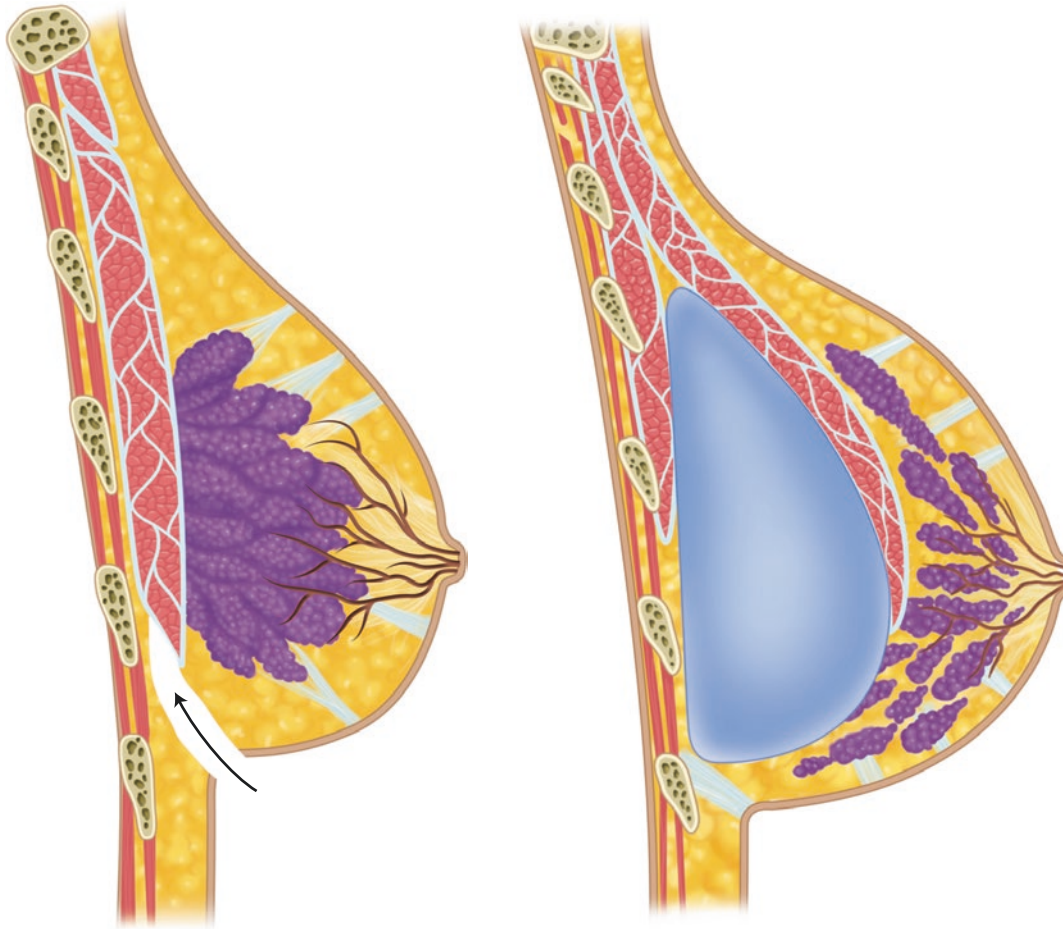

Fig. 17.5 Submammary approach: The dissection is carried out in an oblique fashion, never facing straight down to the muscular plane, as one risks damaging the IMF ligaments and causing a bottoming out of the implant

Fig. 17.6 Breast augmentation with anatomical implants (dual plane II) in a patient with non-ptotic but slightly low-positioned NACs. Note the "lift effect" the implant provides

Fig. 17.6 (continued)

– NAC positioned at the IMF: prepectoral dissection to the level of the upper pole of the nipple (dual plane III) (Fig. 17.7)

The patients presenting a NAC below the IMF will require an augmentation mastopexy.

The lateral dissection of the pocket is limited and somehow some millimeters smaller than previously marked. In our experience, the loose lateral tissue is prone to make the pocket larger in this area, creating lateral malposition in the implant in the following months, especially when the patient is in the supine position.

Once the pocket is completed, a very thorough revision of the hemostasis is carried out and subsequently the pocket is washed with a dilution of 10% povidone-iodine, gentamicin, and cefazolin [31, 32].

The entire team changes gloves, and the thorax is repainted with povidone-iodine. The main surgeon is the only one who touches the implant, and the assistant opens the incision with a leaflet previously washed with povidone-iodine so that the surgeon places the breast implant.

After implant placement, the subcutaneous cell tissue is closed with a continuous 2/0 Vicryl suture and a 4/0 Monocryl intradermal suture.

In cases where the IMF has been lowered (especially if the implant is larger than 250 cc), a continuous suture with Ethibond 2/0 is carried out, between the superficial fascia of the caudal aspect of the wound and the deep fascia of the chest wall.

The wounds are covered with Steri-Strip, and an orthopedic bra is placed on the patient in the operating room. No drains or bandages are used.

Key Points

The pectoralis major is sectioned in its lower and medial portion leaving a small muscle remnant of the caudal insert of approximately 1 cm. This muscle cuff also prevents caudal malposition of the implant.

Fig. 17.7 Breast augmentation with round implants. Upper pole is fuller, and the NAC slightly corrects downwards

Fig. 17.7 (continued)

Key Points
The patients presenting a NAC below the IMF will require an augmentation mastopexy.

17.5 Postoperative Care

All our patients undergoing augmentation mammoplasty were admitted to the hospital for a minimum period of 6 h of nursing and intravenous treatment. We prefer to keep them admitted overnight if possible. After the surgery, we instruct the patient to keep the wounds dry and to use orthopedic bra for 30 days, 24 h. Antibiotic prophylactic treatment with amoxicillin-clavulanic acid 500 mg/125 mg for 5 days [33, 34] and analgesic treatment with paracetamol 1 g and metamizole 575 mg every 8 h for a week are prescribed.

Only passive movements with the arms are recommended during the first week. Abduction of the shoulder over 90° is not advisable during the first days.

If anatomical implants were used, a thoracic band is prescribed from day 1 for at least 2 weeks to avoid rotation. Most rotation events occur in the first 2 weeks after surgery.

The first postoperative visit is scheduled 1 week after surgery by performing an ultrasound scan on all patients to assess the absence of seroma, hematoma, or rotation of the implants in the immediate postoperative period. In this consultation, the patient is instructed to take care of the scar with hydration and taping.

Subsequently, follow-up consultations are carried out in the following fashion: 1 month, 3 months, 6 months, and 1 year after surgery, performing ultrasound control in all of them.

17.6 Outcomes and Prognosis

The immediate recovery period of a breast augmentation is usually short and well tolerated. 3–5 days of breast/chest pain is usually expected. Bigger implants or very tight soft tissues of the breast will often generate more pain in the postoperative phase.

Swelling of the breast, lateral aspects of the chest wall, and abdomen is to be expected in the first week.

Patients are advised to halt any physical exercise for a month. After those first 30 days, the patient is reevaluated in the office and an ultrasound exam is carried out. If the findings are normal, she can start exercising her lower limbs, without using her upper limbs.

After 3 months, more demanding exercise can be carried out: running, swimming, etc.

The patient is instructed to wear a brassiere day and night for at least 6 months. Failure to do so will increase the probabilities of implant malposition. A decubitus position while sleeping should be advised for the first month, whenever possible.

17.7 Complications

Breast augmentation with implants is considered a high-satisfactory surgery. However, the patient should be carefully informed and educated about the possible short- and long-term drawbacks and complications related to the surgical procedure and the implant of a prosthetic device [35–40].

17.7.1 Surgical Complications

17.7.1.1 Hematoma

Preventive coagulation of intercostal and mammary perforators together with accurate hemostasis is key to reduce the incidence of hematomas, which should stay under 1%. In case of hematoma, surgical revision is mandatory. Hematomas likely occur in the first 48 h after surgery, but late hematomas even after years are possible. Those are mainly correlated to a traumatic event and may be clinically evident or not. Many studies have demonstrated the correlation between persistent hematomas and seromas with capsular contractures [41].

17.7.1.2 Infection and Exposure

Sterility and contamination precautions are extremely important to prevent both infections and capsular contracture. Acute infection is uncommon (<2%) but still represents a dreaded event for both patient and surgeon. In our practice, mild infections are initially treated conservatively with administration of large-spectrum antibiotics and echography to discharge suspect collections (which are eventually aspirated and analyzed). In cases of no response, more aggressive clinical presentation (fever >38, diffusely inflamed breast), or implant exposure, temporary implant removal with capsulectomy is performed. After infection resolution and tissue recovery, a new implant is inserted.

17.7.1.3 Seroma

Seroma formation is generally a benign event that occurs as a consequence of an inflammatory process resulting from infection, subclinical contamination of implant, mechanical trauma or idiopathic disease.

Early Seromas

It is defined as a seroma occurring within 12 months from the surgery. Despite many different proposed flowcharts, the approach we adopt is based on personal clinical experience. In case of seroma detection within the first 6 months from surgery and >20 cc ultrasound estimated volume, the fluid is aspirated and sent for microscopy and culture. Conservative treatment is started empirically with large-spectrum antibiotics, NSAID, and corticosteroid. In cases of no resolution after 1 week or relapse, we recommend capsulectomy and implant exchange. We consider surgery also in case of positive microbiology with apparent seroma resolution due to the high risk of secondary capsular contraction.

Late Seroma

The rising concern about late seromas lies in the fact that most anaplastic large-cell lymphoma (ALCL) associated with breast implant will have a late seroma as its first clinical sign. However, it is important to note that most late seromas are not related in any way to an ALCL. The treatment protocol in this case requires the additional cytologic study of the aspirate as described in the following section.

Reported late seroma rates range from 0 to 5% based on the shell characteristics, with the aggressively textured silicon surface being mostly involved.

17.7.1.4 Capsular Contraction

Capsular contraction is by far the most frequent complication, reaching rates of over 20% at 10 years in some case series. It consists of the excessive contraction of the fibrous capsule created physiologically from the body around the implant with the attempt of isolating it. This capsule is usually thin and soft; however, for several reasons, this capsule may contract on the implant becoming thick and hard. Capsular contraction occurs with different intensities defined as per the Baker classification: Grade I—normal soft capsule, Grade II—little hardening of the capsule detectable only by palpation, Grade III—visible contracture and palpable hardening of the capsule, and Grade IV—painful, visible contraction and palpable hardening of the capsule.

There is still a partial understanding of the etiology of capsular contraction. Smooth implant surface has been proved to promote un unfavorable fibroblast organization with high concentration of collagen fibers ending in high risk of contraction. On the other hand, textured surface is thought to disrupt the fibroblast linear organization resulting in irregular vector forces and ultimately in softer and thinner capsule. Recent studies demonstrated that textured implant favors biofilm formation due to its higher surface/area ratio. Consequently, we understood that the bacterial biofilm etiology of capsular contraction has indeed a weaker correlation if compared to texturization itself. Common drawbacks of highly textured silicone implant are, on the other hand, the increased incidence of double capsule and seroma formation. Subglandular implant position has also been reported to be at higher risk for capsular contraction if compared to partial submuscular and submuscular placement. The question and relative odds remain somehow controversial for heterogeneity of the studies and lack of evidence based on fifth-generation breast implants and up-to-date contamination-reducing surgery. Available studies suggest an overall risk of capsular contraction in textured silicone implant around 5%.

We recommend surgery in case of Grade III and IV contraction consisting of complete capsulectomy (whenever possible) and implant exchange. Polyurethane coating has been proven to prevent capsular contraction both in primary augmentation and breast reconstruction. For personal preference, we do not routinely use acellular dermal matrix (ADM), despite good reported outcomes for capsular contraction as secondary prevention. We consider the possible risk of infection and the associated cost as highly inconvenient for a patient who already suffered reoperation for aesthetic purposes.

17.7.1.5 Device Rupture

The fifth generation of breast implant has a significantly increased longevity compared to previous generations. Failure has been reported at <6-year study.

Nevertheless, the rupture of a silicone gel implant is a fairly common event, and the patient should be informed (especially if she is young) that there is a high degree of probability of this event over the years. The incidence of this problem depends greatly on the age of the implant, type of implant, and history of trauma. The diagnosis may be made by physical examination, ultrasonography, or MRI. MRI is considered the gold standard when assessing the integrity of an implant. The treatment of an implant rupture will require exchange of implant and many times capsulectomy, when the capsule is also affected or an extracapsular rupture is detected.

Key Points

MRI is considered the gold standard when assessing the integrity of an implant.

17.7.1.6 Breast Implant-Associated Anaplastic Large-Cell Lymphoma (BIA-ALCL)

BIA-ALCL is an uncommon lymphoproliferative disorder that has been diagnosed in association with breast implants. The first reported cases of anaplastic T-cell lymphoma date from 1997. In 2006, the World Health Organization recognized breast implant-associated ALCL (BIA-ALCL) as a distinct entity from other forms of ALCL.

Multifactorial etiology and lack of exhaustive registers of both implanted devices and diagnosed cases are a considerable obstacle to determine incidence and risk factors of the disease (the highest incidence currently reported is of 1/2.832 in the Australian population). All cases of BIA-ALCL have been correlated with textured implants. Interestingly, the risk is increased for implants with higher surface area and surface roughness. These findings corroborate the hypothesis that biofilm may promote a chronic subclinical inflammation, which in predisposed patients may produce the T-cell degeneration. Textured breast implants in fact harbor significantly more bacteria compared to smooth implants due to increased surface area and are associated with a greater lymphocytic infiltrate.

Mutations in gene p53 have also been identified as a risk factor. The disease usually arises 8–10 years after implant placement as a cold seroma. In early stages, infiltration of malignant cells is limited to the periprosthetic fluid and capsule. Its immunohistochemical markers are uniform expression of CD30 protein and ALK-negative phenotype.

National Ministry of Health protocols have been developed for diagnoses and multidisciplinary treatment of the BIA-ALCL. Implant removal and capsulectomy are part of the treatment and in most of the cases sufficient for the complete resolution of the disease.

17.7.1.7 Mondor Disease

Mondor disease is a mild, self-limited complication consisting of a palpable "string" usually crossing the IMF in an upward/downward fashion. It is caused by the superficial thrombophlebitis of the inferior veins of the breast. It may occur in up to 2–3% of augmentation patients. Its incidence appears to be higher when using inframammary incision. As previously noted, it is self-limited and resolves during the course of several weeks.

17.7.1.8 Galactorrhea

Galactorrhea is defined as a secretion of breast milk not associated with nursing or childbirth [42]. As a general rule, patients should not undergo aesthetic breast surgery prior to a 12-month period after giving birth or halting postpartum lactation. If milk production is still present, it can be medically interrupted with presurgical regimen of dopaminergic agonist (usually bromocriptine).

Although unusual (<1%), galactorrhea may present after breast augmentation; this is more frequent in patients who previously breastfed [43, 44]. Milk production is not considered harmful in itself, but may lead to galactocele (milk accumulation around the implant) and secondary infections. Inframammary approach and submuscular positioning of the implant are protective conditions against galactorrhea, galactocele, and infections [45–47].

In most cases, milk secretion is transient and not associated with higher prolactin levels. However, serum prolactin levels may be elevated as a consequence of direct mechanical stimulus, prolactin-secreting prolactinoma of the pituitary gland, or more complex hormonal dysfunctions such as hypothyroidism and adrenal insufficiency. Pharmacological anamnesis should specifically investigate neuroleptic or psychiatric drug assumption that may influence prolactin levels through dopamine release inhibition.

Prolactin serum level should be determined, along with thyroid hormones: thyrotropin-

stimulating hormones T3 and T4. If the levels are abnormal, an MRI should be considered in order to rule out pituitary adenoma. If serum prolactin levels are high, the patient should be referred to an endocrinologist/gynecologist. In the case of normal prolactin levels, medical treatment may not be necessary [3].

Ultrasound examination is helpful to determine whether liquid accumulation is present around the implant at an early stage; drainage is performed whenever possible to confirm milk presence and to rule out active infection.

Although galactorrhea is somewhat common after breast augmentation, complications derived from it are very rare in our practice (<1/1000).

17.7.2 Aesthetic Drawbacks

17.7.2.1 Implant Malposition

Malposition is a common problem associated with breast augmentation and one of the most common reasons for revisional surgery. This occurs in about 1.2–1.6% of cases.

Malposition may present with different aesthetic deformities, which may respond to two different situations:

- The first defined as a "**malrotation**" is basically an implant malposition consisting of an inward or outward rotation of the axis in the frontal plane resulting in an unpleasant aspect of the breast. Minimal rotations (<15°) are rarely noticed from the patient and thus do not require reoperation. Round implants are obviously not susceptible to rotation, only anatomical ones. The flip over of the implant is rare and may also be considered as 180° rotation on the vertical axis; it is usually associated with a punctual mechanical stress of the breast, and round implants may also flip over.
- The second defined as **implant displacement** is an erroneous location of the implant in relation to the desired footprint. The implant can be dislocated medially, laterally, superiorly, or inferiorly resulting in aesthetic unpleasant results. Bilateral medial displacement of the implants may cause symmastia, which is a dreadful complication for its renown difficult resolution. We consider "double-bubble" deformity (double profile of the inferior pole) as a consequence of an excessive lowering of the new IMF in patients with high/well-defined preexisting IMF and developed breast.

The superior displacement of the implant rarely causes a double-bubble deformity but more likely an overfilled upper pole and NAC "looking down." The "waterfall" deformity is a very frequent finding and consists of a sliding ptosis of parenchymal breast tissue over a fixed (usually submuscular) or encapsulated implant. It is rather a long-term consequence of breast ptosis or, if seen early, a poor indication (missed augmentation mastopexy, retromuscular implant position). It is important to keep in mind that if the implant is placed in a submuscular pocket and no dual-plane technique is used, both units (implant and breast parenchyma) will behave independently, not as one. Thus, the prosthesis lies correctly on the chest wall, but the gland "falls" over it; the treatment implies secondary mastopexy for most of the patients.

Malposition is normally the consequence of loose tissue and nonadherence of the implant. It usually occurs over time and is more frequent in smooth implants. It is also possible in the case of inadequate pocket size.

Attention

It is important to keep in mind that if the implant is placed in a submuscular pocket and no dual-plane technique is used, both units (implant and breast parenchyma) will behave independently, not as one.

17.7.2.2 Wrinkling and Rippling

Wrinkling/rippling is a frequent occurrence observed with the saline implants (over 35%) and retroglandular implant positioning especially when implant-to-parenchymal ratio is greater than 50%. It is due to the visibility of the corrugations of the implant surface.

It is not uncommon to notice rippling after pregnancy and/or years after breast augmentation

since hormones and aging may induce soft-tissue thinning.

Evaluation of implant positioning related to soft-tissue thickness is the most effective tool to avoid this kind of complications. Secondary lipofilling and change to a submuscular and partial-submuscular plane are both effective solutions.

17.7.2.3 Asymmetries

Some asymmetry is present in all breasts; it should be pointed out and discussed before surgery. Significant asymmetries of volume may be corrected with different implant sizes and different shapes, and nipple position may be hard to correct or require additional procedures such as lipofilling or periareolar incisions.

It is important to determine the limit of each procedure and be sure that they meet the patient expectations.

17.7.2.4 Sensory Changes

Sensory alteration may occur after breast augmentation; they are usually transient and are not usually reported as a significant problem for the patient. Periareolar approach is the more relevant factor associated with NAC sensibility problems. Sensory alterations have also been related with big implant volumes >350 cc for both soft-tissue stretching and wider dissection. Anatomical studies describe that relevant NAC innervation comes from intercostal branches, especially of the fourth intercostal nerve. Preservative dissection in the lateral aspect of the pocket is preferred in order to let the implant bluntly and progressively dissect the most lateral aspect of pectoralis major-minor interface where the intercostal nerves perforate the fascia. Even with these precautions, the incidence of nipple sensitivity permanent alterations is about 4%.

17.8 Conclusions

Post-maternity patients usually complain of lack of volume and fullness of the upper pole, along with loose skin, due to the anatomical changes after pregnancy. Breast augmentation is a safe, high-satisfaction procedure in these patients, provided that the nipple-areola complex is not positioned below the inframammary fold (augmentation mastopexy should be considered in these cases).

With a single operation, we are able to:

- Restore the volume lost after pregnancy/breastfeeding or even get a larger cup than before
- Tighten the loose skin of the breast
- Give a more “lifted” look of the breast with the right technique (dual plane, anatomical implants), due to the upward movement of the nipple-areola complex without the need of a mastopexy

Patients should be very well informed about the possible outcomes and drawbacks. Meeting the expectations is the single most important thing when trying to achieve a successful procedure and a happy patient.

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Fat Grafting Augmentation After Breastfeeding

18

Jose Maria Serra-Mestre, Edison Franco-Gonzalez, and José Maria Serra-Renom

Take-Home Points

- To correct the changes produced after pregnancy or breastfeeding, augmentation techniques are commonly used in combination with periareolar, vertical, or Wise pattern mastopexy.
- Composite breast augmentation can address the inherent limitations of prosthetic implants. It corrects localized asymmetries, reduces the distance between the breasts, and optimizes the results simply and safely using smaller and lighter implants.
- Fat grafting alone is a useful technique in medium-sized or large breasts. However, the increase in volume that can be achieved in a single session is limited.

18.1 Introduction

The hormonal changes during pregnancy, postpartum, and post-lactation period produce a series of variations in the breast [1–3]. To prepare for lactation, the breasts increase in volume, change shape, and alter their sensitivity. As for the nipple, both its color and its size are affected by the growth of the glandular parenchyma and its secretory units.

Once the breastfeeding period is over, major histological changes begin such as apoptosis of the epithelial cells and secretory units, which are replaced by adipose tissue and lose the dimensions gained previously in a process known as breast involution [4]. This often results in significant losses of breast volume, ptosis of the nipple-areola complex, and loss of skin turgor and elasticity.

The correction of these changes is a challenge for the plastic surgeon. Several options are available to recover the structure and aesthetics of the breasts, using breast augmentation or mastopexy techniques with implants or fat grafting [5–7].

Fat grafting has now become a widely used technique not only as a complement to other breast surgeries for improving breast contour and symmetry, but also as an alternative to implants in cases of augmentation, mastopexy, or breast reconstruction [8, 9].

In this chapter, we describe the indications and the use of fat grafting in augmentation and mastopexy patients after postpartum and breastfeeding changes.

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_18

18.2 Patient Selection

When the hypotrophy is not accompanied by ptosis or if the patient presents a pseudoptosis, the correction can be achieved by performing a breast augmentation with implants [5], fat grafting, or a composite technique [6]. In cases of more severe sagging, the augmentation must be combined with mastopexy techniques [7].

18.3 Preoperative Evaluation

18.3.1 Physical Examination

Our technique of choice for breast augmentation involves a composite approach with fat grafting and the insertion of a silicone implant at subfascial or submuscular level via an endoscopy-guided axillary approach.

In these cases, when the patient has a pinching test result less than 2 cm, the submuscular approach is used. In patients with a pinching test result more than 2 cm, in whom large increases are unnecessary, and in professional athletes who wish to retain the pectoralis major muscle in its entirety, subfascial dissection is preferred.

If the aim is to raise the nipple-areola complex up to 3 cm, a periareolar technique is used [10]. If the distance from the sternal notch to the nipple is less than 28 cm, we use our vertical scar technique [11]; but if the distance is above 28 cm, we prefer a "T" scar technique using the Wise pattern in order to obtain a more rounded shape [12].

18.3.2 Markings

Prior to surgery, we mark the reference lines with the patient in standing position. The midline is marked from the sternal notch to the navel, and the width of the breast is obtained marking the anterior axillary line and a line 1.5 cm from the midline. Also the current inframammary fold and the orientative point where we will place the new one are marked at the level of the sixth rib plus half the thickness of the pinching test.

Fat grafting is always performed once the surgery is finished, so injection points and areas to be fat grafted are chosen and marked after surgery with the patient seated. In our opinion, this allows the surgeon to have a more precise control in correcting asymmetries and giving volume to the breast.

18.4 Anesthetic Considerations

When surgery is performed under general anesthesia or sedation, we create the tumescence of the donor area using a saline and adrenaline solution at a ratio of 500 cc saline solution, 1 mg of adrenaline, and 20 cc of lidocaine 2%.

When surgery is performed under local anesthesia in a second operation to optimize the outcome, 2 h prior to surgery, the donor area is covered with a topical anesthetic cream (EMLA TM). At the time of surgery, we infiltrate a small quantity of undiluted anesthetic at the two entry points. We then create the tumescence with a 30 cc solution of 2% lidocaine and 0.5 mg adrenaline.

18.5 Surgical Technique

18.5.1 Patient Positioning

Correct surgical positioning is important. In all cases, the patient's arms are extended and held in place at an angle of 90° at the height of the armpit. The gluteal region coincides with the fold of the table, to allow the patient to remain seated during surgery.

18.5.2 Procedures Step-by-Step

18.5.2.1 Breast Augmentation

In small breasts in which the sagging is limited, or in medium-sized breasts in which the upper pole is seen to have lost volume but the sagging is limited, in our opinion, the best solution is to increase breast volume with implants or a combi-

Table 18.1 Advantages and disadvantages of breast augmentation techniques

Technique	Advantages	Disadvantages
Implants	– Reliable and predictable results and breast size – Can be easily removed	– Implant-related complications: capsular contracture, rupture, implant exchange – Recovery period – Scars
Fat grafting	– No implant used – Small incisions – Breast look and feel natural – Quick recovery – Improves body contours	– Donor-site availability – Limited-volume augmentation in a single stage – Fat resorption
Composite techniques	– Smaller implants – Customized shape adjustments can be performed – Improve body contours	– Prolonged operating time – Implant-related complications

nation of implants and fat grafting. This composite technique allows the use of a smaller implant, which helps to improve the results, but fat grafting alone achieves only a limited volume increase in a single session and may not meet patients' expectations (Table 18.1).

Although this procedure can be performed through the areola or the inframammary fold, our technique of choice is transaxillary endoscopic breast augmentation [5], in which a 3 cm long incision is made in the uppermost horizontal fold of the axilla. After locating the edge of the pectoral muscle, the plane between the pectoralis major and minor muscles is opened using Metzenbaum scissors.

A blunt dissection is then made towards the fourth rib until the attachment of the pectoralis major muscle can be felt. The muscle is detached at the fourth, fifth, and sixth ribs with the Serra-Renom endoscopic retractor (Snowden Pencer, Tucker, GA, USA) and a 10 mm 0° telescope, and a coagulation and suction endoscalpel. The muscle fibers at the sixth rib are sectioned from the axillary line to within 1.5 cm of the edge of the sternum.

In almost all patients undergoing breast augmentations, the inframammary fold must be moved downward. This is done under endoscopic view using blunt dissection. Hemostasis is then performed if necessary. The definitive implant is then inserted.

In cases of composite breast augmentation [6], the fat is injected homogeneously in the soft tissue envelope overlying the implant, especially in the upper pole and the medial quadrants. In these cases, we use varying amounts of fat, between 60 and 150 cc, depending on the patient.

If the increase is mainly carried out with implants, fat grafting is also a useful complement to remodel the cleavage or to correct asymmetries detected in one or both breasts [13, 14].

18.5.2.2 Augmentation Mastopexy Techniques

In cases with more severe breast hypertrophy or ptosis, lifting techniques combined with reduction or augmentation are necessary [7]. In these cases, and depending on the amount of breast present after lifting, the increase is made with fat alone or with the insertion of a small implant in order to improve the projection of the breast and achieve correct filling of the superior quadrants.

If the aim is to raise the nipple-areola complex up to 3 cm, a periareolar technique is used [10]. The Hammond technique can also raise the complex beyond this height, though some retouching of the scar will probably be required in a later surgical procedure. This technique may not be feasible if the skin is flaccid or in poor condition, especially in the lower pole (Fig. 18.1a, b).

In cases of more severe ptosis, if the distance from the sternal notch to the nipple is less than 28 cm, we use our vertical scar technique [11]; if the distance is above 28 cm, we prefer a "T" scar technique using the Wise pattern in order to obtain a more rounded shape [12] (Fig. 18.2a–e).

During the fat grafting, in order to be able to assess the results as we inject the fat, we place the patient in the seated position on the operating table. Multiple injection points are made in a clockwise direction in order to increase the whole

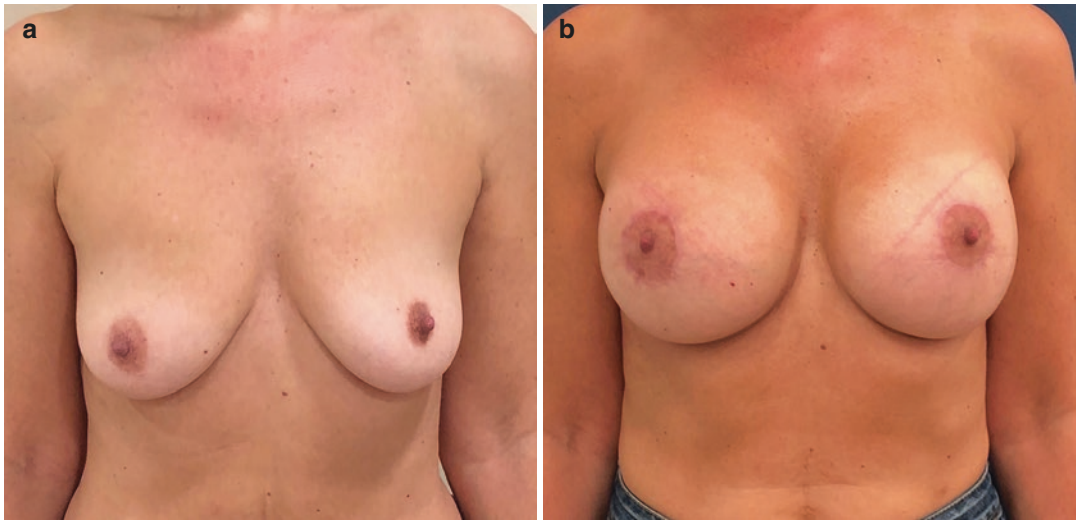

Fig. 18.1 This 49-year-old woman had asymmetrical breasts and ptosis. She is seen before a periareolar augmentation mastopexy (**a**) and 12 months after surgery (**b**). In this case, we performed a composite technique with 220 cc moderate round-shape and smooth silicone implants (POLYTECH, Health & Aesthetics, Dieburg, Germany) and 170 cc of fat in each breast

breast homogeneously, introducing the fat with a blunt cannula in several different areas creating a mesh or crisscross pattern and making tunnels at all levels to prevent the accumulation of fat.

After this first phase of volume increase, we perform a selective injection of the areas to be remodeled, such as the cleavage, or in order to correct asymmetries that may appear after the mastopexy is performed.

We finish with a 6-0 suture in each of these holes and immobilize the area with hypoallergenic adhesive plasters to prevent the movement of the grafts.

18.5.2.3 Fat Grafting

Fat Harvesting

The donor site most frequently used in breast surgery is the periumbilical area. However, in thin patients with abdominal sagging, the inner thigh or knee is usually chosen. In the literature, there is no consensus regarding the best donor site. Some authors favor the lower abdomen, where it is believed that there is a higher concentration of stem cells, but others see no particular advantages between the possible donor sites [15].

After the tumescence, the fat is obtained through low-pressure liposuction (0.5 atm) using 2.4 mm microport harvester cannulas with barbed and beveled 1 mm ports (Tulip Medical Products, San Diego, California, USA) [16, 17].

Fat Processing

Once obtained, the fat needs to be isolated from the blood, debris, components of the tumescent solution, and oil resulting from the breakdown of fatty acids during aspiration. This is done using centrifugation, decantation, or washing [16].

There is no consensus regarding the best technique, as there is still a high degree of discordance due to the inconsistent results obtained from animal and human studies.

Although there is no general agreement, in our clinical practice, we use centrifugation, filtration, and decanting for structural fat grafting and have obtained similar results.

In the case of centrifugation, we use an oblique centrifuge for 2 min at 2000 rpm. Once centrifuged, three levels can be observed. The lower level contains blood and components of the tumescence solution; the middle layer consists of small lipomas; and the top layer contains oil

Fig. 18.2 A 42-year-old patient came to our clinic with a grade IV capsular contracture and breast ptosis. An augmentation mastopexy with fat grafting was performed after complete capsulectomy and implant removal. (**a**) Preoperative frontal view; (**b**) preoperative oblique view of the patient; (**c**) fat grafting injection planning including cleavage remodeling to reduce the intermammary distance; (**d**) postoperative frontal view; (**e**) postoperative oblique view of the result

resulting from the broken down fatty acids. We discard the bottom layer of anesthetic and blood and then remove the upper part containing the fat droplets with a small gauze.

Fat Injection

The key issue in fat grafting is to achieve the correct three-dimensional distribution of fat in different planes from depth to surface, creating a crisscross pattern and avoiding the accumulation of large quantities of fat. The diameter of the cannula used for the injection should be the same as the one used to extract the fat, in order to minimize the mechanical damage to the adipocytes.

Microfat is injected via 0.9 mm cannulas into the subcutaneous plane, in contrast to structural fat grafting.

> ***"Fat injection should be performed in multiple passes, in multiple tissue planes, and in multiple directions to avoid large accumulations."***

18.5.3 Surgical Modifications

In cases of augmentation or mastopexy, the intermammary distance is sometimes excessive; alternatively, there may be asymmetries in the area of medial cleavage. However, even using the most updated surgical techniques, the plastic surgeon has only a relative control over their correction, because the space between the breasts is determined by anatomical factors such as the attachment points of the breast tissue to the periosteal tissue covering the sternum, and also to some extent by the medial attachments of the pectoralis major muscle and by the thickness of this muscle if a retropectoral dissection plane is used.

Recently, we described a procedure in which we use fat grafting as a complement to the different techniques of breast surgery, not only in cases of breast augmentation or mastopexy but in breast reconstruction as well. Using limited amounts of fat, this technique redefines the cleavage correcting asymmetries and reducing the distance between the breasts [13].

Fat grafting is always performed once the surgery is finished, and whenever possible, the cannula is inserted through the previously made incisions. The microfat graft is injected into the subcutaneous layer in the shape of a crescent, upwards from the inframammary fold to the upper quadrants. It is important to extend this crescent to the upper quadrants, creating an inverted "L" shape to recreate a satisfactory medial cleavage and to avoid possible irregularities in the upper internal quadrant.

> ***"Fat grafting is extremely useful in the medial quadrants, and it is also effective for correcting volume asymmetries in other areas of the breast."***

18.5.4 Technical Tips to Improve Outcomes and Avoid Complications

The key issue in fat grafting is to achieve a correct three-dimensional distribution of fat in different planes, avoiding the accumulation of large quantities. Injection should be performed in multiple passes, in multiple tissue planes, and in multiple directions.

It is very important not to create irregularities in the donor sites. After liposuction, with a flat 3 mm cannula without aspiration, we regularize the whole area where the fat was harvested.

Also the use of a blunt-tip cannula is mandatory in order to avoid any tissue damage.

18.6 Postoperative Care

Each patient requires a specific treatment and follow-up depending on the techniques that have been performed. The patient must sleep in the supine position for 2 or 3 weeks, and prompt inspection of wounds is important. Stiches are removed 2 weeks after surgery, and a postsurgical bra is mandatory for the first 2 months of follow-up to protect the breast and reduce discomfort.

At the donor site, in the postoperative period, we recommend the application of chelating creams to reduce bruising, and also lymph drainage and massage to help restore the whole area.

18.7 Outcomes and Prognosis

Fat grafting is not just a complementary technique in breast surgery; in some cases, volume increase can be achieved with fat grafting alone. In all events, the patient must be informed of the procedure's advantages and limitations. Among its advantages, it avoids the complications associated with implants such as rupture or contraction, and also the grafting of autologous fat upholds one of Converse's principles of conservative surgery: "replace like with like." Its main drawback is that the volume increase that can be achieved with a single fat grafting session is limited; like any graft, fat must be injected in a dispersed and homogeneous way and not delivered in bolus form. As long as the patient understands these limitations, satisfactory volume increases can be obtained in two sessions, thus avoiding the use of implants.

In cases of mastopexy in medium-sized or large breasts, fat grafting can avoid the use of implants since it preserves a sufficient amount of breast volume for the augmentation.

In small breasts, an intermediate option is composite breast augmentation. In this technique, the breast volume is increased with fat, and a small implant is also inserted. Its main advantage is that it avoids some of the complications associated with implants and obtains a breast with a more natural appearance and feel.

In certain situations, then, fat grafting is a safe alternative to implants in breast surgery, and it can also serve as a very useful complement to implants. Fat grafting achieves optimal results in terms of symmetry and breast shape.

18.8 Complications

Fat injection in breast surgery is a safe technique with low complication rates. It is important to consider that fat has become an autologous filler, completely biocompatible, nonmigratory, and non-teratogenic.

Despite the low complication rate, the surgeon's experience with the surgical technique is important to the success of the procedure, avoiding irregularities or problems of hypo- and hypercorrection of the defects. In any case, hypocorrection is preferred, as it can be resolved with subsequent injections.

As in any surgical procedure, inflammation or bruises may appear during the days after the intervention. In these cases, the use of anti-inflammatory medication and cold therapy can be helpful. Infection can also be controlled maintaining correct asepsis of the area, close postsurgical monitoring, and antibiotic prophylaxis immediately prior to surgery.

Another possible complication is damage to neighboring structures such as vessels or nerves, which is not frequent in breast procedures. To avoid this, we use blunt-tipped cannulas and we always perform a slight aspiration before injecting the fat to avoid the potential risk of fat embolization.

In the medium to long term, calcifications may appear, but they are easy to recognize. There may also be oil droplets or fat cyst, and if the fat is not injected correctly, areas of steatonecrosis or hardening may appear. Injections may be done in multiple passes, in multiple tissue planes, and in multiple directions, injecting small volumes in each pass.

18.9 Conclusions

Fat grafting has established itself as a safe technique, which is widely used in breast surgery and in other parts of the body for increasing volume and improving tissue quality.

In cosmetic breast surgery, autologous fat injection has become a routine practice for correcting the inherent limitations of implants and allows to achieve an ideal breast shape and contour while also increasing the size. It is especially useful in cases of complicated asymmetries, chest wall deformities, or tuberous breasts.

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Nipple-Areola Complex Restoration After Breastfeeding

19

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and Jesús Olivas-Menayo

Take-Home Points

- Nipple inversion is a frequent condition present since birth or developed later. The main benign cause for acquired nipple retraction is inflammation associated to mastitis, typical during breastfeeding.
- Malignant pathology must always be ruled out.
- Patients' expectations and degree of retraction must be assessed before planning any surgical procedure.
- Plenty of techniques have been described; the key for the right choice is good preoperative evaluation.
- For mild degrees of retraction, suture-based techniques may be successful, but the risk of recurrence is higher.
- Most effective techniques imply transection of galactophorous ducts, impairing later breastfeeding. This must be warned to the patients.
- Incisions should always be placed at the areola border or the nipple base to make them as inconspicuous as possible.
- The use of traction devices alone or in combination with surgery has proven being effective reducing recurrence rate.
- The minimal time for traction device placement should be 15 days to 1 month, but this can be longer if it is required.
- Postoperative care of the wounds and traction device should be taught to the patient.

19.1 Introduction (It Can Include the Anatomy, Proportions, etc.)

The ideal nipple-areola complex (NAC) is centered in the point of maximal convexity of the mound being a visual reference for an attractive and aesthetically pleasing breast. The ideal dimensions of the areola are about 4 cm diameter with the nipples slightly upward oriented about 10–15°. The nipple should be 1 cm wide and projected over the areola about 1.2 cm [1].

Ideal breasts should form an equilateral triangle with the sternal notch and both NACs as the vertex, with sides between 19 and 21 cm. Another important measure is the distance between the nipple and the inframammary fold. In a nonptotic breast, the inferior border of the nipple should be above it.

The blood supply of the NAC depends on both the parenchymal and subdermal plexus arising from the external and internal mammary, inter-

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_19

costal, and thoracoacromial arteries [2]. Sensation of both nipple and areola depends on anteromedial and anterolateral cutaneous branches of the fourth intercostal nerve [3].

The estimated prevalence of inverted nipple is between 3 and 5% of the female population, and in up to 4 out of 5 cases, both nipples are affected. The main etiology is congenital or acquired after inflammatory processes such as mastitis [4]. The repercussion is not only aesthetic, considering that the nipple-areola complex is the key point in terms of symmetry and aesthetics, but also affects breastfeeding as well as the sexual and intimate sphere of the patient. Since it was first described in 1840, numerous techniques and methods have been proposed for its correction [5].

The female breast begins its development in the fifth week of fetal growth with the appearance of 15–20 breast buds of ectoderm along the mammary crests. These extend from the armpit to the inguinal region and remit in the seventh week with the exception of a pair at the fourth or fifth intercostal space level. The persistence of some of these primitive mammary buttons translates into disorders such as polymastia or polythelia. In the fifth month, between 15 and 20 invaginations arise from that ectodermal tissue; these penetrate the mesoderm and will give rise to the galactophorous ducts. At this time, the areolas are formed, and in the eighth month, the proliferation of mesenchymal tissue under the pit makes the nipple protrude [6]. An interruption during the embryonic development of this mesenchymal proliferation or the subsequent maturation of the galactophorous ducts would cause the nipple to invert in a similar way that secondary fibrosis after inflammatory or tumoral processes retracts these structures.

19.2 Patient Selection

Any patient complaining about nipple retraction or dissatisfaction with their aspect should be considered for improvement. During the first interview, plans for future children and the wish to breastfeed should be discussed. Both the patient's desires and the degree of retraction as a guide for the surgeon to choose the most appropriate surgical technique must be taken into consideration in each case. If the patient is not concerned about breastfeeding in the future, techniques that do not preserve the ducts are indicated. On the other hand, when breastfeeding is planned, conservative surgery is indicated always warning the patient that the recurrence rate is higher.

19.3 Preoperative Evaluation

During preoperative evaluation, personal and family history of breast disease or cancer should be obtained. In those patients where nipple inversion had recently developed, screening mammography must be done and any malignant pathology ruled out. Pregnancy history, previous breastfeeding, and specially any wish for breastfeeding if future children are planned must be asked as previously mentioned.

Areolar diameter is measured, and the grade of inversion is established according to Han and Hong (1999) [7] classification, which establishes 3° depending on the severity of the retraction:

Grade I The nipple can be everted manually easily and maintains projection by itself. In this case, the presence of fibrous tissue is minimal and there are enough soft tissues beneath the nipple-areola complex.

Grade II The nipple can be everted with greater difficulty than grade I and tends to return to the inverted position. There is a higher degree of fibrosis, and the galactophorous ducts may be shortened.

Grade III Severe nipple inversion occurs that can hardly be corrected manually. It does not maintain the everted position because of the fibrosis, and the galactophorous ducts are severely shortened. In addition to this, there is a deficit of tissue beneath the nipple-areola complex.

The usual breast measures must also be assessed to detect any asymmetry or ptosis:

- Sternal notch-to-nipple distance
- Nipple-to-IMF distance
- Base width
- Intermammary distance
- Breast triangle
- Breast height

The chosen method for correction will always be based on the degree of inversion and patients' maternity wishes.

– For **grade I** patients, a conservative technique preferably based on the use of sutures and traction devices will be preferred. Correction is possible, and these techniques avoid placement of any visible scar.
– For **grade II**, the decision will depend on patient desires. If any future pregnancy and breastfeeding are planned, conservative techniques should always be used warning the patient about the risk of recurrence. If there is no wish for lactation, a duct-non-preserving technique is preferred.
– For **grade III**, the preferred option should be any procedure that cuts all ducts and retraction to minimize the risk of recurrence and preferably based on flaps instead of sutures. Only if the patient demands preservation of breastfeeding, conservative surgery may be offered always informing the patient of a risk of recurrence over 50–60%.

19.4 Anesthetic Considerations (Local Anesthesia)

The procedure is performed under local anesthesia. Therefore, any allergies or previous reactions to anesthetics should be ruled out during preoperative evaluation. In our practice, we use a mix of 50:50 lidocaine:bupivacaine. Lidocaine has a quick-onset anesthetic effect at the time of injection, and bupivacaine is added for its late effect to make the immediate postoperative time painless [8]. No adrenaline is used because there is some risk of nipple necrosis associated to this procedure. Although some authors advocate the use of sodium bicarbonate to neutralize the acidity of both lidocaine and bupivacaine, we prefer the use of topic lidocaine/prilocaine applied 1 h before the procedure. In cases of preoperative anxiety or if the patient demands it, a mild sedation with iv midazolam is used, achieving greater comfort and a better experience.

19.5 Surgical Technique

19.5.1 Patient Positioning

The procedure is carried out in supine position with the arms of the patients slightly abducted.

19.5.2 Procedure Step-by-Step

Once the nipple-areola complex is anesthetized, the nipple is everted by means of a 3-0 silk stitch and the incision is made in the nipple-areola transition between the 4 and 8 o'clock (Fig. 19.1).

The incision deepens perpendicularly about 1 cm. In that plane, dissection is extended in the cranial direction under the nipple, transecting the fibrous tracts that cause the retraction (Fig. 19.2).

From the areolar edge of the incision, a flap of subcutaneous tissue is tailored. This will be interposed under the nipple. This flap is a key element because it adds projection to the nipple by substituting the absent tissue beneath and preventing the formation of new fibrosis that would otherwise make the inversion recur. The interposition flap is anchored by absorbable sutures to the opposite nipple wall and then the skin is closed (Figs. 19.3 and 19.4).

To avoid umbilicated scars that may alter the final result, 6-0 horizontal mattress stitches are used. These will be maintained for the first 15 days. Finally, a traction device is applied with the splinting of the nipple to maintain the projection achieved during the procedure and prevent inflammation of the surrounding tissues. The base of a 10 cc syringe is used for this purpose. Four notches are carved to anchor two perpendicularly crossed sutures under and over the nipples (Fig. 19.5).

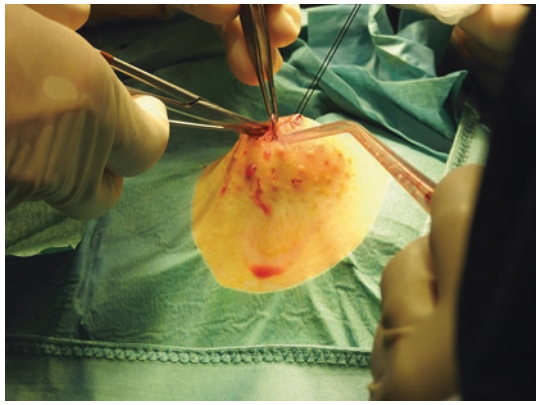
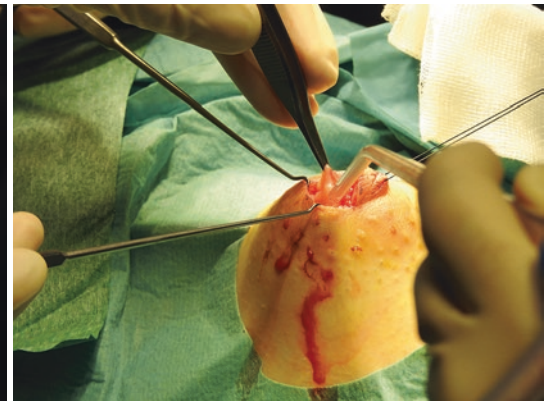

Fig. 19.1 After the NAC is completely anesthetized, it is everted with a 3-0 silk stitch. Once everted, the transition between the nipple and the areola is incised between 4 and 8 o'clock

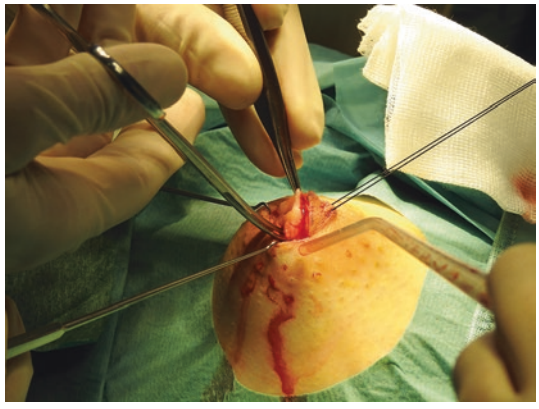


Fig. 19.2 Dissection is carried out in a cranial direction beneath the nipple, and under direct visualization, all fibrous tracts are transected

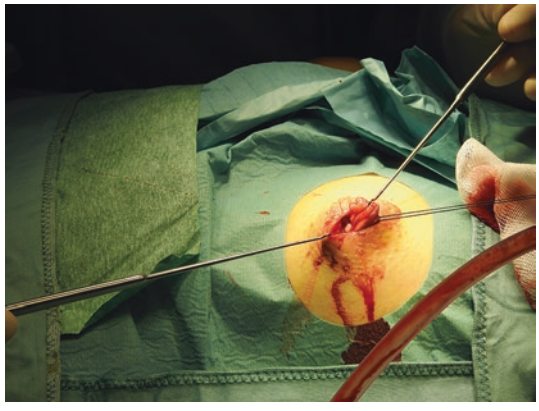
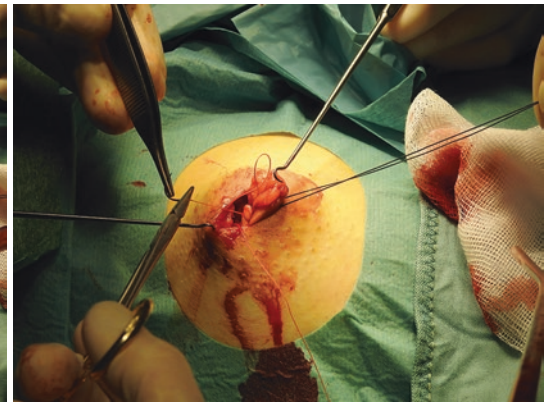

Fig. 19.3 Once all fibrosis is transected, maintained eversion of the nipple should be observed. Once the flap is tailored as shown in the drawing, it is sutured to the upper base of the nipple. This way, it is placed between the two cut ends of fibrous tissue

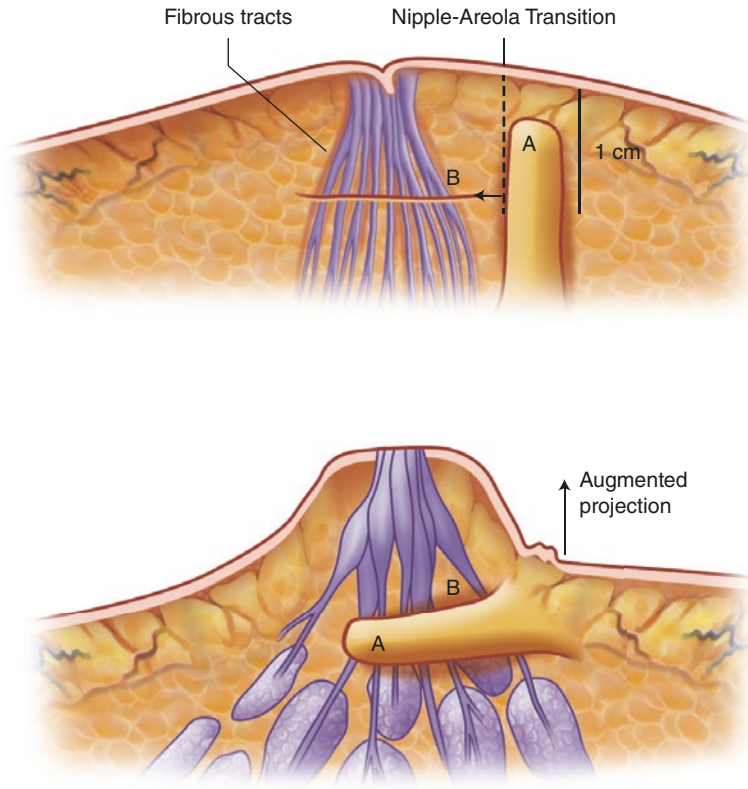

Fig. 19.4 Once the nipple is incised, dissection is deepened 1 cm. Then transection of the ducts is performed. The flap is tailored from the inferior wall of the incision and interposed between the two ends of the fibrous tissue. An anchor stitch is used; this way, fibrosis is replaced with the healthy soft tissue, the nipple base slightly stretched, and projection obtained

Fig. 19.5 Closure of the skin is done with 6-0 monofilament horizontal mattress stitches. Traction device is created with the base of a 10 cc syringe and secured with two perpendicular sutures under the nipple

19.5.3 Surgical Modifications

We have presented our own surgical repair for inverted nipple, indicated for most of the cases, for patients that are not concerned about breastfeeding and that present a grade II or III of retraction. However, the literature contains plenty of modifications with different degrees of complexity. Some of these are discussed and shown below and may have their own indication depending on

the patient. This is divided between techniques that preserve the ducts and those that do not. Here, only a small sample is included, those with a significant number of cases reported and proved effectiveness.

19.5.3.1 Duct-Preserving Techniques

Suture Based

Gould DJ (2015): Through an inferior nipple base incision, blunt dissection of the fibrous ducts is carried out preserving them. Two external 4-0 horizontal mattress sutures are placed perpendicularly plus an external 4-0 purse-string suture. Traction device is maintained for 2 (grades I–II) or 5 days (grade III). A recurrence of 7% out of 191 nipples is reported [9] (Figs. 19.6 and 19.7).

Jeong JH (2017): Three slit incisions and a larger one (5 mm) are made in the four cardinal points of the nipple base. After blunt dissection of fibrous ducts, an absorbable monofilament suture is passed through the periphery and center of the nipple creating a shape of a cross inside a circle. The traction device is used for 14 days. The reported recurrence rate is 4.30% out of 75 nipples (grades II and III) [10] (Fig. 19.8).

Yukun L (2016): Two horizontal and vertical sutures with 1-0 or 2-0 Mersilk nonabsorbable sutures are placed crossing the undersurface of the nipple. The same four ends of the sutures are used to place the retractor made from a 10 cc syringe base. Traction device is maintained from 3 to 6 months depending on patients' discomfort. Recurrence rate decreases depending on the severity of retraction. Out of 257 nipples, 0% rate is for I, 3.2% for II, and 63.3% for III [11] (Fig. 19.9).

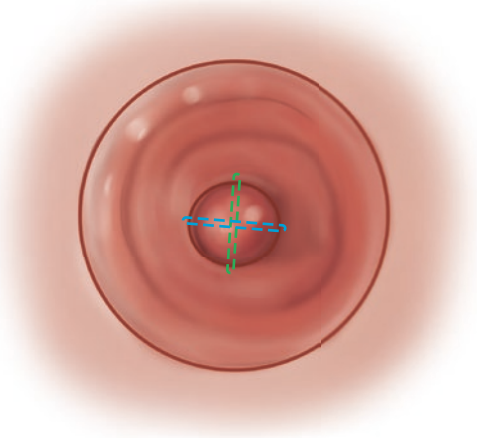

Fig. 19.6 Crossed horizontal mattress sutures

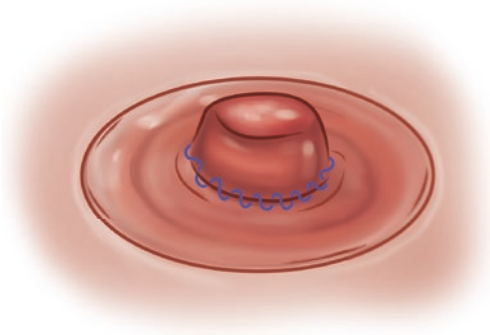

Fig. 19.7 Purse-string suture around the nipple base

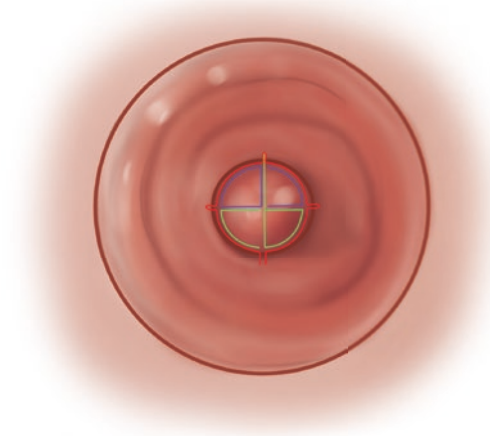

Fig. 19.8 Peripheral and crossing sutures with the shape of a cross inside a circle

Flap Based

Jeong HS (2015): Two triangular subcutaneous flaps are raised from the areola and passed under the nipple after blunt dissection to preserve the ducts. The design of the flaps places the scar crossing the nipple base and the areola. No recurrence has been reported out of 47 nipples (II and

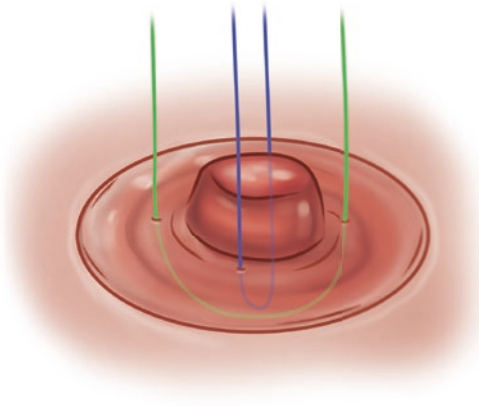

Fig. 19.9 Crossed sutures with free ends to be anchored to the traction device

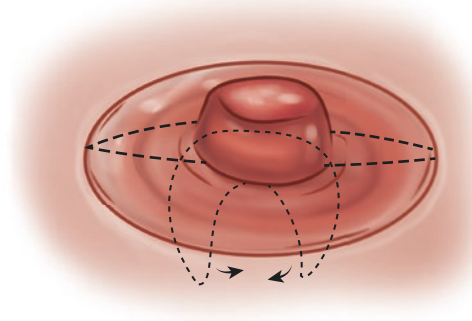

Fig. 19.11 Both flaps crossed under the nipple base

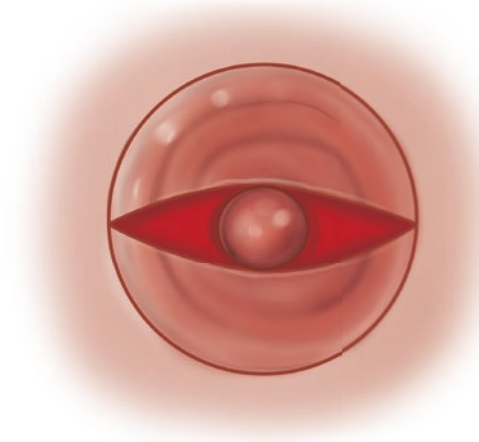

Fig. 19.10 Triangular subcutaneous flaps based around the nipple

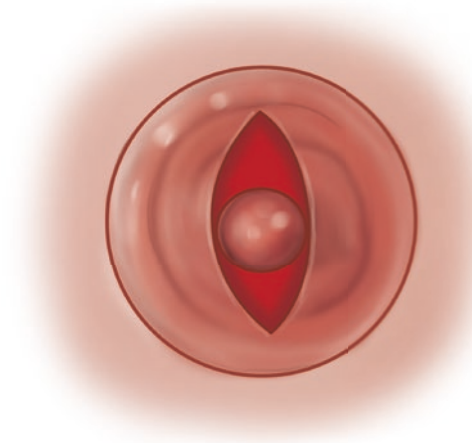

Fig. 19.12 Subdermal flaps with a curved border reaching half of the areola

III grade), and 5 patients that got pregnant reported successful breastfeeding. Sensation was measured with a 100% function eliciting a contraction response [12] (Figs. 19.10 and 19.11).

Durgun M (2014): Two triangular subdermal flaps are raised and deepithelialized. After 90° rotation, these are passed under the tunnels made by blunt dissection. The two flaps are sutured, and a traction device is placed and maintained for 21 days. A 6.25% recurrence has been reported for 28 grade II and III inverted nipples [13] (Figs. 19.12 and 19.13).

Mathur B (2018): This method combines selective release and transection of the ducts with a "drawbridge" flap raised from the nipple base to the areola border to be tunneled under the nipple. With 97 nipples corrected for all types of inversion, the recurrence reported is 0% with 100% sensation preserved [14] (Figs. 19.14 and 19.15).

19.5.3.2 Duct-Transecting Techniques

Flap Based

Han S (1999): For grade III nipple inversion, the original technique published by Han advocates

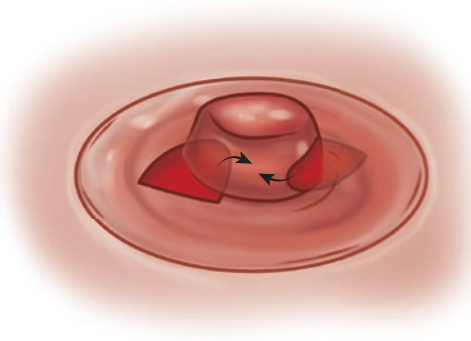

Fig. 19.13 Both flaps joined together under the nipple base

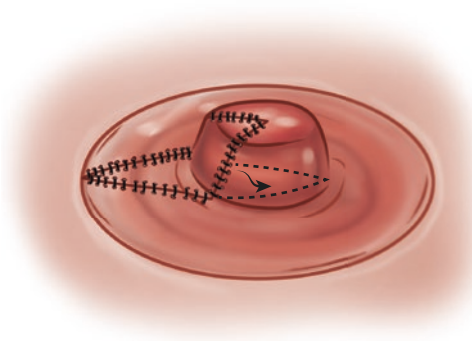

Fig. 19.15 Tip of the flap turned under the nipple base after selective duct transection

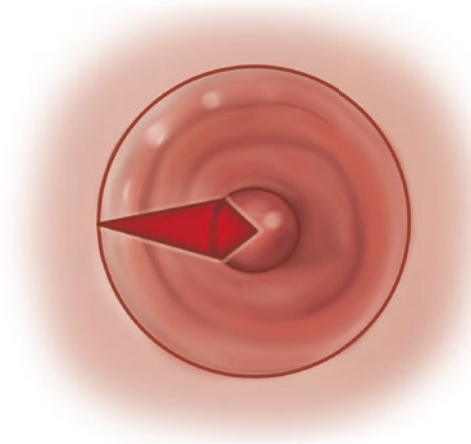

Fig. 19.14 Drawbridge flap with its widest portion in the nipple-areola transition

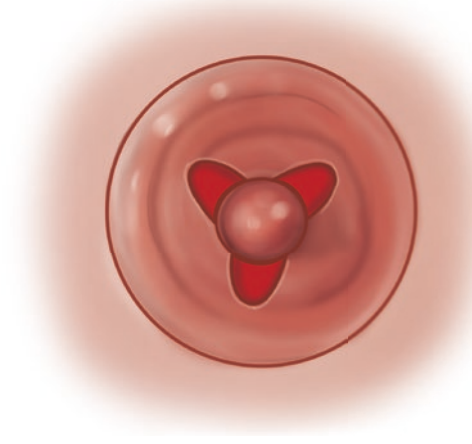

Fig. 19.16 Three dermal flaps based around the nipple

the use of three dermal flaps from the areola that are tunneled under the nipple after cutting the fibrous ducts. The procedure is finished with a purse-string suture at the base. No traction device is employed. Reported recurrence is 2.8% out of 107 nipples [7] (Figs. 19.16 and 19.17).

Perischetti (2011): An incision in the middle of the nipple below the areola plane is used to release central fibrous ducts. In every half of the nipple, a dermoglandular V-shaped flap is tailored. In doing so, this technique would theoretically spare peripheral galactophorous ducts, with breastfeeding being preserved. Out of 52 patients, 5 women became pregnant and 3 of them could breastfeed. After 1 year, recurrence was observed in only 1 patient [15] (Fig. 19.18).

Suture Based

Serra (2004): After transecting all ducts through a nipple base incision, a five-point star suture is

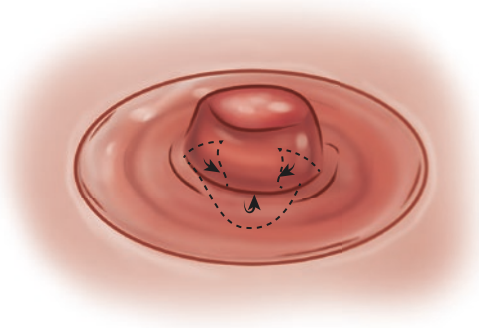

Fig. 19.17 The three flaps transposed under the nipple base after duct transection

Fig. 19.19 Five-point star suture to maintain nipple projection

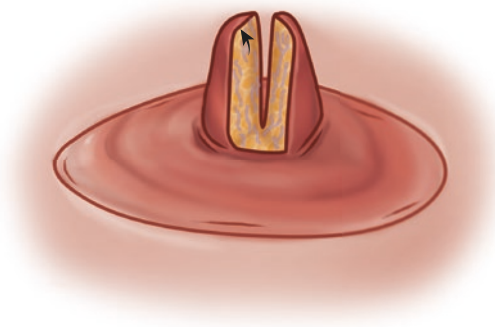

Fig. 19.18 Once the nipple is incised, two VY flaps are raised releasing all central retraction and sparing those in the periphery

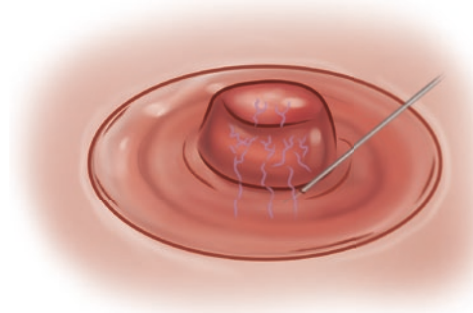

Fig. 19.20 18 G needle through nipple base incision to release fibrous ducts

made to maintain projection. A traction device is placed for 8 days. No recurrence is observed in 12 patients [16] (Fig. 19.19).

Kolker (2009): This minimally invasive technique uses an 18 G needle inserted at the 6 o'clock position of the nipple base to release the shortened ducts until good projection is achieved. A 4-0 monofilament purse-string suture and two crossed 5-0 mattress sutures are placed without any traction device. Since this is applied for all degrees of retraction, the recurrence varies across a 0% in I, 27% in II, and 50% in III [17] (Figs. 19.20 and 19.21).

Lee (2003): Through an inferior periareolar incision, access is gained to the nipple base.

Al fibrous bands and ducts are released, and two internal sutures of the nipple sidewalls are performed near the tip and at the base. This method reported 0% recurrence in 17 patients with grade III inversion [18] (Fig. 19.22).

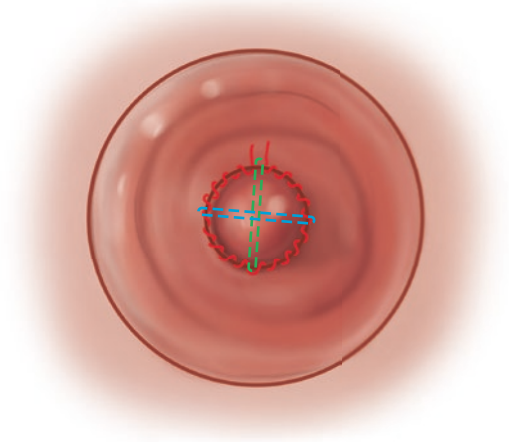

Fig. 19.21 Crossed horizontal mattress sutures and purse-string suture to maintain projection

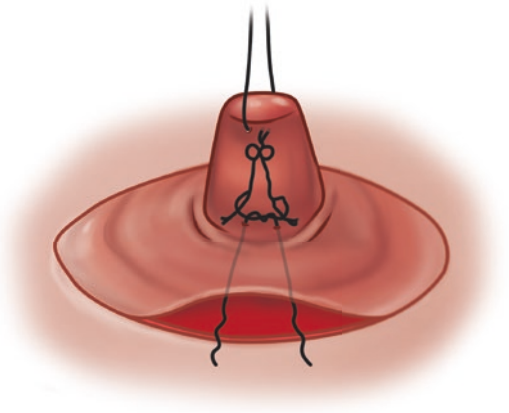

Fig. 19.22 Two internal sutures, at the base and at the tip through a periareolar incision

19.5.4 Technical Tips to Improve Outcomes and Avoid Complications

- Before starting the procedure, the nipple-areola junction must be clearly distinguished and marked. Anesthetics injection should be done after this to avoid any distortion that could mislead the incision placement.
- As mentioned before, a combination of quick- and late-onset anesthetics will prevent any postoperative pain. Avoidance of adrenaline or other vasoconstrictor minimizes the risk of ischemia but also allows for control of any intraoperative bleeding.
- In cases of severe retraction, the transection of the ducts by itself usually is not enough to prevent recurrence. Here, interposition of soft tissue helps avoiding new retraction during wound healing. For a more reliable result, suture of the flap to the opposite side of the nipple base maintains the flap in place and also improves definition of the nipple-areola transition.
- For a better outcome, horizontal mattress sutures for skin closure minimize the risk for a widened or depressed scar, making it almost inconspicuous.
- The traction device should be maintained with the suture anchor for a minimum of 15 days, but if in postoperative revision a tendency to retraction is observed, the surgeon should not hesitate to extend this even up to a month.

19.6 Postoperative Care

After the procedure, the patient is advised to avoid any water in the breast area until removal of the stitches. We maintain the traction device sutures for 2 weeks. During that time, the patient is instructed to periodically check the operated area and call in case of redness or swelling. After the two first weeks, both traction stiches and skin stitches are removed. The traction devices are maintained for two additional weeks with sterile drape to avoid any compression over the nipples wearing the bra or during sleep. At that moment, if the incisions look good, the patient is told to wash those areas carefully drying the wounds later (Figs. 19.23 and 19.24).

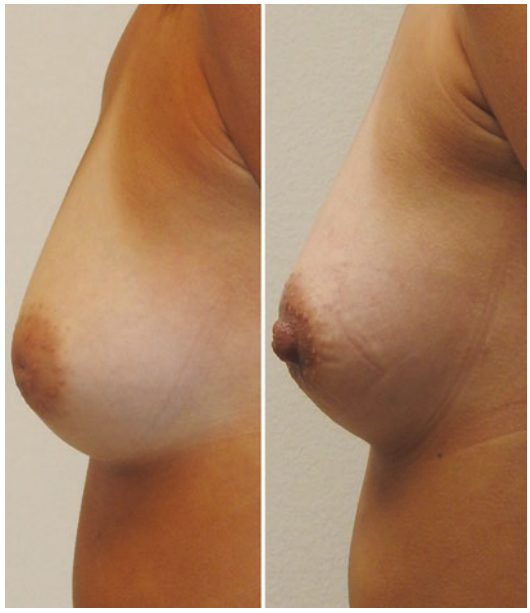

Fig. 19.23 Inverted nipple (left) and the result 6 months after the surgical correction (right)

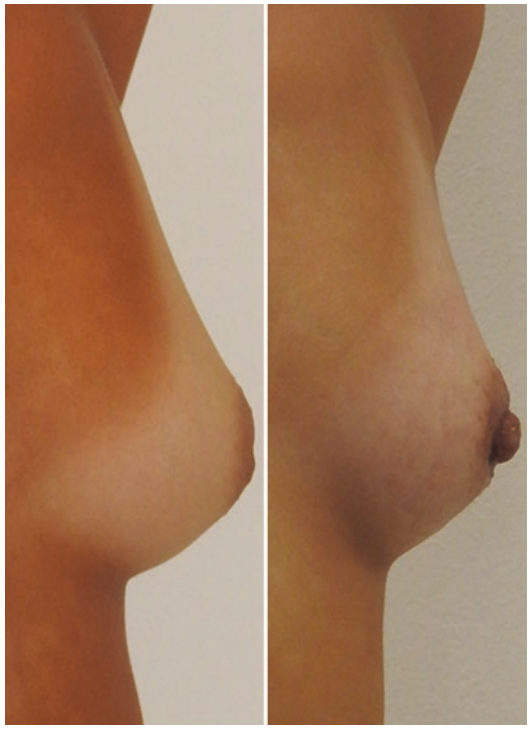

Fig. 19.24 Inverted nipple (left) and the result 6 months after the surgical correction (right)

19.7 Outcomes and Prognosis

Is important to explain the patient that the swelling of the nipple and the areola remains for at least the first month since surgery. This swelling in the areola can sometimes obscure the new projection of the nipple achieved after the correction. Usually, at the second month, the swelling has completely disappeared. However, the patient is instructed to take care of the incisions covering, applying moisturizer twice a day, and protecting the scars from the sun for the first year.

19.8 Complications

Nipple inversion correction is a very safe and simple procedure, easy to perform, and with good outcomes. However, as any other surgical intervention, it carries a small risk for complications. The main complications associated are recurrence, infection, and necrosis.

19.8.1 Recurrence

The most important complication of the procedure is the recurrence of the retraction. This happens due to insufficient release of the fibrous tracts or because of new fibrosis during healing of the wounds. The latter is unlikely to occur since with our technique a dermofibrous flap is interposed between the transected tissue. This prevents new scarring and also adds soft tissue and bulk to project the nipple.

When the first signs of recurrence are observed, conservative measures are taken maintaining the traction device longer. In case the retraction persists, a new surgery may be offered to the patient. This is always offered after 1 year, once the result is definitive and to avoid any surgery during the healing process.

19.8.2 Infection

Galactophorous ducts are colonized structures prone to be the origin of cellulitis or mastitis to the breast. The most frequently identified bacteria are group B Streptococci and *Staphylococcus aureus* [19]. During the intervention, these are transected so migration of these microorganisms may happen. For this reason, we advocate the use of a short antibiotic prophylaxis. In our clinical practice, we use a three-dose prescription of amoxicillin/clavulanic 1 g for this purpose. In addition, the patient is instructed to check for detection of any sign of infection during the first weeks.

19.8.3 Necrosis

Partial necrosis is a very uncommon complication associated with nipple inversion surgery. This should be advised in previously operated and scarred NAC and specially when sutures are used for eversion in the form of purse-string sutures at the nipple base. If this is the case, we recommend close follow-up during the first 48 h. The patient should be instructed to periodically check the color and aspect of the nipple and return in case of any postoperative change.

19.9 Conclusions

Nipple inversion is a very common problem in women; it may be present since birth or develop due to postmaternity body changes. Classification of the degree of inversion and good assessment of patients' expectations are essential for the surgeon to choose the best technique for each case. The surgical intervention we propose here should be advocated for degree II or III or when the patient has no desire for future breastfeeding. This pathology can be treated on a simple procedure, under local anesthesia, and with minor complications. However, some important technical points must be taken into account. The rate of recurrence varies depending on the degree of retraction and the procedure chosen, but with a thorough preoperative evaluation and an adequate technique selection, good outcome may be obtained in all cases.

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Breastfeeding and Breast Surgery

20

Andrés Ros Magallón and Jesús Olivas-Menayo

Take-Home Points

- The function of the breast can be as important as its appearance for some women. Do not forget to inquire about it.
- Silicone implants are as far as it is known safe for both the mother and her child.
- Although the ability to lactate is rarely affected by previous procedures, the rate of exclusive breastfeeding decreases.
- Breastfeeding alone has not shown any effect on the shape of the intervened breast. Many women will not breastfeed out of a misplaced fear of damaging the results of their surgery.

20.1 Introduction

Cosmetic breast surgery was performed in more than half million women only in the United States in 2019 [1]. More than half of those women will be at reproductive age at the time of surgery, and of those wanting to become mothers, more than 80% will want to breastfeed [2]. Although it is fairly common that mothers do not achieve their expectations towards breastfeeding—with more than half of them not breastfeeding as long as they first intended—the ability to breastfeed is important both to the child and the mother [2].

Breastfeeding does have a beneficial effect on infant health. It is reported to reduce the risk of illness by infectious diseases, the sudden infant death syndrome rate, the risk of dying in infancy, the risk of being overweight or obese later on, and the risk of necrotizing enterocolitis, among many others [3]. It also improves the health of the mother, by helping to reduce weight; reducing blood pressure; spacing away further pregnancies; reducing the risk of postpartum depression (when the mother had previously the desire to breastfeed) [4]; reducing the risk of breast and ovarian cancer, cardiovascular disease, type 2 diabetes, metabolic syndrome, and rheumatoid arthritis; and improving bone health [3].

Besides the known health effects of breastfeeding, the ability to breastfeed also forms part of many women's idea of self. The strong emotional attachment that this entails can be a source of litigation if the desire to breastfeed has not been explored properly during patient consultations. Moreover, considering that breast surgery represents the biggest group of plastic surgical procedures giving rise to claims [5], any female patient that consults for breast surgery should be asked about her prior pregnancies and her desire for future ones. If she wants to have more chil-

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_20

dren, her ability to breastfeed in previous pregnancies (if there were any) and her expectations about breastfeeding in the following ones should be assessed and documented. It is important to determine the duration of prior breastfeeding attempts, whether she could achieve at all exclusive breastfeeding or had to supplement it, and for how much time could she maintain each kind of breastfeeding. The time since she stopped breastfeeding should also be documented.

After the obstetric history and the patient's plans have been thoroughly explored, the complications of the procedure that has been requested should be discussed. This kind of approach helps the patient to reflect on her existing desires and the foreseeable outcomes of her options, thus building patient autonomy and improving rapport.

The issues of which the patient should be made aware when explaining the known complications of each procedure are mainly three: the effects of the requested technique on her future ability to breastfeed, the foreseeable changes to the intervened breast after breastfeeding or pregnancy, and the complications that may arise from operating on the breast too early on after breastfeeding.

Of these three, the ability to breastfeed after surgery will be determined by the amount of disruption of the glandular breast tissue needed to achieve the desired result. The different outcomes of breastfeeding after breast surgery will be addressed later on in this chapter. On the other hand, the singular complications that appear after operating on breasts after the patient has stopped breastfeeding her children may have to do with the delay between the last time the patient breastfed and the day the surgery is performed.

Lastly, when explaining the changes that may occur to the intervened breast after pregnancy or breastfeeding, the principal concern should be conveying to the patient the message that breastfeeding will not change the appearance of the breasts, nor put at risk the results of the surgery, as any change will be more likely due to the pregnancy [6–8]. This is especially important, as mothers that believe that breastfeeding may affect the appearance of the breasts will be less successful at it [9].

Key Points

Breastfeeding is often an emotionally loaded issue for many women. Be sure to explore the history and the plans of the patients before taking them to the operating room, as breast surgery can impair significantly their ability to breastfeed.

Women who intend to breastfeed and have received cosmetic breast surgery should be encouraged to do it, as it will not have any effect on the appearance of the breast.

20.2 Breastfeeding After Breast Surgery

Although the different techniques performed for cosmetic breast surgery share a common goal—the improvement of the appearance of the breast—how they achieve it can vary a great deal between them. The different needs of volume for each patient, the excess or defect of the skin envelope, and the concern about visible scars will make some techniques more suited than others depending on what has to be done. However, the way in which these needs are addressed will affect the ability of the patient to breastfeed [10].

The glandular tissue of the normal breast contains up to 20 lobules, each of them draining into a galactophorous duct, that usually opens independently in the nipple. The letdown reflex induces the release of oxytocin needed for milk ejection. Thus, successful breastfeeding depends on the number of intact lobules and galactophorous ducts remaining on the breast and the presence of enough sensitive fibers to enable the letdown reflex [11]. Additionally, milk excretion is limited by the compliance of both the breast stromal tissue and the skin envelope. This explains the reduced success at breastfeeding shown by patients with denser and firmer breasts, such as those with tuberous breasts, whose breastfeeding success can be as low as less than half the rate of the general population [12].

▶ **Important** Breastfeeding success after breast surgery is highly likely to be related to both the amount of undisturbed glandular tissue that is left out and the parenchymal pressure derived from the relative size of the structures of the breast cone compared to the skin envelope.

Even when the loss of functional breast tissue due to the surgical insult may seem final, there is some evidence of regeneration of the galactophorous ducts, both in an experimental rat model and after nipple correction surgery [13, 14]. Nonetheless, the patients could not lactate up until 2–3 years after the surgery, and the regenerated ducts were narrower and their walls thicker, which would again decrease the compliance of the breast.

20.2.1 Breast Reduction and Mastopexy

Approximately a quarter of a million breast lift or breast reduction surgical procedures in women were performed in 2019, which account for 38.5% of all cosmetic breast surgeries in the United States in that year [1]. Approximately two-thirds of these surgeries were performed on women under age 50, which emphasizes the need for adequate knowledge about the consequences that breast reduction and breast lift techniques can have on breastfeeding.

Both breast reduction and mastopexy share surgical incision placement and are often combined to some degree, as it is very rare that a case requires strictly skin resection to reposition the breast. Therefore, both procedures will generate similar issues with the future ability to breastfeed. Firstly, tucking the skin envelope will stretch it over the breast cone, diminishing its compliance and making milk excretion difficult. Secondly, tissue resection will directly reduce the milk production of the mammary gland [15, 16]. The results reported by the available literature about this topic are inconstant, as there is no standard definition of the most widespread concepts about breastfeeding (breastfeeding success, exclusive breastfeeding, supplemented breastfeeding …) and the thresholds for each one are often arbitrarily chosen. Once this limitation is accepted, it is possible to integrate the results of the different studies.

The overall breastfeeding success after breast reduction was often described as the ability to breastfeed at all, and it was reported to be between 43.5 and 81.8% [17–25]. In the studies wherein it was compared against the breastfeeding success of the general population, there was some disparity. One did not find any significant difference [19], and in another, both the initial breastfeeding success and breastfeeding success over time were lower after breast reduction (58% vs. 94% controls) [25]. No difference between pedicle choice was found in two studies [17, 18], but in another, the superior pedicle had significantly greater breastfeeding success (60.7% with the superior pedicle vs. 43.5% with the inferior pedicle vs. 48% with the medial pedicle vs. 55.1% with the lateral pedicle) [24].

The exclusive breastfeeding rate after breast reduction does not have a singular definition, but it can be understood as the ability to provide enough nourishment only by breastfeeding. The reported rates of exclusive breastfeeding after breast reduction were from 21.4 to 53.8% [16, 23, 25–28]. When it was compared with the exclusive breastfeeding rate of the general population, it was found to be significantly lower, both when taken only at a single point (29% vs. 80% controls) [26] and when considered over time (21% vs. 70% controls at 1 month and 4% vs. 22% controls at 4 months) [25].

Supplemented breastfeeding after breast reduction was usually understood as having the ability to breastfeed but not being able to produce enough breastmilk to support the growth of the newborn. It was reported to be between 21.7 and 68% [16, 19, 23, 26, 27]. In the latest study that compared the supplemented breastfeeding rate after breast reduction, it was found to be significantly higher than in the general population (68% vs. 16% controls) [26].

Even though they are not directly related to breastfeeding, there are also some complications of breast reduction and breast lift described in the

literature that can impair the future ability of the patient to breastfeed. These are:

- 0–44.5% of loss of nipple sensation [17–19, 21, 23, 28]
- <2% of nipple necrosis [21, 23, 29]
- 6–10% of nipple retraction/inversion [18, 23]

Additionally, breast ptosis recurrence was found to be twice as frequent after pregnancy [22].

Although there are some disparities and even some contradictory evidence, there is some agreement that even when breast reduction or breast lift did not prevent women from breastfeeding at all, they will likely need to supplement the diet of their children. It is also safe to assume that there is a chance that the patient will not be able to breastfeed at all after the surgery. For breast reduction, if the needs of the patient allow it, try to resect as minimum breast tissue as possible while preserving the tissue under the nipple-areola complex. And for breast lift, whenever possible, try not to rely only on skin resection and gland repositioning to achieve the desired result, as it will reduce compliance, and opt for combining the skin resection with some degree of gland resection, also preserving the tissue under nipple-areola complex.

Pearls and Pitfalls

Greater corrections entail greater risks for the ability to breastfeed. If the patient demands a significant correction of the breast but is not willing to accept the risk of losing the ability to breastfeed, a better alternative is to schedule the surgery after the patient has resolved her desire to breastfeed.

20.2.2 Breast Augmentation with Implants

Breast augmentation was the most frequent surgical procedure performed in 2019 in the United States, with a total of 280,692 procedures in that year. 85% of these were performed on women under age 50 [1]. In addition to its effect on the ability to breastfeed, it is also important to consider the possible effects that the placement of a foreign body close to the mammary gland may have on the offspring of the patient.

The different techniques for breast augmentation with implants share the objective of increasing the volume of the breast cone while preserving its contour and without overstretching the skin envelope. To fulfill this aim, a silicone implant is placed in the subglandular, subfascial, or subpectoral plane. All these planes can be accessed through the usual inframammary groove, transareolar, or transaxillary approaches without needing to disturb the mammary gland. There is one exception, the transareolar approach, that can be followed with a transglandular dissection of the chosen plane. That being the case, breast augmentation does not need to directly damage the mammary gland (except the transareolar-transglandular approach), but the resulting enlargement of breast cone will alter the surface-to-volume ratio. Consequently, the skin envelope will be stretched, presenting lower compliance, which in turn will cause lower and more painful milk excretion through an increase in parenchymal pressure [30, 31]. Fibrosis around the implant and gland atrophy have also been identified as possible factors behind a lower breastmilk production of patients with breast implants.

The overall breastfeeding success after breast augmentation with implants is high, with a range between 63 and 93% [32–35]. Three of the articles found statistically significant differences in breastfeeding success when compared to the general population (63–93–79% vs. 88–99–89% controls) [33–35]. There were mixed results when comparing breastfeeding success by implant placement, as one study found that retromuscular was better than retroglandular placement (82% vs. 17% breastfeeding success) [32], whereas another did not find any difference by incision or placement [34].

The rates of exclusive breastfeeding after breast augmentation with implants were consistently lower than those of the general population, with a range of 47–54% (vs. 80–71% controls) [26, 34, 36–38]. None found differences by incision or implant placement.

Supplemented breastfeeding rates after breast augmentation with implants were about twice the rates of the general population [26, 33, 34]. There is no difference in supplemented breastfeeding rates reported by incision or placement of the implants.

Among the complications described in the literature, the most serious ones are those that involve the effects of the implant material on the newborn. About those, the findings are mixed; some low-quality papers report rheumatic diseases in children breastfed by women with implants, and that more children of mothers with implants had lower birth weight and had to be transferred to hospitals [39, 40]. There is also one study that found esophageal motility problems in some children whose mothers had breast implants, but it was later found that the study was financed by the attorneys of those mothers, who were suing for compensation against the implant manufacturer [41]. However, many good-quality studies dispel those statements, as they did not find any of those complications in children breastfed by mothers with implants [42–46]. Other studies even found that blood silicon levels of women with implants are not different from baseline and that the levels of silicon found in breastmilk of women with implants were 10–210 times lower than those found in cows' milk [47–49].

Other complications of breast augmentation indirectly related to breastfeeding would be loss of nipple sensation, which happened to up to 10% of the patients intervened but was mostly transient [33, 50–52]. One study reported less sensation with an inframammary groove incision vs. a periareolar one [52], but others did not find that difference, giving more importance to the role of greater implants in smaller breasts [33, 53, 54]. Lastly, the transglandular approach was associated with painful breastfeeding, which is a known cause for breastfeeding cessation [50].

The overall breastfeeding success of breast augmentation patients is close to that of the general population, but taking into account the lower rates of exclusive breastfeeding and the higher rates of supplemented breastfeeding, it is safe to assume that the placement of implants for breast augmentation has a deleterious effect on the ability to breastfeed. Moreover, it was found in one study that women with implants used more galactagogues, which constitutes evidence of lower baseline milk production. The main issue with breast augmentation with implants is managing the increased pressure due to increase in the volume of the breast cone. This can be addressed in two ways: by choosing the smallest implant that the patient finds adequate and by placing the implant under the pectoral muscle, so it can spread the pressure more evenly across the mammary gland section [55].

Pearls and Pitfalls

Using an implant with a volume greater to which is advisable by the skin laxity of the patient is contraindicated when the patient wants to still be able to breastfeed.

Although the known benefits of breast surgery are plenty [56], if the patient demands a high-volume implant but she also wants to breastfeed her children, it is better to delay the operation.

20.2.3 Other Techniques for Breast Augmentation

Aside from implant placement, there are other techniques for breast augmentation, although they are more seldomly performed. Breast augmentation through fat grafting is, within the rarity of non-implant procedures, the most commonly performed. There is no specific statistical data about the number of breast augmentation procedures performed, but the total fat transfers to the breast in 2019 were 24,892, which is a tenth of the number of breast augmentations with implants performed in the United States in the same year [1]. Breast augmentation through injection of some alloplastic materials is also possible, but the complications derived from it are often grievous [57].

As it happens with breast augmentation with implants, one should pay special attention to the laxity of the skin envelope and try not to overfill it. Additionally, fat should never be transferred into the glandular tissue, as it can disrupt its structure.

20.2.4 Combined Procedures

All the techniques described above are often performed together, as many cases require mainly one technique and some degree of others to achieve the desired result. The main technique is the one that is often reported, and therefore there is scarcity in the data about the outcomes and the complications profile of combined procedures, but the safest assumption regarding the ability to breastfeed is to consider that the impairment caused by each technique proposed for a case is additive. Moreover, it is known that the combination of procedures in a single surgery is associated with greater needs for revision surgery, which in turn is associated with greater impairment of the ability to breastfeed [58].

20.3 Breast Surgery After Breastfeeding

Some patients' demands will not be easily addressable before they have fulfilled their desire to breastfeed, but scheduling the surgery after breastfeeding comes with some issues of its own. A woman can continue to lactate for years after the pregnancy, but once breastfeeding is stopped for approximately 1 week, any milk left in the breast will be reabsorbed, and in theory, no more milk will be produced even if suckling or pumping is resumed. The problem is then when will that milk be completely reabsorbed?

20.3.1 The Importance of Proper Timing

The usual delay when scheduling a surgical procedure after breastfeeding is of about 6 months. This will be enough time for the breasts of most women to reabsorb the milk that was left after breastfeeding. There are also plenty of cautionary tales about what can happen if one decides to operate too soon [59–61]. Nonetheless, similar complications have been described in patients operated up to 10 years after their last pregnancy, although these are simple case reports [62–67].

The expected complications when operating on a breast that has recently (or not so recently) breastfed are galactorrhea and galactocele formation, which can by themselves put the results of the surgery and the patient at risk, as they can contaminate the implants, burst out sutures, and become infected [65]. Finding galactorrhea in a patient that has not breastfed for long may merit exploration of her endocrine axis [68].

Finding a balance between risk and benefit when choosing a time to operate after breastfeeding is not simple. A year after, breastfeeding shows a lower amount of cases with complications related to milk production, but it may be similar to waiting for just 6 months. With the available evidence, the best policy is to present both options and their associated risks to the patient and let her decide.

20.4 Conclusion

Although the available evidence points out that most breast surgery techniques may not prevent mothers completely from breastfeeding, it is safe to assume that their experience will be significantly different. This may be even more noticeable if they have already breastfed successfully.

Lower milk production can mark the difference between being able to provide exclusive breastfeeding for enough time to get its benefits for both the mother and the children and not having even enough to provide supplemented breastfeeding. Similarly, a more painful breast due to a relatively smaller skin envelope, or an impaired lactation reflex due to nerve damage, can preclude both exclusive and supplemented breastfeeding. Furthermore, they can make the mother stop breastfeeding earlier even when they are able to, as it makes the process more uncomfortable.

When the issue is when to operate on a woman that has just stopped breastfeeding, the usual threshold of 6 months after the last time she breastfed is safe enough for most women, but it is not enough for all of them. Look for lumps and/or discharge through the nipple when exploring the breasts, in addition to asking the patient

whether she had any discharge in the previous months. A patient without any of these findings can still present complications associated with prior lactation, but the chance of it happening will be much lower.

As with any surgery that alters the structure of the breast, obtaining preoperative and postoperative imaging is always recommended, both to detect if there is any lesion in the breast that might alter the surgical plan and to provide a reference of the breasts' structure after the procedure for breast cancer screening purposes.

In general, cosmetic breast surgery will affect both the structure and function of the breast, which in turn will affect the lifestyle of the patient. Enough care should be taken to ensure that the surgery provides the patient with a benefit that is not overshadowed by its downsides. This is only achievable when the patient is allowed to discuss her plans and ideals and is properly explained the possible outcomes of her decisions.

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Part VI

Abdomen

Alterations of the Abdominal Wall During Pregnancy

21

Patrícia Mota

Take-Home Points

- No risk factors were found for the condition. However, multiple pregnancies, macrosomic babies, and twins are associated with severe diastasis recti in postpartum women.
- Ultrasound imaging is a reliable tool to measure Inter-rectus distance during rest and under contraction conditions.
- It is essential for women with alterations in the abdominal wall to be assessed in a multidisciplinary team in order to treat the augmented inter-rectus distance and prevent pelvic floor muscle dysfunctions after birth.

Attention

Diastasis recti is a prevalent concern in postpartum women.

There is limited evidence to recommend an exercise program to women with diastasis.

The individual evaluation of the abdominal wall and pelvic floor function with physiotherapist in women's health is still the best option to guide women with diastasis in the recovery process.

21.1 Introduction

Diastasis recti is an impairment of the connective tissue causing the two rectus abdominis to separate along the linea alba.

The location of Diastasis recti can be below, above, or at the umbilicus, and there are several classifications for clinically significant diastasis.

Women's health physiotherapists often treat patients with diastasis both during pregnancy and after birth, and these patients often present a combination of other musculoskeletal symptoms, such as pelvic floor dysfunctions, low back, or pelvic girdle pain.

It is mandatory that these patients are accessed in a multidisciplinary team and the elected treatment for the abdominal wall should respect the musculoskeletal conditions often combined with the augmented inter-rectus distance.

21.2 Anatomy of the Abdominal Muscles and their Aponeuroses

The anterolateral wall of the abdomen has a laminar configuration composed by six layers including, from surface to depth, the skin, the superficial fascia, fat, the abdominal muscles, the transver-

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_21

salis fascia, and the parietal peritoneum. The muscular layer comprises four paired muscles with fibers oriented vertically (rectus abdominis muscle), obliquely (**external and internal oblique muscles),** and horizontally **(transversus abdominis muscles)** with skeletal attachments on the thoracic cage, pelvis, and the spinal column via the thoracolumbar fascia [1] (See Fig. 21.1). The aponeuroses of these muscles represent sheet-like tendons that form the sheath of the rectus abdominis (rectus sheath) and also serve as the medial insertion of the oblique's and transversus muscles, along the anterior midline of the abdomen, forming a fibrous structure that connects the right and the left side of the abdominal wall, the linea alba (Fig. 21.1).

The rectus abdominis (RA) and the pyramidalis are the only vertical muscles in the abdominal wall. The rectus abdominis muscle originates from the fifth through seventh costal cartilages to insert on the symphysis pubis and crest. Superiorly, the rectus is wide, broad, and thin, becoming narrow and thick inferiorly [1]. Segmentation of each rectus muscle occurs by tendinous intersections that represent attachment of the rectus muscle with the anterior layer of the rectus sheath.

The two RA muscles are separated by the linea alba and each one is invested within a sheath derived from the aponeuroses of the deepest abdominal muscles [1]. The rectus sheath consists of an anterior and a posterior layer (lamella) formed by the aponeuroses of the external and internal oblique and transversus abdominis muscles. These aponeuroses meet at the lateral edge of the rectus along a curved line to form the linea semilunaris, which extends from the ninth costal cartilage to the pubic tubercle. Above the umbilicus, the anterior and posterior sheaths are composed by the aponeuroses from the internal

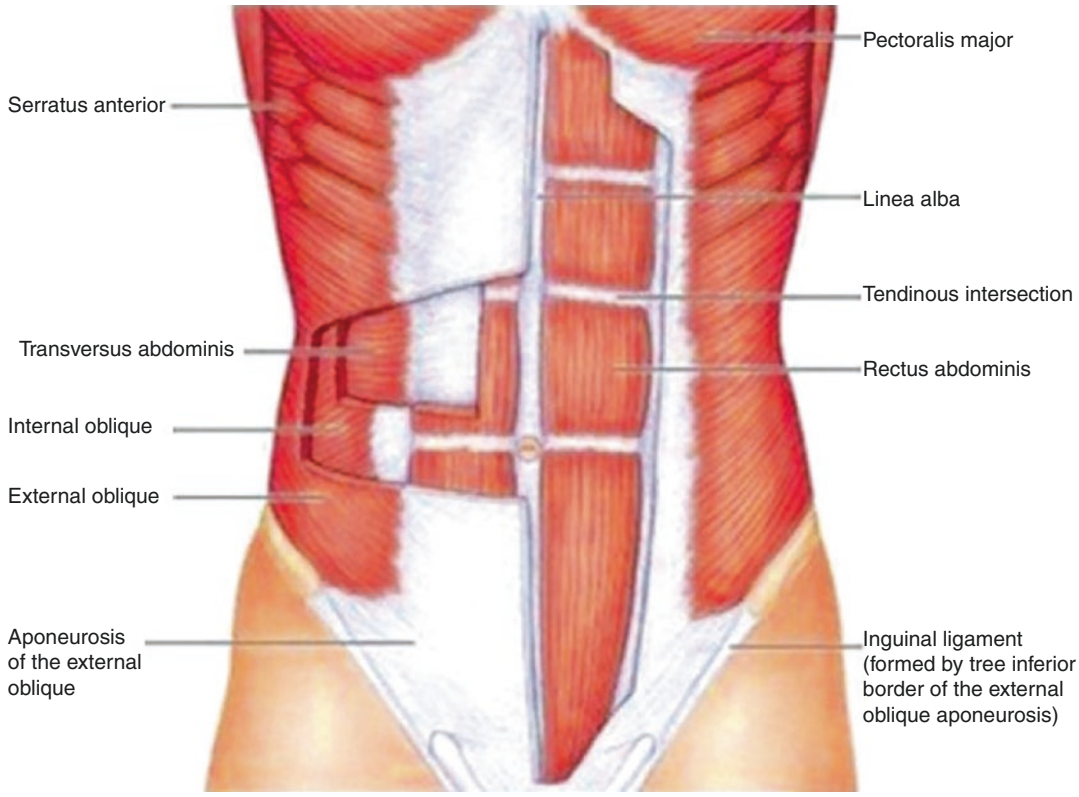

Fig. 21.1 Abdominal muscle. (Adapted from Juarez M. Avelar (eds.), New Concepts on Abdominoplasty and Further Applications; Springer International Publishing, 2016; with permission)

oblique muscle. In effect, the internal oblique aponeurosis splits, allowing one layer to pass anterior and one posterior to the rectus muscle. The anterior wall of the rectus sheath includes also the external oblique aponeurosis and the posterior sheath consists of contributions from aponeuroses of the transversus abdominis (transversalis fascia). Inferior to the umbilicus, approximately halfway between the umbilicus and the symphysis pubis, the external abdominal aponeurosis has no contribution to the formation of the posterior rectus sheath, and all three aponeuroses pass anterior to the rectus muscle. This anterior displacement of the aponeuroses creates a curved line of demarcation, in the posterior lamella of the rectus sheath, called the arcuate line, below which only the transversalis fascia separates the rectus abdominis muscle from the parietal peritoneum.

The linea alba reaches from the xiphoid process to the pubic symphysis and is defined as the fusion of the aponeuroses of the deepest abdominal muscles [2]. The linea alba consists of a three-dimensional, highly structured meshwork of collagen fibers [3] which in conjunction with both rectus sheaths are regarded as the most important structures for the stability of the abdominal wall from a mechanical point of view [3–5]. The linea alba tension is important to maintain the abdominal muscles, particularly the rectus muscles, at a certain proximity to each other [2, 6] in order to optimize abdominal muscles function both as on abdominal viscera support or producing thorax/pelvis movements.

Tension on the linea alba, particularly below the umbilicus, seems to be regulated by the pyramidalis, a small paired triangular-shaped muscle, present in 80% of people, which lies between the anterior surface of the rectus abdominis and the posterior surface of the rectus sheath [7]. The precise function of the pyramidalis muscles is unclear, but together both muscles are thought to assist in tensing the linea alba [7].

The linea alba compliance is highest in the longitudinal direction and smallest in the transverse direction [2] which determines the great resistance offered by the LA to rectus abdominis transversal separation. Even so, the viscoelastic properties inherent to the collagen makes the linea alba prone to increase length when the mechanical stress is prolonged in time [5], namely in the case of a long-lasting increased intra-abdominal pressure, such as that resulting from pregnancy [8–11].

The mechanical stress on linea alba is highly associated to the action of the oblique's and transversus abdominis muscles. The external oblique arises from the lower 8 ribs posteriorly to interdigitate with both the serratus and latissimus muscles. The direction of the fibers is approximately horizontal in the uppermost portion only to become oblique in the lowest portions. After contributing to the anterior portion of the rectus abdominis sheath, the remaining fibers insert onto the linea alba.

The internal oblique arises from the anterior two-thirds of the iliac crest and lateral half of the inguinal ligament to run essentially at right angles to those of the external oblique. The fibers run perpendicular to the external oblique muscle from the thoracolumbar fascia of the lower back, the anterior iliac crest, and the lateral half of the inguinal ligament, to insert on the 10th to 12th ribs inferiorly and the linea alba (Fig. 21.1). The external and internal oblique muscles both function in support of abdominal viscera as well as assist in flexion and rotation of the trunk.

The transversus abdominis muscle is the innermost of the abdominal muscles, being placed immediately beneath the internal oblique muscle from the 7th to 12th costal cartilages, iliac crest, and the lateral third of the inguinal ligament. The muscle bundles run mostly horizontally, except the lower most medial fibers, which run a more inferomedial course to their insertion on the pubic crest and pubis [12]. Their extensive aponeurosis passes horizontally in the middle line of the abdomen and is inserted into the linea alba: the upper portion lie behind the RA muscle and blend with the posterior rectus sheath while its lower part pass in front of the RA muscle [12].

21.3 Changes in the Abdominal Wall Morphology During Pregnancy

Physiological adaptations of normal pregnancy include among others, and, most notably, increased fat depot. The mechanisms responsible for adipose tissue depot-specific structural and functional differences are unknown [13].

The most obvious morphological change during pregnancy is the increasing abdominal circumference (Fig. 21.2). This aspect is associated with stretch marks or striae gravidarum, a common, disfiguring, gestational change that affects between 55 and 90% of women [14]. Stretch marks present as atrophic linear scars and can cause distress, often leading to a decrease in quality of life [14].

During pregnancy, the rectus abdominis muscle, the subcutaneous, and fat tissue undergo pressure from the inside by the increased abdominal volume. The abdominal muscle and subcutaneous fat tissue become thinner until delivery. A mechanical force affects the thicknesses of the rectus abdominis muscle and the subcutaneous tissue during pregnancy [15]. It is common to assume that, because of the increased abdominal pressure during pregnancy, with the increased abdominal circumference, the stretch marks, fat depot, diastasis recti, and ventral hernias are related. However, there is no evidence that these conditions can be related.

The functional role of the abdominal muscles during pregnancy appears to be similar to those in the non-pregnant state [8] and is suggested to be important for trunk movement, pelvic stabilization, and restraint of the abdominal contents [1]. However, the musculoskeletal morphology of the anterolateral wall of the abdomen changes as pregnancy progresses [16]. The weight and dimensions of the uterus and its contents increase from 40 to 1000 g, and its capacity from 4 mL in non-pregnant state to 4000 mL at term [17]. The maternal inferior thoracic diameter is increased [18, 19] as well as the anterior and lateral dimensions of the abdomen. These changes modify the spatial relationship between the superior and the inferior abdominal muscle attachments [17] increasing the length of the abdominal muscles, particularly the rectus abdominis [19]. At 38 weeks of gestation, the length of the abdominal muscles increased a mean of 115% with respect to the beginning of pregnancy [16]. The increment of the anterior abdominal dimensions may alter the angle of the abdominal muscle attachment in the sagittal plane [16]. Alterations in the spatial relationship of muscle attachment and the muscle's angle of insertion may alter the muscles line of action and therefore their ability to produce torque [16, 20].

Fig. 21.2 Increasing of abdominal circumference from first month to ninth month of pregnancy

21.4 Inter-rectus Distance and Diastasis Recti Abdominis

One of the muscles thought to undergo change in pregnancy is the rectus abdominis. As the fetus grows, the two muscle bellies of the rectus abdominis, connected by the linea alba, elongates and curves around as the abdominal wall expands, with most separation occurring at the umbilicus [8, 19, 21]. The augmented inter-rectus distance (IRD), often referred to as *diastasis rectus abdominis* (DRA), is described as a change in the abdominal musculature, specifically in the linea alba and rectus abdominis sheath, with onset in the last trimester of pregnancy and whose peak of incidence occurs immediately after birth and the first weeks following childbirth [8, 10, 21, 22]. Although some studies suggested that an augmented IRD could reduce the abdominal integrity and functional strength, contributing to pelvic instability and back pain [20, 23, 24], no scientific evidence exists about the functional implications of an augmented inter-rectus distance or even about the effect of the exercise on prevention and/or reduction of IRD.

21.4.1 Classification and Prevalence of Diastasis Recti

Criteria and IRD cut-off value for the diagnosis of DRA vary in the literature [2, 6, 8, 9, 25–28], and to date there is no international consensus on the measurement location. In a cadaver study, Rath et al. (1996) defined a widening of the IRD more than 10 mm above the umbilicus, 27 mm at the level of the umbilicus, and 9 mm below the umbilicus, as pathological DRA [6]. Others defined DRA as a widening of the IRD more than 2.5 cm at one or more assessment points using digital calipers [29]. In a more recent ultrasound study, Beer et al. (2009) suggest that in nulliparous women, the linea alba should be considered "normal" when the IRD width is less than 15 mm, at the xiphoid level, 22 mm at 3 cm above the umbilicus, and 16 mm at 2 cm below the umbilicus [2]. Lately, Mota et al. (2018) found that in primiparous women, the IRD may be considered "normal" up to values wider than in nulliparous [30] using the same methodology of Beer et al. (2009) [2].

This way, Mota et al. (2018) suggest that during pregnancy, the linea alba can be considered normal up to 79 mm when measured at 2 cm below the umbilicus, 86 mm at 2 cm above the umbilicus and 79 mm, at 5 cm above the umbilicus [30]. At 6 months postpartum, the linea alba can be considered normal up to 21 mm when measured at 2 cm below the umbilicus, up to 28 mm at 2 cm above the umbilicus, and up to 24 mm at 5 cm above the umbilicus [30]. Use of normative IRD values in primiparous women may be found in the diagnosis of the condition and in the decision of treatment strategies (Table 21.1).

Studies have found that DRA may affect between 30 and 100% of pregnant women [8, 21], and that it may remain separated in the immediate postpartum period in 35–60% of women [21, 25]. However, the condition has also been found in 39% of older, parous women undergoing abdominal hysterectomy [26] and in 52% of urogynecological menopausal patients [28]. Reported prevalence of DRA or increased IRD varies and may be inaccurate due to different IRD cut-off values for the diagnosis [2, 6, 8, 25, 28, 29, 31] and use of different measurement assessment methods.

Table 21.1 Quantitative classifications of diastasis using different location measurements on the linea alba and women background variables. Rath et al. on a study with cadavers [6]; Beer et al. on a study with nulliparous [2]; Mota et al. on a study with primiparous [30] (maximum inter-rectus distance values in mm)

	Women	Location of measurement on the linea alba		
		Superior	Middle	Inferior
Rath et al.	<45 years old	10	27	9
	>45 years old	15	27	17
Beer et al.	Nulliparous	15	22	16
Mota et al.	Primiparous	24	28	21

▶ **Warning** No scientific evidence exists on the functional implications of an augmented inter-rectus distance

In primiparous women, the inter-rectus distance may be considered "normal" up to values wider than in nulliparous

No scientific evidence exists on the effect of the exercise on prevention and/or reduction of inter-rectus distance

21.5 Risk Factors for Diastasis Eecti Abdominis

There is scant knowledge about the risk factors for DRA. Two studies analyzed several variables such as, age, ethnicity, body mass index, height, weight gain during pregnancy, pre-pregnancy weight, gestational age at delivery, type, and duration of birth [21, 27]. An association of DRA during pregnancy with Caucasian ethnicity and lack of regular exercise during pregnancy was suggested [27]. It is considered that women with DRA have a greater number of pregnancies and deliveries [28, 32], and among multiparous women, it is suggested that there is a strong association between provision of childcare and DRA during pregnancy [27]. However, these studies were limited by the sample size, reliability of the instruments used, and were not definitive in its ability to delineate risk factors. Additionally, Mota et al. (2015) [21] found that in primiparous women, there were no risk factors associated with DRA (Table 21.2), and women with DRA were not more likely to have lumbo-pelvic pain than women without DRA at 6 months postpartum [21].

However, it may be interesting to study women with severe DRA, for example, with more than one child, to understand the risk factors and the impact of severe DRA in women's body.

▶ **Warning** Women with severe DRA should be studied to understand the risk factors and the impact of severe DRA in women's body

Table 21.2 Possible risk factors for diastasis recti in postpartum women

Variables	With DRA	Without DRA	*P* value[a]
Mean age (years)	31.6 (2.2)	32.5 (2.9)	0.4
Pre-pregnancy BMI	21.7 (3.5)	22.2 (3.0)	0.2
Weight gain during pregnancy (kg)	12.8 (3.3)	12.4 (3.5)	0.7
BMI at 6 month postpartum	22.3 (3.7)	22.5 (3.2)	0.8
Hypermobility (positive ≥4 out of 9 on Beignton)	3.2 (2.5)	2.9 (2.5)	0.6
Mean baby weight birth (kg)	3.2 (0.3)	3.1 (0.3)	0.1
Abdominal circumference in late pregnancy at 2 cm below the umbilicus	105.5 (7.2)	104.7 (7.1)	0.1

[a] No risk factors were associated with DRA in 6 months postpartum [21]

21.6 Procedures and Instruments to Assess the Inter Rectus Distance

The most common methods to assess IRD are palpation [8, 25, 33, 34] and calipers [35, 36] (Fig. 21.3). However, the reported prevalence of DRA (or augmented IRD) may be inaccurate because of the lack of reliability, the low responsiveness (ability of a tool to detect small differences or small changes), and lack of validity (ability of an instrument to measure what it is supposed to measure) [37] in the methods and instruments used to measure the IRD. Recently, ultrasound imaging has been suggested as a useful method to assess muscular geometry and as an indirect measure of muscle activation via changes in muscle thickness during contraction [38].

Coldron et al. (2008) used ultrasound to characterize RA changes during the first year postpartum [10] and Mendes (2007) et al. claimed ultrasonography to be an accurate method to measure diastasis recti when compared with surgical compass during abdominoplasty [39].

Fig. 21.3 Palpation of the linea alba versus ultrasound imaging

Across-days reliability may be of interest to physiotherapists who perform repeated assessments of abdominal muscle function over time [38]. Factors such as relocation of the original imaging site, reproduction of the same transducer pressure and orientation, as well as maintenance of a relatively stationary transducer position during muscle contraction could adversely affect reliability [38] and accurate interpretation of ultrasound imaging and lead to erroneous conclusions [40].

The reliability of ultrasound imaging to measure IRD at rest and during contraction was tested and showed good reliability to measure women [31]. The authors recommend it to be used for studying DRA and its recovery in postpartum women.

Recent studies have suggested alternative methods to study the biomechanical implications of DRA [41]. However, these methods should be interpreted with caution, as they were not yet tested for its reliability [42].

▶ **Warning** Ultrasound imaging is a reliable method to assess inter-rectus distance in postpartum women.

Other methods are suggested to study diastasis, but they should be first tested for reliability.

21.7 The Effect of Exercise on Diastasis Rectis Abdominis

It has been suggested that antepartum activity level may have a protective effect on DRA and exercise may improve post-partum symptoms of DRA [9]. Postnatal women are encouraged to resume abdominal exercises shortly after delivery to restore their abdominal shape and fitness [6, 18, 32]. To date, there is scant knowledge on the most effective abdominal exercises both during pregnancy and after childbirth. In particular, there is little evidence on which exercises are most effective in reduction of the rectus diastasis. The rationale behind the abdominal strengthening programs is the assumption that the contraction of all abdominal muscles will reduce the horizontal abdomen diameter in such a way that a horizontal force will be generated producing the approximation of both rectus abdominis, particularly at the umbilicus level [43]. However, there is no evidence that this horizontal tension will produce an approximation of the rectus abdominis muscles. The horizontal force is the result of the overall action of the deep abdominal muscles (oblique's and transversus abdominis muscles) which are anteriorly attached to the lateral side of each rectus abdominis muscles [44] and posteri-

orly connected to the lumbar vertebral column. Thus, the horizontal tension produced by these deep abdominal muscles could pull the rectus abdominis muscle laterally toward the fixed sites on the vertebral column, increasing the inter-rectus distance.

The abdominal crunch is one of the most used exercises in abdominal strengthening programs. However, the abdominal crunch has been considered a risk exercise for development of rectus diastasis [8], and lately core training with the drawing-in exercise has been recommended both in the general population [45, 46] and during pregnancy and even after childbirth [11]. It has been proposed that the activation and training of the transversus abdominis draws the bellies of the rectus abdominis muscle together [32], which improves the integrity of the linea alba and increases fascial tension, allowing efficient load transference and torque production [11, 47]. However, due to the low number and quality of the studies, there is insufficient evidence to support this statement. Additionally, there are studies suggesting that the activation of the transversus muscle has a widening effect of the linea alba, and the abdominal crunch produces a narrowing of the IRD [48]. A recent RCT found that curl-up exercises improve abdominal muscle strength without worsening inter-recti distance in women with diastasis recti abdominis postpartum. https://doi.org/10.1016/j.jphys.2023.05.017.

▶ **Warning** No scientific evidence on the effect of exercise in diastasis recti

Transversus muscle activation has a widening effect on the linea alba.

21.8 Conclusions and Future Directions

Ultrasound measures the IRD in mm and such levels of assessment are difficult to detect by palpation.

The ultrasound imaging is recommended to access IRD and the evolution of DRA in postpartum women.

The IRD cut-off value for categorizing DRA needs to be further studied. Further studies are needed to evaluate the effect of different abdominal exercises in the reduction of the IRD during the postpartum period. Given the high prevalence and the concern, many women experience with this condition, further high-quality randomized controlled trials on the effect of different abdominal exercises on the DRA are warranted.

Measurements of other structures (muscle length, thickness), comparison with multiparous women, and longer follow-up studies than 6 months postpartum could be of value in future studies.

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Physiotherapy Treatment for the Abdominal Wall

22

Rafael Vicetto Martinez

22.1 Foreword

DRA is a complication of the abdominal wall, generally underestimated by health professionals that should be taken into account for its associated problems.

The linea alba is the anatomical structure on which this lesion is based, and the evolution of the patient will largely depend on the degree of its distension.

The importance of raising patients' awareness of their daily activities is to enable them to make correct management of pressures which will prevent worsening of diastasis. This will be crucial to the recovery process of the abdomen, as gentle training motions in hyperpresion will cause an increase in pressure that may harm the abdomen.

Prior to any treatment based on abdominal surgery, it is vital to strengthen the abdominal wall. A specific program of exercises will result in an approximation of the recti and an increase in abdominal tone (within existing functional limitations).

It is necessary to always perform an abdominal untrasonography as well as a manual examination of the area for a correct differential diagnosis. Information must also be gathered about existing pelvic floor status, lumbar pathologies, or digestive disorders.

22.2 Introduction

The disparity found in the prevalence of Diastasis rectus abdomini (DRA) is due to differences in the inter-rectus distance (IRD) considered normal or pathological, in the location of the point of measurement (supraumbilical, umbilical or infraumbilical), in the measurement protocol (in rest or in contraction of the lower abdomen), and in the measuring instrument employed.

There is no international consensus as to the degree of separation that should be considered pathological, but not as to the location of the measurement.

In a study with cadavers, Ratz et al. [1] found that the width of the linea alba increases with age and after 45 years of age, mostly at the supraumbilical level.

These authors considered that, below 45 years of age, diastasis is pathological if the IRD is greater than 10 mm in the supraumbilical area, 27 mm at the level of the umbilicus, and 9 mm below it. Beer et al. [2], based on ultrasonography measures, suggest that in nulliparae, the IRD

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/978-3-030-43840-1_22.

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© Springer Nature Switzerland AG 2023
M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_22

should be considered normal if it is less than 22 mm at 3 cm above the umbilicus and 16 mm at 2 cm below.

Other authors, based on palpation, consider that there is diastasis when the separation between the recti of the abdomen is wider than two fingers [3], or 2.5 cm measuring with calipers and ultrasound scanner [4].

22.3 Patient Selection

We must take into account different points that we explain below.

1. Importance of the Anatomy and Action in the DRA
2. Pregnancy and Postpartum
3. Obesity/Overweight
4. Pelvic Floor
5. Musculoskeletal Problems (Low Back Pain and Diaphragm)
6. Postures that Increase Intra-abdominal Pressure and Worsen Diastasis
7. Evaluation of the Abdominal Muscle

22.3.1 Importance of the Anatomy and Action in the DRA

Previous studies have pointed out the important role of the abdominal muscles on the stabilization of the pelvis, especially the transverse abdominal, which acts as a corset [5, 6].

An association has been found between the weakness of the abdominal muscles and the ability to stabilize the pelvis, both in pregnancy and in the postpartum period, as a result of structural adaptations of these muscles during gestation [7] and may cause, among other problems, back pain and pelvic floor dysfunction [8–11].

Studies with electromyography and ultrasonography have demonstrated a synergic coactivation of the abdominal muscles and the muscles of the pelvic floor that would help to increase intravaginal pressure in situations of increased intra-abdominal pressure, helping to maintain urinary continence [12–15].

Given the importance of the abdominal muscles in the management of intra-abdominal pressures [15, 16], we consider it important to assess the degree of diastasis present in the postpartum period, to address adequately the recovery of the webbing of the abdomen, and to avoid exercises that may increase the damage (all those that require the action of the rectus abdominis muscles, flexors of the trunk, and hyperpressive abdominal movements).

During the postpartum period, many women resort to programs of abdominal strengthening in an attempt to recover their figure as quickly as possible, but the effectiveness of these programs is not evidence-based and often prove to be counterproductive.

It has been observed that IRD decreases during the isometric contraction of the abdominal muscles [17] and that the decrease of the IRD in the postpartum period was correlated with improvements in the isometric strengthening of the flexors of the trunk; not to be confused with the isometry which requires a shortening of the muscle fibers, from which the former differs greatly [18].

On the other hand, the use of an abdominal supportive belt immediately after birth seems to be effective to decrease diastasis [19], as it increases lumbo-pelvic stability and redirects intra-abdominal pressure, unloading the lumbar rachis [16].

22.3.2 Pregnancy and Postpartum

It has been shown that the IRD increases as pregnancy progresses, with prevalence in the third trimester between 66.6 [3] and 100% [20].

Greater weight gain in pregnancy and parity are factors associated with IRD [8, 9]. The prevalence of IRD remains high in the immediate postpartum, being important enough in 53.3–62.5% of women so as to require protection exercises [3, 21].

This prevalence decreases in the postpartum period, but it is not spontaneously resolved in many women [3, 22]: 36–52.4% at 2 months postpartum [3, 20] still show IRD, up to 39% at

6 months postpartum, and even a year after giving birth differences can be found with respect to control groups [23].

It will be therefore important to design, during pregnancy, a correct exercise plan that strengthens the abdominal area and prevents abdominal hyperpressure, as well as to provide general care of the abdomen in the postpartum recovery period [11].

22.3.3 Obesity/Overweight

Overweight is one of the main parameters that affect the linea alba via an increase of pressure in the central line of the abdomen, which coupled with eventual movements that require an activation of the rectus abdominis, increasing abdominal hyperpressure and with it abdominal distension. Overweight women will show greater diastasis, as visceral containment by the anterior musculature of the abdomen becomes anatomically impeded because of the increased pressure in the central line of the abdomen.

Overweight in the postpartum period is a decisive factor in both the establishment of abdominal diastasis and in its subsequent treatment, as the excessive abdominal volume further complicates recovery in these cases.

22.3.4 Pelvic Floor

The key reason why we have to take into account the structures of the pelvic floor in our assessment of the abdominal diastasis is that visceral contents in pregnancy cause a considerable weight increase in the urogenital area, so pregnant women are more prone to being affected. Urinary incontinence will be more common in patients who have increased abdominal distension, as the abdominal wall is weakened and cannot correctly manage pressure [16].

Abdominal diastases are often accompanied by musculature weakening, which in turn causes in many cases loss of urine, rectal dysfunctions which hinder evacuation because of the change in the ano-rectal angle (constipation, hemorrhoids), low back pain because of a structural imbalance, and changes to body biomechanics.

Recovery should be focused on postural control, avoiding positions that increase intra-abdominal pressure, which may cause discomfort and further problems to the pelvic floor.

The control of the exercises by the physiotherapist will be the key to a successful recovery of the abdomen.

22.3.5 Musculoskeletal Problems (Low Back Pain and Diaphragm)

The abdominal space is delimited by the diaphragm in its superior part, by the perineal muscles in the inferior part, by the lumbar spine in the posterior area, and by abdominal muscles in the anterior area (transverse abdominis, internal obliques, external obliques, and rectus abdominis).

In ideal conditions of equilibrium, any variation in pressure should be equally distributed throughout the entire abdominal space, affecting all visceral except the urethra. This balance is broken by diastasis.

Variations in abdominal pressure can be brought about by performing physical activity requiring trunk flexing movements (classic "sit-ups") or by brusque reactions of the organism such as sneezing.

Back injuries are one of the leading causes associated to bad abdominal balance and IRD dysfunction [5]. Lumbar spine re-education and motor control are the bases for recovery in physical therapy.

Breathing itself implies a pressure variation in the abdomen, as the descent of the diaphragm to facilitate the entry of air to the lungs reduces space and increases pressure.

A bad distribution of this pressure can cause various physical problems (hernias, lower back pathologies, lower extremities injuries, etc.).

22.3.6 Postures that Increase Intra-abdominal Pressure and Worsen Diastasis

When the recti of the abdomen are activated, with movements such as flexing the trunk, pressure throughout the abdominal compartment is increased, causing damage to the linea alba, as it cannot withstand the stress.

The vast majority of patients are unaware of this and also the way the move worsens their injury.

There are movements to avoid in order not to cause hyperpressure:

- Efforts in abdominal flexion, repetition of bad movements in daily life, such carrying heavy weights, as well as a multitude of movements is maintained in flexion in daily activities..
- Some sports that involve rotation of the trunk and abdominal hyperpressure such as golf, tennis, or certain yoga and pilate poses.

But there are also other alterations in our body which can create harmful pressure, such as chronic coughing, bouts of allergies, and constipation, all of which lead to apnea.

22.3.7 Evaluation of the Abdominal Muscle

We may assess abdominal diastasis by manual palpation of the abdomen, taking into account the number of fingers that fit between the recti [3, 21]. This measurement offers satisfactory intrarater reliability [24], but poor interrater reproducibility [21, 24].

Calipers have shown high intrarater reliability [22, 25] and a high degree of agreement with ultrasonographic measurements taken above the umbilicus [4, 10]. Ultrasound has proved accuracy and validity and is considered the gold standard in the evaluation of IRD [4, 23, 24].

Besides assessing IRD, ultrasonography enables to evaluate the cross-sectional area of the recti abdominis [23], offering fundamental data for establishing a correct diagnosis.

22.4 Pretreatment Evaluation

22.4.1 Physical Examination/US Examination

22.4.1.1 Manual Measurement of IRD

Three measurement points will be checked for manual control; it is considered that there is an IRD, if there is a perceived inter-recti distance of more than two fingers or if the patient presents a mountain-like abdomen. This technique is explained in the following lines and in the Video 22.1.

1. Body position of the patient for the assessment

   Patient is lying in supine, and knees are supported to achieve relaxation of the abdominal muscles.
2. How to activate musculature for assessment

   We will ask for a slight flexion of the trunk in the patient, without forcing and keeping the shoulder blades in contact with the stretcher.

   This will activate the recti abdomini and enable us to evaluate the inter-recti distance.

22.4.2 Position of the Hand in the Abdomen

1. Relaxed hand in the area, exerting no pressure:

Fig. 22.1 Assessment above the umbilicus

(a) Assessment above the umbilicus—Fig. 22.1
(b) Assessment at the umbilicus—Fig. 22.2
(c) Assessment below the umbilicus—Fig. 22.3

22.4.3 Ultrasonography

We position the transducer and locate the two recti abdomini in the two areas that are to be analyzed for diastasis assessment: supraumbilical and infraumbilical.

We will not be able to assess the umbilical area via ultrasound because of image issues.

The patient is requested to slightly flex the abdomen, evaluating the approximation of the recti abdomini muscles, determining the distance in centimeters.

Fig. 22.2 Assessment at the umbilicus

Fig. 22.3 Assessment below the umbilicus

In cases of very acute diastases, it may be more complicated to establish an exact measurement, because if the separation is very pronounced, the two recti cannot be viewed in the screen within the same shot.

A panoramic view may be necessary, if the linear probe of the ultrasound machine allows it.

Ultrasound has shown accuracy and validity and is considered the gold standard in the evaluation of IRD [4, 23, 24]. In addition to measuring IRD, it allows to assess the cross-sectional area of the recti abdomini [23]. (See Video 22.2).

In the abdominal assessment, we must take into account how the alba line acts, as well as the abdominal muscles since it is essential to assess it for a correct recovery program (See Video 22.3).

22.5 Technique for Recovery

You can work with the three types of abdominal, costal, or diaphragmatic and upper breaths to become aware of the tissues of the abdomen and the costal movement.

The person can be seated, place the hands first between the navel and pubis and breathe bringing the air to this area and connect the movement (Fig. 22.4) that occurs in these tissues when breathing; then move to place the hands at the costal level and feel the movement of the ribs when inspiring and exhaling and finally placing the hands at the upper level just below the clavicles and inspiring and letting the air out.

During the whole exercise, one of the hands can be left on the abdomen to feel if abdominal tension is produced at any time when the air is drawn (Fig. 22.5).

Define the physical space of the abdomen so that the person knows the place that occupies his abdomen and the muscles that she has to activate. In short, become aware of the real space that your abdomen occupies and integrate it not only at the intellectual level but at the sensory-motor level.

You can perform various exercises that involve activation of the abdomen; usually the area that is most difficult to identify and feel is the lower abdomen area; to wake up this area, you can perform the following exercise: lie down in supine

Fig. 22.4 Starting posture

Fig. 22.5 Palpation of the oblique and transverse muscles

position, you are instructed to inspire and when exhaling to contract the lower abdomen from pubis upward, as practice is acquired in this exercise, it can also be performed in sitting and standing.

We explain how to perform a simple exercise to activate the transverse muscle during the entire gluteus lift movement. We will get activation of the abdominal area and functional recovery of the abdomen (Figs. 22.6 and 22.7).

We should always check and assess the condition of the diaphragm in the patient; if there is tension, it should be treated.

As the diaphragm has been indicated in the exploration section, the diaphragm can be blocked both in inspiration and in expiration.

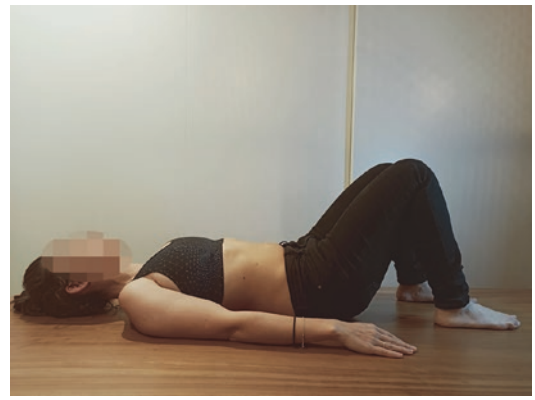

Fig. 22.6 Lying posture for abdominal control

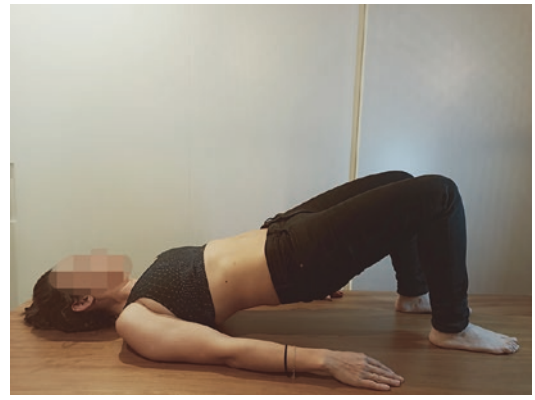

Fig. 22.7 Posture lying down for muscle activation and abdominal work

There may also be restriction in one hemidiaphragm and not in the other.

This blockage can affect the functionality of the abdomen and may limit or hinder its recovery. Once the exploration has been carried out, these tensions can be worked with manual tension relaxation techniques, such as costal flange maneuvers and/or diaphragmatic breathing release and reprogramming exercises.

During the session, the different abdominals alternate, such as the straight and oblique abdominals, as well as the oblique abdominals between them, and this allows the fibers of the muscles to move by sliding which improves their flexibility and sensitivity.

You can also perform lumbopelvic stabilization by saying how to work the body's ability to control the position of the pelvis and trunk in different postures and movements.

As an example: stand with arms along the body with about 45 degrees of separation, as leg is raised and from this posture a self-elongation is made, the arms push towards the ground and the leg that is raised performs a front-to-back swing always attending to the abdomen as if there is no bulge.

Remember that classic abdominal exercises are contraindicated both in the existence of diastasis and in the postpartum due to its harmful effect on the pelvic floor.

22.6 Post-treatment Care

The entire recovery program should be based on eliminating possible excess pressure at the abdominal level that can manage an increase in pressure with the consequent damage at the tissue level.

22.7 Complications

After carrying out a program for abdominal recovery and learning everything necessary for abdominal care, we must take into account that a new pregnancy will cause new abdominal diastasis that should be treated in the future.

22.8 Conclusions

The treatment of diastasis is not only an aesthetic issue, the correct functioning of the abdomen is important both for the pelvic floor and for the individual's posture. Its assessment is not limited only to measure this diastasis but to assess all the elements that influence the abdomen as well as understand the functionality of the abdomen. There are also many techniques that can be applied for treatment.

As indicated at the beginning of the articles, many women come to the physiotherapy office without a diagnosis of diastasis, sometimes it is the woman herself who suspects the existence of a diastasis. It is important to inform and "self-diagnoses" "herself."

It would be necessary to find a channel so that assessment of the abdomen was always done in a postpartum; if needed it can be referred to a physiotherapist for treatment. Ideally, a physiotherapist should evaluate every woman who has given birth. Today, this seems complicated but at least health professionals who evaluate women after childbirth should know by the diagnosis of diastasis and its effects on the body in order to refer the person to a physiotherapist for recovery.

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23 Non-surgical Abdominal Treatments

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Take-Home Points

- Non-surgical abdominal treatments are suitable for patients who do not need significant reshaping in an area.
- Non-surgical abdominal treatments require little or no downtime, no general anesthesia or incisions, they do not leave scars, and side effects are minimal for most patients.
- Results can last if the patient maintains his/her weight; thus, it is essential to have a healthy lifestyle.

23.1 Introduction

During pregnancy, endocrinological, immunological, metabolic, and vascular changes may affect abdominal skin [1] and have an impact on women's life [2]. These changes include formation of new stretch marks (striae gravidarum), lax skin, and localized fat accumulation [3, 4]. Reference procedures to substantially reduce these alterations are invasive techniques, such as liposuction or abdominoplasty. Thus, non-invasive procedures can be the most suitable options for the aesthetic recovery of the abdominal tissue.

Interest in non-invasive approaches has grown, thus non-surgical abdominal treatments are increasing as well. Due to the high demand for safer procedures with faster recovery, fewer side effects and less discomfort, new modalities have been developed to address body contouring from a less invasive perspective.

23.2 Abdominal Fat Reduction

Currently, liposuction is already the most common and effective procedure for body contouring, but given its invasive nature and inherent risks, there has been continuous research for the development of non-invasive methods [5]. Non-surgical treatments for abdominal fat reduction are comparatively new in the field of excess fat removal and include minimally invasive treatments that selectively break down fat cells in specific areas to reduce the size of subcutaneous fat pockets (fat deposits that sit beneath the skin, but above the muscle) [6]. Non-invasive body contouring currently represents the fastest growing area of aesthetic medicine.

The four leading non-invasive techniques available for reducing localized subcutaneous adipose tissue are cryolipolysis, radiofrequency (RF), low-level laser therapy (LLLT), and high-intensity focused ultrasound (HIFU) [6, 7].

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/978-3-030-43840-1_23.

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_23

23.2.1 Cryolipolysis

The cryolipolysis technology, developed in the 1990s, is an effective alternative to invasive treatments for silhouette remodeling [5, 8, 9] and different studies have proven its efficacy and safety [6, 7]. Cryolipolysis is a technique in which controlled cold exposure is performed in the selective destruction of fat cells [10]. The first study in animal models was carried out by Manstein et al., renowned dermatologists from the Massachusetts Hospital [9].

Scientific basis: The principle of cryolipolysis is based on the effect of controlled local cooling of the skin (at temperatures low enough to freeze fat cells) that can induce selective damage and subsequent loss of subcutaneous fat without harming the overlying skin [11]. Cryoadipolysis takes advantage of differences in cold-sensitivity of different cell types, being adipocytes the most susceptible cells. This is because adipocytes contain excess of triglycerides that crystallize under temperature around 10 °C [12, 13]. On the other hand, the surrounding cells contain more water (Table 23.1), which freezes below −5 °C [9]. These facts make the adipose tissue more susceptible to cold than other tissues such as muscle, nerves, and skin [4, 5]. When fat cells are cooled, cryolipolysis produces crystallization of the cytoplasmic lipids within the adipocytes. However, the destruction of adipocytes does not affect serum lipid levels or liver function tests significantly [10]. Cold induces an inflammatory response that causes programmed death (apoptosis) of adipocytes [14]. Apoptosis causes cellular contraction, maintenance of organelle integrity, blistering of the membrane surface, condensation/fragmentation of nuclear chromatin, without negatively affecting the neighboring cells [12], and gradual decrease of the subcutaneous fat layer. Because skin, muscle, and nerve tissues freeze at a lower temperature than fat, they remain unharmed [5, 15, 16]. Its effects are not immediate, although a statistically significant reduction can be achieved within approximately 2 months from application [17].

Application: Cryolipolysis targets subcutaneous fat, which is the fat that is above the muscle, which can be treated and reduced effectively and is not pronounced in obese patients with considerable skin flaccidity [18]. This is not the case with visceral fat, which is the fat surrounding the organs under the abdominal muscles, making it difficult to remove [19]. This procedure can selectively focus on and reduce subcutaneous fat while leaving the surrounding structures intact [5, 7]. Cryolipolysis is a body contouring procedure not intended as a method for weight loss (Fig. 23.1). Treatments take 35–60 min to perform, and patients usually need one or two sessions. Clinical efficacy data have shown fat reduction across multiple treatment locations, such as the submental area, arms, flanks, abdomen, and inner and lateral thigh [10, 20, 21]. This chapter focuses on the abdomen and flanks. Despite being a safe technique, special attention should be given to patient selection and prepara-

Fig. 23.1 Example of cryolipolysis device

tion in order to obtain the expected result and ensure patient satisfaction [22].

Expected results: Cryolipolysis is considered a safe and effective procedure, with high patient satisfaction rates [22]. Usually, there is about 25% decrease in the thickness of the subcutaneous fat layer within 90 days after treatment and in some patients results can be maintained in the long term (between 6 and 9 years after treatment) (Fig. 23.2) [8, 13]. The decrease in the number of adipocytes results in a lower capacity to store fat in the treated area. Being a targeted treatment that only affects cooled subcutaneous fat [9], body fat that is not cooled by the applicator will not be affected, being distributed evenly. Cryolipolysis is not dependent on the operator, which should be considered an advantage of the technique, although long-treatment sessions are an important disadvantage. See Video 23.1 [17].

Post-treatment care: There typically is minimal recovery time after and patient will be able to return to her normal daily routine immediately after the procedure. Since it is common for the treated area to feel bloated and to look swollen for the first 3 weeks after the treatment, wearing compression tights or yoga pants may be of help for feeling good during this period. Prevent weight gain; it will help to maintain the achieved results. Avoid the use of anti-inflammatory medications such as ibuprofen, naproxen, and Celebrex for 6 weeks after the treatment. The inflammatory response in your body is the mechanism which removes the fat cells, and inhibiting the body's ability to get a response may slow the progress of your result. Moisturize the area with moisturizer and sunscreen.

Contraindications for treatment: Patients with cold-sensitive conditions such as Raynaud's Syndrome or any disease related to cryoglobulinemia, cold agglutinin disease, paroxysmal cold hemoglobinuria, cold urticaria, severe varicose vein dermatitis, or loss of skin continuity due to prolonged exposure to the localized cold inducer. The literature also cites some other conditions with positive rheumatoid factor (Sjögren's Syndrome, lupus, vasculitis, rheumatoid arthritis, hepatitis C) [22].

Side effects: Expected side effects are temporary erythema, mild swelling, tingling, bruising, and transient numbness that usually resolve within 14 days after treatment [8]. Serious or lasting side effects are extremely rare.

23.2.2 Low-Level Laser Therapy (LLLT)

Numerous studies have shown laser therapy's ability to induce a variety of cellular reactions in non-photosynthetic cells [23–26], and increasing evidence suggests that laser therapy may alter cellular bioenergetics, influencing intracellular functional-biochemical properties and producing a diverse and observable clinical effect [27]. In the last decade, the use of LLLT as an adjuvant of liposuction for non-invasive body remodeling, cellulite reduction, and improvement of the blood lipid profile began to be investigated, and LLLT can also help in autologous fat transfer procedures by improving the viability of adipocytes. However, the underlying mechanism seems to be unclear [28].

Scientific basis: It is based on experiences that the application of a 635-nm laser leads to the formation of small temporary openings in the adipocyte membrane, which allows fat to be released into the interstitial space without destruction of the cells. As a result, a reduction in the thickness of the subcutaneous adipose tissue occurs. It seems that this mechanism is a consequence of the photoexcitation process of cytochrome c oxidase in the respiratory chain of mitochondria [29–31].

Application: LLLT is intended to treat the abdomen and flanks for fat reduction and can be used on other areas. The treatment, which usually takes 25 min per area, is typically painless and patients only feel a warming sensation.

Expected results: The first experiments with LLLT that supposedly produced the aforementioned effect showed that the application of 635 nm of 10-mw intensity for 6 min produced a fat reduction of approximately 99% [31], although later studies, such as Brown's et al., did

Fig. 23.2 Abdominal fat reduction with one cryolipolysis session, before (**a**) and results at 3 months (**b**)

not support these findings [28]. Results are noticeable after about 6 weeks and finally after about 12 weeks. Research by Decorato et al. [32] showed that a single treatment with a 1060-nm diode laser on the flanks resulted in an average fat reduction of 13% at the 6-week follow-up, which was maintained at 12 weeks. Bass and Doherty found a 16% reduction in fat thickness of the abdomen 12 weeks post-treatment [33]. In a separate pilot study comparing hyperthermic laser lipolysis with cryolipolysis, there were no statistically significant differences in outcome when measuring fat reduction of the flanks (24% versus 22%, respectively) [32].

Post-treatment care: Usually patients resume normal activities immediately after treatment, without downtime, pain, or the need of compression garments.

Contraindications for treatment: Patients with active deep vein thrombosis or thrombophlebitis, hemorrhagic conditions, local malignancy, recently radiated tissue, skin disease (e.g., eczema), and tuberculosis. Also, precautions need to be taken in patients with impaired cognition or communication and in patients with infection [34].

Side effects: Side effects of the diode laser include discomfort during treatment, burns, temporary nodules, and prolonged tenderness [33].

23.2.3 Non-thermal Pulsed Ultrasound

The pulsed, focused ultrasound system is an innovative technology that delivers bursts of pulsed focused ultrasound to non-thermally and selectively destroy targeted subcutaneous fat cells [35]. Ultrasound fat reduction uses highly focused sonic waves to break down fat cell walls in the treatment area, thereby releasing the fat inside to be metabolized by the body and reducing the size of a fat deposit [6].

Scientific basis: Depending on the acoustic parameters used, ultrasound energy can induce a wide range of biological effects that can be intelligently crafted to cause positive outcomes in the targeted tissues. While low levels of ultrasound can produce beneficial, reversible cellular effects, higher levels of ultrasound energy (such as high-intensity focused ultrasound) can quickly raise the temperature of the targeted tissues, causing instantaneous coagulative cell necrosis [35]. The pulsed focus ultrasound system achieves fat cell reduction in a non-thermal fashion. The ultrasound energy transmits through the skin, creating rapid pressure changes that cause the fat cells to break down while leaving surrounding tissues unharmed [36]. The pulsed, focused ultrasound energy delivers results with a non-thermal cavitation effect that only targets the adipose tissue in the subcutaneous fat layer while controlling the temperature elevation (i.e., less than 0.5 °C increase) in the targeted tissues. The selective destruction of adipocytes leaves the surrounding collateral tissues in the treatment area unharmed. This approach is likely, partially responsible for its favorable safety profile [35].

Application: Treatments are intended for use on the abdomen and flanks. Patients usually need one to three sessions spaced 2 weeks apart. Its combination with other cosmetic therapies, such as radiofrequency, mechanical adipose destruction and/or injectable lipolysis, has shown promising results [37].

Expected results: Ultrasonography measurement showed a mean reduction of 0.5 mm of subcutaneous fat thickness that persisted for at least 3 days after treatment. One multicenter clinical study showed that a single treatment performed on the abdomen, thighs, and flanks led to a mean reduction of approximately 2 cm in the treatment area circumference 2 weeks after the session, maintaining these results at the 12-week follow-up visit [38]. Three non-thermal, pulsed ultrasound treatments can safely and significantly reduce abdominal fat [35].

Post-treatment care: No special post-treatment care is required, and no downtime is needed.

Contraindications for treatment: Infections and open skin lesions in the target area and the presence of active metallic implants, such as pacemakers or defibrillators in the treatment area. Precautions must be taken when the patient has keloids, implants, permanent dermal fillers, and

in the presence of factors that could alter or impair wound healing, such as smoking [39].

Side effects: This technique usually has no adverse effects due in large part to the mechanism of action of the pulsed focus ultrasound system [35].

23.2.4 Red Light-Emitting Diodes Therapy

Recently, there has been an increasing interest in attempting to treat obesity using non-invasive near-infrared radiation. Photobiomodulation with red light-emitting diodes therapy is one of the newest technologies for non-surgical fat reduction, which uses red light therapy to reduce the volume of subcutaneous fat cells. This technology uses 650-nm red light-emitting diodes. Near-infrared radiation is light existing between visible-spectrum rays and mid-infrared rays, longer than a visible ray and shorter than a mid-infrared ray, with a wavelength of 0.72–1.6 μA [40].

Scientific basis: Instead of removing or destroying fat cells, photonic lipolysis, or "red light therapy," delivers specific wavelengths of light through the skin using a specialized lamp. This light triggers the selected fat cells to create small openings and release some of their contents, thus helping them shrink in size. The 600–900 nm range light energy can pass through human tissues much easier than other wavelengths. Once absorbed into the skin, it is transformed into cellular energy that stimulates a variety of metabolic events [41] such as increase in energy levels by the release of ATP, increase of blood flow/circulation, bringing more oxygen and nutrients to cells and tissues, and increase in the production of collagen and fibroblasts, as well as phagocytosis, or cellular clean-up; formation of new capillaries; activation of the lymphatic system; stimulation or decrease of inflammation and stimulation of DNA or RNA synthesis; repair and restoring of damaged soft connective tissue; and lowering effects of oxidative stress/free radical damage associated with aging [42].

Application: It is intended to treat the abdomen, hips, or thighs. Treatments take about 30 min to perform, and patients usually need three or more sessions to achieve their goals.

Expected results: Results begin to appear within a few hours after treatment and continue to improve as the body metabolizes the fat, which is naturally eliminated as waste.

Post-treatment care: No special post-treatment care is required, and no downtime is needed.

Contraindications for treatment: Patients who are pregnant or have reduced liver function should not undergo treatment.

Side effects: Red light therapy is a very low-risk treatment with no determined side effects.

23.2.5 High Intensity Focused Electromagnetic Field (HIFEM)

High intensity focused electromagnetic field is a technology developed for non-invasive, non-ionizing, non-radiating, and non-thermal procedures to simultaneously build muscle and burn fat (Fig. 23.3). Muscles represent approximately 35% of the human body's weight, but existing aesthetic treatments only address fat. The HIFEM technology penetrates through the skin to impact muscle tissues and abdominal fat, being the only technology that simultaneously develops muscle and burns fat, all without affecting the surrounding tissues [43].

Scientific basis: The energy produced by HIFEM penetrates through the skin to impact muscle tissues and abdominal fat. Focused energy induces 20,000 muscle contractions per session. During normal voluntary muscle contractions, muscle fibers relax between each nerve stimulus due to the inability of the central nervous system to receive another impulse while the former is still in action. Through this technology, impulses are generated, which are independent of brain function and at such a rapid rate that it does not allow for relaxation. Under normal conditions, the greatest amount of tension that could be developed and maintained physiologically is called maximum voluntary contraction (MVC).

Fig. 23.3 Example of HIFEM device

It usually lasts only for a fraction of a second. Contractions with a tension greater than MVC are defined as supramaximal. HIFEM can generate supramaximal contractions and maintain them for several seconds, which significantly increases the physiological stress/workload necessary to allow the muscles to adapt. HIFEM energy interacts selectively with motor neurons while the skin is unaffected. Induced supramaximal muscle contractions are accompanied by a rapid metabolic reaction in fat cells, generating intensive lipolysis [44]. This metabolic reaction overwhelms fat cells, which become dysfunctional and begin their programmed death (apoptosis). The resulting effect is a combination of muscle strengthening, muscle growth, and fat alteration. The lack of weight loss after treatment thus appears to be a logical effect since the weight of lost fat tissue is compensated by the weight of gained muscle volume [45].

Application: It is intended for men, women, young, middle-aged or even older people who are not satisfied with the shape/condition of their body. See Video 23.2. The use of the device is not limited to (treating) patients who cannot achieve the desired result of muscle definition in the gym (Fig. 23.3), but it also shows potential for candidates who are not suitable for other body modeling procedures, for example, heating or freezing technologies. It is cleared to reduce fat and stimulate muscles in multiple body areas, such as abdomen, buttock, arms (biceps and triceps) and calves, and there are special protocols designed for treating each of these body parts. During the procedure, the patient can lie down and relax. A course of treatment generally consists of four 30-min sessions spaced 2 or 3 days apart. The procedure does not require any recovery time. Usually, patients can return to their daily routine immediately after each session.

Expected results: Positive results are usually observed 2–4 weeks after the last session and continue to improve for several weeks after treatment. According to clinical studies, mean increase in muscle mass is 16% and mean fat reduction is 19% [46, 47]. The effects have been tested in various clinical studies, in which very well-established evaluation methods (MRI, CT, ultrasound, and histology) were used during the tests, and results consisting of muscle gain and fat loss were obtained. One study on women at 3 to 36 months after delivery showed a mean decrease of 17.7% in abdominal fat thickness. Muscle thickness increased a mean of 17.85%, and abdominal separation decreased a mean of 16.6%. The improvement measured in this group of postpartum women was 60% higher than that observed in the normal population. The study concluded that the HIFEM procedure is highly effective and safe for the change of image in postpartum women, especially thanks to its effect on abdominal

separation. Compared to other non-invasive body-shaping technologies, HIFEM showed competitive results regarding waist circumference reduction. A study on cryolipolysis reported a circumference reduction of 6.86 cm, [48] an LLLT study reported waist reduction of 6.83 cm, [49] and an RF study showed 4.93 cm [50]. Studies on HIFU showed a reduction of 4.1–4.7 cm [38, 51]. Based on the results obtained in a study with HIFEM, where mean waist reduction was 4.37 cm, it seems this technology is highly competitive.

Post-treatment care: No special post-treatment care is required, and no downtime is needed.

Contraindications for treatment: This technology uses a strong magnetic field, so it is contraindicated in patients who have metallic and electronic implants (e.g., cardiac pacemakers). Its application is also contraindicated in the area of the head and heart or in patients with specific medical contraindications such as malignant tumor, injured or damaged muscles, fever, and pregnancy.

Side effects: Muscle fatigue is a relatively frequent side effect that resolves within 12–48 h, [45] and mild muscle soreness resolved one day after the first session within 24 h [46].

In Table 23.1, a summary of all the abdominal fat reduction technique can be found.

Table 23.1 Summary table for abdominal fat reduction techniques

Technique	Indications	Advantages	Disadvantages	Side effects
Cryolipolysis	Subcutaneous fat reduction	Reduce subcutaneous fat while leaving the surrounding structures intact Minimal recovery time results can be maintained in the long term	Is not a method for weight loss Not appropriate for patients with cold-sensitive conditions Results are noticeable after about 90 days	Temporary erythema, mild swelling, tingling, bruising, transient numbness
Low-level laser therapy	Abdomen and flanks fat reduction	Is painless and patients only feel a warming sensation Results are noticeable after about 6 weeks Patients resume normal activities immediately after treatment	Precautions must be taken when the patient has keloids, implants, permanent dermal fillers, and in the presence of factors that could alter or impair wound healing, such as smoking	Discomfort during treatment, burns, temporary nodules, prolonged tenderness
Red light-emitting diodes	Abdomen, hips, or thighs fat reduction	Results begin to appear within a few hours after treatment	Patients who are pregnant or have reduced liver function should not undergo treatment	It is a very low-risk treatment with no determined side effects
High intensity focused electromagnetic field	Reduce fat and stimulate muscles in multiple body areas, such as abdomen, buttock, arms (biceps and triceps), and calves	Positive results are usually observed 2–4 weeks after the last session and continue to improve for several weeks after treatment	It is not allowed for patients who have metallic and electronic implants, malignant tumor, injured or damaged muscles, fever, or pregnancy	Muscle fatigue, mild muscle soreness

In my experience, the best results for abdominal fat reduction are obtained with cryolipolysis and HIFEM. Both techniques combined promote better outcomes

23.3 Stretch Mark Reduction

Stretch marks (also known as striae gravidarum) are common adverse skin reactions caused during pregnancy that affect approximately 50%–90% of pregnant women. In pregnant women, younger age, maternal and family history of stretch marks increased pre-pregnancy and pre-delivery weight, and increased birth weight were the most significant risk factors identified for striae gravidarum [52]. In pregnant women, itchy stretch marks can be a sign of gestational herpes [53]. Stretch marks are also seen in other conditions, such as rapid weight gain (obesity), muscle hypertrophy (bodybuilders), endocrinopathies (such as Cushing's syndrome), breast augmentation, as a side effect of topical use and abuse of corticosteroids and as a complication of tissue expanders. In women, they are more frequent in the thighs, abdomen, and chest, and in men, in the upper arms [54–58]. Therapies targeting stretch marks should induce a controlled inflammation in the dermis that results in the stimulation of neocollagenesis through the recruitment of fibroblasts; these are listed in Table 23.2 and some of them are detailed above. To be effective, in addition to neocollagenesis, these modalities should also reduce erythema and improve pigmentation in the case of striae alba [59].

Table 23.2 List of technologies for non-invasive procedural therapies to treat stretch marks

Lasers
Ablative fractional CO_2 laser (10,600 nm)
Non-ablative fractional Er:YAG laser (1540 nm)
Non-ablative diode laser (1450 nm)
Nd:YAG laser (1064 nm)
Flashlamp-pumped pulsed dye laser (585 nm)
Copper bromide laser
Excimer laser (308 nm)
Radiofrequency (RF) (ablative/non-ablative)
Non-fractional
Fractional
Microneedle radiofrequency (MNRF)
Microneedling therapy or percutaneous collagen induction therapy
Light-based therapies
Intense pulsed light
UVB/UVA1 combined therapy and targeted phototherapy
Infrared light
Galvanopuncture
Carboxytherapy
Microdermabrasion
Platelet-rich plasma (PRP)
Chemical peeling

23.3.1 Laser Treatment

Several treatments have been proposed to aesthetically improve striae. The natural course of stretch marks argues for an increased vascularity in the early lesions (striae rubra). Hence, here, vascular lasers should have a beneficial effect, since hemoglobin works as a chromophore for specific lasers acting in this vascularity. Various types of lasers have been tested in the treatment of stretch marks with diverse results (see Table 23.1). The 585 nm pulsed dye laser with a 10 mm spot size using 3.0 J/cm^2 fluence can improve the appearance of striae and a histologic evaluation argued for the restoration of the elastin fiber network, as a small study found [60]. Other studies using the flashlamp-pumped pulsed dye laser (585 nm) showed some beneficial effects, such as striae width decrease, skin texture improvement, and increase of collagen expression with the exception of collagen I [61].

Scientific basis: Light energy emitted by laser devices on the skin is coherent, cohesive, and monochromatic light energy that acts on a specific tissue chromophore. Lasers target different chromophores such as water, hemoglobin, and melanin, and therefore improve the overall appearance of the stria by increasing collagen production, decreasing vascularization (especially in striae rubra) and increasing melanin pigmentation [62, 63].

Application:

1. **Pulsed Dye Laser:** It has shown that it is effective only for the immature element of stretch marks (striae rubra), being directed at the vascular element; it is not effective on dark skin and is associated with pregnancy-induced

hypertension; when combined with radiofrequency, it has a better response even in stretch marks [60, 64, 65]
2. **Copper Bromide Laser:** In one study, a 577 nm laser showed a mild-to-moderate effect on skin types II and III [66]
3. **1450-nm Diode Laser:** Not useful on skin of color (IV–VI) and associated with many complications [67]
4. **1064-Neodymium-Doped Yttrium Aluminum Garnet Laser:** Targets are immature striae with satisfactory results achieved so far [68–70]
5. **Excimer Laser:** It only repigments temporarily and does not have an effect of atrophy [71]
6. **Fractional Photothermolysis:** It has shown efficacy in the treatment of mature and immature stretch marks and an increase in the number of collagen and elastin fibers, with a good safety profile [72–74]

Expected results: Although a variety of lasers have been used in striae distensae (SD), results are inconsistent, and there is a lot of variety. The best results obtain an improvement of 80%, [75] and a satisfaction of 71.4% [76]. Ablative and non-ablative fractional lasers may have shown the maximum beneficial result [59]. Lasers in combination with other modalities, such as topical agents and additional energy devices, like radiofrequency, have also demonstrated promising preliminary results [62]. Usually, three to five sessions are required before effects are noticeable, and results appear within 2–6 months after the final session.

Post-treatment care: Keep the skin moisturized, and no special post-treatment care is required. No downtime is needed.

Contraindications for treatment: On ethnic skin (skin types IV-VI), treatment with flashlamp-pumped pulsed dye laser (585 nm) should be avoided due to the risk of permanent pigmentary changes [77].

Side effects: The treatment is usually well tolerated. There were no significant long-lasting adverse effects, except transient mild erythema and pigmentation.

23.3.2 Radiofrequency (RF)

RF technology is different from cosmetic lasers, since it produces an electric current instead of light. The energy produced is not likely to decrease due to tissue diffraction or epidermal melanin absorption, thus being appropriate for any type of skin [78]. RF original devices were monopolar or bipolar, and the newer that are available today can be multipolar, fractional, pulsed, and phase-controlled [79]. This technology supplies uniform heat at controlled depth to the dermal layers, causing direct collagen contraction and immediate hardening of the skin, leading to the remodeling and reorientation of collagen bundles and the formation of new collagen for months after treatment. This technology has been used in conjunction with other modalities like pulsed dye laser [80], autologous platelet-rich plasma [81], pulsed magnetic fields [82], and infrared light therapy [83], as well as topical options, like retinoic acid [84], and found it to be more efficacious than RF alone in management of SD.

Scientific basis: The supposed mechanisms of fat reduction after RF are thermal stimulation of adipocyte metabolism through enzymatic degradation mediated by triglyceride lipase and apoptosis and adipocyte rupture. Radiofrequency energy is conducted electrically to the tissue, generating heat when the inherent resistance (impedance) of the tissue converts the electric current into thermal energy. This generated heat results in tightening of the skin within the dermal tissue through immediate denaturation and contraction of collagen fibers and later forms new collagen in subsequent weeks and months [85]. Fractional RF treatment is characterized by the delivery of very short and high-intensity electric shocks at an adjustable repetition frequency. Fractional RF uses a handheld device with a series of microneedles, which can vary in number from 5 to 225, and produce a series of "microdamaged" heat points in/on the skin that initiate the regenerative process.

Application: Radiofrequency has become popular for its effectiveness to treat acne scars,

keloids, rosacea, and inflammatory acne, as well as to improve skin laxity and reduce rhytides [86]. Radiofrequency can be used on areas of the body other than the abdomen, including the neck, face, arms, thighs, knees, and buttocks. It generates lower temperatures than lasers and can be focused specifically on the dermis [87]. The treatment protocol requires one or more passes over the area to be treated, depending on the complexity of the case, and each therapy session can last from 15 to 35/45 min. The treatment requires the application of a simple gel or a gel with hyaluronic acid or other active ingredients, to enhance the anti-aging effect.

Expected results: Studies on the effects of the use of RF devices in combination with laser still suggest that it is a synergistic, effective, and safe modality that could be a good alternative for stretch marks. A study combining both technologies in Asian patients with a darker skin tone, and in which a session with RF and pulsed dye laser was performed, plus two additional sessions with pulsed dye laser, 89% of the patients had a general improvement from "good" to "very good," and 59% had elasticity results improved from "good" to "very good." All histological evaluations showed an increase in the amount of collagen fibers, and six of the nine samples had an increase in the number of elastic fibers. Hyperpigmentation is considered only in one study patient, which improved in 3 months [80].

Post-treatment care: No special post-treatment care is required, and no downtime is needed. After the procedure, patients should not be exposed to the sun in the following 2 weeks and must apply a filter or protective cream on the treated area for at least 1 month whenever outdoors [88].

Contraindications for treatment: Patients with implantable medical devices, such as pacemakers or defibrillators, collagen vascular diseases, or autoimmune diseases. Caution is required with patients who are under radioactive treatment or have recurring herpes infections [89, 90].

Side effects: The side effects of RF treatment are rare but when they occur, they tend to be reddening of the skin, erythema, edema, or swelling that usually lasts for up to 24 h [91], and micro burns [88]. As in the case of non-fractional RF, fractional RF can also have side effects, which are characterized by burning points that heal within 5–7 days [88].

23.3.3 Microneedling (Collagen Induction Therapy)

Microneedling, also known as skin puncture or percutaneous collagen induction therapy, is a technology that involves the use of fine needles (1–1.5 mm) to create microdermal wounds [79]. This is considered a safe therapy for skin rejuvenation because it produces minimal damage to the skin and much less epidermal damage than, for example, laser ablation. There is also a lower risk of hyperpigmentation and with microneedles, making it an appropriate treatment option for people with thin, sensitive, or ethnic skin types (>III) [79].

Scientific Basis: These controlled microskin injuries with minimal epidermal damage stimulate a cascade of dermal wound healing (inflammation, proliferation and remodeling), which leads to the release of the platelet-derived growth factor, fibroblast growth factor (FGF), and transforming growth factor alpha and beta (TGF-α and TGF-β) [92, 93]. Subsequently, a fibronectin network is created, providing a matrix for the deposition of type III collagen, which is eventually replaced by type I collagen, resulting in decrease in appearance of fine lines and wrinkles, skin laxity, and scarring [94]. One day after needling therapy, keratinocytes begin to proliferate and release growth factors to promote collagen deposition by fibroblasts. Needling therapy modulates the expression of several genes in the skin (vascular endothelial growth factor, fibroblast growth factor, epidermal growth factor, type I and III collagen) that promote extracellular matrix remodeling [93, 95]. A study with individual human skin biopsies [96] only revealed changes in growth factor expression associated with the de novo synthesis of collagen (e.g., TGFβ1–3, FGF, EGF, VEGF, TNF-α).

Application: Microneedling is a relatively new treatment option in dermatology with many applications, including skin rejuvenation, acne scarring, rhytides, surgical scars, dyschromia, melasma, enlarged pores, and transdermal drug delivery [97]. (See Fig. 23.4 and Video 23.3) No single optimal treatment has been indicated for SD, so needling therapy may be considered a reasonable therapeutic option for the treatment of striae lesions [98]. A major advantage of microneedling is that it is less invasive and can be applied under local anesthesia (reinforced EMLA cream, emulsion in which the oil phase is a eutectic mixture of 7.0% lidocaine and 7.0% prilocaine, containing tetracaine 6.0% as well). In microneedling therapy, the epidermis remains relatively intact, which helps to limit post-procedural adverse events, such as bleeding, swelling, and pain [99]. It requires wearing a compression garment for 4–5 days following the procedure, and skin care is necessary.

Fig. 23.4 Example of microneedling device

Expected results: In a study on women with striae distensae, 43.8% of stretch mark distensions showed a clear improvement 3 months after the final session, and >85% of patients were somewhat or very satisfied with the results of their treatment (See Fig. 23.5) [98].

Post-treatment care: In the morning and at nights after treatment, a soothing and moisturizing compound should be applied, and also wear a compression garment for 4–5 days following the procedure.

Contraindications for treatment: Patients with dermatosis like vitiligo, lichen planus, and psoriasis as a consequence of trauma leading to koebnerization (or Koebner's Phenomenon), which can aggravate the dermatosis; patients with blood clotting disorders and on any anticoagulant therapy, like warfarin or heparin, as it can cause uncontrolled bleeding; patients with rosacea; skin malignancy, moles, warts, and solar keratosis (as needles may disseminate abnormal cells by implantation); patients with chronic skin diseases like eczema; history of taking isotretinoin in the last 6 months; extreme keloidal tendency; on chemo or radiotherapy; and if the area is infected [100].

Fig. 23.5 Before and after of microneedling treatment

Table 23.3 Summary table for stretch mark reduction techniques

Technique	Indications	Advantages	Disadvantages	Side effects
Laser	Treatment of mature or immature stretch marks, depending on the laser type	Striae width decrease, skin texture improvement, and increase of collagen expression (except collagen I)	Not good results on skin of color (IV–VI)	There were no significant long-lasting adverse effects, except transient mild erythema and pigmentation
Radiofrequency	Acne scars, keloids, rosacea, and inflammatory acne, as well as to improve skin laxity and reduce rhytides on areas of the body other than the abdomen, including the neck, face, arms, thighs, knees, and buttocks	Appropriate for any type of skin Remodels and reorients collagen bundles and promotes the formation of new collagen for months after treatment	Not allowed for patients with implantable medical devices, collagen vascular diseases or autoimmune diseases. Caution with patients who are under radioactive treatment or have recurring herpes infections	Are rare: reddening of the skin, erythema, edema or swelling that usually lasts for up to 24 h
Microneedling	Skin rejuvenation	Lower risk of hyperpigmentation than laser Modulates the expression of several genes in the skin that promote extracellular matrix remodeling Appropriate for people with thin, sensitive or ethnic skin types (>III)	Not allowed for patients with some dermal diseases (see contraindications for treatment), or blood clotting disorders and on any anticoagulant therapy	Pain, reactivation of herpes simplex, impetigo Allergic contact dermatitis to the material used in needles Tissue damage and hemorrhage with linear hypertrophic scars or post inflammatory hyperpigmentation

In my experience, the best results for stretch mark reduction are obtained with microneedling

Side effects: Complications are almost negligible. Side effects include pain, reactivation of herpes simplex, impetigo, allergic contact dermatitis to the material used in needles, more tissue damage and hemorrhage with linear hypertrophic scars or post-inflammatory hyperpigmentation due to the dermaroller being used in many treatments. Also, there is a risk of exposure to blood [100].

To conclude, in Table 23.3, a summary table for stretch mark reduction techniques can be found.

23.4 Lax Skin Tightening

23.4.1 Radiofrequency (RF)

Radiofrequency generates heat in different tissues by transforming energy through three basic mechanisms from electromagnetic field. When collagen is heated to 65–75 °C, there is immediate denaturation of the triple helix, followed by recoil and contraction of collagen fibers [4]. The final goal of this technology is to induce thermal damage to stimulate changes in collagen confor-

mation and produce neocollagenesis in deep layers of the skin and subcutaneous tissue [101].

Scientific basis: Studies have observed that the amount of synthesized collagen depends on the heating intensity of the connective tissue [102] and the rising of temperature and the depth of heating depends on the level of energy used and on the impedance of biological tissues [103]. The thermal effects of RF can change the shape, length, and diameter of collagen fibers for the reorganization of collagen [102]. Collagen is a protein composed of three polypeptide chains that form a triple helix structure. The process of thermal contraction of collagen begins with denaturation of the triple helix, which means that collagen undergoes a transition from a highly organized crystalline structure to a gel-like state. Collagen contraction occurs by the cumulative effect of the unwinding of the triple helix due to the destruction of intermolecular cross-links and the residual stress of such links. About 8 weeks after collagen denaturation, there is an induction of new collagen synthesis (neocollagenesis) [85]. Radiofrequency energy is free from the influence of diffraction, absorption by chromophores, or other tissue interactions, which, therefore, have no influence on the epidermal melanin. For this reason, it can be used on any skin types, and it is possible to control the depth of the energy's infiltration [104].

Application: There is no standard procedure to reference the parameters used with RF, such as frequency and device power, treatment time and temperature maintained in the skin; thus, it is necessary to use appropriate parameters for the achievement of therapeutic results, since the effects induced by electromagnetic fields are dependent parameters [105, 106]. The outcomes so far have shown that the RF treatment is effective and safe for treating aging skin and scars in mild-to-moderate degrees of severity, and patients go back to their normal lives after the procedure [107].

Expected results: Significant statistical outcomes about the effects of RF on skin laxity are low and limited. In animal studies, the most significant changes were found 2 months after the last application. In the biopsies taken at this time, an increase in the amount of collagen, elastic fibers, and mucopolysaccharides was noted [108]. The treatment of laxity sometimes requires more invasive or combined treatments to achieve better results, such as laser, botulinum toxin, or fillers, etc., allowing to reach maximum effects with minimum downtime [107].

Post-treatment care: No special post-treatment care is required, and no downtime is needed.

Contraindications for treatment: Patients with implantable medical devices, such as pacemakers or defibrillators. It is also contraindicated in collagen vascular diseases or autoimmune diseases. Caution is required with patients who are under radioactive treatment or have recurring herpes infections [89, 90].

Side effects: This technology causes few side effects and little to no downtime. Almost all studies have reported no permanent side effects following treatment [91]. Some common side effects are pain (generally low), reddening of the skin after a procedure, erythema that typically disappears within 24 h after treatment, or edema or swelling that can be expected to last for up to 24 h after treatment, although some patients may experience edema for up to one week.

23.4.2 Ultrasound Skin Tightening

Microfocalized ultrasound has been developed to achieve a significant stretching of the skin using a non-invasive method [109].

Scientific basis: Microfocalized ultrasound is focused on the subcutaneous tissue, at a depth of up to 5 mm in the middle-to-deep reticular layer of the dermis and subdermis. In contrast with high-intensity focused ultrasound, microfocused ultrasound uses much lower ultrasound energy to treat the superficial layers of the skin, i.e. 0.4–1.2 J/mm^2 of energy, a frequency of 4–10 MHz, and a focal depth of only 1.5–4.5 mm, [110] in spite of which it reaches a temperature over 60 °C

for a short time, producing small points (<1 mm^3) of thermal coagulation. At these points, collagen fibers in the facial planes, such as the superficial musculoaponeurotic system and the platysma, as well as the deep reticular dermis, are denatured, contract, and stimulate de novo collagen. This occurs by breaking the intramolecular hydrogen bonds that cause collagen chains to fold and assume a more stable configuration, resulting in shorter and thicker collagen. In addition, de novo collagen formation and new forms of viscoelastic collagen occur within the areas of thermal tissue coagulation, resulting in the stretching of lax skin. Intermediate papillary dermal and epidermal layers are not affected [109].

Application: There is no standard protocol for abdominal treatment. Studies report procedures with different number of passes, time of exposure and energy, and results are disparate as well [37].

Expected results: Results are seen within 2–6 months, but multiple sessions may be required before effects are noticeable. One study reported a mean waist circumference reduction of 4.4 cm after an application (two passes) of high-intensity focused ultrasound to the abdomen and flanks with a mean energy dose of 137 J/cm^2 [111].

Post-treatment care: No special post-treatment care is required, and no downtime is needed.

Contraindications for Treatment: Infections and open skin lesions, and the presence of active metallic implants, such as pacemakers or defibrillators, in the target area. For facial treatments, it is contraindicated when there is active severe or cystic acne. Precautions include treatment directly over keloids, implants, permanent dermal fillers, and the presence of factors that could alter or impair wound healing, such as smoking [39].

Side effects: Brief discomfort during treatment can be minimized with oral non-steroidal anti-inflammatory drugs. Other treatment-related adverse events include transient erythema, edema, and occasional bruising.

23.5 Intense Pulsed Light with Radiofrequency (RF)

This is a combined treatment to heat deeper layers of skin and induce a natural healing response, which in turn triggers collagen production. The addition of intense pulse light allows treating the skin at multiple levels and can help focus the RF energy more effectively. The goal of combined RF and light sources is to safely and effectively target tissue that will selectively absorb energy to produce thermal changes without injury to surrounding tissues and stimulate collagen generation [112].

Scientific basis: This technology combines light and radiofrequency into a single energy source. Although each has different selectivity mechanisms, both techniques work synergistically to generate localized heat in a target tissue. The main advantages of this combined technology are a reduction in optical or laser energy, which provides greater security and makes it suitable for all skin types, and a potential compensation for this reduction with electrically conducted RF energy [112]. At the same, the effectiveness of the treatment is not compromised because the energy of the RF that is simultaneously conducted coagulates the target without damaging the surrounding tissue [113].

Application: Treatments can be performed in-office with little to no downtime. Clinical applications of the combined technology include the removal of hair and leg veins, skin tightening, skin rejuvenation, and wrinkle reduction.

Expected results: Results appear gradually as the skin produces new collagen. Most patients begin with three to five sessions, spaced 3–4 weeks apart.

Post-treatment care: Keep the skin moisturized and with sun protection and no special post-treatment care is required. No downtime is needed.

Contraindications for treatment: It may not be suitable for darker or tanned skin.

Side effects: Adverse side effects are minimal and include transient, mild erythema, mild swell-

Table 23.4 Summary table for lax skin tightening techniques

Technique	Indications	Advantages	Disadvantages	Side effects
Radiofrequency	Treat aging skin and scars in mild-to-moderate degrees of severity	Collagen conformation, neocollagenesis in deep layers of the skin and subcutaneous tissue It can be used on any skin types Possible to control the depth of the energy's infiltration	There is no standard procedure to reference the parameters used with RF The treatment of laxity sometimes requires more invasive or combined treatments Effects on skin laxity are low and limited	Pain (generally low) Reddening erythema Edema Swelling
Ultrasound skin tightening	Developed to achieve a significant stretching of the skin	In contrast with high-intensity focused ultrasound, microfocused ultrasound uses much lower ultrasound energy to treat the superficial layers of the skin	There is no standard protocol for abdominal treatment and results are disparate Contraindicate on infections and open skin lesions and the presence of active metallic implants	Brief discomfort during treatment Transient erythema Edema Occasional bruising
Intense pulsed light with radiofrequency	Deeper layers of skin for collagen production: Removal of hair and leg veins, skin tightening, skin rejuvenation, and wrinkle reduction	Reduction in optical or laser energy, which provides greater security and makes it suitable for all skin types	Not suitable for darker or tanned skin	Transient, mild erythema Mild swelling Post-inflammatory hyperpigmentation (resolved within 24 h) Hypertrophic scarring

In my experience, the best results for lax skin tightening are obtained with microfocalized ultrasound

ing, post-inflammatory hyperpigmentation that is resolved within 24 h post treatment, and less frequent, hypertrophic scarring [112].

In short, a summary table for lax skin tightening techniques can be found in Table 23.4.

23.6 Conclusion

A wide range of technologies are currently available to improve the appearance of the abdomen after pregnancy. Some of these are low energy devices that use radiofrequency, light energy, or a combination of low energy sources to improve the appearance of the body. Although they are not invasive, they require multiple treatments and can only achieve relatively superficial effects. Results obtained through these procedures can be maintained and improved by following a balanced diet, avoiding weight gain, and exercising regularly.

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Mini Abdominoplasty

24

Carlos Gullón Cabrero
and Ramón Calderón Nájera

Take-Home Points

- The traditional abdominoplasty does not allow any option for correction within the given situations in which we need to correct the sequelae that occurs after a pregnancy or obesity.
- It is crucial to identify alternative procedures, allowing us to offer diversified solutions for the different cases.
- Different degrees of skin laxity and muscle aponeurotic system define the condition for different treatments.
- Miniabdominoplasty and modified abdominoplasty are surgical techniques that offer good alternatives for plastic surgeons to treat sequelae of pregnancy.

24.1 Introduction

Some plastic surgery procedures are aimed at correcting or improving congenital situations, and others are aimed at recovering a previous situation that has been altered. In the second group, there is a typical one for its frequency, the so-called pregnancy sequelae that fundamentally affect the breasts and abdomen.

The problems that abdominal contour surgery can correct include damage to lower abdominal skin, varying amounts and locations of excess fatty tissue, and bulging of the abdomen caused by musculofascial flaccidity. The etiology of acquired abdominal contour can be traced to the effect of pregnancy, aging, and weight gain or weight fluctuations, lifestyle, medications, hormones, genetics, embryologic development, and previous incisions.

The relatively rapid increase in volume that occurs in the abdominal cavity results in dilation of the muscle aponeurotic system, alteration in the distribution of abdominal fatty tissue, and dilation with associated loss of elasticity of the abdominal skin.

These phenomena present constantly after pregnancy to a greater or lesser extent depending on the quality of the tissues, the weight control during pregnancy, the previous state of the patient as to the strength of her muscle aponeurotic system, and hormonal factors that can affect to a greater or lesser extent the cutaneous appearance and the redistribution of fat that occurs during pregnancy. Alterations in the pelvic floor, dilation of the vagina, or the sagging of pelvic organs, such as the bladder of urine, are phenomena associated with sharp increase in volume of abdominal content. Therefore, the recuperation of a woman who has suffered injuries after successive

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_24

pregnancies falls within the multitude of care specialists, including but not limited to her plastic surgeon (gynecologists, urologists, general surgeons, and physical therapists).

After pregnancies, the abdominoplasty in a more complete way restores the muscular system by neurotic, adapts the fat distribution, and eliminates the cutaneous excess in the abdominoplasty. The abdominoplasty can be carried out when there is a marked sagging and allows us to remove the entire skin section from the anterior aspects of the abdomen between the navel and the pubis.

When the abdominal skin is not excessive, but there is redundancy and an altered distribution of fat or an alteration of the muscular aponeurotic system that almost always consists of the diastasis of the rectus abdominis muscles, we perform a mini abdominoplasty or a modified abdominoplasty, which will henceforth be the subject of the development of this chapter. These surgeries, which are variations of traditional abdominoplasty, allow us to satisfactorily treat that group of patients who would otherwise be left without adequate treatment. Mini abdominoplasty was firstly described by Greminger at the end of the 1980s [1].

The separate assessments of the tissues involved in the correction of the abdomen will allow us to make the most correct decision in each case and can offer a complete treatment to each of the parties involved. We consider the treatment of fatty tissue a very important part in the estimation of the final result, being exceptional that we can avoid the use of liposuction as a fundamental step of the surgery procedure.

The preoperative conditions of the patients must be adequate, and in this sense, we consider it very important to avoid complications. Abstaining from smoking 6 weeks prior to surgery and the prophylaxis of deep vein thrombosis with heparin, as well as the use of the intermittent pneumatic compression system in the lower extremities are some of the measures we need to follow to avoid complications.

Key Points

When the abdominal skin is not excessive, but there is redundancy and an altered distribution of fat or an alteration of the muscular aponeurotic system that almost always consists of the diastasis of the rectus abdominis muscles, we perform a mini abdominoplasty or a modified abdominoplasty.

24.2 Patient Selection and Timing

Miniabdominoplasty is indicated for those patients in which the traditional abdominoplasty is not necessary, because they present a marked supraumbilical laxity. If we are speaking about details in the differentiation of techniques between the miniabdominoplasty and the modified abdominoplasty, the selection of the patient would depend on the grade of laxity and state of the aponeurotic muscle system. Throughout this chapter, the ideal patient for each of the individual techniques is specified, as well as a decision tree to select the correct technique.

In respect to timing, it is important that the patient waits at least 3 months after natural childbirth to proceed with this intervention; in the case of caesarian section, it is recommended that the patient wait at least 6 months post childbirth to proceed with a miniabdominoplasty. It is important to note that the patient is not in a position to have children after the intervention, so that the results are maintained over time [2].

Key Points

Miniabdominoplasty is indicated for those patients for whom traditional abdominoplasty is not necessary, because they present a marked supraumbilical laxity. It is important that the patient waits at least 3 months after natural childbirth to proceed with this intervention; in the cases of a caesarian section, it is recommended that the patient wait at least 6 months post childbirth to proceed with miniabdominoplasty.

24.3 Discussion: Combination of C-Section with Miniabdominoplasty [3]

During pregnancy, there is increase in vascularization of the muscles and abdominal skin. The uterus multiplies in size, and there is a notable

increase in the abdominal perimeter at the expense of the uterine size. After delivery, there is a progressive regression of the uterus that will not be completed until the following several weeks. The muscles and skin will also begin the contraction process which will take several months. In some cases, this process can take more than 4 or 5 months.

Performing miniabdominoplasty under these conditions can lead to very unsatisfactory outcome. The size of the uterus will prevent the correct plication. Muscle dilation and lack of skin contraction will severely increase the difficulty in estimating the amount of tissue to be resected.

Not a few women experience alterations in fatty deposits, a situation that can vary in the months following childbirth. This fact introduces a further confounding variable when deciding on the correct surgical treatment.

Occasionally, births or caesarean sections can involve a significant blood loss, compromising the viability of the abdominal flap and even putting the patient's health at risk. Also, the rate of infections of a tummy tuck is higher in the context of a delivery or caesarean section.

Almost one-third of the patients present a residual bulge of the abdomen without definition of the waist, a situation that only happens in 9% of the patients submitted to an abdominoplasty without delivery or cesarean section.

Likewise, the umbilical herniation rate is increased by 15% and the skin excess by 14% in cases of abdominoplasty associated with caesarean section or delivery. In the same way that we would not do a breast reduction in the case of a nursing woman, because the breasts are in a temporary situation of volume increase and glandular activation, it seems appropriate to dismiss the option of abdominoplasty after caesarean section or delivery.

Pearls and Pitfalls

In conclusion, we can say that the degree of satisfaction is low, the aesthetic results are worse, and the complication rate is higher.

24.4 Approaches to the Treatment of Abdominal Sequelae After Pregnancy

Combining traditional liposuction and abdominoplasty technique gives surgeons different treatment options. For those patients in whom liposuction will not sufficiently correct their lower abdomen, but for whom a complete abdominoplasty is an unfeasible treatment due to low supra umbilical laxity, there are procedures such as mini abdominoplasty or modified abdominoplasty. In mini abdominoplasty procedures, we focus our attention on correcting lower abdomen defects with direct access to the muscles of this region. Modified abdominoplasty, an intermediate procedure between mini abdominoplasty and full or traditional abdominoplasty, thus allows the treatment of moderate flaccidity of the upper musculofascial system.

Within modified abdominoplasty, there are three possible variants in terms of surgical technique. We will choose the most appropriate to correct the patient's abdominal defects.

The two main variables that condition us in choosing the most appropriate technique of abdominoplasty surgery are the laxity of the abdominal skin and the state of the Aponeurotic Muscle System.

Laxity of the Abdominal Skin: when there is no supraumbilical skin flaccidity or it is minimal, we will think about alternative treatment options to those of traditional abdominoplasty.

Aponeurotic Muscle System: infraumbilical muscle aponeurotic flaccidity can be treated in all modalities of abdominoplasty. We employ different options of alternative procedures when there is associated supraumbilical musculofascial flaccidity.

Once we have evaluated the patient's condition with respect to both variables, we can choose between the following (Table 24.1):

- **Type I:** Mini abdominoplasty
- **Type II**: Modified adbominoplasty

Table 24.1 Classification of the abdominoplasty technique depending on the state of the abdominal skin and of the muscle aponeurotic system

Type	Skin	Aponeurotic Muscle System	Treatment
I	Minimum supraumbilical laxity	Infraumbilical diastasis	Mini abdominoplasty
II	Minimum supraumbilical laxity	Infraumbilical and supraumbilical diastasis <3 cm	Modified adbominoplasty
III	Minimum supraumbilical laxity	Infraumbilical and supraumbilical diastasis > or =3 cm	Modified abdominoplasty with supraumbilical scar
IV	Medium supraumbilical laxity	Infraumbilical and supraumbilical diastasis > or =3 cm	Modified abdominoplasty with infraumbilical middle scar
V	Marked supraumbilical laxity	Infraumbilical and supraumbilical diastasis > or =3 cm	Abdominoplasty

- **Type III**: Modified abdominoplasty with supraumbilical scar
- **Type IV**: Modified abdominoplasty with infraumbilical middle scar
- **Type V**: Traditional abdominoplasty

Key Points
In mini abdominoplasty procedures, we focus our attention on correcting lower abdomen defects with direct access to the muscles of this region. Modified abdominoplasty, an intermediate procedure between mini abdominoplasty and full or traditional abdominoplasty, thus allows the treatment of moderate flaccidity of the upper musculofascial system.

24.5 Miniabdominoplasty

24.5.1 The Ideal Candidate

The ideal candidate for miniabdominoplasty has suffered alterations at the level of the lower abdomen, without distortion of the upper abdo-men. The treatment for the accumulation of fat varies and must be adapted in each case by associated liposuction techniques. Also, the excision of suprapubic skin with variable extension to the flanks should be adapted to the existing flaccidity.

24.5.2 Surgical Technique

We carve a flap of skin and the supra-aponeurotic fat to the level of the navel. This gives us access to the underlying muscular plane that we will correct by approximating the rectus abdominis muscles (Fig. 24.1). We chose non-absorbable poly filament sutures of zero or two for this approximation to ensure consistency of the closure. Ideally, we will give two layers of the sutures that will give greater firmness and security.

After flexing the operating table between 20 and 30°, we estimate the amount of skin to excise. It is advisable to avoid leaving dead spaces when approaching the flap on the muscular plane. In this sense, we can suture the flap to the supra-aponeurotic plane causing obliteration of the cavity and associate a vacuum drain. Both measures will significantly prevent the appearance of a seroma [4].

After finishing the procedure, we will place a compression bandage and a sash during the 4–6 weeks that will contribute to the union of both layers of tissue. In patients whom we have performed muscle repair, it is advisable to avoid exercise to that specific area during the first 12 weeks. This ensures perfect consolidation of the muscular plane repaired in the surgery. We avoid excessive compression of the area that could compromise the vascular supply.

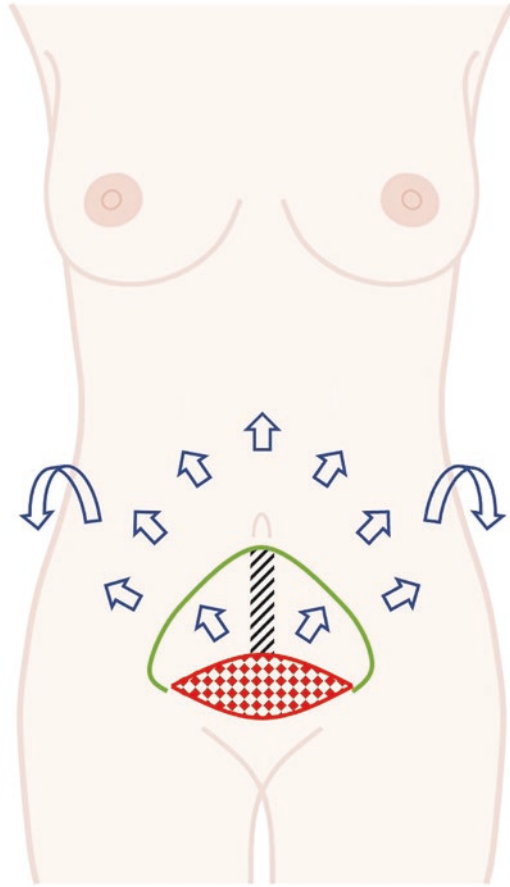


Fig. 24.1 Miniabdominoplasty technique. The green line represents the delimitation of the area of undermining. The solid red line represents the skin incision and the interior area, symbolized by the red dots, represents the excision. The middle zone with the transverse black lines is the plication. The blue arrows represent the liposuction zones

24.6 Modified Abdominoplasty and Its Variants

Modified abdominoplasty is an intermediate procedure between mini abdominoplasty and complete or traditional abdominoplasty. It is the most appropriate technique when a mini abdominoplasty is not suitable because there is diastasis of the rectus abdominis muscles above the navel, but the patient also does not require a complete abdominoplasty, mainly because the laxity of his skin in the supraumbilical area is not marked.

In cases of pregnancy sequelae, modified abdominoplasty is a useful surgical procedure because there are many patients with failure in the abdominal aponeurotic muscular system who have had a good skin recovery after childbirth and have no marked laxity at the supraumbilical skin.

Table 24.2 Graduation of the level of abdominal skin laxity and the disorder of the muscular aponeurotic system

	Supraumbilical cutaneous laxitude	Diastasis of the rectus abdominis muscles
Modified adbominoplasty	− or +/+++	+/+++
Modified abdominoplasty with supraumbilical scar	− or +/+++	++/+++
Modified abdominoplasty with infraumbilical middle scar	++/+++	++/+++

As we said above in this chapter, the modified abdominoplasty technique has three possible variants (Table 24.2):

1. **Modified adbominoplasty**: patients who presents minimum supraumbilical laxity and infraumbilical and supraumbilical diastasis less than 3 cm wide.
2. **Modified abdominoplasty with supraumbilical scar**: when the patient concurs minimum supraumbilical laxity and infraumbilical and supraumbilical diastasis bigger than 3 cm wide.
3. **Modified abdominoplasty with infraumbilical middle scar**: patients with medium supraumbilical laxity and infraumbilical and supraumbilical diastasis wider than 3 cm.

In Fig. 24.2 you can see the decision process of the most appropriate modified abdominoplasty technique.

Key Points

In cases of pregnancy sequelae, modified abdominoplasty is a useful surgical procedure because there are many patients with failed results in the abdominal aponeurotic muscular system who have had good skin recovery after childbirth and have no marked laxity at the supraumbilical skin.

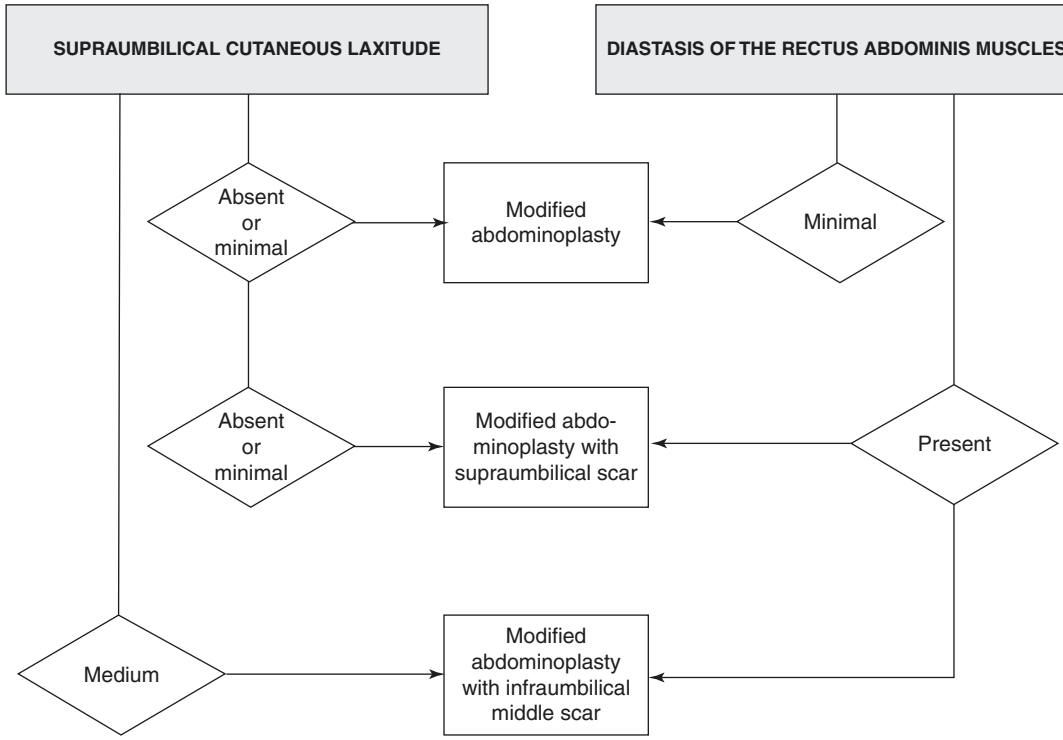


Fig. 24.2 Decision process of the modified abdominoplasty procedure variants

24.6.1 First Variant: Modified Abdominoplasty

24.6.1.1 The Ideal Candidate

The ideal candidate is one with lack of excess skin at the supraumbilcal area, but presents some degree of musculofascial flaccidity.

This procedure is indicated primarily in four groups of patients:

1. When the cutaneous excess affects the supraumbilical area but not excessively. In this case, the lower abdominal incision will be longer but without overcoming both anterior iliac spines.
2. Those cases in which we cannot perform a complete abdominoplasty because there is not enough skin to eliminate the entire segment that goes from the navel to the lower abdominal incision.
3. Cases in which there is moderate sagging at the level of the aponeurotic muscle system.
4. The existence of contraindications to perform a traditional abdominoplasty such as the presence of scars that may compromise the viability of a traditional abdominal flap. We are going to deal with this case specifically at the end of the chapter.

24.6.1.2 Surgical Technique

Marking of this surgery begins in the lower abdominal fold. The location of the future scar should be located about 7 cm from the bulbar fork and laterally 1 or 2 cm above the inguinal fold. We avoid incision over the inguinal skin because it is sometimes excessively thin. In the case of modified abdominoplasty, the incision does not usually go beyond the anterior iliac spines. In any case, we always keep in mind that the future scar should be perfectly covered by underwear or bathing clothes even if it is of the right size (Fig. 24.3).

The intervention begins with liposuction that can involve the entire abdominal surface. Prior to liposuction, we must be sure there is no defect in the abdominal wall in order to preserve the integrity of the abdominal content. An ultrasound study could be necessary in case of doubt. Next we perform the detachment of the abdomi-

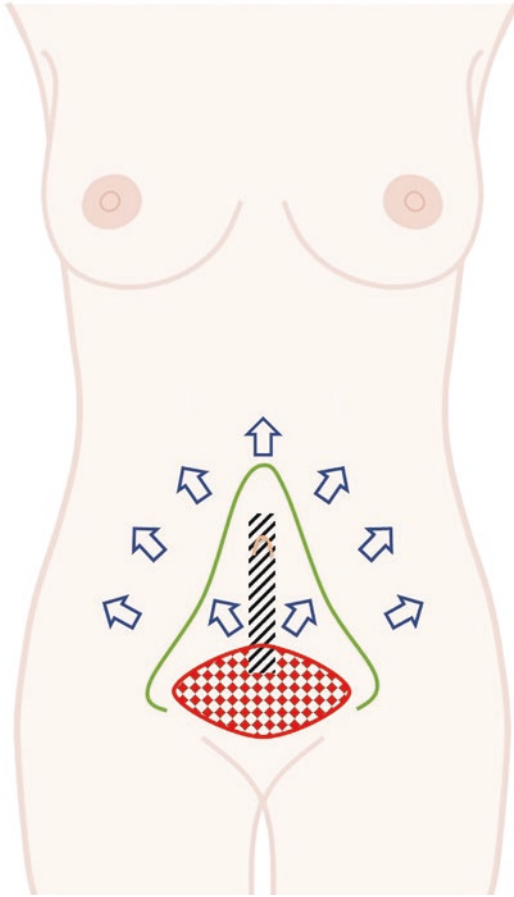


Fig. 24.3 Modified abdominoplasty technique. The green line represents the delimitation of the area of undermining. As we can see in this case, the undermining goes up to above the navel unlike the mini abdominoplasty. The solid red line represents the skin incision and the interior area, symbolized by the red dots, representing the excision. The middle zone with the transverse black lines is the plication. The blue arrows represent the liposuction zones

nal flap beyond the navel. With a penrose drain, we can hug the belly button and pull its stem inferiorly. In this way, we can perform a short distance plication at the supraumbilical level. At that moment, the navel can be left intact or detached from the umbilical ligament when the distance from the navel to the pubis is long. In patients with supraumbilical sagging or muscular weakness at that level, the navel can be transposed to a lower level losing its original position.

This technique is especially useful in patients with supraumbilical sagging or periumbilical cutaneous excess. In this maneuver, the presence of umbilical hernia should be ruled out. The detection of the hernia is facilitated through the forced traction of the navel and its trans section at the level of its entry into the abdominal wall. The defect is repaired by suturing and approaching the edges of the straight muscles, then the navel is displaced inferiorly never more than 2 or 3 cm, and finally must be placed no less than 10 cm from the upper edge of the pubic hair.

The navel is reinserted after the plication of the rectus muscles with four zeros sutures in a position that can be slightly higher than what would happen when suturing the abdominal flap. This causes an aesthetically pleasing result with the formation of a small skin fold in the upper half of the navel. When the skin is sutured, the lower traction produces this effect. The rectus abdominis are sutured in an elliptical way to resolve the diastasis.

The operating table flexes approximately 30°, and the flat is advanced in the medial inferior direction; at this time, we assess the necessary skin resection and balance the discrepancies between the upper and lower edges of our wound in terms of length and thickness of the fat. The wound is closed by planes looking for a meticulous closure of the superficial fascia and avoiding any tension in the skin suture that could lead to hypertrophic scarring. Aspiration drains can be used. The cavity created can be closed by some stitches from the superficial fascia to the muscular aponeurosis producing its obliteration. Personally, we prefer the second option, and this technique also avoids, in most cases, the use of drains and the possible appearance of a postoperative seroma.

24.6.2 Second Variant: Modified Abdominoplasty Without Umbilical Deinsertion

24.6.2.1 The Ideal Candidate

The ideal candidate must have the navel in a high position. Never less than 10 cm from the pubic hair.

For patients with marked supra and infraumbilical abdominal fullness, diastasis that affects

all the rectus muscles and without supraumbilical skin sagging or minimum cutaneous laxitude (Fig. 24.4).

24.6.2.2 Surgical Technique

We perform the plicature of the upper abdomen through a semicircular incision in the upper half

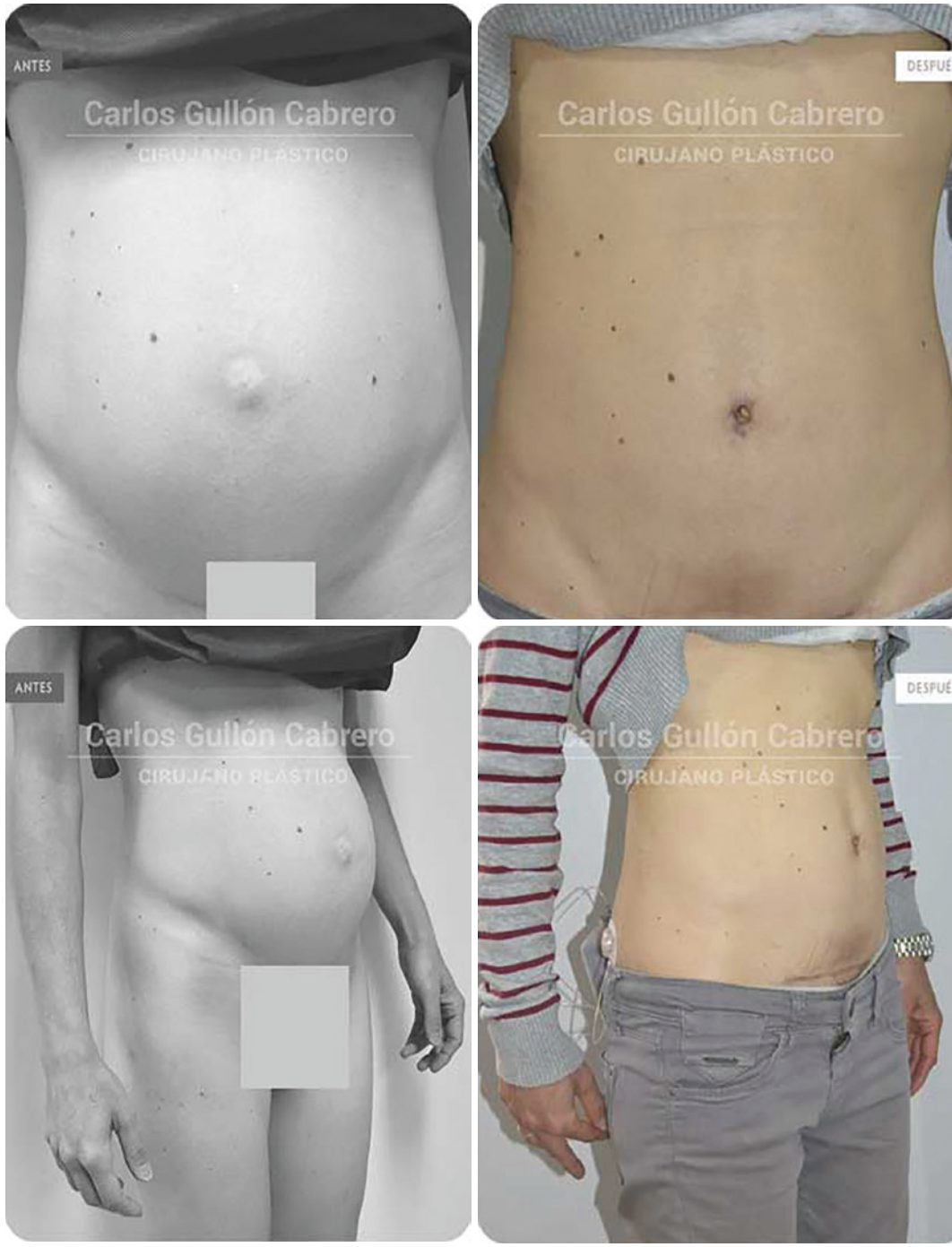


Fig. 24.4 Before and after of a patient who had significant rectus diastasis with abdominal bulging and adiposity. Six months postoperatively, the patient demonstrates an ideal female abdomen. This is a good example of an ideal candidate for modified abdominoplasty without umbilical disinsertion

of the navel. This requires the use of specific instruments that facilitate this action. The abdominal panniculus is elevated in the supra-aponeurotic plane with the aid of fiberoptic retractors. In this type of patients, there should be no superior skin sagging, or this should be minimal. In the case of plications of 4 or more centimeters, the skin detachment must laterally exceed what is necessary to undertake the plication because the skin must subsequently adapt to the new situation (Fig. 24.5).

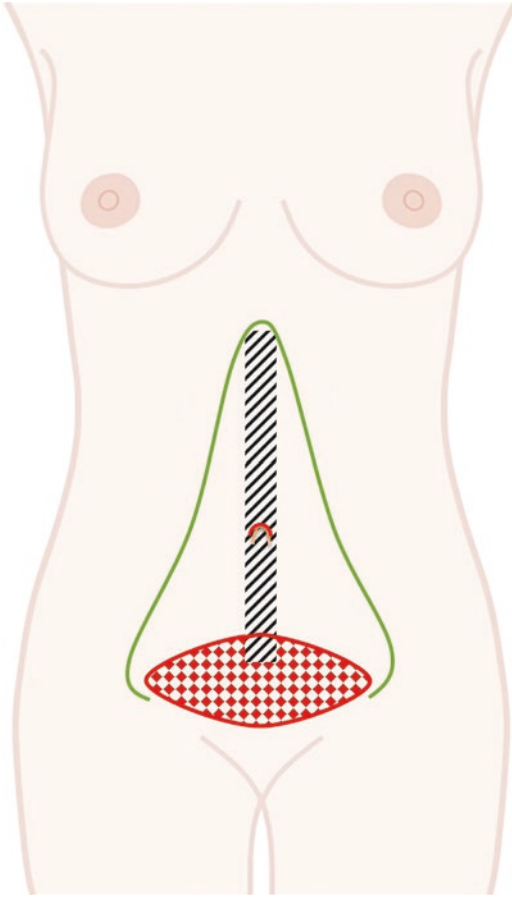


Fig. 24.5 Modified abdominoplasty without umbilical desinsertion technique. The green line represents the delimitation of the area of undermining. The solid red line represents the skin incision and the interior area, symbolized by the red dots, representing the excision. The middle zone with the transverse black lines is the plication

24.6.3 Third Variant: Modified Abdominoplasty Without Umbilical Desinsertion and Supraumbilical Skin Tension

24.6.3.1 The Ideal Candidate

For patients in whom we do not want to vary the umbilical position, who have supraumbilical sagging but not enough to perform a classic abdominoplasty, there is the possibility of completely tightening the abdominal skin (Figs. 24.6, 24.7, and 24.8).

24.6.3.2 Surgical Technique

Skin resection must be done only after being sure about the quantity of skin to resect. Sometimes "looks are deceiving" (Fig. 24.9).

We perform abdominal detachment as in classical abdominoplasty. After performing the plication (Fig. 24.10), the cutaneous flap is pulled as much as necessary, and the excess skin is removed (Fig. 24.11). In these cases, we see that the umbilical opening cannot be included in the resected segment, so it closes in planes, leaving a suprapubic vertical scar (Fig. 24.12). We recommend that once the wound closure is finished, infiltration with PRP (platelet rich plasma) of the wound edges to improve healing, maturation, and final appearance of the scars [6].

24.6.4 Modified Abdominoplasty in Patients with a Previous Scar

Paracostal incisions frequently used prior to the advent of cholecystectomies through video surgery limited regular abdominoplasties due to the risk of necrosis in the triangular area between the previous scar, the mid-line, and the edge of the flap (Fig. 24.13). The best option would be limited undermining association with liposuction. In these cases, the undermining area can be limited to the infraumbilical area only to expose the mus-

Fig. 24.6 Before and after of a patient who had diastasis of the rectus muscles with abdominal bulging and adiposity throughout the abdomen, flanks, and back. The modified abdominoplasty technique is complemented with the following procedures: liposuction of the abdomen, flanks, and back and back lipofilling to improve skin quality and decrease the appearance of the skin folds and firmness of the tissue (Fig. 24.7)

Fig. 24.6 (continued)

Fig. 24.7 Liposuction of the back rolls gives better result and lipofilling of the sulcus contribute to achieving it

culoaponeurotic system that will be plicated on a horizontal way. In this way, we completely avoid the devascularization of the abdominal flap.

For vertical scars associated with discreet flaccidity on the upper third but accentuated on the lower half of the abdomen, we perform a classic abdominoplasty, improving and centralizing the scar or ending in an inverted T. The preexistence of a vertical scar allows the surgeon to supplement its resection by removing a vertical strip and improving the waistline.

Scarring in the middle third of the abdomen and periumbilical area: scars in this position are not common but, when they occur, it is hard to move them to a less obvious place, except when massive flaccidity is present. The best option is to remove some excess skin through the existing scar while improving its appearance. Liposuction may help with the outcome.

Scarring in the upper third associated with flaccidity can be treated with reverse abdominoplasty.

Key Points

Paracostal incisions frequently used prior to the advent of cholecystectomies through video surgery limited regular abdominoplasties due to the risk of necrosis in the triangular area between the previous scar, the mid-line, and the edge of the flap.

Fig. 24.8 Pre- and post-operative photos of a more complex case to solve, because the patient, with sequelae of pregnancy, had marked sagging around the navel and a prior abdominoplasty. We chose to proceed with the technique of a modified abdominoplasty without umbilical desinsertion and supraumbilical skin tension. To resolve sagging optimally, in this case, we had to lengthen the infraumbilical scar, performing a complete vertical scar between the navel and the horizontal scar. Three months postoperatively, the patient had a remarkably good contour and demonstrates complete recovery of the fullness of the abdominal muscles and significant improvement of the skin, leaving few stretch marks and irregularities compared to her previous situation. Despite the skin mass around the navel, there was not enough skin flaccidity at the supraumbilical area to perform a traditional abdominoplasty. This a very important point because before resecting the skin excess, we must be sure about the quantity of skin to resect

Fig. 24.9 Abdomen is marked with necessary lines to perform the surgery. It is important to mark the middle line to correctly position the navel. This can also help us to perform a high definition liposuction [5]

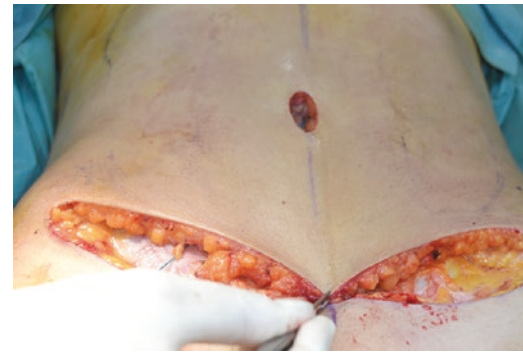
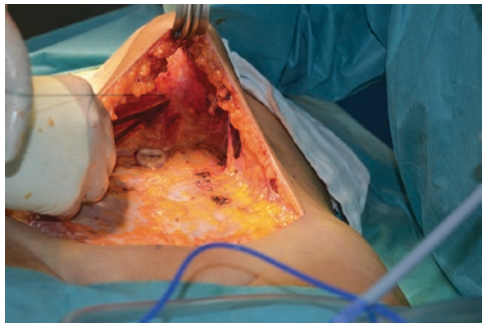


Fig. 24.11 Skin resection must be done only after being sure about the quantity of skin to resect



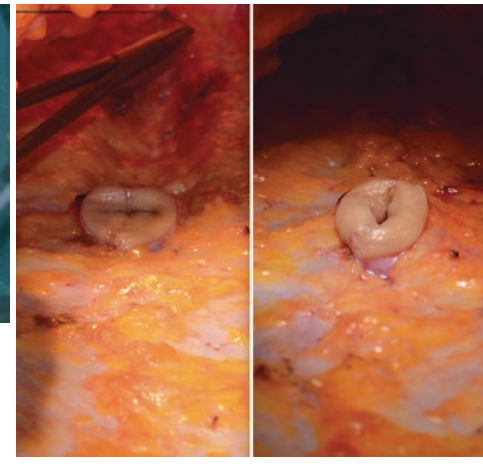


Fig. 24.10 Rectus muscle plication. Closure of the muscular diastasis is performed vertically with 2-0 or 0 sutures of permanent braided filament in two imbricating layers to enhance muscular corset. Additional muscle tightening procedures that focus on the internal oblique and transverse abdominal muscles can be performed at this moment. We can also define the waist line by suturing the superficial fascial system from side to side vertically after liposuction

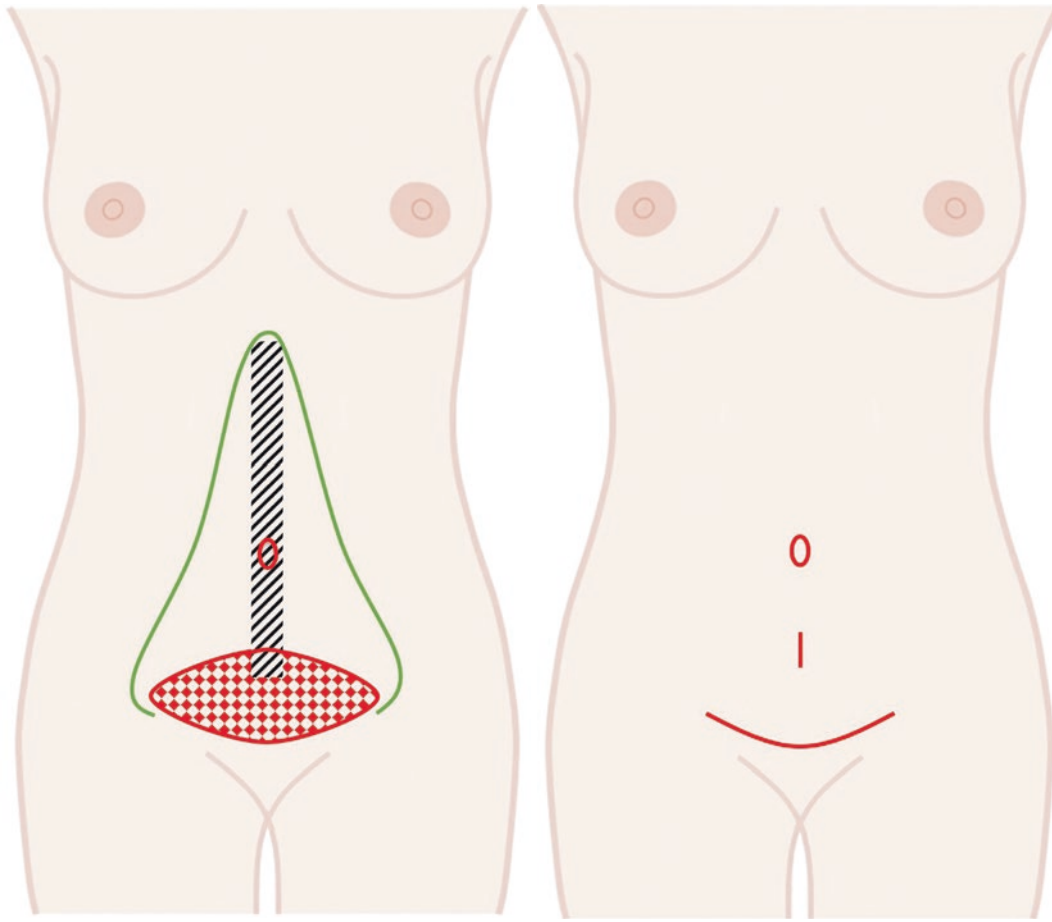


Fig. 24.12 Modified abdominoplasty without umbilical desinsertion technique (left image) and postoperative result (right image). Left image: the green line represents the delimitation of the area of undermining. The solid red line represents the skin incision and the interior area, symbolized by the red dots, representing the excision. The middle zone with the transverse black lines is the plication. Right image: red line represents the scars

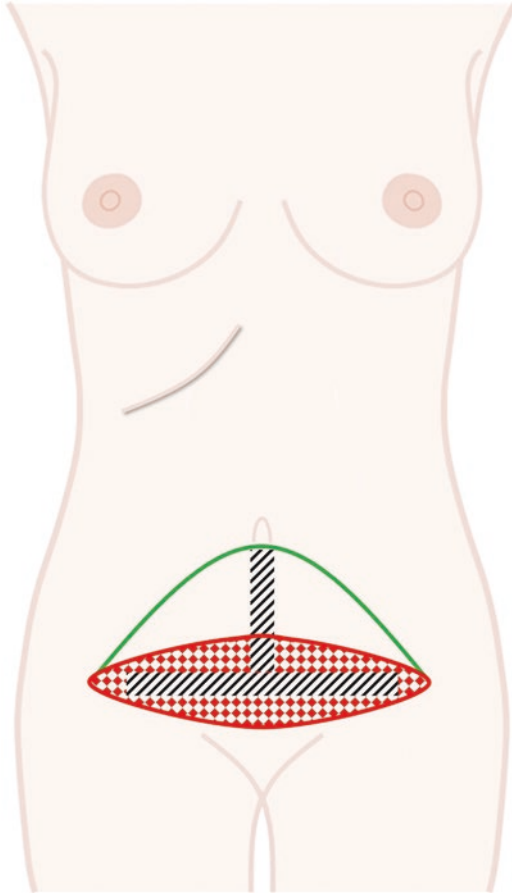


Fig. 24.13 The green line represents the delimitation of the area of undermining. The solid red line represents the skin incision and the interior area, symbolized by the red dots, representing the excision. The middle zone, with the transverse black lines, is the plication

24.7 Surgical Techniques [7]

24.7.1 Sutures

For the plication of the rectus abdominis muscles, we use non absorbable synthetic sutures—ethibond excell or ticron—of 0. We prefer to use a continuous two-layer suture, which seems to ensure the integrity of the tissue approach more efficiently. These polyester sutures provide us with permanent support and resistance that is maintained indefinitely, making them especially suitable for this procedure. The inflammatory reaction in the tissues is minimal and is followed by a gradual encapsulation of the suture by fibrous connective tissue. The retention of the indigo pensil force does not show significant changes over time.

For the cutaneous and fascial suture, we can use synthetic absorbable monofilament sutures—Monocryl or Serafast—of 3/0 or 4/0. These sutures offer resistance to wound retention to support the tissue during the critical healing period from the fifth to the seventh day. Additionally, there is minimal trauma to the tissue due to the monofilament design that reduces drag resistance two or three times compared to braided absorbable sutures and an appropriate polymer that uses a hydrolytic process to minimize tissue reaction during absorption.

At fascial level, sometimes stiffened sutures may be necessary -Vicryl 2/0-. Multifilamentous and interlaced synthetic absorbable sutures that maintain tensile strength will be used for 3–4 weeks. The adequate approximation of the superficial fascial system will promote the local conditions of zero tension for the skin suture. This is a critical detail if we want to obtain a skin scar of the best quality.

24.7.2 Mesh

In the cases of umbilical hernias associated with a diastasis of the rectal abdominal muscles, the general surgeon is summoned to operating room for taking care of repairs. It is executed with a Ventralex™ Hernia Patch mesh of 8 cm, ePTFE coated polypropylene. Visceral side of the mesh is covered by hydrogel to reduce adhesions to the bowel. Absorbable ring of the patch keeps the mesh flat.

It is placed in the intrabdominal plane and uses polypropylene strips to reinforce the plication. The polypropylene strip then stays embedded in the plication. Polypropilene low density mesh is preferred for better tolerance.

24.8 Postoperative Care

1. Use of a pressure therapy garment: the patient wears on a corset-like sash during the first month of post-operation (Fig. 24.14). They are not allowed to remove it before the first 5 days, until they are seen in the office for the first revisions. After first 5 days, the patient should only remove the garment to complete their hygienic routine.
2. Hygiene: during the first few days of post-operation, the patient cannot remove the compression bandage. It is removed once during the first consult, and the wound is treated with clorhexidine to eliminate the scabs that have been produced. Then betadine is applied and the sutures are covered with surgical tape. After this appointment, the patient can shower in their home, avoiding getting the tape wet. If the tape does get wet, the patient should dry it with cold air and soak it with betadine.
3. Massages and lymphatic draining: it is recommended that the patient seeks out manual or mechanical methods of lymphatic draining after the first week of post-operation with professionals who poses understanding of the subject matter. Additionally, it is recommended to seek massages with radiofrequency devices such as Indiba Deep Care.
4. Activity: the patient can walk beginning on the first day of recovery. Rigorous exercise can resume after a month of operation. If there has been a plication of the abdominal rectal muscles, it is recommended that regular activities do not resume for the first 3 months.

Fig. 24.14 Sash recommended for the first month post-operation

24.9 Outcomes and Prognosis

The patient should be able to see partial results from the beginning. The inflammation should be progressively reabsorbed until the third month and can last longer if the intervention is accompanied by liposuction. In this case, the final results can be seen in the sixth month of post operation.

It is recommended that the patient maintains healthy living so that the results can last longer. If the patient experiences a change in weight, it is probable that the distribution of fat falls differently compared to before the intervention, especially if the mini abdominoplasty is accompanied by liposuction.

In respect to the evolution of the scarring, it is expected that during the first year of development it is colored with a red, garnett, or pinkish hue. One year after the intervention, the scarring should present as white, and if there has not been any complication such as keloids or dehiscent scarring, it is expected to see the scar hidden by bikinis or underwear lines.

To assist in the healing process, it is recommended that the patient apply pressure to the scar (with their underwear already being worn). It is also recommended that during the first trimester, the patient uses silicone patches and applies oil or cream, such as rosehip oil.

24.10 Complications [8]

As with any surgical intervention, the miniabdominoplasty is a procedure that can present itself with complications; the majority of them are infrequent when the operation is correctly executed and the preventative measures are followed.

24.10.1 Seroma

While less frequently occurring then in a conventional abdominoplasty, a seroma has the highest rate of occurrence within the scope of the miniabdominoplasty. It is caused by a significant separation that takes place and consists of accumulation of serous fluid between the abdominal wall and the skin that is normally reabsorbed into the body. However, there are occasions where it requires draining. The cavity created can be closed by some stitches from the superficial fascia to the muscular aponeurosis producing its obliteration. Personally, we prefer the second option, and this technique also avoids, in most cases, the use of drains and the possible appearance of a post-operative seroma.

24.10.2 Hematoma

It is possible to experience an episode of bleeding during or after surgery. If a post-operational hemorrhage occurs, it could require urgent treatment to drain the accumulated blood or a blood transfusion. The bleeding frequently comes from epigastric arcade perforators. To prevent this complication, ensure that the patient stops consumption of anti-inflammatory medication 10 days before the surgery. Coagulation mode electrocautery dissection helps prevent this condition.

24.10.3 Infection

An infection is an uncommon occurrence in this type of surgery. If it occurs, it would be necessary to seek treatment that includes antibiotics or additional surgery. Antibiotic profilaxis during the surgical act with third-generation cefalosporins can be taken into consideration to prevent this situation.

24.10.4 Cutaneous Necrosis

This complication can be caused by the separation of skin flaps or excessive pulling of the skin. Hypertension, diabetes, smoking are risk factors that must be considered. The absence of smoking during the 6 weeks prior to surgery can help to prevent this situation.

24.10.5 Changes in Skin Sensitivity

Changes in skin sensitivity can occur in the lower abdomen and tends to disappear 6 months after the surgery in majority of the cases.

24.10.6 Deep Venous Thrombosis and Pulmonary Embolism

This procedure requires a person to maintain a position for an extended amount of time which increases the risk of suffering the complication. We must be extremely careful with patients that take oral contraceptives, those with records of thromboembolism, or those who present vericous veins in their legs. Following protocol, we always employ prophylaxis of deep vein thrombosis with heparin, as well as the use of the intermittent pneumatic compression system in the lower extremities. We start the day before the intervention and finish 7 days after the surgery.

24.10.7 Hypertrophic Scar and Keloids

In some cases, the intervention can produce skin abnormalities. Hypertrophic scarring can occur due to excessive tension of the skin. At fascial level, sometimes stiffened sutures may be neces-

sary, i.e.,Vicryl 2/0. Multifilamentous and interlaced synthetic absorbable sutures that maintain tensile strength will be used for 3–4 weeks. The adequate approximation of the superficial fascial system will promote local conditions of zero tension for the skin suture. This is a critical detail if we want skin scar of the best quality. Keloids heavily depend on the patient's genetic predispositions.

We recommend that once the wound closure is finished, infiltration with PRP (platelet-rich plasma) of the wound edges to improve healing, maturation, and final appearance of the scars.

24.10.8 Intestinal or Intra-abdominal Perforation

There are some documented cases in the literature of intestinal or intraabdominal perforation generally associated with consequences of previous abdominal surgeries or important hernias of the abdominal wall. It is important to understand the previous diagnostics to avoid this complication.

24.11 Conclusion

- Adequate assessment of the patient prior to surgery is necessary. The degree of skin and musculofascial laxity, the presence of scars, and the evaluation of abdominal wall defects are some essential items to know before the performance or any abdominoplasty.
- Appropriate knowledge of the different treatment modalities is essential to achieve best results with less complications.
- Prevention of thrombosis, seroma, and tissue necrosis are largely within our reach.
- Liposuction almost always plays a leading role in achieving the best result.

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Lipoabdominoplasty

25

Javier Buendía Pérez

Take-Home Points

- Right selection of the patient is key to success.
- Abdominal wall exploration is mandatory.
- Among the variety of techniques described, every patient needs a customized surgery plan.
- Take time for correct placing of the scar.
- Early mobilization is key to prevent thrombosis.

25.1 Introduction

Abdominoplasty is one of the most demanded procedures in plastic surgery. Since its introduction, the evolution of the technique has been widely modified and completed with different procedures [1] in order to achieve better results. For years, plastic surgeons have tried to improve outcomes by means of different incision patters, planes of dissection, sutures, drains, liposuction, etc. However, a standard technique has not been adopted.

Optimal skin removal with minimal tension and adequate perfusion of the flap associated with proper reconstruction of fascia layers are the main goals of this procedure [2]. Once this is achieved, the abdominal contour is improved substantially but there could be some areas that can be refined by means of associated liposuction when required [3].

Considering the multiple approaches and options for this surgery, one should select the appropriate technique depending on the specific characteristics of each patient in order to improve results and avoid complications in a predictable way.

25.1.1 Anatomy

The abdomen has multiple structure to consider [4], and its knowledge is crucial for optimal assessment of the desired surgery [5, 6]. Embryological development of the abdominal wall is based on the three layers which confer a very complex anatomy with a number of different structures. The development of these structures is segmental which results in segmental innervation and irrigation [7]. Different congenital or developmental defects may occur, and they should be explored before any surgical procedure [8].

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/978-3-030-43840-1_25.

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_25

The core of the abdominal wall is composed by four muscles and it has nine layers:

Skin
Fat
Deep fascia
Rectus
External oblique
Internal oblique
Transversus
Fascia trasversalis
Peritoneum

Within the functions of the abdominal wall are vertebral column stabilization, trunk movement, and containment of abdominal viscera. Furthermore, it is involved in maintenance of upstanding position, forced expiration or other activities that require increase of intra-abdominal pressure.

25.1.1.1 Blood Supply

The arterial supply comes from the boundaries of the abdominal wall. Medially, intercostal arteries arise between transversus and internal oblique muscles accompanied by intercostal, iliohypogastric, and ilioinguinal nerves. These branches pierce the rectus muscles and anastomose with the epigastric axis. From the top, the superior epigastric artery arises behind the rectus and goes down toward inferior epigastric. It is originated from the internal mammary after its division in musculophrenic and superior epigastric. From the lower part, the inferior epigastric artery arises from the external iliac and ascends behind the rectus muscles conforming to the epigastric axis with the superior epigastric. Just below the deep inferior epigastric artery, the iliac circumflex arteries arise from the same origin and contribute to the blood supply with its ascending branches.

All these arteries provide rich irrigation to skin via multiple perforator branches which are powerful tools in reconstructive surgery [9].

Blood drainage veins are the same as the arteries described above. Superior to umbilicus, the drainage is ultimately via superior vena cava and inferior to the umbilicus the drainage is via saphenous-femoral to the inferior vena cava. It is important to remember the link between the ligaments teres and the venous drainage that can reperfuse during portal hypertension means resulting in dilation of abdominal veins.

25.1.1.2 Lymphatic Drainage

Parallel to the vein drainage, the lymphatic vessels course in the abdominal wall. Again, superior abdominal wall tends to drain in the axilla and inferior wall tends to drain in the groin area. Due to the embryological origin of the umbilicus, gastrointestinal tutors may spread by the ligament's teres to the abdominal wall area.

25.1.1.3 Innervation

Abdominal wall innervation comes from T7 to T12 by its anterior divisions coming in segmentary nerves that course between transversus and internal oblique from medial to inferior. From L1 root and a contribution of T12 arises the iliohypogastric and ilioinguinal nerves. These nerves provide sensation to the anterior abdominal wall in the suprapubic area and groin and femoral region. They perforate the transversus muscle and make connections in the same plane as the nerves described previously.

The iliohypogastric and ilioinguinal nerves arise from the lateral side of iliopsoas. The first provides sensation to the lateral hip region and motor innervation to internal oblique and transversus muscles. The second runs inferior to the first and perforates the transversus giving communicating branches with the iliohypogastric nerve. It passes through the superficial inguinal ring giving branches to spermatic cord/round ligament. Then it pierces the skin of upper and medial thigh and the pubic area via the anterior scrotal/labial nerve. The ilioinguinal nerve does not cross the deep inguinal ring so it cannot be encountered through the inguinal canal.

25.1.1.4 Skin and Muscles

As described previously, there are nine components in the abdominal wall. From superficial to deep layers, each component has its role in contributing for better outcome during surgery.

Skin and Subcutaneous Tissue

Skin is the most superficial component of the abdominal wall. Assessing its quality, excess, laxity, etc. is crucial for abdominoplasty procedures. Under the skin, the subcutaneous tissue contains fat, whose distribution is a key point for surgical procedures, and Camper's and Scarpa's fascia. The latter is an important layer to consider in abdominoplasty for many reasons. It divides the superficial fat from the deep fat, and it may have a role in lymphatic drainage.

In this layer, the umbilicus is one of the key points of the abdominoplasty because it is a recognizable landmark of the abdominal wall. Normally it is situated in the midline 9–12 cm above pubis. The fascia around this area is one of the most commonly affected by abdominal hernias due to the changes during or after pregnancy. Its blood supply is provided by dermal vessels and from the umbilical ligament.

Muscles and Fascia

External Oblique

The outer muscle of the abdominal wall is the external oblique muscle. It originates in the lower ribs and runs obliquely from superolateral to inferomedial. It is inserted in the iliac crest and folds to form the inguinal ligament. At its end towards the midline its aponeurosis extends to the rectus sheath.

Internal Oblique

It courses deep to the external oblique and forms the mid layer of the anterolateral wall. It is originated from the iliopsoas fascia, iliac crest, and thoracolumbar fascia running in the opposite direction of the external oblique to insert in the ribs and the pubic tubercle. Inferiorly, it will be a part of the conjoined tendon with the transversus muscle. At its medial end, the aponeurosis continues as well to the rectus sheath. Above the arcuate line, the internal oblique fascia passes around rectus muscle surrounding it but inferior to the line, it only courses in the anterior aspect of the sheath.

Transversus Abdominis

This is the thinnest and deepest layer of the abdominal muscle wall. Its fibers are transversally oriented and originated from ribs, iliac crest, lumbar vertebrae, and iliopsoas fascia. Its contribution to the rectus sheath is similar to internal oblique. Above the arcuate line, the fascia courses behind rectus and below passes through the anterior aspect of the sheath.

Fascia

The muscular/deep fascia covers the muscles with different configurations especially within the inguinal canal and the rectus sheath. This layer is key for correct management in abdominoplasty procedures.

In the deepest part of the abdominal wall, we encounter the transversalis fascia posterior to the transversus muscle. Its disruption defines an abdominal hernia. Deep in the transversalis fascia is the parietal peritoneum which surrounds the abdominal viscera.

25.2 Patient Selection

The more common consultation for this kind of surgery is after pregnancy and post bariatric patients. In these conditions, the muscle-aponeurotical structures are dilatated and are not able to retract to their initial status. Thus, resulting in thinning of the skin, losing elasticity and appearance of striae, and in an elongation of the fascia which will more commonly determine rectus diastasis. Hyperextension of the rectus sheath ends in an anterior abdominal wall weakness that can be associated with ventral hernia. Previous exploration of abdominal wall defects is crucial to avoid major complications.

As mentioned, skin excess and fascial loosening are key points to assess during patient exploration. On the other hand, fat distribution and its management is key for a better outcome considering abdominoplasty. For this purpose, associated liposuction is a helpful option.

Different classification of patients have been described depending on the fat and skin distribution; however, these are not very practical because in author's opinion, modern abdominoplasty is a customized, well-balanced mixture of all the techniques available.

25.3 Preoperative Evaluation

In the first consultation, the surgeon must review patient's medical history and previous conditions. BMI and weight stability should be considered. Current medication, allergies, and previous surgeries must be recorded.

Smoking habit can seriously impair wound healing and may be considered as exclusion criteria. Patients must quit smoking at least 3 weeks before surgery to be considered for surgery. Other exclusion criteria are BMI over 30, anticoagulation/hypercoagulability conditions, active infectious condition, and high cardiovascular risk.

Future pregnancy desires have to take into account to postpone surgery, or patient should be warned that aesthetic result may be worsened after future pregnancies. Furthermore, body weight changes also may change the final result, so one should encourage the patient to go for the surgery in a weight-stable period for at least the past 3–6 months.

25.3.1 Physical Examination

A detailed exploration is done in all patients. First of all, we explore the patient in an upstanding position. The skin excess is measured by pinching the panniculus as well as the elasticity. Distribution of striae, if present, is assessed to be included as much as possible within the planned skin excision. Skin adherences zones are better explored upstanding. Distribution of fat (supraumbilical, flanks, infraumbilical, etc.) is recorded and marked for comparison when the patient is lying down. One should pay attention to symmetry, previous surgeries, scoliosis, or hip asymmetry. Presence of previous scars is very usual, especially C-section. One should take into account those scars for correct placement of the incision considering possible blood flow impairment due to previous surgeries. A very low scar can be easily reached if the patient has a good laxity, but in some cases, it is preferable to make a vertical incision to avoid jeopardizing wound healing.

Once this is completed, we should ask the patient to lie on the bed to re-explore skin excess, laxity, and fat distribution. Previous scars may change scar planned site. In this position, we explore abdominal wall integrity by manual palpation, and we also assess the degree of rectus diastasis. Care should be taken to explore any hernias if present [10].

Determining and explaining to patients all their personal characteristics in this phase will lead to better design of the surgical procedure as well as better comprehension of scar position and techniques needed by the patient.

Whenever the patient is correctly explored and the surgery indicated, a few key steps are to be completed. Pre- and postoperative photographs should be taken at the office in a standard setting.

Informed consent has to be reviewed at the office with the patient and signed before the day of surgery. Any other or special consideration is discussed, and if requested, surgery outcomes or complications photographs are showed to the patient. At this point, surgeon must explain in a realistic way the possible limitations to the aesthetic results depending on patient characteristics.

Finally, preoperative instructions are given. They should include avoidance of anticoagulant/antiaggregant drugs the days before surgery, shower with antiseptic solution, bowel purgation to decrease abdominal pressure, etc.

25.3.2 Markings

Incision location is one of the most important aspects in this procedure. Classically, the lower horizontal mark is between 5 and 7 cm above the labia cojunction area in an upstanding position. Then the midline is carefully traced. Depending

on the patient characteristics, this marking may vary and ascend some centimeters considering natural folds or other particularities. Lowering the scar more may distort labia majora and produce pubic lymphedema.

Once the lower aspect of the scar is placed, lateral extension is marked depending on the planned resection: usually the limit is planned in the superior iliac spine which confers a slight upward curvature to the incision. The ideal final scar should be low enough to be covered by bottom clothes, especially bathing clothes. The goal is to plan the shortest and lowest scar with minimal tension.

Also, in upstanding position, the selected areas for liposuction are marked. Then the patient is asked to lie in the examination table. The lateral extension is checked asking patient to bend so that the skin bulge/excess is hanging. We also asses the estimated skin excision by pinching test, and we can mark it as the upper incision line but keeping in mind that these lines are not definitive. It is important to understand that the more lateral extension is made, the more horizontalization of the scar would result at the end of the scar due to the lateral thigh tension.

At this point, we have to alert the patient if any vertical scar would be needed if umbilical scar cannot be removed completely. It is preferable to design a little vertical scar rather than ending with excessive tension at the central part of the wound.

When incision marking is complete, we have to confirm its symmetry in length and position paying special attention to the preexisting asymmetry.

25.4 Anesthesia

Although this surgery is performed under local and regional anesthesia [11, 12], we prefer general anesthesia. We also prefer to do the surgery as an admission procedure. However, it could also done as an outpatient procedure.

Epidural catheter can be placed to control postoperative pain, but in our practice, we prefer to do a TAP (transverus abdominal plane) block [13–16]. This block has gained popularity when ultrasound-guided techniques have been described [17]. A variation of the classic TAP block, the subcostal TAP block, has also been described; it is designed to provide more reliable coverage of the upper abdominal wall [18–21].

Once patient is under anesthesia, lower limbs garments are placed, and intermittent pressure boots can be used to reduce thromboembolism phenomena.

25.5 Surgical Technique

Since the first report by Demars and Marx [22] at the end of the nineteenth century, the concept of abdominoplasty has changed to a multimodal approach combining different techniques. Various skin incisions, planes of dissection, levels of undermining, placing of drains, suture techniques, and combined liposuction had been described. Thus, it resulted in various procedures such as classical abdominoplasty, high-lateral-tension abdominoplasty, lipoabdominoplasty, fleur-de-lys abdominoplasty, vertical abdominoplasty, reverse abdominoplasty, etc.

No standard technique is accepted, due to the wide variability of patients requiring customized surgical plans.

Due to the different variables on the surgery, we can summarize options in each part.

Depending on patient's phenotype, different techniques have been described. All of them are similar in some way. First, liposuction, if indicated is performed. Then lower incision is made and desired undermining is carried out. Careful hemostasis is done. After this, fascia plication is marked and sutured as desired. Finally, skin excision is made and wound is sutured.

25.5.1 Patient Positioning

Patient is placed in a standard upright position. Surgery table is checked for hip flexion. Arms are usually placed open (to make the liposuction more comfortable) and must be secured. Alignment of patient is corrected. After skin resection, patient is made to bend forward to facilitate skin closure. Once surgery is finished, patient should be placed in "V" shaped position while resting.

25.5.2 Procedure Step by Step

Since every patient may benefit from a variety of techniques, we try to combine all tools available to improve our results by minimizing complications. In this manner, our approach is usually between classical abdominoplasty and lipoabdominoplasty.

Preoperative markings are design following the previous exposed principles, in a custom fashion for each patient. Liposuction areas are marked also.

If liposuction of flanks is performed, we prefer to start in a prone position. Infiltration with Ringer Lactate and epinephrine is made in a tumescent fashion, and when the vasoconstriction is achieved, the liposuction starts [23, 24]. Wounds are closed when posterior side surgery is finished, and patient is turned to supine position.

Once patient is correctly placed, new drapes are placed after skin preparation. Previous markings are redrawn to avoid mistakes. Again, if any area was planned to be lipoaspirated, we commence with the liposuction. Infiltration is made and fat is removed taking care to place incisions over the skin resection areas. Incision is made in the previous marked location, and dissection is carried out on the desired plane which usually is sub-Scarpa in the first 5–7 cm over the incision and then turned into supra muscular fascia with limited undermining within the rectus on the upper abdomen area. With this maneuver, we preserve lymphatics and also preserve lower incision attachments to prevent excessive cranial migration. Lateral areas are selectively detached (preserving perforators under direct vision). If liposuction is done in that area, detachment is carried out by cannula. Umbilicus is freed and dissection is finished [25]. Careful hemostasis is done. Skin is removed starting in the middle line and adjusting tension from lateral to medial. Drains are placed and wound is closed. Finally, umbilicus is performed. At this point, any refinement in liposuctions is executed, if needed. Wound is draped and nitroglycerin ointment is carefully placed over the wound. Compression is made with tapes/garments and patient is awakened.

25.5.3 Surgical Modifications/ Approaches

25.5.3.1 Abdominoplasty with Umbilical Transection (No Transposition)

Considered as an extension of miniabdominoplasty, this technique is specially considered for patients with high position of the umbilicus and excess of tissue in the lower abdomen. Incision is placed in a standard position and dissection is carried out prefascially, then umbilicus stalk is transected pulling upward and taking care not to harm abdominal viscera. Whilst in this maneuver, circumferential scar in the umbilicus area is avoided. The deep portion of the stalk is carefully closed to avoid hernia. Dissection continues within the edges of the rectus abdominis muscles to the sternum. Thus, a perfect exposition of any diastasis is achieved, and plication is carried out easily with the preferred method. Skin excess is removed, and umbilicus stalk is fixed to abdominal wall in a caudal position maintaining a minimum distance of 9–10 cm from the pubis. Compared to miniabdominoplasty, a longer scar may be expected and also a bigger tissue resection is done (Fig. 25.1).

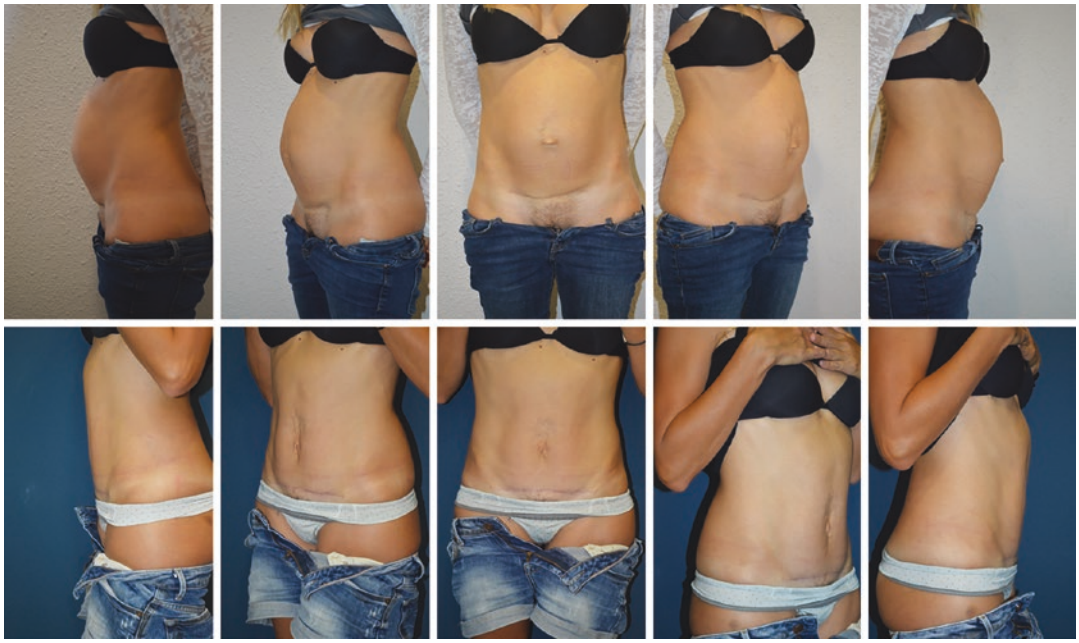

Fig. 25.1 A 43-year-old patient presenting previous C-section and umbilical hernia. Abdominoplasty with umbilical transection, hernia correction, and fascia plication without umbilicus transposition. Umbilicus is reattached to abdominal wall

25.5.3.2 Classical Abdominoplasty

In this approach, incision is made in the lower abdomen and undermining of skin and fat is made over the muscular fascia up to costal arch border to xiphoid. Upper incision is made up to the umbilicus and the flap is tensioned downward with umbilicus transposition. With this, upper and lower abdominal tissue excess is treated. Tissue undermining is carried as far as necessary to achieve a non-tension wound closure. With this undermining liposuction, upper abdomen is not recommended to avoid vascular complications [26] (Figs. 25.2 and 25.3).

25.5.3.3 High-Lateral Tension Abdominoplasty

This modification pursues not only the treatment of abdomen but also hips and upper thigh. Skin resection pattern places less tension in the middle part with focus on a wider resection and tension in the lateral aspects. The final scar is larger than in classical abdominoplasty due to an increased lateral resection and skin removal in order to avoid dog ear formation [27, 28] (Fig. 25.4).

25.5.3.4 Vertical Abdominoplasty, Fleur de Lys Abdominoplasty, and Reverse Abdominoplasty

These techniques are reserved to patients with preexisting vertical laparotomy [29] or after massive weight loss [30, 31], which are not the main goal for this book.

25.5.3.5 Lipoabdominoplasty

Lipoabdominoplasty probably is the most modern and popular approach for aesthetic treatment of abdominal wall. It was popularized by Saldanha, and it is widely used and considered a safe technique [32]. In this approach, undermining is made by cautery dissection in the very

Fig. 25.2 A 34-year-old patient with classical abdominoplasty and breast lift with implants

Fig. 25.3 A 52-year-old patient with classical abdominoplasty (Note the previous scars) with limited flank liposuction and breast reduction

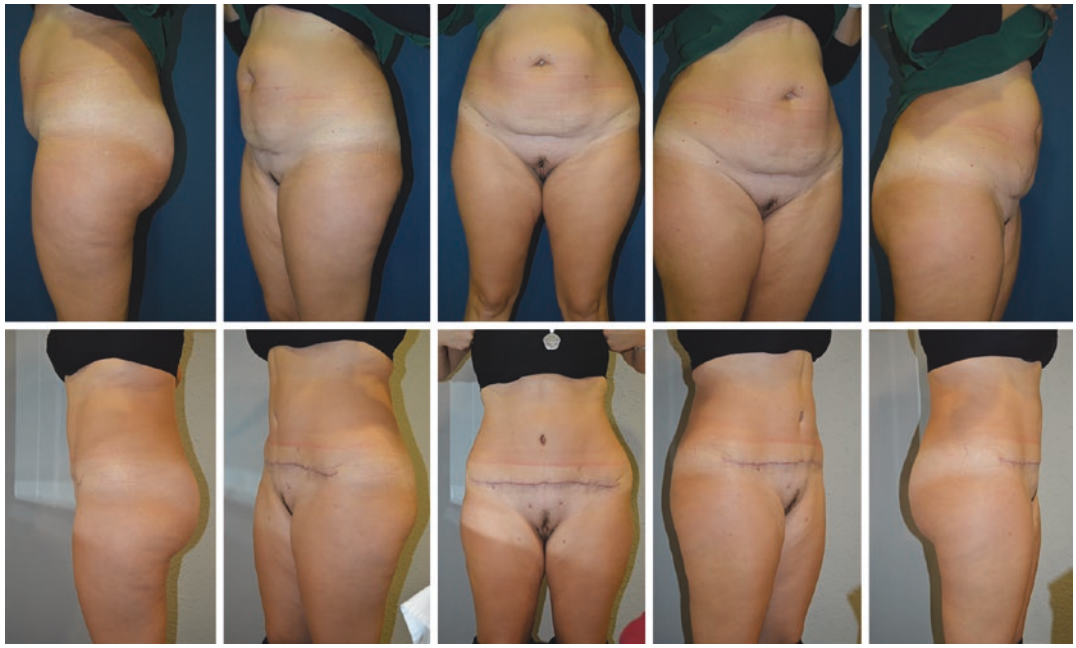

Fig. 25.4 A 48-year-old patient underwent HLT abdominoplasty

middle part and the detachment of lateral abdominal wall is made from the tunnels of the liposuction cannula. Selective detachment while preserving perforators as well as removing fat excess is the key to understand this technique [33–39].

Markings are variable depending on surgeons but are much similar than in classical abdominoplasty. Saldanha described a 12 cm horizontal line with two ascending arms of 8 cm each. These marks can be customized by the surgeon for the patient.

It is started with extensive liposuction on the upper abdomen and subcostal area. The lower abdomen is aspirated in the superficial layer to help visualize the plane for dissection afterward. Then, incision is made, and dissection is followed in a sub-Scarpa plane [40]. Umbilicus is isolated and above the insertion, dissection is done only in the central part within the inner rectus limits to facilitate fascial plication. Additional open liposuction is made, if necessary. Fascial plication is done after defatting the central portion. If needed, additional undermining is done to prevent central deformities after plication. The skin's taylor-tack is removed and umbilicoplasty and wound closure are done (Figs. 25.5 and 25.6).

25.5.4 Technical Tips to Improve Outcomes and Avoid Complications

25.5.4.1 Skin Incision/Excision

This is the start of every approach, and it is a standard but has to be customized for each patient. The lower incision is planned in the lowest position possible without harming the pubic area. Length of lower incision depends on the patient needs and surgeon's preferences. Depending on the technique, lateral extension is slightly curved upward or a bit more horizontally.

Superior skin mark for skin excision is usually planned near the umbilicus. Some may not mark this line as the skin excision is carried out in a Taylor-tack fashion. It is desirable that the

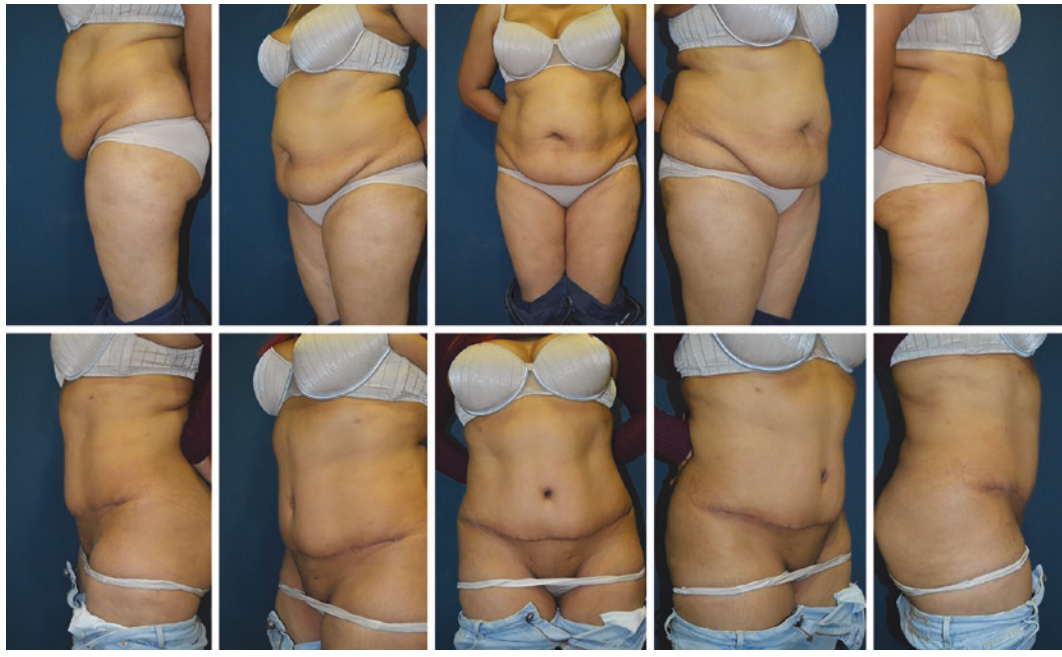

Fig. 25.5 A 53-year-old patient underwent lipoabdominoplasty

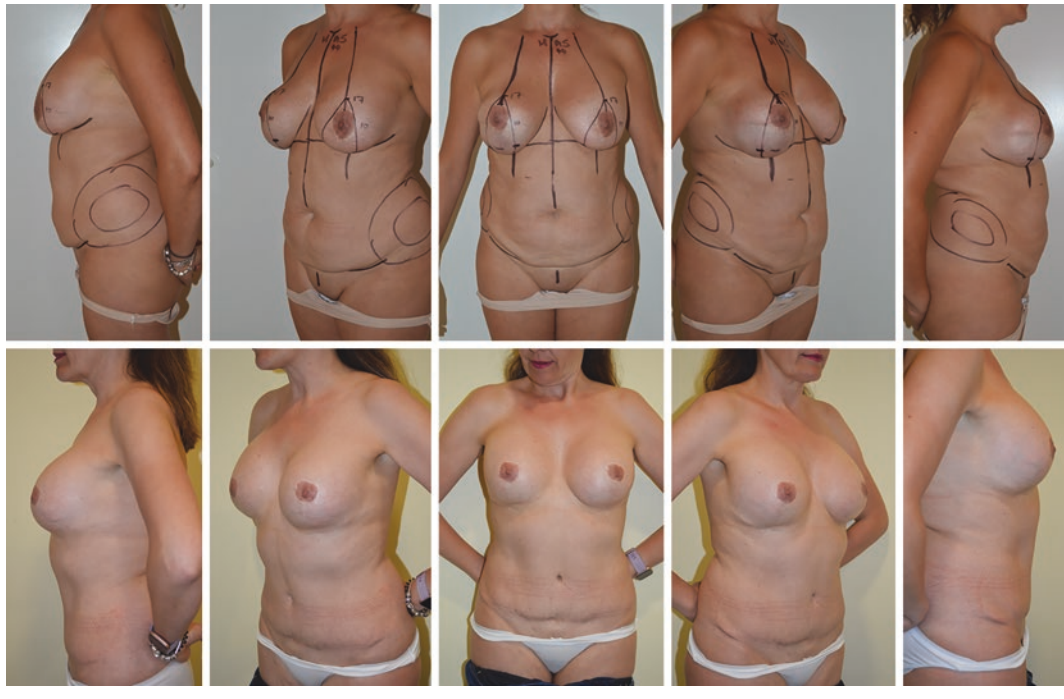

Fig. 25.6 A 45-year-old underwent combined lipoabdominoplasty and implants exchange

removed skin contains the periumbilical scar but sometimes a short vertical scar is placed in the midline.

Assessment of tissue removal is usually done by pinching the panniculus but depends on skin properties and dissection extension. The final amount of skin removed is decided intraoperatively by bending the patient and custom-resecting the desired tension.

25.5.4.2 Plane of Dissection

There are mainly two options for this issue. The first and classical is detaching the skin and fat from the abdominal wall from the muscle/deep fascia. This is a natural plane, and its dissection is carried out quickly and easily. It guarantees an even dissection and correct visualization of rectus edges. On the other hand, a subscarpal plane is preferred by many modern authors [41–45]. It is believed to preserve lymphatic tissue intact so that seroma rates may decrease. It also has the advantage of thinning the upper flap which is similar to the lower flap in width. Conversely, it is a more difficult plane to dissect, and it may end a bit uneven. It is also can result in less accurate localization of rectus borders.

25.5.4.3 Liposuction

Liposuction has become more and more important in this procedure in the last decades. As it is incorporated to the abdominoplasty procedure, it was believed to damage abdominal flap vascularization [46], so its application has varied widely from just flanks lipoaspiration to a combination of skin resection, selective detachment, and extensive liposuction [47], as in lipoabdominoplasty described by Saldanha.

Applying liposuction [48] in deep [49] and superficial [50] layers has changed the concept of abdominoplasty from aggressive skin excision and significant wound tension to a well-contoured abdominal flap with less wound tension [51–54]. A lower tension would decrease complications related to skin perfusion. However, some authors advocated that liposuction may cause trauma to abdominal perforators impairing abdominal flap perfusion. Nowadays, it is well accepted that perfusion of abdominal flap is preserved applying extensive liposuction when limited central undermining is done, so that lateral perforators are preserved [55–58]. The lipoaspiration makes selective detachment of the lateral abdominal flap which makes mobilization possible toward the lower incision. We prefer standard or power-assisted liposuction in order to minimize nourishing vessels damage (Fig. 25.7).

25.5.4.4 Level of Undermining

Depending on the preferred approach, the level of the undermining varies. In classical concepts, the undermining limits are from costal borders to xiphoid process. With the application of liposuction, undermining is usually restricted to skin resection area and upward within the cephalic portion of the rectus abdominis. Selective undermining of lateral portions is carried out by means of lipoaspirate tunnels or carefully blunt dissected under direct vision preserving perforator vessels [59, 60].

25.5.4.5 Umbilicus Transposition

Patient characteristics such as skin elasticity, tissue excess, position of the umbilicus, grade of diastasis, and striae distribution determine the need to transpose the umbilicus. Contrary to mini abdominoplasty, where the umbilicus is not transected, in modern abdominoplasty approaches, patients who have high position of navel and very elastic skin may benefit from an umbilicus transection without transposition. It is important to consider the final position of the umbilicus, which if placed too low would impair normal appearance of the abdomen. We usually perform a circular incision and remove the underlying fat. If fascia was already sutured, no stalk plication is performed, on the other hand, if umbilicus stalk is too long, a few 3/0 reabsorbable stiches are placed to fix umbilicus to fascia. Finally, skin is sutured with nylon thread of 4–5/0.

25.5.4.6 Fascia Plication

From the previous exploration, rectus diastasis is assessed. The most common plication is vertical, suturing the medial edges of the rectus fascia.

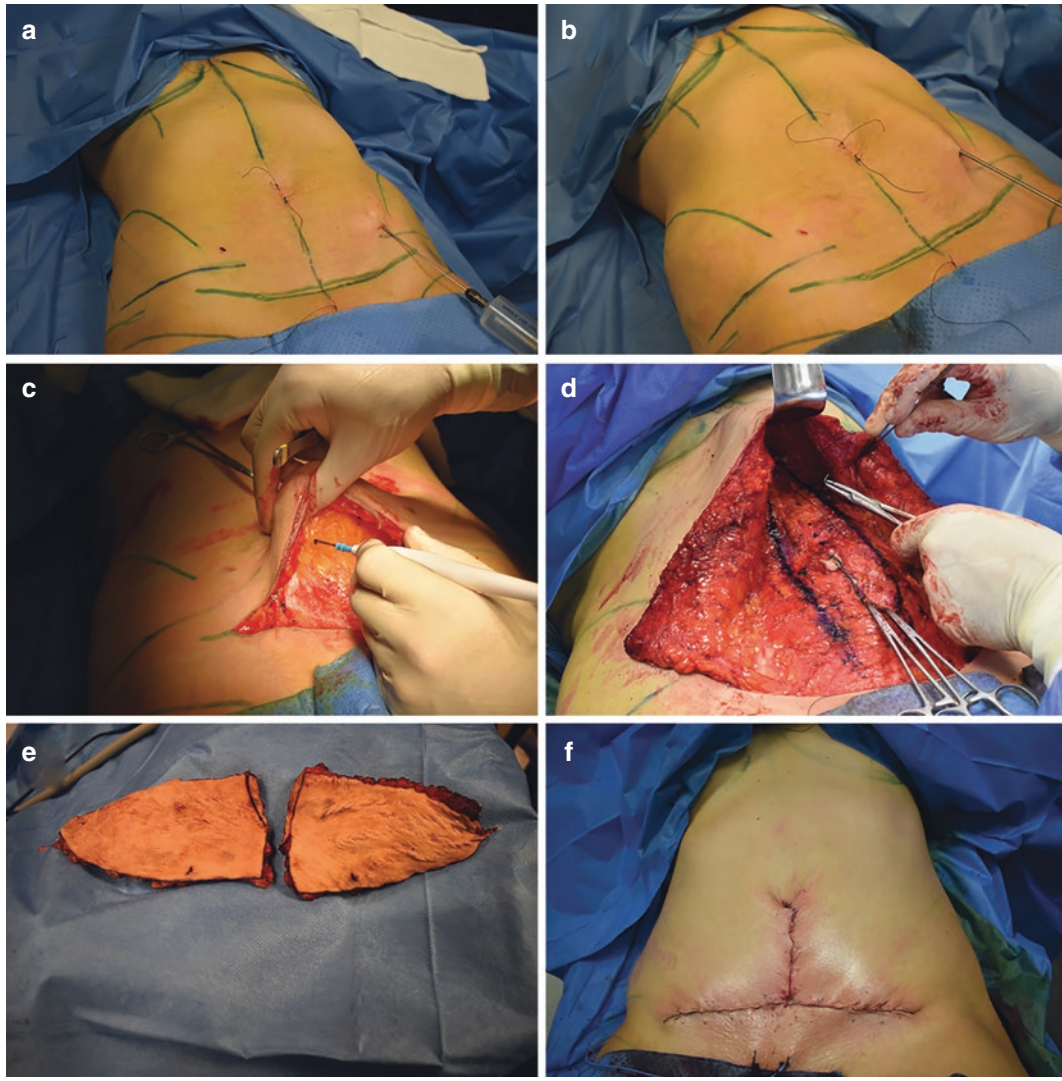

Fig. 25.7 Procedure step by step. Infiltration (**a**). Liposuction (**b**). Flap dissection (**c**). Abdominis rectus plication (**d**). Tissue excised (**e**). Closure (**f**)

Sutures can be placed in one or two layers with running or simple stiches. Recently, modern barbed sutures have simplified this aspect providing secure fixation with significant reduction of surgical time [61–63]. The use of absorbable or non-absorbable sutures or a combination is chosen by the surgeon.

If umbilicus is transected, care should be taken not to injure the bowels, and a layer-by-layer closure must be applied in that part. Once it is closed, fascia plication may be easier and can be done in a running fashion from top to bottom. If umbilicus is not transected, which happens more often leaving it attached to abdominal wall, care should be taken not to strangulate its irrigation with fascial sutures.

Additionally, horizontal or oblique plications may be performed depending on the fascia bulging and preferences of the surgeon.

25.5.4.7 Strategies to Control Seroma

Seroma is well accepted as the most common complication in abdominoplasty. Depending on the surgeon's preferences and the technique

employed, several options are available [64]. The most common is placement of drains, which may be uncomfortable especially if the patient is discharged with it. Usually, they are maintained from 24 h to 5–7 days. We usually prefer 14G Blake™ drains.

Another way to prevent seroma is by using fibrine sealants. Since the price of these products is higher than simply drains it requires perfect application. They are not usually combined with drains because they could beobliterated .

Other maneuvers entail placing progressive tension sutures to obliterate the space between planes and, as mentioned earlier, the use of a sub-Scarpal plane of dissection [65–71].

Finally, compression garments are well accepted as a crucial part of the postoperative care.

25.5.4.8 Wound Closure

This is probably the most standard aspect of the surgery. It is a standard to close first the Scarpa fascia, then the dermis and finally the cutis. Variations are mostly in the kind of suture used. As in fascia plication, barbed sutures (V-loc™ from Covidien™ or Stratafix™ from Ethicon™) have gained popularity by means of a quicker closure time and a lesser amount of implanted material because they are knotless. As for intracuticular suture, the options are running monofilament/barbed suture or cyanoacrylate glue. Umbilicus is usually sutured with interrupted stitches of 4–5/0 nylon thread.

Recently, application of diode laser at the end of surgery is suggested to improve scar appearance and improve aesthetic results [72].

25.6 Video Case Report

A 37-year-old patient with history of umbilical hernioplasty (mesh) and two C-sections. Lipoabdominoplasty was performed (Fig. 25.8). Umbilicus was saved but due to extreme thinning of skin in the infraumbilical area, a vertical scar was made (Videos 25.1, 25.2, 25.3, 25.4, 25.5, and 25.6).

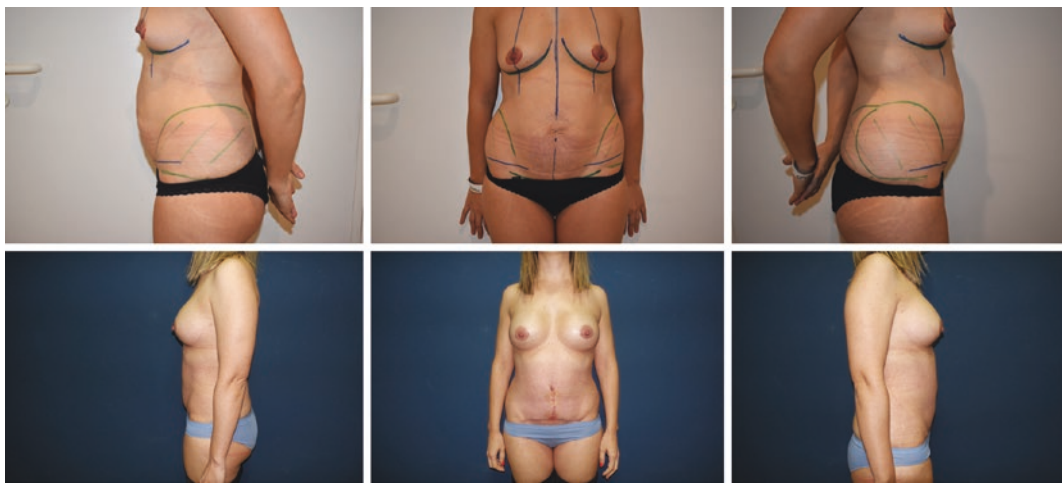

Fig. 25.8 Preoperative and postoperative pictures of the patient

25.7 Pre/Postoperative Care

After consultation, patients may be informed of all the processes they are undergoing. Avoidance of antiaggregant drugs or smoking should be reinforced. We usually educate patients for adequate preparation of skin and wound care after surgery. Compression garments and stockings should be prescribed and tried before to ensure correct fit.

Once the surgery is complete, early mobilization is mandatory in order to prevent venous thrombosis. Compression garments are placed, and patient is educated to wear them correctly. Chlorhexidine is applied every day to the wound within the first 5–10 days. Drains are removed when total drainage is less than 30 mL in 24 h. Patients are encouraged to prevent traction of the wound by hip flexion while resting. After drain removal, lymphatic drainage massage can be made. As its benefits are not measurable, the patient is continuously re-explored after the surgery and any possible complication is advised on time.

Compression garments are used for at least 1 month, and sports practice is not recommended during the first 4 weeks. Silicone patches for scars are recommended after the third week for the next 3 months.

25.8 Outcomes and Prognosis

Abdominoplasty is a very popular procedure. While major complications rates are very low (<2%), the overall complications (up to 30%) rates are not negligible fundamentally related to wound healing. There is also high revision rates related to fine-tuning procedures. Satisfaction rates are very high (>86%) and previous symptoms improvement are also very consistent (>95%) [73–78].

Considering all these factors, abdominoplasty (even associated with other procedures) is considered to be a safe and satisfying procedure.

25.9 Complications

Complications pose a challenge to the surgeon, especially considering that almost all of these cases are selective procedures where healthy patients have high expectations [79, 80].

25.9.1 Seroma

This is the most common complication in abdominoplasty. As mentioned earlier, there are different strategies to avoid it but no single maneuver is proven to be 100% effective. The use of drains is very popular, but they may increase the infection rate and the time to remove them remains uncertain. The sub-Scarpa plane is believed to improve seroma rate but there is still lack of blinding on the studies supporting the benefits. Progressive tension sutures or obliterating dead space sutures as described by Baroudi [81] are a good alternative but may cause pain and bleeding at some point. Fibrin glue adhesives can also be used but they may be costly [82].

> Fortunately, when seroma is detected, its treatment is usually easy and effective. Most seromas are solved by simple puncture and drainage. If necessary, some agents such as corticosteroids can be administrated locally, but the evidence of these treatments remains unclear despite they being common.

25.9.2 Infection

Infection is the second most common complication following abdominoplasty. It may occur after seroma is developed or alone. However, infections rates are low (1–4%) when patients are carefully selected. It is usually presented as erythema or inflammation.

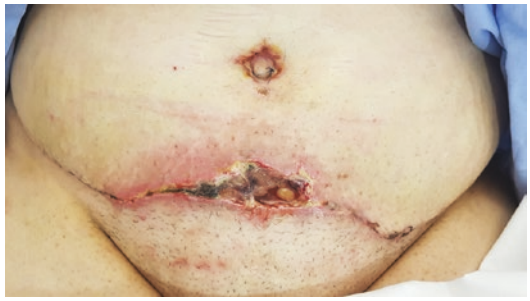

Fig. 25.9 Superficial infection resulting in wound dehiscence

In most cases, infections are well controlled with a standard antibiotic therapy [83, 84]. Smokers, sub-optimal controlled diabetic, or obese patients in conjunction with excessive tension of wound closure raise infection rates [85].

If more aggressive infections are developed, such as necrotizing fasciitis [86], debridement is mandatory (Fig. 25.9).

It is well accepted that in any soft-tissue surgery longer than 1–2 h, prophylactic antibiotics decrease the risk of infection. Antibiotic therapy should be adapted to the particular setting in each case, but usually first-generation cephalosporin is sufficient as a prophylactic antibiotic.

25.9.3 Hematoma/Bleeding

Although they are not very frequent, postoperative hematoma may result in hemodynamic instability and require urgent revision surgery [87]. Cautious hemostasis must be done in every procedure [88]. Usually, these events happen during the first 24 h. After that period, hematomas can appear but usually are asymptomatic since the accumulated volume is not high, and there is no active bleeding [89]. If present, needle aspiration can be done to remove the liquid but, in most cases, it could be coagulated, and conservative treatment is the option.

Risks factors other than surgical technique include hypertension, previous coagulopathy, and higher BMI.

25.9.4 Skin Necrosis

Adequate skin perfusion is the most important objective in abdominoplasty. Perfusion may be jeopardized by different factors. Excessive tension at the wound should be avoided, preservation of perforator vessels should be done as much as possible and smoking habit must be avoided in order to achieve a well-perfused flap. Recently, the use of nitroglycerin ointments has demonstrated better flap survival in mastectomy flaps and may be used in abdominoplasty with the same objective.

When skin necrosis is present, it usually begins as skin epidermolysis which may advance to wound dehiscence/infection (Fig. 25.10). This process may be tortuous and may require surgical debridement or other therapies [90] such as negative pressure devices [91, 92] (Fig. 25.11). In most cases, conservative treatment is the best option and wound healing is completed by second intention.

25.9.5 Venous Thrombosis

Although it is not a risky procedure, it can be life-threatening, which is usually underestimated [93]. Risk factors include elevated BMI [94], general anesthesia, long operative time, immobilization, etc. [95]. Patients at utmost risk are those undergoing combined procedures [96, 97]. Different stratification scales have been reported [98], but commonly patients are classified into four groups of risk: low, moderate, high, very high [99]. Each patient should be assessed preoperatively, and precautionary measures are adopted depending on each risk group including early mobilization, correct positioning, compression stockings, intermittent pneumatic compression boots, and low-molecular-weight heparin.

Fig. 25.10 Umbilicus necrosis

Appropriate use of chemoprophylaxis of venous thrombosis does not increase hematoma or bleeding rates.

25.9.6 Hypertrophic Scars/Keloids

A correctly positioned thin scar is the most desirable aspect of the surgery for patients. However, personal predisposition may affect the quality of the scar. Tension on the wound may lead to hypertrophic scar. In our opinion, it is better to make a little inverted T scar rather than a stiffer wound closure. Recently, immediate treatment of the wound at the end of the surgery with 1210-nm laser has been described as an effective method to improve scar quality. After surgery is recommended, use local compression at the scar to prevent or treat hypertrophy, usually silicone patches.

Treatment of hypertrophy may require local infiltration of steroids, laser treatment, or local excision.

Fig. 25.11 Skin necrosis and treatment with NPWT

25.10 Conclusion

Abdominoplasty is a surgery which is very much in demand in the postpartum. Pregnancy entails big transformation in women's body within a short period. Thus, different aspects of body contour and muscle integrity should be carefully considered. Restoring abdominal anatomy may be challenging and cautious evaluation of expectations with the patient is key for a better outcome.

Despite it not being a very technically demanding surgery, different factors influence the final result making the whole procedure seem complex. Considering this, a customized plan for each patient should be made. Careful physical evaluation detecting hidden hernias is the first and very important aspect to consider in case of liposuction so as to avoid major complications [100].

Different surgical techniques are available in the armamentarium to provide the best option in each case [101]. Familiarity with all procedures makes the surgeon confident in order to obtain the best possible results. Each technique has advantages and disadvantages which is left to the surgeon to choose.

Depending on the designed surgical plan, postoperative care may vary but it is well accepted that prophylactic antibiotics reduce wound infection, and early mobilization reduces thromboembolic episodes. Seroma is the most common complication but usually is easy to manage with serial punctures. The overall complication rate is low, when patient is well and surgical techniques are selected correctly.

Patient satisfaction with abdominoplasty is often very high, and it is a very safe procedure considering all precautions mentioned before. In most cases, not only we correct physical problems, such as the rectus diastasis, but we also improve patient's quality of life.

Final Review

- Abdominoplasty is one of the most demanded procedures after pregnancy.
- Mastering anatomy is key to performing a safe procedure.
- Correct selection of patient ensures better outcome.
- Correction of rectus diastasis may improve lower back pain.
- Placement of scar is probably the most important technical issue.
- Patient satisfaction is usually very high.
- Long-lasting results are achieved as long as patient's weight is unmodified.

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26 Simultaneous Correction of Postpartum Breast/Belly Badness Utilizing TABA

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Take-Home Points

The most common contour changes after pregnancy are seen in breast and tummy including both flanks and lateral breast areas.

- Mommy makeover has two procedures combined in one surgery: breast contouring and abdomen contouring.
- TABA (transabdominal breast augmentation) and abdominoplasty combined surgery through an abdominoplasty incision is a satisfactory option for mommy makeover.
- TABA is preferred in the pursuit of minimizing incisions and maximizing aesthetic results in one single procedure.

26.1 Introduction

Contour changes and deformities of the breast and abdominal wall after pregnancy are common. Breast contouring and abdominoplasty are surgeries that make significant improvement in body contour of women in her post-maternity period. It is widely known as mommy make over.

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Mommy makeover has two procedures combined in one single surgery: breast contouring and abdomen contouring. Breast contouring after pregnancy is a fruitful and effective procedure in which the excess skin and ptotic breast tissue are removed and the contour, mount of the breast restored and regained. Even a better shape, volume, and contour can be achieved with this breast surgery. Tummy contouring after pregnancy is also a significant surgery in which the excess skin and fat are removed, and the muscle and fascia layers, i.e., so-called myoaponeurotic layers, are tightened, shaped, and repositioned.

It has been proved that abdomen and breast contouring increases the self-esteem, the quality of life, and self-image. This combined surgery also increases a woman's confidence in sexual encounters.

TABA (transabdominal breast augmentation) and abdominoplasty combined surgery through an abdominoplasty incision is a favorable technique. We prefer transabdominal breast augmentation in the pursuit of minimizing incisions and maximizing aesthetic results in one single procedure. Indications, technique, post-op management, and pearls and pitfalls regarding this technique will be found in detail here in this chapter [1].

The technique of transabdominal placement of breast implants was first described by Hinderer in 1975 in a single case report [2]. There had been subsequent published reports

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_26

with short-term follow-up [3]. All of these combined techniques were done under general anesthesia [3–7]. Here, in this chapter, we will be presenting our experience with monitored anesthesia care in an ambulatory setting using propofol, ketamine, and intercostal nerve blocks [8–12].

26.2 Patient Selection

There are two patient populations that are candidate for combined TABA and abdominoplasty. The first group is the patients who gave birth and desire abdominoplasty and have concomitant involutional breast volume loss. Patients who request a combination of breast augmentation and abdominoplasty in one single surgery are optimal candidates. The second population is patients who seek abdominoplasty with combined breast augmentation and has moderate skin laxity after weight loss of 25 to 50 kg. TABA can be used effectively in this group of patients as well, if ptosis is not severe (Grade 1 and occasionally Grade 2 ptosis and pseudoptosis).

Patients are required to qualify for full abdominoplasty and bilateral breast augmentation. Patients who already had a significant previous breast surgery and upper abdominal surgery are not considered good candidates for this surgery. Similarly, patients with significant breast ptosis (some of the Grade 2 ptosis and all Grade 3 ptosis) are not candidate for this combined surgery.

Patients should quit smoking at least 4 weeks before surgery. Smoking should not be allowed until full recovery is established.

26.3 Marking

The conventional marking for a low bikini incision is performed with the patient in the standing position. Both inframammary folds (IMF) are marked.

26.4 Anesthesia

Majority of surgeries can be performed under monitored anesthesia care in the outpatient setting. Briefly, the technique for monitored anesthesia care is induction with a combination of propofol and ketamine followed by nerve blocks. Nerve blocks are as follows: posterior intercostal block from T4 to T12 using a combination of lidocaine, epinephrine and bupivacaine, and anterior intercostal block of T2 and T3 in the posterior axillary line and bilateral ilioinguinal nerve blocks. Patients are also given a strong antiemetic combination including metoclopramide, droperidol, and ondansetron. Patients receive propofol, fentanyl, ketamine, and midazolam as needed during the operation.

26.5 Surgical Technique

Surgery begins with conventional abdominoplasty flap dissection. Umbulicus is freed. Dissection ends up at arcus costarium (Fig. 26.1).

A funnel-shaped tunnel 8–10 cm long is made with distal openings at the inframammary fold. A 4 cm wide opening is created with electrocautery to pass through the inframammary fold. This last opening is made to allow the passage of a gel filled or saline implant. Electrocautery is also used to free up the lower insertion of pectoralis major muscle.

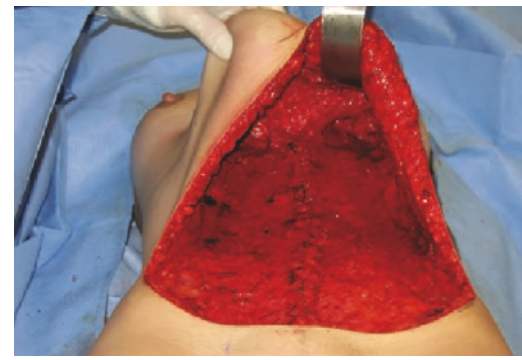

Fig. 26.1 Intraoperative image of transabdominal breast augmentation approach. Surgery begins with conventional abdominoplasty flap dissection

Fig. 26.2 Intraoperative image of transabdominal breast augmentation approach. Once the subpectoral plane is entered, a balloon dissector is introduced and inflated to develop the pocket for implant placement. Further pocket dissection is performed with a hockey-stick dissector

Further dissection is done bluntly with finger. Finger dissection helps to enter the subpectoral space with simultaneous distraction on the breast tissues to help elevate the pectoralis major muscle away from the chest wall. A Snowden–Pencer balloon dissector is then inflated to 600 cc to define the subpectoral pocket, with further adjustments made with a hockeystick dissector and blunt finger dissection as necessary (Fig. 26.2).

After adequate pocket creation, the implant is placed. To minimize trauma during implant insertion, a Keller Funnel device can be used. This can be especially helpful for textured implants.

Implants may be placed above the muscle to address a greater degree of ptosis. But our preference is subpectoral placement unless otherwise indicated.

The patient is placed in the sitting position to assess and evaluate for symmetry and further adjustments are made while the patient is still in sitting position. After further adjustment, the inframammary tunnels are partially closed with permanent suture of no. 1 Maxon (Covidien, Mansfield, MA. USA) In addition, external bolster sutures of 0-Prolene (Ethicon, Inc., Somerville, N.J. USA) on Xeroform (Covidien, Mansfield, MA. USA) pledgets are used to further define the inframammary fold.

After breast augmentation is completed, procedure continues with conventional abdominoplasty. Fascial plication from the xiphoid to pubic symphysis with interrupted and running permanent sutures is done. Excess skin is removed. For further postoperative pain relief, bupivacaine is injected into the bilateral rectus sheaths just lateral to the suture plication. Two Jackson–Pratt drains are placed and brought out in the midsuprapubic region. Finally, the lower abdominal skin is closed in layers using absorbable barbed sutures while umbulicus inset is completed. Final adjustment can be made with liposuction cannulas. This final touch is made for both flanks, upper abdomen, and for any area that adipose tissue thickness is not homogenous or redundant.

26.6 Postoperative Care

After dressing application, the patients are sent to the recovery room. Patients are traditionally discharged to home after appropriate monitoring unless they had extensive additional procedures warranting inpatient admission.

Patients with following comorbidities might be evaluated for inpatient admission:

- Patients with body mass index (BMI) over 30 kg/m^2
- Diabetic patients (especially insulin-dependent patients)
- heavy smokers

During postoperative visits, patients are instructed in appropriate taping and breast bandeau wear, if indicated.

26.7 Complications

Complications can be classified as abdominoplasty and breast related.

The most common abdominoplasty-related complication is wound complications in the distal end of abdominoplasty flap. Minor wound dehiscence might be seen. These wound problems are simply managed with office-based wound care. Other complications are hematoma and seroma. Breast-related complications are double-bubble, implant malposition in the sub-

glandular plane, capsular contracture (including Baker grade 3). Overall, our minor complication rate is 21.9%.

Major complications are seen in patients with comorbidities such as patients with body mass index (BMI) over 30 kg/m^2, diabetic patients (especially insulin dependent patients), heavy smokers. Overall, major complication rate is 7% in our daily practice for TABA cases.

Key Points

- Transabdominal breast augmentation in the properly selected candidates is an excellent choice for those who desire both abdominal and breast rejuvenation.
- It is an outpatient procedure and is tolerated very well under monitored anesthesia care with nerve blocks.
- The elimination of the additional incision, especially on the breast, where telltale scar hypertrophy can occur, is a distinct advantage.
- The procedure also allows for superior repositioning of the inframammary fold with simple suture placement.
- Natural gravitational drainage of the breast dissection site into the abdominoplasty region helps to prevent blood and serum accumulation within the implant pocket.
- A true no-touch technique where the inserted breast implants never come in contact with skin flora may lead to overall decreased capsular contracture development by circumventing bacterial contamination associated with biofilm production.
- The symptomatic capsular contracture rate is minimal *(0.8%)*
- The majority of complications is minor and can be managed in the office setting. Complication rates paralleled those of prior published reports for abdominal contour procedures in women.

Pearls and Pitfalls

- The majority of cases (94%) can be performed under monitored anesthesia care with intercostal nerve blocks.
- Operative time is approximately 2.5 h.
- There is definitely a learning curve.
- Implants are placed in almost 95% of cases in subpectoral plane, and predominantly gel-filled implants (almost 70%) are preferred.
- The average implant placed is 350 cc.
- TABA lets to combine additional procedures at the same operative setting. The most commonly requested additional procedures are suction-assisted lipectomy, fat grafting, scar revisions, nipple reduction, and purse stringing of the areola.

26.8 Conclusion

After a single case report by Hinderer in 1975, there have been only very few case series over the ensuing decades examining the safety, efficacy, and outcomes of transabdominal breast augmentation [2–7]. Our large series published in 2017 highlights the benefit of breast augmentation delivered through an abdominal route combined with abdominoplasty through a single incision for subpectoral or subglandular placement of either silicone or saline prostheses [1]. This is the largest reported series of transabdominal breast augmentation to date, providing long-term follow-up in a diverse population. We experienced that the procedure is a safe, straightforward technique with excellent patient outcomes in the appropriately selected population.

It is worthy to underline the importance of ideal candidate. Ideal candidate is a healthy, minimally to moderately ptotic patient who has completed birth-giving and is eligible for both breast augmentation and abdominoplasty. Patients, who are either postpartum or do not desire children, are candidate for this combined surgery.

Patients who had large-scale weight loss (25–50 kg) either through laparoscopic gastric bypass or through intensive lifestyle modification can also be considered good candidates for this procedure.

For the subset of patients who undergone gastric bypass operation, the concerns for nutritional deficits should be addressed preoperatively. It should be emphasized that there is no association with any documented major or minor complica-

tions in this specific patient subset [13]. Patients with abdominal laxity and minimal ptosis, who is done with childbearing and without medical comorbidities, can achieve good outcomes with TABA and abdominoplasty combined surgery (Figs. 26.3, 26.4, 26.5, and 26.6).

Fig. 26.3 Patient: A 38-year-old woman with a history of hypomastia and two prior pregnancies presenting with lower abdominal skin laxity and moderate ptosis. Procedure: This patient underwent transabdominal breast augmentation, abdominoplasty, and suction assisted lipectomy to the flanks and thighs with subpectoral placement of 450-cc implants bilaterally. (*Left*) Preoperative images. (*Right*) Postoperative result at a follow-up appointment 21 months after the operation

Fig. 26.4 Patient: A 55-year-old woman with a history of umbilical hernia repair, C section delivery, and three prior pregnancies presenting with bilateral hypomastia and lower abdominal skin laxity. Procedure: The patient underwent transabdominal breast augmentation and abdominoplasty in addition to suction-assisted lipectomy and fat grafting to the central chest. The patient underwent subpectoral placement of smooth, round, high-profile saline implants; 320-cc implants were inserted bilaterally. Shown here are images obtained preoperatively (*left*), 1 year postoperatively (*center*), and 10 years postoperatively (*right*)

Abdominoplasty wound complication rates are parallel to standard rates [14–16] Hensel et al. reported an overall complication rate of 32% for abdominoplasty [15]. Our major complication rate is 7.0% and our minor complication rate is 21.9%. The existing literature also delineates an increased risk of complications in smokers, diabetics, and obese patients [16].

Combined procedures, i.e., breast surgery and tummy surgery, in one single stage has been a subject of debate. But combined standard cosmetic breast and abdominoplasty procedures have been previously shown to be good [17]. The majority of complications is at the abdominoplasty site and parallel to the complication rate of abdominoplasty alone. Davison et al., Grazer and Goldwyn have reported higher rates of deep venous thrombosis and pulmonary emboli after abdominoplasty [18, 19]. We have a lower deep venous thrombosis rate and no pulmonary embolus case. It may be related to performing our surgeries in the outpatient setting and having the patients immediately ambulated [12]. The advantages of early ambulation after surgery are widely known in the plastic surgery literature [20, 21]. We believe that the type of anesthesia we used and its help to motivate our patients for early mobilization and finally our early mobilization helps to minimize deep venous thrombosis risk.

Breast complication rates are significantly lower than that of the abdominoplasty. It is clear that there is an open drainage of the implant pocket into the abdominoplasty area. This aids in

Fig. 26.5 Patient: A 43-year-old woman with a history of three prior pregnancies presenting with bilateral hypomastia and abdominal skin laxity around belly button. Procedure: Transabdominal breast augmentation, abdominoplasty, and a nipple reduction. Smooth, high-profile saline implants were inserted bilaterally in the subpectoral plane; a 270-cc implant was inserted on the left and a 290-cc implant was placed on the right side. The patient is shown here preoperatively (*left*) and at 20 months postoperatively (*right*)

Fig. 26.6 Patient: A 39-year-old woman with a history of cesarean delivery and one prior pregnancy presenting with bilateral pseudoptosis. Procedure: The patient underwent transabdominal breast augmentation and abdominoplasty. Smooth round silicone implants were inserted in the subpectoral plane; 350-cc implants were placed bilaterally. The patient is shown here pre-operatively (*left*) and at 8 years postoperatively (*right*)

the prevention of blood and fluid collection in the pocket. And finally this is a factor to decrease predisposition to infection and capsular contracture as well. In addition, the technique for implant placement is a no touch technique that ostensibly prevents contamination of the implant or pocket with breast-borne microorganisms. It is believed that all these contributed to our minimal overall capsular contracture rate of 0.8% (1 of 114), which is among the lowest reported in the current literature [1, 22–24].

We feel that caution should be exercised in offering transabdominal breast augmentation to those patients who are overweight, smokers, or poorly controlled diabetics. Many authors have commented on the elevated risk of wound complications in smokers and patients whose body mass index is greater than 25 kg/m^2 [25]. Smoking cessation should be documented for a minimum of 4 weeks preoperatively, with consideration for urine cotinine testing (nicotine levels), and ideally indefinitely thereafter in these patients given the association with increased postoperative morbidity described in this chapter.

It is highly recommended to have certain selection criteria while choosing the patient. These criteria should be as follows: implementation of preoperative urine cotinine testing, strict observance of smoking cessation, and filtering patients with high body mass index and high smoking rates.

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Liposuction 360°

27

Ibrahim Fakih-Gomez, Adrián Sánchez-Balado, and Jesús Olivas-Menayo

Take-Home Points

- Liposuction of the anterior area and flanks in supine position should achieve a flat abdomen and abdominal muscle marking. To achieve the latter, it is necessary to remove more fat from the midline (linea alba) and paramedian zone (linea semilunaris) in women and complement it with the transverse bands of the rectus abdominis in men. In post-maternity women, after C-section scar, care should be taken with postoperative adhesion on the lower abdomen.
- In the posterior area (prone position), one should treat the flanks again, since from the supine position it is difficult to access all the adipose complex of this area. It must be nearly "emptied" (minimal fat component) to achieve an aesthetic waist.
- Bra roll is very common in overweight women. It is essential to perform fat extraction liposuction of the roll and release adhesions of the thoracic area skin to the latissimus dorsi. Eliminating these septal attachments, we will achieve a homogeneous transition from the thoracic area to the waist.
- "Venus Dimples "is considered to be an aesthetic ideal of health, youth, and beauty in many cultures. Marking of dimples must be done imperatively to reach a harmonic and juvenile supragluteal zone.
- Control over skin retraction is essential. The use of complementary intraoperative devices such as ultrasound-assisted liposuction (VASER®) or radiofrequency-assisted liposuction (BodyTite®, Renuvion®), as well as postoperatively such as radiofrequency or ultrasound and pressotherapy or massages will reduce secondary fibrosis, favor lymphatic drainage, and achieve an adhesion of the skin to the underlying tissues.
- Current devices for liposuction include:
  - Suction-assisted liposuction (SAL): manual reciprocation of a cannula that uses shear forces to perforate fatty tissue for removal by suction.
  - Power-assisted liposuction (PAL): vibrating and reciprocating cannula controlled by the surgeon manually, which reduces operator fatigue sliding smoothly through fibrous tissues.
  - Water-assisted liposuction (WAL): introduces high-pressure water jet to gently disrupt and dislodge fatty tissue during liposuction.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/978-3-030-43840-1_27.

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© Springer Nature Switzerland AG 2023
M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_27

- Ultrasound-assisted liposuction (UAL) involves the introduction of ultrasonic energy into adipose tissue, which emulsifies fat to provide easier and more gentle suction with SAL in the second step.
- Laser-assisted liposuction (LAL): introduces laser energy through a cannula or by delivering laser energy via a quartz treatment tip without a cannula to disrupt adipose tissue and emulsify fat for easier suction
- Radiofrequency-assisted liposuction (RFAL): radiofrequency device that contracts the fibroseptal network seeking for a greater skin retraction.

27.1 Introduction

Liposuction, as an isolated procedure or in combination with other surgeries, is one of the most used techniques in plastic surgery. According to the International Society of Plastic Surgery (ISAPS), liposuction is the second most popular procedure worldwide with more than 1.5 million surgeries in 2018 [1].

Developed by Illouz in 1977 [2] liposuction evolved greatly in the past decade, increasing its sophistication in surgical approach and in development of new instruments. Improvement in infiltration designs and extraction cannulas, better knowledge of physiology and absorption of local anesthetics, use of adrenaline and increased tumescent volumes have greatly improved safety. Better control of bleeding and postoperative pain meant that we could perform larger volumen extraction without increasing associated comorbidities, which in turn allows us to treat larger body areas. Performance of circumferential or 360° liposuction becomes a controlled and safe process, both for the surgeon and the patient, obtaining superior aesthetic results, as we are able to sculpt the abdomen and back region. Treatment of bra roll, upper and lower flanks, creation of Venus dimples and release of fibrous adhesions to the underlying musculature are just possible with this technique, which added to high definition liposuction of the anterior area, marking the abdominal muscles, achieves a flat, outlined abdomen and an hourglass silhouette considered an ideal of beauty. Likewise, current intraoperative and postoperative management has led to better skin retraction, decreasing bruising and fibrosis [3].

▶ **Warning** Deep knowledge of local anesthetics, different instruments and technologies cannot be overemphasized. It is essential to control all the factors surrounding this procedure.

27.2 Patient Selection

A detailed examination of the patient's body is essential to obtain good results. We must bear in mind that presence of a sagging abdomen, a lax skin that has lost its elastic and retraction properties, or weakness and herniation of the abdominal wall will not be completely corrected without open surgery. In these cases, combination of liposuction with abdominoplasty would be our recommendation, thus obtaining better access to abdominal wall repair or excision of cutaneous excess.

We will obtain better results if the patient can be classified into one of the following groups.

1. Good elastic skin quality
2. Patients with normal weight or slightly overweight without marked excess skin
3. Existence of isolated fatty deposits in both the abdomen and flanks
4. Undefined waist
5. Venus dimples (posterior iliac spine ligaments) not clearly defined
6. Presence of "bra roll" without marked excess skin
7. Thin or normal weight patients seeking greater muscular definition (360° high definition liposuction)

▶ **Warning** To enhance your results, make sure to select good skin quality patients. Do not risk with obese or massive weight loss patients due to poor skin quality and retraction. It will lead to unhappy patient and surgeon.

In post-maternity women, body shape will change within months after delivery. We recommend performing liposuction once stability has been reached, allowing the skin to adapt naturally. It may take up to one year, so patience is advised. Early treatment might lead to good results in the early postoperative period, but further body changes will obscure the treatment with suboptimal results.

27.3 Preoperative Analysis

27.3.1 Previous Analysis

In our practice, we take a series of patient photographs that allow us to analyze the problems we can solve (Fig. 27.1) and the ones susceptible of improvement with other techniques. In this way, we get the patients to understand and actively participate in telling us what bothers them the most and what would they like to improve. With this dialogue, we also get a better doctor–patient relationship, in which both of us are aware of the objectives to be achieved with surgery.

Presence of fibrous adhesions in the abdominal and throchanteric area is well known. Anatomical studies verified the existence of areas of skin adhesion to deep planes, producing folds that cause excess fat to overlap and hang over (Fig. 27.2).

Knowledge and functionality is essential in liposuction, being able to decide which areas of adhesions we must respect and which to weaken to achieve a better skin transition, eliminating crease effect, and getting a smooth and homogeneous abdomen and back.

Transverse fibrous zones represent a real stop in skin continuity, acting in a similar way to the submammary fold or the nasogenian groove. Excess fat will protrude above giving a hanging abdomen aspect. Eliminating or weakening these fibrous areas with liposuction cannulas releases skin from its deep adhesions and allows us to balance the transition between different zones [4] (Fig. 27.3).

Previous scars are evaluated if present, and the patient is informed about the difficulties that can be present to release the underlying fibrous tissues. Sometimes they can act as a fix point where skin can hang over if skin retraction is poor. If we suspect this might occur, abdominoplasty may be advisable. Also in case of adherences, fat grafting under the scar can be done to further increase the quality of tissues.

A complete blood test is essential. Nutritional status, coagulation factors, water balance, and patient's general condition are evaluated. In case of previous history of thromboembolism, deep venous thrombosis, or hypercoagulability factors, it is advisable to evaluate the risk of post-surgical thrombotic complications using the Caprini score (Fig. 27.4) [5]. If oral contraceptives or hormone replacement therapy are taken, we recommend to discontinue treatment for a minimum of 2 weeks prior to surgery to reduce risk of thromboembolic events. In procedures where more than 6000 cc of lipoaspirate is to be expected, we recommend the use of prior patient autotransfusion. The use of blood substitutes in the postoperative period in high volume liposuction procedures favors a more accelerated recovery and less post-surgical weakness [6].

27.3.2 Preoperative Markings

First, trace the midline in the front and rear positions. Then mark the most protuberant areas on the abdomen and flanks. Take your time to palpate and draw linea alba, linea semilunaris, and inguinal ligament on each side, since they are the key framing lines in a female. Also outline inframammary fold, adhesion zones and folds or previous depressed scars and fat grafting areas if needed. In the back, mark the midline, lattisimus dorsi and gluteus maximus limits, Venus dimples, bra rolls, and all adhesion zones (usually under bra rolls). Finally, we draw our planned liposuction incisions.

Use different colors to signal each treatment area, so as to have a clear image of each zone during surgery (Video 27.1).

Fig. 27.1 Series of patient photos: front, 3/4 left side, total left side, rear, 3/4 right side, total right side

Fig. 27.2 Adhesion zone under bra roll that causes excess fat to hang marked with a red asterisk

Fig. 27.3 Hanging effect of the abdomen in areas of transverse fibrous adhesions in woman after C-section

Each Risk Factor Represents 5 Points

- ☐ Major lower extremity arthroplasty (<1 month)
- ☐ Hip, pelvis or leg fracture (<1 month)
- ☐ Stroke leading to immobility (<1 month)
- ☐ Multiple trauma leading to immobility (<1 month)
- ☐ Acute spinal cord injury (paralysis) < 1 month
- ☐ Major surgery lasting over 3 hours

Each Risk Factor Represents 3 Points

- ☐ Age over 75 years
- ☐ History of DVT / PE
- ☐ Family history of DVT/PE (1st degree relative)
- ☐ Major surgery lasting 2-3 hours
- ☐ BMI > 50
- ☐ History of Inherited Thrombophilia
- ☐ History of Acquired Thrombophilia

Each Risk Factor Represents 2 Points

- ☐ **Active Cancer**
  - - - -> Cancer diagnosed within the last 6 months (except skin and thyroid cancer)
  - - - -> Recurrent or Metastatic Malignancy
  - - - -> Patient on Active Cancer Treatment
- ☐ Age 61-74 years
- ☐ Central venous access
- ☐ Laparoscopic surgery (> 60 minutes)
- ☐ Arthroscopic surgery (> 60 minutes)
- ☐ Major surgery (> 60 minutes)
- ☐ Morbid obesity (BMI >40)

Each Risk Factor Represents 1 Point

- ☐ Malignancy other than mentioned above
- ☐ Age 41-60 years
- ☐ Varicose veins (current)
- ☐ Swollen lower limbs (current)
- ☐ Medical patient currently at bed rest >3 days
- ☐ Obesity (BMI >30)
- ☐ Congestive heart failure (<1 month)
- ☐ Sepsis (<1 month)
- ☐ Serious lung disease including pneumonia (<1 month)
- ☐ COPD exacerbation
- ☐ Leg plaster cast or brace (current)
- ☐ Other risk factors (specify)

For Women Only (Each Represents 1 Point)

- ☐ Oral contraceptives or HRT
- ☐ Pregnancy or postpartum
- ☐ History of unexplained stillborn infant or recurrent spontaneous abortion (≥ 3)

Total Risk Factor Score:

Total Risk Factor Score	Risk Level
≤ 2	Low
3 - 4	Moderate
≥ 5	High

DVT indicates Deep Vein Thrombosis; PE, Pulmonary Embolism; BMI, Body Mass Index; COPD, Chronic Obstructive Pulmonary Disease; HRT, Hormone Replacement Therapy. Adapted with permission from Joseph A. Caprini.

Fig. 27.4 Caprini score to evaluate risk of DVT

27.4 Anesthetic Considerations

In supine position, an endotraqueal tube is placed and securely fixed to avoid unwanted complications. It is imperative to assess tube fixation, as during the surgery, movement of the whole body is expected.

Use of local anesthetics with adrenaline in the infiltration phase may help the anesthesiologist to decrease the amount of intraoperative analgesia and opioids, which will reduce postoperative nausea and vomiting.

Close blood pressure control cannot be overemphasized, especially if large volume liposuction is planned. Recommended systolic pressure is around 100 mmHg. If we reach this goal, lipoaspirate will get more fatty and less bloody, increasing safety procedure, reducing postoperative bruising and leading to a faster recovery.

Controlled hemodilution can also be added to prevent blood loss. It should be noted that postoperative hemoglobin might be lower than expected within the first 24 h, but will raise to the real value after this period.

Some authors advocate for intravenous use of tranexamic acid to control postoperative hematoma, but in our practice, we have not seen a clear difference. Nevertheless, more research should be done in order to elucidate whether it might be helpful.

27.5 Surgical Technique

27.5.1 Current Devices for Liposuction

Since the first attempt of performing fat extraction through minimal incisions, by the French surgeon Charles Dujarrier in 1921, technological advances have appeared to make liposuction easier and more predictable. Sophistication of surgical materials and the surgeon's desire to improve liposuction procedures in search for best results made development of different devices possible till date [7].

27.5.1.1 Suction-Assisted Liposuction (SAL)

In 1977, brothers Arpad and George Fisher were the first to use suction together with sharp curettes for fat extraction. They ended up having large number of postoperative complications due to tissue damage with this aggressive method. Years later, Frenchman Yves-Gerard Illouz introduced the use of blunt tip cannulas, helping standardize the surgical technique and dramatically decreasing number of complications. It is from this moment when demand for SAL increases, technique is refined, and a wide variety of cannulas appear, with different tips and distinct distribution and sizes of holes in the distal part. Curved or straight cannulas were developed, with a great variety in length and diameters, from 0.9 mm cannulas widely used in facial surgery, to ones larger than 5 mm used in body contour liposuction.

Likewise, suction can be achieved from adjustable vacuum systems, where it is possible to control the pressure applied throughout the system, or manually by performing vacuum with syringes, obtaining lower pressures. The latter helps reduce damage on the adipocyte, a method focused on fat graft extraction through liposuction process. Introduction of fat grafting in a plastic surgeon's arsenal caused a radical change in body contouring surgery: its complementary use with liposuction led to a consistent improvement of postoperative results and developed a new concept of liposculpture. The capacity of body modeling through liposuction and minimal incisions was born, something impossible to perform previously without large surgeries or tedious dissections, along with its scar sequelae.

Today SAL is the most used system in the world, being a low cost method with a less pronounced learning curve. Post-surgical results are very technical-dependent based on fat extraction and production of subcutaneous tunnels, creating a three-dimensional dense fibrous septa network called retinacula cutis superficialis (RCS) and retinacula cutis profunda (RCP) (Fig. 27.5) that later, in the healing process, produces retraction of the dermis and the skin [8].

A major disadvantage of this system is that it is time and energy consuming if large volume liposuctions are performed, as well as a higher rate of blood loss. In addition, it might be more challenging when extracting fat in more fibrous areas, or in cases of secondary liposuctions in which scar tissue is present. Finally, cutaneous retraction is little compared to other techniques, which will be described later in this chapter [9].

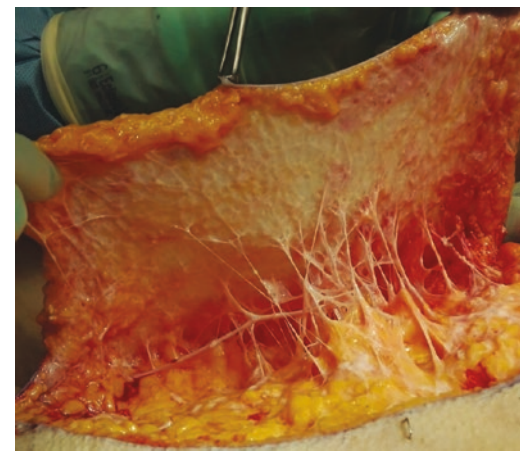

Fig. 27.5 RCS and RCP a true retaining connective network between skin and deep tissues after liposuction

27.5.1.2 Ultrasound-Assisted Liposuction (UAL)

Described by Zocchi, this form of liposculpture uses ultrasound energy to generate mechanical lipolysis and facilitate subsequent fat extraction. It is based on conversion of electrical energy into 16 kHz ultrasound waves, which ultimately create a molecular destabilization of tissues, and eventually their cavitation and cell fragmentation.

Therefore, it is a technique that requires two surgical phases. Initially, applied ultrasounds favor fat cell fragmentation, and then by means of suction-assisted liposuction, extraction of fatty tissue is carried out.

UAL's characteristics and way of functioning is what defines its advantages. By performing a relatively atraumatic adipocyte disruption, its use in more fibrotic areas, secondary liposuctions or HIV-associated lipodystrophies obtains better results and facilitates the process. Surgical bleeding is reduced considerably, being able to perform higher volumen extractions in one surgery without needing to autotransfusion or controlled hypovolemia methods. Less operative bleeding causes a reduction of hematomas and peri- and post-surgical ecchymoses, achieving greater patient comfort during the following weeks. Finally, many authors claim that extracted tissue is of better quality in case fat grafting is to be performed during the same procedure, due to cavitation and its protective effects on fat cells.

Third generation UAL device, known as VASER® (Fig. 27.6), allows for greater fragmentation of fatty tissue at minimum temperatures, which reduces the risk of thermal damage associated with previous generation devices.

Despite many defenders, UAL market is not extense. Its high cost and longer learning curve, as well as risk of thermal damage made many surgeons opt for other technologies with faster learning curves [10].

27.5.1.3 Power-Assisted Liposuction (PAL)

This system is based on the use of cannulas connected to an engine that generates high-speed movement, either oscillating or reciprocating.

Fig. 27.6 VASER machine, third-generation UAL

The first PAL device, FDA approved, was MicroAire Surgical Instruments in 1998 (Fig. 27.7), with a cannula that vibrates reciprocally between 2000 and 4000 rpm and a 2 mm excursion.

With these characteristics, the constant movement of the cannula tip facilitates its penetration through tissues, making its use in fibrotic tissues, HIV lipodystrophy and secondary liposuctions of great help, hence considered by many surgeons the ideal liposuction system. In addition, in primary liposuction surgery, PAL allows optimizing the process, reducing surgical time, blood loss and permits larger volume extraction with less effort.

Fig. 27.7 MicroAire surgical instruments with its reciprocating cannula

The problem of first-generation PAL systems has been mainly associated with excessive vibration in the cannula handle, which is transmitted to the surgeon's hand creating a sense of discomfort. Therefore, new generation devices reduced associated vibrations and noise generated. As no heat is produced, thermal damage is not possible.

Among the disadvantages of PAL is its high price, since MicroAire device or similar is necessary, as well as specific cannulas and mounting systems. Learning curve, as with UAL, remains longer than with SAL. Despite all drawbacks, many surgeons consider that advantages of PAL far outweigh its disadvantages, making it one of the best selling systems in the market nowadays [11].

27.5.1.4 Laser-Assisted Liposuction (LAL)

Application of laser in plastic surgery has increased exponentially in recent decades, from its use in facial resurfacing to the elimination of tattoos and vascular lesions. Apfelberg and his team in California incorporated, in 1994, the neodymiun-doped, yttrium aluminum garnet (nd:YAG) laser to a liposuction cannula. With a frequency of 1064 nm, the main chromophore of nd:YAG is water. Despite promising results, this system was not approved by the FDA, so research focused on finding a new system that provided three additional benefits to liposuction: reduction of operative bleeding, acceleration of post-surgical recovery and favoring as much cutaneous retraction as possible. The best-known system up to date is SmartLipo® (Fig. 27.8), which uses photothermolysis, acting selectively on the desired tissue (desired chromophore) without affecting the surrounding ones. There are several lasers available nowadays, with nd:YAG and diode laser being the most studied and performed. Different wavelengths can be used depending on the desired target, including collagen, fat, water, or hemoglobin. Lasers range between 800 and 1400 nm, with the lowest wavelength being more selective for hemoglobin and blood vessels and the highest for water (acting primarily on collagen and fat), generating greater cutaneous retraction.

Fig. 27.8 SmartLipo device, the best-known system of LAL

Therefore, LAL systems allow selective lysis of adipocytes, reducing total fat volume; selective coagulation of blood vessels, reducing peri and postoperative bleeding thus minimizing appearance of ecchymosis in subsequent weeks; and

selective thermal damage on dermal collagen, initiating cellular repair process with increased fibroblasts and collagen generation, and ultimately consequent cutaneous retraction. Despite these promising ideals, comparative studies of LAL with SAL have not found statistically significant improvements between both techniques.

The main disadvantages of LAL lie in the possibility of thermal damage, longer learning curve, as well as cost of the equipment [12].

27.5.1.5 Water-Assisted Liposuction (WAL)

Using a cannula with a fan form triangular tip, water is injected under pressure in a pulsatile manner for infiltration of a tumescent solution. WAL system, known as BodyJet® (Fig. 27.9), performs atraumatic and blunt hydrodissection of fatty tissue, as well as expansion of intercellular space, favoring its posterior extraction. The flow and pressure are controlled by the surgeon and adjustable during the procedure. There are many similarities between the concept of WAL and UAL. Both aim to dissect tissue and generate lipolysis, which then facilitates lipoaspiration by suction. However, in the case of WAL, there is no heat production, so thermal damage to the dermis is not a concern. On the other hand, it does not generate additional retraction, present with UAL [13].

Fig. 27.9 Bodyjet a device using WAL

27.5.1.6 Radiofrequency-Assisted Liposuction (RFAL)

BodyTite® (Fig. 27.10) is a bipolar device, based on the application of a radiofrequency current generating lipolysis and dissolution of fat cells, producing tunnels when fat dissolves, along with thermal effect on the skin for cutaneous retraction later. On the other hand, an aspiration cannula that removes coagulated and dissolved fat is incorporated in the same device. BodyTite is composed of a hollow Mercedes-tip cannula and is silicone coated, except for the tip where aspiration takes place and is one of the system poles. Another circular electrode is located in the outer

Fig. 27.10 BodyTite bipolar radiofrequency applicator

skin area. Radiofrequency current flows between the two poles, generating skin retraction due to thermal damage through all skin layers and lipolysis at the tip of the cannula. Dissolved fat is aspirated at the moment through the holes provided by the cannula tip. This device incorporates a real-time measurement of skin temperature in the external zone, which allows for a uniform application, improving patient safety and reducing risk of burns. The system is equipped with internal and external temperature sensors so that the operator is alerted when to proceed and when to stop avoiding heat damage. After BodyTite, approximately 30% of the fat is extracted but must be supplemented with SAL or PAL to finalize liposuction.

Renuvion J Plasma® (Fig. 27.11) uses both helium and RF energy to heat tissue. By adding energy to helium gas, the device creates plasma, which contours to the application area and evenly delivers the energy. RF waveform then flows through this conductive plasma to create additional beneficial heating of tissue. As the tip of the device is drawn across an application area, the energy is applied uniformly along the overlying dermis, septa, and muscle fascia. This allows for a full coagulative treatment (Fig. 27.12), customized in real time to the unique contours of the subcuticular space. With Renuvion, less than 0.1% of helium gas is converted into plasma, so most will remain in its gaseous state. As helium is more thermally conductive than air, the unconverted gas flows across tissue, drawing away excess heat like a subdermal air conditioner, minimizing any unintended thermal effect.

Fig. 27.11 Renuvion device

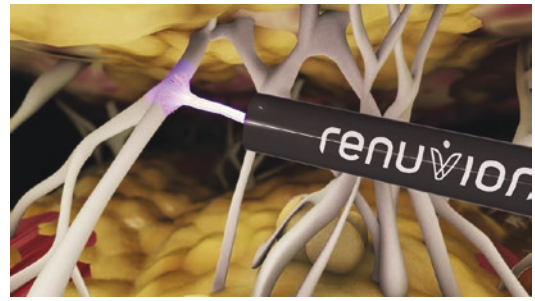

Fig. 27.12 Coagulative treatment of Renuvion J Plasma on the retaining connective network ligaments to produce cutaneous retraction

The main advantage of RFAL compared to previous systems is the degree of cutaneous retraction produced, achieving optimal results with this process. Detractors of this type of technology argue that thermal damage to tissues is one of its main disadvantages, but in review studies performed, there is no clear evidence of higher incidence of skin damage [14] (Table 27.1).

27.5.2 Patient Positioning

After preoperative markings, the patient lies over an auxiliary bed in a supine position. Normally, we use general anesthesia for large volumen liposuction and sedation in case less volume is to be aspirated.

After intubation, the patient is rolled to prone position over the operating table (Video 27.2). Skin of the posterior trunk is prepared with betadine, and drapes are placed (Fig. 27.13). A pillow is placed under the hip and knees are protected with a cushion (Fig. 27.14).

27.5.3 Procedure Step by Step

Incisions are made and access ports are placed to protect the skin, which are secured with 2/0 silk suture (Video 27.3). We use home-made ports with a 2 cc syringe as shown in Video 27.4. Then we start infiltration of Klein solution from 1 to 2 access points (one in the intergluteal crease and the other, if needed, in the back's midline at T11–T12 vertebra level) in a fanning out manner

Table 27.1 Comparison of different types of liposuction methods used nowadays

	SAL	UAL	PAL	LAL	WAL	RFAL
Fat emulsification	–	+++	++	++	++	+++
Skin retraction	–	+	–	+++	–	+++
Temperature control	–	–	–	++	–	+++
Comfort	–	+++	+	+++	++	+++
Marketing	–	+++	+	+++	+++	+++
Cost	+++	–	+	+	+	–
Time	–	–	+++	–	–	–

+: most advantageous, −: less advantageous

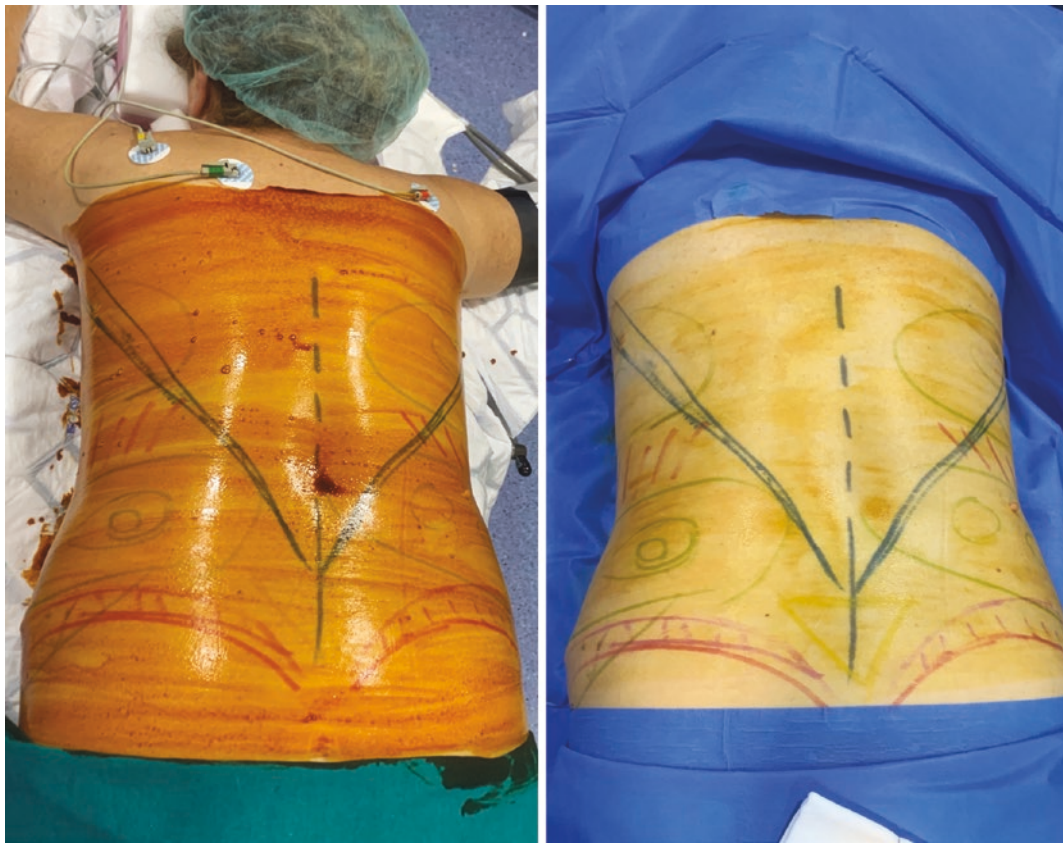

Fig. 27.13 Skin preparation with betadine and placement of drapes

(Fig. 27.15). We always perform SAFE liposuction (separation, aspiration, fat equalization) [15]. The key concept of 360° liposuction is the treatment of "bra roll." In the back, at the mid-level area, there exists a zone of fibrous adhesions normally accentuated by the constant use of bras upon many years. This causes the effect of hanging fat we previously described. It is extremely important to treat this area intensively during liposuction of the back, both to weaken the inserts and to shape the costal area, and make a beautiful transition to the concavity of the waist [16]. If strong adhesion or excess skin is present, open surgery is mandatory (Fig. 27.16).

Surgeon's sensations in the liposuction technique will also be different. A much more com-

Fig. 27.14 A pillow is placed under the hip to facilitate liposuction and lower abdominal pressure

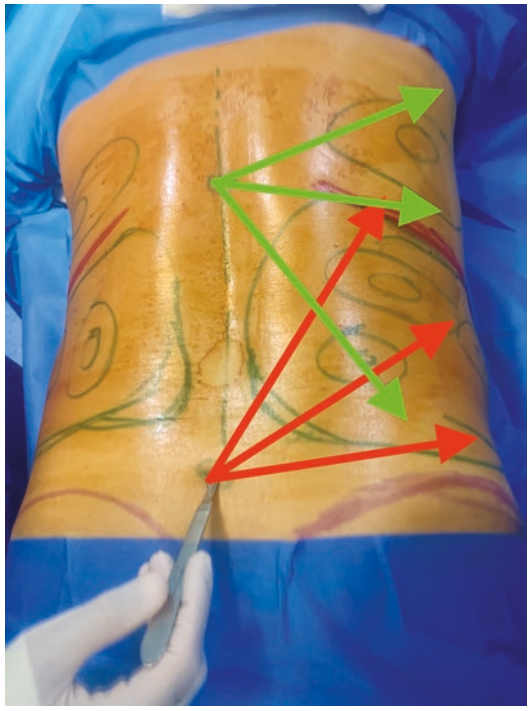

Fig. 27.15 From 2 access points and in a fanning out manner, we can infiltrate and aspirate the full back

pact fat with denser subcutaneous tissue and thicker dermis constitutes this area, all of which will make use of more aggressive cannulas useful

Fig. 27.16 Strong adhesions (marked with an asterisk) which cause bra rolls (b) to hang over

and safe. However, always take precaution of not perforating the rib cage, and thus a possible thoracic damage. (Fig. 27.17).

27.5.4 Surgical Modifications

As for the lower area, preparatory analysis and identification of the gluteus silhouette, the sacrum triangle and depressions of the posterior iliac spine, known as Venus dimples, is essential.

Liposuction should always be done above the upper gluteal fold, creating a difference in subcutaneous tissues thickness that visually enhances the buttock area and improves the rounded contour. Sacral and lower back area is usually very grateful, as skin retraction is powerful, paying special attention to Venus Dimples, which provide a much desired and youthful aesthetic improvement.

Fig. 27.17 We usually treat bra rolls and break adhesions with a basket cannula, a very safe instrument in the back due to thick dermis

Approaching the flanks from the prone position also brings great aesthetic improvement to body contouring surgery by generating new dissection tunnels, removing more fat, and leaving this area almost completely "fat-empty." Once the posterior part is done, patient is flipped to a supine position, the anterior trunk skin is prepared with betadine and new drapes are placed (Video 27.5). Infiltration and liposuction of the anterior part are usually done through 5 incisión ports (2 at the pubis in line with each lateral border of rectus abdominis, 1 at the supraumbilical area, and 2 at the inframammary fold (Fig. 27.18).

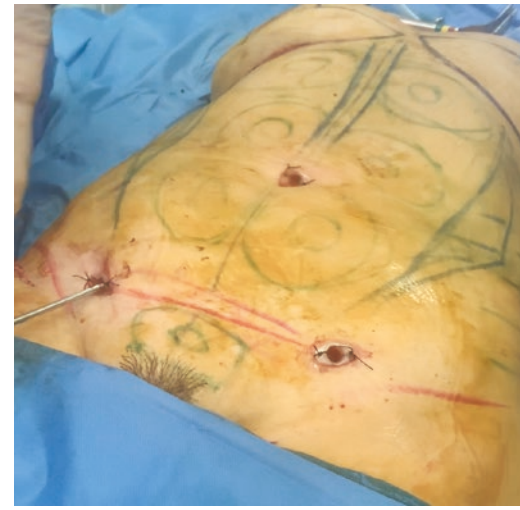

Fig. 27.18 Incisions with ports placed on the anterior trunk

27.5.5 Technical Tips to Improve Outcomes and Avoid Complications

Liposuction is done to all the anterior part making special attention to linea alba and linea semilunaris. To mark all lines, we perform dermal carving with a basket cannula. It is essential to remove more fat with a tonal progressión so that the lines are marked with a natural appearance [17].

▶ **Warning** The ideal glass-hour shape will be considerably improved when treating the flanks aggressively.

27.6 Postoperative Care

After surgery, a compression garment for the liposuction area is placed, which will be maintained for 4 weeks. Usually we use panty type prefabricated garments that cover thighs and abdomen (Fig. 27.19). Also, white foam may be added under the garment to generate a more even compressión and therefore better skin retraction. Also it avoids surface irregularities

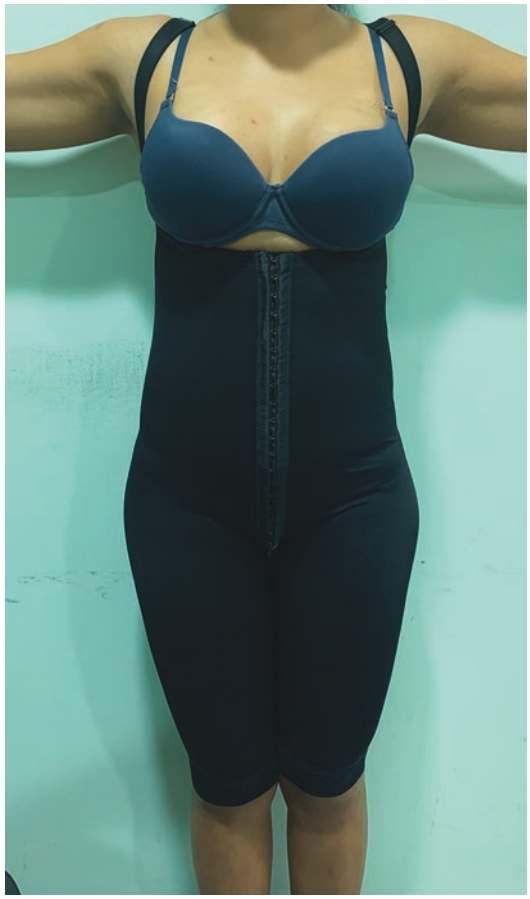

Fig. 27.19 Compression garment goes from the knees till the inframammary fold

due to improper use or ill-fitting compression garment [18].

Bladder is emptied at the end of the surgery and the patient leaves the operating room without catheterization.

It is essential to maintain close control of blood pressure, trying not to exceed 120 mmHg of systolic blood pressure. To achieve this goal, good pain control in the first postoperative hours is imperative, so as to avoid bleeding and fluid accumulation.

▶ **Warning** Controlled perioperative management of blood pressure is imperative. Valsalva maneuvers, nausea, and vomiting will rise blood pressure therefore increasing bruising in the postoperative period.

In our case, analgesia consists of intravenous infusión pump with paracetamol, dexketoprofen +/− a mild opioid. We usually add ondansetron, metoclopramide, tranexamic acid, and captopril during the first 24 h to prevent nausea and unwanted blood pressure spikes.

The patient is encouraged to stand up and deambulate as early as possible. In our experience, walking the same afternoon of surgery has led to an early recovery and fewer complications. By not carrying a bladder catheter, the patient feels free to walk which favors early deambulation; most of the times, even to go to the toilet.

A blood sample is taken to measure hematocrit. If no setbacks are present, and the patient's general condition is good, they can be discharged with office revision 4 days later.

▶ **Warning** Sun exposure should be discouraged during the first month to avoid pigmentation of subcutaneos hematomas that appear after liposuction. Sun cream SPF 50+ is recommended during summer, as clothes do not prevent some penetration of UVA radiation.

27.7 Outcomes and Prognosis

After 30 to 40 days, inflammation has decreased considerably. The provisional result is getting closer to the final result, which can be assessed 3 months after surgery (Figs. 27.20, 27.21, and 27.22). In this type of procedures, external radiofrequency, and ultrasound machines are important to deal with extensive internal trauma and inflammation, as well as favoring reduction of postliposuction fibrosis (Fig. 27.23). In years prior to usage of these devices, results obtained were not entirely satisfactory for surgeons,

Fig. 27.20 Preoperative and 1 year postoperative photo

Fig. 27.20 (continued)

Fig. 27.21 Preoperative and 1 year postoperative photo

Fig. 27.21 (continued)

although patients were satisfied. With the advent of these technologies, application of 10–20 sessions has visually improved the final result, both in the surgeon and the patient's eyes. We believe it is a must for adjuvant therapy after circumferential liposuction of 360°. Also, we recommend between 10 and 20 sessions of lymphatic drainage especially in the first 2 weeks after surgery (Fig. 27.24). We also provide the patient with a chart of food that cause and fight inflammation, encouraging them to have more of the later (Fig. 27.25) [19].

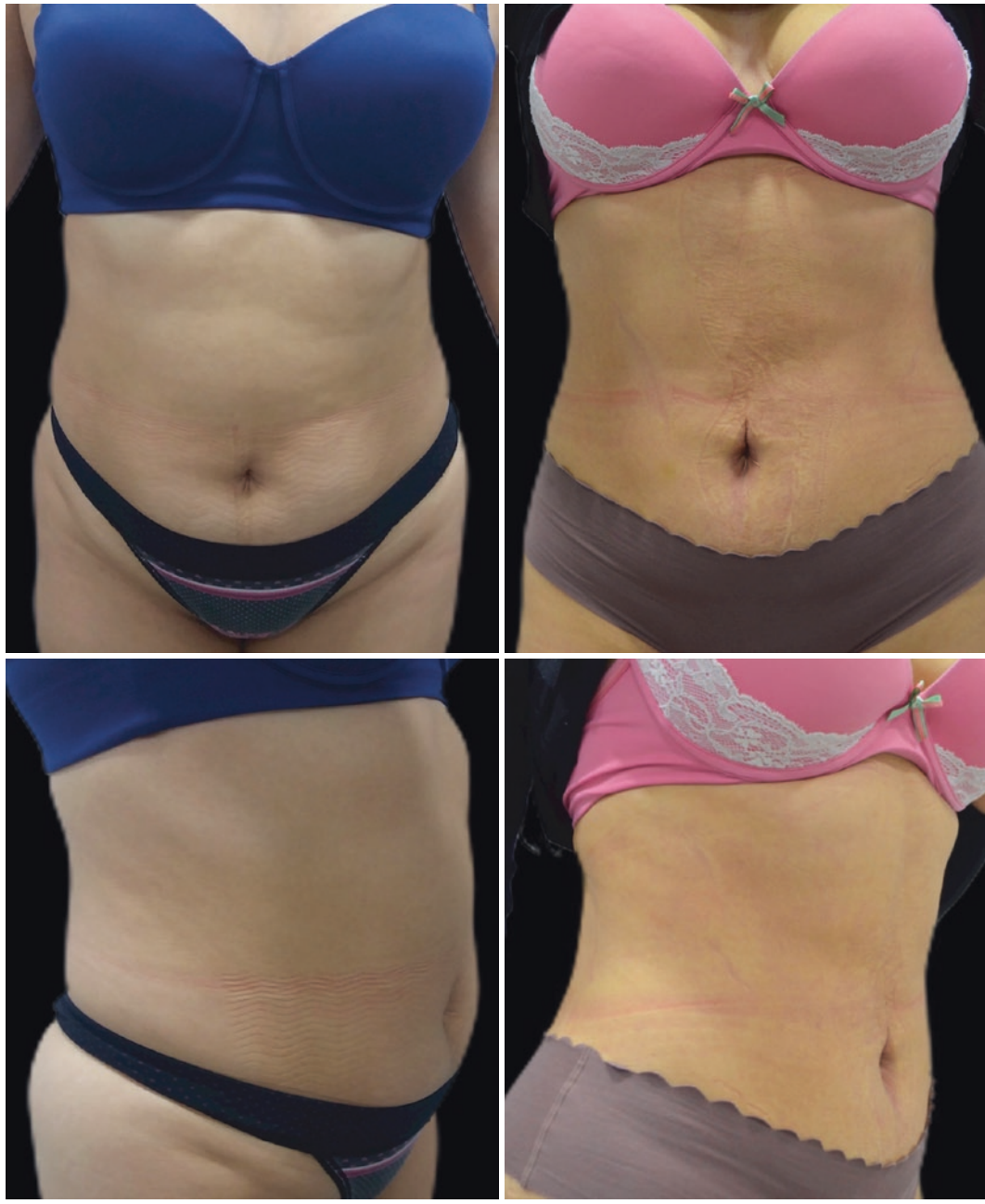

Fig. 27.22 Preoperative and 1 year postoperative photo

Fig. 27.22 (continued)

Fig. 27.23 External ultrasound is done to favor skin retraction and reduce inflammation

Fig. 27.24 Pressotherapy device helps lymphatic drainage thus reducing inflammation

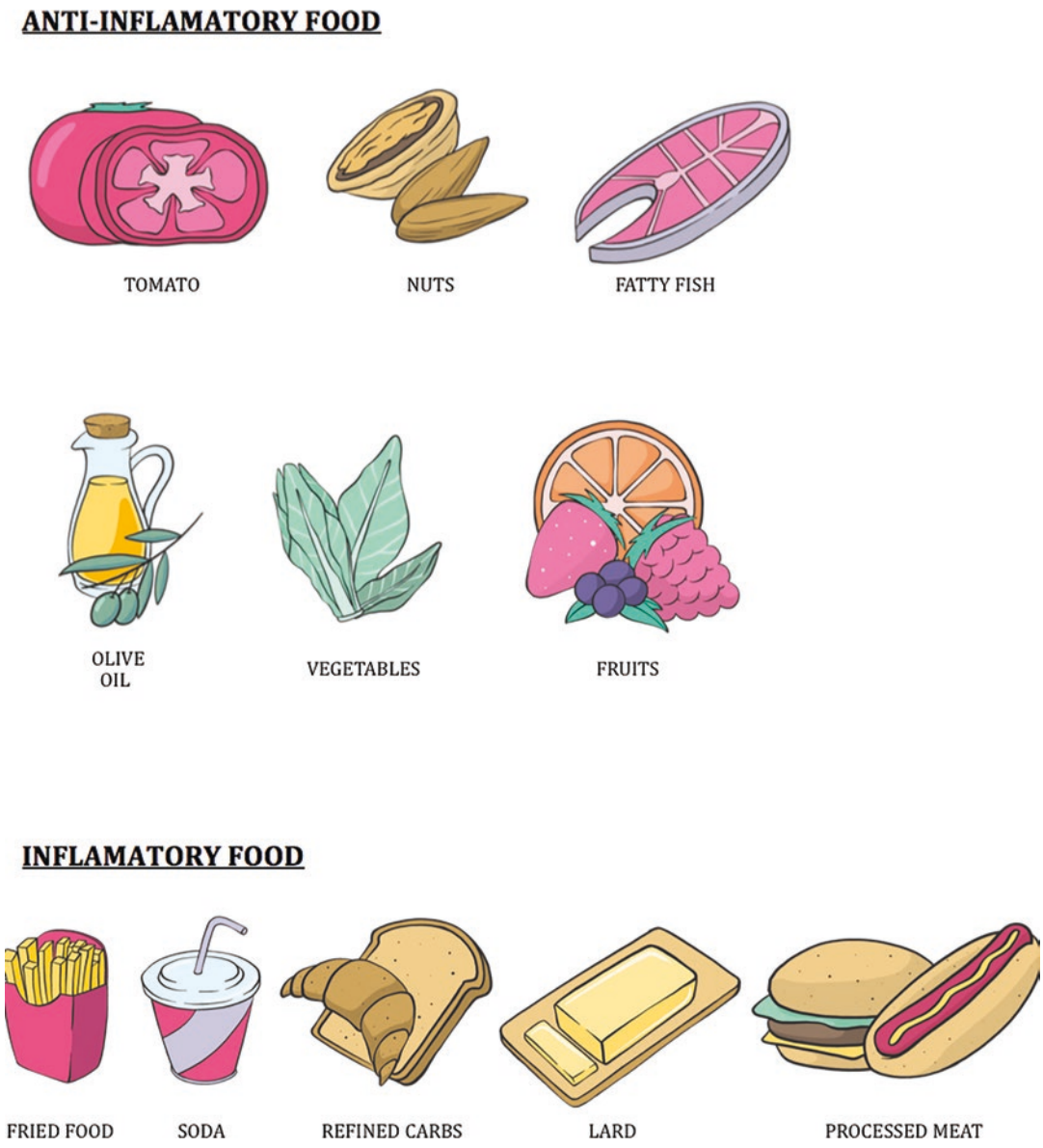

Fig. 27.25 Food that fight and cause inflammation. Source: https://www.health.harvard.edu/staying-healthy/foods-that-fight-inflammation

27.8 Complications

Complications include organ or rib cage damage, as some undetected hernias may be present and inadvertently perforated. Although this is a major complication, it is very uncommon. Control over the cannula, continuous palpation of tissue being aspirated, and tangential movements may help decrease this complication.

Deep venous trombosis may be present in the postoperative period due to venous stasis during surgery, immobilization in the postoperative period and individual factors discussed previously. Virchow's triad should be suspected and treated accordingly with heparine.

Sudden desaturation, non-responding to oxygen support, with or without chest pain, will point out pulmonary embolism. This can be a life-threatening complication and may require intensive care support. If suspected, undergoing a CT scan to ensure diagnosis is mandatory, and we advise to consider consultation with intensive care unit to prevent a fatal outcome.

As for typical liposuction consequences, bruising will be present in almost every case. Patient should be advised that it will resolve within a month. Discoloration may appear, especially with early sun exposure, but will improve with time.

Weakness is also common, usually if large volume liposuction was performed. Iron supplementation, blood transfusion, or autotransfusion may be helpful. We recommend early deambulation, iron, and vitamin supplements and high protein diet to all our patients to accelerate recovery time.

27.9 Conclusion

Liposuction still remains one of the most performed cosmetic surgical procedures worldwide. 360° liposuction addresses the front and back part in a holistic approach to achieve a more aesthetic figure. Liposuction technologies have significantly advanced over the last generation. The appearance of new devices allows us easier surgeries, safer techniques, and more consistent and improved results with better skin retraction. Postmaternity liposuction is a tricky procedure due to skin laxity after pregnancy. Preoperative assessment of skin quality and use of enhancing skin-retraction machines is mandatory.

Disclosure The authors received no funding support and declared no potential conflicts of interest with respect to the research, authorship, and/or publication.

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Umbilicoplasty

28

Valderi Vieira da Silva Júnior, José Frota, and César Cals

28.1 Introduction

The navel is an important scar for abdominal aesthetics [1]. It is described as an aesthetic subunit in itself, a mark that is essential to the overall aesthetics of the abdomen [2]. Your appearance and position are important to the end result of a tummy tuck. However, its reconstruction and appearance improvement are always difficult for the plastic surgeon [1].

It is the body's first natural scar and has its position described between the third and fourth lumbar vertebrae. It measures between 1.5 and 2 cm deep, rests on the midline between the upper iliac crests and changes with age and is influenced by the thickness of abdominal fat, weight changes, pregnancy, hernias, and scars. It has four fibrous cords, which are reminiscent of the umbilical vein, the uracus, and the two umbilical arteries and exert deep traction to fix and deepen it. It helps to define the middle portion of the abdomen, demarcates its lower portion, and its absence and mispositioning define an unnatural aspect of the abdomen [1, 3].

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The navel shape can be described based on six forms described by Delpierre et al.: T-shape, vertical oval, horizontal oval, round, distorted, or protruding. In general, the most common shapes are round and vertical. However, in older or overweight patients, the horizontal shape becomes more common [4].

28.2 Surgical Techniques

28.2.1 Procedures Step by Step: Umbilicoplasty and Abdominoplasty

Postpregnancy changes are very undesirable for some women, and abdominoplasty appears to be a high satisfaction option for the patient because of the great improvement in body contouring [5]. A badly made belly button may even be acceptable, but its absence becomes noticeable and a cause for extreme stress. Important factors for good navel reconstruction are the position, depth, shape, and location of the scar. Thus, for a good completion of surgery, the navel should be well located and finished [1]. Although the midline is considered a pleasing navel position, a 2003 study by Rohrich noted that most navels do not rest on the midline [6], which may be acceptable but slightly lateralized midline positions.

Tummy tuck evolved in terms of technique, safety, aesthetic outcome, and decreased compli-

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_28

cations. This made the results more natural. However, the navel is still a major challenge because it presents many healing and shape variables, thus the success of the surgery is based on the result of a reconstructed navel [4].

Umbilicoplasty (or omphaloplasty) is the method to give a more anatomical and natural appearance to the abdomen, and there are several techniques [4]. Since Vernon first described it in 1957, almost every abdominoplasty technique has described a custom omphaloplasty method, resulting in a wide variety of different incision patterns used to relocate the umbilical scar [7–19]. Over the years, there have been many studies in the literature focusing on the positioning of the navel in the abdomen, as well as its ideal anatomical shape, size, and depth. Although these studies share some commonalities in determining what is ideal, there are still differences [20].

The definitions of high or low navel position are left to the surgeon's personal judgment. These are probably the reasons why there is no standardization regarding its repositioning during abdominoplasty, as well as there is no consensus on the ideal umbilicoplasty technique [21]. Its main purpose is to create a natural, deep, and scarring navel. Some techniques use attachment points or local flaps. However, some may be shallow or wide and unnatural [3]. In addition, the scar formed around the navel is the most noticeable that the panties or pants cannot cover. Therefore, the best aesthetic result is targeted [20].

Classical umbilicoplasty consists of the vertical elliptical incision of the treated navel, the fixation of the stump on the abdominal wall, and the subsequent steriorization of the abdominal flap by a vertical elliptical incision. However, despite the similarity of various techniques of this particular approach, surgeons have continually modified this umbilicoplasty pattern in the hope of obtaining a more aesthetically pleasing form, better scar appearance, and adequate umbilical depth [20].

Many techniques have emerged to try to simulate a more natural navel, but many leave the navel stigmatized as it was operated, which frustrates the surgeon, especially the patient. They vary widely, but most have some result limitation, whether in shape or contour, depth, level of complications such as wound dehiscence, stenosis, broad, or small. However, all of them aim to make the navel as natural as possible [20].

28.2.2 Technical Tips to Improve Outcomes and Avoid Complications

28.2.2.1 Tactics for a Good Umbilicoplasty

For successful umbilicoplasty, the final incision design on the remaining umbilical stump is a very important variable. There are a variety of stump incision forms, and the round or oval shape accounts for 90% of the studies [20].

Incision in the abdominal flap is also another decisive factor in the outcome. As the circular scar is associated with a higher rate of navel stenosis, there was a constant attempt to create noncircular incisions [22]. It was believed that complications with umbilical opening stenosis could be the way the abdominal flap is incised. Variations in abdominal flap incision design have been described to give better aesthetic results and more discrete scars, such as inverted U described by Malic. In addition, many designs of the abdominal flap incision have been described, such as round, vertical ellipse, Y or U shape, inverted V, vertical line and vertical oval. However, the incision in the abdominal flap does not always coincide with the incised shape in the navel [18].

Other authors have described a variation of inverted U and the fixation of the abdominal flap through the dermis to the abdominal fascia to give a periumbilical depression effect [23, 24] and Castillo describes the Y incision [25].

The fixation of the umbilical stump to the rectus muscle or not, the degreasing or not of the abdominal flap in the region where the remaining stump will be fixed to create the periumbilical concavity (80% of the studies) are maneuvers

that can influence the final aesthetic result of the navel [20]. Hazani suggests an incision in the inverted U-shaped abdominal flap with fixation of this flap portion in the aponeurosis and skin grafting in the defect region [26].

Some authors advocate the fixation of the stump to the deep plane of the rectus abdominis fascia [20]. Dogan does not find it necessary [27]. This maneuver may cause greater tension in the final suture of the stump to the abdominal flap, resulting in hypertrophic scars, especially in obese patients, where the flap thickness is greater. For this, it is suggested the fixation of de-epidermal portion of the abdominal flap in the rectal fascia to decrease this tension and have satisfactory aesthetic result of the scar [28].

Additionally, the measurement of this incision design is also an important factor in obtaining the best aesthetic result and reducing stenosis. Some studies determine the exact measurement of the incision to be 1.8–2 cm. However, they have not been able to avoid the artificial aspect of the operated navels but have reduced the complication of large navel-like navels, as a measure that can avoid this situation has been standardized [28].

The position of the navel in the abdominal wall is also very important. In the work of Abhyankar et al., study was conducted with a group of 75 women, a distance of 25.69 cm between the xiphoid and the pubis was observed. From the navel, the pubic symphysis was 16.18 cm. And the average navel depth was 1.16 cm [1].

In 2013, an observational study of the navel anatomical surface was developed. Studies have shown that besides being midline, the most attractive position is the divine ratio or golden ratio. That is, the ratio of measurement from the lower portion of the xiphoid appendix to the navel to the lower abdominal portion is 1.62. Bone pelvic marks are not considered reliable as a reference for umbilical positioning [29].

Rodriguez et al. concluded that the pubic umbilical distance may vary depending on the patient's weight, and 15 cm distance may be a good parameter to define the new navel position in abdominoplasty [30].

The discussion to define the shape, the ideal position, and the best surgical reconstruction of the navel is ongoing. Studies that propose to elucidate and standardize the ideal navel position in the abdomen have failed to define this. Anthropometric measurements involve different navels among women of different ethnicities, ages, and body mass index. Therefore, the navel reinsertion only by measurement makes this technique unreliable and reproducible in umbilicoplasty [20].

The type of surgical thread used can also be a deciding factor for a good end result. Although more data are needed to have an objective conclusion on the type of suture around the navel, 77.8% of the studies concluded with nonabsorbable sutures. Given the high incidence of poor-looking or hypertrophic scars in the umbilical incision, it has been suggested that suturing with nonabsorbable threads may reduce these complications following umbilicoplasty [20].

28.2.2.2 New Stage: Navels without Scars

In a quest to achieve more natural navels, techniques were developed that included the amputation of the original navel to perform a complete umbilical reconstruction [31].

Clo and Nogueira propose an X-incision and the making of four V-flaps, which are fixed in the aponeurosis of the musculature, leaving a deep and scar-free navel [32].

In another technique, stitches are given in the abdominal flap dermis where it was calculated to be the new navel, and they are attached to the abdominal aponeurosis just below. However, a shallow navel index was observed between 20 and 30% of cases, which may be high incidence in the technique to reduce complications [31].

To reduce this shallow aspect, there are some tactics, such as using the decorticated umbilical remnant to fix the skin of the abdominal flap where the new belly button will be made. This fixation with stitches is made around and in the center of the remaining navel stump. That is, instead of amputating, it is partially used to secure the background of the new one. This tactic

is also very well used in patients with excess adipose panicle to decrease tension at these fixation points and to reduce the risk of rupture or dehiscence of the points, which is the main cause of shallow navel [31].

The surgical thread used may have an influence on the end result of this reconstruction and some studies describe several options for dermis fixation, such as nylon, prolene, ethilon, vycril, ranging from 2, 3, 4 to 50. However, 70% of the studies prefer the use of nylon because it is nonabsorbable and 40% describe the fixation of the dermis in the rectal fascia [20].

There are situations where a very large umbilical hernia, especially in pregnancy, causes the umbilical fundus adhesions to be broken or become too loose to the point of losing all depth. In this case, the risk of necrosis of this umbilical skin or shallow final aspect of the navel is most likely. In this case, the total amputation of the stump and the reconstruction of a new navel are indicated.

28.2.2.3 Umbilical Tunnel Reconstruction Technique: Belly Button like a Tunnel

The navel is considered a tube for some authors and its correction is based on the purpose. There are techniques for each type of belly button, which differ in depth and diameter, and they attempt to simulate the side walls of the belly button [33, 34].

In very thin patients who do not have enough skin in the umbilical area, even using the bottom of the navel to try to get deeper, shallow navel cannot be avoided. In this case, the umbilical wall should also be reconstructed to simulate a greater depth. Thus, local flaps are used. However, there is the inconvenience of leaving apparent scars. Therefore, it would be more indicated in patients with light skin and less likely to develop hypertrophic scars.

Tunneled neo-navel surgery is based on the making of V-shaped flaps from a midline incision, two upper and two lower flaps. The idea is to simulate the umbilical tube wall tissue with an upper and lower flap, which rotates in the opposite direction against each other. The third flap should have the most central epithelialized portion to cross under one of the flaps and be fixed to the central portion to simulate the bottom of the navel. The fourth flap is excised. The drawback is the risk of the middle scar becoming apparent from the poor skin quality of the patient. But it is a well-indicated technique in cases of navel amputation, as it becomes more predictable and highly reproducible (Figs. 28.1, 28.2, 28.3, and 28.4).

Some authors have described techniques for making this tunnel with local flaps fixed between

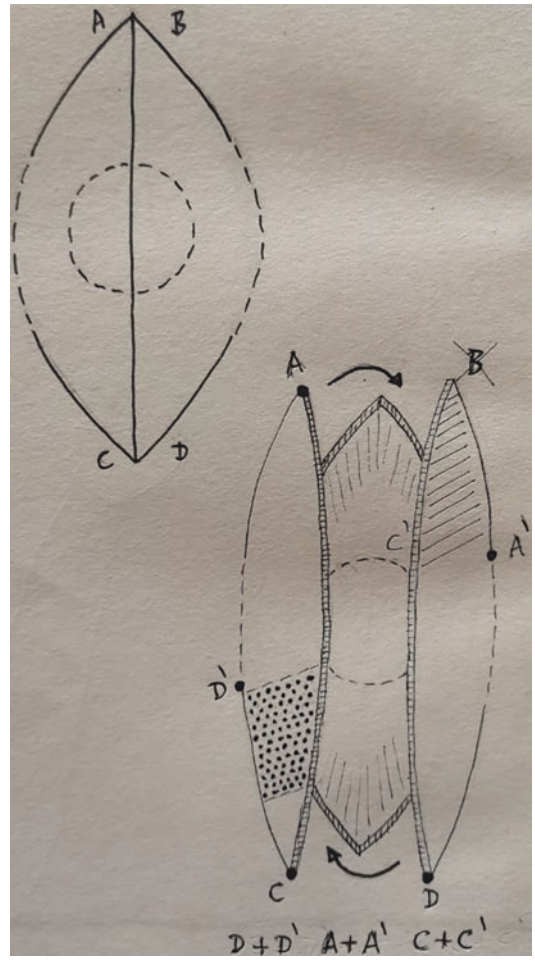

Fig. 28.1 Umbilicoplasty technique for reconstruction in cases of total amputation of the umbilicus. Flap marking and skin incision for making the new umbilicus

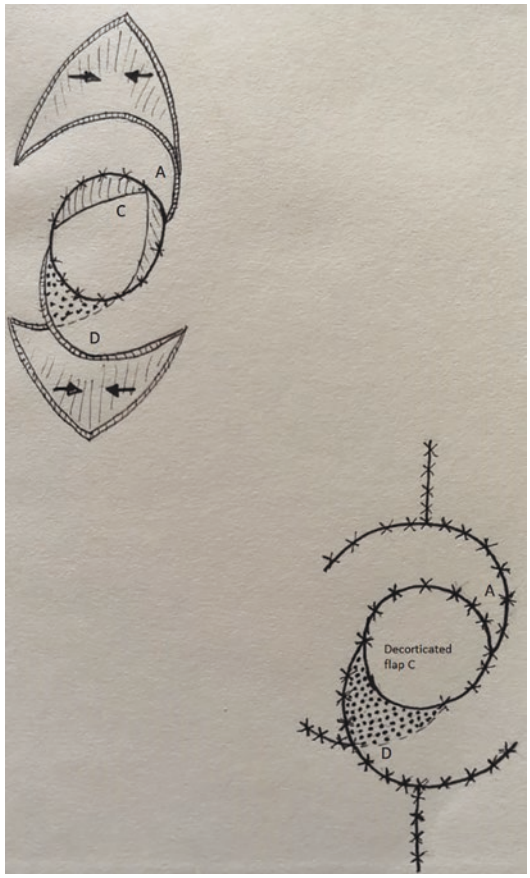

Fig. 28.2 Making of V-shaped flaps from a midline incision, two upper and two lower flaps. The idea is to simulate the umbilical tube wall tissue with an upper and lower flap, which rotate in an opposite direction against each other. The letter "A" flap crosses to opposite side. The letter "C" flap should have the most central depithelialized portion to cross under letter "D" flap and be fixed to the central portion to simulate the bottom of the navel. The letter "B" flap is excised

them and the bottom in the rectus abdominis aponeurosis [35].

28.2.2.4 New Approach (Associate Old Stump with Neoumbilicoplasty Technique)

We describe this technique as hybrid because it associates the fixation of the abdominal flap dermis in aponeurosis, as in the technique we described in 2013 [31] and the utilization of the remaining umbilical stump.

The umbilical stump is fixed in the aponeurosis of the rectus abdominis, especially in cases of shallower appearance. A vertex-shaped portion is appended with a vertex to the umbilical center in the position between 12 and 2 o'clock and the lower second between 6 and 8 o'clock. The abdominal flap is degreased in the portion that will rest on the old stump. In this degreased region, six nylon 2.0 fixation points are made up to the rectum aponeurosis, causing the stump to be covered by the skin of the abdominal flap. The points are in the following positions: 12, 2, 4, 6, 8, and 10 h. After all closure of the abdominal wall, the skin is inserted, making two small V-flaps, which will be fitted and sutured within the triangular designs (Fig. 28.5).

This technique proved to be much more effective in relation to aesthetic results, depth, and hidden scars compared to neoumbilicoplasty without utilization of the stump (Table 28.1).

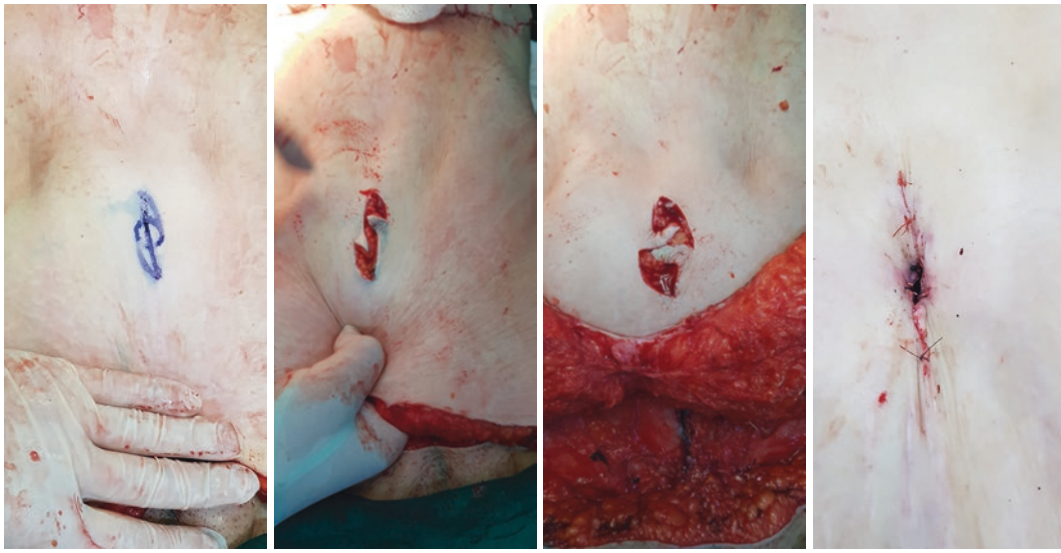

Fig. 28.3 Skin marking, incision, and confection in the new umbilicus in a 40-year-old patient

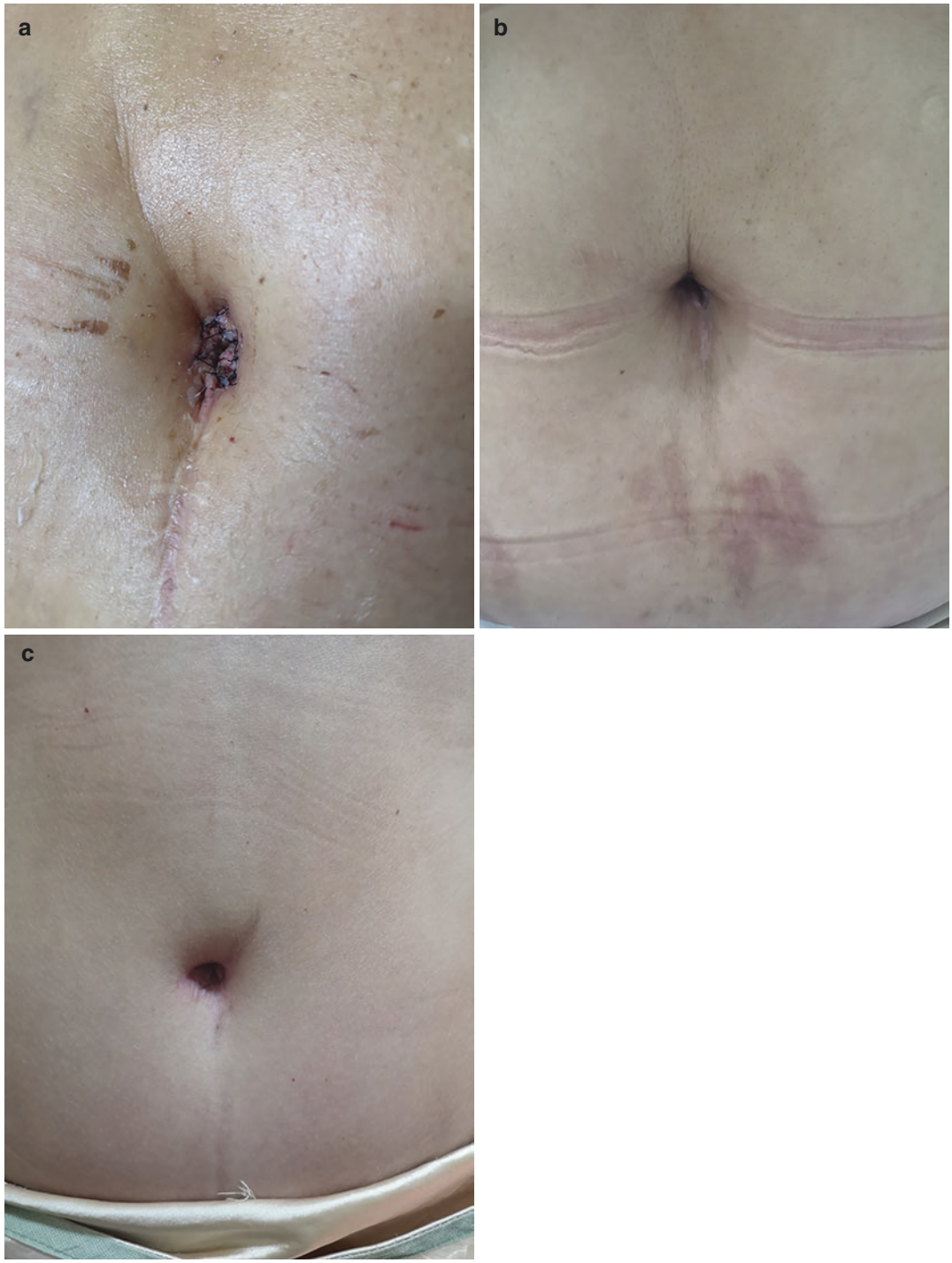

Fig. 28.4 Postoperative. (**a**) 10 days. (**b**) 60 days. (**c**) 90 days

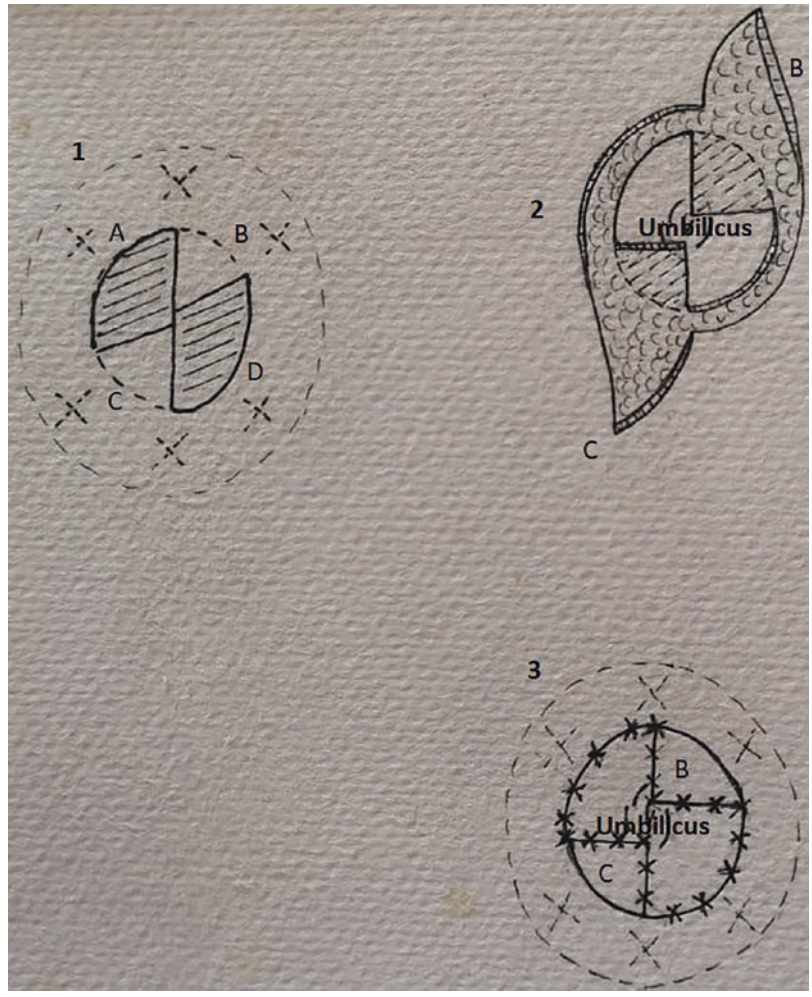

Fig. 28.5 (1) Preparation of four triangular flaps in a detached abdominal flap. (2) Excision of A and D and exposure of the umbilical stump with amputation of two triangular segments where flaps B and C will be sutured. (3) Final appearance of the suture of flaps B and C to the umbilical stump

Table 28.1 Comparison between different techniques of umbilicoplasty

Techniques	Benefits	Disadvantages
Incision in the abdominal flap and direct suture in the remaining stump	Easy execution	Apparent scar, less natural result
Navel without scars	Natural result, without scar	Risk of shallow navel
Stump making with local flaps	Natural result	Apparent scar in the periumbilical region, difficult to perform
Neoumbilicoplasty with remaining stump	Natural result	Runtime increase

28.3 Postoperative Care (Wound Dressing)

Subclinical local infection can be a limiting factor for the final result and for the increased risk of suture dehiscence. For this reason, antibiotic ointment and gauze are used on the navel at the end of the surgery, and it is maintained for 15 days, when the use of silicone gel starts twice a day for 4 months. The early use of orthoses is avoided so as not to force the scar and break the suture, which are started after 30 days. As a result, a lower rate of these complications was observed.

28.4 Outcomes and Prognosis

The use of new techniques associating the construction of a tunnel over a remaining umbilical stump proved to be much more effective in relation to the aesthetic, depth, and hidden scarring results in relation to neoumbilicoplasty without using the stump. In techniques that did not use the remaining umbilical stump, the navels were shallow, and there were high rates of reoperation to make it deeper.

The making of new navels or the correction of umbilical complications can be performed under local anesthesia in an isolated procedure.

28.5 Complications

The incidence of seroma can also increase the risk of dehiscence of the stitches when it drains through that region. Therefore, the points of adhesion of the flap on the abdominal wall are important to reduce this incidence. The infection rate can be decreased with the use of local antibiotic ointments. Keeping the measurement of the new umbilical design between 1.8 and 2.0 cm is important to avoid wide and ugly navels. Techniques that do not use the anterior umbilical stump tend to result in shallow and unlit navels. Those that do not fix the abdominal flap around the stump may result in hypertrophic scars and stigmatized navels similar to a cacimba.

28.6 Conclusions

Regarding the shape and quality of a beautiful belly button, Lee and Craig's conclusions were that it should have a vertical, oval design. In studies by Malic et al. and Lesavoyh et al., it was concluded that the upper navel hook is preferred by patients and is a desired component in a beautiful navel [20]. In addition, apparent scarring, stenosis, dehiscence, shallow, and misplaced navels are the challenges to come up with a perfect technique that brings natural results.

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Abdominal Wall Restoration

29

Carlota Tuero, Pablo Marti, Gabriel Zozaya, and Carlos Sánchez Justicia

29.1 Umbilical Hernia

29.1.1 Introduction

Umbilicus is located in the midline, halfway between the xyphoid process and the pubic symphysis. It is the remainder of the insertion of the umbilical cord and it is a weakness point in the abdominal wall. It is protected in the lower part by the obliterated uracus and the medial umbilical ligaments and in the upper part by the round hepatic ligament. The limits are the two rectus sheaths on both sides, the umbilical fascia posteriorly and the linea alba anteriorly [1].

Umbilical hernia is located at or near the umbilicus in a range from 3 cm above and 3 cm below [2]. It is a common entity with higher prevalence in women than in men, with a 3:1 ratio [3]. Furthermore, there is a peak around the age of 40, which may be related to pregnancy [4].

The main risk factor is the increase in the intra-abdominal pressure, so this entity is more frequent in obese patients, cirrhotic, abdominal tumors or in multiparous women [1, 5]. In the literature, there is an incidence rate of umbilical hernia among pregnancy of 0.08% [6].

29.1.2 Patient Selection and Timing

29.1.2.1 Patient Selection

Patient selection is important in order to reduce or even avoid postoperative complications. Certain comorbidities such as tobacco use, obesity, diabetes, and malnutrition are related to postoperative complications and should be modified before surgery.

Tobacco impairs wound healing and increases the risk of infection; so, nonsmoking during the last 4 weeks before surgery reduces the infection rate. Malnutrition should also be avoided with protein repletion before the intervention.

Obesity and diabetes impair tissue perfusion and immune response; patients ought to lose weight before surgery and keep a strict control of glycemia to reduce postoperative complications [7].

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/978-3-030-43840-1_29.

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_29

29.1.2.2 Timing: Umbilical Hernia Before, During and After Pregnancy

There is still no consensus about the perfect timing for surgery in a pregnant woman or planning pregnancy. Surgeons usually recommend one-year lapse between the hernia intervention and pregnancy. There is no evidence support, however, if an early pregnancy increases the rate of recurrence [8].

In a pregnant woman, when the hernia is small and asymptomatic, it may be better to postpone the surgery until she gives birth [8]. Unlike, when the hernia is symptomatic, some studies describe a high rate (58%) of complications (strangulation or incarceration), so they recommend elective surgery before complications appear and before delivery, with low risk. The most frequent complication is surgical site infection, but the main disadvantage is the scant data regarding recurrence rate [9, 10].

After childbirth, elective repair is possible 8 weeks postpartum, but it is better to wait one year for the patient to recover and return to normal body weight. If the woman would like to have more children, surgery can be postponed for a longer time [8] (Table 29.1).

Another option that has been described is repairing the umbilical hernia during the cesarean section. It is an optimal therapeutic option that takes more time than performing only the cesarean, but it is safe, there is no additional pain, neither more morbidity, and avoids readmission. However, there is still little report experience about recurrence [9, 11, 12] and some studies describe scarce aesthetic results and high incidence of complications such as skin necrosis, wound infection, seroma, and hematoma; so, further studies are needed [13].

There is also hesitance about the use of mesh reparation during pregnancy, because there is high risk of lateral mesh detachment or inadequate overlap of the hernia defect. Furthermore, the mesh may restrict the elasticity of the abdominal wall leading to associated pain [14]. A study made by Oma et al. found no differences in the recurrence rate between mesh repair and simple suture repair in women who underwent surgery before pregnancy. They hypothesized that as the pregnancy progresses, the tension on the hernia repair increases. This tension may cause mesh detachment or migration and explain the lack of mesh benefit. Besides, they also concluded that umbilical hernia repair was associated with a greater risk of recurrence compared with epigastric hernia repair [15].

29.1.3 Preoperative Evaluation

29.1.3.1 Physical Examination

Umbilical hernias may appear as an umbilicus bulge that causes abdominal pain or discomfort (Fig. 29.1). This bulge increases with Valsalva maneuver and decreases with the decubitus.

The neck of the hernia is usually narrower than the content with a high risk of strangulation or incarceration; so, these hernias are related to a higher morbidity and mortality than groin hernias. Men are more likely to present an umbilical incarcerated hernia, meanwhile in women, the typical presentation is an easily reducible mass. When there is an incarcerated hernia, the patient presents a large bulge, which is impossible to reduce into the abdomen. Bowell obstruction symptoms are usually associated. An emergent or urgent surgical intervention is required [16]. If there is evidence of intestine suffering and we

Table 29.1 Algorithm of treatment

Type	Planning pregnancy	During pregnancy	After pregnancy
Small, asymptomatic hernia	Repair 1 year after childbirth	Repair 1 year after childbirth	Repair 1 year after childbirth
Large/symptomatic hernia	Repair and wait 1 year until pregnancy	Repair in second trimester	Repair after childbirth
Irreducible hernia	Emergency repair and wait 1 year until pregnancy	Emergency repair	Emergency repair and wait 1 year until pregnancy

Fig. 29.1 Umbilical bump

need to perform an intestinal resection, mesh placement after hernia repair is still in doubt due to the high infectious rate.

Larger umbilical hernias are related to skin erythema, necrosis, or ulceration [3].

29.1.3.2 Diagnosis

The diagnosis is easy and usually performed through clinical exploration. The increase in the abdominal pressure helps the diagnosis;, however, in certain patients, such as obese or when the hernia is small, an ultrasound or a CT is needed.

29.1.4 Anesthetic Considerations

Hernia repair is a very common procedure, because elective repair after diagnosis is advised. There are numerous anesthetic considerations regarding this intervention, depending on the medical status of the patient. Surgery may be performed with regional anesthesia with or without sedation or general anesthesia. Furthermore, general anesthesia may be associated with regional one after the procedure in order to avoid postoperative pain. When we perform laparoscopic repair of the abdominal wall, general anesthesia is required.

Regional anesthesia is rapid and starts acting between 5 and 15 min but shows some disadvantages like increasing the risk of urinary restriction and delaying ambulation.

Regarding general anesthesia, when performing abdominal wall surgery, we need to avoid coughing during extubating. Some centers, when the surgery is nearly to end, change the endotraqueal tube and place a laryngeal mask instead, which is well tolerated. Sometimes, after general anesthesia, we can perform a TAP, which is a regional blockage, in order to avoid postoperative pain and achieve an early recovery diminishing narcotic requirement [17].

29.1.5 Surgical Technique

29.1.5.1 Patient Positioning

The patient is placed in supine position in the operating room table and secured to avoid any shifting although no angulation of the able is needed. The arms are usually open in the form of a cross. The surgeon is located in the right side of the patient and the first assistant on the opposite one. When there is a laparoscopic approach, the surgeons are also placed at both sides of the patient and the television on his/her feet.

29.1.5.2 Procedures Step by Step

There are mainly two repairing options: tissue suture and prosthetic repairs and they can be performed through laparoscopic or open approach.

1. Open Technique

   The beginning of the open repair is very similar. It consists in a periumbilical incision, curvilinear or vertical, and a posterior subcutaneous dissection (Fig. 29.2). Afterward, the hernia sac is identified and dissected to its attachments and later reduced or resected (Figs. 29.3 and 29.4). Once the sac is removed,

Fig. 29.2 Periumbilical incision

Fig. 29.4 Hernia defect

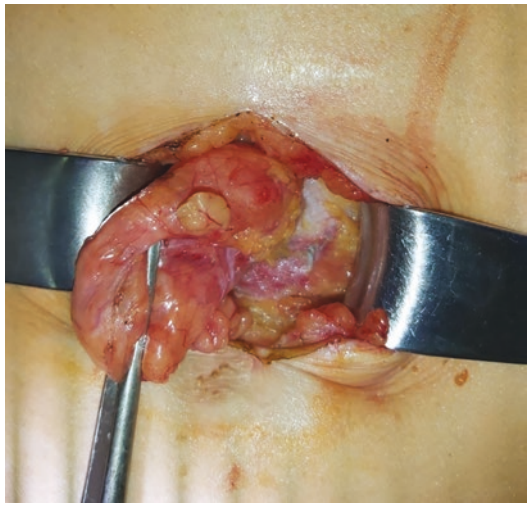

Fig. 29.3 Hernia sac dissected

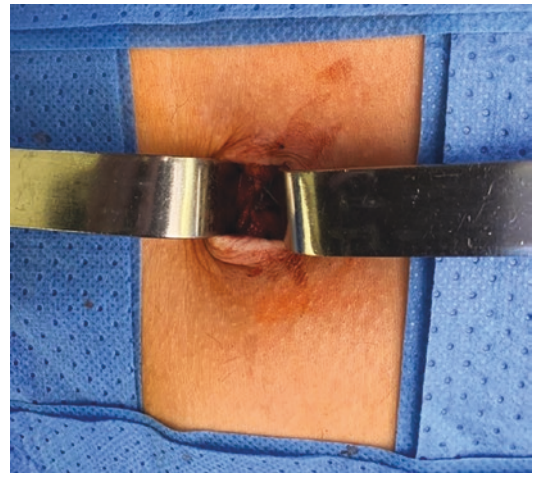

Fig. 29.5 Tissue primary suture

we have different options in order to repair the fascia:

– *Tissue-suture repairs (Herniorrhaphy):*

(a) Simple primary suture

This technique is based on the tissue-suture repair of the fascia (Fig. 29.5 and Video 29.1), usually performed with nonabsorbable suture, but we may use as well long-acting absorbable sutures; monofilament, multifilament or barbed in a continuous or interrupted suture. Additionally, the defect closure may be vertical or

horizontal [16]. Furthermore, the size of the suture is 1/0 or 2/0, depending on the magnitude of the defect. The main disadvantage of this technique is that it implies tension of the tissues, so it is related to a higher rate of recurrence.

(b) Mayo repair

This repair consists in overlapping 2–3 cm the abdominal wall fascia in a "vest-over-pants" manner with two rows of sutures [18].

(c) Keel technique

This is an uncommon technique, which uses two-layered of suture inverting the medial part of the rectus sheath and suturing both sides.

– *Prosthetic repairs (Hernioplasty):*

These techniques require more surgical time than the herniorrhaphies due to the flap dissection and the mesh reinforcement [19]. This reinforcement may be performed with absorbable or nonabsorbable suture. Whenever we close the fascia, we utilize nonabsorbable monofilament suture, 2/0 or 1/0 depending on the size of the defect. Afterward, we place a polypropylene mesh and fix it to the fascia with 2/0 nonabsorbable monofilament suture. It is also important to make a repair without tension, overlapping the defect at least 5 cm with the mesh. Mesh can be placed in different locations (Fig. 29.6) with or without closing the defect.

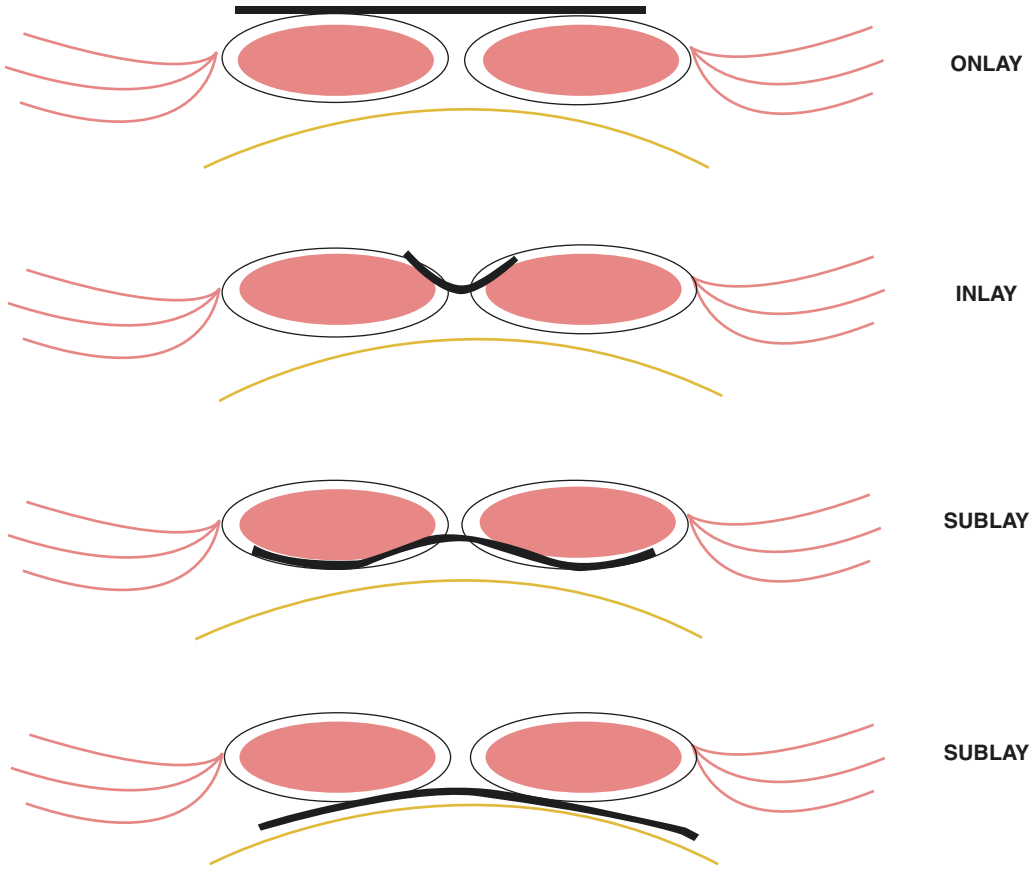

Fig. 29.6 Mesh location

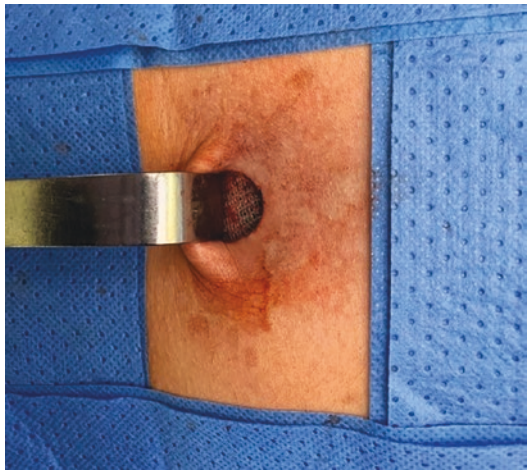

Fig. 29.7 Preaponeurotic/onlay mesh

Fig. 29.8 Retromuscular dissection with posterior rectus sheath closed

(a) Preaponeurotic (Onlay mesh)

A wide subcutaneous dissection is performed in order to place the mesh (Fig. 29.7), with an increased rate of seroma and/or hematoma in the postoperative period leading to more surgical site infection [1]. When there is a large flap dissection, a drainage is usually placed in order to reduce the seroma, increasing the postoperative hospital stay [19].

(b) Fascial layer (fixed to the ring, inlay technique)

When the fascial defect is wide, we can place the mesh covering the defect and fixing it to the ring, instead of closing the edges with tension. Usually, the peritoneum is closed under the mesh avoiding the contact with the viscera. If this is not possible, there are new bilayer devices that have been designed for this type of repairs. The mesh has a double side: one is polypropylene and the other is a nonadherent material that may be in contact with viscera. The main disadvantages are that these meshes are expensive, and they have a high recurrence rate [20].

(c) Retromuscular technique (Sublay mesh)

This technique requires more surgical experience, especially when the neck of the hernia is narrow. Sublay mesh avoids a wide subcutaneous dissection and reduces the hematoma and seroma formation. The dissection is performed behind the rectus muscle and above the posterior rectus sheath (Fig. 29.8). The peritoneum and the posterior sheath are sutured, and then place the mesh. Afterward, suturing the anterior rectus sheath is recommended.

(d) Preperitoneal technique (Sublay mesh)

Placing a preperitoneal mesh also requires surgical experience and it is a longer procedure due to the wide dissection performed. This repair, as the retromuscular one, has a low rate of seroma and hematoma, because there is no subcutaneous dissection. If we suspect that the peritoneum is open, we should close it with continue suture before placing the mesh. Suturing the posterior and anterior rectus sheath is also recommended.

(e) Mesh plug

The mesh is inserted inside the defect. It is a simple technique, but there is scant literature comparing this repair to others. It is known that mesh plug implies a higher risk of migration and enterocutaneous fistula formation.

– Laparoscopic technique

There are several procedures, but laparoscopic intraperitoneal onlay mesh (IPOM) is the laparoscopic repair most performed worldwide.

IPOM starts creating pneumoperitoneum in the left subcostal margin, and afterward, placing three trocars on the left flank. After exploring the abdominal cavity, the hernia is identified, and the sac reduced. Before placing the mesh, the hernia defect is measured to assure the size of the prothesis. Then, a special mesh that allows contact with abdominal viscera is located covering the defect with an overlap of 5 cm at least. The mesh is usually fixed with absorbable tuckers.

29.1.5.3 Technical Tips to Improve Outcomes and Avoid Complications

Mesh repair is usually the elected treatment due to the lower recurrence rate in comparison with herniorrhaphy [21]. The recurrence after simple-tissue repair was 11% compared with 1% when mesh was used [22]. When the hernia is over 2 cm, prothesis repair is the elective treatment and furthermore, the latest literature also recommends the use of mesh when the hernia is <2 cm [23]. A recent RCT concluded that flat mesh is preferable than patch repair with lower recurrence and complication rate [24].

About wound infection and complications related to umbilical hernia repair, there is no evidence that the use of mesh is related to a higher morbidity rate [21, 22].

Regarding the type of mesh, standard polypropylene is the most frequently used. This prothesis is suitable for repairs when the peritoneum is closed and there is no contact with the viscera. Light-weight meshes are increasing its use, because this technology induces less foreign-body response, allowing a better tissue incorporation [1, 25].

29.1.6 Postoperative Care

The discharge is usually on the same day as the operation. We recommend avoiding heavy lifting and physical work for a month and start walking as soon as possible. It is possible to have tightness or pain on the first few days, that will gradually disappear, and it can be managed with painkillers. Sometimes, when there is a wide dissection, a drain is placed, which is normally removed around 5–7 days after surgery.

Regarding the wound, bruising and tenderness is normal on the first few days. The stitches should be removed 10 days after surgery. Some lotions will help in healing the wound; besides, sun protection of the scar is recommended on the first year after surgery.

29.1.7 Outcomes and Prognosis

This surgery has relatively good outcomes, with low recurrence rate and scarce complications. As we mentioned before, recurrence is higher in repairs without mesh, besides, long-term follow-up results have found that periumbilical pain is more prevalent with herniorrhaphies.

29.1.8 Complications

The most prevalent complications are large seroma, bleeding in the immediate postoperative period, wound infection, and recurrence of the hernia.

Bleeding in the postoperative period may be avoided with a careful hemostasis during the intervention; we need to assure a correct bleeding control in order to avoid emergency reinterventions during immediate postoperative period. The emergency reintervention is related to an increase rate of wound infection. Furthermore, seroma formation may be prevented with the compartmentalization of the subcutaneous tissue during

the closure by fixating it to the fascia with a mid-term absorbable multifilament suture. Regarding wound infection, it should be prevented with a chary asepsis and with the administration of a single dose of antibiotic (Cefazoline 2 g one dose during anesthetic induction). Furthermore, laparoscopic approach has lower wound infection rate compared to open approach. However, laparoscopic technique has risks related to intraperitoneal foreign body. Besides, tucker fixation of the mesh may cause postoperative pain, adhesions, nerve injury or bowel obstruction.

The main risk factors for recurrence are: large seroma, surgical site infection, smoking, ascites, diabetes, hernia size >2 cm, obesity with a BMI over 30 kg/m^2 and excessive weight gain following repair [1, 26].

29.1.9 Conclusions

Umbilical hernia repair is a simple procedure with low complications rate. It is important to diagnose this entity and be able to determine when is the best moment to perform the surgery, overall in fertile women.

We have to avoid emergency surgery related to incarcerated or strangulated hernia, because mortality and morbidity are increased. Sometimes, bowel resection is needed; instead, elective surgery gives satisfying results and a low rate of morbidity with no mortality associated.

Take-Home Points

- Hernioplasty is the elective procedure for umbilical hernia repair with low recurrence rate and low morbidity associated.
- Placing a mesh is recommended even when the defect is small (<2 cm).
- About mesh location, flat mesh has better outcomes than patch repair and preperitoneal position performed better.
- Women planning or during pregnancy with small and asymptomatic hernias should undergo surgery after childbirth, preferably 1 year after.
- Women planning pregnancy with large or symptomatic hernias should undergo surgery and wait 1 year until pregnancy.
- Women during pregnancy with large and symptomatic hernias may undergo surgery during the second trimester.
- Irreducible hernia should undergo emergency repair even during pregnancy.

29.2 Rectus Abdominis Diastasis

29.2.1 Introduction

Rectus muscles are normally fused in the midline with an approximate distance of 1 or 2 cm between them, forming the linea alba. This linea reaches from the xiphoid process to the pubic symphysis varying its width, which is higher in the periumbilical area [27].

A diastasis of the abdominal rectus (RAD) is an acquired condition characterized by a midline abdominal wall protrusion when the intra-abdominal pressure increases. This pathology appears due to the laxity of the ventral abdomen musculature and the widening of the linea alba and may be measured by the inter-recti distance (IRD) [28].

Sometimes this entity is misclassified as a primary or a ventral hernia, but the continuity of the midline is preserved, so there is no fascial defect [3]. However, this weakness of the abdominal wall is a risk factor for the development of midline hernias due to the deterioration of the connective tissue. A 45% of patients with umbilical and/or epigastric hernias had concomitant RAD [29].

29.2.2 Patient Selection

RAD can be congenital or acquired and may occur in male and female and in a wide range of ages. We have normally two different profile of patients: middle-aged and older men with central obesity and fit young women with normal BMI with a history of pregnancies.

RAD in pregnancy appears mostly in the third trimester and remains until the first week following childbirth [30]. This appearance is due to hormonal changes, the increased intra-abdominal pressure, and the increase in the uterus size. Other risk factors for the development of RAD are previous abdominal interventions, body weight-loss related to diet or bariatric surgery, high age, and genetically conditioned defects in collagen structure [31, 32].

Some studies describe a relationship with abdominal aortic aneurysm with a higher prevalence in this population (67% versus 17%) [33].

RAD Risk Factors:
Multiparity
Heavy lifting
Previous abdominal interventions
High age
Defects in collagen structure
High body Mass index

29.2.2.1 Normal Values of Inter-recti Distance (IRD)

There are few studies defining the normal width of the linea alba, which varies regarding the reference location. The first of all, published by Rath et al. in 1996 (Table 29.2), concludes that this line is widest at the umbilicus, and in people over 45 years, this linea increases above and under the umbilicus 5 mm; conversely, the umbilical area is not affected by age [34]. Afterward, Beer et al. measured the linea alba in 150 nulliparous women with ultrasound at three different positions: at the xiphoid, 3 cm above the umbilicus, and 2 cm below the umbilicus (Table 29.3). They considered normal values between the tenth and the 90th percentile, which were the following distances: 15 mm at the xiphoid, 22 mm above the umbilicus and 16 mm below the umbilicus [27].

Table 29.2 Rath classification

Location	Width <45 years	Width >45 years
Above umbilicus	10 mm	15 mm
Umbilicus	27 mm	27 mm
Below umbilicus	9 mm	14 mm

Table 29.3 Beer classification

Location	Width
Xyphoid	15 mm
Above umbilicus	22 mm
Below umbilicus	16 mm

Table 29.4 Nahas classification

Deformity	Etiology	Correction
Type A	Pregnancy	Anterior sheath plication
Type B	Myoaponeurotic laxity	External oblique plication
Type C	Congenital	Rectus abdominis advancement
Type D	Obesity	Anterior sheath plication and rectus advancement

Mota et al., also measured the linea alba at three different locations (2 cm below the umbilicus and 2 and 5 cm above the umbilicus) in four time points: pregnancy weeks 35–41, 6th, 12th and 24th week postpartum. They conclude that in primiparous women, the IRD may be considered normal up to values wider than for nulliparous women because the values for IRD obtained were higher than in nulliparous women [35]. We have another classification made by Nahas et al. based on the myofascial deformity and the etiology (Table 29.4) [36].

The reported prevalence of DRA or increased IRD varies and may be inaccurate due to the few studies, the different cut-off points for the diagnosis and the lack of consensus on the best measurement location. However, based on Beer study, we consider there is a diastasis when the distance between the two rectus muscles is over 2.2 cm.

29.2.2.2 Prevalence of RAD in Pregnancy

The incidence of RAD is higher at the third trimester and in the puerperium and resolves gradually in the postpartum period with individual variability [30, 37, 38], a 33% of women still have RAD at 12 months postpartum [32].

The female pattern of DRA is focused on the umbilicus, but it can be extended supraumbilical and infraumbilical. The prevalence is higher above the umbilicus than below [31, 38]. These results are due to the anatomical disposition of the rectus sheath; the area of change is located at the arcuate line. Above this line there is only an anterior layer formed by the aponeuroses of the external and internal obliques and the transverse preventing rectus separation.

Regarding the number of pregnancies, Rett et al. concluded that, RAD above the umbilicus has similar prevalence between primipara and multipara, however, RAD below is most prevalent in multipara, with a significant difference [39].

29.2.2.3 RAD Classification

In 2019, the German Hernia Society and the International Endohernia Society established a classification in order to assess and unify RAD treatment [40].This classification includes

1. Length of the rectus diastasis, based on the European Hernia Society Classification [2]:
   (a) Subxiphoidal (M1)
   (b) Epigastric (M2)
   (c) Umbilical (M3)
   (d) Infraumbilical (M4)
   (e) Suprapubic (M5)
2. Width based on Ranney's classification [41]
   (a) W1 <3 cm
   (b) W2 3–5 cm
   (c) W3 >5 cm
3. Previous abdominal surgery within the width and length of the RAD
4. Concomitant hernias (epigastric, umbilical, post-incisional)
5. Number of pregnancies
6. Skin condition (skin laxity and skin folds)
7. Methods of diagnosis (clinical, calipers, ultrasound, TC)
8. Severity and localization of preoperative pain

29.2.3 Preoperative Evaluation

29.2.3.1 Physical Examination

The most frequent presentation is an asymptomatic fusiform bulge above the umbilicus. It usually appears standing and also when the intra-abdominal pressure increases and reduces its size with the decubitus.

It has also been postulated that the diastasis may alter trunk mechanics, compromise pelvic stability, and change posture, increasing the risk of low back and pelvic girdle pain [42, 43]. Some authors have found a moderate positive and significant association between RAD and lumbopelvic pain and between RAD and fecal incontinence and pelvic organ prolapse [37, 44].

29.2.3.2 Diagnosis

The main diagnosis is clinical, based on a physical examination, but the ultrasound and calipers are an adequate method to assess the diagnosis. Ultrasonography is an accurate technique to measure RAD above the umbilicus and at the umbilical level [45, 46]. Besides, it is simple, noninvasive and it can be repeated many times. The main drawback is that this procedure depends on the radiology skills [27]. Ultrasound has replaced CT as the method of choice, due to the expense and the radiation exposure.

Regarding surgery planification, the most important entity we have to discard is a concomitant midline hernia. In obese patients, where physical exploration is more problematic, a CT before surgery should be performed.

29.2.4 Anesthetic Considerations

Anesthetic considerations about rectus abdominis diastasis are the same as the ones mentioned before regarding umbilical hernia. We can perform regional or general anesthesia and in case of choosing the later, add a TAP blockage in order to reduce painkillers intake. There is still no consensus regarding the best choice, but both seem adequate alternatives. When the repair is performed through laparoscopic approach, general anesthesia is required.

29.2.5 Surgical Technique

Treatment of RAD is challenging, because there is still a lack of consensus, without guidelines

resuming the indications or comparing the different surgical techniques. Besides, there are scant studies with high scientific quality.

We have to consider that RAD is not a true hernia; so, there is no risk of strangulation. That is why most patients undergo conservative treatment, and surgery is mainly performed due to cosmetic reasons, severe functional impairment, or when there is a concomitant hernia.

Conservative management based on exercise and weight loss is usually the first management step. Sometimes the help of a physiotherapist is required, with some training programs [42]. Numerous exercise regimens have been described, but an accepted protocol for therapeutic exercises has not been published so far. These exercises are focused on strengthening the rectus muscles. There is a nonsurgical 18-week program named "The Tupler Technique." This program consists ofwearing an abdominal splint, which helps to repair the connective tissue by relieving the pressure on the zone [47].

Several papers have found an improvement on RAD with exercise [42, 48], showing that pregnant women who underwent exercises after delivery had significantly lower RAD compared to sedentary women (12.5% vs 90%) [49]. But, some authors, instead, do not find any significant differences between groups who underwent exercise program and sedentary ones [50].

Another technique that has also been described is the neuromuscular electrical stimulation. This procedure ameliorates the DRAM in postnatal women and, when combined with exercise, its effect increases [51].

Physiotherapy achieves a limited improvement in the size of the diastasis and its symptoms. Surgery, instead, significantly improves pain and abdominal wall function. Physiotherapy should be an alternative in patients who are unable to undergo surgery, and overall, an addition to surgical intervention in order to achieve a satisfying functional outcome [52].

29.2.5.1 Patient Positioning

Similar to umbilical hernia surgery, there is no special arrangement. The patient is placed in the operating table mattress in supine position, with arms open, and fixed to avoid shifting although no angulation of the table is usually required.

29.2.5.2 Procedures Step by Step

In symptomatic patients, when conservative treatment is not enough or the diastasis is wider than 3 cm, surgery is the elective treatment. Sometimes, there is no correlation between the clinical features and the site of widest diastasis. In many patients, the site of highest abdominal protrusion does not correlate with the biggest IRD, so the decision whether or not undergo surgery is more influenced by the upright examination of the patient [28].

Regarding surgery, there are different approaches varying from the type of suture, the use of mesh, the number of layers of suture, etc. A review performed with 1591 patients did not find any significant differences between surgical procedures [52].

When there is excess skin, rectus plication is combined with abdominoplasty, but a systematic review performed with both techniques concluded that most evidence is of low quality and RCT are required to make some conclusions [53]. When there is no excess skin, surgery may be performed through open, laparoscopic or hybrid approach. Notably, the main indications for surgery are cosmetic reasons, but the 85% of surgical interventions are open procedures [52].

29.2.5.3 Surgical Technique

- *Open approach*
- Open repair begins with a phannenstiel incision, with a superior flap dissection toward xiphoidal process (Fig. 29.9). If we do not associate an abdominoplasty to the rectus plication, the incision may also be performed on the midline. However, better esthetical results are obtained with the phannenstiel incision. When the flap is dissected, we mark the rectus sheath with a purple line (Fig. 29.10) in order to signalize the suture path.
- Once the dissection is performed, the repair may vary. When the RAD is mild to moderate, suture plication alone is a good option (Fig. 29.11 and Video 29.2). Meanwhile, if the

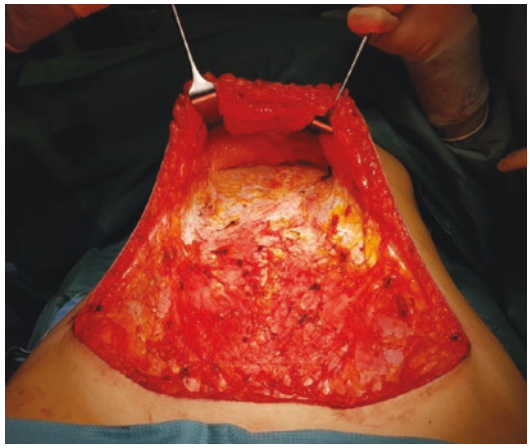

Fig. 29.9 Superior flap dissection

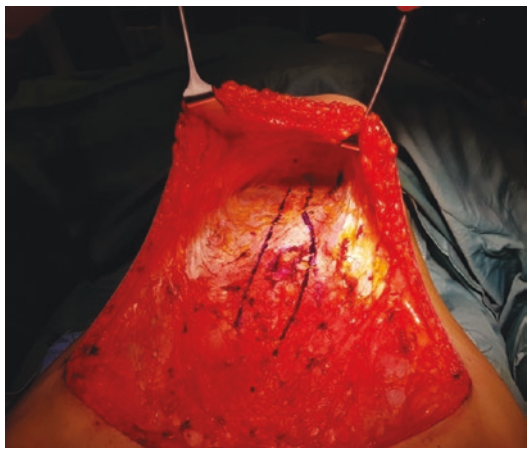

Fig. 29.10 Rectus sheath marked in purple

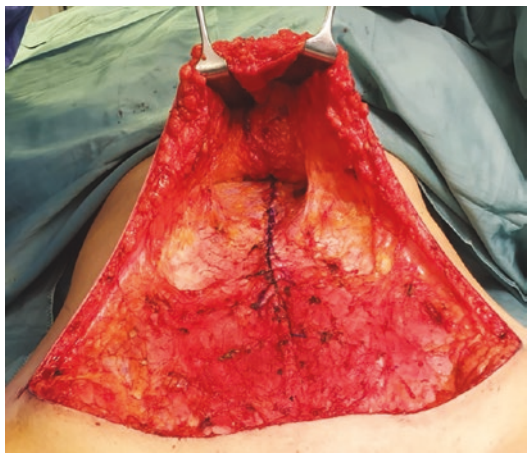

Fig. 29.11 Rectus abdominis plication

RAD is moderate to severe, we can plicate the rectus sheath and place a mesh.

1. Tissue-Suture Repair

   An RCT comparing two-layer linea alba plication versus one layer using non-absorbable suture found no differences regarding outcomes, but did find a recurrence rate of 33% when barbed suture was used [54].

   (a) Simple suture

   In this technique, the anterior sheath of the abdominis rectus is sutured in a single-continuous layer with slow-absorbable suture or a permanent one. The length of the closure goes from de xiphoidal process to 2 cm above the pubic symphysis.

   (b) Two-layer technique

   The two-layer repair is based on one absorbable interrupted suture and over it a running continuous for further reinforcement and bury the knots from the first layer [55].

2. Repair with mesh

   (a) Preaponeurotic (onlay mesh)

   The mesh is usually placed over the rectus anterior sheath, covering the whole abdominal wall: from the costal margin to the pubic symphysis and until the anterior axillar line bilaterally. It is fixed with absorbable suture or tuckers.

   (b) Rives (Retrorectus repair)

   In this technique, a dissection behind the rectus is performed separating it from its posterior sheath, in order to put the mesh retrorectal. Before placing the mesh, we can plicate the posterior sheath in the midline and afterward, suture as well the anterior sheath. The main disadvantage of this procedure is the risk of developing an incisional hernia due to the opening of the anterior rectus sheath.

The current literature evidence is not enough to determine which technique is better, but there is an RCT that concludes that

absorbable midline plication was as efficient as nonabsorbable [56].

– *Laparoscopic technique*

Minimally invasive procedures are recommended when skin removal is not necessary [57]. There are several approaches, from hybrid to robotic going through laparoscopic [57]. These techniques are not frequently used, because they are technically difficult, and they require advanced laparoscopic surgical skills. The placement of the trocars changes depending on the type of the procedure, but they are usually placed suprapubic and periumbilical.

– *ELAR (endoscopic-assisted linea alba reconstruction):* This hybrid procedure consists of performing and umbilical skin incision with a cranial extension of 2–3 cm. The space between the subcutaneous tissue and the anterior rectus sheath is widely dissected. Afterward, the anterior rectus sheath is open at 2 cm from the medial margin till the xyphoid process. Then, this anterior sheath is sutured with continuous, nonabsorbable suture and a mesh is placed above. The mesh is sutured to the incision margin of the anterior rectus sheath with continuous suture. After the procedure, it is recommended to locate a redon and also to wear binders for 6 weeks after the operation [58].
– *THT (Endolaparoscopic reconstruction of the abdominal wall midline with linear stapler):* Two trocars are placed to create pneumoperitoneum and discard or remove adhesions to the abdominal wall. Afterward, an umbilical incision is performed, the umbilicus is disinserted, and the anterior fascia of the two rectus abdominis is open. The space is dissected, leaves the rectus muscles laterally, and each branch of an endostapler is inserted inside each sheath of the rectus in cranial direction. Then a second stapler charge is used and once we have enough space, we can insert a single port access and continue the section with the staplers cranially, up to the costal margin. Then, we can place a mesh and create pneumoperitoneum again to check the correct execution of the surgery [59].
– *eTEP (extended totally extraperitoneal repair):* This technique starts placing an epigastric trocar on the left side to insert the camera and dissect the retrorectus space. Once dissected, the camera is shifted to the right epigastric side to dissect the contralateral retrorectus area. Afterward, two more trocars are placed and the diastasis is sutured. A medium weight macroporous polypropylene mesh is placed, and no fixation is usually needed.

29.2.5.4 Surgical Modifications: Umbilical Hernia Concomitant with Rectus Abdominis Diastasis

Rectus divarication and concomitant umbilical hernia are often associated and consequently, they need a combined repair. Most patients are women with a normal BMI in a good physical shape handicapped by the bulge and the weakness of the abdominal wall and male patients with abdominal obesity. Concomitant RAD was defined as the most important risk factor for hernia recurrence (31 vs. 8%); so when it is present, it is important to repair the defect. The recommended treatment for these patients is an herniorrhaphy with rectus plication (Video 29.1) and some authors firmly recommend mesh reinforcement due to the high recurrence rate [29]. Sometimes, when there is an excess of infraumbilical skin, an abdominoplasty may be associated to the procedure (Figs. 29.12 and 29.13).

Standard abdominoplasty with herniorrhaphy presents a "vascular challenge" with higher risk of complete devascularization of the umbilicus with higher necrosis (4.2%) and higher wound complication rates (11.7% vs. 6.3%) [60, 61]. However, some authors have tried to address this challenge proposing a lateral approach to the hernia leaving the contralateral blood supply or approaching the defect through a midline incision. Another technique is a mini-abdominoplasty, performing a suprapubic incision and dissecting the flap above the abdominal fascia upward,

toward the xiphoidal process. The umbilical stalk is disconnected through the dissection so that, afterward, we can repair the hernia and perform the rectus plication and the abdominoplasty without periumbilical scarring or risk of umbilical necrosis. This technique is not possible to be performed in obese patients; the ideal ones are women after pregnancy with RAD and excess of skin infraumbilical [62].

There are also several endoscopic/laparoscopic procedures (Table 29.5) that vary depending on the space dissected to perform the rectus plication, the trocar placement, the location of the mesh, etc.

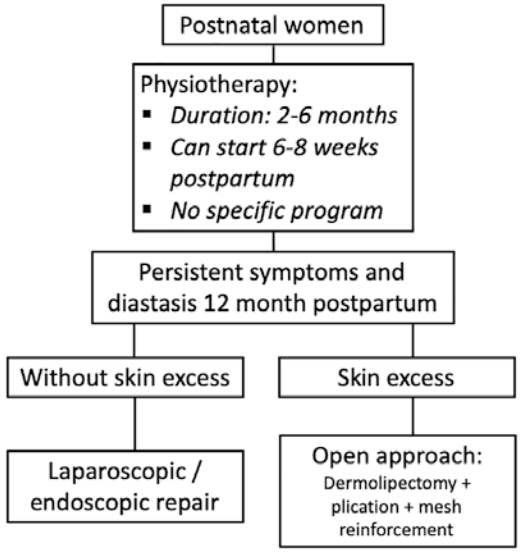

Fig. 29.12 Algorithm for choosing the properly diastasis technique in postnatal women

29.2.6 Postoperative Care

About postoperative care, recommendations are the same to those after umbilical hernia repair. Besides, 4–6 weeks after this surgery, it is recommended to wear an abdominal binder to avoid seroma [47].

29.2.7 Surgical Complications and Outcomes

Overall complication rates vary between studies and were primarily minor and related to the simultaneously performed abdominoplasty. Only a few authors reported major complications. The main overall complications were hematoma and

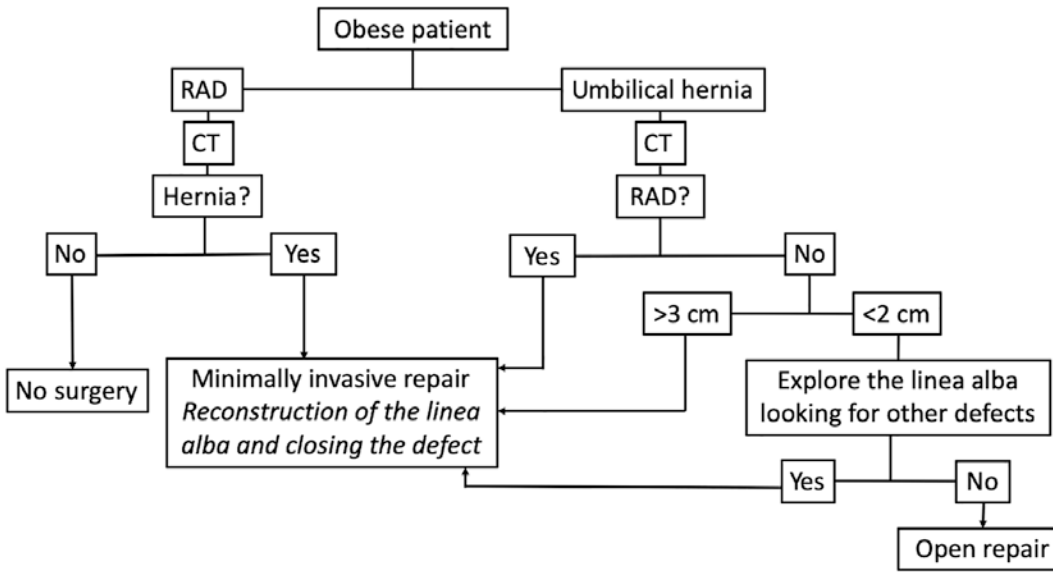

Fig. 29.13 Algorithm for choosing the properly abdominal wall reconstruction technique in obese patients

Table 29.5 Endoscopic techniques

SCOLA (Subcutaneous onlay laparoscopic approach)
REPA (Preaponeurotic endoscopic repair)
Totally endoscopic linea alba repair + preperitoneal mesh in hernia defect
ELAR (Endoscopic-assisted linea alba reconstruction)
E-TEP (Extended totally extraperitoneal repair)
E-MILOS (Endoscopic mini/less open sublay technique)
MILAR (Minimally invasive linea alba reconstruction)
TESLAR (Totally endoscopic supraaponeurotic linea alba reconstruction)
THT (Endolaparoscopic sublay stapler repair)
E-ELHAR-glue (Extended endoscopic hernia & linea alba reconstruction glue)
LIRA (Laparoscopic intracorporeal rectus aponeuroplasty)

seroma formation, wound infection, necrosis of the skin flaps, and hypertrophic scarring [63–65]. Complications were more frequent with the use of mesh [66]. Regarding the technique, the open procedure has higher infection rate, and the laparoscopic one has higher incidence of bowel obstruction/injury and adhesions. Besides, it is believed that when we perform a plication of the rectus sheath, the intra-abdominal pressure increases, decreasing the venous return and increasing the risk of deep vein thrombosis [67]. However, a systematic review found no deep vein thrombosis [65]. About recurrence, results differ, reporting rates from 0 [68] until 40% [69].

Satisfaction was generally reported to be high, but only few studies provided means of assessing the level of satisfaction [69].

29.2.8 Conclusions

RAD should not be misclassified as a ventral hernia. This entity is more prevalent between young women with normal BMI with a history of pregnancies. The diagnosis is clinical, but in obese patients, whose physical examination is more challenging, a CT should be performed in order to discard concomitant midline hernia.

Surgery is often performed due to cosmetic reasons and may be executed through open or laparoscopic approach. The open approach is the most used technique worldwide, but of late, laparoscopic repair has been described and may be used when there is no excess skin and there is no need to associate an abdominoplasty. The RAD repair, regardless of open or laparoscopic approach, consists in one or two-layer rectus sheath plication and, depending on the size of the defect, places a mesh. Sometimes, if RAD is concomitant with umbilical hernia, we have to associate an hernioplasty. RAD concomitant with umbilical hernia is a risk factor for hernia recurrence.

Take-Home Points

- Rectus abdominis diastasis does not present a risk of incarceration; so, surgery is usually performed due to cosmetic reasons.
- It is usually diagnosed through clinical examination, appears as an asymptomatic fusiform bulge.
- In obese patients, a CT should be performed before surgery, in order to discard midline hernia associated.
- Supraumbilical diastasis is more prevalent than infraumbilical.
- If the diastasis is mild to moderate, a one- or two-layer suture should be enough.
- If the RAD is moderate to severe, we should place a mesh in order to reinforce the plication.
- RAD plication may be performed with nonabsorbable suture or slow-absorbable with similar results.
- Physiotherapy should be an alternative in patients who are unable to undergo surgery, and overall, an addition to surgical intervention in order to achieve a satisfying functional outcome.
- More studies are needed to clarify which is the best surgical treatment for these patients.
- Rectus abdominis diastasis and umbilical hernia are frequently associated.
- RAD is a risk factor for herniorrhaphy recurrence; so, when present, we need to repair it as well.
- Best treatment is herniorrhaphy with rectus abdominis plication and mesh reinforcement.
- If there is skin excess associated an abdominoplasty may be also performed.
- The main risk of this technique is the umbilical necrosis.

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Endoscopic Diastasis Recti Plication

30

Juan Bellido-Luque and Beatriz Bascuas-Rodrigo

30.1 Introduction

The abdominal wall is an anatomical structure responsible for the protection of the abdominal viscera, maintaining its position during changes in gravitational forces and increased intra-abdominal pressure.

Diastasis recti (DR), also known as Diastasis of the Rectus Abdominis Muscles (DRAM), is defined as distancing from the muscular rectus borders (inter-rectus distance or IRD) in the midline measured in relaxed state greater than 2.2 cm (according to the Beer classification) [1], and it is characterized by bulging in the anterior wall of the abdomen when the patient exerts contraction of the abdominal musculature and/or increase of the intra-abdominal pressure, which involves a gradual thinning and widening of the linea alba, combined with a general laxity of the ventral abdominal wall muscles [2].

This condition appears due to a reduction of the consistency of the intercrossed fibers that make the linea alba, generating a separation of both aponeurosis of the rectus abdominis muscles [3], which, therefore, is clinically translated as the appearance of a bulging of the midline above and below the umbilicus (if the weakness also affects the infraumbilical midline) [4] representing an aesthetic and symptomatic problem that involves deterioration in the functions of the abdominal wall muscles where patients can experience similar complaints as patients with ventral hernias, such as lower back pain, functional, and cosmetic impairment, although diastasis recti does not pose any threat of strangulation [5, 6].

Diastasis recti is frequently misclassified as a primary ventral hernia, though the musculofascial continuity of the midline and subsequent absence of a true hernia sac is what sets this condition apart from a ventral hernia.

There is currently no consensus as to the definition and classification of diastasis recti. There are only two studies, which try to define diastasis recti and classify it depending on the width of the separation between the muscles. Beer et al. defined the normal width from which the diastasis recti is considered, in 150 nulliparous women between the ages of 20 and 45, using ultrasound (Table 30.1). Therefore, there is a physiological distance between the two rectus muscles.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/978-3-030-43840-1_30.

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_30

Table 30.1 Beer classification

Level	Normal width of the linea alba	
	Age < 45 years	Age > 45 years
Xiphoid	10	15
3 cm above umbilicus	27	27
2 cm below umbilicus	9	14

Diastasis recti occurs most frequently during pregnancy, and 12 months postpartum up to 33% of women still experience diastasis [7]. Diastasis recti is a common and frequent pathology during pregnancy (specially third trimester) and puerperium, with a 30–70% [8] prevalence. DRAM usually regresses spontaneously after childbirth in most women. However, it can be permanent in 15% of the patients, especially in multiparous women. It is important to remember that RD is an important mechanism in that the organism adapts to the growth of the pregnant uterus, but when it persists a year after giving birth, it can no longer improve (and, on the contrary, it will be aggravated by any cause that increases the abdominal pressure) [9].

Other risk factors for DR appearance, with uniform distribution between both sexes, are weight gain or active practice of sport activities that imply an intense use of the abdominal muscles.

The symptomatology of these patients includes low back pain without other apparent clinical causes (70.2%), empirically expressed as the reduction of trunk flexion capacity, and disorders related to “abdominal prolapse" (93.6%), including meteorism, slow transit, abdominal pain and increased the sensitivity of the abdominal wall to traumas, as well as urinary incontinence (44.42%), mainly, but not exclusively, of effort.

Until very recent times, DR has been considered as an almost exclusively aesthetic condition and their treatment has been conducted to plastic surgeons, who employed techniques such as abdominoplasty, which were not always a correct indication for this type of patients.

At present, there is no consensus among the international surgical community on the surgical treatment of diastasis recti regarding indications or surgical technique.

Currently, there is neither consensus on the preferred surgical management of diastasis recti, otherwise, the most commonly used surgical technique is the plication of the superficial aponeurosis of both recti muscles [10, 11], by way of an abdominoplasty; thereby achieving the relocation of both muscles to their normal position and balancing once again all the abdominal wall musculature.

However, in the recent years, the evolution of laparoscopic and endoscopic techniques is leading to a mini-invasive approach of thin condition presenting these approaches as an alternative procedure to the most commonly used techniques for its treatment.

30.2 Patient Selection

Nowadays, the most accepted surgical indications of diastasis recti are (Table 30.2) as follows:

- **Presence of symptoms:** a negligible proportion of patients suffering from diastasis recti have discomfort at this level, which is increased with abdominal movements.
- **Esthetic deterioration:** with the contraction of the abdominal muscles and standing, a lump appears, above all in epigastric place. This lump is caused by the bulging of the weakened linea alba, which could lead to a serious esthetic defect. This esthetic problem is even more evident in young multiparous women: surgical correction is more frequently employed in such women.

Table 30.2 Endoscopic rectus plication indications

General indications	Specific indications
>2 cms DR size	No fatty tissue/skin excess
Symptomatic DR	Symptomatic midline hernia associated
Sthetic deterioration	No previous mesh in “onlay” position

DR Diastasis Recti

– **Association with a symptomatic umbilical hernia:** this problem occurs in those patients with a symptomatic umbilical hernia, associated with diastasis recti above and/or below the umbilicus. If we surgically correct just the hernia, we will be correcting the defect on anatomically weak tissue, which is the damaged linea alba. As a consequence, the probability of a hernia recurrence could increase, and the esthetic result would be uncertain. Therefore, in the case of the co-existence of diastasis recti and a symptomatic umbilical hernia, the simultaneous correction of both pathologies would be recommended. There are currently no studies published on the minimally invasive surgical treatment of diastasis recti associated with umbilical hernias.

Treatment of DRAM, associated or not with abdominal wall hernias, in patients with excess skin is usually performed by a large transverse incision in the lower abdomen associated with dermolipectomy [12–14]. Plication techniques are the most commonly used and may or may not be associated with mesh placement. However, there is a group of patients in whom there is no need for skin resection, in which conventional operation with midline longitudinal incisions results in unfavorable results from the aesthetic point of view [15, 16].

In order to improve these results, in the 1990s, the first alternatives of DRAM correction with the use of endoscopic techniques without the need for large cutaneous incisions were described [17, 18].

According to these facts, we propose as candidates for this endoscopic technique those patients that suffered from diastasis recti associated to primary midline hernias, which were 2 cm or larger in diameter.

30.3 Preoperative Evaluation

30.3.1 Physical Examination

The diagnosis of rectus recti is made on the history and physical examination. The presence of a midline abdominal bulge following pregnancy is usually diagnostic.

Physical examination can confirm the diagnosis based on a midline bulge above or below the umbilicus that is amplified by having the patient lie flat and perform a straight leg raise [19].

Confirmation of rectus diastasis can be made using computed tomography (CT), magnetic resonance imaging, or ultrasound, but these tests are usually not necessary.

30.3.2 Imaging Tests

For the study of diastasis recti, imaging methods such as CT scan or ultrasound have been employed (Fig. 30.1).

The CT scan has the advantage of being able to use bony ridges for the measurement of the separation of the rectus muscles [20].

The advantages of using ultrasound are that it is a noninvasive method, cheap, and without exposure to radiation [21]. At the same time, ultrasound is sure to measure the real distance of the separation of the rectus muscles [21].

30.3.3 Markings

Before surgery, we mark the following landmarks (Figs. 30.2 and 30.3):

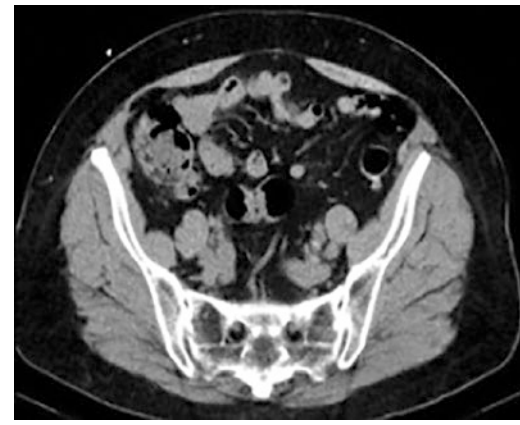

Fig. 30.1 CT scan: 4 cm size infraumbilical diastasis recti

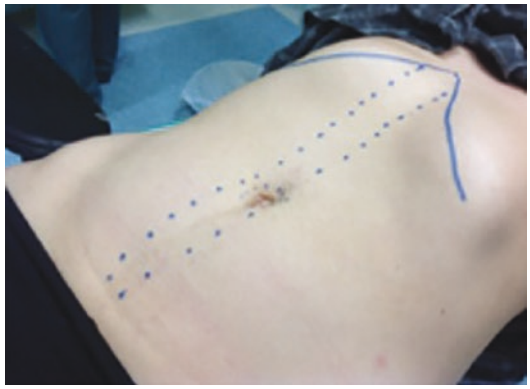

Fig. 30.2 Preoperative view in rectus diastasis and umbilical hernia

Fig. 30.3 Diastasis and umbilical hernia (Continous line) with incision locations. Subcutaneous dissection limits (Dotted line)

- Subxiphoid area
- Suprapubic optic trocar access
- Left and right 5 mm trocar accesses
- Diastasis recti area
- Dissection area

30.4 Anesthetic Considerations

The patients are subjected to general anesthetic and antimicrobial prophylaxis with 1 g of Amoxicillin-Clavulanic in the induction of the anesthesia.

30.5 Surgical Technique

30.5.1 Patient Positioning

The patient is positioned in the supine position, slightly in the Trendelenburg position, to avoid the subcutaneous dissemination of the gas toward the chest wall and the possible appearance of subcutaneous emphysema. Both arms and legs are open. The surgeon is located between the legs of the patient, the assistant on his right, and the surgical nurse on the left.

30.5.2 Procedure Step by Step

A 10 mm incision is made in the suprapubic midline and a space is created between the subcutaneous cellular tissue and the superficial aponeurosis of the linea alba using retractors (Fig. 30.4). In the case of a previous caesarian scar, the incisions will be made on this scar, therefore not adding any esthetic deterioration to the patient.

Once the suprapubic linea alba is exposed, a 10 mm BTT trocar is introduced (Blunt Tip Trocar, Covidien©) for the optic. Sliding on the superficial aponeurosis and under direct vision, two 5 mm trocars are placed, one on each side of the BTT trocar separated by around 5 cm

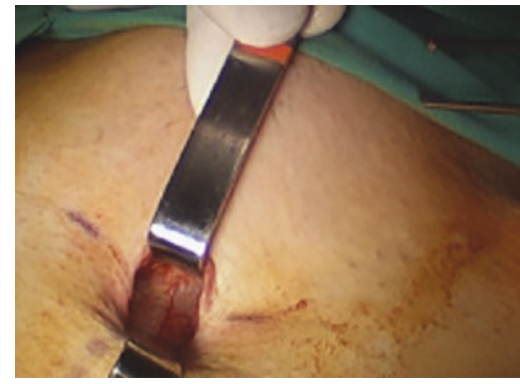

Fig. 30.4 Open midline fascial dissection

(Fig. 30.5); 8–12 mmHg CO_2 pressure is used, being sufficient to maintain an adequate working space.

Under endoscopic vision, the supra-aponeurotic space is dissected, exposing the linea alba and both superficial aponeurosis until reaching the umbilical region (Video 30.1).

The umbilicus is deinserted above the hernial sac, reintroducing this into the intra-abdominal compartment, and the supraaponeurotic dissection is resumed above the umbilicus until the subxiphoid region. It is important that the lateral dissection does not exceed more than 3 cm from the lateral rim of both rectus muscles to minimize the probability of ischemic skin and subcutaneous cellular tissue and the appearance of postoperative seroma (Figs. 30.6 and 30.7).

Subsequently, and once all of the linea alba has been dissected until the subxiphoid region

Fig. 30.5 Trocars placement

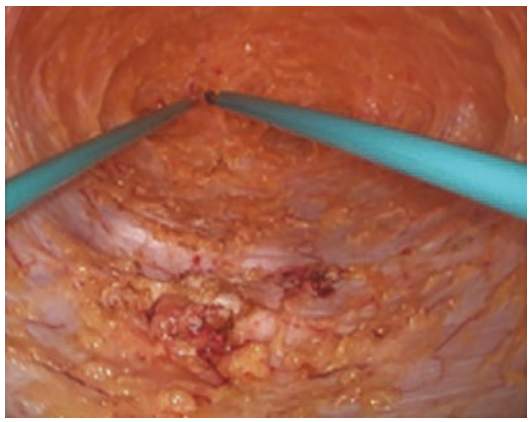

Fig. 30.6 Endoscopic view

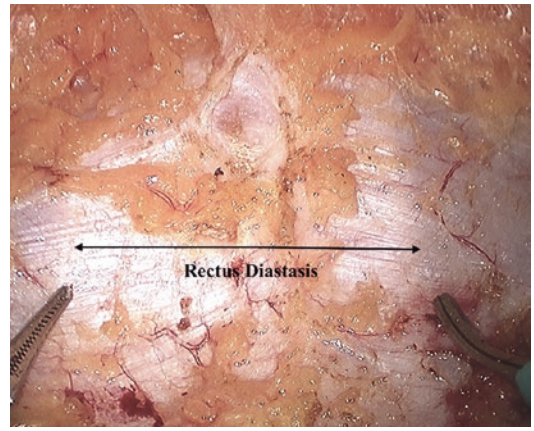

Fig. 30.7 Rectus diastasis

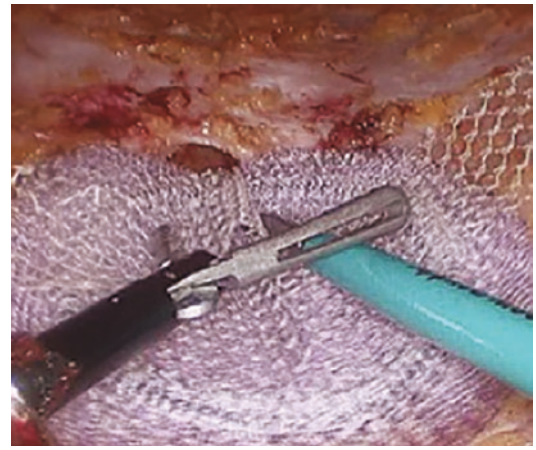

Fig. 30.8 Mesh placement through the defect

and until both superficial aponeurosis, we introduce a prosthesis (Polypropylene on the parietal face and PTFE on the visceral face, VentralexTM hernia patch, Bard©) through the BTT trocar (Fig. 30.8).

The mesh will be placed in every patient in order to perform a complete abdominal wall reparation and avoid recurrence.

The size of the mesh depends on the size of the defect. In defects of 2 cm size, the prosthetic size will be 4.3 × 4.3 cm. For bigger defects, a size of 6.4 × 6.4 cm will be selected.

Once placed in the preperitoneal space, we fix both arms of the polypropylene mesh on the edge of the defect with two reabsorbable sutures (Fig. 30.9).

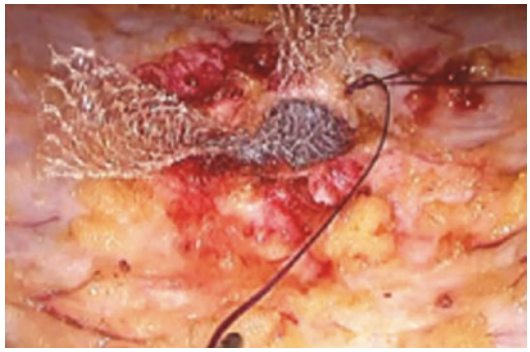

Fig. 30.9 Mesh fixation

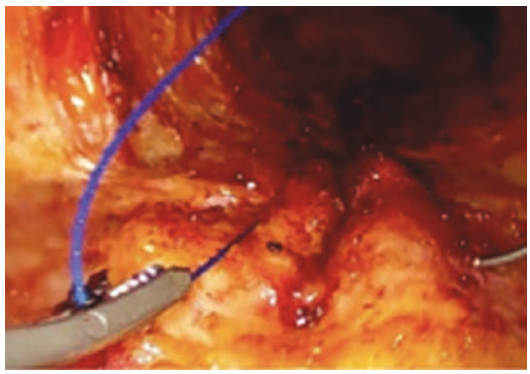

Fig. 30.10 Rectus plication with barbed suture

The plication of both aponeurosis is achieved with the use of a continuous nonabsorbable barbed suture no 1 (VLOC™ PBT, Covidien©), which facilitates this step enormously. The plication is carried out from the subxiphoid until the suprapubic region (Fig. 30.10).

After the plication of both aponeurosis, the umbilicus is reinserted in its normal position through a suture to the plicated fascia, with intracorporeal knotting.

Once this step is carried out, we place the subcutaneous suction drain (Blake©) through one of the 5 mm trocars (Fig. 30.11). This drain will be removed once the 24-h fluid production is less than 10 mL.

30.5.3 Other Surgical Techniques/No Surgical Techniques

Diastasis recti repair is challenging for most surgeons, since guidelines on indication and methods for repair do not exist. However, it is widely accepted that if the condition is symptomatic or associated with midline hernias, the simultaneous corrective surgery of both pathologies should be recommended.

Fig. 30.11 Wounds and drain view

There exist different options for the surgical correction of diastasis recti. The most commonly used ones are

- **Conventional surgery:** the procedure involves an incision along the length of the diastasis, with a consequent increase in the probability of wound infection and the esthetic deterioration, which this supposes. After this, the diastasis is corrected with the plication of both superficial aponeurosis with or without the use of reinforced meshes, depending on the technique used by the surgeon.
- **Abdominoplasty:** plastic surgeons use a suprapubic approach for the correction of diastasis recti in those patients with excess abdominal skin and subcutaneous cellular tissue (Table 30.3). Using retractors, the subxiphoid region is reached from the incision made in the suprapubic area and, with the plication of both superficial aponeurosis, the diastasis recti is corrected. The operation is finalized with the removal of remaining skin and subcutaneous cellular tissue. At the same time, the umbilicus skin is deinserted, reinserting it once all the abdomen skin has been stretched. The scar made in abdominoplasty is ovoid between both anterior superior iliac spines and the other scar is circular periumbilical, with a more acceptable final esthetic outcome [10].

Table 30.3 Main advantages/disadvantages comparing DR repair techniques

	DR+ skin/FT excess Sthetic results	DR− skin/FT excess Sthetic results	DR+ midline hernias	Intra-abdominal complications	SSI rate	Seroma rate
Abdominoplasty	++++	+	+	+	++	++
Conventional open surgery	++	+	+++	++	+++	++
Laparoscopic surgery	++	++	+++	++++	+	++
Endoscopic surgery	+	++++	+++++	+	+	+++

DR Diastasis Recti, *FT* Fatty Tissue, *SSI* Surgical Site infection

– **Laparoscopic procedure:** the third option for the correction of diastasis recti is the minimally invasive laparoscopic approach. The correction is feasible through the prior plication of both aponeurosis in the context of an abdominoplasty, and subsequent intraperitoneal placement of a reinforced mesh by laparoscopic access [22]. A completely laparoscopic approach has also been employed using intra-corporeal sutures or trans-fascial stitches using a Reverdin needle, associated with intra-abdominal reinforced meshes.
– **Endoscopic approach:** there is only one published article in which a totally endoscopic access for the treatment of parietal defects is employed, through the use of conventional endoparietal or percutaneous sutures [23]. However, the majority of published studies on this use endoscopic access without gas, as an aid to conventional abdominoplasty or to mini-abdominoplasty [24, 25]. In this technique, a totally endoscopic access is employed through three suprapubic access trocars, using working pressures of CO2 of 8 mmHg, for the simultaneous correction of primary defects of the midline associated with diastasis recti.

Besides all different surgical options, diastasis recti is mostly treated conservatively. If conservative therapy is preferred, patients can be referred to a physiotherapist for training programs that specifically target diastasis recti, with the aim of reducing the inter-rectus distance and improvement of quality of life.

30.5.4 Technical Tips to Improve Outcomes and Avoid Complications

– Lateral dissection: The suprafascial subcutaneous extension on both sides should reach up to 3–4 cm from the midline to avoid the chance of skin vascular hipoperfussion.
– Drain removal: The drain should be removed when the output is less than 10 mL/24 h to avoid seroma formation. This tip is crucial to decrease the seroma rate during the postoperative period.
– Rectus plication: The anterior rectus sheaths plication become easier when a barbed nonabsorbable suture is used.

30.6 Postoperative Care

After the procedure, a compressed bandage is placed to diminish the dead space between the aponeurosis and the subcutaneous cellular tissue.

An abdominal girdle should be used at least 2 months after surgery.

Postoperative clinical checkups usually are established at 1, 7, 30, 180, and 360 days and thereafter annually.

An ultrasound scan of the abdominal wall is carried out preoperatively, 30 and 360 days after surgery and annually after the first year of surgery in three locations (xiphoid, 3 cm supraumbilical and 2 cm infraumbilical positions).

30.7 Outcomes and Prognosis

Controversy also exists over the analysis of the duration of the plication of the diastasis recti. Different studies value the recurrence of the diastasis after the plication of both muscular aponeurosis, but the majority of these have a small sample size, are retrospective, and with a short follow-up period.

In our experience, no clinical or ultrasound recurrence has been observed in the diastasis and/or the midline hernia in any of the patients during the first postoperative follow-up year. Of the 47% of patients reviewed after 24 months, this was also the case.

With the use of a totally supra-aponeurotic endoscopic approach, it is feasible to simultaneously correct diastasis recti and symptomatic midline hernias in patients without excess skin or subcutaneous cellular tissue, with no recurrence of the diastasis recti being observed, either clinically or ultrasonographically, during the follow-up.

30.8 Complications

In the majority of published articles, the most frequent complication associated with diastasis recti correction is the appearance of postoperative seroma in around 20% of patients operated on. With the change to an abdominal compressed bandage linked to a medical corset positioned once the operation was finished, we have noticed that the rate of seroma can be easily reduced (9%).

30.9 Conclusions

In the last decade, with the claim of abdominal wall surgery as a superspecialty of general surgery, the interest of the wall surgeons has also focused on the DR and thanks to the technical and cultural heritage of general surgery, which includes the knowledge, use and development of prostheses, techniques and equipment that allows a minimally invasive approach, also in the pathology of the abdominal wall, the surgical community has begun to wonder if there could be less invasive techniques than abdominoplasty as treatment for the DR.

The use of a totally supra-aponeurotic endoscopic approach brings considerable esthetic advantages, allowing the simultaneous correction of both pathologies, with minimal complications.

Diastasis greater than 6–7 cm of separation between the rectus, or those associated with severe musculoaponeurotic laxity of the abdominal wall, could benefit from the use of reinforced prosthesis.

Eventually, this technique improves final esthetics results at first postoperative year when compared with the preoperative cosmetic state, with high overall satisfaction, and diminishes back pain when diastasis recti is surgically corrected.

As a final conclusion, we can state that DR, in most of the cases, is not only a cosmetic defect and, therefore, it should not be surgically managed just as a cosmetic defect. That is why abdominal wall surgeons should begin to analyze this condition in a different way and take it into account as a pathology that deserves more consideration. The patient population is very large and disorders associated with DR are sufficiently serious as to alter the quality of life of the patients. Minimally invasive surgical techniques, associated with correct preoperative and postoperative physiotherapy, allow us to offer an adequate intervention for this condition.

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Part VII

Genitalia

Anatomic Changes in External and Internal Reproductive Organs

31

Borja Fernández-Ibarburu, Jesús Olivas-Menayo, and Mónica Gomes-Ferreira

Take-Home Points

- The external genital organs and the vulva include the labia majora and minora, the clitoris, the vulvovaginal glands, and the perineum. The understanding of the anatomical purpose and function of these structures, as well as to the changes during gestation, are essential for giving adequate medical attention to patients.
- The fundamental understanding of the internal genital anatomy of women (uterus, ovaries, fallopian tubes, cervix, vagina), and its changes during pregnancy, facilitates the compression of pathology associated with the structures and enables the surgical treatment of the same.
- The female reproductive system contains two main parts: *the uterus*, which hosts the fetus, produces uterine and vaginal secretions, and passes the male sperm through to the fallopian tubes; and *the ovaries*, which produce the female egg cells.

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31.1 Introduction

The female reproductive system is a collection of internal and external organs. The external genitalia comprise the structures outside of the true pelvis, including the labia majora and minora, vestibule, Bartholin glands, Skene glands, clitoris, mount of Venus, perineum, urethral meatus, and periurethral area. The internal genitalia is within the true pelvis, including the vagina, cervix, uterus, fallopian tubes, and ovaries.

The reproductive system is for the purpose of procreating. Due to its vital role, many scientists argue that the reproductive system is among the most important systems in the entire body.

After pregnancy, the female reproductive system can change significantly. It is important for medical professionals to know why these changes occur and how we can reverse some of them, if it is the woman's desire.

31.2 Female External Genital Organs

The female external genital organs are found in what is commonly referred to as the vulva (Fig. 31.1). This includes the mount of Venus, the

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_31

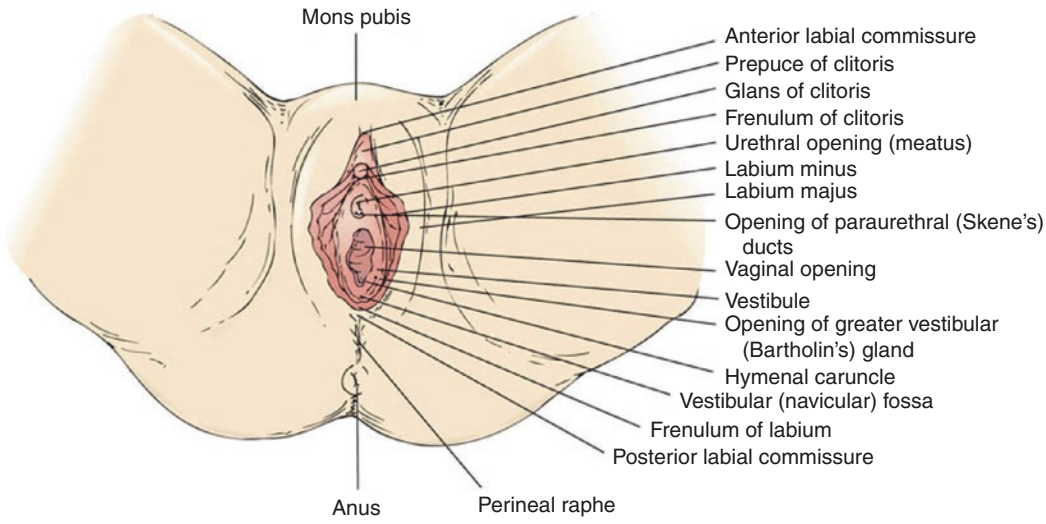

Fig. 31.1 Anatomy of the vulva. (Reprinted from Firoozi F. Female pelvic surgery. Springer 2015 with permission)

labia majora, labia minoras, vestibule, clitoris, vulvovaginal glands, and the perineum.

Regarding the arterial supply of the external genital apparatus, it is derived from the deep external pudendal branches of the superior femoral artery and the internal inferior pudendal artery on each side (Fig. 31.2).

Vulvar cutaneous venous drainage occurs through the outer pudendal veins, to its mouth in the saphenous vein. The clitoris carries out its venous drainage through the deep dorsal veins (they flow into the internal pudendal vein) and through the superficial dorsal vein, to the external pudendal vein, and finally the greater saphenous vein.

There is a wide network of interconnected lymphatic vessels responsible for draining the external genitalia and perineum. These extend from the skin of the lips, clitoris, and surround regions to form three or four main trunks that join the superficial inguinal nodes (on the cribriform fascia). From there they reach deep into the inguinal nodes, medial to the femoral artery (the last deep inguinal nodes, which are located under the inguinal ligament in the femoral canal, are often called Cloquet's node). These, in turn, drain through the femoral canal to the pelvic nodes [1]. Deep lymphatic vessels from the clitoris can drain directly into the deep inguinal nodes or through the inguinal canal to the external iliac nodes. This complex lymphatic drainage network has clinical relevance, as these are the nodes in which the vulvovaginal and cutaneous vulvar neoplasms find their way of dissemination [2].

Regarding nerve supply, the predominant injector of the vulva comes from the pudendal nerve (S2, S3 and S4) through its lower rectal and perineal branches, and the dorsal nerve of the clitoris (Fig. 31.3). The sensory insertion of the anterior third of the labia majora comes from the ilioinguinal nerve (LI), while it is the pudendal nerve, which, through the posterior labial branches of the perineal nerve (S3), innervates the posterior 2/3 of the same. The lateral region receives inertia in addition to the perineal branch of the posterior femoral cutaneous nerve (S2) [1].

31.2.1 Mont of Venus

The mount of Venus consists of an adipose prominence that covers the public symphysis, which, after adolescence and adulthood, becomes more prominent, hair grows, and atrophies well after menopause. The hymen frames the vaginal opening and is considered a portion of the vestibule.

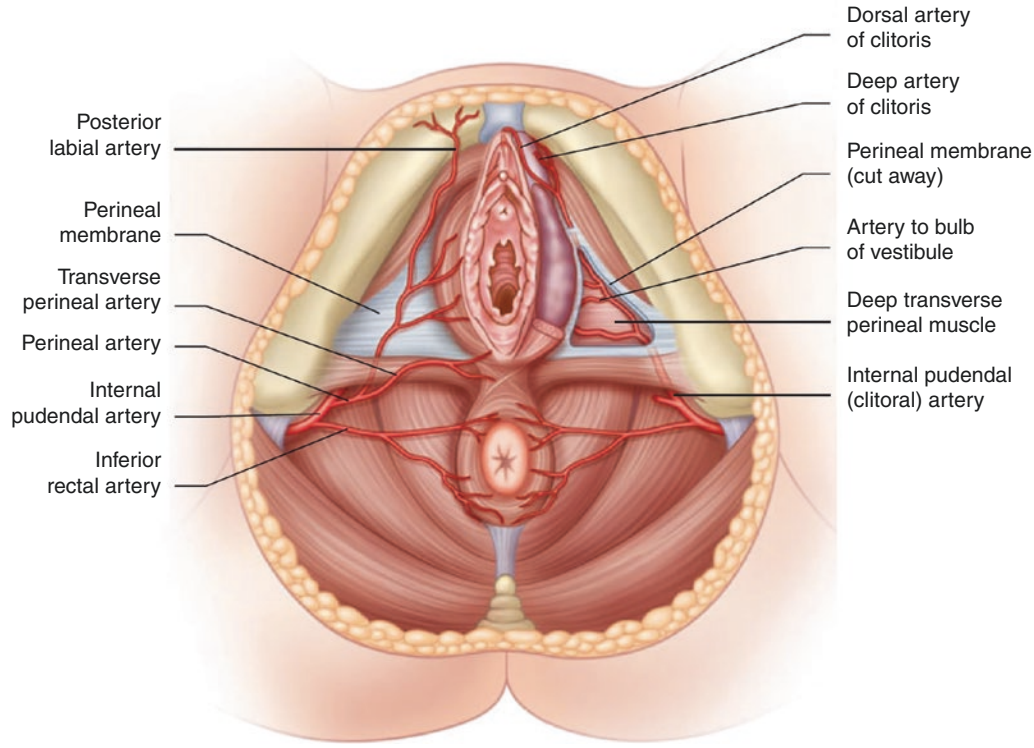

Fig. 31.2 Vulvar blood supply. (Reprinted from Firoozi F. Female pelvic surgery. Springer 2015 with permission)

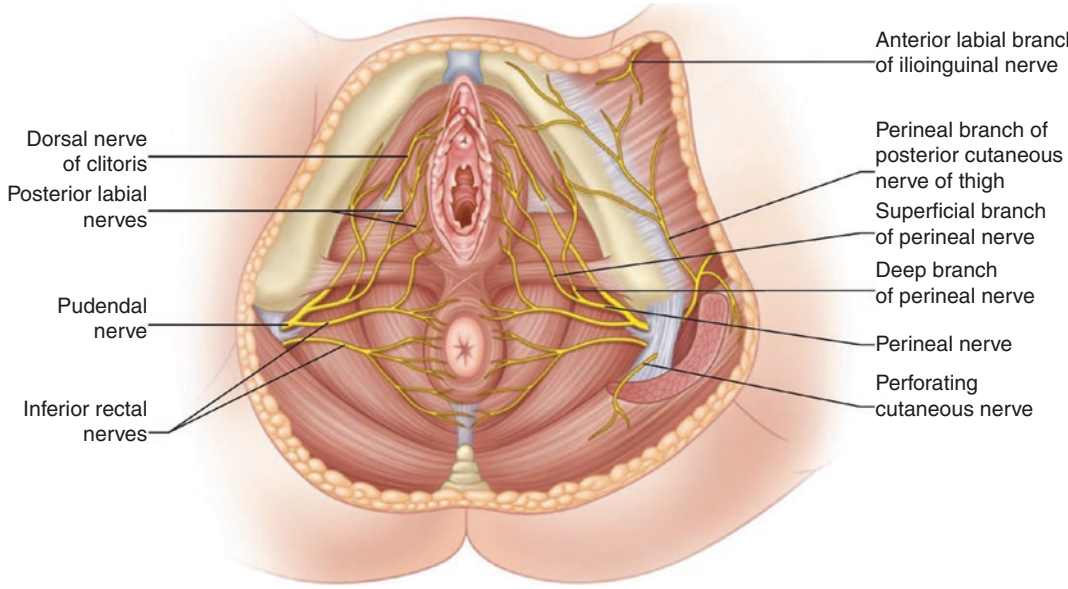

Fig. 31.3 Vulvar innervation. (Reprinted from Firoozi F. Female pelvic surgery. Springer 2015 with permission)

31.2.2 Labia Majora

The labia majora consist of two prominent, bresuper-elongated and longitudinal skinfolds on either side of the vaginal introitus. They are the prominent ones of the vulva, and they make up its lateral margins [3]. Each lip has a hairy pigmented outer surface and a pink-looking inner surface with prominent sebaceous glands. The content between both surfaces consists of loose connective tissue and subcutaneous fat (they have a superficial fatty layer similar to Camper's fascia, and a deeper membranous layer—Colles' fascia—which is in continuity with Scarma's fascia of the anterior wall of the abdomen), interconnected with smooth muscle fibers (similar to the dartos muscle of the scrotum in the male), vessels, nerves, and glands [1]. The lips meet anteriorly to form the anterior commissure, while posteriorly they join at a slightly elevated connecting ridge, called the posterior commissure (superficial to the period body), constituting the posterior limit of the vulva [2]. It is the subcutaneous fatty deposits that cause the lips to rise on either side of the vaginal cleft (they decrease in thickness with age), and it is through them that the vessels and superficial nerves responsible for their sustenance circulate. The main arterial supply comes from the superficial branches of the pudendal artery, while the incitation comes from cutaneous branches of the pudendal nerves, nerve, and femoral skin nerves [4].

31.2.3 Labia Minora

The labia minora consist of two thin skin folds of small size devoid of hair, found between the labia majora. They delineate the vaginal vestibule laterally, and each lip forks anteriorly to surround the clitoris [2]. They are homologous to the median raphe of the penis and scrotum in men, and contribute to the structure of the clitoral frenulum and sheath (When the labia minora are bifurcated, the upper layer on each side passes over the clitoris forming the foreskin, while the lower layer passes under it to form the frenulum [1]). They have abundant sebaceous and sweat glands (apocrial glands, as well as in the perianal floor) in addition to presenting a rich venous drainage, and an important nervous supply, which makes them more sensitive to touch than the labia majora [4].

31.2.4 Clitoris

The clitoris consists of a small, cylindrical, and erectile structure, partially encompassed by the anterior edges of the labia minora after bifurcation [1] (Fig. 31.4). It is located in front of the urethra and is made up of the glans (the only part visible externally between the folds formed by the bifurcation of the labia minora), body and two crura ("legs") [3]. The body of the clitoris is covered with a loose tissue foreskin and can be felt through the skin. It consists of two corpora cavernosa composed of erectile tissue surrounded by dense fibrous tissue and divided medially by an incomplete fibrous pectineal septum (by adhering superiorly to the pubic symphysis, this fibrous tissue forms a suspensory ligament). The corpora cavernosa separates as they extend superiorly, and each of them ends in a crura that joins the periosteum of the ischiopubic branch on each side [1]. Each end of the clitoris is covered by the corresponding ischiocavernosus muscle [3]. The glans of the clitoris is a small tuberosity of spongy erectile tissue distal to the body and connected to the vestibular bulb on each side by thin bands of erectile tissue. Its epithelium presents great cutaneous sensitivity (the dorsal nerve of the clitoris accesses the glans after crossing the urogenital diaphragm [2]), which represents an important aspect in the sexual response [1].

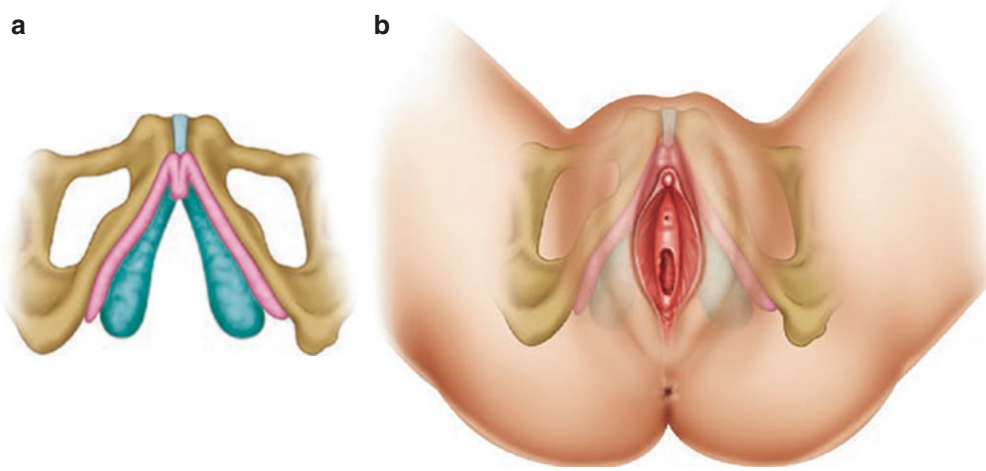

Fig. 31.4 Anatomic drawing of the clitoral organ (colorations of original drawings from the author). (**a**) (Left) Drawing showing the clitoral organ flanked by the symphysis and the inferior rami of the pubic bone (description given from inside to outside): bulbi vestibuli being covered by the bulbo-cavernosi muscle; clitoris comprising the clitoral tip and clitoral bodies radially stretched by the suspensory ligament, as well as the clitoral crura paralleling the bulbi vestibuli at their lateral border. (**b**) (Right) Illustration of clitoral topography projected on the vulva. (Reprinted from Dan mon O'Dey. Vulvar Reconstruction Following Female Genital Mutilation/Cutting (FGM/C) and other Acquired Deformities. Springer 2019 with permission)

31.2.5 Greater Vestibular Glands: Bartholin's Glands

The vestibule is the cavity between the labia minora and presents on its surface different structures that should be known. Among them are the external vaginal and urethral orifices, and the opening of the two maternal vestibular glands (Bartholin glands) and the numerous minor vestibular glands [1], vaginal and external urethral orifices, and the opening of the two major vestibular glands (Bartholin glands) and the numerous minor vestibular glands [1]. The vestibule bulbs (equivalent to the spongy body of the penis in the male [3]) consist of two elongated structures of erectile tissue, about 3 cm long, which rest on either side of it and flank the vaginal opening. In front of it, they are joined by a narrow joint (in contact with the glans of the clitoris), while its posterior edge expands and contacts the major glands and stables. The deep face of each vestibular bulb is in contact with the lower portion of the perineal membrane, while superficially, each one is covered by the bulbo-cavernous muscle [1] (in addition to serving as an aid in the constriction that occurs to avoid Venous drainage of the erectile bulbs and stables, it can act as a vaginal sphincter [3]). The external urethral meatus is located in the superior portion of the vestibule and is located in a papillary elevation with a sagittal cleft approximately 2 cm below the clitoris and above the vaginal opening. The opening of the ducts of the paraurethral glands (Skene's glands) is located on each side of the urinary opening (posterolateral aspect of it). Skene's ducts run parallel and inferior to the urethra, at a distance of approximately 1–1.5 cm [2]. The major vestibular glands (Bartholin's glands) are homologous to the male bulbourethral glands. They consist of two small, oval, or rounded structures that flank the vaginal opening (at 5 and 7 o'clock), in contact and often covered by the lower part of the vestibular bulb [1]. In addition, they are very close to the posterolateral wall of the vagina, around 15 mm deep from the vestibule surface, slightly posterior and lateral to the opening of the corresponding duct [4]. These ducts (1.5-cm-long each) are also visible on each side of the vestibule, in the groove formed by the hymenal ring and the labia minora, at the junction of the middle and posterior one-third of the lateral margin of the vaginal opening [2]. The

position of the glands and their ducts must be known for their clinical relevance when evaluating an abscess/Bartholin cyst in patients with lip inflammation [2]. The major vestibular glands are composed of tubulo-acinar tissue, the cells being columnar type secretors. Its function is to secrete a whitish or clear mucus useful in lubrication during sexual intercourse [1].

31.2.6 Changes with Pregnancy, Labor, and Postpartum Period

Throughout pregnancy, a multitude of changes occur in the woman's body, mainly due to the action of hormones, biochemical and mechanical factors. This set of modifications represents the anatomical and physiological adaptations necessary to carry the pregnancy to term. Such changes appear from the moment of fertilization, and revert progressively after childbirth, until returning to a situation similar to the moment before pregnancy in most cases [5]. There are situations in which the return to normality of the parts affected by pregnancy does not occur spontaneously at the end of the pregnancy, and surgical correction of the same may be necessary to achieve this.

During pregnancy, as with the rest of the organs, relevant changes occur in the characteristics of the female external genitalia. There is an increase in vascularization and hyperemia in the skin of the vulva and the perineal area, which generates in these tissues an edematous appearance, and a coloration with cyanotic dyes. Furthermore, they acquire a softer and more elastic consistency [5]. Due to the action of progesterone, venous compliance increases, which, combined with the mechanical changes generated in the uterus and the increase in circulating volume, can cause the appearance or worsening of varicose veins in the skin of the vulva [6].

The labia minora can undergo modifications in the same way that occurs with the labia majora. Hypertrophy of the labia minora is defined as the protrusion of the lip tissue beyond the limits of the labia majora, and it appears that the estrogen receptors present in them play a fundamental role in this anomaly [7]. Excess circulating estrogens in the presence of normal IGF-1 levels cause hypertrophy of the labia minora. In addition, the increase in the total amount of circulating blood per unit of time within the urogenital tissue (as in acute inflammation, pregnancy, etc.) also seems to contribute to said hypertrophy, as it happens with vultures varicosities. Therefore, there could be a relationship between local blood circulation and the growth of the labia minora. All these facts can be appreciated during pregnancy, and the reasons why women request corrective surgical treatment of this disorder range from purely aesthetic reasons to functional ones (discomfort, pain, or itching are not uncommon), or both [7].

In addition to the vulvar region and labia minora, venous compression by the supine gravid uterus affects the pressure of the draining veins of the lower extremities and the pelvic organs, exacerbating varicose veins in the legs and causing hemorrhoids to develop. On the other hand, increased venous pressure is the major cause of typical lower extremity edema of pregnancy. This compression markedly reduces blood flow in the veins, causing a predisposition to thrombosis, compared to the basal state outside of pregnancy [3]. Regarding other apparent changes in the external anatomy of women, the increase in skin pigmentation stands out. In addition to the abdominal line alba, the vulva, areola, and nipples may be affected. This increase in pigmentation tends to disappear almost completely after delivery. Although the pathogenesis of this discoloration is not known exactly, it is believed that it may be due to the increase in the melanocyte-stimulating pituitary hormone, favored by the action of gestational progesterone [5].

31.3 Female Internal Genital Organs

The internal genitalia are the structures within the true pelvis, including the uterus, cervix, vagina, fallopian tubes, and ovaries (Fig. 31.5). It is very important for medical professionals, espe-

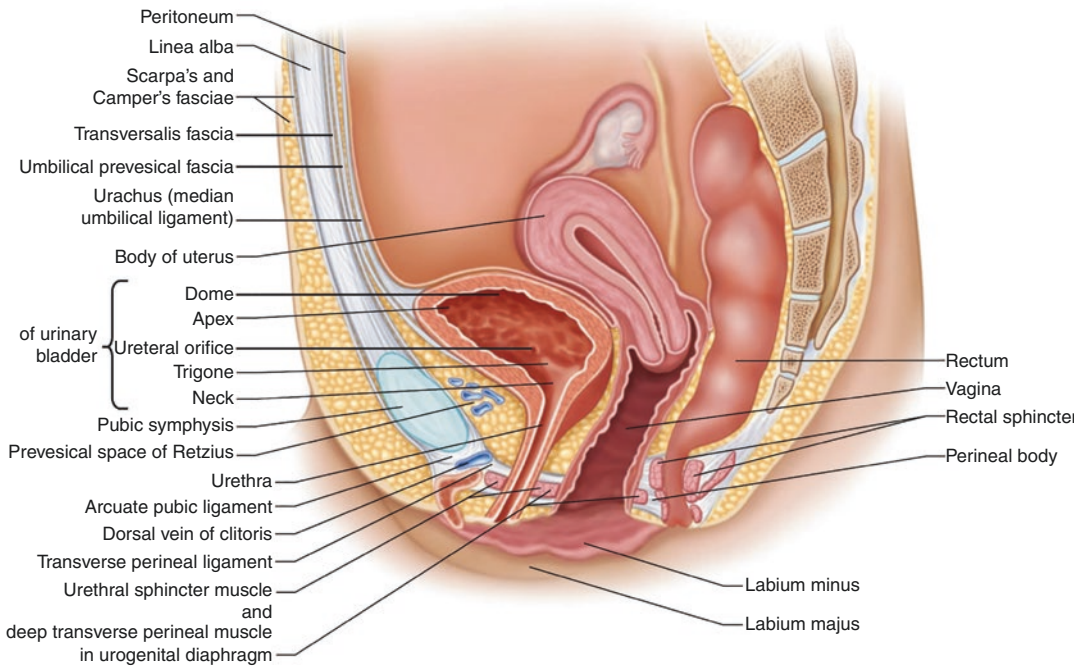

Fig. 31.5 Relationship of bladder to neighboring organs. (Reprinted from Firoozi F. Female pelvic surgery. Springer 2015 with permission)

cially those in the field of obstetrics and gynecology, studying the female reproductive system to understand anatomy exclusive to females.

31.3.1 Uterus

The uterus is a thick-walled muscular organ located in the pelvis between the bladder and the rectum [8]. Between both structures are the uterovesical spaces in front and the rectus-uterine pocket behind, while the broad ligaments are in a lateral position [9]. The uterus can be divided structurally and functionally into two main regions: The muscular body, which It constitutes the upper two thirds and the uterine cervix, which forms the lower third [9].

Both structures are joined by the isthmus, a slight narrowing that defines a transition area, where the endocervical epithelium gradually transforms to form an endometrial surface [10]. In the nulliparous adult woman, the cervix adopts a forward position with respect to the axis of the vagina (anteversion), while the body of the uterus also leans forward with respect to the cervix (anteflexion) [9]. The uterine cavity (normally measuring about 6 cm from the external cervical opening of the cervix to the fundus wall [9]) is a triangularly flattened potential space, which is continued with the cervical canal through the cervical opening internal at its lower pole. Its upper pole is represented by the fundus, the portion of the body that is above the level of the mouth of the fallopian tubes [8].

Externally, the uterine wall is composed of a serous layer, a thick and firm intermediate layer of smooth muscle (myometrium, which contains lymphatic vessels, blood and nerves [9]), and an internal mucous layer (endometrium, consisting of epithelium single-layer columnar, connective tissue endometrial stroma [9]) [8]. Regarding its structural configuration, the upper surface of the uterus is convex and generally directed forward as previously mentioned. Its anterior face is flattened and is oriented downward and forward, resting on the bladder (its peritoneal covering makes a recess at the height of the isthmus in the upper part of the bladder, creating the bottom of

the uterovesical sac). The posterior surface of the uterus is convex and has a close relationship with the rectum. The peritoneum covering the posterior body wall and the upper portion of the cervix extends down over the posterior fornix of the vagina to the rectum to form the Pouch of Douglas [8].

The lateral margins of the body of the uterus are convex. On both sides, the parietal peritoneum is reflected laterally to form the broad ligament (anterior and posterior leaves), which extends like a flattened sheet to the lateral pelvic walls, where they fuse with the peritoneum that covers them. The broad ligament is divided into a superior mesosalpinx, posterior mesovarium, and inferior mesometrium [9].

The main vascular supply of the uterus comes from the uterine artery, which arises as a branch of the anterior division of the internal iliac artery (Fig. 31.6). Along its path, anastomoses occur both with branches of the ovarian artery as it rises above the uterine body, and with branches of the vaginal artery, when descending to irrigate the cervix (From this junction two medium longitudinal vessels, called arteries, arise adjacent of the vagina, which descend down the front and back of the vagina) [9]. The internal iliac veins are responsible for the venous drainage of the uterus through the uterine veins, which extend laterally in the broad ligaments. These circulate adjacent to the arteries and passing over the ureters. There is a connection between the ovarian and vaginal venous plexuses, similar to the arterial configuration [9].

The predominant innervation of the uterus comes from the inferior hypogastric plexus. Lymphatic drainage exists in both the superficial and deep parts of the uterine wall. These collecting lymphatic vessels of the uterine body and cervix eventually drain into three main groups of lymph nodes: the internal external iliac nodes, and obturators. In addition, the lymphatic vessels from the uterine fundus and the fallopian tubes accompany the lymphatic drainage of the ovaries, leading to the para-aortic nodes [9].

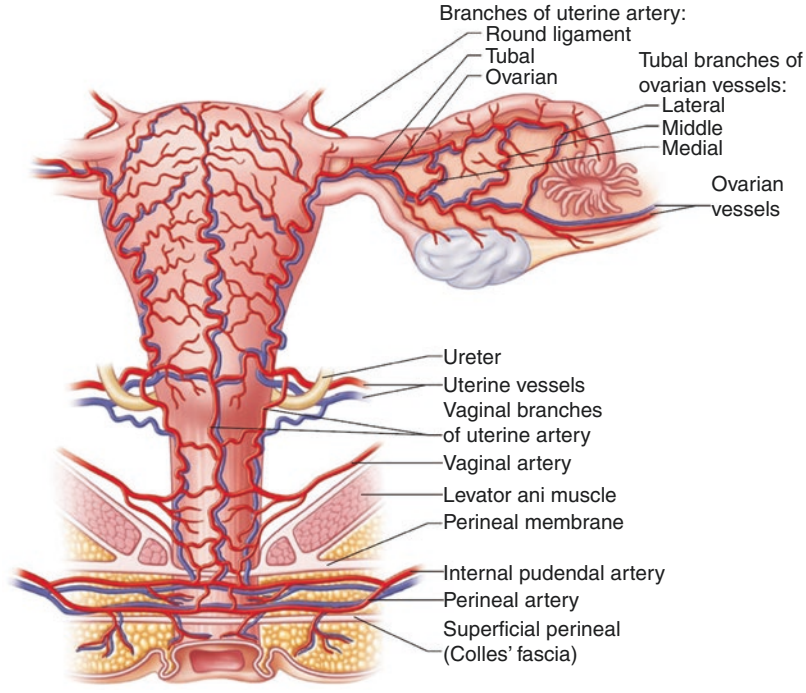

Fig. 31.6 Blood supply of female internal organs. (Reprinted from Firoozi F. Female pelvic surgery. Springer 2015 with permission)

31.3.2 Cervix

The lowest part of the uterus is called the cervix or cervix.

Cylindrical and pink in appearance, it has a central hole (around 3–5 mm in diameter in nulliparas and 1 cm or more in multiparas) [11]. In nulliparas, the appearance of the hole is circular, while after gestation it acquires a transverse incision appearance. The adult cervix in gilts has a length of around 2.5 cm [9].

The upper cervical end communicates with the uterine body through the internal cervical opening, while the lower end opens into the vagina through the external cervical opening [9]. Between the two openings is the endocervical canal, a narrow duct (about 0.5 cm) whose mucosal epithelium (endocervix) extends into multiple grooves and folds entering the underlying collagen stroma, at varying depths [11].

The outer portion, surrounded by the fornices and in contact with the vaginal epithelium, is called the exocervix. It consists of a nonkeratinized squamous epithelium (it has around 20–40 layers of squamous cells, which distinguishes it among other things from the endocervical mucosal epithelium [11]) and changes its constitution to a simple columnar epithelium when contacting the endocervix, in the squamocolumnar union [10]. It receives a rich vascularization from the descending branch of the uterine artery, and the vaginal artery. The lower hypogastric plexus constitutes the main innervation of the cervix, although the sacral roots and the sympathetic system also contribute to it, from the sacral and lumbar prevertebral chain [11].

31.3.3 Ovaries

The ovaries are two organs composed of dense fibrous tissue with an oval appearance (after the start of ovulation, its surface is regularly distorted, due to the scarring resulting from the degeneration of the successive ovulations [9]), flattened, compressible, approximately 3 × 2 × 2 cm inside which the eggs are embedded [10]. In the nulliparous adult female, the ovaries are located on either side of the uterus close to the lateral pelvic wall. They are suspended in the pelvis by a double peritoneal fold, the mesovarium (which in turn is attached to the upper surface of the posterior portion of the broad ligament) [9]. Three-dimensionally, the lateral surface of the ovary is in contact with the parietal peritoneum in the ovarian fossa, behind which are retroperitoneal structures, such as the internal iliac vessels, the ureter, obturator vessels and nerves, and the origin of the uterine artery [9].

The medial surface faces the uterus and its vessels in the broad ligament. On the upper edge is the distal section of the uterine tube with its fimbriae. The lower edge faces the pelvic floor, while the anterior edge faces the posterior leaf of the broad ligament and contains the mesovarium.

The posterior border is free and is shunted towards the peritoneum, which, as already mentioned, covers the upper part of the internal iliac vessels and the ureter [9].

The ligament and peritoneal support of the ovary are the infundibulopelvic (suspensory) and ovarian ligaments, and the mesoovarium.

The suspensory ligament of the ovary attaches to the superolateral portion of the ovary and contains the ovarian vessels and nerves. The ovarian ligament joins the medial- medial end of the ovary to the lateral angle of the uterus, via a path posterior to the uterine tube. Finally, the mesoovarium constitutes a short peritoneal fold that joins the ovary to the posterior part of the broad ligament [9] (Fig. 31.7).

The main vascularization of the ovary is provided by the ovarian arteries, originating from the abdominal aorta. They have their origin in a location immediately inferior to the renal arteries. From birth, they travel a lower path and cross laterally over the ureter, giving branches to it and to the fallopian tube. In addition, the ovary receives a substantial arterial contribution from the uterine artery, through utero-ovarian anastomosis [10]. The ovarian veins are responsible for venous drainage from the ovary. These emerge from the ovary as a pampiniform plexus in the mesoovar-

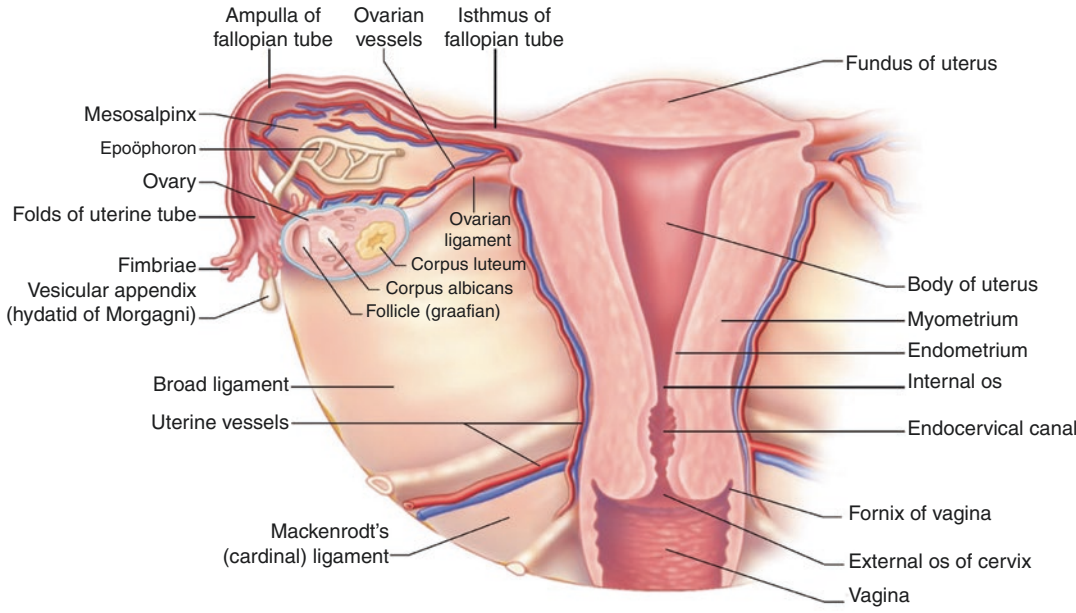

Fig. 31.7 Uterine ligaments and relationships to ovaries and fallopian tubes. (Reprinted from Firoozi F. Female pelvic surgery. Springer 2015 with permission)

ium and the suspensory ligament. From there, two veins emerge from the plexus with the ovarian artery on each side.

They are usually joined in a single vessel before entering the main venous return line. The one on the right ends directly into the inferior vena cava, while the one on the left flows into the left renal vein [9].

The innervation of the ovary derives from the autonomic plexuses. The upper part is made up of branches of the renal and aortic plexus, while the lower part receives reinforcement from the superior and inferior hypogastric plexuses [9]. Lymphatic drainage occurs thanks to a series of vessels that follow the ovarian veins to the paraaortic lymph nodes, located near the origin of the renal arteries [9].

31.3.4 Fallopian Tubes

The fallopian tubes constitute bilateral muscular structures of tubular morphology (up to 10 cm canvas) with a lumen that connects the uterine cavity (they are attached to the upper body of the uterus) with the peritoneal cavity [10]. Microscopically, the walls of the uterine tubes show a visceral, a muscular, and a serous mucous layer [9].

The medial tube opening is located in the upper portion of the uterine cavity. From there, the tube circulates laterally and superiorly. It can be divided into four main parts, from medial to lateral: Intramural (0.7 mm wide and 1 cm long, included in the myometrium), isthmus (1–5 mm wide and 3-cm long, rounded, muscular, and firm), blister (this is the widest part of the tube, with a maximum luminal diameter of 1 cm, and is where fertilization usually takes place) and fimbriae (mucous folds about 1 mm wide, attached to the edges of the infundibulum) [9].

The vascular supply of the uterine tubes derives from the ovarian arteries in its most lateral third, and the uterine arteries in its two medial thirds [9]. Venous drainage, analogous to the arterial supply, occurs through the pampiniform plexus in the ovarian veins (two-thirds lateral) and renal vein, respectively. The medial third of the tubes drain through the uterine plexus into the internal iliac vein [9].

Lymphatic drainage occurs through the ovarian lymphatic vessels, which empty into the para-

aortic ganglia, and uterine vessels, which do so into the internal iliac chain. The nerve branches responsible for the innervation of these structures come from autonomic fibers that mainly accompany the ovarian and uterine arteries. They have both sympathetic and parasympathetic contribution. The vagina can be defined as a fibromuscular tubular structure (it has a thin and flattened wall, and it is distensible [11]) nonkeratinized stratified epithelium [9]. It extends from the insertion ring of the hymen into the introitus, in a posterior superior direction (starting from the standing position), to the fornices that surround the uterine cervix [10]: at an angle of 60–70° with the horizontal plane, with the axis of the uterus (which is variable depending on the content of the bladder and rectum) [9].

It has a length (variable according to age, ovarian function, previous pregnancies, etc.) of 8–8.5 cm from the hymenal ring to the top of the anterior fornix, 7–7.5 cm to the top of the lateral fornix, and 9–9.5 cm to the upper part of the posterior fornix [11]. Structurally, it can be divided into three parts. The lower third of the vagina is surrounded and supported by the pelvic and urogenital diaphragm [8], and in turn, is encompassed by bulbous spongy skeletal muscle fibers [9]. At this level, the vagina shares common walls with the rectum and urethra [11].

The middle third crosses under the lower margin of the pubic symphysis, just below the ureterovesical junction. The levator ani muscle adjoins the posterior and lateral vaginal walls, more sharply at the junction of the middle third with the lower third. This region, together with the most cranial, has the highest degree of mobility of the vagina [11]. The upper third finds its greatest support in the cardinal ligaments, as well as in the adjacent walls, shared with the bladder and rectum [11]. Laterally, the upper portion of the vagina is supported by the levator ani muscle, along with the transverse cervical, pubocervical, and to a lesser extent the uterosacral ligaments [9].

Some important anatomical relationships of the vagina, with the proximal pelvic structures, are located in its anterior and posterior aspect. Previously, the vagina is in intimate contact with the urethra, bladder, while it is subsequently in close contact with the rectum [11]. The superior area of the posterior vagina is separated from the rectum by the peritoneum of the rectus-uterine pocket and by moderately dense fibromuscular tissue (Denonvilliers' fascia). In the lower room, the vagina is separated from the anal canal by the body of the perineum [9].

Microscopically, the vagina is lined by a mucosa of non-keratinized stratified squamous epithelium (devoid of mucous glands and hair follicles [10, 11]).

The lower stroma consists of collagen embedded in elastic tissue, and in depth to this, there is a layer of smooth muscular coverage (an internal circular layer, and an external longitudinal layer, which provide it with capacity for expansion and contraction [10]). The total thickness of the vaginal wall in women of childbearing age is around 2–3 mm [11]. The vagina has a rich vascular supply coming from the descending branch of the uterine artery, the vaginal artery (originates directly from the uterine artery or as a branch of the internal iliac artery [8]), and the internal pudendal artery. The vaginal arteries descend through the anterior and posterior surface of the vagina. Finally, the medial rectal branches of the internal iliac artery may also contribute to the arterial supply of the vagina [9].

The venous drainage of the vagina occurs thanks to the lateral plexuses that, on each side, connect with the uterine, vesical, and rectal plexuses. These eventually flow into the internal iliac veins [9]. Vaginal lymphatic drainage is interconnected with the lymphatic vessels of the cervix, rectum, and vulva. The superior vessels accompany the uterine artery to the external and internal iliac nodes. The intermediate vessels accompany the vaginal artery to the internal iliac nodes. The vessels that drain the lower vaginal portion of the hymen are part of the same network that drains the skin of the vulva and the perineum (See Sect. 31.2 of the chapter) [9]. The innervation received by the vagina is divided according to its location. The one corresponding to the upper third comes from the pelvic plexus,

with input from the hypogastric plexus, prevertebral nodes, and sacral nerves. The lower third is innervated by the pudendal nerve (S2–S4).

31.3.5 Changes with Pregnancy, Labor, and Postpartum Period

During pregnancy, multiple changes occur in the female reproductive system, and in the associated abdominal structures. To allow uterine expansion during pregnancy and to facilitate the passage of the fetus through the birth canal, the walls of the pelvis, the succus, and the adjacent viscera are modified for an adaptive purpose [9]. In addition to those mentioned, practically all the woman's organic systems undergo some type of change during pregnancy. In most of them, all these alterations revert to their basal state in a short period of time [8].

In the same way that it happens with the external genitalia or the cervix, the vaginal tissue undergoes an increase in its vascularization [12]. Generates or produces a violet coloration of it, called "Chadwick's sign" [13]. Furthermore, it becomes more elastic, and the action of steroid hormones on the vaginal epithelium produces a significant increase in vaginal and cervical secretion [12]. In order to prepare the vagina for delivery, the connective tissue under the vaginal epithelium decreases and the smooth muscle fibers thicken. The vaginal mucosa itself increases in thickness and its epithelial cells acquire a characteristic oval shape. With the increase in estradiol throughout pregnancy, an increase in glycogen concentrations occurs (specifically in epithelial cells). This glycogen is metabolized into lactic acid by *Lactobacillus acidophilus* (they dominate the vaginal flora during pregnancy), which reduces the vaginal pH that remains acidic [14]. This fact gives the vagina greater protection against infestations [12].

On the other hand, exposure to gestational diethylstilbestrol can generate glandular columns interspersed with the usual squamous epithelium of the upper two-thirds of the vagina, causing a disorder known as vaginal adenosis [10].

At the end of the pregnancy, the vagina contracts slowly, and the folds restore around the third week, when the edema disappears, and the vascularization returns to normal [8]. In spite of this, and although the supporting tissues of the pelvic floor may also gradually recover their previous tone (fascial distention and muscular trauma suffered by the pelvic floor may not recover their pregestational state, depending on the circumstances of delivery [8]), the vagina does not return to its previous basal state [10]. It is for these reasons that women who give birth vaginally should be instructed to perform Kegel exercises (intermittent contraction of the pelvic floor muscles) to maintain and improve the supporting tissues of the pelvic floor [10]. In cases where they are not effective, they may require surgery, in order to recover their continence function.

The uterus is the organ that undergoes the most transformations during pregnancy [12]. It is modified to become a thin-walled muscular organ with sufficient capacity to accommodate the fetus, placenta, and amniotic fluid [13]. In the nonpregnant woman, this organ weighs around 70 g and is almost completely solid, except for a small cavity of just under 10 mL. At the end of gestation, the volume of the uterus is around 5 L. It reaches a capacity 500–1000 times greater than its pregestational state, managing to weigh close to 1100 g [13]. This increase in size is due to hypertrophy (there is also some hyperplasia early in pregnancy, thanks to the increased vascularization of the myometrium [9] of smooth muscle cells, accumulation of fibrous tissue, and the increase in elastic tissue, which then explains the thinness of the uterine walls) [13]. The main stimulus in this growth process is hormonal, and comes from the action of gestational estrogens (some growth factors have been identified: e.g., IGF-1) that interact with the estrogens promoting uterine growth [9] during the first week [13].

To carry out the uterine growth, it is necessary for the uterine blood flow to increase concomitantly. Estrogen causes the vasodilation necessary to achieve this increased flow [13]. The role of estrogens decreases from week 12 onward,

where changes occur thanks to the action of progesterone and increased synthesis of polyamines [12]. It is also from week 12, when the uterus becomes large enough to start displacing adjacent organs [13]. As the gestation progresses (from week 22–24), the marked effect of the distension of the uterine fibers becomes relevant in the increase in uterine size. The fibers are stretched and distributed in bundles from the fundus to the cervix, a configuration that will be essential when the time of delivery arrives [12].

The myometrium, therefore, thins as pregnancy progresses (2- to 3-cm thick in early stages) [9], making it possible to reach the moment of delivery with a few millimeters thick [12].

The uterine isthmus (lower uterine segment) also undergoes a period of gradual changes [10]. The evolution consists of an initial hypertrophy accompanying that of the uterine body during the first trimester, reaching triple its length to approximately 3 cm. From the second trimester, the wall of the isthmus is equal to that of the body in thickness, and its union is externally blurred. This condition lasts until the middle of the third trimester, when the lower uterine segment becomes thinner (it diminishes its vascularization and contractile capacity) considerably less than 1 cm thick (it acquires distensibility and allows the fetus to descend at the end of gestation). Despite the progressive thinning of the myometrial, in this transition zone, it remains thickened. This musculature constitutes the main contractile portion of the uterus, which will generate the external forces during labor [9].

It is worth remembering the marked hypertrophy suffered by the uterine artery in pregnancy, which defines its dominance with respect to the vaginal and ovarian artery in uterine vascularization [9]. Furthermore, the uterine vessels supply the placenta, and the increased flow they acquire is essential for its function [13].

In the physical examination of the pregnant woman, it is relevant to know that the uterus generally emerges from the pelvis from the 15th week of gestation and can be palpated in the maternal womb just above the pubic symphysis. By week 20, the fundus is at the level of the navel and reaches the xiphoid appendix by week 36 [9]. Finally, after delivery, through a catabolism process, the uterus rapidly decreases in size from approximately 1 kg to approximately 100–200 g after 3 weeks [10]. In the myometrium, the edema disappears, the hypertrophied fibers regain normal length and thickness, and most of the preformed fibers disappear, which are replaced by fibrous tissue [12]. The return to its pregestational basal size usually takes 6–8 weeks [8].

The function of the cervix is to retain the fetus inside the uterus during pregnancy and facilitate its expulsion at the end of it [9]. The cervix is made up of connective tissue rich in collagen, smooth muscle, and cervical glands as mentioned in previous sections. The influence of estrogens increases vascularization, edema, hypertrophy, and hyperplasia of the cervical glands, with the consequent increase in secretion [6]. This secretion, thickening as the pregnancy progresses, ends up occluding the entire cervical canal, generating a mucous plug that is expelled prior to delivery [12].

The mentioned hypervascularization gives the cervical tissue a dark or bluish appearance, and a soft appearance [11].

Frequently, the friable surface of the cervix during pregnancy produces minor episodes of bleeding with minimal trauma, which can frighten pregnant women. This trait should be explained beforehand, in order to avoid stressful situations in patients. Similarly, due to the characteristic gestational tisular fragility, it is recommended to perform a Pap test or Pap test before pregnancy, since it has the same appearance as atypical glandular cells [6].

As a result of high estrogen levels, the endocervical mucosa is evolved (proliferation of endocervical glands gives the cervix a red and "bleeding" appearance with a friable surface—Arias Stella reaction [4]) on the exposed surface of the cervix. It is a metaplasia process in which the reserve cells are programmed to generate mucous cells, rather than squamous cells [11]. These new cells are capable of producing a large amount of mucus, which, together with the action

of progesterone, creates an immunological and anti-infective barrier thanks to the cytokines and immunoglobulins it contains [4].

This characteristic eversion suffered by the cervix is not only due to hormonal action, but also due to other factors such as the decrease of the connective tissue (this would allow the muscle fibers to push the endocervical tissue outward) and enzymatic and biochemical modifications at this level . That would prepare the cervix for delivery [12].

As a whole and through gestation, the cervix undergoes a reversible transformation, from a closed, rigid, and noncompliant structure (responsible for maintaining a pregnancy) to a light distensible tissue ring (capable of expanding to allow the fetus to pass through this way). It is hormonal control that generates the changes in the structure of collagen and glycosaminoglycans, which contribute to the final successful softening and dilation of the cervix [14].

Finally, after delivery, the uterine cervix returns to normal early (its diameter decreases to 1 cm of dilation in the first week [8]) provided it has not suffered any significant trauma [12]. It loses elasticity, recovers its pregestational firmness, decreases vascularization, and returns to its normal shape. At the same time, a squamous metaplasia process begins that eliminates the eversion zone, allowing a complete and reliable study 4–6 weeks after delivery, if it was vaginal, or even earlier if it was by cesarean section [12].

The ovaries can double in size during pregnancy and decrease significantly after menopause. With the expansion of the uterus, the ovaries and uterine tubes (the Fallopian tubes suffer slight hypertrophy during pregnancy but are not affected by a general increase in size [13]) move up and laterally [9]. Hypertrophy and verticalization of the round ligaments occur. Wide ligaments tend to open outward to accommodate the large size of the uterus and ovarian vessels. Uterine veins increase in diameter in the same way and appear to act as a blood reservoir during uterine contractions near delivery [9].

Due to hormonal mechanisms, the maturation of the new follicles is suspended. The corpus luteum, which maintains pregnancy until 6–7 weeks and produces progesterone, disappears at that time. For this reason, surgical interventions at the ovary level before these weeks can cause an abortion [13]. In addition to the expected increase in size of the ovaries during pregnancy, solid tumor-like images (luteoma), corresponding to an exaggerated Juteinic reaction that can persist until natural delivery. All these modifications disappear spontaneously during pregnancy or after delivery [12].

31.4 Conclusion

The anatomical knowledge of the female genital region, both its external organs (mount of Venus, the labia majora, labia minora, vestibule, clitoris, vulvovaginal glands, and the perineum) and internal organs (uterus, cervix, vagina, ovaries and uterine tubes), is essential for a proper approach and management of patients with pathology associated with these locations. In addition, these organs undergo marked anatomical and functional changes during pregnancy and postpartum, the study of which is important to adapt clinical management to new circumstances. Although it is true that many of these anatomical modifications that occur are transient, and the different organs recover their previous basal state to a great extent, there are certain regions that can be irreversibly affected during pregnancy. Those are the circumstances where a surgical modification (e.g., labiaplasty) of the consequences of pregnancy can be tremendously beneficial for patients, both sexually and psychologically. That is why an adequate anatomical knowledge of the structures modified during pregnancy greatly favors the possibility of obtaining a good aesthetic and functional result with surgery.

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Lasers, Radiofrequency and Fillers

32

Alexander Bader

32.1 Introduction

32.1.1 Histology

The Vaginal wall is structured of four layers:

1. Superficial layer of stratified squamous epithelium
2. Subepithelial dense connective tissue layer (composed primarily of collagen and elastin)
3. Smooth muscles layer (muscularis)
4. Adventitia (composed of loose connective tissue).

Vaginal subepithelium and muscularis together form a fibromuscular layer beneath the vaginal epithelium, providing longitudinal and central support.

The connective tissue underlying the vagina contains relatively few cells: mainly fibroblasts producing components of extracellular matrix (ECM), besides fat cells and mast cells. All elements are embedded in an ECM, composed of fibrillar elements (collagen and elastic fibres) embedded in nonfibrillar viscoelastic matrix/ground substance (proteoglycans, glycoproteins, and hyaluronan). These tissues contain significant amount of smooth muscle cells (with exception of Arcus tendinous Fasciae Pelvis) [2]. The fibrillar component contributes the most to the biomechanical behavior of these tissues in the vaginal wall, and passive tissue strength is given by ECM. Collagen and elastin are the two major ECM components of pelvic floor connective tissues, providing resistance to stretching and other tensile forces, and elasticity and resilience to the tissues, respectively, whereas structural glycoproteins create tissue cohesiveness. The ECM of vaginal tissue largely determines its tissue tensile strength and its mechanical stability, and is remodeled and maintained by fibroblasts. It is the delicate balance between production and degradation of ECM proteins in connective tissue that is critical to the pelvic floor integrity [3].

32.1.1.1 Collagen

There are 28 types of collagen. The collagens I, III, and V, present in the vagina, and its supportive tissues are thought to be the principal determinants of soft tissue strength. Collagen I fibers are universally present and are large, high tensile strength fibers and offer strength and great resistance to tension. Collagen III forms smaller fibers of lower tensile strength, are predominant in tissues that require increased flexibility and distension and that are subject to periodic stress, and is the major collagen subtype in vagina [4]. It is the primary collagen subtype in vagina and supportive tissues. Type V collagen forms small fibers of low tensile strength, it is in the vagina and sup-

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© Springer Nature Switzerland AG 2023
M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_32

portive tissue has not been elucidated yet. Type III and V collagen fibers copolymerize with type I collagen to form fibrils with controlled diameters and tensile strength. These fibrils influence the biomechanical characteristics of a given tissue. Higher fiber I/III ratio results in higher tensile strength. An increase in collagen III and V decreases the mechanical strength of connective tissue by decreasing fiber size [5]. Cross-linking of tropoelastin and procollagen to form mature functional collagen and elastin fibres is by Lysyl oxidase (LOX) family of enzymes [6].

Mature, slowly metabolizing collagen is susceptible to nonenzymatic cross-linking, known as glycation/ Maillard reaction. These advanced glycated end-products (AGEs) of collagen accumulate with age. The "overmatured" collagen is stiffer and more fragile [7]. This mechanism is the major cause of substantial dysfunction of collagenous tissues and is responsible for complications of connective tissues seen at older age.

32.1.1.2 Elastin

Elastin, an insoluble polymer, is formed by assembly of tropo-elastin monomers by lysyl oxidases (LOX). Elastin allows the tissue to stretch and return to its original shape without energy input. In most organs, elastin biosynthesis is limited to a brief period of development. The assembly of elastic fibers is complete by maturity when tropo-elastin synthesis ceases. In undisturbed tissues, elastic fibers produced in the third trimester of fetal life last the rest of life [7]. In the female reproductive tract, however, elastic fiber turnover is continuous. LOX is essential for elastic fiber homeostasis [8]. Fibulin-5 (elastic binding protein crucial for elastic fibre assembly [9]) acts as a bridge between cells and tropo-elastin for effective cross-linking and assembly of tropoelastin into mature elastic fibers. Increased synthesis of tropo-elastin and fibulin-5 may be necessary to counteract for disruption of elastic fibers and to regenerate elastic fibers in the vaginal wall. Synthesis and assembly of elastic fibers are crucial for recovery of pelvic organ support after damage.

The quantity and quality of collagen and elastin are regulated through a precise equilibrium between synthesis, maturation, and degradation, and this process results in a dynamic process of constant remodeling that is important for maintaining tissue integrity and tensile strength. They remodel their surrounding matrix in response to mechanical and biochemical stimuli. Precursor collagens and elastin are synthesized by fibroblasts and are then secreted into ECM as raw material of fibril assembly. These mechanosensitive cells produce anabolic proteins such as collagens, and activate catabolic/ proteolytic enzymes, such as Matrix metalloproteinases (MMPs). Degradation depends upon combined activity of MMPs and their regulation of release, activation, or sequestration of growth factors, growth-factor-binding proteins, cell surface receptors, and "cell-to-cell" adhesion molecules [7]. MMPs degrade ECM components (collagen, elastin, proteoglycans, and glycoproteins) and are responsible for loss of strength of fibrous collagen and hence loss of tissue integrity. Activity of MMPs is antagonized by tissue-derived inhibitors of metalloproteinases (TIMPs) [7].

32.1.2 Tissue Remodeling and Clinical Impacts

Pelvic floor defects are visible as a bulge on anterior and/posterior vaginal walls with resultant SUI, incomplete defecation/fecal incontinence, chronic pelvic pain, vaginal relaxation, sexual dysfunction, and social isolation. In some cases, the only complaint may be the appearance.

Factors contributing to development of POP can be divided into genetic and acquired factors. Acquired factors include pregnancy and parity as well as myopathy and neuropathy. Obesity, smoking, pulmonary disease, and constipation are examples of POP-promoting factors. Patients with these risk factors tend to develop POP in a higher frequency with ageing and menopause as superimposing factors [10].

Where pelvic floor muscles are weakened, decrease in pelvic connective tissue resilience—related to age and menopause—may facilitate progression to symptomatic POP. Age is a risk factor for POP. There is a 10% increased risk for each decade of life [11]. The cumulative incidence of primary operation for POP and incontinence increases from 0.1% in age group 20–29 up to 11.1% in age group 70–79 [11]. Among types of POP, cystocele has the greatest incidence [12]. POP is one of the most common reasons for gynacological surgery in women after the fertile period. The failure rate is relatively high: An estimated 30% of women require reoperation [11]. The biomechanical microenvironment may be further compromised if non-resorbable polymeric meshes are used to replace tissue function [13].

32.1.2.1 Genetic Predisposition

Genetic predispositionmay play a role as well. When a mother has POP, the relative risk (RR) for the daughter of developing POP is 3.2. With a sister's positive medical history, this RR is 2.4 [10].

32.1.2.2 Parity

Parity is the strongest factor in development of POP. After an injury such as childbirth, supporting connective tissue of vaginal wall will remodel in order to adapt to the tensile stress. During childbirth, neuromuscular damage occurs. Not only direct injury to levator ani muscle resulting in mechanical disruption, but also damage to nerve supply, **especially pudendal nerve,** can lead to their inability to contract [10]. When pelvic floor muscles relax or are damaged, suspensory ligaments sustain the loads of pelvic organs for short periods of time, connective tissues stretch, and eventually fail if pelvic floor muscles do not close the pelvic floor in time. The increased flexibility and decreased tensile strength associated with an increase in collagen III, together with decrease in elastin levels, likely contribute to progression of POP. Other childbirth-related factors associated with prolapse include high infant birth weight, prolonged second stage of labor, and maternal age less than 25 years at first delivery [10].

32.1.2.3 Pelvic Surgery

Retropubic urethropexy or needle suspension procedures may result in more anterior deviation of anterior vaginal wall, which alters the distribution of force on all vaginal walls. As a result, apex and posterior vaginal wall may become prone to development of support defects, including enterocele or rectocele. Elevated intra-abdominal pressure: In women who are working as laborers/factory workers, and those suffering from chronic constipation, chronic obstructive pulmonary disease, stretch injury to pudendal nerve is common. Increasing body mass index (BMI): Women with BMI >25 kg/m^2 have a three-fold higher risk of having POP compared to nonobese women. Women with joint hypermobility have a significant higher prevalence of POP, connective tissue factor is involved. With Collagen abnormality, women may metabolize collagen such as there is a decrease in type I collagen and an increase in type III collagen [10].

32.1.3 Histological Changes [14]

32.1.3.1 Premenopausal Vaginal Mucosa

Premenopausal vaginal mucosa is characterized by squamous stratified nonkeratinized epithelium and lamina propria protruding into under surface of epithelium, with papillae rich in small blood vessels. The connective tissue is rich in fibrillar and nonfibrillar components (as described above), and in blood vessels, that penetrate as small capillaries inside the papillae, providing metabolic support (nutrients, oxygen, and other molecules) to intermediate and superficial cell layers. The high permeability of the matrix permits easy diffusion of water, ions, nutrients, signaling molecules, through the ECM maintaining tissue hydration. Epithelial cells proliferate from the basal layer, as they differentiate and move

towards the mucosal surface and eventually shed off. Glycogen synthesized by the intermediate cells is stored in the superficial cells from where it is eventually released and utilized by Lactobacilli, maintaining the acidic pH of vagina.

32.1.3.2 Postmenopausal Vaginal Mucosa

Postmenopausal vaginal mucosa is characterized by tissue atrophy, with significant thinning with reduction of epithelial layers, renewal dynamics and absence of superficial cell de-squamation. The epithelium-connective tissue interface effaces smooth due to reduction and/or absence of papillae and blood vessels. There is significant reduction in fibrillar components quantity and quality. Fibroblasts are characterized by smaller cytoplasm. Cells exhibit lower number of organelles, especially the rough endoplasmic reticulum (RER) and Golgi apparatus, both of which are involved in synthesis and turnover of molecular components of ECM.

32.1.4 Role of Energy-Based Devices (EBD) [14]

When absorbed in sufficient amounts, light/thermal energy can induce changes in the skin and muscle matrix. Lasers devices allow for delivery of light to the skin in a controlled manner. The past decade has seen a surge in technological advancements energy-based devices (fractional laser and radiofrequency) that work on vaginal wall to reverse its age-related tissue remodeling. Thermal energy delivered on vaginal wall stimulates neovascularization, and collagen formation, and proliferation of glycogen-enriched epithelium leading to improved natural lubrication and urinary continence.

The wavelengths across the electromagnetic spectrum are differentially absorbed by different tissue chromophores, including hemoglobin, melanin, and water [15]. Distinct physiological characteristics of the target tissue and technical parameters of energy-based devices influence the tissue interactions at cellular level. These include laser wavelength, energy density, pulse duration, spot diameter, tissue absorption, hydration, and oxygenation, blood supply, degree of keratinization, and insulating properties (adipose tissue).

Controlled power of the energy source must be used in vaginal tissue that varies in its water content and cellular component with age, and under hormonal influence, among other factors [15].

32.2 Lasers

32.2.1 Technology Parameters

Wavelength and pulse duration are the most important laser parameters that govern effects of laser light on skin/mucosa. Fluence, irradiance, and spot size are additional laser settings that influence clinical outcomes.

- **Wavelength:** Emitted light determines its depth of penetration into skin/mucosa. Long wavelengths of light penetrate more deeply into tissue than shorter wavelengths. Chromophores absorb light most effectively at different wavelengths. To exert the greatest effect, wavelength should be near the maximum absorption of target chromophore and should be of enough length to penetrate to the depth of target. Because light scattering decreases with increasing wavelength, greater penetration is achieved with longer wavelengths of light. In contrast, high absorption of light by water molecules in epithelium markedly limits the depth of penetration of light emitted from mid-infrared (2940 nm erbium: yttrium aluminium garnet, Er: YAG) and far infrared (10,600 nm carbon dioxide, CO_2) lasers.
- **Pulse duration**: Setting is determined by the thermal relaxation time of the target chromophore.
- **Thermal relaxation time:** It is defined as amount of time it takes temperature of a target to return to the ambient temperature following heating [16]. If an object is heated for a period equal to or shorter than its thermal relaxation time, accumulated heat and resultant damage is confined to target object alone. This selective photothermolysis dramatically reduces

the risk of scarring. For example, the CO_2 laser penetrates skin to a depth of 0.05 mm, and thermal relaxation time of this thickness of tissue is approximately 1 ms [17, 18].

- **Fluence**: Itis a measurement of amount of energy delivered/unit area.
- **Irradiance**: **Power** describes the rate of energy delivery and is measured in J/s (watts). Irradiance relates this measurement to size of the treated area, and describes the rate of energy delivery/unit area (watts/cm^2) [19]. Irradiance is calculated from laser power output and spot size. It is a measurement of intensity of energy delivery. Very high irradiance achieves much faster heating than low irradiance. Decreasing the pulse duration of a laser device without changing the energy results in higher level of irradiance. Slow heating (low irradiance) coagulates tissue, while fast heating (high irradiance) can vaporize tissue.
- **Spot size**: Spot size is the diameter of beam of light emitted that hits tissue's surface. Light delivered through a small spot size is more susceptible to scattering than light delivered through large spot sizes. Larger spot sizes are preferred when targeting structures in the mid or deep dermis. Spot size is less important for superficial targets.

32.2.2 Laser Technology Categories

The three major categories include continuous wave lasers, pulsed lasers, and fractionated lasers.

Continuous: They emit continuous laser beam as long as foot/ finger switch is pressed. Scanning devices are not always effective in preventing cutaneous damage. As a result, continuous wave lasers have been mostly supplanted by pulsed lasers.

Pulsed lasers: Pulsed lasers produce a laser beam that is emitted in short pulses with long period (0.1–1 s) between pulses. Pulsed ablative CO_2 and Er:YAG lasers are used for laser skin resurfacing [17]. They are usually indicated and used for precisely ablating superficial skin lesions while leaving behind a very narrow zone of thermal damage.

Fractionated lasers (Fig. 32.1): Fractional photothermolysis most commonly are used for skin resurfacing and the treatment of scars [20, 21]. They are divided into nonablative and ablative Lasers.

- **Nonablative fractionated** lasers, thermally, coagulate narrow vertical columns of epidermis and variable portions of dermis. This is

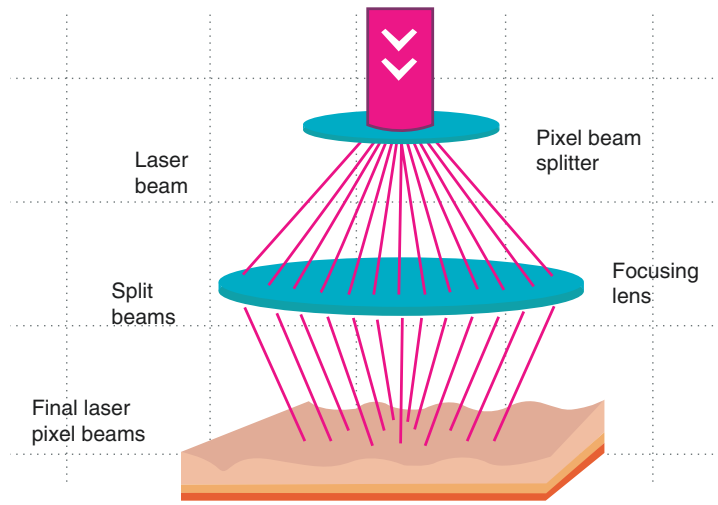

Fig. 32.1 Laser beam fractionated by holographic lens, printing 9 × 9 (81 microbeams) on 1 × 1 cm. (Courtesy: Alma Lasers)

Figure A: CO_2 laser energy is delivered to the vaginal tissue using a pixel pattern, promoting faster healing and vaginal wall rejuvenation.

achieved with near infrared lasers (1320, 1440, 1540, 1550, and 1927 nm). These lasers emit light that is absorbed by water in skin to a lesser extent than light from mid and far infrared lasers, which are used for fractional ablation. Following treatment, thermally coagulated epidermis is rapidly sloughed off and reepithelialization is completed within 2–3 days. The thermally coagulated dermis is gradually replaced with new collagen deposition and collagen remodeling. A series of treatments usually is necessary to gradually remodel the entire skin surface.

- **Ablative fractionated** laser-delivery creates ablative MTZs in skin that extend into the dermis. This is achieved with mid infrared (2940 or 2790 nm) and far infrared (10,600 nm) lasers, which emit light that is strongly absorbed by water [22, 23]. A zone of thermally coagulated tissue also occurs around the ablated zone. With Er:YAG (2940 nm) laser, peripheral coagulated zone is very narrow, which accounts for frequent appearance of pinpoint bleeding during treatment. The CO_2 (10,600 nm) laser yields a thicker coagulated zone, which reduces bleeding. Reepithelialization usually occurs around 4 days after treatment with fractionated Er:YAG laser and after about 7 days following fractionated CO_2 laser therapy. This relatively short time course to reepithelialization is an advantage over traditional laser resurfacing with pulsed CO_2 or Er:YAG lasers, which requires a healing period of around 7–10 days.

32.2.3 Clinical Applications in Vaginal Conditions

Indications

- Vaginal dryness, burning/itching
- Loss of elasticity and tone (laxity/ vaginal relaxation syndrome)
- Urinary incontinence
- Thrush & bladder infections
- Painful intercourse
- Vaginal/vulva pain
- Mild Prolapse
- Reduced sensitivity & sexual arousal
- Lichen Sclerosus
- Vulval skin resurfacing for scars, tissue laxity or skin rejuvenation

32.2.4 Vaginal Atrophy

For the treatment of Vaginal Atrophy, Laser Vaginal application focuses on restoring functionality by reversing the age/mechanical stress related vaginal remodeling that results in vaginal laxity. Surgical techniques for vaginal tightening aim to modify the caliber of the vaginal canal but do not alter the quality of vaginal mucosa and/or its functionality. Microablative fractional lasers, RF, induce superficial tissue shrinkage as well as deep stimulation of ECM layer of submucosa [24–27]. Histologically evident alterations in postmenopausal atrophic vaginal mucosa following fractional CO_2 laser treatment have provided an understanding of the underlying molecular mechanisms responsible for tissue remodeling [28–30]. Neocollagenesis, production of ground substance components within ECM, and glycogen and acidic mucins within epithelium and on epithelial surface, transform the mucosa from an atrophic state to a healthy premenopausal state [30].

32.2.4.1 Mucosal Responses Following Fractional Laser Treatment

Following fractional CO_2 laser treatment stratified squamous epithelium is thicker and comprised of 20–40 cell layers that provide cells for differentiation and superficial shedding. Basal layer cells are closely packed and appear stratified. Increased papillary projections with blood capillaries (Fig. 32.2), of basal layer, protruding into the surface of epithelium with indentations are seen. Intermediate layer cells appear enlarged, with nucleus surrounded by a wide cytoplasm rich in glycogen. Shedding of superficial epithelial cells with exposure to glycogen into the vaginal lumen is seen. The Lactobacilli vaginalis dependent on glycogen from shedding of superficial epithelial cells, acidify the vaginal transudate

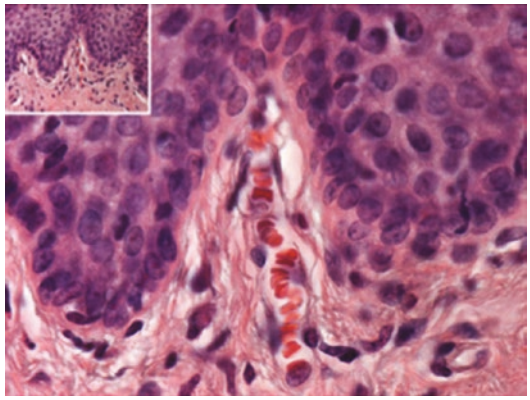

Fig. 32.2 Common feature following treatment. At the center of the figure, a papilla with a small and long vessel inside is easily identifiable due to its erythrocyte content and the thin endothelial profiles. In the insert, numerous newly formed papillae following treatment are recognizable. H&E staining. (Courtesy: Calligaro A)

at mucosal surface, and restore the vaginal pH to acidic premenopausal state, preventing colonization of pathogens [31, 32]. Increased vascularity (capillaries penetrating newly formed papillae underneath the epithelium) in connective tissue supports the renewed activity of fibroblasts and provides the metabolic support for epithelial cell proliferation and differentiation (Fig. 32.3). The macroscopic imaging of the vaginal wall shows fractionated (Fig. 32.4) without any damage or bleeding. The long term efficacy is also visible macroscopically with the quality of the vaginal tissue to show improved in terms of vascularization, rogation and secretion (Fig. 32.5).

32.2.4.2 Biomolecular Effects of EBD Application on Vaginal Mucosa

- Stimulation of connective tissue remodeling by fibroblasts has been correlated with activation of **heat shock proteins (HSPs)** response persisting at least 3 months following treatment [33]. The HSP gets activated and other growth factors come into play to induce type 1 versus type 3 collagen. The HSP47 in RER plays an important role in early stages of post-treatment collagen biosynthesis [34–39].
- Acute inflammation is largely an expression of innate immunity, which involves induction

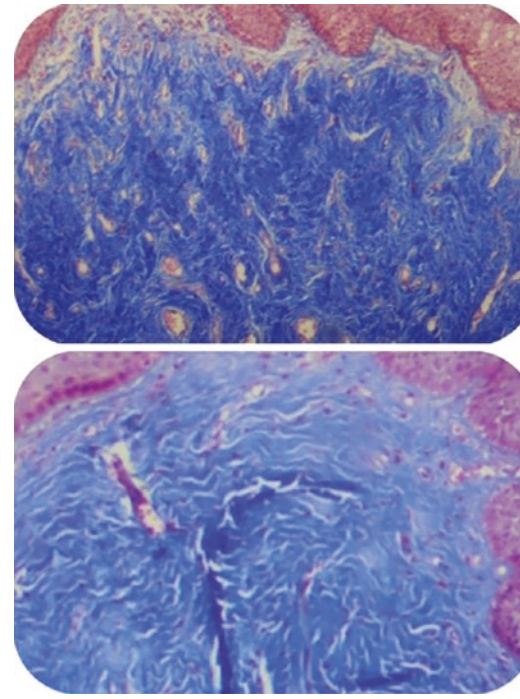

Fig. 32.3 Histological picture showing the improvement in the collagen quality 6 months after CO_2 Laser Fractional application in a patient with vaginal atrophy (Courtesy of Dr. Jorge Elias)

Fig. 32.4 Fractional CO_2 Laser application to the upper vaginal wall. This picture was taken immediately after the application

of cytokines, chemokines, and antimicrobial peptides that stimulate influx and activation of monocytes and neutrophils. Local increase in different **cytokines**, particularly TGF-b (stimulating collagen), basic fibroblast growth factor (bFGF; stimulates angiogenetic activity with endothelial cell migration and proliferation), epidermal growth factor (EGF; stimu-

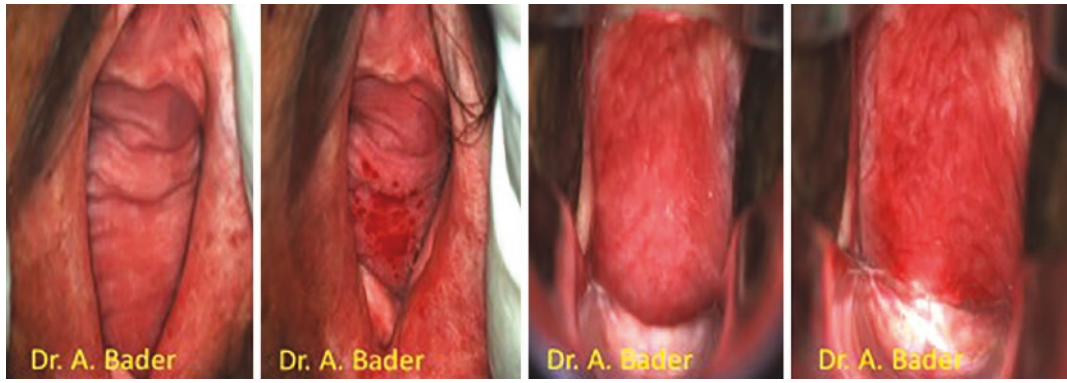

Fig. 32.5 The efficacy of Fractional CO_2 Laser applied on atrophic anterior vaginal wall. The serial of the pictures shows the vaginal tissue before the application (1), immediately after the application (2), three months after application, (3) and six months after the application (4)

lates re-epithelization), PDGF (stimulates fibroblasts to produce ECM components), TNF-a, and vascular endothelial growth factor (VEGF; regulates vasculogenesis and angiogenesis) is seen. Their expression is initiated in the suprabasal layers of epithelium (glycogen synthesis) and in connective tissue with stimulation of fibroblast activity and formation of new vessels [40].

After inflammatory phase of wound healing, dermal fibroblasts produce new ECM, primarily composed of type I and type III collagen fibrils. Fractionated laser treatment significantly induces type I procollagen mRNA and protein. Significant induction of type I and type III procollagen mRNA is observed at 2 weeks and remains high for at least 5 weeks after treatment. Average peak induction after with fractionated CO_2 laser is 8.4-fold [40]. In addition, tissue wound repair involves increased **vascularization**. Fractionated CO_2 laser treatment increases density of CD31-positive vessels **endothelial cells** at 3 and 5 weeks after laser treatment [40].

Long pulse, nonablative modes have been evaluated for their ability to induce deep thermal effects on vaginal mucosa. Deep coagulation by **stacking repetitive Er:YAG laser** pulses on the same tissue site has been described [41]. This mode generates a thermal change in deeper layers, with only minor superficial ablation (5 μm) on surface, but with enough caloric effect to thermally alter the chromophore. Using a **large spot size** (>5 mm), heating can be achieved and with repetition of exposures (stacking), this deepens the heat effect in lamina propria to a depth of at least 500–1000 μm (depending on degree of tissue hydration), inflicting the "Joule effect" (photothermal and thermochemical effect) on vaginal mucosa. With local rise in temperature, bradykinin and histamine are released with relaxation of precapillary arteriolar sphincters, and vasodilation, an effect called "Phenomenon of Thermal Reperfusion" [41–43].

32.2.5 Stress Urinary Incontinence (SUI)

Urethral support can be improved by inducing thermal effects on suburethral tissue using energy-based devices. Numerous studies [44–50] confirm improvement in urinary control following treatment with Er:YAG laser, CO_2 laser, and RF all of which trigger a photo-thermal effect, as deep as 0.5 mm inside the anterior vaginal wall, and results in 30% reduction in tissue volume. The thermally induced neocollagenases improve thickness, elasticity, and firmness of the vaginal wall, and act locally at the suburethral plexus level [45, 46].

32.2.6 Laser Tightening for Vulvar Laxity [51]

As with any other aging human tissue, the natural course of labia majora often involves tissue atrophy and poor circulation, that is associated with loss of hormonal support, or following pregnancy, delivery and significant weight loss in younger women with resultant loss of labia volume, flaccidity and ptosis. On the other hand, protuberant labia majora can lead to functional difficulties in sexual stimulation and satisfaction, complicate hygiene maintenance, influence choice of undergarments and sport-wear and negatively impact self-confidence and self-image. Severe skin laxity is often best managed with interventions such as injectable cosmetic fillers and surgery. Surgical Labia Majora Plasty may be associated with nerve ending damage, significant anatomical deformities, scarring and hair growth toward the vaginal entrance, which can further exacerbate patient discomfort and dissatisfaction. As an alternative to surgery, dermal rejuvenation of lax labia majora using EBD is preferred with the use either of fractional laser, or RF that deliver heat gently and cause tissue remodelling by neo-collagenases [51].

Procedure: A topical anesthetic cream to be applied for 15–20 min prior to the application. A thin layer of oil is applied over the target area. The device probe is then moved over the skin in circular movements ensuring the temperature does not exceed 42 °C (as indicated by the device monitor) for more than 5 s. The human tissue is tolerant of temperatures up to 45 °C. Beyond these levels, irreversible reduction in cell viability occurs. Rehydration cream is applied immediately after the treatment and continued for 5 days. Patient tolerates the procedure well with no downtime. Results may be visible immediately after the session, but continuous improvement over the 3–6 months following treatment is seen (Figs. 32.6 and 32.7), which is the estimated time for new collagen regeneration [52]. Follow-up after 6 months is advised. A maintenance treatment session every year is recommended.

Fig. 32.6 Labia Majora Skin tightening using ablative De-Focused CO_2 Laser tip. The results usually are remarkable

Fig. 32.7 Labia Majora Skin tightening using ablative De-Focused CO_2 Laser tip. The results usually are remarkable after one session. The technique frequently would improve also the perineal body skin with important impact for functional enhancement alongside with the aesthetic aspect

32.3 Radiofrequency for Vaginal Rejuvenation

Radiofrequency devices that emit focused electromagnetic waves are used in clinical medicine to generate heat to the underlying connective tissue of the vaginal wall. These energy-based devices induce immediate contraction of collagen, induce new collagen and elastin formation/production, increase growth factor infiltration, neocollagenesis, vascularization, increased vaginal transudate, and increased small nerve fiber density.

With the interactions between radiofrequency and tissue, the heat generated in the dermis reaches a thermal dose threshold, above which the collagen begins to denature (60 °C) and to denature completely (70–75 °C) [1]. Partial denaturation of collagen by RF is maximal at 67 °C and correlates with optimal neocollagenesis and clinical effects in the tissue. Temperature at 40–45 °C induces production of collagen by fibroblasts and is effective in skin tightening [53]. However, surface temperatures of the skin exceeding 45 °C have been correlated with pain and thermal burns during and after RF treatment [54]. No thermal burns have been reported in vaginal tissue treated with RF up to 47 °C; however, burns and blisters have been seen at approximately 55 °C. Temperature is controlled by using a dedicated software (Alinsod R. Personal communication).

In 2010, Mollheiser et al. [25] reported on the first pilot study using nonsurgical RF treatment to subjectively improve the vaginal tightness. In 2012, Sekiguchi et al. [55], from the Women's Clinic LUNA, in Japan reported on a second series of 30 patients treated with RF for vaginal restoration. Both Millheiser et al. [25] and Sekiguchi et al. reported on women who had delivered vaginally and had loss of sensation [55]. Mollheiser et al. [25] used sheep vagina as an animal model system and showed that temporal changes of collagen tissue remodeling in the sheep vagina reflected a possible mechanism to explain the human subjects' perceptions of increased vaginal tightness, in 1–6 months period of RF treatment. They further reported that over

the period of 6 months after RF treatment, sexual function scores improved in their study sample of women, and their level of personal distress decreased significantly, with Malay version of Female Sexual Function Index (FSFI) scores higher than 15 [55, 56]. Alinsod [56] Performed a pilot study in a similar manner with RF on 23 patients. The study was performed in 2015 on patients from 26 to 58 years old with vulvovaginal laxity and 6 out of 23 subjects were lost to follow-up before each of the second and third treatments could be performed. They reported that they were highly satisfied with the results and didn't need any further treatment. The rest completed the second and third treatments. No burns, no blisters, or major complications occurred during or after treatments [57].

32.3.1 Classification of RF Technology

- Monopolar RF (Fig. 32.8)
- Bipolar RF (Fig. 32.9)

The configuration of electrodes in RF devices can be monopolar, bipolar, or tripolar, all of which have been used for cutaneous applications. In a monopolar system, which has been employed for vaginal applications, the electrical current passes through a single electrode in the hand piece to a grounding pad [1].

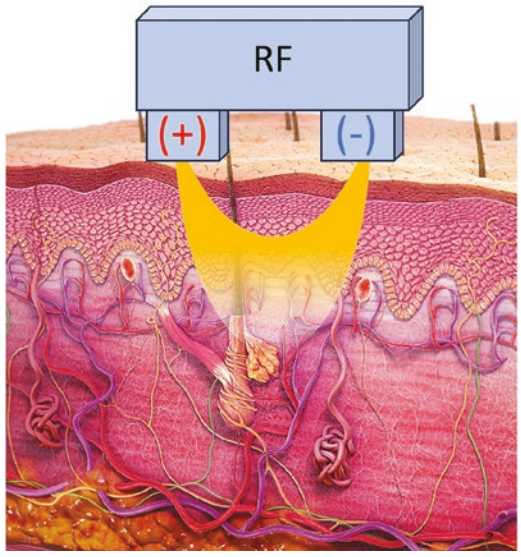

Fig. 32.8 Monopolar RF

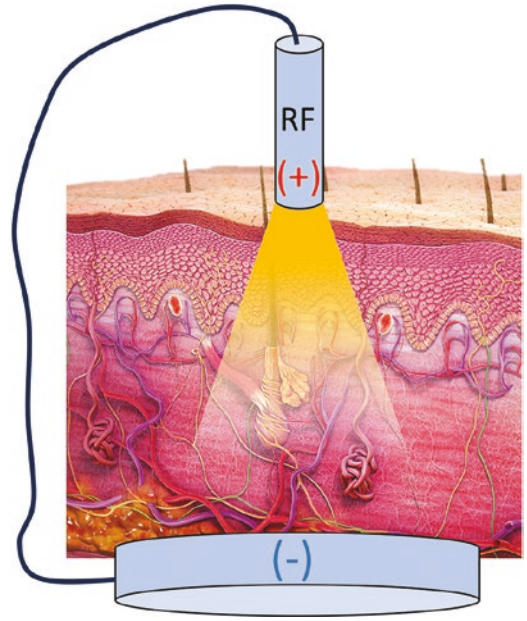

Fig. 32.9 Bipolar RF

32.4 Hylauronic Acid Dermal Fillers

As with any other human tissue, the natural course of the labia majora often involves tissue atrophy, which is mainly a consequence of normal vaginal ageing and associated poor circulation and loss of hormonal support, or of pregnancy, delivery, and significant weight loss in younger women.

Atrophy of the tissues in this area manifests by loss of labia volume, flaccidity, and ptosis. Protuberant labia majora can lead to functional difficulties in sexual stimulation and satisfaction, complicate hygiene maintenance, influence choice of undergarments and swimsuits, and negatively impact self-confidence and self-image. These aesthetic, psychological, and/or functional effects often drive women to seek labiaplasty solutions.

Labia Majora Plasty can be approached via radical and invasive procedures, in which part of the labia majora skin is surgically removed, while the remaining tissue is lifted and stretched. Yet, these techniques are associated with clinical sequelae, such as nerve ending damage, significant anatomical deformities, scarring, and hair growth toward the vaginal entrance, which can further exacerbate patient discomfort and dissatisfaction. Another option could be the fat transfer to Labia Majora. This surgical procedure may need general anesthesia and may lead to other complications in the donor site; hence, it is beneficial for the patient.

A less invasive approach sounds ideal solution especially if the results are with similar quality of fat transfer but with the benefit of having an office procedure without the need of admission or anesthesia. This approach could even be better if we consider using high quality of filling material with consistency and a density which will be able to restore the shape of the Majora. Hyaluronic Acid (HA) sounds as an ideal material for such purpose. The specifications of the Hyaluronic Acid (HA) would play the most important role for the final aesthetic outcome but also the longevity of the results.

Lately, there has been an increased demand of patients requesting improvements in body contouring with safe and minimally invasive procedures [58].

External female genitalia lose elasticity and volume with age. The thickness of the vulvar epithelium reaches its peak during reproductive years and decreases with age. Indeed, the thickness of the whole epithelium is influenced by estrogens, which induce nuclear modifications among the superficial epithelial cells during each menstrual cycle. Thus, macroscopically, the labia majora decrease their volume and tone and change their coloration, because vascularization rapidly decreases after menopause. Following the loss of follicular activity, the external genitalia lose subcutaneous fat, while connective tissue relaxes and becomes less elastic; this is associated with pain during sexual intercourse [59–62].

Soft tissue fillers reduce contour defects through replacement of tissue volume lost due to aging, trauma, or other events. Soft-tissue fillers can be used alone or in combination with other aesthetic procedures. Dermal fillers (injectable implants/soft tissue fillers) are medical device implants injected/ placed into dermis for increasing the tissue volume. A wide variety are available, including biodegradable products (hyaluronic acid, collagen, calcium hydroxyapatite, and poly-L-lactic acid), products that remain indefinitely in tissue (polymethylmethacrylate microspheres, hydrogel polymers, and silicone), and viable autologous fat. As opposed to permanent fillers, which persist indefinitely, temporary fillers are eventually resorbed by the body. Some agents, such as injectable collagen and hyaluronic acids, function primarily through a volume-filling effect. Others, including calcium hydroxyapatite and poly-L-lactic acid fillers, act as scaffolds for endogenous collagen formation.

Hyaluronic Acid (HA) is a substantial component of the ECM (extra cellular matrix) of the skin, it is the basic substance where cells can proliferate, differentiate and migrate, and has direct and indirect effects on the cell matrix as well as on cell to cell interactions. With aging, it is frequent the occurrence of defects of the matrix metalloproteinases 1 that cause proteolytic cleavage of dermal collagen and reduce the synthesis of HA; those alterations result in a modified dermal morphology with reduced turgor pressure within the tissue [63].

Hyaluronic acid, a naturally occurring glycosaminoglycan, is an essential component of extracellular matrix of dermis. It plays a key role in maintenance of skin structure and function, and its high water-binding capacity is of value for maintenance of moisture in skin. The clinical effects of treatment typically persist for 6–12 months [64]. Naturally occurring or uncross-linked hyaluronic acid is degraded in skin within a few days. Therefore, most preparations are altered through cross-lining that allows the molecule to resist rapid degradation by hyaluronidase and other factors in the skin. The amount of uncross-linked (soluble) and cross-linked (insoluble) hyaluronic acid in a gel influences gel viscosity. Decreasing proportion of cross-linked contributes to less viscous product and smoother flow during injection, reduces

hardness of gel, but may contribute to a shorter duration of effect. Stimulation of collagen synthesis may contribute to treatment efficacy as mechanical tension on fibroblasts, is associated with regulation of collagen synthesis, and may contribute to clinical effect of filler [65].

32.4.1 Anatomy Related to Fillers

The labia majora (Figs. 32.10 and 32.11) are two prominent longitudinal cutaneous folds that extend from the mons pubis to the perineum. Anteriorly, they are joined forming the anterior labial commissure, located just above the clitoral hood, and posteriorly they form the posterior labial commissure, located approximately 2 cm from the anus. The labia are thicker anteriorly. They have connective tissue and subcutaneous adipose tissue intermixed with smooth muscles resembling the scrotal dartos muscle [66].

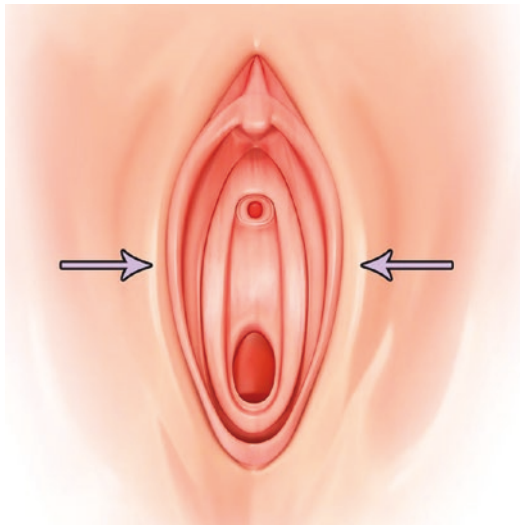

Fig. 32.10 Labia Majora

Fig. 32.11 Labia Majora and Pudendal cleft

The labia majora constitute the lateral boundaries of the pudendal cleft, which contains the labia minora, interlabial sulci, clitoral hood, clitoral glans, frenulum clitoridis, the Hart's Line, and the vulvar vestibule, which contains the external openings of the urethra and the vagina. Each labium majus has two surfaces, an outer, pigmented and covered with strong, pubic hair; and an inner, smooth and beset with large sebaceous follicles. The labia majora are covered with squamous epithelium. Between the two, there is a considerable quantity of areolar tissue, fat, and a tissue resembling the dartos tunic of the scrotum, besides vessels, nerves, and glands. The labia majora are thicker in front and form the **anterior labial commissure** where they meet below the mons pubis. Posteriorly, they are not really joined, but appear to become lost in the neighboring integument, ending close to, and nearly parallel to, each other. Together with the connecting skin between them, they form another commissure the **posterior labial commissure** which is also the posterior boundary of the pudendum. The interval between the posterior commissure and the anus, from 2.5 to 3 cm. in length, constitutes the perineum. The anterior region of the perineum is known as the urogenital triangle which separates it from the anal region. Between the labia majora and the inner thighs are the **labiocrural folds**. Between the labia majora and labia minora are the interlabial sulci. Labia majora atrophy after menopause.

32.4.2 Application of HA in Labia Majora

After skin preparation with an antiseptic solution, the infiltrations of hyaluronic acid fillers in this

Fig. 32.12 Labia Majora Augmentation by Hyaluronic Acid. The material was injected with linear technique following the normal anatomy of the area. The improvement of the perineal body is remarkable

region should be placed between the lip dartos and the fibrous tunic containing the adipose body of labia majora. The vulva is supplied by the anterior labial arteries, branches of external pudendal arteries, posterior labial arteries, and branches of the internal pudendal arteries. An adequate knowledge of their localization is fundamental to avoid intraluminal infiltration with potential severe complications, such as vascular occlusion or embolization.

The procedure involves administering HA filler to the subcutaneous tissue of the labia majora through an injection using a small-diameter cannula. Proper instruments are essential, as only a blunt-tip cannula reduces the risk of inadvertently injuring the tissue or blood vessels and helps prevent further complications. It is also essential to determine the location of blood vessels and nerves supplying the vulva prior to treatment. They are located within the lower pole of the labia majora, so caution is advised when the first injection is done at the lower pole.

The first step involves a thorough decontamination and anesthetizing of the area to be injected. Local anesthesia is used with approximately 5 mL of 2% lidocaine administered along the labia in a single injection. It is repeated in the same manner on both labia. First, a 16G needle is used to access the labia. Then, the 18G cannula is used to administer the filler to the upper pole of the labia. A linear, downward application mode should be followed. It is important to administrate the product in the whole length of the Labia Majora, but the most important and in order to create a natural shape (Fig. 32.12) is to divide this as one-fourth of the syringe at the top pole, two-fourths in the middle, and one-fourth at the lower pole. In order to achieve tissue augmentation or labial contour enhancement, a very superficial subcutaneous injection is performed. In order to correct tissue volume, the filler should be administered slightly deeper (Fig. 32.13). The depth of injection plays an important role, as accessing too deep structures may result in administering the filler to the adipose tissue, thus losing its effect [67].

32.4.3 Adverse Effects

Most frequent adverse effects associated with hyaluronic acid filling agents are transient and mild, and include pain, bruising, oedema, and erythema at injection site. Fan-like needle use, rapid injection (>0.3 mL/min), and high-volume injections have been associated with increased

Fig. 32.13 Labia Majora Augmentation by Hyaluronic Acid. The material was injected with linear technique following the normal anatomy of the area. The improvement of the volume is remarkable due to deep administration of the product

rates of adverse effects. Noninflammatory nodules/bluish discoloration of skin can occur when injections are placed too superficially. Delayed hypersensitivity and granulomatous reactions to hyaluronic acid filling agents are rare—0.02% of treatments. Delayed reactions typically manifest as inflammatory papules/ nodules that appear weeks to months after injection. Complications such as bacterial and mycobacterial infections/ vascular occlusion resulting in tissue necrosis are also uncommon [73].

32.4.4 Reversal [73]

Misplacement/excessive injection of hyaluronic acid fillers can be treated with injection of hyaluronidase. It is well tolerated; local injection site reactions occur infrequently, and urticaria, angioedema, or anaphylaxis rarely occur. Due to potential for anaphylaxis, patients should be tested to evaluate for immediate hypersensitivity reactions prior to injection. Optimum dosing of hyaluronidase has not been established; doses range from <5 to 75 units/injection site. Doses of 10 units are effective. Hyaluronidase can also be used in filler-induced granulomatous reactions, in failed improvement with intralesional and topical corticosteroids, and with hyaluronic acid embolic event.

32.5 Conclusion

The use of energy-based devices for vaginal laxity treatment, such as minimally ablative fractional laser and radiofrequency, is currently gaining popularity in the community and momentum in the medical field. The idea that nonsurgical treatment using energy devices can increase moisture is difficult to be accepted without understanding the cause and a plausible mechanism of action of treatment to support it.

Treatments using minimally ablative fractional laser are based on photothermolysis, creating many microscopic areas of necrosis within the treated tissue, inducing wound-healing with subsequent new collagen and elastin fiber formation [77–79]. Treatment using radio frequency devices also aims to induce neocollagenesis, by fibroblastic activation and also induces vascularization, which restores elasticity and moisture levels at the vaginal mucosa [58].

Positioning of these energy-based devices for the treatment of vaginal laxity, defining the ideal patient profile, requires further research. Three studies on both minimally ablative fractional laser [37, 38, 82] and radiofrequency [33, 63, 64, 83] have mostly included patients with mild to moderate primary or secondary vulvovaginal laxity and associated secondary medical or sexual conditions (orgasmic dysfunction, stress incontinence, atrophic vaginitis).

Regarding clinical efficacy, minimally ablative fractional laser has been shown in multiple case series, to improve the condition of Vaginal tissues and symptoms of vulvar and vaginal atrophy as well as urinary incontinence [32, 38, 76, 84]. Following radiofrequency treatment, an increase in collagen production as well as improvement of maturation index, deepening of rete pegs and thickening of stroma was shown together with clinical benefits such as a 70% improvement rate in stress incontinence symptoms [58].

Although the number and quality of the studies using minimally ablative fractional laser and radiofrequency devices is growing, clinical randomized, sham-controlled evidence is sparse; with only one large, randomized, sham-controlled, multicenter study using the CMRF therapy. Further data are forthcoming, such as an ongoing trial comparing laser treatment to minimally absorbed local vaginal estrogen. Ongoing research should involve standardized validated instruments to assess patient's complaints and outcomes [82].

Energy-based devices are increasingly applied to improve function and aesthetic vaginal health. Although the clinical evidence base is increasing, the use of energy-based devices for feminine genital rejuvenation of mild and moderate conditions seems an attractive, effective and safe option which can be add to the toolkit of many health care professionals who are currently delivering medical aesthetic/functional treatments [82]. However, randomized controlled trials (RCT), peer-reviewed publications, meta-analyses, and other objective evaluations all aim to protect patients from a medical procedure that has not been adequately tested and proven safe and effective. This review, drafted by a large group of experts may lack some of the above-mentioned "protective tools," but we hope that it offers relevant collective information to define directions for future research.

Declaration of Conflicting Interests The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this chapter.

Ethical Approval The authors confirm that the necessary written, informed consent was obtained from patients for this chapter.

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Labiaplasty and Clitoral Hood Reduction

33

André Gonçalves de Freitas Colaneri

Take-Home Points

- The hypertrophy of the labia minora generates physical and mainly psychological discomfort.
- Labiaplasty techniques have a high degree of satisfaction and low risk of complications.
- At least 1 cm of the labia minora should be kept in any labiaplasty technique to avoid complications.

33.1 Introduction

The widespread exposure of the nude body on television, the Internet, magazines, and other media together with the practice of intimate waxing have increased women's awareness of their genital anatomy and led to comparisons between self and others [1–5], with the resulting development of an aesthetic ideal; all these have increased the interest for labiaplasty.

When the labia minora protrude outside the labia majora and become exposed, the vulva presents a flacid and rugged appearance, which can be upsetting and embarrassing to many women [6].

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Enlarged labia minora or nymphae is most often a genetic condition [3, 6], but may have other causes, such as stretching by manual pulling or use of equipment, chronic irritation, dermatitis from urinary incontinence, hormonal changes or use of exogenous steroids, sensitivity to topical estrogens, filariosis, and myelodysplasia [6–9].

The feeling of enlarged labia minora is very common after pregnancy. Hormonal changes may contribute to this change. In addition, the labia majora undergo a process of fat resorption usually starting at the age of 35 and accentuated around 40 years of age. Because it is more common nowadays for women to get pregnant after 30 years of age, when they stop having children, they are close to 35. Therefore, the enlarged labia minora combined with the decreased volume of the labia majora result in greater exposure of the nymphae, producing a feeling of increased growth.

In most cases (92.9%), the hypertrophy is bilateral [3] and a certain degree of asymmetry is the rule.

Enlarged nymphae may cause great embarrassment to the patient when she undresses, during sexual intercourse, or when wearing tights that make the volume noticeable. They may also cause discomfort or pain during physical exercises, vaginal penetration, or while wearing tight clothes, in addition to hindering hygiene [3, 8]. In rare cases, the nymphae may be hurt, cause

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_33

chronic inflammation and recurring candidiasis. However, despite these physical complaints, the main reasons why women search for labiaplasty are psychological discomfort and embarrassment, irrespective of physical symptoms [10, 11]. In the vast majority of cases, the complaint comes from the patient, not from her partner. Many women say their partner is not in favor of the surgery, does not bother about or even notice the hypertrophy. The search for the surgery is mainly motivated by the psychological upset and the embarrassment, and the aim is to enhance self-esteem and, as a result, the quality of life.

It is different from other aesthetic plastic surgeries, such as a breast implant or liposuction, where patients share their concerns, doubts, and results with friends; labiaplasty is a solitary procedure. Most patients will tell no one about the surgery—intended or undergone—or they will just tell the closest relative who will stay with them at the hospital. Therefore, discretion is crucial, as well as logistic arrangements that allow the patient to undergo surgery and recover without any help.

Patients usually arrive on their own, and take a cab to leave the hospital 6 h after the end of the surgical procedure. In most cases, the surgery is performed on a Friday and the patient may get back to work on Monday, that is, they miss only one day at work.

Labia minora hypertrophy is the main complaint about genital aesthetics and thus a major driver of increasing awareness about intimate surgery.

Labiaplasty is the most demanded intimate surgery. Its goal is to correct the labia minora hypertrophy, removing excess tissue without interfering with the vaginal protection function of the nymphae or with genital lubrication.

33.2 Labia Minora Hypertrophy Classification

The labia minora's function is to protect the vaginal introitus and help with lubrication. Overresection of the labia may cause dyspareunia, facilitate vaginal infections, and impair lubrication. Therefore, resection should leave at least 1 cm of tissue in the labia minora.

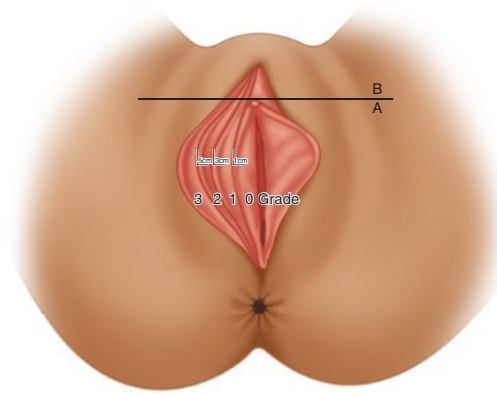

Fig. 33.1 Colaneri's Classification [12]

We have categorized the labia minora's size into four groups (Fig. 33.1), with the objective of covering as much information as possible about the hypertrophy, including size and extension of the resectable portion, and to help choose the optimal surgical technique.

Considering that the labia minora should measure at least 1 cm [1, 3, 6, 11, 13] and that resection should not leave less than that, irrespective of a smaller or absent coverage by the labia majora, our classification is as follows:

33.2.1 Colaneri's Classification [12] (Fig. 33.1)

Degree of hypertrophy	Extension of hypertrophy
Grade 0: ≤1 cm	A: Affects only the nymphae below the clitoris
Grade 1: >1 cm and ≤3 cm	B: Affects above the clitoris and extends to the prepuce
Grade 2: >3 cm and ≤5 cm	
Grade 3: >5 cm	

33.2.1.1 Concerning the Size of the Labia Minora

Grade 0: ≤1 cm

Absence of hypertrophy, labia minora with up to 1 cm from their base near the vaginal introitus to

the most extended border. No indication for labiaplasty [1, 3, 6, 11, 13]. If there is protrusion and exposure of the labia minora, the case should be considered as atrophy and decreased volume of the labia majora, and the approach should be a fat graft or any other kind of filling, rather than labiaplasty.

Grade 1: >1 cm and ≤3 cm
This mild hypertrophy of the labia minora is resectable up to 2 cm, still keeping 1 cm intact. In such cases, wedge resection is not the major indication according to several authors [3, 8]. Direct resection or de-epithelialization (when labia are smaller and thin) are good options [3, 6, 14].

Grade 2: >3 cm and ≤5 cm
At this level of hypertrophy, wedge resection and direct resection approaches are good alternatives, while de-epithelialization should not be used, since it may result in a thick appearance of the nymphae [14].

Grade 3: >5 cm
Marked hypertrophy, with likely thick and wide-based labia.

In such cases, wedge resection and flap rotation are good options, because the pedicle is reliable and the procedure removes the thicker tissue at the most protruded portion. Direct resection and de-epithelialization techniques, if chosen, will result in an appearance of thickened labia minora. Should direct resection be the chosen technique, it should use laser, to allow emptying labia minora internal tissues, thinning the labia, and avoiding the thick appearance.

33.2.1.2 Concerning the Extension of Hypertrophy, that is, Labia Minora, Clitoral Hood, and Prepuce

A: The hypertrophy affects exclusively the labia minora.

B: The hypertrophy affects the labia minora and the area above the clitoral hood, potentially extending to the prepuce.

In cases categorized as B, the resection should extend to the clitoral hood and/or prepuce, for a better aesthetic outcome.

33.2.1.3 Concerning Asymmetry of the Labia Minora

Some degree of asymmetry is the rule. While some asymmetry is common between any double organs, such as ears, hands, eyebrows, etc., vaginal labia minora tend to be more prone to asymmetry, quite often significant. Therefore, we chose not to include a classification based on asymmetry; instead, in cases with major asymmetry, we recommend to describe each of the nymphae separately, for example: Right: grade 3 B; Left: grade 1 A.

To illustrate the different grades of hypertrophy, direct resection cases have been selected, since the markings on the surgical specimen help to visualize the excess tissue (Figs. 33.2, 33.3, 33.4, 33.5, 33.6, 33.7, 33.8, 33.9, 33.10, 33.11, and 33.12).

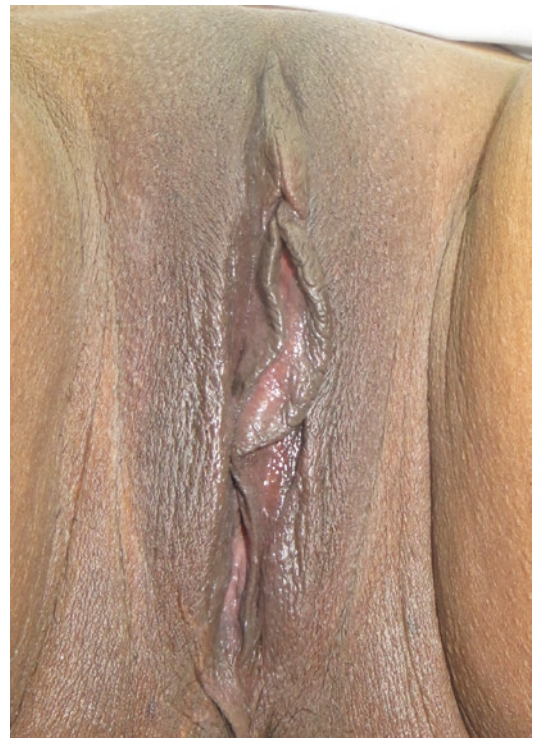

Fig. 33.2 Grade 0

Fig. 33.3 Fat graft in labia majora—postoperative

Fig. 33.4 Grade 1A

Fig. 33.5 Markings

Fig. 33.6 Specimen

Fig. 33.7 Grade 2B

Fig. 33.8 Markings

Fig. 33.9 Specimen

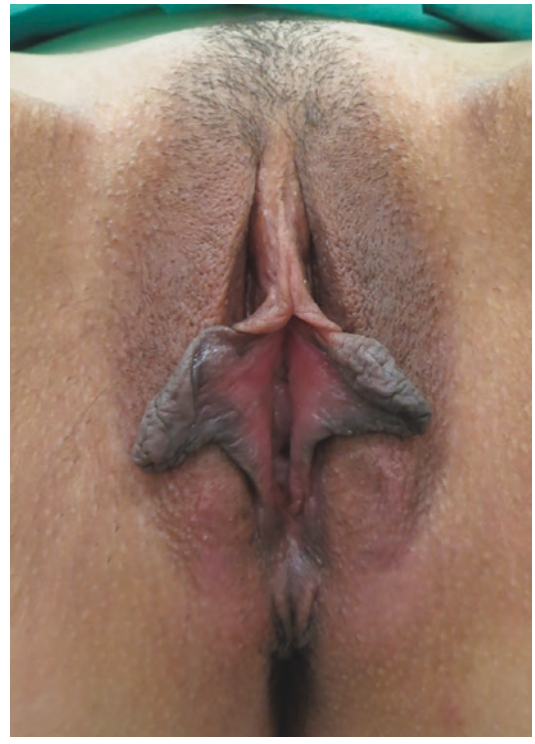

Fig. 33.10 Grade 3A

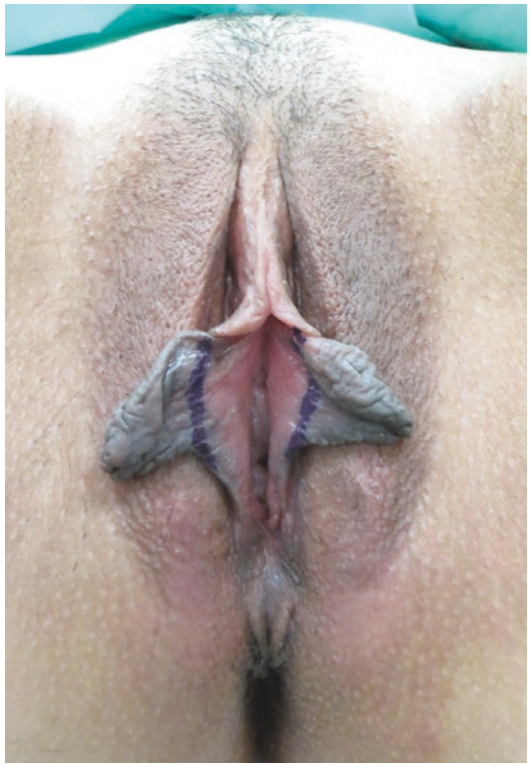

Fig. 33.11 Markings

Fig. 33.12 Specimen

33.3 Vascular Anatomy of the Labia Minora

In 2015, Georgiou reported a cadaveric study on the anatomy of the nymphae using tomography and angiography with contrast and tridimensional reconstruction [5]. The vascular anatomy was described with an unprecedented level of detail, with an impact on the choice and indication of labiaplasty techniques (Figs. 33.13) [15–17].

Four main arteries, originating from the internal pudendal artery, were described in each of the labia minora; one of these arteries, centrally located and of higher caliber, is dominant in relation to the others. This vessel, called central labial artery (C), runs perpendicular to the base of the labia minora, toward their border, where it turns toward the clitoris, running close to the border until it ends in the proximal portion.

Another two of the four arteries are located posterior to the central artery and are called posterior arteries 1 and 2 (P1 and P2). Both run parallel to the central artery and end close to the border of the nymphae.

The fourth artery is located anterior to the central artery and was called anterior labial artery (A). It runs in the same direction as the other vessels, but is shorter and ends in the proximal portion.

Contrary to previous knowledge, this study has shown that the arteries are superficially located, running quite close to the mucosa (internal) or to the skin (external) of the labia minora, rather than inside the loose submucosal tissue. This extreme proximity has led the author to suggest that the de-epithelialization technique might threaten these arteries [5].

Georgiou [5] has mapped the points from where the arteries emerge at the base of the nymphae, and compared them to the labia minora base length, showing proportionality. Taking as a standard the posterior-anterior distance from the base of the nymphae, the following proportions have been found:

P1 artery: emerges at 17% of the length of the nymphae

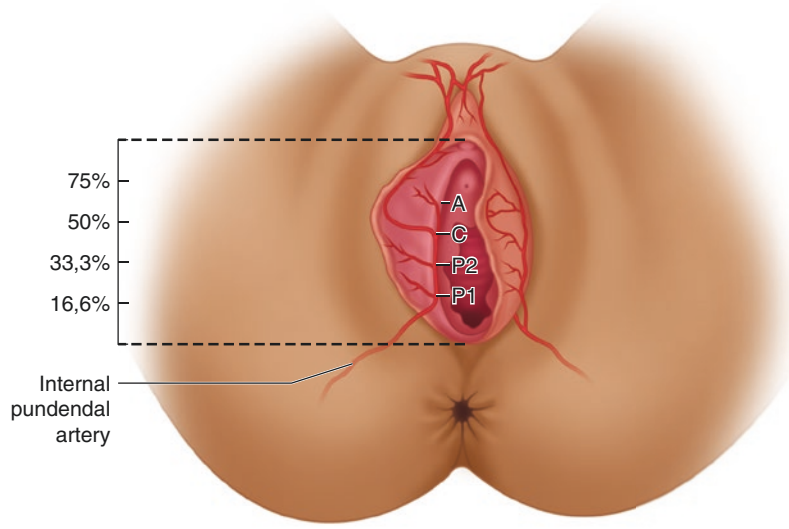

Fig. 33.13 Vascular Anatomy of the Nymphae. *A* anterior labial artery, *C* central labial artery, *P2* posterior artery 2, *P1* posterior artery 1

P2 artery: emerges at 32% of the length of the nymphae

C artery: emerges at 55% of the length of the nymphae

A artery: emerges at 76% of the length of the nymphae

The correlation found is very close to a precise geometrical division, should we divide the distal half of the nymphae into 3 portions and the proximal half into 2 portions (16.6%, 33.3%, 50%, 75%). This is very helpful for marking and preparation of flaps, should the wedge resection technique be chosen.

The external pudendal artery gives off two small central branches that supply the prepuce and the clitoris, plus two small lateral branches that run around the clitoris and form an anastomosis with the internal pudendal system, through the frenulum of the clitoris, in the proximal mucosa of the labia minora.

This anatomical study showed that the pudendal innervation runs in close proximity to the arteries. Therefore, preserving the arteries will also preserve the nerves and the sensitivity of the nymphae.

In a different anatomical study on the nerve density in the labia minora, Kelishadi [15] reported that the nerve distribution is heterogeneous without any statistical difference between the anatomical regions analyzed. The author concludes that any technique may be used safely, with no risk of altering the sensitivity of the nymphae.

33.4 Labiaplasty Techniques

The main objective of any labiaplasty technique is to reduce the labia minora and avoid their protrusion past the labia majora, making them less conspicuous or embedded [10]. Based on this principle, several techniques have been developed, each with specific features and indications. We will now address in detail the most widely used techniques, weighing their advantages and drawbacks.

33.5 Direct Resection of the Labia Minora

The first technique developed to reduce the labia minora is also the simplest and the most widely known and used by surgeons. Direct resection of the labia minora borders was initially described by Capraro in 1971 [18] (Fig. 33.14).

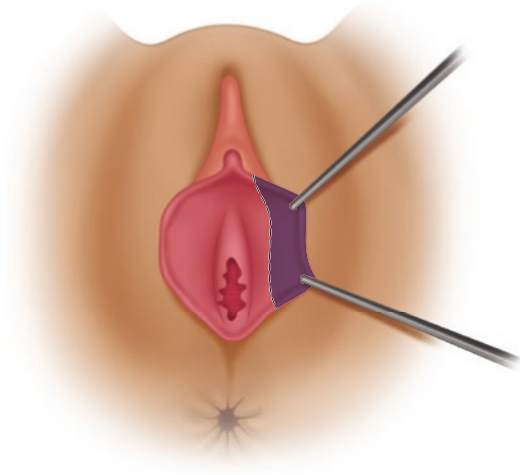

Fig. 33.14 Direct resection technique

33.5.1 Direct Resection

Based on the author's experience with over 600 cases, I consider this technique as very versatile, appropriate for any type of hypertrophy, with good results and a high level of patient satisfaction.

Its advantages are as follows: fast and simple execution, potential indication in all cases of hypertrophy, from mild to severe, preservation of the vascular-nervous bundle, allows for removal of the darker portion of the labia minora, low rate of complications, and high level of satisfaction.

Disadvantages reported in the literature: the resection of the border removes the natural contour of the labia minora, leaves a visible scar, maintains a wide base that may appear as thickening, remaining tissue at the clitoral insertion.

However, in my experience, removing the usually darker borders of the labia minora is something the patients like and sometimes even ask for, because it confers a lighter appearance to the genitalia. The borders are often less rugged, the healing is good, and the scar barely visible, provided the resection is careful and the stitches are made with thin thread and close to the edge. On the other hand, the labia minora actually get thicker. This can be minimized or solved by laser resection, which allows for the internal removal of the internal tissue, reducing the content of the labia minora and making them thinner.

After marking and photographic documentation, we proceed with surgical site preparation, including antiseptic measures and draping. Infiltration of the proximal incision borders is done with an anesthetic solution containing 110 mL saline, 20 mL of 7.5% ropivacaine HCl without vasoconstrictor, 20 mL of 2% lidocaine without vasoconstrictor, and 1 ampoule of adrenaline 1 mg/mL.

We wait at least 7 min for the full effect of ropivacaine and vasoconstriction before proceeding; after segmental clamping with Halsted mosquito forceps, the resection is done along a slightly curved line following the natural contour of the labia minora (Figs. 33.15 and 33.16). For the resection of the prepuce, a more linear structure, we use straight forceps.

After clamping a segment, we can open and close the forceps a few times for coaptation of the edges and vessel closure. Segmental resection is done with knife followed by a mild and quick cauterization (at 15 W) of the remaining tissue. Before releasing the forceps, we make one stitch with Vicryl 5.0 rapid under the Halsted forceps tip to avoid separation of the incised segment

Fig. 33.15 Markings

Fig. 33.16 Clamping using only the Halsted tip along the marking line and incision

Fig. 33.17 Suture after removal of the clamp, with no bleeding

borders (Figs. 33.17 and 33.18). The incision is then closed with a running suture. With good coaptation of the edges and vessel stenosis, there is usually no bleeding.

The clamping and segmental suture technique is repeated down to the distal portion of the labia minora. Importantly, the clamping must coincide with the markings to avoid irregularity, asymmetry, and misalignment of the suture borders. Sometimes, when there is a little bleeding between the borders, we need to give separate stitches. This usually happens in the middle portion, where the central artery is located. We often need to remove with scissors the proximal edge of the clamped tissue, since the forceps is thinner at the tip and thicker at the base, leaving more crushed tissue in the area proximal to the clamping.

Once the suture is completed and after photo documentation of the vulva and surgical specimen, Dermabond® is applied to the wound edges.

Fig. 33.18 Early post-op. Note the homogeneous, linear incision border, with no folds

33.6 Important Remarks

While direct resection labiaplasty is a simple and easy procedure, it may cause irreparable sequelae if incorrectly executed. Once resected, the labia minora cannot be properly reconstructed. They are a unique structure, with a thin, rugged skin found nowhere else in the body. Therefore, some points require attention.

- For resection, less is better than more. Should the surgery leave an excess tissue, it can be removed.
- Markings should be done with a surgical pen, never stretching the labia minora or pulling them with a thread or tweezers. These practices cause distorted markings and the result is an irregular resection, excessive removal of tissue from the mid portion, and misalignment of the labia minora borders.
- The anesthetic infiltration should use a small volume and be applied as proximal as possible to the incision line to avoid distorting the tissue to be resected [11].
- After the infiltration, at least 7 min are required for vasoconstriction and full effect of ropivacaine. Bleeding is usually minimal or absent. Hematoma formation may distort the tissue and make it difficult to assess the portion to be resected.
- Marking should always be done before anesthetic infiltration, to avoid distortion. The resection should follow strictly the markings, which should be curved, symmetrical, and rechecked before resection (Fig. 33.15). Once the incision line is infiltrated, the tissue may be distorted; therefore, the markings are critical to avoid mistakes during resection. If the markings are done along a straight line from the clitoris to the vaginal introitus, the resection of the mid portion of the labia minora will be excessive, with a poor aesthetic result—the clitoris area will be overexposed and more conspicuous.
- The proximal portion, close to the frenulum of the clitoris, should only be resected with the tip of the forceps, to avoid leaving a residual flange close to the clitoris. This segment should not be cauterized, to avoid burns to the clitoris, and should be at least 2-mm distant from the clitoris.
- The resection should be homogeneous, with no misalignment of the clamping, to ensure a linear border of the labia minora (Fig. 33.16). After clamping the segment a few times, it is helpful to remove the forceps and see if the edge of the crushed area is in line with the resected segment. This will allow to change the clamping before proceeding with a resection that might be incorrect.
- It is important to trim the crushed tissue at the base of the forceps should there be excess tissue in this area.
- The suture should be done using a thin thread, like Vicryl 5.0 rapid, should be applied to the incision borders without too much tension to avoid creases on the suture line (Fig. 33.17).
- Extensive resection close to the vaginal introitus should be avoided; the procedure should leave a sufficient amount of tissue to be stretched during penetration. Excessive resection might cause pain during penetration. For the same reason, we should also avoid joining the scars on both sides close to the introitus.

33.7 Postoperative

Labiaplasty is a quick, minor surgery, and allows for an early return to office work. Therefore, the procedure may be done with the utmost discretion and confidentiality, without the need for taking holidays or a leave of absence. We usually suggest performing surgery on a Friday or Saturday, with return of the patient to work (office) within 3 days.

Since edema formation occurs mostly in the first 72 h postoperatively, this period should allow to minimize it. To limit swelling, we recommend the use of ice packs as much as possible during these 3 days. The less swelling, the better the recovery will be. A marked edema increases the risk of dehiscence and discomfort, especially with walking due to friction of the nymphae, which in turn aggravates the edema. The use of glove-shaped ice-water packs should start imme-

diately after surgery, in the operating room. Patients who adhere to the maximum use of ice packs and avoid too much movement during the first 3 days will certainly have a better recovery.

Due to the risk of bleeding during the first 21 days, hot and long baths are prohibited, as well as manipulation and attempts at washing with water jets. Because the wound is protected with Dermabond®, the bath causes no pain or discomfort—any attempt at washing the area may remove this film and expose the wound, increasing local sensitivity. After bathing and voiding, the area should only be dried with great care. The glue helps protect the wound and reduce discharge from the raw area, adding to the patient's comfort.

After a week, the film loosens and exposes the scar—by then, some adherence of the nymphae to the underwear may occur. If this happens, the use of Oncilom Orabase ointment helps protect the area and solve the problem. This ointment is also helpful to reduce major edema and for added comfort in such cases.

Between the second and third week postoperative, the Vicryl 5.0 rapid stitches start to loosen. By day 21, the edema is usually small, the wound healing is good, and the patient may resume physical exercises.

Sexual activity should not resume until one month after surgery.

33.8 Technique for Direct Resection of the Labia Minora with Laser

The technique of direct resection with laser has the same indications, and requires the same markings and care as the one performed by clamping. The laser cauterizes the vessels during resection, thus reducing bleeding. However, since with the clamping technique the borders are coapted before resection and the bleeding is minimal, there is no advantage of one technique over the other. In my view, the great advantage of using the laser is the possibility of resecting the excess portion of the labia minora with the wedge-shaped bloody edge, reducing the internal volume and thus the thickness of the nymphae (Fig. 33.19).

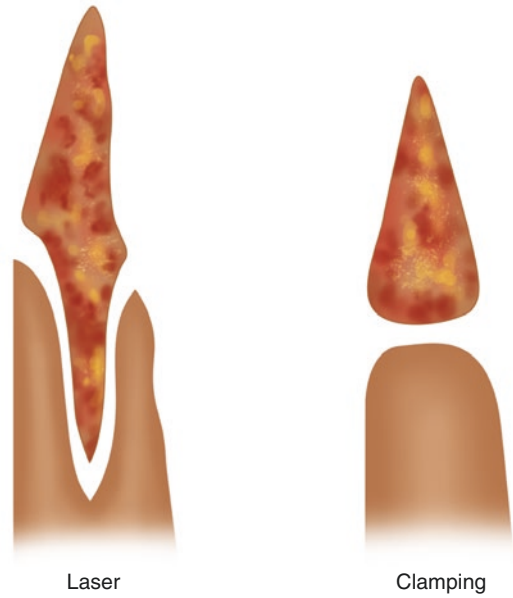

Fig. 33.19 Wedge laser resection, removing internal tissue, and thinning the labia minora. Resection by clamping, maintaining the thickness and potentially causing the impression of thicker nymphae

Direct resection has been criticized for leaving the nymphae looking thicker, especially in cases with marked hypertrophy—the use of laser avoids this problem. Internal wedge resection with knife leads to heavy bleeding, large edema and bruising. Due to cauterization during the use of laser, internal wedge resection is possible and easy to perform. We just have to point the laser to the base of the nymphae and make an oblique resection of both the lateral and the medial sides. In this way, the surgical specimen will have a wedge-shaped raw border and the nymphae will lose content and internal volume, thus getting thinner (Figs. 33.19, 33.20, 33.21, and 33.22).

According to the detailed anatomical study of the vascularization performed by Georgiou [5], the vessels in the labia minora run inside the mucosa or the outer skin, rather than in the internal tissue. Thus, the removal of the internal tissue facilitates the emptying of the contents, without impairing the vascularization of the labia minora.

Fig. 33.20 Pre-op hypertrophy grade 2A, thick nymphae

Fig. 33.21 Surgical specimen, showing the wedge of bloody tissue inside the nymphae

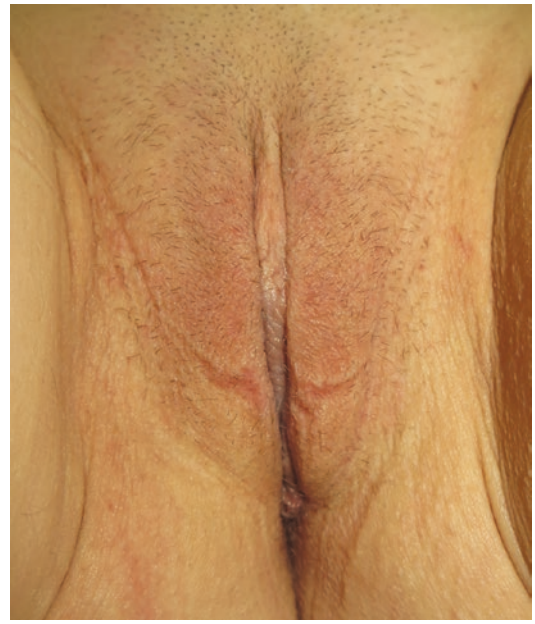

Fig. 33.22 Postoperative 1.5 m after laser labiaplasty, showing thinner nymphae

33.9 Considerations on the Technique for Direct Resection of the Labia Minora

The reduction of labia minora by direct resection of the edges was the first technique to be described—it is the simplest and still the most widely used by surgeons. It has been shown to be effective, rapid, with few complications and a high degree of satisfaction among patients.

Critics of the technique mention the fact that it changes the shape of the border, altering the original texture and color of the nymphae; another issue mentioned is the scar on the edge, which could generate some discomfort or sensitivity [14]. Another cited disadvantage is the risk of leaving a fragment of the frenulum of the clitoris, which gives an artificial appearance. The appearance of thickening after amputation of the distal portion and maintenance of the proximal one, usually thicker, is also cause for criticism.

In the author's experience, the vast majority of patients prefer the removal of the darker and more rugged distal border. For some, the main complaint is the visibility of the dark part tissue. Therefore, in the author's experience, removing the rough, irregular, and dark portion does not seem to be disadvantageous.

The remnant of the labia minora next to the clitoris can be avoided using Halsted forceps with a very thin tip for clamping, followed by trimming of the edge.

To avoid irregular and misaligned borders, the suture should be done with Vicryl 5.0 rapid, right at the edge and without too much tension, thus avoiding to crease the tissue excessively. In this way, the resulting scar is usually very discrete and homogeneous. Among the more than 500 cases of labiaplasty operated by the author to date, no patient had complaints of oversensitivity, pain, or hypertrophic scar, an opinion shared by other authors [9, 13]. The clamping technique does not leave a bloody area, due to the coaptation of the edges, and the risk of cicatricial contraction is reduced or even absent, as in the author's series.

The thick appearance of the labia minora is a fact, and it becomes evident in cases with marked hypertrophy, where the base is wider. This drawback can be overcome only by using the laser wedge resection technique, which empties the contents of the nymphae, with consequent thinning and a better end result.

The resection of the edges maintains all innervation and vascularization of the remaining portion—this technique is the least harmful to the structures of the labia minora. Compared with flap rotation techniques, there is no risk of necrosis and minimal risk of dehiscence, provided the suture is delicate and well coapted.

33.10 Complications

Complications of labiaplasty are rare and are usually associated with poor surgical technique or insufficient postoperative care (Figs. 33.23 and 33.24). A small amount of discharge is common and not considered as a complication; it can be minimized by a delicate edge-to-edge suture and the use of Dermabond®.

Fig. 33.23 Pleated borders, probably due to suturing with thick threads, too tight and too far from the edges

Dehiscence is directly related to an increased edema or inadequate suture; therefore, avoiding major edema is a key factor for a good recovery. Since the mucosa heals very well, even small areas of dehiscence do not usually affect the aesthetic result.

Infection is a rare occurrence. Among the more than 500 labiaplasty procedures in the author's series, we had only one case. In this case, the complication occurred, because the patient washed vigorously the genitalia with water jets; fearing an infection, she kept washing repeatedly and the more she washed, the worse the pain and the edema. She only contacted us 12 days later, when she was admitted with dehiscence and infection. She was treated with ciprofloxacin for 14 days and prednisolone for 5 days; the events resolved, and the wound healed properly.

Excessive resection or inadequate technique may have devastating consequences for the patient. For resection, less is better than more. If

Fig. 33.24 Asymmetric resection, with distal amputation of the labia minora

the resection is insufficient, a new surgery can remove excessive tissue. On the other hand, an excessive resection cannot be properly corrected. If the clitoris hood is resected exposing the clitoris, the patient may experience pain and increased clitoral sensitivity at the mere contact with her underwear. A poorly employed technique can also compromise the outcome. Thick threads and tight sutures away from the edges can lead to pleated scars.

33.11 Techniques for Segmental Approach with Wedge Resection and Flap Rotation

Some techniques have been described using flap rotation after segmental wedge resection. The advantages described by this technique are the maintenence of the natural contour, texture, and color of the labia minora, by resecting a segment at the base or from the mid portion of the nymphae.

To ensure a safe supply of vessels and nerves to the flaps, these techniques are less indicated in cases where nymphae are smaller than 3 cm. With very thin pedicles, the risk of necrosis increases depending on the type of flap [3].

Another important precaution is to avoid tension on the flap. The risk of dehiscence and fistulization increases with tension. It is important to remember that postoperative edema will naturally increase tension along the suture line.

While the authors who described the techniques of segmental resection and flap rotation report an advantage of maintaining the texture and color of the labia minora, many of the author's patients complain about the dark portion and would rather have it removed. Even when edges are kept intact, many of these techniques result in a juxtaposition of upper and lower flaps; since they do not have the same color as the distal areas, the result is an evident color gradient, which does not actually fulfill the promise of keeping the natural color of the edges (Fig. 33.43).

33.11.1 Martincik J, 1971

First author to propose the technique of labiaplasty by wedge resection and flap rotation, Martincik described the technique what he called a cuneiform resection of the labia minora [19]. It consists of the removal of a posterior fragment of the labia minora, maintaining a flap with an upper pedicle (Fig. 33.25). The author reported 12 cases, being 11 with a satisfactory result (91.6%) and one case of postoperative hemorrhage.

33.11.2 Gary J Alter, 1998

Gary Alter described in 1998 the technique of wedge resection of a central, V-shaped fragment of the labia minora, in the area with greater projection [4] (Fig. 33.26). His sample included 4 patients. According to this author, the advantages

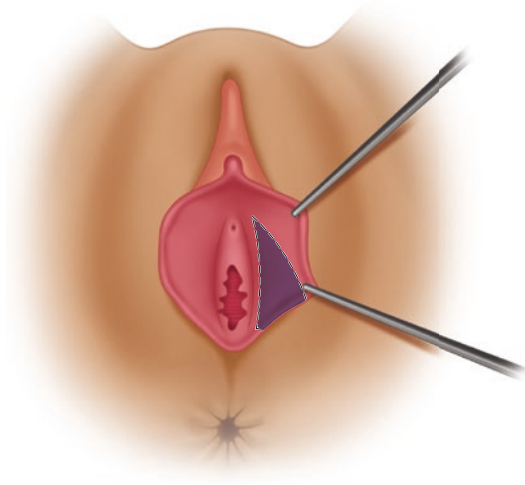

Fig. 33.25 Martincik's technique with posterior wedge resection

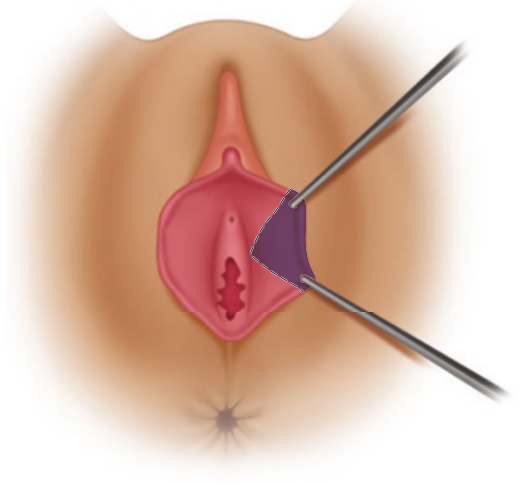

Fig. 33.26 Gary Alter wedge resection of a central, V-shaped fragment of the labia minora

of the technique are to preserve the edges, texture, and color.

Alter highlights the importance of avoiding excessive resection to avoid tension on the introitus. For better accuracy during marking, the author suggests introducing some fingers in the vagina, to estimate the safe amount of tissue to be resected. Since asymmetry is frequent, the marking varies according to each of the nymphae. The resection starts with the smaller of the two nymphae, and the best symmetry should be sought for when reducing the larger side.

The subcutaneous tissue is sutured with absorbable thread 4.0 (the author does not specify), and the outer suture is done with Vicryl 4.0 and 5.0. Small flanges are removed for better alignment of the flaps. The final size of the labium should be around 1 cm. The Vicryl suture can be removed within a week if irritation occurs.

In 2008, 10 years after report his first labiaplasty technique, Alter proposed a procedure to extend the central resection of the edges of the labia minora up to the clitoral hood [20] (Figs. 33.27, 33.28, 33.29, 33.30, 33.31, and 33.32). According to the author, this technique helps to preserve the color and the edges of the labia minora, improving the quality of the scar.

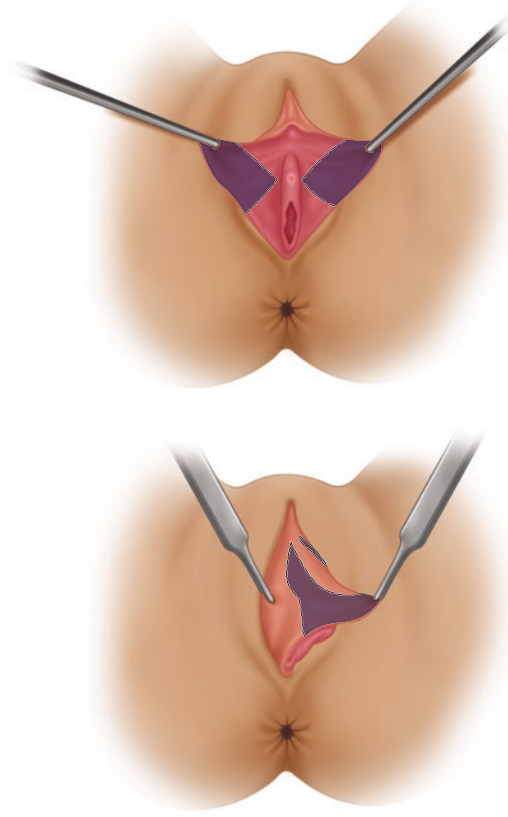

Fig. 33.27 Gary Alter wedge resection extended the central resection of the edges of the labia minora up to the clitoral hood

Fig. 33.28 Central wedge medial marking

Fig. 33.29 Lateral "hockey stick-shaped" marking with extension to the prepuce, as described by the author

The medial marking is done by a V that extends to the vagina. The lateral marking is done in the form of a hockey stick or "L," curving anteriorly and laterally to resect the lateral excess of the labia minora and clitoral prepuce. Therefore, the lateral and medial resections are marked differently, the subcutaneous tissue remaining between the resected parts. The inner flange of subcutaneous tissue is resected. The borders are approximated and sutured in at least two layers (subcutaneous and mucosa—medial, subcutaneous and skin—lateral) with Monocryl 5.0.

Of the 401 cases operated, 4% had complications and 2.9% needed a second surgery. The satisfaction rate was high, 98%.

33.11.3 Oren Tepper, 2011

In 2011, Tepper reported the technique of star labiaplasty, used on a series of 8 patients [21]. Using two pedicles, upper and lower, the author proposes removing the middle tissue with a star-shaped resection (Figs. 33.33, 33.34, and 33.35).

Daher, in 2015, published a series of 64 cases using the star technique [22], which he described in more detail:

After applying 2% lidocaine ointment to the vulvar mucosa, the marking is done, followed by infiltration of the incision lines with 2% xylocaine and adrenaline 1:100,000 IU. The incision is made along the whole thickness of the nympha, through the three leaflets. The author advises to leave the labia minora protruding 1 cm from the edge of the labia majora. After hemostasis, an anchor stitch is given at the distal edge of the flaps (A). The next stitch is given to join the four internal points of the star (BCDE). The thread used in the plane and continuous suture, both internally and externally, is chrome catgut 4.0. The author reported two cases (3%) with

Fig. 33.30 Intraoperative

Fig. 33.31 Preoperative

complications—both with hematoma. In the original Matarasso paper, two of the eight patients (25%) experienced dehiscence.

33.11.4 Stefan Gress, 2013

In 2103, Gress published a series of 812 cases with a compound labiaplasty technique that combines direct resection of the edges of the labia minora with upper pedicle flap rotation, along with reduction of the clitoral hood and the protrusion of the clitoris [23] (Figs. 33.36, 33.37, and 33.38).

The surgery is performed under local anesthesia with 1% lidocaine, 0.5% bupivacaine, and adrenaline 1:100,000. The reduction of the labia minora is performed by direct resection, maintaining a flap and smaller upper pedicle, to ensure continuity of prepuce. The resection is extended laterally to the prepuce. It is important to maintain a sufficient amount of subcutaneous tissue to avoid affecting the blood supply to the flaps. A crescent-shaped skin segment is removed below the clitoris and will be responsible for the lower traction of the clitoris. It is important to leave at least 1.5 cm between the resected segment and the urethral orifice, to avoid disruption of the urine stream. If this is not possible, this resection should be avoided. Another segment of skin, in the form of a rectangle, is removed cranially to the clitoris. Care should be taken during cauterization of this segment, to avoid damage to the innervation of the clitoris that runs beneath this area.

The first suture to be performed is the one above the clitoris, with Vicryl 5.0 in the subcutaneous and Vicryl 6.0 on the skin. Below the clitoris, the suture is done with Vicryl 5.0. The remainder of the labia minora, in the area of direct resection and flap, is sutured with Vicryl 5.0 and Monocryl 6.0.

Fig. 33.32 Two months postoperatively

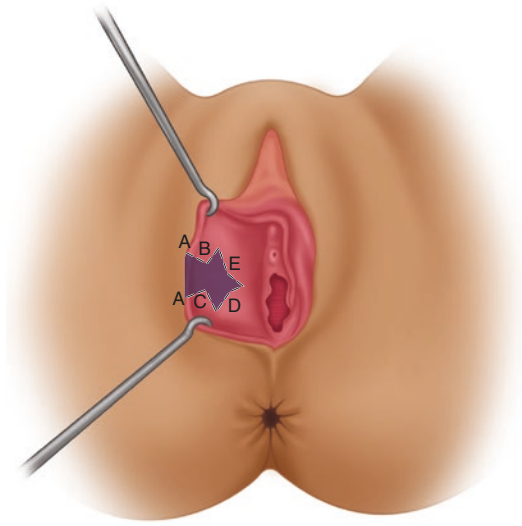

Fig. 33.33 Tepper technique with star resection

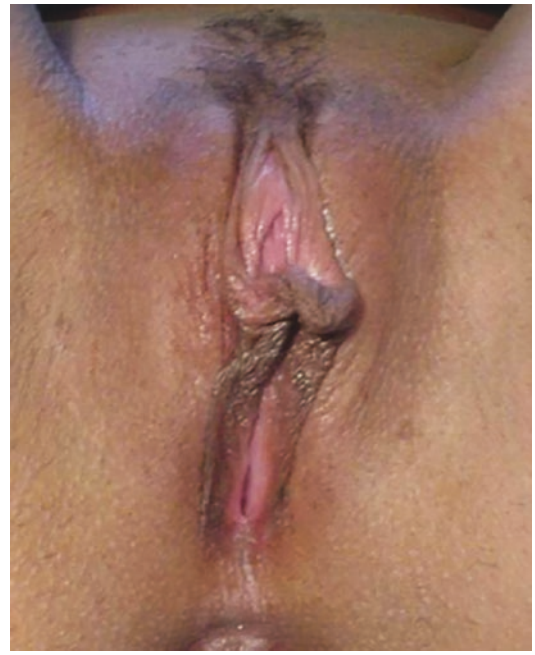

Fig. 33.34 Preoperative

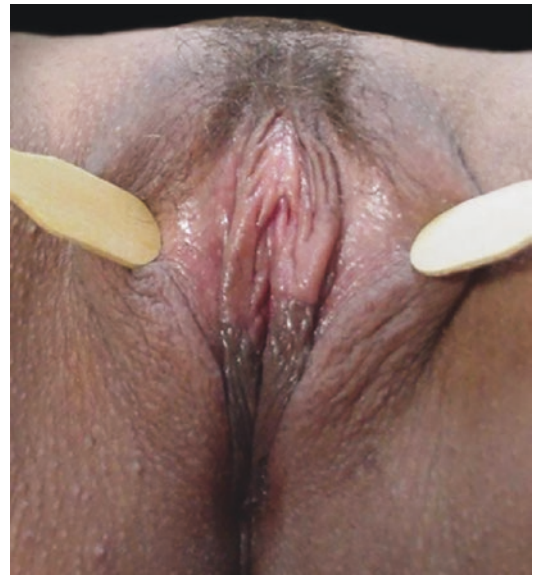

Fig. 33.35 Late postoperative periods. (Images taken from Daher's population [22]. Courtesy of Marcelo Daher, M.D.)

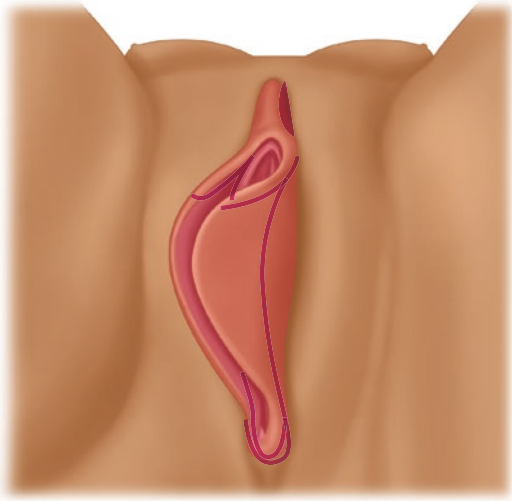

Fig. 33.36 Stefan Gress compound labiaplasty technique. Resected area, lateral view

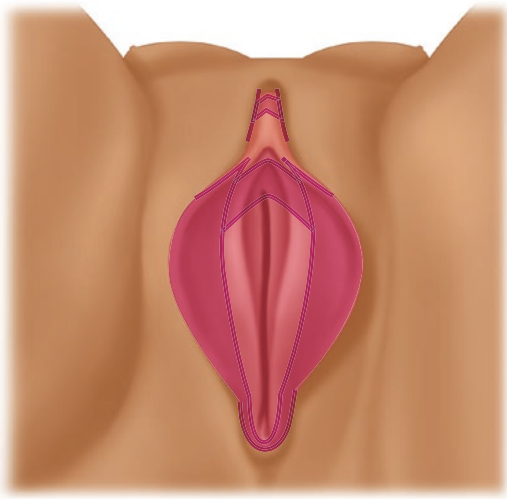

Fig. 33.37 Stefan Gress compound labiaplasty technique. Resected area, frontal view

As a result of the surgery, the labia minora should have the planned size—not less than 1 cm—the clitoral hood should have proper tension and the clitoris should have migrated to the level of the labia majora.

The satisfaction rate with the surgery was 94%. Healing complications requiring surgical reintervention occurred in 6.4% of the patients.

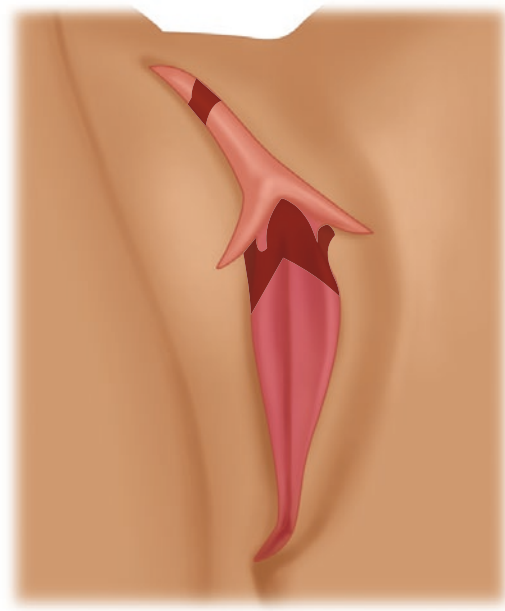

Fig. 33.38 Stefan Gress compound labiaplasty technique. Resected area

Reintervention for bleeding was required in 0.8% of the patients. No cases of necrosis occurred.

33.12 Considerations on the Techniques for Segmental Resection and Flap Rotation (Wedge Resection)

Flap rotation techniques for reduction of the labia minora cause more devascularization than direct resection and de-epithelialization procedures, and are not recommended by many authors when labia minora measure less than 3 cm [3]. Very thin or very long flaps increase the risk of dehiscence and necrosis (Fig. 33.44). Dehiscence is the most frequent complication with these techniques (Fig. 33.39) and may be due to devascularization [5], overtight edges, inadequate suture, or poor postoperative care. Compared to the technique of direct resection, the techniques of wedge resection and flap rotation are more prone to dehiscence [16].

Fig. 33.39 Dehiscence of flap of wedge resection

The upper pedicle flaps are less vascularized, since their pedicle contains the anterior labial artery (Fig. 33.42), which is the smallest of the four arteries supplying the labia minora. This may justify the higher rate of dehiscence with the techniques of posterior wedge resection and anterior flap rotation [2, 5]. Techniques using central or anterior wedge and a larger posterior flap preserve better vascularization, with lower risk of dehiscence [5] (Figs. 33.40, 33.41, and 33.42).

Even though wedge resection and flap rotation techniques have the alleged advantage of maintaining natural contour and edges, they provide an unnatural color contrast at the junction of the flaps [3], mostly evident in dark nymphae (Figs. 33.43 and 33.44).

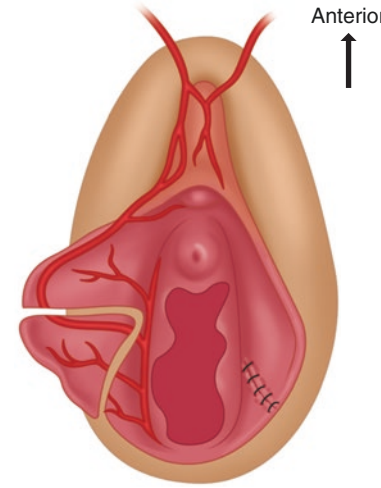

Fig. 33.40 Segmental posterior wedge resection, with anterior pedicle flap rotation. The higher dehiscence rate can be explained by the increased devascularization, with only the anterior labial artery remaining intact

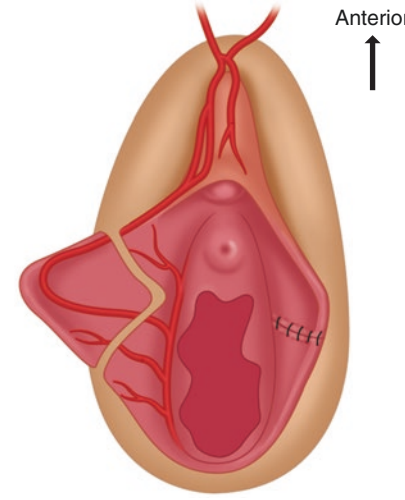

Fig. 33.41 Middle segment wedge resection. The anterior labial artery and the two posterior arteries remain intact, providing a good vascularization

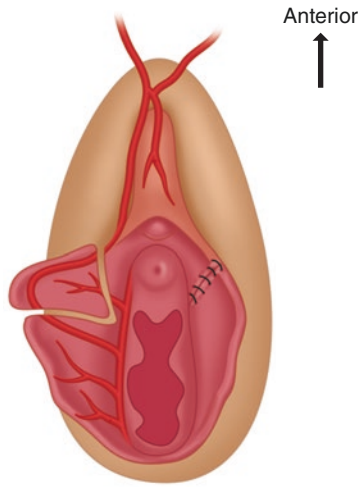

Fig. 33.42 Anterior segmental resection with posterior pedicle flap rotation. The maintenance of the posterior and central labial arteries provides a safer flap, with better vascularity

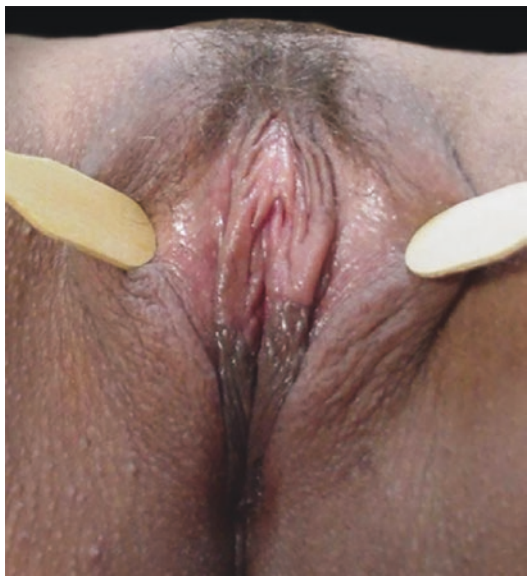

Fig. 33.43 Image showing difference in color between flaps. (Courtesy of Marcelo Daher, M.D.)

Fig. 33.44 Nympha D long with narrow base. Direct resection better indicated than wedge resection

33.13 De-epithelialization Technique

33.13.1 Hee Youn Choi, 2000

The de-epithelialization technique described by Choi [6] aims to reduce the labia minora without altering the contour and color of their edges, as happens with direct resection; it also avoids the overtight flap or the incomplete resection, which may occur with the wedge resection technique.

It consists of de-epithelialization of the central and lateral portions of the labia minora (Fig. 33.45). The technique was designed with the purpose of preserving the neurovascular supply to the nymphae.

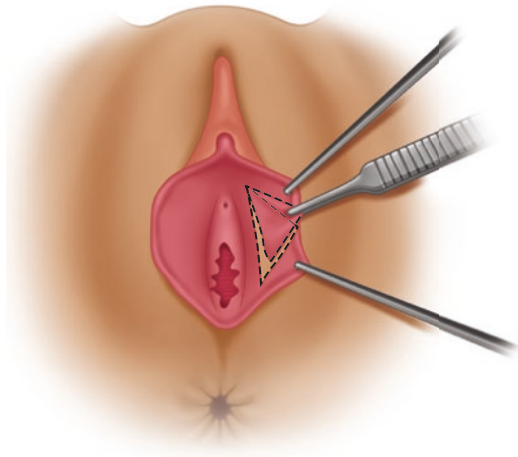

Fig. 33.45 De-epithelialization technique described by Choi

Six patients were operated using this technique. After de-epithelialization of the medial and lateral surfaces of the labia minora, the incision borders were sutured with catgut 4.0. Care should be taken not to extend the resection to the introitus and to ensure that the labia minora measure around 1 cm. None of the patients had any complication and all were satisfied with the surgery.

33.14 Considerations on the De-epithelialization Technique

The de-epithelialization technique is described in the literature as a good alternative for patients with small hypertrophy of the labia minora [3, 14] or very thin nymphae. In secondary labiaplasty, when the first procedure did not result in a sufficient reduction or if further reduction is desired, de-epithelialization is a good alternative [20]. In cases with more marked hypertrophy or thick labia minora, this technique will result in a thickening of the nymphae [14], since their content is maintained and is just compressed at the base. The distal portion of the nymphae is maintained and sutured to the base; therefore, in cases with long labia minora, there will be redundant tissue, since the distal arch is longer than the base. Nymphae with long and thin pedicles also have no indication for this technique.

Designed by Choi in 2000 with the purpose of preserving the blood supply to the labia minora, the de-epithelialization technique lost some interest after the paper published in 2015 by Georgiou [5]. In this excellent work on the anatomy of the labia minora, the vascularization is shown to be intramucosal or cutaneous (external) rather than located in the internal tissue of the nymphae. As Georgiou himself describes in his article [5], Choi's technique may affect vascularization.

33.15 Conclusion

Labiaplasty is a surgery in which every technique chosen has a high degree of patient satisfaction, greater than 90% and a low risk of complications. The improvement is not only physical, but also psychological. It is important that the surgeon is aware of the technique and performs it accurately.

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Monte Venus Plasty and Labia Majora Plasty

34

Lina Triana and Esteban Liscano

Take-Home Points

- Listen to your patient, understand what she wants, and what she needs. This is the only way to do a correct surgical plan and end up with a happy patient.
- Always have in mind when planning the mont venus plasty that you do not overresect, since you can pull up the genitalia and this just not only does not look good put can even end up exposing too much the clitoris glans and this is really uncomfortable to the patient.
- Always have in mind when planning a labia majora plasty to never overresect excess on the lower one-third, since you can easily expose the vagina and end up with an unhappy patient with a dry and itchy vagina.

34.1 Introduction

The pubic region has been through time an important area in art history, area that together with the breasts give the female identity in art. Mont Venus and Labia Majora fullness are important cosmetic landmarks, giving a youthful appearance of the area, this is why asking for a fuller Labia Majora area is something that many women ask for in today's world [1, 2].

Nowadays, there is a bigger concern about the appearance of the external genital area in the female population [3]. Some women come to our plastic surgery office to have a rejuvenation of the external genital, something that just years ago was not even conceivable.

The external genital organs or vulva include the mons pubis, labia majora, labia minora, Bartholin glands, and clitoris.

The external genital organs have three main functions:

- Enabling sperm to enter the body
- Protecting the internal genital organs from infectious organisms
- Providing sexual pleasure

Mont Venus also called the Mont Pubic is an area above the pubic pone where an accumulation of subcutaneous tissue, mainly fatty tissue, is present and serves like a cushion.

During sexual intercourse, this Mont Venus area serves as a cushion, important to have in mind when planning in doing any procedure in this area.

The Labia Majora are the posterior prolongation of the Mont Venus and are also abundant in subcutaneous, fatty tissue, helping protect the external introitus or vagina entrance. They are two cutaneous folds, one on each side of the vagina entrance, each being wider on the anterior portion and becoming narrower on their posterior area

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_34

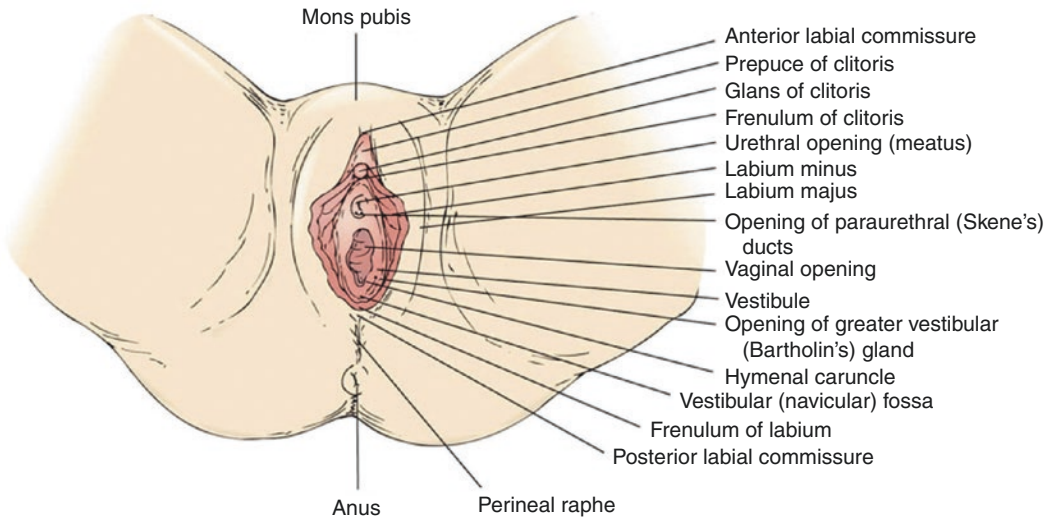

Fig. 34.1 External genital structures

[2]. When any surgical procedure is performed in this area, it is important to keep the upper or anterior area wider than the inferior or posterior area of the Labia Majora to keep them with a natural look. Labia Majora converge posteriorly with the labia minora and together form the posterior commissure or posterior fourchette [4]. It is important while looking at the external genitalia to identify the different structures that are independent but interrelated and can be disrupted when working on them individually (Fig. 34.1).

Naturally, both Mont Venus and Labia Majora are covered with pubic hair, but today, there is a trend to take away any hair in the genital area making these areas more exposed. Labia Majora also have an inner part that lacks hair important to be respected when planning a resection in this area.

Both the Mont Venus and the Labia Majora are covered with skin and not with mucosa as other genital structures, this is an important factor to have in account when performing a surgical procedure in these areas, since any scar in skin tends to be more visible once completely healed than in a mucosa. And since these areas, specially the Labia Majora region, are more exposed to friction, after years of this friction and when genetic factors as dark skin are associated, they tend to end up hyperpigmented, making even more visible any scar in the area. Also begin pregnant can contribute to hyperpigmentation in the area secondary to hormonal changes during pregnancy.

Since Labia Majora and Mont Venus are two areas that generally are exposed to friction, they have a protective role for our genital area. When planning in having a surgical or nonsurgical procedure in these areas, we always need to remember that these extra cushioned areas are there for a reason and must never plan fully obliterating them.

The blood supply in the area is provided by branches of the internal and external pudendal artery, the veins drain into the pudendal and femoral veins, and the nerve supply comes from the pudendal nerve and branches of the ilioinguinal and genitofemoral nerves.

34.2 Patient Selection

Pearl and Pitfalls

Always start consultation with the patient dressed so that she can feel free to talk about what really bothers her. It is crucial for a correct surgical plan.

When evaluating a patient for any genital procedure, it is very important to first listen to the patient. Since we are still talking of a taboo procedure, it is important to really give the patient space to first feel comfortable before asking to take their cloth off for examination.

Once rapport has established, proceed to ask the patient why they are with you today. Listen carefully to the patient, and then once you have a good grasp of what she wants, proceed to the exam room.

34.3 Preoperative Evaluation

Always exam the patient in standing position first and then in a lithotomy one, and in front of a mirror, but before you start to give the patient your input on what you are looking, ask her to now show you what she wants. You can be surprised on how what they said to you initially can be so different on what they show you in the mirror or no what you consider can be best for them according to your findings.

Once you listen to her and she shows you in the mirror what bothers her, now you are ready to exam the patient. Always examine the patient with a mirror so that you can show her what you are talking about, many times patients do now know the correct names for each external genital structure.

There is no well-known existing classification method for the Labia Majora or Mont Venus approaches, but they can be classified as atrophic or hypertrophic defects of the Labia Majora and atrophic or hypertrophic defects of the Mont Venus.

34.4 Atrophic Labia Majora

Pearl and Pitfalls
Explain the patient she will need more than one procedure to have a nonatrophic appearance.

Usually, atrophic cases are secondary to the normal aging process, since Labia Majora are puffy regions, rich in subcutaneous fatty tissue, that with time tend to deflate. With deflation or tissue atrophy secondary to the normal aging process plus excess friction in the area and earth's gravity force that pulls everything down, labia majora not only deflates but also elongates, making them look deflated, wrinkled, and aged.

When not too much filling is needed, the use of fillers can be a good treatment plan to increase volume in the labia majora, but lipofilling is the most commonly used approach, since usually, large volumes are needed for good results.

34.5 Atrophic Mont Venus

A natural aging process make us lose subcutaneous tissue and skin turgidity that when summed up with some skin laxity make our pubic region look deflated. This can not only be a nonappealing condition, but since our natural cushion in the area is lost, diminishing protection can lead us to even painful situations when friction is present in the area.

Fillers usually do not help in this area, since large amounts would be normally needed; so, the best option is always fat transfers to the pubic area.

34.6 Excess Skin Labia Majora

When excess skin is encountered in the Labia Majora, resection of this excessive skin is normally planned, but when planning any reduction procedure in the Labia Majora, it is important to end up with a treatment plan that does not leave an exposed introitus. An exposed introitus can be left when too much skin is needed to be excised from the labia majora or when there is presence of very loose skin the Labia Majora area. An exposed introitus will leave the patient with a dry vagina, something really difficult to treat.

When not too much excess is present, nonsurgical options can be done, these include nonsurgical skin-tightening technologies and even the use of fillers or lipofilling, but when too much loose skin is present, skin surgical resection must be done.

34.7 Excess Skin Mont Venus

With age and again, planet earth's gravity force plus pregnancies and changes in weight, we end up with loose skin in the pubic region, making our genital area look old. This is when a Mont Venus plasty with skin resection can be planned. Also, nonsurgical technologies can be used to help skin tightening in this area.

When taking away too much skin for a Mont Venus plasty, we can end up pulling too much the labia majora and clitoris hood area, exposing the clitoris head, a condition very uncomfortable for the patient.

34.8 Hypertrophic Labia Majora and Mont Venus

Excess fat or subcutaneous tissue in these areas can be annoying for the patient, since these areas can look bulky and limit the use of tight clothing. Excessive Mont Venus and Labia Majora regions can look unnatural and not appealing, this is why reduction techniques with surgical and nonsurgical approaches based on decreasing excess fat with or without skin tightening or skin resection can be used.

The patient must always be aware that once the excess fat is taken away, her external introitus and clitoris hood areas will be more noticeable and also some loose skin can be seen as a consequence of reducing the fat without resecting skin.

Also, Mont Venus excess should never be planned as to leave no cushion, remember this area must be cushioned for a reason, to serve as protection and cushion for sexual intercourse.

And never forget the line between hypertrophic Labia Majora and normal looking ones can be a very thin one. Some patients will ask for really bulky labia, since if you see a baby girl, you will see really puffy labia majora that come together in the mid line and cover completely the labia minora, clitoris hood, and outer introitus, so, many women when say to doctor I want a younger look, what they want is to look like a baby girl.

34.9 Hyperpigmentation in the Labia Majora and Mont Venus

Pearl and Pitfalls

Explain the patient you are not able to cure the hyperpigmentation condition, you will just decrease the darkness, but it can keep on hyperpigmentating.

Hyperpigmentation in the area comes with years of friction and a tendency of the skin for dark color especially in dark or Latin skins, this dark color also contributes to a less nice appearance of the area and must be addressed to be able to have a better aesthetic result when planning any cosmetic procedure in the area.

Hyperpigmentation is most commonly present in the Labia majora than in the Mont Venus and can be treated with nonsurgical options that include depigmentation creams, chemical peels, and lasers.

34.10 Treatment Plan Algorithm: Aesthetic Approach to Labia Majora and Mont Venus

Here we present an algorithm for approaching the labia majora and Mont Venus region summarizing different treatments plans (Fig. 34.2).

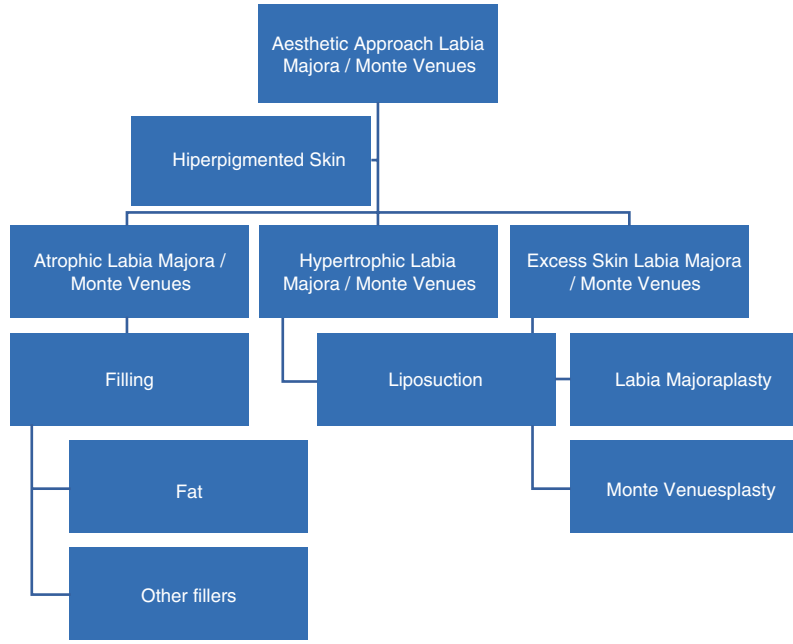

Fig. 34.2 Treatment Plan Algorithm: Aesthetic Approach to Labia Majora and Mont Venus

34.11 Preferred Author Surgical Techniques

34.11.1 Liposuction of the Excessive Labia Majora and Mont Venus

Pearl and Pitfalls

If you take too much fat, you can end up in the future with a deflated, wrinkled appearance.

Liposuction of these regions can be done with 3.0 canulae and a liposuction machine prior to tumescent infiltration in a 1:1 ratio. Important to notice that when aggressively liposuction in done on the Labia Majora, they can end up with a deflated look with time, so I do not consider a good idea to aggressively deflate them with liposuction.

Very important to do a good evaluation on an excessive Mont Venus patient, since many times, the excess is secondary to a protuberant pubic bone and liposuction will only make a mild change of an excessive appearance [5].

34.11.2 Lipofilling the Labia Majora and/or the Mont Venus Regions

Pearl and Pitfalls

In an attempt to avoid leaving a scar too much lipofilling can be done and you can end up with an unnatural labia majora appearance.

Preferable donor areas (nearby zones): Inner thighs, inner knees, and periumbilical. Also, the Mont Venus or Labia Majora can serve us when excess fat is present in one and the need to add filling on the other is present.

This procedure is a good option for filling out deflated labia majora, as seen in Fig. 34.3.

Liposuction is done with a 60 cc syringe and 3.0 canulae prior to tumescent infiltration in a 1:1 ration. The fat is extracted and simple decantation technique (while leaving extracted fat in syringe, no closed system is used) to separate de oil and blood from the fat. No washing, centrifuging, or straining is done to prepare the fat for injection [6].

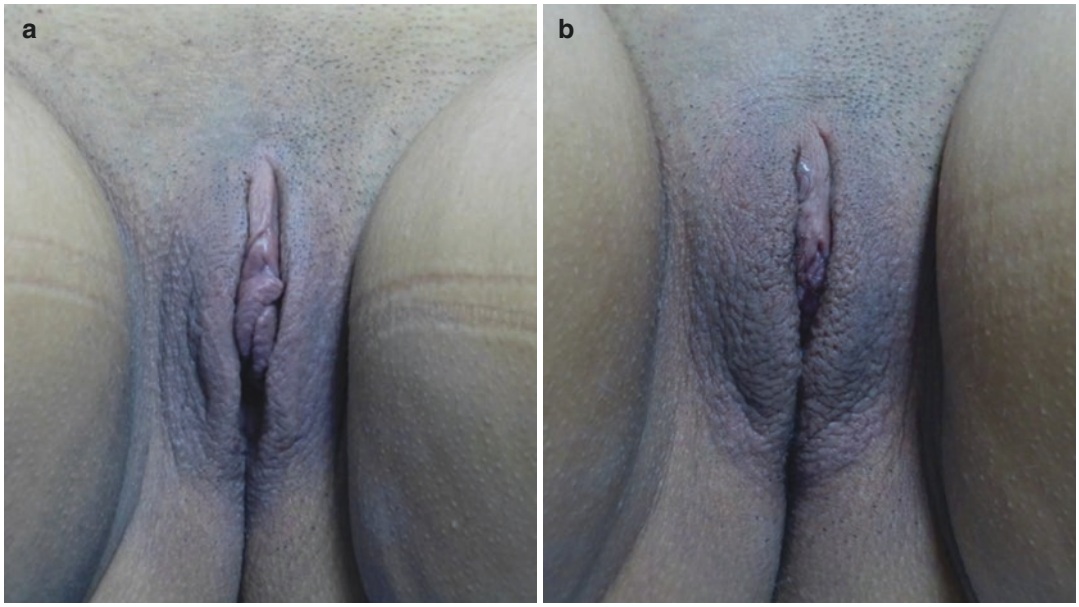

Fig. 34.3 (**a**) Atrophy of the Labia Majora. (**b**) After fat injection to fill loose skin space in labia majora

The excess oil and liquid are taken out and 10 cc syringes are filled with the fat previously taking out any trabeculae found in the fat. Fat is transfer from one 10 cc syringe to another through a connector that has a strainer (Coleman system). This is done several times making sure that when the fat is introduced in the area to be filled, there will be no need to use force to introduce it, this is done with the aim of preventing fat lakes.

Fat is injected in a retrograde manner with an 18 gauge disposable canulae in a spaghetti layered technique preventing fat lakes, fat lakes will increase complications such as fat cysts and fat necrosis. While injecting the fat, it is advisable to hold the area being injected with an index and second finger pinch to better direct injection site and prevent fat going on unwanted areas. We must not forget that the subcutaneous area has a sac-like anatomy and this is where the aim of the lipofilling should go, injecting too deep or too superficial can bring us future complications as injecting in vessel areas when too deep or when too superficial leaving visible irregularities in the skin. How much fat to inject? I was shy at the beginning never going over 15 cc on each side, today, if here is a lot of atrophy, I can easily inject 35 cc on each labia majora. Also, many times if you only inject the labia majora, you can end up with a depression like deformity in the lower pubic area, so make sure and watch for that and when observed inject also some fat on this area when required.

After injecting, massage the area to prevent irregularities and future fat cysts, also mold while injecting the Labia Majora so that the upper or anterior portion is wider that the posterior one.

Remember always to previously come to an agreement with the patient on how much fat will be injected and make them know more than 50% of the injected fat will be reabsorbed. They must know beforehand that to have a puffy appearance, they will need more than one lipofilling procedure [6]. In Fig. 34.4, you can see some of the instrument used for lipofilling procedure.

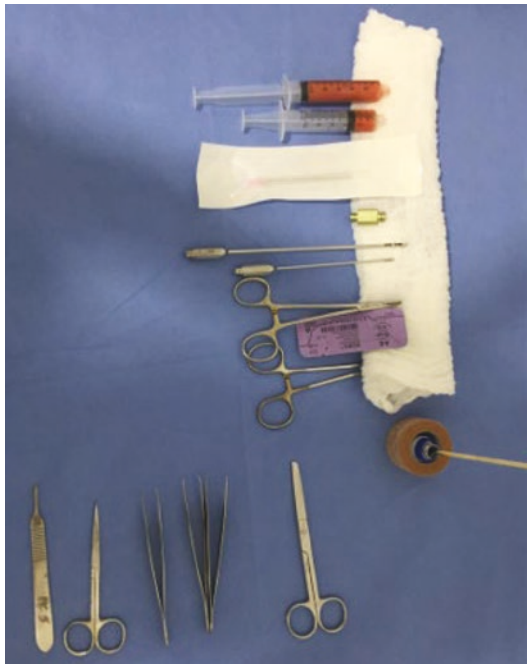

Fig. 34.4 Instruments used for lipofilling and/or resection of excess skin

34.11.3 Resection of the Labia Majora—Labia Majora Plasty

Pearl and Pitfalls

Never leave an open introitus, it does not look ugly, but worse you can have a patient with a dry and itchy vagina.

When there is too much excess skin on the Labia Majora, lipofilling will not be enough and resection must be taken in consideration.

The excision is done in an ellipse manner marked by a pinch test. Markings are the most important step in the procedure. It is advisable when marking to intend to take out less skin than what it is needed, since taking too much skin out can lead to an exposed vagina. A good way to check you will not end up with an exposed vagina can be once excess skin to be taken out is marked to put some stiches approximating the borders of the marked skin while watching for an over exposed vagina mucosa.

Fig. 34.5 Difference between hairy and nonhairy area on inner border of resection

The first marking must always be the inner or medial incision line and must be placed on the border of the inner Labia Majora hair line (Fig. 34.5). Caution must be taken not to draw this medial incision line on the hairless skin of the Labia Majora. Attempts to leave the incision too near the labia minora must be avoided since will obliterate the fold between the labia minora and majora can will promote an inner introitus exposure that can lead in the future to a dry vagina.

The external or outer incision of the ellipse to be resected must be marked medial to inguinal fold and never intend to extend it all the way to this crease since again too much external traction will be made and the vagina will end up being exposed. It is advised to leave at least 1.5 cm from the inguinal crease, or more, to the outer or lateral incision of the ellipse. If too much excess skin is present, especially in massive weight loss patients you must plan to resect less skin than that needed to prevent a future dry vagina patient. Although most patients have more laxity in the posterior one-third of their labia majora make sure you do not exaggerate the resection in this area (Fig. 34.6).

Since Labia Majora has excess subcutaneous tissue when resecting the previously marked excessive ellipse just take away the skin and leave all the subcutaneous tissue when filling is also needed. Also, since this skin has hair make sure

Fig. 34.6 (**a**) Excess skin to be resected. (**b**) Scar on inner border of Labia Majora hair line. (**c**) Final result after resection and healing process

no hair follicules are present in the area before suturing.

Make sure when suturing the incision borders are everted to prevent an inverted scar: suture in a subcutaneous manner with the preferred skin closing suture. I regularly use vicryl 4-0 for the internal sutures done in two layers, one deep with individual stiches and one more superficial but deep on the skin in a subcuticular manner, suturing is ended with subcuticular 4-0 prolene suture.

34.12 Mont Venus Pexy—Mont Venus Plasty

Usually when there is excess skin for a tummy tuck there is also the need to lift the Mont Venus region so many mont venus palsty are done in the same surgical procedure when a tummy tuck is done. The markings are best done both in a standing and sitting position while showing the patient how long can the scar be. Trying to achieve a good result through a very small incision is not a good idea, if you have excess skin you need to resect skin and resecting skin means having a scar that can end begin even longer than a C section. It is important to discuss this with the patient previous to the surgery so you can proceed freely and take excess skin when needed without worrying about dog ears.

The markings are done pinching the excessive skin upwards trying to leave the scar where the natural lower abdominal crease is situated. The skin to be resected is marked in an ellipse shape (Fig. 34.7). Careful revision of how much skin to be resected must be made before starting skin excision (Fig. 34.8). Some patients prefer a lower scar than their natural crease so discuss this with the patient but make sure to remember her the best scar is achieved at the natural crease.

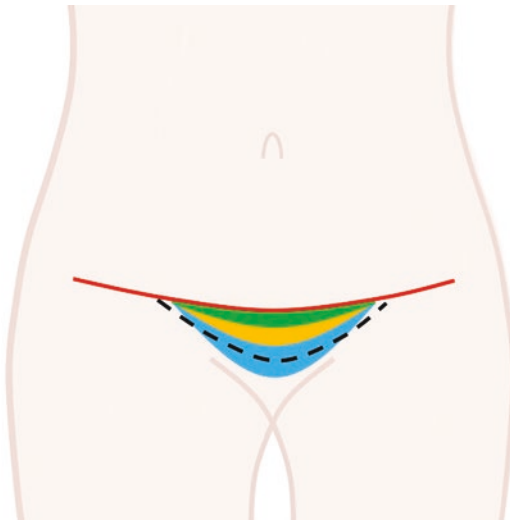

Fig. 34.7 For a Mont Venus Pexy the skin to be resected is marked in an ellipse shape

Fig. 34.8 Careful revision of how much skin to be resected must be made before starting skin excision on a Mont Venus Plasty

This time skin and subcutaneous tissue from the lower border of the ellipse is incised, and dissection at the level of the abdominal muscle fascia is continued in an upward manner. Once the dissection is at the level of the upper border of the previously marked ellipse, the surgeon checks if more or less skin must be resected. The upper border of the ellipse skin is resected. Dissection on the upper and lower borders of the excised ellipse must be dissected to bring together in a layer by layer the scar borders in a no tension approximation manner. More dissection is generally done on the upper border, you will need to see the rectus fascia if you are doing a pexy. Constant checks must be done on how much is dissected on the inferior border to prevent too much of a pull on the external genitalia.

Before starting the layer by layer closure always put at least 3 deep sutures on the inferior pubic tissue to bring it to the rectus fascia, these stiches are done with vicryl 0. Afterward 3-0 vicryl sutures can reinforce the area as needed and deep subcuticular vicryl 3-0 suture is done. Skin closure is finalized with subcuticular continuous prolene 4-0.

If too much tissue has been dissected, it is a good idea to leave a drain. When I use it, do not

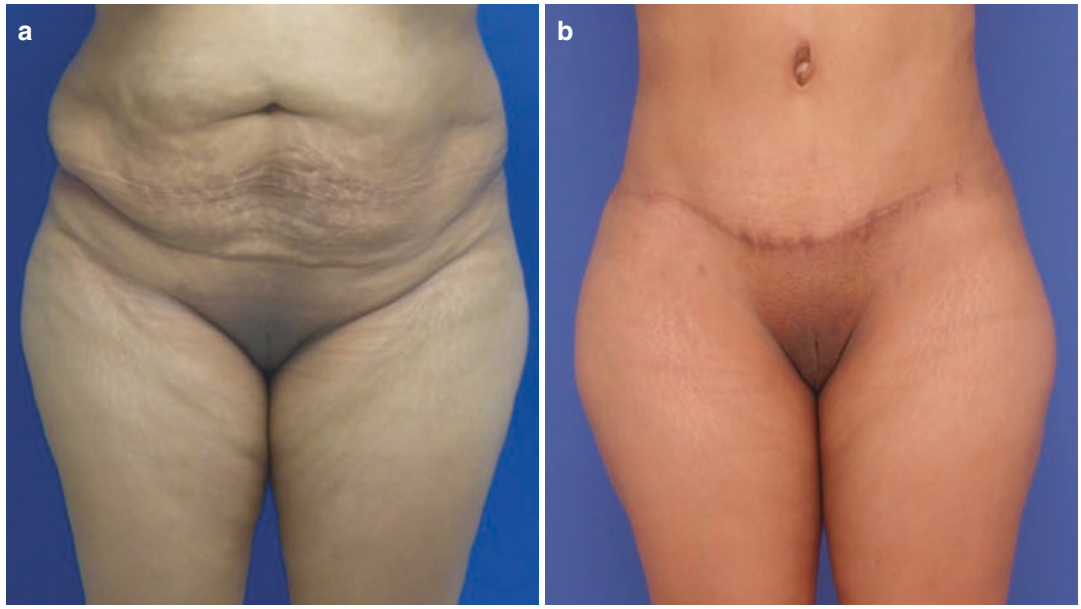

Fig. 34.9 Before (**a**) and after (**b**) Mont Venus Plasty pictures

do it all the time, I use a close drain system. Ideally scar should be concealed in natural lower abdominal crease (Fig. 34.9).

34.13 After Care and Complications

It is advisable to have the area as dry as possible especially the labia majora region, so no tight clothing for a week after the procedure and best to keep the area as ventilated as possible.

When a Mont Venus pexy is done, it is a good idea to prevent the patient from an upright position for a week to prevent the pexy sutures to rupture, remember the skin has been attached to the rectus fascia.

Sexual intercourse and exercising should be discontinued for at least 6 weeks.

Major complications in these regions are rare, but infections, hematomas, and suture dehiscence's can happen, making in necessary many times for an reintervention to take place.

34.14 Showing Scarring

Pearl and Pitfalls

For those patients that do not accept a scar and have a Latin background, you can offer a nonsurgical option: although skin can be tightened, fatty tissue will be eventually lost.

Since we are suturing skin and not mucosa when performing a Labia Majora or Mont Venus plasty, stitching is generally done as when suturing skin in any other body part, so it is important to leave incision borders everted to prevent a depressed incision.

Also, it is important to always let the patient know, especially if they have a Latin origin and/or they have dark color in the Labia Majora skin that the scar can be visible, can end up being whiter that the rest of the skin and being more noticeable (Fig. 34.10).

Fig. 34.10 Showing scar

34.15 Exposed Vagina

A frequent complication especially when starting to perform a surgical Labia majora reduction procedure is ending up with an exposed vagina (Fig. 34.11). This is why although tempted to leave a concealed scar by planning the inner incision in the natural fold between the Labia Majora and the Labia Minora, when not respected the nonhairy skin of the labia majora, we can end up with an exposed and opened vagina that will leave the patient with a dry vagina condition especially when menopause comes.

Also, when a big excess skin in the area is present and the lateral skin excision is planned on the crural crease again a high risk of ending up with an open vagina will be present. In these patients, it is preferable to plan leaving some excess skin and summing up to the procedure lipofilling of the labia majora in the same surgery than ending up with a patient with a dry vagina [3].

Fig. 34.11 Exposed vagina

34.16 Exposed Clitoris

Also ending up with an exposed clitoris hood and overall pulled-up genital appearance can also be seen when too much skin is resected in a Mont Venus plasty. This deformity can even be seen after a tummy tuck when too much skin and a too low tummy tuck incision is intended. A pulled-up genital appearance is not appealing but what is worse is an overexposed clitoris head that can be very annoying to any woman to the point that she can just do not wear any rough and tight clothing.

34.17 Fat Cysts

Pearl and Pitfalls
Prevent fat lakes during lipofilling, so cysts do not appear in the picture.

Fat cysts can always be present after fat injections and since in this area large amounts of fat must be injected to have good results, remember there is a higher rate of fat reabsorption in these areas [7].

Fat cysts rarely are visible, they usually are referred by the patient as an incidental discovery and are painless but in some cases can hurt when touched.

In some cases, it is advisable to inject the cyst with corticosteroids, this can help to decrease the size, but there is no evidence to prove this: as per the experience gained by our author, this might have been possible due to secondary atrophy of the hypertrophic scars.

Usually when a fat cyst is present, even when painful, massage must be done regularly in the cyst. Some decrease in size with massage and time. Very rarely a fat cyst in this area must be surgically removed.

34.18 Fat Reabsorption

Fat reabsorption in the genital area happens in a higher percentage than in other body region, fat reabsorption has been observed by the author to be more than 50% in this area. This is why it is advisable to fill more than what is needed so we can end up with some volume. Need to know that the more we inject the higher the risk of developing fat cysts for the patient.

34.19 Ptosis

Ptosis can be present after a Mont Venus pexy since it is difficult to kep the lifted tissue up, this is shy it is so important to really make a good fixation on the rectus fascia [8, 9].

34.20 Nonsurgical Techniques

Pearl and Pitfalls

When there is real excess skin nonsurgical tightening technologies will just not be enough and you must be clear with the patient to prevent false expectations.

Nonsurgical options can be used to both enhance or tighten skin in the Labia Majora and Mont Venus regions.

When not much filling is needed fillers such as hyaluronic acid can be used in the area specially when wanting to reduce wrinkles and a no need for a real filled up appearance of the Labia Majora (Fig. 34.12). When hyaluronic acid is used, I personally use Voluma form Allergan, if it is injected deep in the subcutaneous layer, it will go to the fat compartment and will be lost,

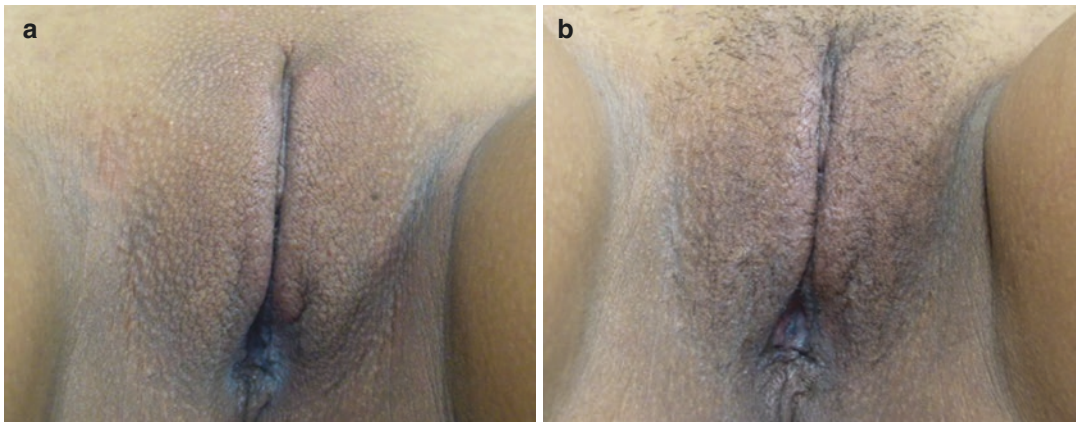

Fig. 34.12 Before (**a**) and after (**b**) 5 radiofrequency sessions on labia majora

intending to really fill this area as when done with lipofilling would demand too much product and would be too costly. Injections can be done with canulae 18–21 gauge but in this case need to be injected first the area with local anesthesia. Xylocaine 1% is used and infiltration is done in a more lateral way to prevent losing natural parameters with the infiltration injection. Hyaluronic acid injections can also be done with needle but many puncture sites need to be done, so in these cases topical anesthesia a is done one hour before the procedure. Other fillers different than hyaluronic acid can also be used but remember this area needs to be soft and there is no presence of a hard and bony structure under the injected area so if the injected area ends up feeling hard it will not be a natural result.

Also, nonsurgical technologies used for skin tightening in other areas can also be used in Labia Majora and Mont Venus but with low expectations since it is not advisable to repeat the procedures regularly because many of these technologies include hot temperatures in the area that when applied repetitively can end up decreasing the subcutaneous or fatty tissue, something we do not want happening in these regions that need to have a puffy appearance. One of the most popular nonsurgical devices that I use for tightening the labia majora is a monopolar radiofrequency doing one weekly treatment for at 5 sessions, some patients may need a total of 10 sessions. In most of these patients I also advice the use of a filler at the end of the radiofrequency treatment.

Hyperpigmentation in the area is more common in the Labia Majora region and can be treated with depigmentation creams, chemical peels and lasers. Important to let the patient know when using lasers or chemical peels that more than one treatment will be needed, usually more than three and that the procedure lightens the color but will never leave the area white. Also, since the patient will keep on experiencing friction in the area, hyperpigmentation will keep on taking place as part of their skin condition.

34.21 Nonsurgical Techniques Complications

When nonsurgical heat-producing devices are used for skin tightening, we can end up decreasing fatty tissue in the area where applied, this is why it is important not to abuse these skin-tightening treatments in the Labia Majora and Mont Venus regions, since we will end up with atrophic not pleasing areas.

When using chemical peels and/lasers for skin lightening, it is very important to let the patient know that complications such as hyperpigmentation can be present after the procedures, even darker tones that the ones that the patient experienced before the treatment. In Latin skin patients, this hyperpigmentation risk after the lightening procedure can be as high as 30%.

34.22 Conclusions

The Labia Majora and Mont Venus are the most visible regions of the external genitalia making them appealing to work on when seeking for aesthetic results in the area especially after possible changes with motherhood.

Although we are working in the genital area these two regions have skin and not mucosa making them more surgeon challenging for scars to fade with time.

Resection techniques for reducing excess skin and pexy surgeries are the most commonly used in the regions as well as lipofilling when volume is needed.

Overall when planning a Labia Majora and Mont Venus aesthetic procedure, it is very important to listen to the patient first to better understand what she wants, set the right expectations, and bring into the equation the external genital area as a whole.

As with any other external genital structures, a good treatment plan for the genital area must be managed as a whole and not only for a specific subregion, only by doing so we can end up with optimal results [7].

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Vaginoplasty and Perineoplasty

35

Melihcan Sezgic and Percin Karakol

Take-Home Points

- Vaginal rejuvenation is a surgical combination of procedures such as tightening the vaginal canal and its opening, excision of unnecessary vaginal tissues and skin, suturing the levator muscles, and reshaping the perineal body.
- Female sexual dysfunction is a multifactorial problem, not only have physiological causes but also have a strong psychological aspect too. It is crucial to obtain proper patient history before surgery.
- Approximately 50% patients who demand for surgery has additional medical problems related with birth such as urinary incontinence, fecal incontinence, perianal tears, etc.
- Vaginal rejuvenation procedure focuses on the posterior vaginal wall, which is the most popular approach, also posterior approach is the best technique for maintaining muscle wall integrity.
- The satisfaction rate increases when vaginal rejuvenation is combined with other genital aesthetic surgeries (labioplasty, lipoinjection, clitoral hood reduction, etc.)

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/978-3-030-43840-1_35.

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35.1 Introduction

Healthy sexual life is very important for relationships, as it affects life quality, especially the self-esteem of partners. Vaginal laxity is the main cause of sexual dysfunction in postpartum women. Also, it is a self-reported medical condition, which can affect woman's sexual enjoyment and satisfaction [1]. Although there are other causes of vaginal laxity, the most common cause is normal vaginal delivery. The muscles that surrounds the vagina weakens and separates due to the excessive stretching of vagina during delivery, causing postpartum vaginal laxity. Because of the perineal and vaginal muscle defects, which are formed after delivery, friction sensation decreases and this causes an impairment of sexual satisfaction [2].

Vaginal tightening procedures have gained attention in recent years and it may not be correct to consider them merely as a cosmetic surgery. Sexual dysfunction is a common problem in postpartum women that may lead to loss of confidence a self-esteem. Sexual dysfunction due to the reasons, such as dyspareunia, difficulty to reach orgasm, decreased libido, is common in women up to 40%, who had vaginal labor [3]. Although there are a limited number of studies in the literature, it has been shown that vaginal tightening procedures correlated with improved sexual function and low complication rates [4].

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_35

35.1.1 Vaginal Rejuvenation

The term vaginal rejuvenation(VRJ) includes vaginoplasty and/or perineoplasty as surgical procedures that tighten the vaginal barrel and strengthen the perinal body [5]. The American Society of Plastic Surgeons reported a 30% increase in vaginal rejuvenation procedures between 2005 and 2006 [6]. Although statistics have not been available since 2006, it is not difficult to guess that vaginal rejuvenation procedures are increasing day by day.

VRJ is a surgical combination of procedures such as tightening the vaginal canal and its opening, excision of unnecessary vaginal tissues and skin, suturing the levator muscles, and reshaping the perineal body. The surgical technique used in VRJ is very similar to classical colporrhaphy in pelvic floor defects and vaginal prolapse surgery. VRJ is a procedure, which is often associated with perineoplasty; it includes removing adequate amount of tissue from the perineum and tightening the vaginal introitus.

35.1.1.1 Perineoplasty

Surgical reconstruction of vaginal introitus called perineoplasty. As previously described in the literature, removal of perineal skin and distal vaginal mucosa, approximation of bulbocavernosus muscles and superficial transverse muscles is the aim of the perineoplasty surgery [7]. This is usually performed by removal a wedge diamond-shaped tissue involving; the posterior lower one-third of the vagina and the perineum superior to the anus. After the resection of skin, mucosa, and fibrotic scar tissue, the levator muscles are reapproximated and the defect is repaired vertically. As a result of the elevated and strengthened perineum, vaginal orifice is narrowed, potentially visual appearance and sexual function is improved.

35.1.1.2 Vaginoplasty

Excision of mucosa from vaginal fornices is called vaginoplasty. Unfortunately, there is no standard method in this procedure. Excision procedures can be performed as anterior colporrhaphy, posterior colporrhaphy, and lateral colporrhaphy. Since postpartum vaginoplasty is usually combined with perineoplasty, posterior colporrhaphy can be considered as a more suitable method. Lateral colporaphy is preferred more frequently in nulliparous women as they have a strong vaginal muscle integrity.

35.1.2 Anatomical Highlights

35.1.2.1 Vagina

The vagina consists of a mucosal epithelium that is supported by fascia, fibroconnective tissue, loose areolar tissue, and muscle layer (Fig. 35.1). Moreover, there is not sufficient muscle support in its mid-distal portion, so it is also supported by superficial transverse perineal muscles and levator ani muscle [4]. Also the vaginal mucosa is very elastic, allowing the baby's head to pass through it without any perineal muscle tears. However, obstetrical interventions and incidents such as multiple and long lasting labor, forceps usage during labor and a large fetus, consequently alters the muscular and fibroconnective tissue support, resulting in loose and widened vagina. As well as obstetrical reasons, genetic factors and age are also cause vaginal laxity too.

Key Points

From superficial to deep, there are three different layers in vaginal epithelium(Mucosa, Hypodermis, Muscle). Posterior wall of vagina is very close to anal cavity, so this must be considered in surgery.

35.1.2.2 Perineum and Pelvic Floor

As shown on Fig. 35.1, perineum is a fibromuscular connective tissue located between vaginal orifice and anal canal.

The perineum is the zone of junction of the pelvic muscles. As it also provides structural support to the vagina, obstetrical perineal injuries usually cause a dilated vaginal introitus and sensation of wide vagina. Multiple labors and episiotomies usually cause a deformity of perineal muscles as well as the vaginal orifice (Fig. 35.2).

The pelvic floor consists of the levator ani muscle (3 parts; Iliococcygeus, Pubococcygeus,

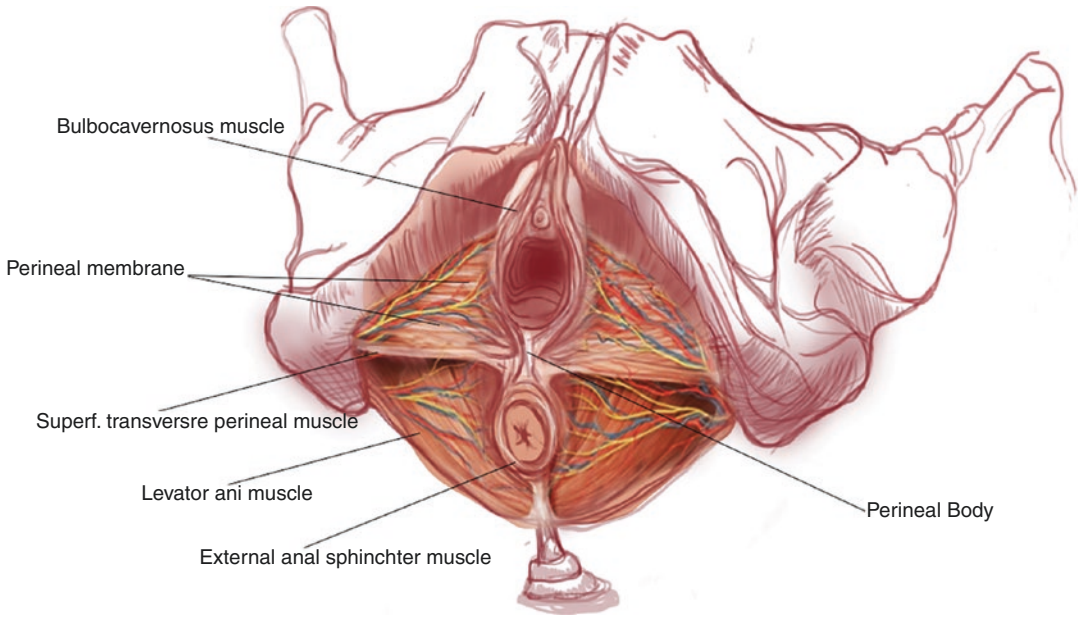

Fig. 35.1 Perineal anatomy

Puborectalis), the coccygus muscle, and the fascia of the muscles. It is a funnel-shaped structure that surrounds the vagina and anus. This structure weakens during normal vaginal delivery and causes pelvic floor dysfunction. Also, incontinence symptoms may appear after complicated vaginal births.

35.1.2.3 Changes in the Postpartum Period

Due to the increased progesterone hormone during pregnancy and the psychological problems associated with pregnancy, the woman feels sexually inadequate and ugly during pregnancy. Progesterone hormone also reduces vaginal secretions, and can cause vaginal thinning and dyspareunia too. Women usually do not complain about vaginal laxity in the early postpartum period, because the vaginal relaxation, which occurs after vaginal delivery, reduces the dyspareunia, which is caused by vaginal scar formation and progesterone. So, until the start of the first menstrual period after birth (about 6 months), women do not complain about vaginal laxity, since vaginal laxity minimize dyspareunia. Nevertheless, vaginal secretion increases after the start of menstrual period and the vaginal laxity disturbs women during coitus. Therefore, request for vaginal rejuvenation approximately occurs 6 months after vaginal labor.

The relationship between vaginal laxity with pregnancy and childbirth has been agreed, but its pathophysiology is not fully understood yet [8]. It is thought that, due to the sudden increase in the size of the levator ani muscle(microtrauma) and macrotrauma that occurs via avulsion of the levator ani muscle, may play a role in the pathophysiology [9]. There is no objective or standardized diagnostic test for vaginal laxity, so it remains to be a self-reported problem in postpartum women.

A magnetic resonance imaging(MRI) study compared MRI findings of primiparous women who had undergone vaginal delivery and nulliparous women [10]. According to their findings, levator ani muscle tears(especially pubococcygeus injuries) were present in primiparous women in contrast to nulliparous women.

35.1.3 Effects of Vaginal Delivery

Most women are concerned that vaginal delivery will cause a loose vagina and will adversely

Fig. 35.2 Damaged perineal body with wide vaginal orifice and extensive scarring due to multiple previous episiotomies (39 year-old patient, G3P3)

affect their postnatal sexual life. For this reason, approximately 59% of cesarean births are the women who prefer cesarean delivery instead of vaginal delivery [11]. It can be said that this is both true and false at the same time. Cai et al. [12] compared women who had vaginal delivery with who had caesarean delivery about the affect on postnatal coitus. According to their study, there was a significant difference between the two groups in terms of intravaginal pressures, that they were significantly lower in the vaginal-delivery group than those in the cesarean-delivery group. On the other hand, there was no important difference between two groups about their female sexual function index(FSFI) scores, which includes foreplay time and sexual satisfaction. However, there was a notable difference in the coitus time. In the light of these results, there may be a vaginal laxity after the vaginal labor, but this has not been shown to affect sexual function of postpartum women [12].

There is also a discrepancy about this problem. The study that mentioned above is only investigate sexual satisfaction on women. Since vaginal orgasm rate in women is lower than clitoral orgasm rate in the population, we can assume that women interpret her sexual satisfaction through clitoral orgasm. Since there is not enough study on the sexual satisfaction of the partners of postpartum women, the effect of vaginal birth on sex life remains unclear.

In addition to the abovementioned, the contraction of the pubococcygeal muscle, which is a pelvic floor muscle, is also required for the formation of clitoral orgasm in women. Therefore, the repair of the pelvic floor muscles can contribute to sexual satisfaction, in patients with pelvic floor dysfunction.

▶ **Important** Female sexual function is not affected by the types of labor, but there is not enough evidence of the effect of vaginal labor on sexual life of partners.

35.1.3.1 Episiotomy

Episiotomy is one of the most commonly performed surgical procedures in gynecology, which is first described in the eighteenth century [13]. The aim of the episiotomy is the widening of the birth canal, aid the exit of the fetal head, also it is associated with reducing the morbidity of vaginal birth by decreasing the possibility of spontaneous perineal tears. However, in recent years, there is a trend toward a more restrictive use of episiotomy, because the scientific data indicates that the routine use of episiotomy may increase the risk of perineal trauma [14].

Although episiotomy is performed to prevent perineal trauma (anal sphincter, rectum) during vaginal labor, it may also result in some delayed complications such as deformation of anatomic structures, widening of episiotomy scar, dyspareunia, and sexual dysfunction [15].

Fig. 35.3 Photo of a 45-year-old patient, demonstrating relaxed introitus and a muscle wall defect on the previous episiotomy area

For women who undergone episiotomy in her previous labor, there is almost always a muscle wall defect in the area of previous episiotomy scar (Fig. 35.3). So previous episiotomies should be questioned before the surgery and also the episiotomy scar should be evaluated for revision, because this is important in determining the surgical plan of patient.

35.2 Patient Selection

As there is no valid questionnaire to evaluate sexual dysfunction of the patients, a complete medical, gynecologic, sexual history should be questioned. It is important to examine the patient alone, without her partner. This allows the patient to communicate their demands more sincerely. Undoubtedly, before the surgery, great percentage of women claimed that their partner wanted to feel a tighter vagina besides their own desires [16]. Majority of the women who applied to clinic for the surgery request usually had a pleasing sexual life before their pregnancy and want to regain their satisfactory sexual life. However, sexual dysfunction is a highly complex and multifactorial issue that may easily be affected by the patient's psychological situation. Therefore, the psychological history of the patient must be questioned before the surgery.

▶ **Important** Female sexual dysfunction is a multifactorial problem, it not only has physiological causes but also has a strong psychological aspect too. If any psychological concerns are spotted during the first interview, psychological counseling should be done before the surgical procedure.

Since urogynecological diseases such as pelvic floor dysfunction and bladder prolapse may be presented as sexual dysfunction, the patient should be questioned for urogynecologic background. According to Moore et al. [17] who took a detailed medical history from the patients that requested for vaginal rejuvenation surgery, they found out that 50–75% of patients had problems such as urinary incontinence, voiding dysfunction, defecatory dysfunction, and dyspareunia. Since the vaginal rejuvenation procedure cannot adequately correct the defects due to prolapse, any existing prolapse(uterine prolapse, enterocele, and cystocele) should be corrected prior to vaginal rejuvenation surgery or preferably simultaneously. Therefore, it is critical to analyze the patient in depth by asking the right questions in order to understand the symptoms of any prolapse.

Patients that requested for vaginal rejuvenation surgery should be informed about the risks of the procedure. The risks includes wound dehiscence, bleeding, infection, pain, scars, reduction in sexual satisfaction, or other reasons [16]. Since there are no usable long-term data on

the effectiveness or safety of these procedures, it is necessary to give the patient elaborate information about the procedure [16, 18].

! Attention
Because there is not an adequate certain evidence to support any of the vaginal rejuvenation surgery from the standpoint of improvement to sexual satisfaction or self-esteem, it would be a mistake to explain to patients that these surgical procedures will *absolutely* enhance sexual satisfaction.

35.3 Preoperative Evaluation

Sexual dysfunctions, which includes problems such as dyspareunia, decrease in sexual desire, and orgasm problems, are common disorders in society [19]. Although the cause of the majority of patients admitting hospital for VRJ procedures is sexual dysfunction, cosmetic reasons also play a role for the surgery. Moreover, some authors have come up with a concept of "Genital beautification" that involves combination of some female genital cosmetic surgery techniques (labium minor reduction, vaginal rejuvenation, labial brightening, and mons pubis liposuction) [20]. Since we live in a digital age, such combined procedures have gained popularity rapidly (Fig. 35.4).

Due to the rapid trend of these procedures, there has been an increase in the demand for additional surgical procedures in recent years, even in the patients presenting with only vaginal laxity request. We think that performing perineoplasty together with other cosmetic genital surgical procedures increases the satisfaction rate of the surgery and also the quality of sexual life of the couple.

Because most of the women who are interested in vaginal rejuvenation procedure may also have prolapse (cystosele, rectocele, uterine prolapse, etc.) at the same time, existing prolapse should be diagnosed preoperatively and must be repaired before the vaginal rejuvenation.

Fig. 35.4 Perineoplasty combined with labioplasty and labia majora lipofilling

Table 35.1 Comparison of vaginal dimensions, Introitus width; transverse measurement 1 cm above the level of the introitus; surface contact; total of transverse measurements of four sites in upper and lower vagina, length; total linear length of the vagina. (Adapted from *Barnhart* et al. [21])

	Introitus width	Surface contact	Length
Mean (mm)	26.1	143	62.7
Range (mm)	18.7–37	106.8–185	40.8–95

The common feature of the patients who requested for surgery was that they were multiparous and were older than 40 years. And about 50% of these patients had urinary incontinence that did not respond to medical treatment. In these patients, transobturator Tape (TOT) surgery was also performed before vaginal rejuvenation procedure. TOT is a surgical procedure, which is technically based on placing a propylene mesh through the obturator foramen underneath the mid part of urethra.

Age, parity, height, and weight are important parameters about vaginal dimensions and they should be noted on first patient interview [21]. Although the relationship between the vaginal measurements cannot be certainly proved, the variation of the human vaginal dimensions (Table 35.1) for each patient may cause a change in the surgical excision size for vaginoplasty.

35.3.1 Physical Examination

Preoperative examination should be performed on both lithotomy and standing position. Since some patients also asked for labia minora reduction, the standing position is ideal for assessing the ptosis of the labia minor. While the patient is on lithotomy position, posterior vaginal wall integrity should be controlled carefully with vaginal speculum in order to evaluate any infection, discharge, and muscle defect. Also when the patient is at the examination table, the patient should be checked for presence of any prolapse while the patient is straining. Sometimes an asymptomatic and mild degree prolapse can be discovered in this way.

Preoperative gynecological consultation should be done in patients with prolapse, urinary incontinence, and vaginal discharge. Also preoperative gynecologic consultation might be considered in patients who have not had gynecological examination for more than 6 months. In patients with vaginal discharge, the operation should be planned after the treatment is completed and the discharge has ended.

In addition, a hand mirror can help to better understand the patient's requests. Therefore, it is more convincing to describe surgical procedures with the help of a hand mirror that the patient can see herself. Better understanding of the procedures to be performed makes her feel more comfortable about the surgery and assists in the postoperative rehabilitation process.

35.4 Anesthetic Considerations

Surgery can be performed under epidural anesthesia or general anesthesia. General anesthesia should be preferred if other procedures are combined simultaneously(such as fat injection, TOT). Since epidural anesthesia has a higher risk of urinary retention, general anesthesia is preferred on routine.

Also, pudendal block can be applied for analgesia after surgery. Lidocaine 1% or bupivacaine 0.25% are the most commonly used solutions for procedure. Bupivacaine 0.25% is recommended for postoperative long-term analgesia(up to 5 h).

Using *only* local anesthesia is not advised for perineoplasty procedure.

As general anesthesia makes the both patient and surgeon more comfortable during procedure, we prefer general anesthesia in vaginal rejuvenation surgery.

35.5 Surgical Technique

Because of the main aim of vaginal rejuvenation is to reduce the vaginal diameter and restore it back to prechildbirth state, it is essential to achieve vaginal muscle integrity to achieve this

goal. Repair of the posterior vaginal wall and the introitus are key elements in VRJ procedure [17].

Posterior vaginoplasty, when combined with perineoplasty, is an advantageous technique for the woman, because it increases the grip sensation of the penis on sexual intercourse. There is an increasing trend for posterior technique, since muscle repair and plication with tightening of the vaginal introitus are thought to be the most effective method to increase sexual pleasure. Moreover, as mentioned before, the term vaginal rejuvenation also focuses on posterior vaginal wall too.

Key Points

Prophylactic or postoperative systemic antibiotherapy is not necessary for surgical procedure.

35.5.1 Patient Positioning

After general anesthesia is performed, patient should be adjusted for lithotomy position unless additional procedures will be applied. Vaginal rejuvenation surgery can only be done in the lithotomy position.

The lithotomy position that provides the best surgical access is standard lithotomy position. It requires the legs to be separated from the midline into 30–45 degrees of abduction, with the hips flexed until the thighs are angled between 80 and 100°. Because the lower legs should be parallel to the plane of the torso, the legs are placed into stirrups, with the knees bent [22].

35.5.2 Procedures Step by Step

35.5.2.1 Surgical Markings

Surgical markings should be done when the patient is under general anesthesia and positioned properly. *There is no single surgical plan, each patient have to be evaluated differently*. For perineoplasty, a triangular-shaped marking should be made; base is placed at vaginal introitus and the apex is placed at the perineum.

Perineoplasty

The center line of the markings should be done carefully at 6 o'clock position so as not to deviate the perineal raphe (Fig. 35.5).

Since the previous episiotomy incision site is the most important point that disrupts the muscle integrity of the posterior wall, in some cases, perineoplasty surgical drawings may be modified according to this region in patients who have previously undergone an episiotomy procedure. Also, perineal skin resection is not essential for every perineoplasty operation. Perineoplasty can be performed in selected cases without skin excision.

Vaginoplasty

Vaginoplasty markings should also be made in the form of a triangle; base is placed at the vaginal introitus, apex is placed approximately 10 cm proximal to vaginal introitus (Fig. 35.6).

As indicated in the literature, a trapezoid- or diamond-shaped drawing pattern(apex in the proximal one-third of the vagina and the nadir on the perineum superior to the anus) generally applies for combination of perineoplasty and vaginoplasty [17] (Fig. 35.7).

Key Points

Rectal touch is performed before starting surgery and the integrity of the posterior vaginal wall is checked again.

35.5.2.2 Surgical Procedure

(See Table 35.2 *for step by step procedure)*

The labia minora retractor can be used if present, otherwise securing the labia minora to the skin with suture provides sufficient visibility.

Local anesthetic solution is prepared by mixing 5 vials of 2% Lidocain that also includes epinephrine (2 mL) with 10 cc saline solution; 20 mL of local anesthetic infiltration is performed on the posterior vaginal wall and perineum according to fanning technique before starting the procedure. Local anesthetic infiltration is not only done to reduce intraoperative bleeding but also for hydrodissection.

Fig. 35.5 Perineoplasty surgical markings. The blue area indicates the resected skin

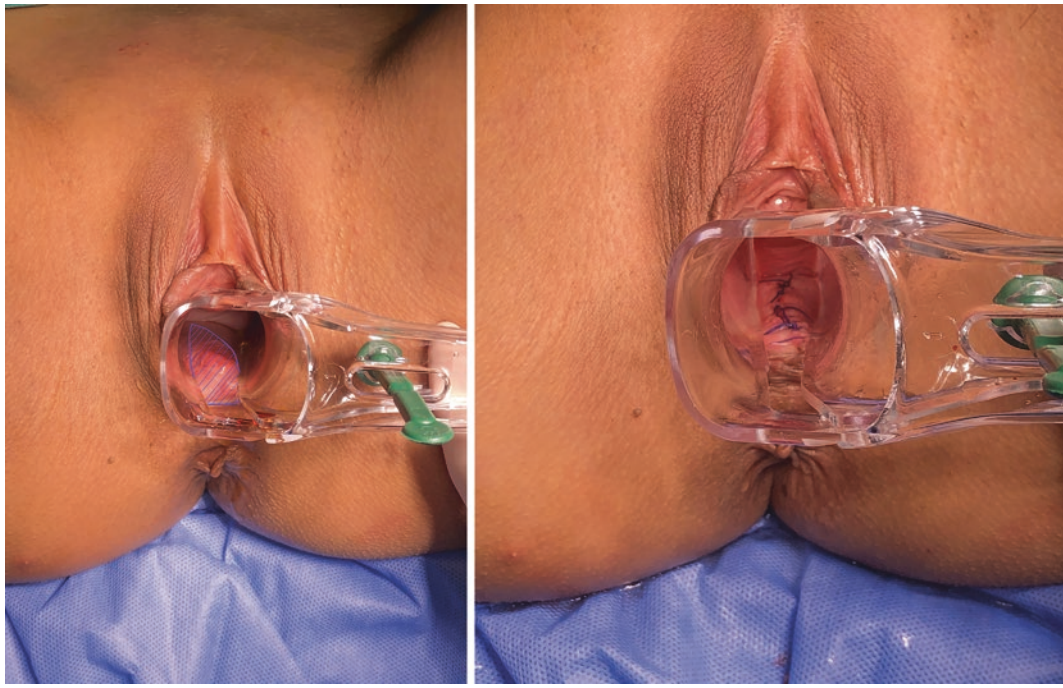

Fig. 35.6 Vaginoplasty resection pattern (marked in blue)

After waiting for at least 10 min for the epinephrine to take hemostatic effect, posterior vaginal wall excision is performed according to surgical markings, vaginal mucosa is elevated with both sharp and blunt dissection till the levator muscles are exposed. Before and after excision, vaginal diameter is frequently measured by surgeon's fingers. Dissection can be done according to surgeons preference; blade, scissors, electrocautery, or laser (Video 35.1).

Subsequently, meticulous hemostasis is achieved with bipolar cautery prior to closure. Closure of the incision site is started from the muscle layer. For narrowing the vagina diameter, rectovaginal fascia plication is performed routinely with PDS 2-0 sutures (Video 35.2). If there is excessive vaginal laxity, levator plication can be performed, but overplication should be avoided, since it may cause dyspareunia. Thereafter, vaginal mucosa is closed using Vicryl 3-0 sutures proximal to distal in a running fashion.

! Attention

It is important to preserve the perineal raphe in surgery.

Likewise, perineal excision is performed by descending to the muscles(superficial transverse perineal muscle and bulbocavernosus muscle), including the mucosa and submucosal area. Extra skin that removed from the perineum provides a cosmetically good appearance as well as narrowing the outer introitus. Afterwards, hemostasis is achieved with bipolar cautery. For closure of perineal site; bulbocavernosus and superficial transverse perineal muscle ends are sutured to each other with PDS 2/0 sutures. The mucosa is closed using Vicryl 3-0 sutures too.

Important

If the outer introitus caliber is narrower than the inner introitus, it can often rupture during intercourse and cause pain.

After closure of surgical incisions, topical antimicrobial agents containing Bacitracin,

Fig. 35.7 Diamond-shaped perineoplasty-vaginoplasty excision pattern

Table 35.2 Stages of the surgical procedure

Surgical procedure step by Step	Figure, Video
1. Provide sufficient visibility • Labia Minora Retractor or • Temporary fixation of l.minora to skin	7b
2. Surgical Markings	7c, 7d, 9a
3. Local anesthetic infiltration • Should be done after marking, before excision	8a
4. Vaginoplasty excision & closure • Excision—Distal to proximal • Closure—Proximal to distal	Videos 1 and 2, 8b, 8d, 11c, 12a
5. Perineoplasty excision & closure	14a, 14b
6. Topical antimicrobial application & Dressing	–

Neomycin, or combination of them are applied to surgical incisions. Afterward, a sterile soft gauze is placed on the genital area. There is no need for large intravaginal dressings. Routine postoperative bladder catheterization is not necessary.

35.5.2.3 Case Reports

Case 1

- 35 year old, G2P2 patient (2 vaginal labor).
- Sexual dysfunction and vaginal laxity complaint, labioplasty demand.
- Perineoplasty, vaginoplasty, and labioplasty procedures were performed.
  - There was a poorly healed episiotomy scar in the inferolateral part of the vagina (Fig. 35.8a). Also, there was a defect in the inferolateral part of the vaginal introitus (the area indicated by the arrow) (Fig. 35.8b).
  - After local anesthetic infiltration (Fig. 35.9a), vaginoplasty mucosal resection was made (Fig. 35.9b), the defect was sutured in running fashion, and vaginal introitus integrity was restored (Fig. 35.9c and d).
  - Perineoplasty was performed according to modified perineoplasty marking (Fig. 35.10a, b).
    Perineal muscles are approximated (Vicryl 2-0).
  - Labioplasty markings was made (Hockeystick method) (Fig. 35.10c, d).
  - Dog ear excision may be planned if necessary (Fig. 35.11).

Case 2

- 34 year old G3P2 patient (2 C/S).
- Vaginal Laxity complaint.
- Vaginoplasty and lipoinjection to labia majora were performed. Patient did not agree to the labioplasty procedure.
  - Patient had a loose posterior vaginal wall on examination (Fig. 35.12a). Posterior vaginoplasty was planned as the laxity was found only in the posterior wall (Fig. 35.12b).

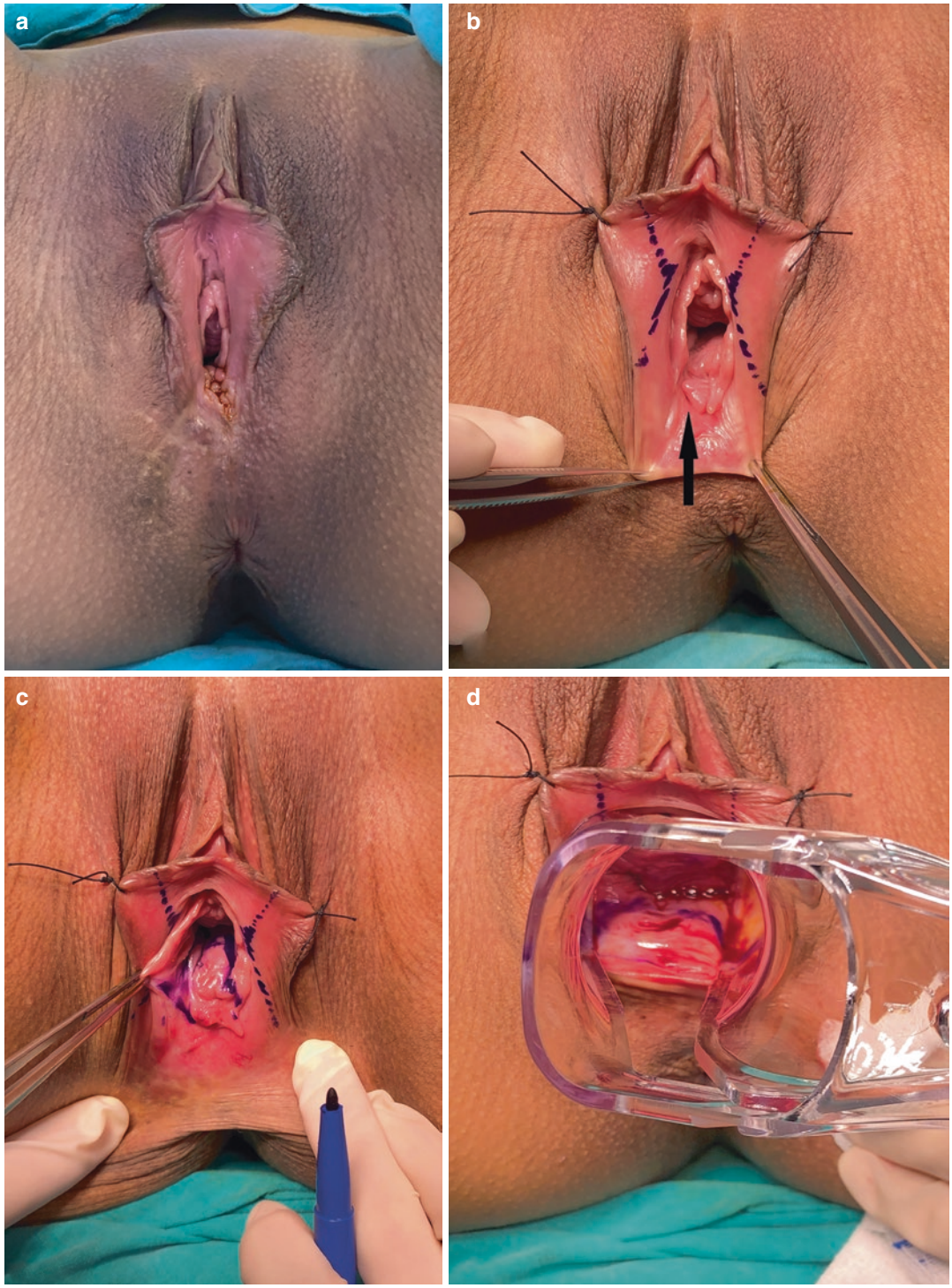

Fig. 35.8 (**a**) Preoperative view of the patient(showing relaxed introitus, mild muscle defect), (**b**) the defect on the vaginal introitus and perineal body, (**c** and **d**) Labioplasty and vaginoplasty surgical markings

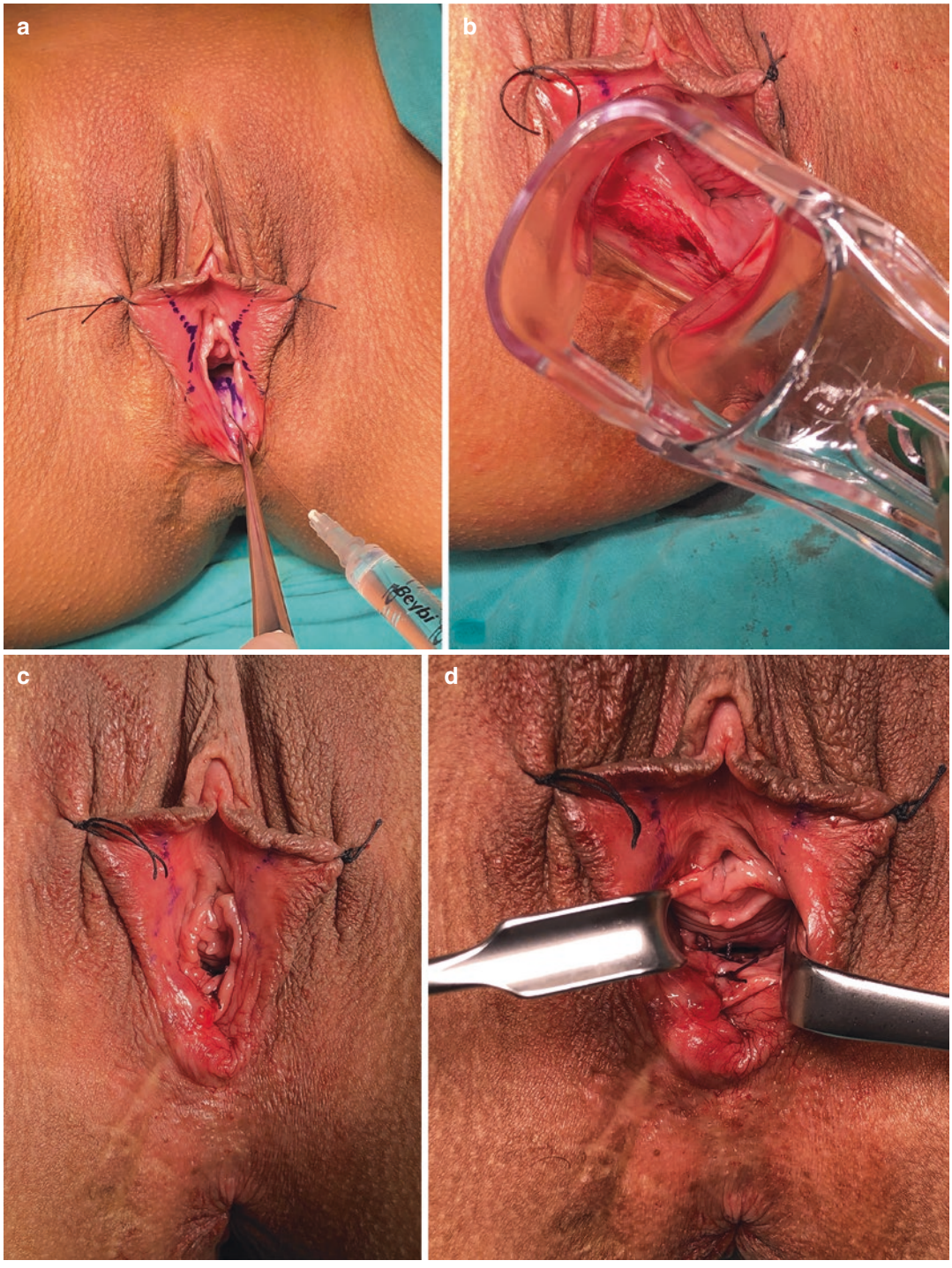

Fig. 35.9 (**a**) Local anesthetic infiltration, (**b**) Vaginal mucosa was resected, (**c** and **d**) Vaginal introitus was reconstructed (circular form)

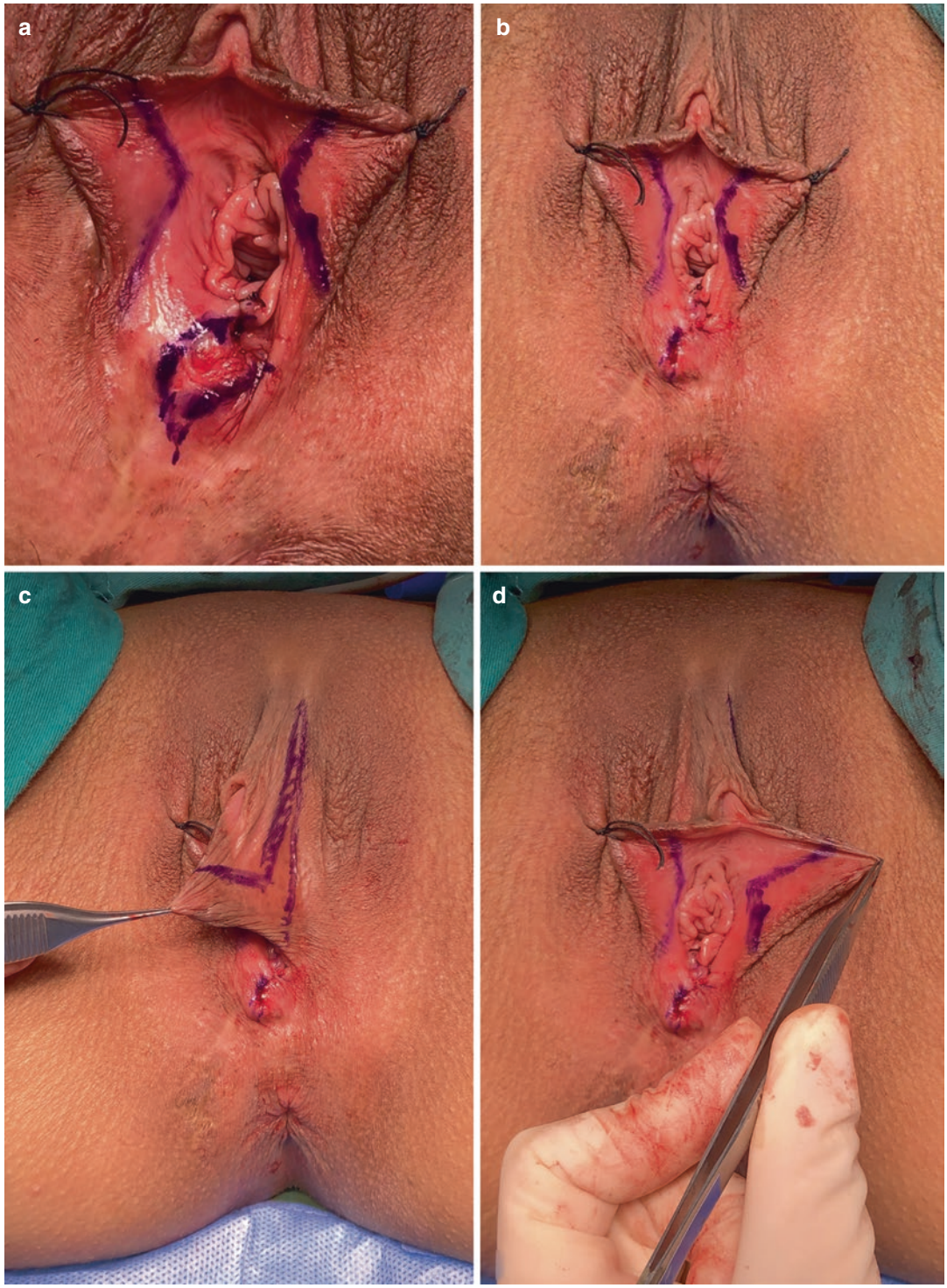

Fig. 35.10 (**a**) Perineoplasty markings extended through mucosa, (**b**) Appearance after the perineoplasty, (**c** and **d**) Labioplasty markings

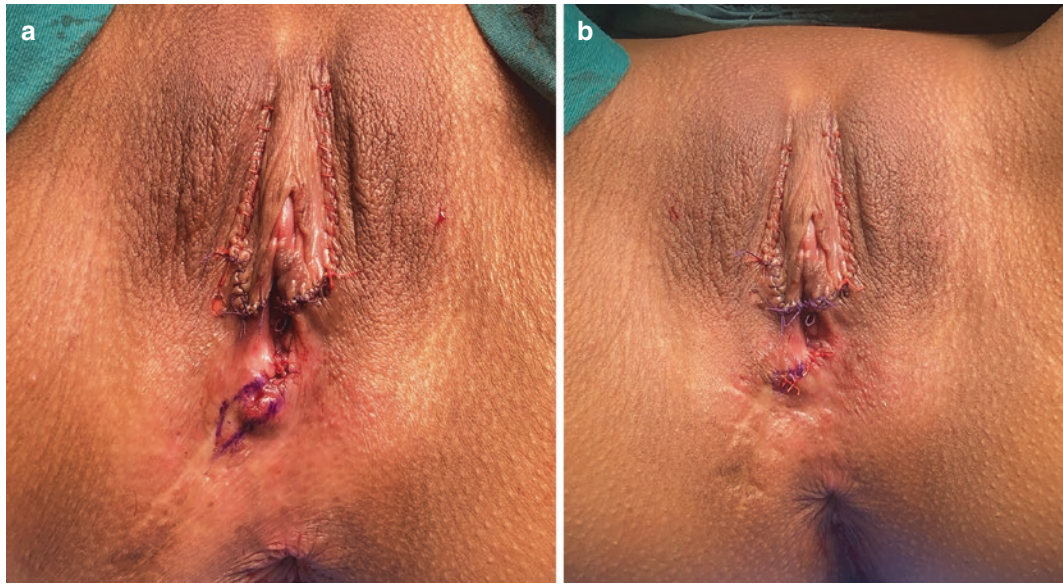

Fig. 35.11 (**a**) Correction of dog ear, (**b**) Immediate postoperative photo

- Levator muscle plication was necessary in order to straighten out the loose posterior wall (Fig. 35.12c). After muscle plication and mucosa closure, posterior wall muscle integrity was achieved (Figs. 35.12d and 35.13a).
- Fat then was harvested from abdomen. After 3 min centrifugation at 1000 rpm, it was mixed with the PRP (harvested from blood) (Fig. 35.13b, c).
- Fat was injected into the labia majora with low volume for each pass via multitunnels and multiplanes (Fig. 35.13d).

Case 3

- 42 year old G2P1 patient (1 vaginal labor).
- Vaginal laxity and sexual dysfunction complaint.
- Perineoplasty, vaginoplasty and labioplasty was performed.
  - Patient had a posterior muscle defect on examination. Also, there was a hymen remnant, which was excised later (Fig. 35.14a, b).
  - Perineoplasty without skin resection was planned. Impaired levator muscles and perineal muscles were sutured on the midline and vaginal introitus was reconstructed (Fig. 35.15a, b).
  - Labioplasty was performed by using the same technique as we mentioned earlier (Fig. 35.15c and d).

35.5.3 Surgical Modifications, Different Approaches, and Nonsurgical Techniques

As we mentioned before, vaginal rejuvenation procedure focuses on the posterior vaginal wall; there are also different vaginoplasty techniques such as anterior approach and lateral approach (Fig. 35.16). Although they are not as popular as the posterior technique, the use of anterior technique and lateral technique in appropriate patients provides satisfactory results. Moreover, each technique has different advantages and disadvantages (Table 35.3).

There is no standardized method of vaginoplasty procedure in the literature. Although none of them prove superiority to each other; anterior, posterior, lateral or combination of these techniques are the only methods described for vaginoplasty procedure.

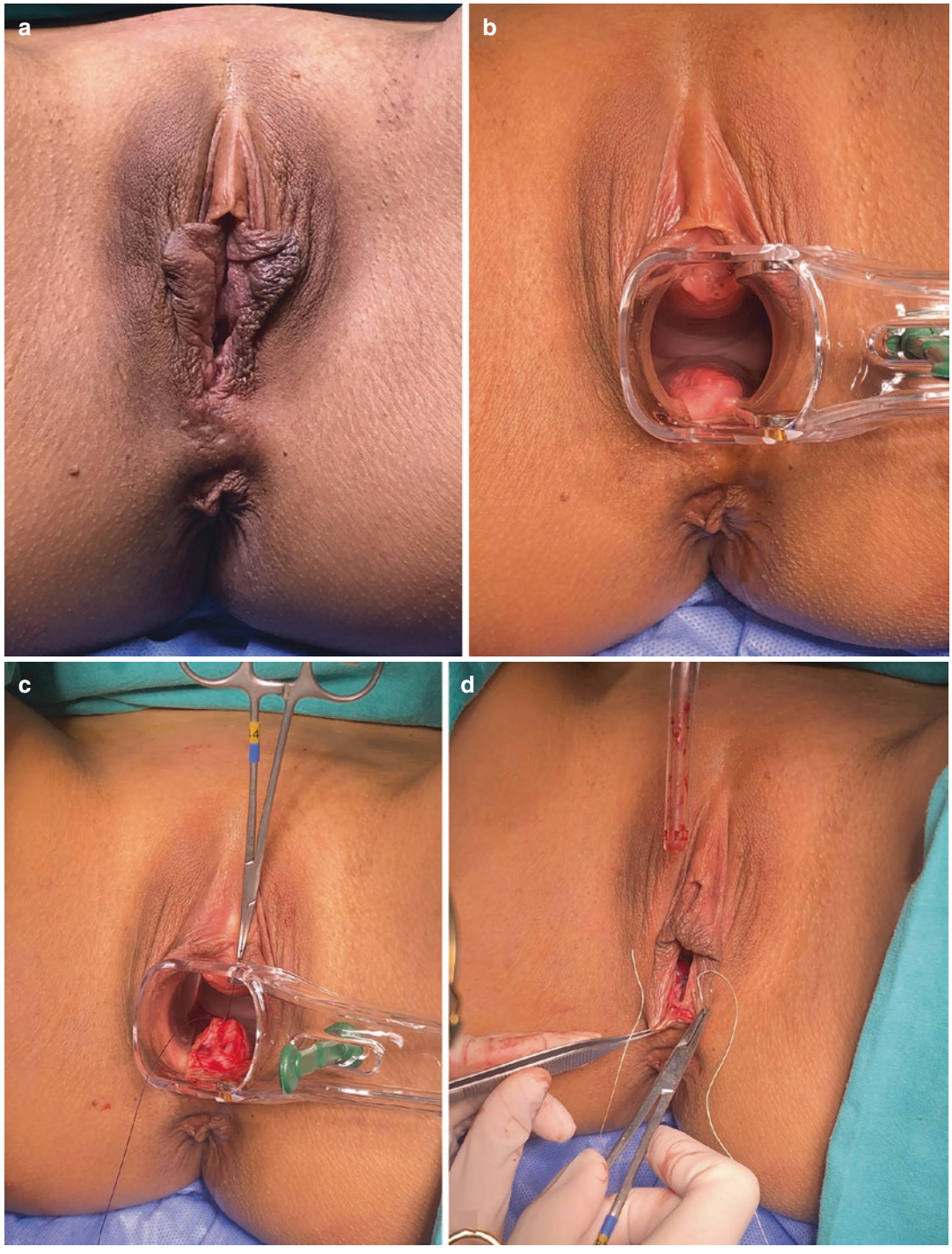

Fig. 35.12 (**a**) Preoperative photo, (**b**) Bulge of posterior vaginal mucosa indicating posterior wall weakness, (**c**) muscle plication was performed, (**d**) Closure of mucosa in the same fashion

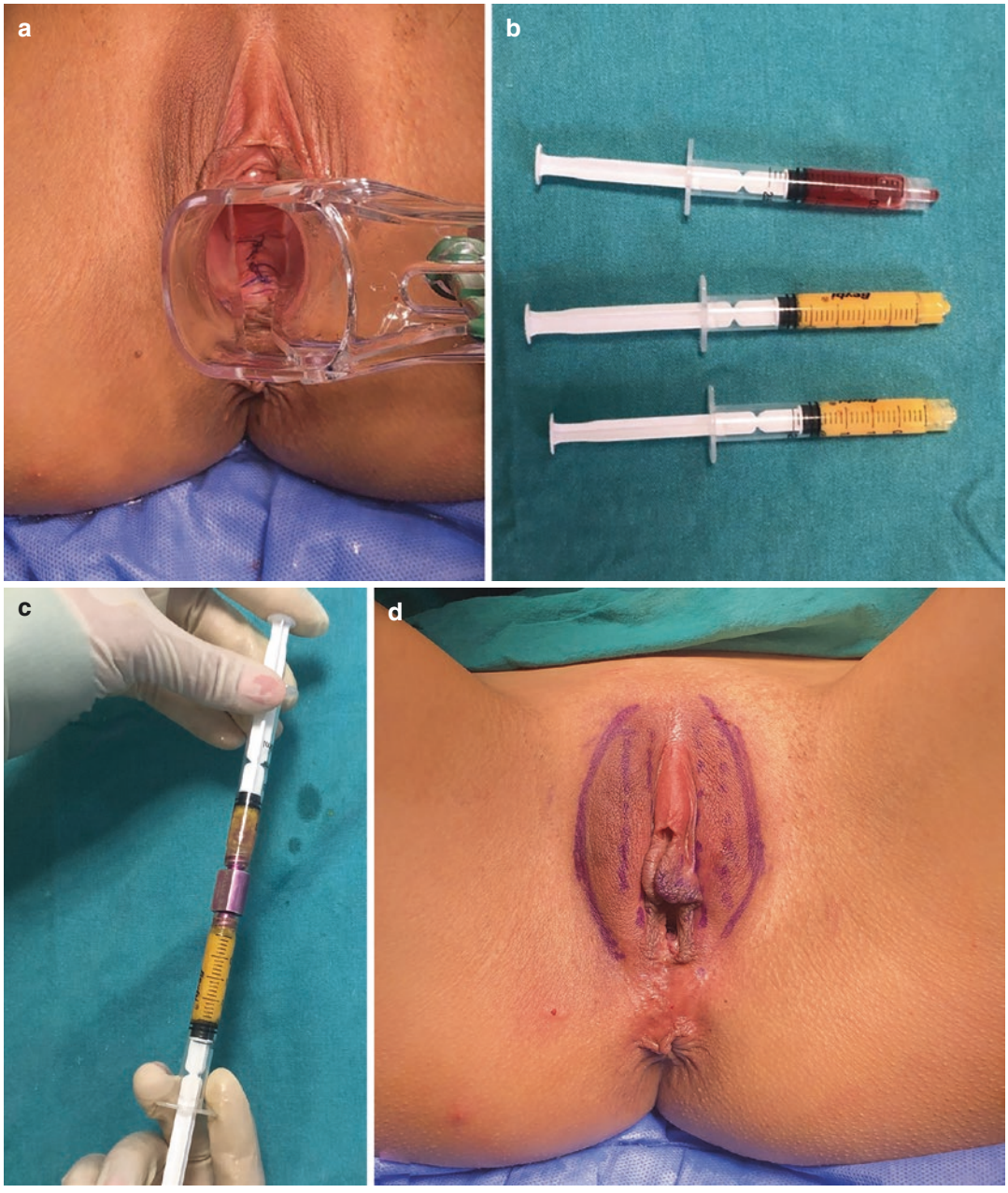

Fig. 35.13 (**a**) Appearance of vaginal mucosa after closure, (**b**) harvested fat graft and PRP, (**c**) PRP and fat graft was mixed, (**d**) Immediate postoperative photo (after fat grafting to labia majora and clitoral hood)

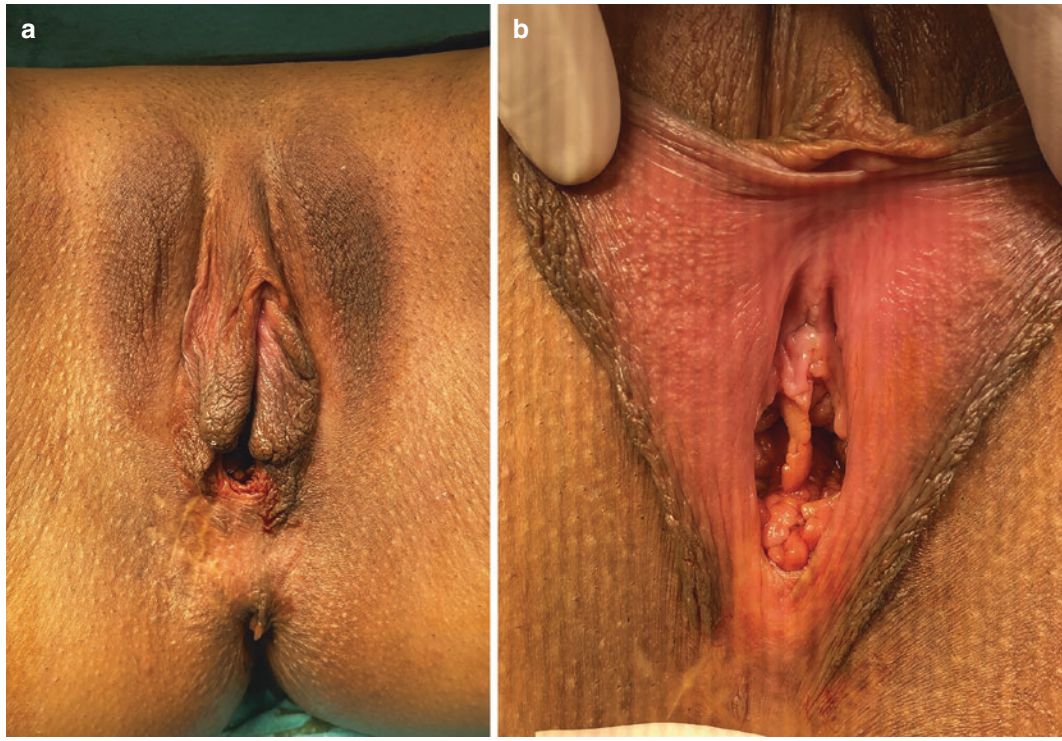

Fig. 35.14 (**a**) Preoperative photo, (**b**) loose posterior vaginal wall and hymen remnant

35.5.3.1 Anterior Approach

Anterior vaginoplasty is a method that can be applied to patients who have the symptoms of stress urinary incontinence and also have loose muscle tone on anterior vaginal wall that determined in the examination. Since postpartum women have more muscle integrity disruption on the posterior wall than the anterior wall, it is not a popular technique anymore. Also, it is not very common procedure because of its limited indication.

In the anterior approach, limited amount of excision is generally recommended. Due to close relationship between anterior vaginal wall and urethra, overresection of anterior vaginal mucosa can cause overcorrection of urethral angle and this results in reoccurrence of urinary problems again [24].

Scar tissue resulting from anterior vaginoplasty may increase sexual pleasure during coitus by stimulating the Grafenberg region (G-point) on the anterior vaginal wall. However, this is only possible unless the urethral angle is disturbed during surgery.

Since TOT is a surgery that corrects impaired urethral angle, the improvement of sexual dysfunction depends on the success of TOT surgery as much as anterior vaginoplasty.

35.5.3.2 Lateral Approach

In lateral vaginoplasty, two mucosal strips are resected from the lateral portion of vagina. Some studies suggests that lateral technique is more effective, because it does not cause scars on sensitive areas of vaginal wall [25]. However, it does not correct pelvic floor defects.

In women with orthopedic problems (congenital hip dislocation, etc.), there may be asymmetrical looseness on the one side of vaginal wall. Therefore, the lateral approach can be chosen, because this technique allows asymmetrical drawings on both sides.

Adamo et al. investigated outcomes of lateral technique in their study, which they evaluated the

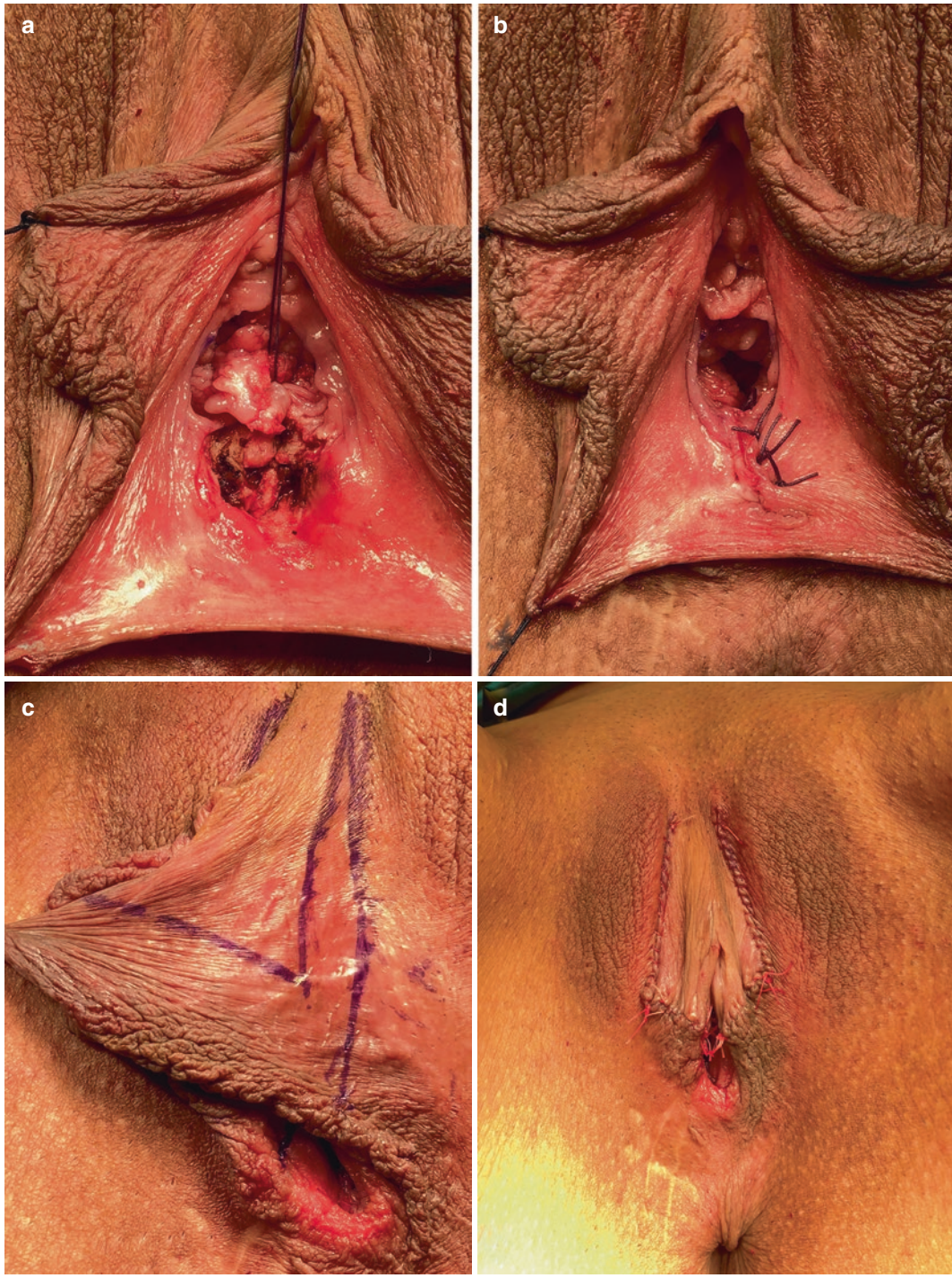

Fig. 35.15 (**a**, **b**) After mucosal excision muscles (levators, bulbocavernosus, superficial transverse perineal muscles) were approximated, (**c**) Labioplasty markings, (**d**) Immediate postoperative photo

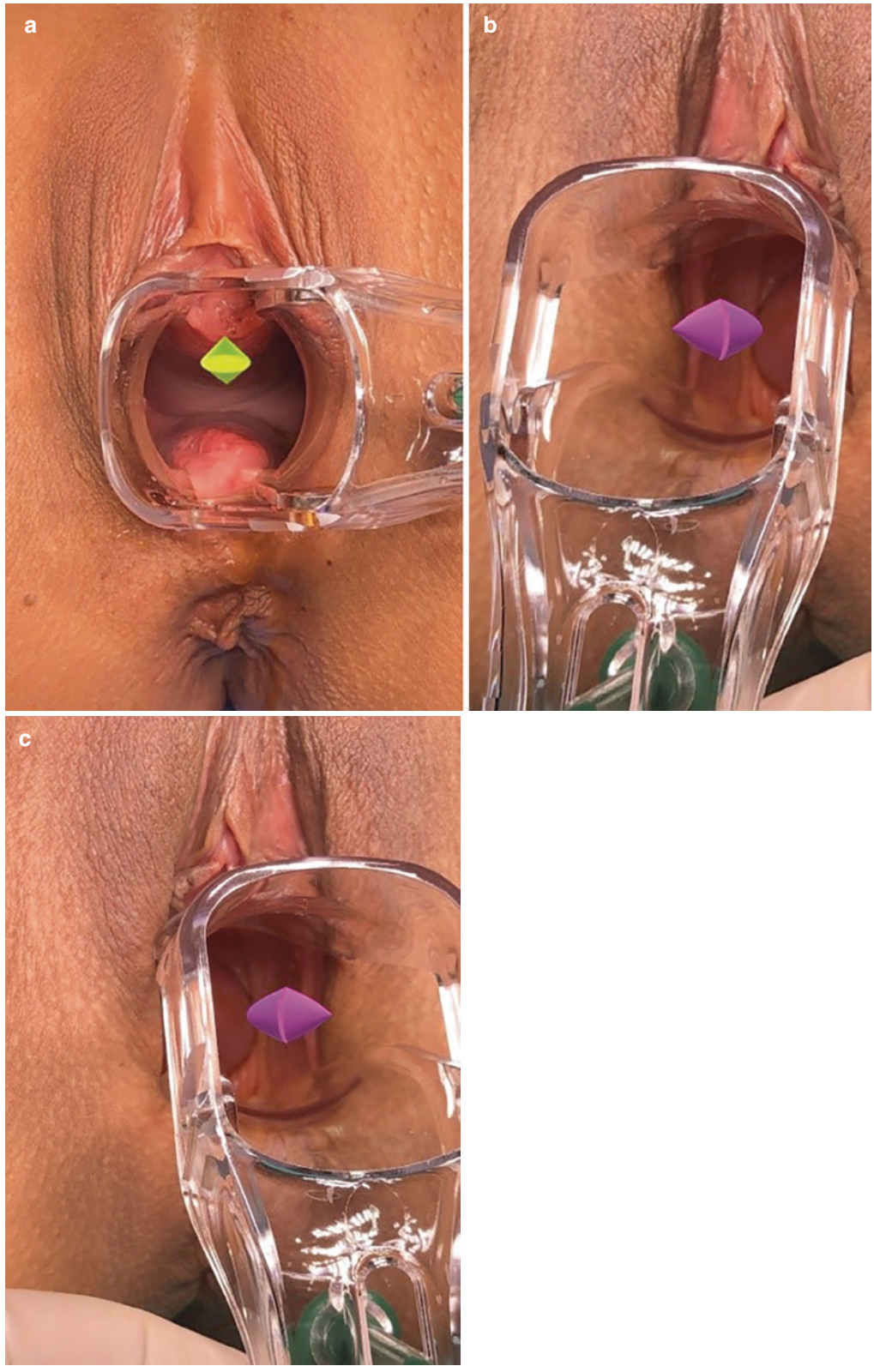

Fig. 35.16 Markings of different approaches. (**a**) Anterior technique, (**b**, **c**) Lateral technique

sexual improvement of 40 patients who were performed lateral vaginoplasty [26]. According to their results, 95% of patients noticed significant improvement. Nevertheless, there is no patient standardization in their studies. Only the ages of the patients were pointed out and there was no information about symptoms such as urinary incontinence, prolapse, parity, and type of birth. Since these symptoms are important for the success of surgery, further studies are needed in order to prove that the lateral technique is superior to others.

Key Points
Both lateral incisions are closed simultaneously, not one by one.

35.5.3.3 Additional Procedures

Vaginoplasty and perineoplasty can be combined with wide range of genital aesthetic procedures such as labioplasty, clitoral hood reduction, lipoinjection, vaginal thread application, radiofrequency, laser,etc.

Although there is no scientific data, we observed that postoperative libido increase was higher in patients who have undergone labioplasty with vaginoplasty than the patients who have undergone only vaginoplasty procedure.

Fractional Laser(FL) Applications
FL increase collagen remodeling and production of elastic fibers. Because laser application is microinvasive and can be applied under local anesthesia, sometimes, it may be an alternative for surgery in patients with mild vaginal laxity. What's more, for patients with moderate and severe vaginal laxity and poor posterior wall support, laser application 6 weeks (the time period for restoration of vaginal pH and bacterial flora) prior to surgery increases the extracellular matrix proteins and support healing postoperatively.

Radiofrequency (RF)
RF application enhances vaginal sensitivity and vaginal secretions as they increase vaginal localized blood flow. It may be the first option in women who have vaginal birth without episiotomy. It is also demonstrated on the experimental studies that intravaginal RF treatment significantly increases collagen and elastin density in vagina [27]. So, postoperative RF treatment may be an option in patients who are not still sexually satisfied after the operation.

Hyaluronic Acid Fillers
Intravaginal hyaluronic acid fillers (DESIRIAL®) also have positive effects for vaginal dryness. It increases vulvovaginal hydration, so it reduces vaginal discomfort. It can be applied after surgery in order to support healing.

Fat Grafting
As with all other procedures in aesthetic surgery, the use of lipoinjection is common in genital aesthetic surgery too. Because of the stem cells that lipoaspirate contains, lipoinjection supports healing when combined with other surgical procedures. In addition, there are some studies suggesting that g-spot amplification with fat graft (can also be made with fillers) may increase sexual pleasure, although its efficacy has not been fully established yet. Also, according to our experience, fat grafting into the clitoral hood may also contribute in increasing the sexual pleasure.

35.5.4 Technical Tips to Improve Outcomes and Avoid Complications

- Before making the decision of surgery, listen to the patient carefully, ask right questions, and allow time for the patient to fully explain her expectations and concerns. Not all sexual dysfunctions can be corrected by surgery!
- Questioning the symptoms and demands of each patient and making surgical plans according to their findings:
  - Choose appropriate method for every patient (vaginal muscle integrity is inspected in physical examination).
- The right time for operation; immediately after menstruation(to reduce the edematous effect of progesterone).
- Do not infiltrate a local anesthetic before marking the surgical site. Since the size of sur-

Table 35.3 Comparison of different techniques

	Advantages	Disadvantages
Anterior	• Can be done together with bladder prolapse surgery(such as TOT) • Brings the labia minor to the midline • Relieves urinary incontinence symptoms	• Excessive mucosal excision may cause lateral banding and constriction • Steep learning curve and high risk of complications (such as urethral injury, persisting urinary incontinence)
Lateral	• Preferred in women who had undergone multiple urogynecologic surgeries before(such as rectal,urinary, prolapse surgery) • Causes less scarring [23]	• Does not provide adequate tightening in patients with posterior wall defects • Longer surgery time than other techniques
Posterior	• Can be combined with perineoplasty in single excision pattern • Easier learning curve • Most effective method to provide pelvic floor integrity(when combined with perineoplasty)	• Risk of rectum injury and rectovaginal fistula • Does not aid urinary incontinence symptoms • Overcorrection may cause significant pain during intercourse

gical field increases with infiltration, the possibility of underresection or overresection increases.
- A too long midline incision always carries the risk of external anal sphincter damage.
- Start Kegel exercises in the early postoperative period (3 weeks).
- Use vicryl instead of rapid vicryl for mucosa closure. Antimicrobial-coated vicryl should be preferred if it is available.
- Prevent urinary retention and constipation (straining may cause wound dehiscence) in the early postoperative period.
- Recommend patients to use Lubricant gel before coitus in the period between the postoperative third and sixth week:
  - It decreases the likelihood of wound dehiscence by reducing friction.

35.6 Postoperative Care

The patient should remove the dressing before her first urination. There is no need for dressing afterward. There is a risk of urinary retention in 1 of 10 patients in the postoperative period, and it usually occurs at postoperative 4 h. While most urinary retention improves with heat application, bladder catheterization may be required in resistant cases.

▶ **Important** Postoperative cold application to the inguinal region reduces postoperative swelling and pain when multiple surgical procedures are performed.

If patients have not undergone additional surgery, they usually are discharged on the same day of surgery. Starting from the first postoperative day, genital region can be washed daily with warm water. After washing and wiping process, topical antimicrobial agents containing Bacitracin and/or Neomycin are applied only to the external incisions and vaginal introitus. Application of topical antimicrobials to vaginoplasty incision is not necessary, because they may interfere with the vaginal bacterial flora. Topical antimicrobial agents can be used until the first postoperative week, and they are not essential after postoperative first week. Daily sanitary pads, cotton underwear, and soft seamless clothes are recommended up to second postoperative week.

The first postoperative examination is done on the third day after discharge. Examination with vaginal speculum is not recommended on early postoperative period, because it may cause tension on sutures. Also, vaginal touch is performed on third day in order to check for hematoma.

Second postoperative examination is done 3 weeks after discharge. Vagina is examined by

vaginal speculum. Unless there is a wound dehiscence or a complication, sexual intercourse is allowed after postoperative third week. If a wound dehiscence is present, this period can be extended to 6 weeks.

If the 3-week period after surgery coincides with menstruation bleeding, the use of tampon is not allowed, because the tampon makes an uncomfortable feeling on the way out. Sanitary pads are recommended instead of tampons.

Kegel exercises (described in detail in Sect. 35) are routinely recommended to all patients, starting after the first sexual intercourse after surgery.

Late postoperative follow-up examination is performed postoperatively at the second, fifth, and tenth months, respectively. In addition, at each appointment, their own sexual satisfaction and their partner's sexual satisfaction are questioned.

Also, in the postoperative period, pictures should be taken at each follow-up control with the patient consent.

35.7 Outcomes

Postoperative patient satisfaction rates were found to be high in the majority of studies that investigating outcomes (Table 35.4). However, we can specify that the number of patients in the studies is insufficient to make a definitive conclusion about the satisfaction rate of surgery. In addition, satisfaction rates in almost all studies are indicated for the sixth month. Since there is no long-term research, it is still unclear whether the surgical procedure or their partner improves the patient's sexual well-being. Longer-term studies with higher numbers of patients may provide more accurate information about the outcomes.

In the literature, posterior vaginoplasty with perineoplasty is the most popular technique for vaginal rejuvenation. According to Goodman et al. [29], 12.5% of the patients who requested vaginal rejuvenation surgery stated the reason for surgery as "to look better." Therefore, it can be said that vaginoplasty and perineoplasty increase patient satisfaction when combined with other cosmetic procedures. Therefore, while the overall satisfaction rate for vaginoplasty and perineoplasty was 83%, the satisfaction rate increased up to 91.2% in combined procedures [29].

The exact cause of dyspareunia that occurs after surgery is still unclear. Abedi et al. [33] investigated 79 women that they performed posterior vaginoplasty with perineoplasty. Although the satisfaction rate of surgery was 97%, the prevalence of dyspareunia increased. There are different opinions about the reason of dyspareunia in the literature. Kahn et al. reported that Levator approximation performed while strengthening the pelvic floor increases dyspareunia rate [34]. Moreover, Abedi et al. and Adamo et al. expressed that the scar tissue in vagina may be responsible for dyspareunia [26, 33].

According to our experience, women under 45 years of age are generally satisfied with the surgical results, because they are in a hormonally active period that have positive effects on vagina. On the other hand, the postmenopausal vaginal changes (such as vaginal dryness), which are more apparent in women over 45 years of age, reduce the success rate of surgery on this population. In addition, we can point out that partner sexual satisfaction has increased for both female groups.

Within patients less than 45 year old, who have a wide vaginal introitus, moderate to severe vaginal wall laxity and experiencing a decrease in sexual quality of life (with the same partner) after birth of her child are the ideal patients for vaginal rejuvenation surgery (Fig. 35.17).

Table 35.4 Comparison of vaginoplasty and perineoplasty outcomes

Author	Study design and technique	Follow-up period	Patient satisfaction	Partner satisfaction
Pardo et al. (2006) [28]	• 53 women • Mean age 45 • Anterior and posterior vaginoplasty with Perineoplasty(except one case)	6 months	94% able to reach orgasm 96% felt an adequate tightening of the vagina *Quality of Sexual Life* 66% a great improvement 24% significant improvement 6% slight improvement 4%-no improvement	
Adamo and Corvi (2009) [26]	• 40 women • Mean age 35 • Lateral vaginoplasty except perineoplasty	6 months	*Vaginal sensitivity* 5% no improvement 40% some improvement 55% significant improvement *Sensation of wide vagina* 5% no improvement 95% significant improvement	20% no improvement 37.5% some improvement 42.5% significant improvement
Goodman MP et al. (2010) [29]	• 47 women, 45 partner • Vaginoplasty and/or Perineoplasty	6–42 months	*Overall satisfaction* 83% satisfied 17% not satisfied *Effect of surgery* 86.6% mild/significant enhancement 51.1% significant enhancement 35.5% mild-moderate enhancement 13.3% negative/no effect 11.1% no effect 2.2% negative effect	82.2%-mild/ significant enhancement 55.5% significant enhancement 26.7% mild-moderate enhancement 17.8% negative/no effect 15.6% no effect 2.2% negative effect
Moore RD et al. (2014) [30]	• 78 women • Mean age 43.6 • Posterior vaginoplasty and perineoplasty (41% had concurrent anterior repair) • Outcomes were analyzed with PISQ (Pelvic Organ Prolapse/ Urinary Incontinence Sexual Questionnaire)-12, preoperatively and postoperatively (6 months)	6 months	• The overall sexual function (Total PISQ-12) statistically improved; (30.3 ± 6.6 vs. 38.2 ± 5.2, $P < 0.001$) • There was no change in 3 categories; Q1-desire, Q5-pain, Q11-partner premature ejaculation	
Inan et al. (2015) [31]	• 40 women • Mean age 32.8 • Posterior vaginoplasty with perineoplasty • Preoperative and postoperative outcomes were compared by Female Sexual Function Index(FSFI) questionnaire	6 months	• A statistically significant improvement was prevalent in the patients for sexual desire, arousal, lubrication, orgasm, and sexual satisfaction ($p < 0.005$) • No significant improvement for dysparenuia ($p = 0.184$)	
Ulubay et al. (2016) [32]	• 64 women • Mean age 48 • Posterior vaginoplasty with perineoplasty (26.3% had concurrent TOT procedure)	6 months	87.9% satisfied	92.6% satisfied

Fig. 35.17 (**a**) Preoperative photos (wide vaginal introitus and posterior vaginal wall laxity, (**b**) Photo in the second postoperative month (new vaginal introitus and significantly improved sexual activity)

35.8 Complications

According to most studies in the literature, the major complication rate for vaginal rejuvenation is less than 5%. However, since none of the studies in the literature are prospective, further studies are needed to reach a definite complication rates [28, 29]. Some of the most common complications are mentioned in Table 35.5.

Table 35.5 Common complications of vaginoplasty and perineoplasty

Minor complications	Major complications
• Hematoma, Infection, Abscess, Ecchymosis • Wound dehiscence, poor scar formation, cosmetically unappealing appearance • Insufficient tightening, overtightening • Inability to allow penetration because of overtightening of vaginal introitus • Early Dispareunia	• Urinary or fecal incontinence • Adjacent organ injuries; Bladder (especially in TOT surgery), Urethra (anterior vaginoplasty), Rectum (posterior vaginoplasty), Peritoneal injury • Pelvic floor dysfunction • Exposure or infection of mesh material • Late dyspareunia

35.8.1 Complication Management

Intraoperative meticulous hemostasis and postoperative cold application reduces the risk of hematoma. There is no need for routine use of surgical drains.

When inadequate tightening symptoms are present, usually patient is followed up until the second postoperative month. After 2 months, minimal invasive procedures such as vaginal thread application, fat grafting, and filler injections can be considered. Surgical revision may be planned after 6 months in patients with still ongoing complaints.

If dyspareunia occurs up to the second postoperative month, lubricant gel is recommended. If dyspareunia still persists after the second postoperative month, up to 50 units of botulinum toxin injection can be done in order to relax the muscles and relieve pain. In addition to the muscle relaxation, botox has also been shown to be effective in treating wound healing too [35, 36].

Lubricant gel and botulinum toxin can also be used in patients with overtightening symptoms in the early postoperative period (up to the second month).Vaginal dilators may be used in patients whose symptoms persist after postoperative 2 months. If the patients still have symptoms after postoperative 6 months, surgical procedures such as z-plasty, scar revision, and scar release should be considered.

35.8.1.1 Wound Dehiscence Management

Wound dehiscence is the most common minor complication according to our data. Sexual abstinence(minimum 3 weeks), maintaining a good genital hygiene, and prevention of constipation are required in order to prevent dehiscence. Most of the mucosal defects usually heal by secondary intention. Delayed primary closure of defect may be considered if wound does not heal by secondary intention within a certain period of time.

If wound dehiscence occurred within the first 3 days postoperatively, resuturation should be reconsidered. But if wound dehiscence occurred after the third postoperative day, it is necessary to wait for the wound to heal by secondary intention for one month. If the wound still exists after one month, reoperation should be planned (Fig. 35.18).

Reoperation and resuturation can be performed under local anesthesia. Since there is almost always a mucosal defect (rather than muscle defect), which the patient can easily tolerate, the operation can be carried out under local anesthesia. Reoperation is more extensive procedure than resuturation, which may involve more comprehensive debridement and flap surgery.

In the secondary healing process, prophylactic oral antibiotics is prescribed to patient for a period not exceeding 2 weeks. In wounds with moderate and high exudate, local application of rifampicin may help to decrease the exudate. Sexual intercourse is interrupted during this period. If this period overlaps with the menstrual period, antifungal vaginal suppositories should be prescribed also. They are used in order to prevent opportunistic fungal infection as the bacterial vaginal flora and pH is changed, in menstrual period.

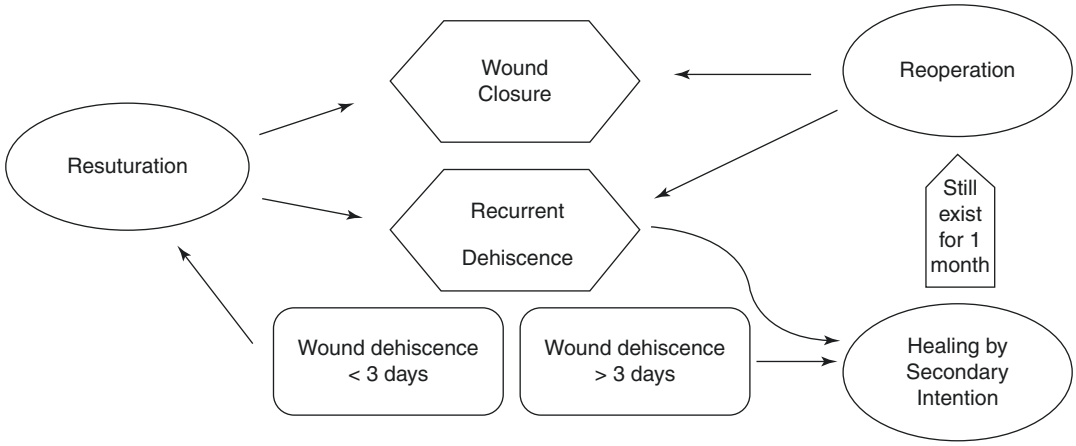

Fig. 35.18 Wound dehiscence algorithm for vaginoplasty and perineoplasty

35.9 Conclusion

Women have many stressors during pregnancy such as physical changes in pregnancy, stress of birth, and psychological changes (being a parent). For this reason, women want to return to their prenatal life as quickly as possible after the birth. Vaginal laxity is a common cause of female sexual dysfunction in postpartum women. It occurs because of the vaginal stretching during childbirth. Since normal sexual function is a fundamental component in people's well-being, the popularity of postpartum vaginal tightening procedures is increasing day by day. VRJ is combination vaginoplasty and/or perineoplasty. Although there are multiple techniques for VRJ surgery, none have proven their superiority to each other. Some studies have shown improvement in sexual function after surgery, also combining with other genital aesthetic procedures increases satisfaction rate much more. However, studies in the literature are not adequate in terms of follow-up periods and patient numbers. As a result, as the number of patients underwent VRJ procedures increases over time, it will be possible to express clearer ideas on this issue.

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Part VIII

Pelvic Floor

Anatomic Changes in the Pelvic Floor After Pregnancy

36

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Take-Home Messages

- The term pelvic floor refers mainly to the coccygeous and levator ani muscles (puborectalis, pubococcygeous, and ischiococcygeus)
- The main function of the levator ani muscles is to close the urogenital hiatus, anchor the vagina and anus upward, and stretch the perineum toward the pubic symphysis.
- Pregnancy is a predisposing factor to develop some degree of pelvic floor dysfunction regardless of mode of delivery.
- Vaginal delivery, and especially the use of forceps and maternal age, is an important risk factor for the development of stress urinary incontinence, fecal incontinence, pelvic organ prolapse, and sexual dysfunction.
- The puborectalis muscle is the most affected part of the levator ani during labor.
- The pudendal nerve is responsible for the motor innervation of the anal sphincter and sensitive innervation of the genitalia.
- During labor, overdistension, stretching, or compression of the pudendal nerve may occur, resulting in a diminished strength of the levator ani and anal sphincter, contributing to urinary and fecal incontinence and pelvic organ prolapse. This denervation is usually temporal and improves with time.
- Most women with postpartum stress urinary incontinence will recover within one year although they have a greater disposition for long-term recurrent stress urinary incontinence.
- Levator ani avulsion and perineal tears favor postpartum sexual dysfunction.

36.1 Introduction

The correct functioning and position of the female pelvic floor result from the interaction of muscles, nerves, and ligaments, acting on the pelvic organs.

The upright posture in humans, especially in women, required the evolution of a supportive system to maintain the pelvic organs in their corresponding position.

In addition, this support system must contribute to the physiologic process of micturition, defecation, sexual intercourse as well as keeping urinary and fecal continence.

During pregnancy and labor, the pelvic floor is exposed to a significant stress and may be damaged.

The following chapter provides a fundamental understanding of pelvic support anatomy including the relationship between the genital, urinary, colorectal, and musculoskeletal systems with their corresponding vascular and nervous supply and explains the relationships and function

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© Springer Nature Switzerland AG 2023
M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_36

between the pelvic organs and their support mechanisms.

Finally, we will discuss the influence that pregnancy and labor have on the pelvic floor.

36.2 Bony Pelvis

The bony pelvis is composed of the sacrum, the coccyx, the ilium, the ischium, and the pubis. The last three are joined together becoming a single bone on each side called the **innominate or pelvic bone**. Both pelvic bones articulate posteriorly to the sacrum-coccyx at the sacroiliac synchondrosis and anteriorly to the pubis at the symphysis pubis (Fig. 36.1).

A conceptual line called the **iliopectineal line** divides the pelvis into two, the false or greater pelvis above it and the true or lesser pelvis below it.

The **greater pelvis** is limited by the sacrum posteriorly, the iliac fossa laterally, and the abdominal wall anteriorly and contains the sigmoid colon and segments of the small intestine. The sacrum and the coccyx limit the **true pelvis** posteriorly, laterally it is limited by the ischial bones, anteriorly by the pubic symphysis, the superior rami of the ischial bones and the obturator foramina, and inferiorly by the pelvic musculature. It houses the pelvic organs, which are from back to front: the rectum and anus, the reproductive organs, and the bladder. It has the shape of an obliquely truncated, bent cylinder with its greatest height posteriorly and has an important role in childbearing.

The **ilium** is the upper part of the pelvic bone; it articulates with the ischium, acetabulum, and pubis. Its superior part is the iliac crest that ends in the anterior iliac spine. Proximate to its articulation with the ilium, it has a concave space called the greater sciatic notch.

The **ischium** has a body, a superior and inferior rami, and a tuberosity. It articulates with the ilium and meets the pubis to form the ischiopubic arch. In the posterior part of each ischium are the **ischial spines** that separate the greater from the lesser sciatic notch. They also represent the broader part of the true pelvis and are therefore an important landmark in obstetrics when assessing if the fetus has entered the true pelvis during labor. During vaginal or rectal examination, they can be easily palpated.

The **pubis** is the anterior bone of the pelvis, made up of a body and two rami. It articulates with the contralateral one by a synarthrodial joint called the **symphysis**. Below the superior ramus is the obturator foramen. Underneath the symphysis is the pubic arch.

The **sacrum** is the posterior wall of the true pelvis and is made of 5–6 sacral vertebrae fused together. Its anterior margin is the promontory. On either side, the sacral nerves leave the spine through the nerve outlets located on the anterior and lateral surfaces. The coccyx is attached inferiorly and is the posterior border of the pelvic outlet.

The **coccyx** is made of four coccygeal vertebrae attached to the inferior part of the sacrum at the sacrococcygeal joint; it is the posterior border of the pelvic outlet.

36.2.1 Pelvic Shapes

Based on the pelvic shape, the greatest transverse diameter of the inlet, and its division into anterior and posterior segments, four types have been described: gynecoid, anthropoid, android, or platypelloid being the first one the most common (Fig. 36.2).

The posterior segment determines the type of pelvis, whereas the anterior segment determines the tendency. These are both determined, because many pelvis are not pure but are mixed types. For example, a gynecoid pelvis with an android tendency means that the posterior pelvis is gynecoid and the anterior pelvis is android shaped.

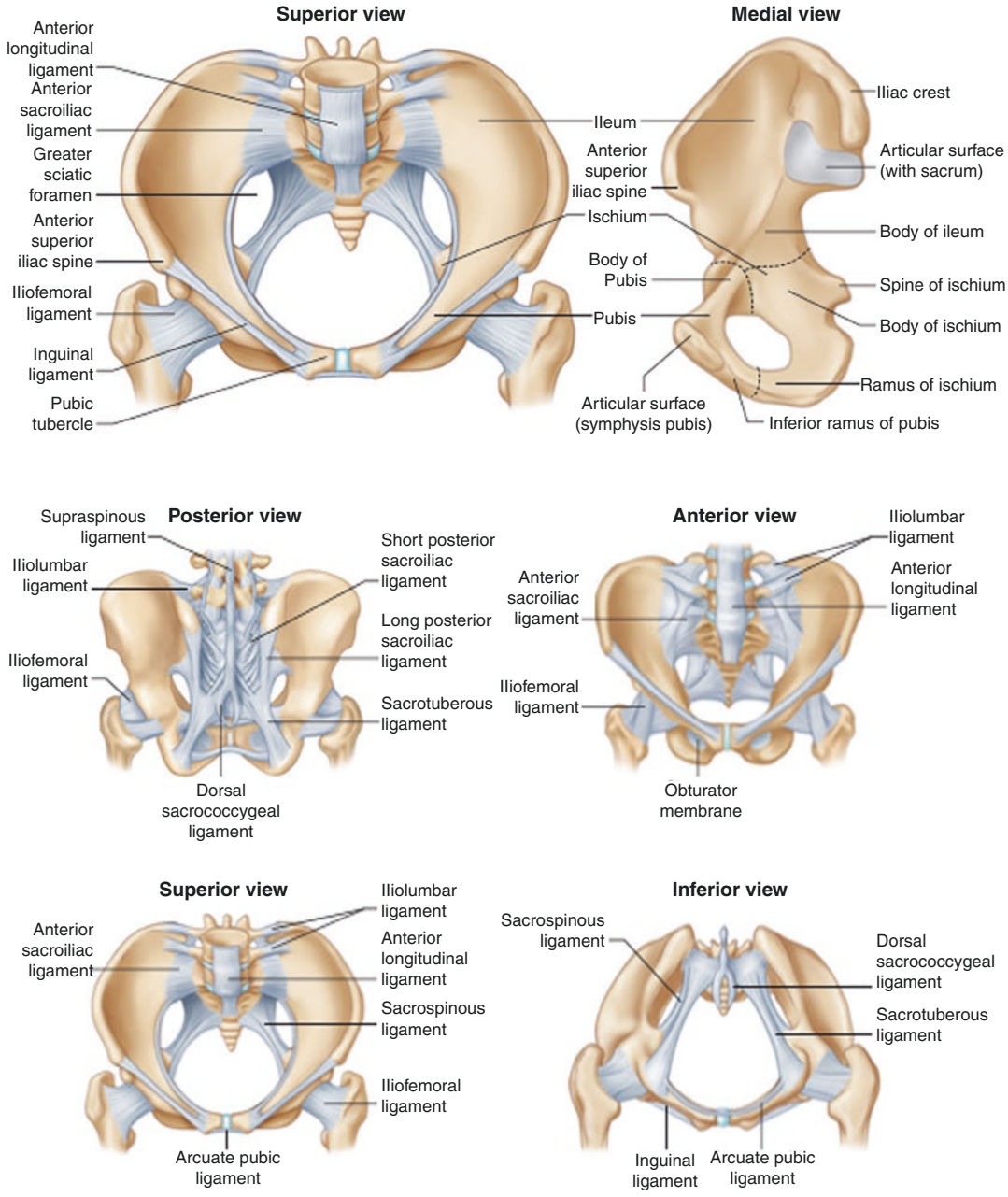


Fig. 36.1 Bones and ligaments of the bony pelvis (Reprinted from Firoozi F. Female pelvic surgery. New York, Springer 2015 with permission)

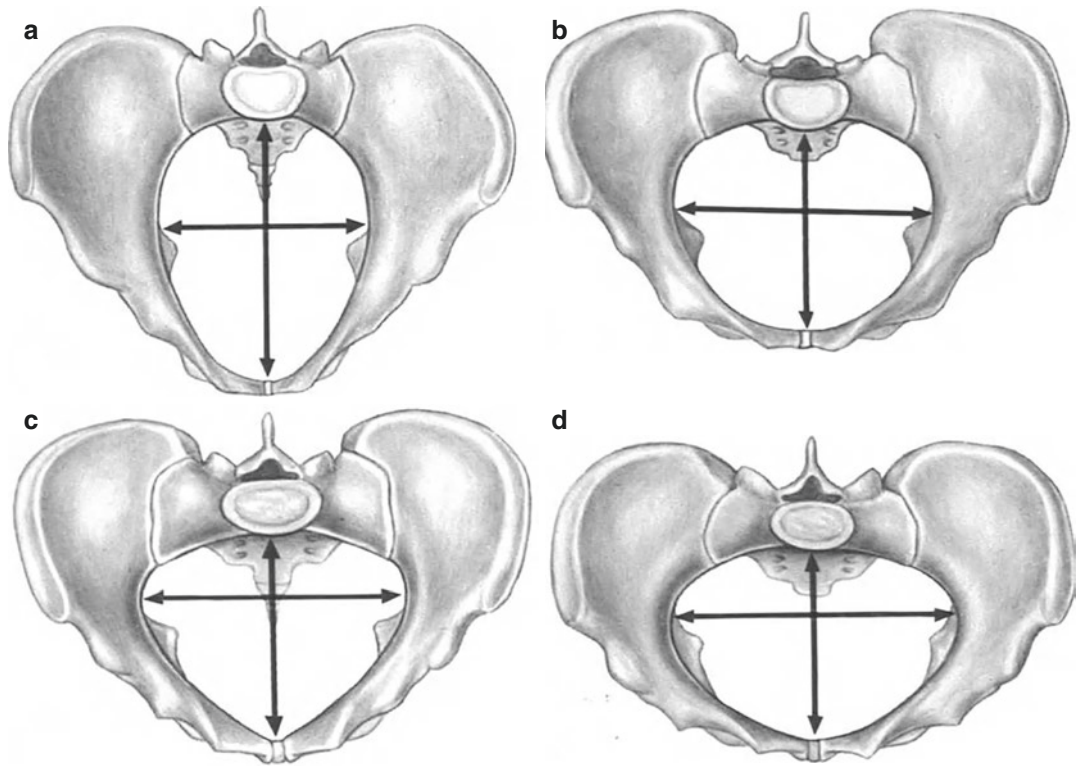


Fig. 36.2 Pelvic shapes. Anthropoid (**a**), **gynecoid** (**b**), **platypelloid** (**c**), and **android** (**d**) (Reprinted from: Werner L. Applied anatomy of the pelvis. 1st Ed. Springer. 1987 with permission). *It should include the different pelvic shapes: anthropoid, gynecoid, platypelloid, android.. (**a**) Anthropoid Pelvis: its largest diameter is the anteroposterior one. (**b**) Gynecoid Pelvis: the normal one in women. The inlet is round, the subpubic angle large, and the greater sciatic notch wide and deeply excavated. The ischial spine is squat and the sacrum concave. (**c**) Android Pelvis: it has male characteristics. The inlet is heart shaped. (**d**) Platypelloid Pelvis: oval shaped with the largest diameter transversely

36.2.2 Planes and Diameters of the Pelvis

The pelvis is described as having four imaginary planes (Fig. 36.3):

1. The plane of the **pelvic inlet,** also called the **superior strait,** is the superior part of the true pelvis. Limited by the sacrum, pectineal line and pubis. The female inlet has a round shape fitting the fetal head.
2. The plane of the **midpelvis** is at the level of the ischial spines and has usually the smallest pelvic diameter, with the interspinous diameter measuring around 10 cm. It is used as an important reference for describing the descent of the fetus in the pelvis. The anteroposterior diameter at this level normally measures more than 11.5 cm.
3. The plane of the **pelvic outlet** or the inferior strait consists of two triangular-shaped areas with the line drawn between the ischial tuberosities as a common base. The posterior triangle is drawn between the sacrum, and sacrotuberous ligament and ischial tuberosities. The anterior triangle is formed by the inferior rami of the pubic bones. There are three diameters in the pelvic outlet: anteroposterior, transverse, and posterior sagittal.
4. The plane of greatest pelvic dimension, the birth canal.

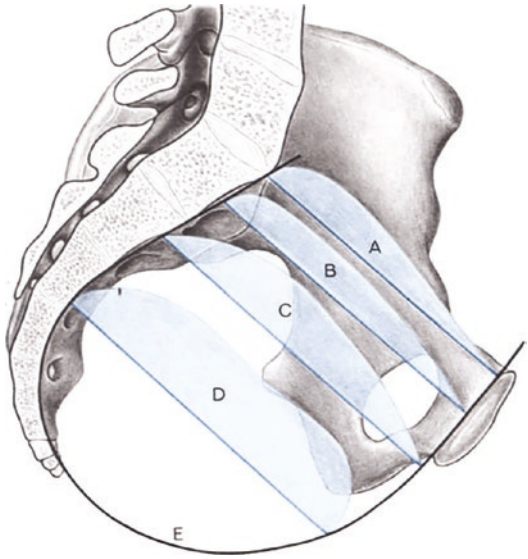


Fig. 36.3 Planes of the pelvis: *(**a**) Plane of the pelvic inlet (**b** and **c**), narrow part of the pelvic cavity, (**d**) plane of the pelvic outlet, (**e**) birth canal. (Reprinted from: Werner L. Applied anatomy of the pelvis. 1st Ed. Springer. 1987 with permission)

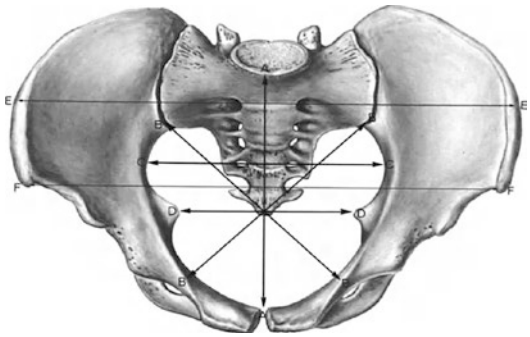


Fig. 36.4 Diameters of the female pelvis. *(**a**) Conjugate, (**b**) Oblique, (**c**) Transverse, (**d**) Pelvic cavity between ischial spines, (**e**) Intercristal distance, (**f**) Interspinous distance. (Reprinted from Werner L. Applied anatomy of the pelvis. 1st Ed. Springer. 1987 with permission)

Pelvic diameters (Fig. 36.4):

1. The most superior is the **anteroposterior diameter or true conjugate** that runs from the promontorium to the upper part of the symphysis pubis, which usually measures more than 10 cm.
2. The **transverse diameter** is the greatest distance from the pectineal line on both sides and measures around 13 cm.
3. Two **oblique diameters** between the sacroiliac joint and the iliopectineal eminence, often less than 13 cm long.
4. **Diagonal conjugate**: Distance between sacral promontory and inferior margin of symphysis pubis
5. Anatomical conjugate: Distance between sacral promontory and superior margin of symphysis pubis
6. Intercristal distance: Greatest distance between iliac crests
7. Intertrochanteric distance: Distance between the two greater trochanters

36.3 Muscles, Ligaments and Fascia

36.3.1 Muscular Pelvis

In the erect posture, the primary support for the pelvic organs are the pelvic floor muscles, which offer them a firm and elastic base (Fig. 36.5).

The pelvic **muscles** play an important role in supporting the pelvic organs in the correct position and in the process of micturition, defecation, sexual intercourse, and delivery of the fetus (Table 36.1). The ligaments stabilize the organs in the correct position to receive optimal support from the pelvic muscles (Figs. 36.6 and 36.7).

The pelvic floor muscles are those of the pelvic diaphragm (levator ani and coccygeous muscle) and those of the urogenital triangle (Fig. 36.8).

The iliococcygeus muscle is attached to the arcus tendineus and runs from the symphysis to the ischial spine and ends at the coccyx where it meets the anococcygeal raphe forming **the levator plate**. It joins the obturator internus at the ischial spine and the pubococcygeus at its medial insertion in the pubis.

The **levator plate** is a horizontal structure that acts as a support for the upper vagina, uterus, and rectum.

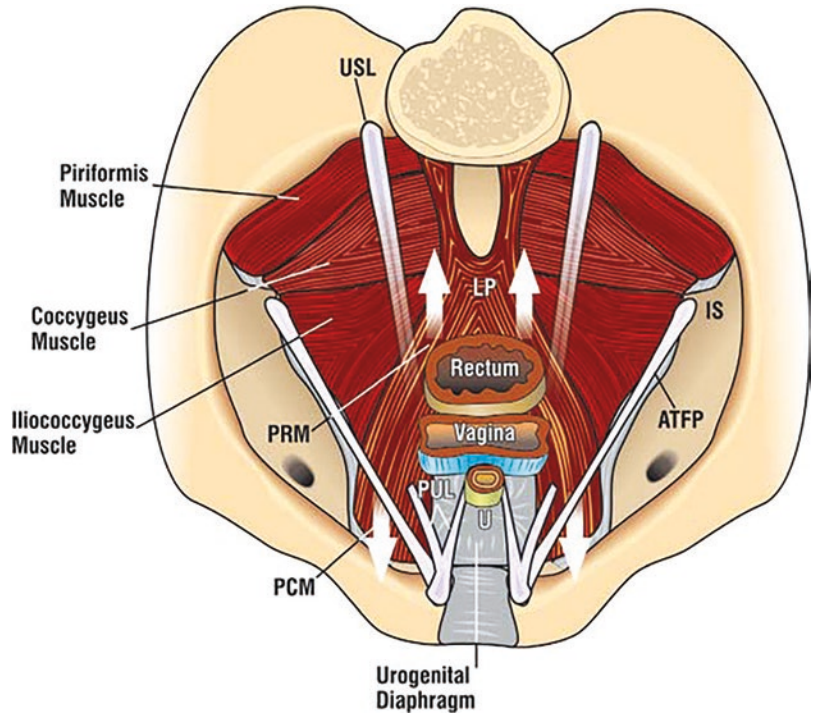


Fig. 36.5 Upper layer of muscles of the pelvic floor: (Reprinted from Petros P. The female pelvic floor: function, dysfunction, and management according to the integral theory. 3rd edition. Germany. Springer; 2010 with permission) *Piriformis muscle, coccygeous muscle, ischiococcygeus muscle, ischial spine, puborectal muscle, pubococcygeous muscle, uterosacral ligament, levator plate, vagina, rectum, pubourethral ligament)

Table 36.1 Muscles of the pelvic floor and their function

Muscle	Function
Puborectalis	Closure of the genital hiatus; fecal continence; pelvic floor support
Pubococcygeous	Maintains pelvic floor tone in upright posture
Iliococcygeus	Voluntary control for micturition
Obturator internus	Lateral rotation of the thigh; lateral rotation, extension, and abduction of the upper leg
Coccygeous	Pelvic organ support; flexion and abduction of the coccyx
Piriformis	Lateral rotation and abduction of the thigh; retroversion of the pelvis

The pubococcygeus is a horizontally disposed muscle that has its origin at the inner surface of the pubis and ends at the coccyx where it meets the sacrococcygeal ligament. Some of its lateral fibers insert into the lateral wall of the distal vagina (pubovaginal fibers); others go around the rectum and join with fibers from the coccygeous and ileococcygeous to form the levator plate.

The puborectalis has its origin on the inner side of the pubis, medially to the pubococcygeous, it is oriented vertically, and goes backward/downward around the vagina, rectum, and perineal body to insert in the anococcygeal raphe and coccyx. It pulls the rectum anteriorly creating the anorectal angle and contributes to closure of the genital hiatus and fecal continence.

The obturator internus rests on the inner side of the obturator membrane. It has its origin on the superior pubic rami and ischium and after abandoning the pelvis through the lesser sciatic foramen, it inserts on the greater trochanter of the femur. It is involved in lateral rotation of the thigh and lateral rotation, extension, and abduction of the upper leg. It is innervated by the obturator internus nerve (L5–S2).

The coccygeous muscle lies over the sacrospinous ligament, it joins the ischial spine with

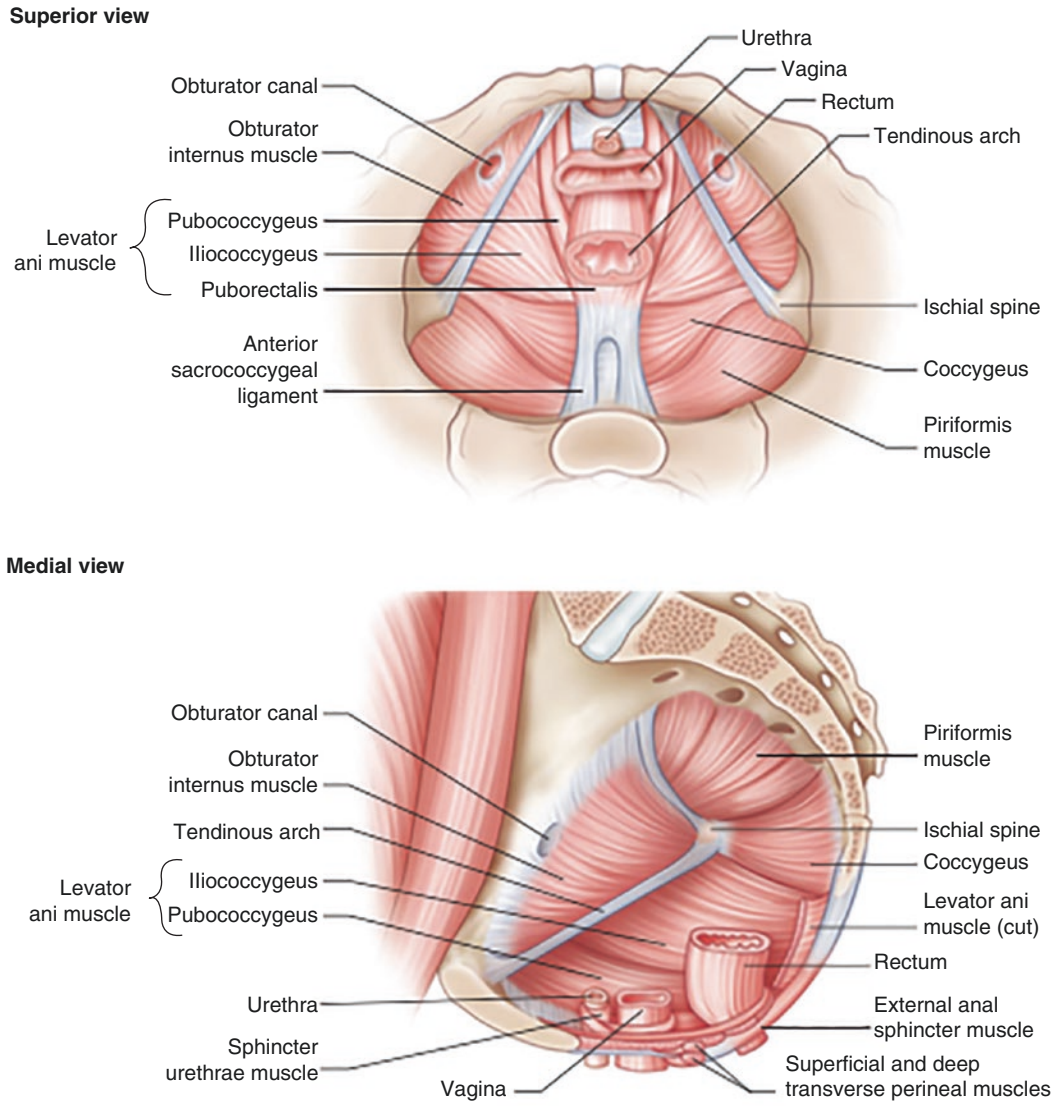


Fig. 36.6 Superior and medial view of the muscles of the pelvic floor. (Reprinted from Firoozi F. Female pelvic surgery. New York, Springer 2015 with permission)

the lateral side of the sacrum and coccyx. Apart from being involved in the support of pelvic organs, it participates in the flexion and abduction of the coccyx.

The piriformis muscle extends, lateral to the coccygeus, from the anterolateral surface of the sacrum (second to fourth sacral segments) to the greater trochanter passing through the greater sciatic foramen. Superiorly it is related with the lumbosacral plexus.

36.3.2 Ligaments and Fascia

There are two types of **fascia**: the parietal one, which covers the skeletal muscles and attaches them to the bony pelvis, it is usually referred as the **pelvic fascia**; and the visceral or **endopelvic fascia,** which covers the pelvic organs and attaches them to the pelvic wall acting as passive support when the urogenital hiatus is open (Figs. 36.9 and 36.10). The endopelvic fascia is

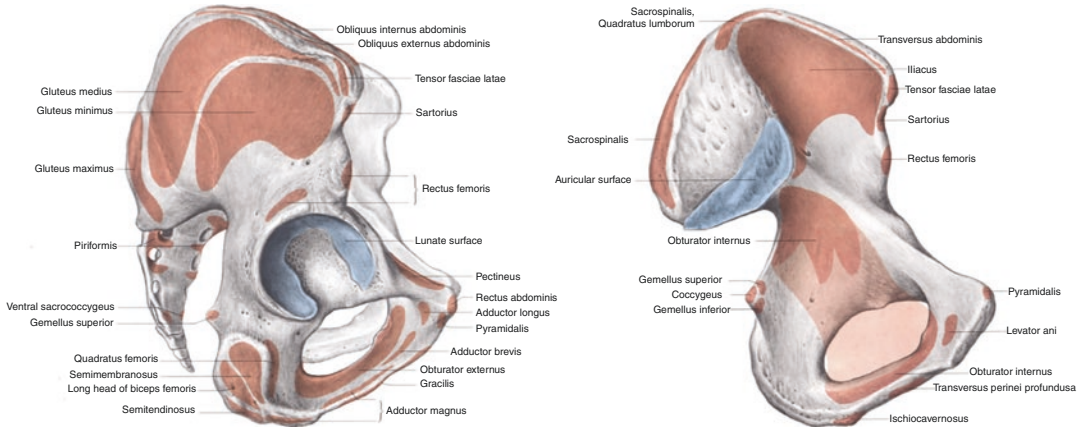


Fig. 36.7 Muscles attachment areas: (Reprinted from Werner L. Applied anatomy of the pelvis. 1st Ed. Springer. 1987 with permission). * Same labels as in the images

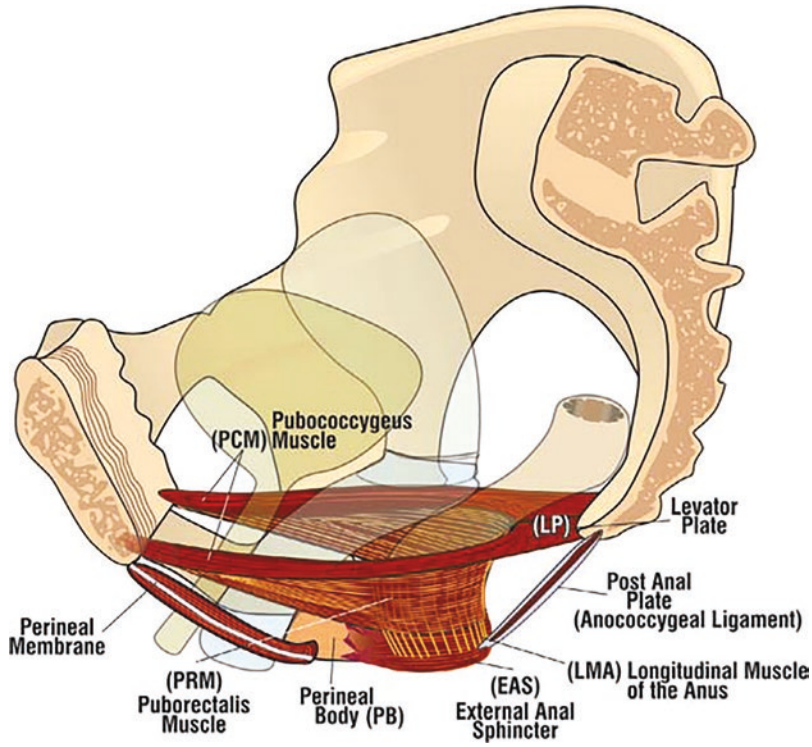


Fig. 36.8 3D view of the pelvic organs and muscles. (Reprinted from Petros P. The female pelvic floor: function, dysfunction, and management according to the integral theory. 3rd edition. Germany. Springer; 2010 with permission)

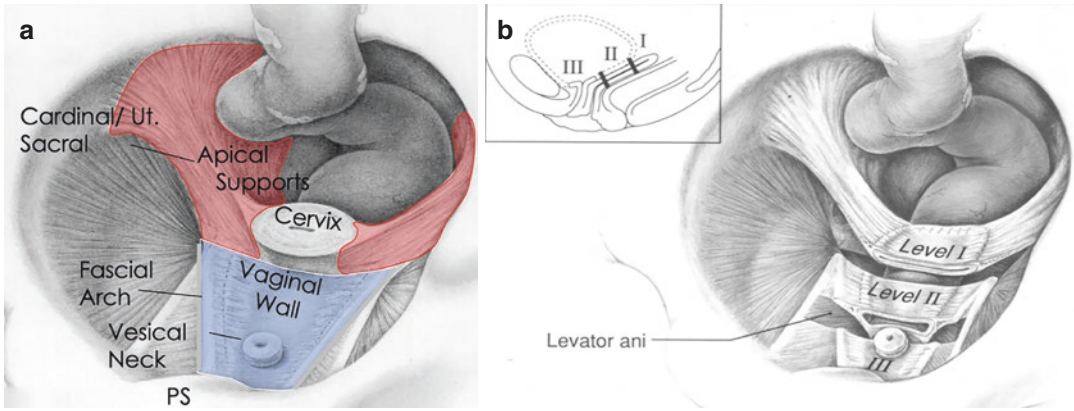


Fig. 36.9 Structures (**a**) and Levels (**b**) of pelvic floor support [1] (Reprinted from M. Huebner, JOL DeLancey with permission. Levels of pelvic floor support: what do they look like on magnetic resonance imaging? International Urogynecology Journal (2019) 30:1593–1595 with permission)

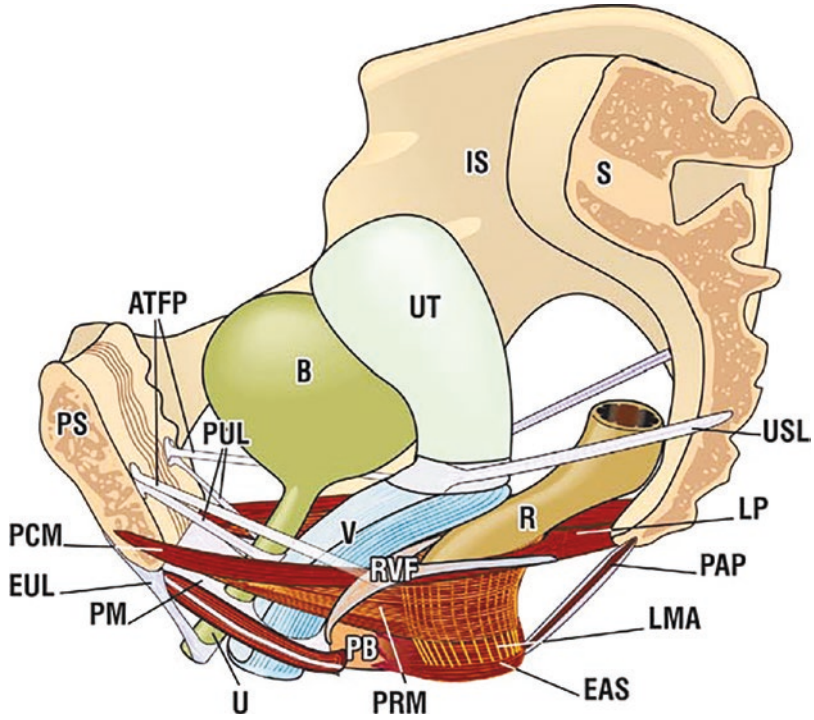


Fig. 36.10 3D sagittal representation of the main connective tissue of the pelvis, organs, muscles, and bones. (Reprinted from Petros P. The female pelvic floor: function, dysfunction, and management according to the integral theory. 3rd edition. Germany. Springer; 2010 with permission). *Pubourethral ligament, pubis, ischion, sacrum, uterus, bladder, arcus tendineus fascia pelvis, pubococcygeous muscle, puborectalis, external anal sphincter, longitudinal muscle of the anus, levator plate, external urethral ligament, urethra, rectovaginal fascia, post anal plate, perineal membrane, perineal body, vagina, rectum, uterosacral ligament

different to the parietal one as it is much more lax and less resistant that contains an important amount of nerves and vessels.

Remember: the **pelvic fascia** covers the skeletal muscles and attaches them to the bony pelvis and the **endopelvic fascia** covers the organs and attaches them to the pelvic wall.

The **sacrospinous ligament** connects the lateral border of the sacrum and the coccyx to the ischial spine. It has a triangular shape with the base oriented to the sacrum; on its medial part, it merges with the sacrotuberous ligament. It marks the division between the greater and the lesser sciatic foramina and lies on the dorsal aspect of the coccygeal muscle. The pudendal neurovascular trunk runs lateral to the sacrospinous ligament at its attachment to the ischial spine.

The **sacrotuberous** ligament originates in the posterior superior iliac crest and goes downward along the edge of the sacrum to end at the ischial tuberosity. It has fibers that connect to the hamstrings and limits the lesser sciatic foramina inferior and laterally.

The **iliolumbar** ligament joins the iliac crest with L4–5.

The **iliofemoral** ligament attaches the crest of the ilium to the acetabulum.

The pubourethral ligament or **urethropelvic** ligament located over the anterior wall of the vagina runs from the inferior side of the pubic symphysis to insert medially into the mid urethra and laterally into the pubococcygeus muscle and vaginal wall. It supports the urethra.

External urethral ligament joins the external urethral meatus to the descending pubic ramus, the clitoris, and the pubourethral ligament.

The **pubocervical** or **vesicocervica**l fascia lies below the bladder; it is intimately attached to the pubourethral ligament. Its insertion at the pelvic wall is where the levator ani and obturator internus meet at the arcus tendineus.

Arcus Tendineus Levator Ani is a linear thickening of the pelvic fascia covering the obturator internus muscle that extends from the pubic symphysis to the ischial spine. It serves as the insertion point for the muscles of the levator ani, the urethropelvic fascial and the pubocervical fascia.

The **Cardinal Ligaments/Anterior Cervical Ring Complex** represent the posterior support of the anterior vaginal wall, vaginal apex, and uterus. It inserts laterally at the sciatic foramen and then goes around the cervix to end at the uterosacral ligaments. Around the cérvix is the cervical ring, which serves as an anchoring point for the uterosacral and cardinal ligaments as well as the pubocervical and rectovaginal fascia.

The **uterosacral or sacrouterine ligaments** suspend the apex of the vagina and serve as an insertion point for the longitudinal muscle of the anus. The uterosacral arises from the second to fourth sacral vertebrae and merges with the cervical ring posteriorly.

The **Pubovesical Ligament** goes from the pubis to the precervical arc of Gilvernet of the anterior wall of the bladder, acting as the structural support of the anterior wall of the bladder.

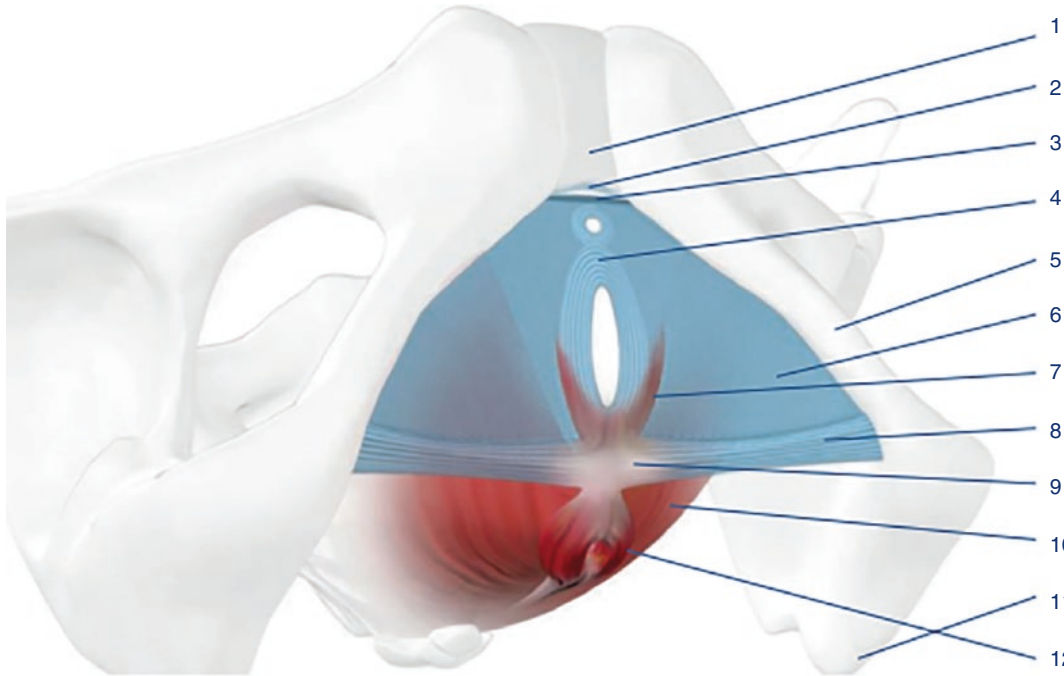
As described by **DeLancey** [2], there are three levels of support: Level I is the superior or proximal support, which attaches the vaginal apex to the ischial spines and sacrum through the cardinal and uterosacral ligaments. Level II is the paravaginal or midvaginal support that attaches the vagina to the puborectalis fascia anteriorly and the obturator internus fascia posteriorly. Level III is the distal support where the vagina is attached to the puborectalis, the perineal membrane, and perineal body. These attachments keep the vagina and the organs that it supports (bladder, urethra, cervix and rectum) in the right position and with a correct function, when this attachments fail, it may result in uterine prolapse, cystocele, rectocele, and enterocele.

36.4 Perineum

Limited by the ischiopubic rami, ischial tuberosities, sacrotuberous ligaments and coccyx is the perineum. It lies below the pelvic floor musculature. It has a rhomboidal shape made of two triangles that have as a common base the virtual line drawn between the ischial tuberosities. The anterior triangle is the urogenital hiatus and the posterior one is the anal hiatus (Fig. 36.11).

The **urogenital hiatus** is divided into the superficial and deep perineal spaces. The perineal membrane separates the urogenital triangle from the levator ani. The muscles of the superficial space are the ischiocavernosus, bulbocavernosus, constrictor of the vulva, and the superficial transverse perineal muscles; The deep perineal space contains the external urethral sphincter, the urethrovaginalis, and the deep transverse perineal muscles. The openings for the rectum, vagina, and urethra are called the urogenital hiatus.

The **perineal membrane** is a dense fibromuscular sheet that covers the anterior part of the pelvic outlet. It inserts in the pubic arc and posteriorly, it joins the perineal body connecting these two structures offering the support for the distal urethra and posterior vaginal wall, preventing their downward descent against the effects of increased intra-abdominal pressure and gravity.



1 symphysis pubis
2 inferior pubic lig. (arcuate lig.)
3 transverse perineal lig. (*Krause* lig.)
4 urethrovaginal m.
5 inferior ischio-pubic ramus
6 deep transversal perineal m. (urogenital diaphragm)
7 bulbospongiosus m.
8 superficial transversal perineal m.
9 tendinous center of the perineum (perineal body)
10 levator ani m.
11 ischial tuberosity
12 external anal sphincter m.

Fig. 36.11 Muscles and bones of the pelvic floor. (Reprinted from Gress S. Aesthetic and functional labiaplasty. Springer International Publishing AG 2017, with permission)

The **ischiocavernosus** muscle starts at the ischial tuberosities and inserts on the upper crura and body of the clitoris.

The **bulbocavernosus** muscle originates in the perineal body and run parallel to the vestibular bulbs to insert into the body of the clitoris, it constricts the vulvar hiatus and the dorsal vein of the clitoris during clitoral erection.

The **vulvar constrictor muscle** goes from the perineal body, around the vagina and ends at the clitoris, its fiber merge with those of the ischiocavernosus and bulbocavernosus.

The **Superficial transverse perineal muscle** has its origin at the ischium and inserts in the perineal body. The deep transverse perineal muscle runs from the ischial tuberosity to the perineal body.

The **perineal body** is an area of dense connective tissue where the superficial and deep transverse perineal muscles, bulbocavernosus muscle, perineal membrane, external anal sphincter, posterior vaginal muscularis, and fibers from the puborectalis and pubococcygeus muscles come together and act as the support for the vagina and contribute to normal anal function.

The **anal hiatus** lies below the levator ani muscles. It is the space situated between the sacrotuberous ligaments, the coccyx, and the perineal membrane and perineal body. In the center of the anal hiatus are the external and internal anal sphincters and anal canal.

Lateral to the anal sphincter on each side is the **ischiorectal fossa**, a space filled mainly with adipose tissue located between the levator ani and the perineum. It is limited laterally by the ischium, obturator internus, and the sacrotuberous ligament and medially by the levator ani. On the lateral margin is the Alcock canal, which contains the pudendal neurovascular trunk (Fig. 36.12).

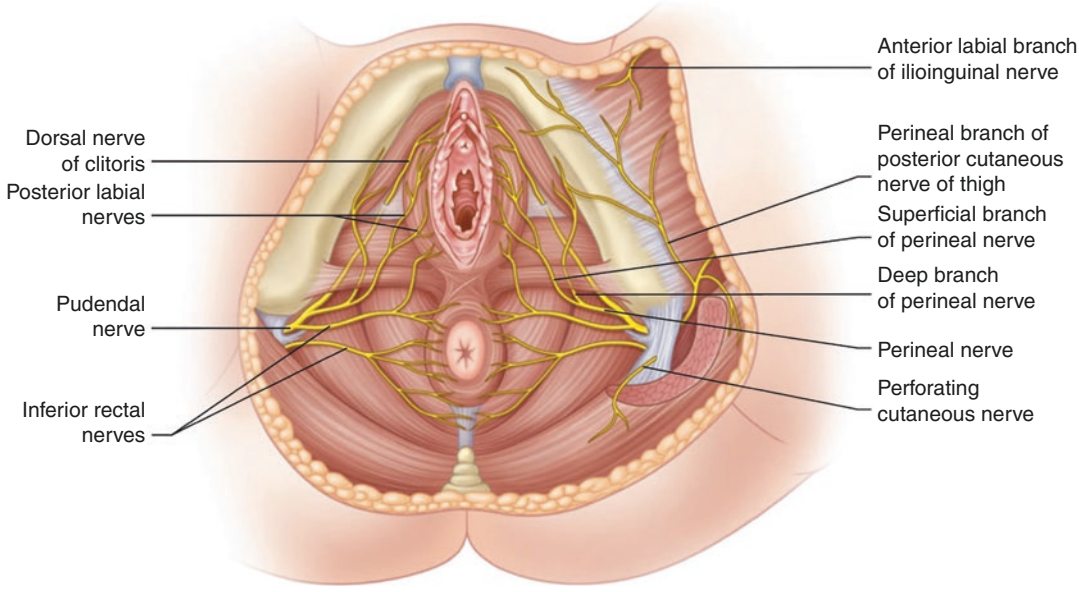


Fig. 36.12 Pudendal nerve and its branches. (Reprinted from Firoozi F. Female pelvic surgery. New York, Springer 2015 with permission)

36.5 Pelvic Spaces

The different pelvic organs are separated from each other by their fascial component and by potential spaces filled with avascular areolar connective tissue, which is relatively lax, allowing them to expand independently of the others. These spaces are very useful for surgical dissection (Fig. 36.13).

The vesicouterine pouch is a peritoneal recess between the anterior surface of the uterus and the dome of the bladder.

The rectouterine pouch is the space between the posterior vagina, rectum and uterosacral ligaments.

The perivesical or **Retzius** space is located between the lower anterior portion of the abdominal wall and the bladder. It contains a prominent venous plexus called the venous plexus of Santorini.

The **vesicovaginal** or vesicocervical space is found between the bladder, proximal urethra, and vagina under the peritoneal reflection at this point.

The **rectovaginal** space separates the posterior vaginal wall from the anterior surface of the rectum, and lies above the perineal body.

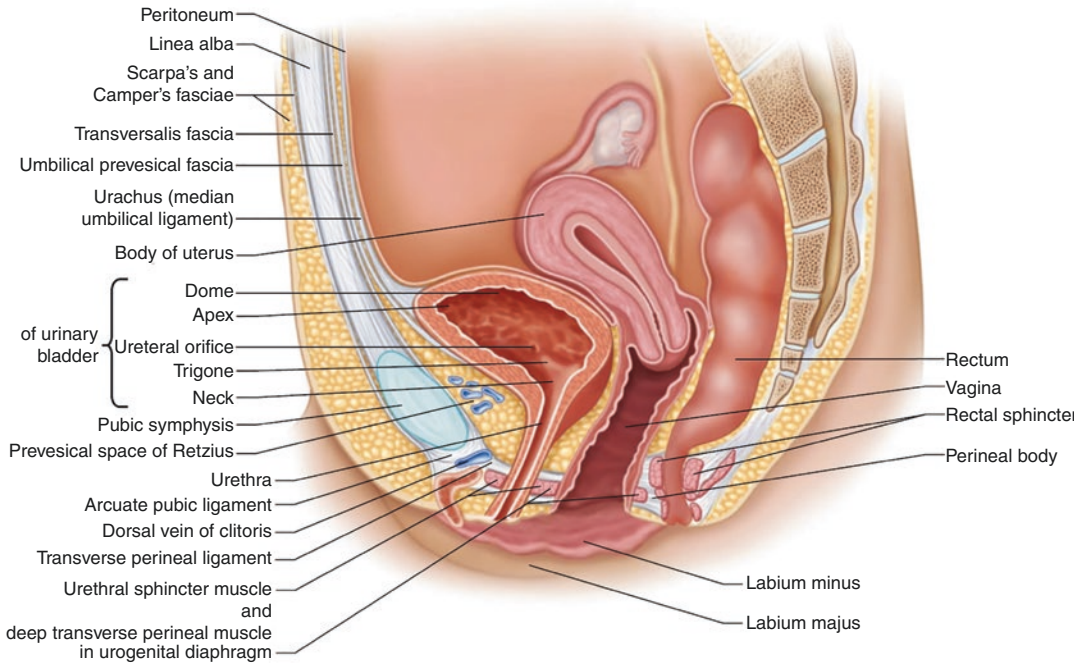


Fig. 36.13 Relationship of the pelvic organs. (Reprinted from Firoozi F. Female pelvic surgery. New York, Springer 2015 with permission)

36.6 Organs

36.6.1 Bladder

The bladder is a hollow, distensible organ that acts as the reservoir for urine. It has a globular shape when distended and lies flat when empty, with a capacity of approximately 500 mL. It lies behind the pubic symphysis separated from it by the Retzius space. The upper and posterior part of the bladder is covered by a reflection of parietal peritoneum that separates it from the uterus, creating the vesicouterine pouch. The rest of the bladder is extraperitoneal (Fig. 36.14).

The bladder is limited anteriorly by the pubis and attached to it by the pubovesical ligaments, laterally by the pelvic wall, inferiorly and posteriorly by the lower uterine segment, the anterior part of the cervix and the anterior vaginal wall.

The bladder has two principal components: the dome and the base. Histologically, three different layers are described, the inner part is the mucosa, made of a transitional epithelium called the urothelium supported by a layer of connective tissue, the lamina propria. The most external layer is the adventitia and between those two is the muscular layer that differs from the dome to the base. The muscular part of the dome is the **detrusor muscle**, made of three layers of smooth muscle disposed in different directions, the outer and inner layers run longitudinally and the middle layer circularly. This configuration is essential for the complete emptying of the bladder during contraction. The thickness of the dome is significantly reduced when the bladder is full. The base of the bladder is the **trigone**, a triangular-shaped area limited by the internal urethral meatus and the two ureteric orifices and the detrusor loop, which is a thickened part of the detrusor muscle, the base does not change its thickness. The muscular fibers from the trigone fuse with the muscular layer of the distal ureter and the proximal urethra.

The dome and the base have different innervations, the first one responds to β or cholinergic stimulation, causing contraction and emptying of the bladder and the base is mostly innervated by the parasympathetic nervous system and therefore responds to α-adrenergic stimulation, favoring continence.

The bladder receives its blood supply from the **superior vesical** artery, which comes off the

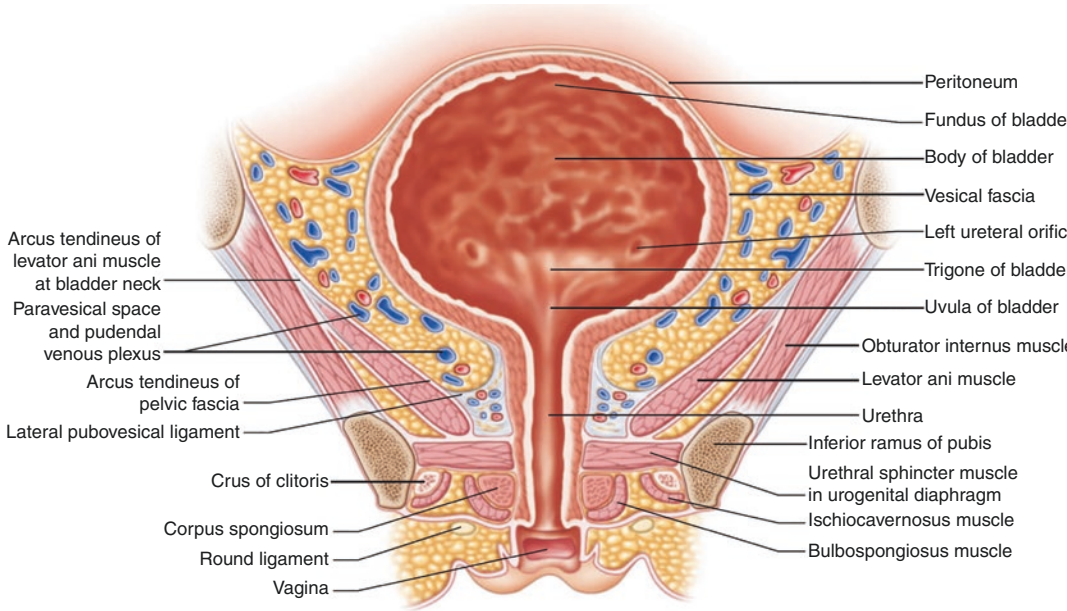


Fig. 36.14 Bladder and urethra: (Reprinted from Firoozi F. Female pelvic surgery. New York, Springer 2015 with permission)

obliterated umbilical artery and the **inferior vesical** artery, which is a branch of the internal pudendal artery or the vaginal artery. It is innervated by sympathetic and parasympathetic fibers of the **pelvic plexus** (S2–S4) and **hypogastric plexus.**

36.6.2 Urethra

The female urethra measures around 4 cm long and 6 mm in diameter. It connects the bladder to the vaginal introitus and is responsible for urinary continence. It is attached to the bladder at the bladder neck, which is an intramural portion of the urethra into the bladder base. On the distal two-thirds of the urethra, it runs along the anterior vaginal wall, as it crosses the perineal membrane, its lumen is slightly curved and then ends at its external orifice in the vestibule just above the vaginal opening.

The urethra is formed by three layers, which are the mucosa, the submucosa, and the fibromuscular layer that includes the urethral sphincters. The mucosa is made of transitional epithelium in the proximal part and a nonkeratinized squamous epithelium on the distal part, which is sensitive to estrogenic stimulation and a submucosal vascular plexus rich in arteriovenous anastomoses.

The fibromuscular layer is divided into a circular layer of striated muscle on the outside and an inner longitudinal layer of smooth muscle, which is the **internal urethral sphincter**. The **external urethral sphincter** mechanism is formed by the striated urethral and periurethral muscles that act as unit called the **striated urogenital sphincter**. The muscles involved are the external urethral sphincter that lies adjacent to the urethral wall in the proximal two-thirds, the compressor urethrae, which are fibers from the urethra that reach the pubic rami and the **uretrovaginalis** with fibers that merge around the vagina. These last two are also known as the deep transverse perineal muscle. The urethra rests on the periurethral endopelvic fascia and on the anterior vaginal wall that contribute, together with the sphincter, to the proper urethral function (Fig. 36.15).

Near the meatus are the paraurethral or Skene glands that empty into the lumen on the dorsal surface of the urethra.

The urethra receives its blood supply from vesical vessels and pudendal vessels as well as from the vaginal artery and the artery of the cervix that come off of the uterine artery. The external urinary sphincter is under somatic control from the pudendal nerve, the rest of the urethra receives parasympathetic and sympathetic nerves through the hypogastric plexus.

36.6.3 Vagina

The vagina is a hollow fibromuscular cylinder located in the midline of the pelvis that extends from the cervix to the vestibule and measures about 6–7 cm long, slightly shorter on its anterior side to due the insertion of the cervix. When the vagina meets the cervix it makes a fold on giving place to the anterior and posterior fornices of the vagina and two lateral fornices. The vagina is wider near the cervix and gets narrower as it reaches the vestibule.

It is laterally attached to the pelvic side walls by the endopelvic fascia (**arcus tendineus fascia pelvis**). On the anterior surface it lies below the urethra, bladder and ureters separated by the endopelvic fascia or vesicovaginal adventitia. On its back surface it rests on the perineal body and distal rectum from which it is separated by the rectovaginal septum and Denonvilliers fascia. More proximally, the back surface is covered by peritoneum and as the rectum separates from the vagina it makes a fold which is called the Douglas or rectovaginal pouch. Laterally it fuses with the levator ani. It is disposed in a superior-posterior direction and held by the cervix and the uterosacral ligaments. As it crosses the perineal membrane, at the junction of the lower third with the rest of the vagina, it bends and is constricted due to the anterior traction of the levator ani. The bulbocavernosus muscles and body, which can be voluntarily contracted, surround the distal third.

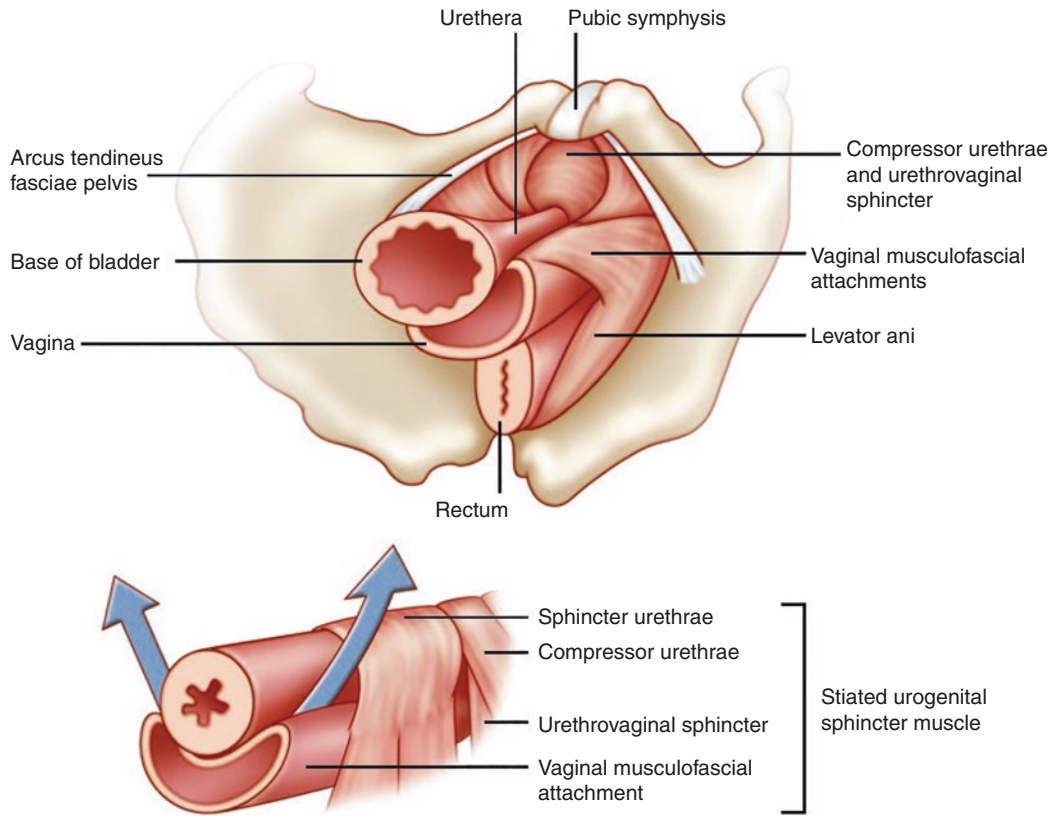


Fig. 36.15 Hammock theory: Urethral support and sphincter mechanism. (Reprinted from Firoozi F. Female pelvic surgery. New York, Springer 2015 with permission)

The inner lining of the vagina is the mucosa, a nonkeratinized squamous epithelium without glands and with many folds that allow distensibility during intercourse and labor while the rest of the time the vaginal walls are in contact with one another. The vaginal venous plexus, lymphatics, and nerves are organized along the submucosa. There are three layers of muscles, the outer one organized longitudinally and the inner and middle layers circularly. The adventitia is an extension of the endopelvic fascia, which contains lymphatics, nerves, and blood vessels.

The blood supply comes from an extension of the uterine artery and a vaginal branch of the internal iliac, which form an anastomotic arcade along both lateral sides of the vagina and give branches that supply the anterior and posterior vaginal walls. The vaginal artery may arise from the hypogastric artery, the uterine artery, or the superior vesical artery.

The pudendal vessels supply the distal vagina and the middle and inferior haemorrhoidal arteries the posterior vaginal wall.

The somatic innervation to the vagina, bulbocavernosus muscle and ischiocavernosus muscle come from the perineal nerve, a branch of the pudendal nerve. The hypogastric plexus provides the sympathetic and parasympathetic fibers for the vaginal mucosa.

Lymphatic drainage of the upper two-thirds of the vagina is to the obturator and internal and external iliac nodes, and the distal third is to the inguinal nodes.

36.6.4 Rectum

The rectum is the part of the colon that starts when the sigmoid colon enters the pelvis and ends at the anal orifice. As the rectum passes the

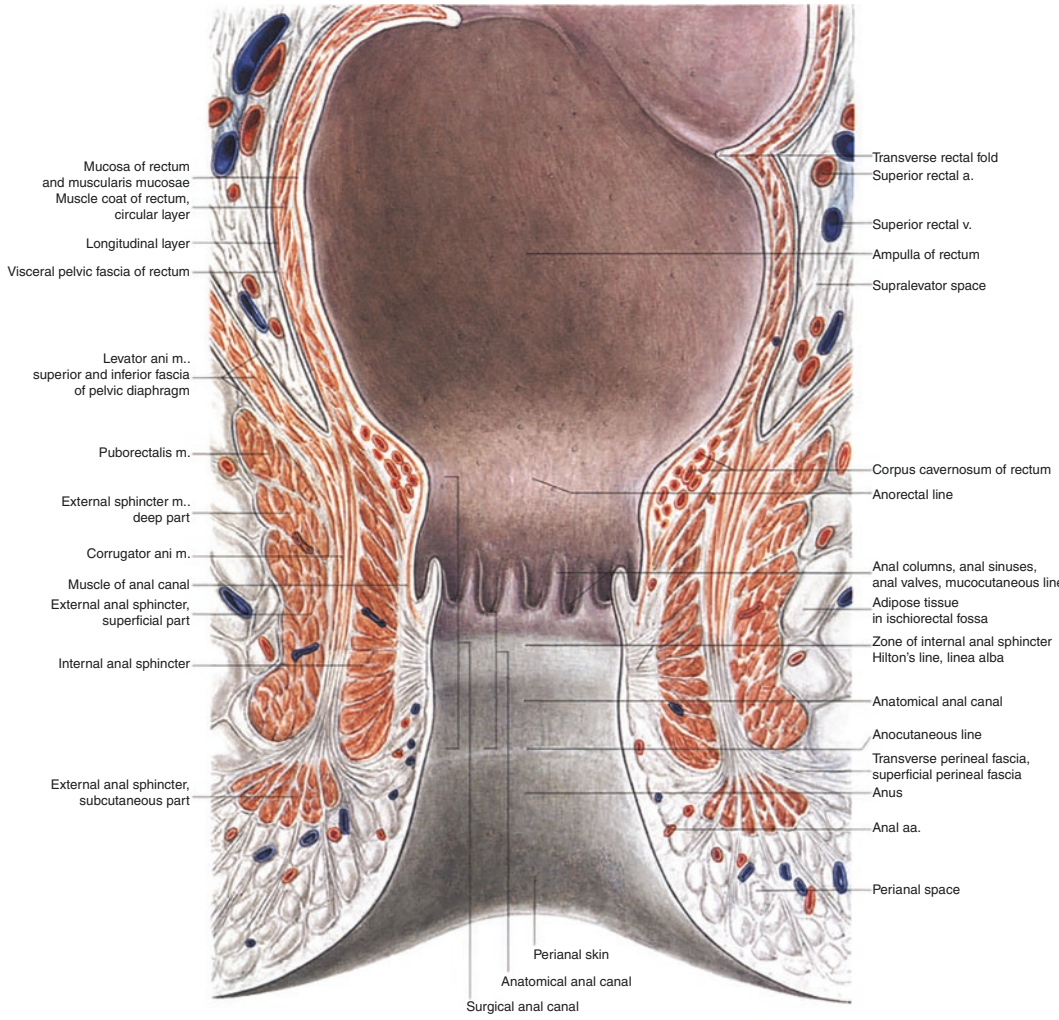


Fig. 36.16 Rectal ampulla, anal canal, and sphincter mechanism. (Reprinted from Werner L. Applied anatomy of the pelvis. 1st Ed. Springer. 1987 with permission)

posterior vagina, it loses its anterior peritoneal cover and gets wider, becoming the rectal ampulla. At its distal end, the puborectalis muscle embraces it and pulls the rectum anteriorly, creating a 90° angle that controls continence or defecation. This point is called the anorectal junction and below it starts the anus (Fig. 36.16).

The rectum lies behind the vagina from which it is separated by the rectovaginal septum and anterior to the sacrum and levator plate. On its lateral and inferior walls, it merges with fibers from the levator ani. On the distal end, the mucosa of the colon changes to a nonsquamous epithelium that continues with the perineal skin, which contains hair.

The rectum has two layers of smooth muscles, the inner one disposed circularly and the external one organized horizontally. The internal anal sphincter rises from a thickened part of the inner layer below the perineal flexure of the rectum. It is under autonomic control and is responsible for 85% of the resting anal pressure. The external layer of smooth muscle concentrates on both sides of the rectum and attaches to the perineal body and coccyx and goes downward over the external sphincter. The external sphincter con-

sists of striated muscle that works together with the puborectalis portion of the levator ani to keep the sphincter tonically contracted and can also be voluntarily contracted. The anal sphincter complex includes the internal and external anal sphincter and the puborectalis.

The anorectum receives its blood supply from an anastomotic arcade of vessels from the superior haemorrhoidal artery, which is a branch of the inferior mesenteric artery, the middle haemorrhoidal artery, which is a branch of the internal iliac, and the inferior haemorrhoidal artery, which is a branch of the pudendal artery.

36.7 Blood Supply

The arterial supply to the pelvis comes primarily from branches of the common iliac artery, which divides into the external iliac artery (for the lower limb)and the internal iliac artery for the pelvis and gluteal region (Figs. 36.17 and 36.18).

The ovaries, fallopian tubes, ascending and sigmoid colon, and rectum receive the blood supply from branches of the aorta.

The internal iliac artery runs lateral to the internal iliac vein. It divides into two trunks; anterior and posterior.

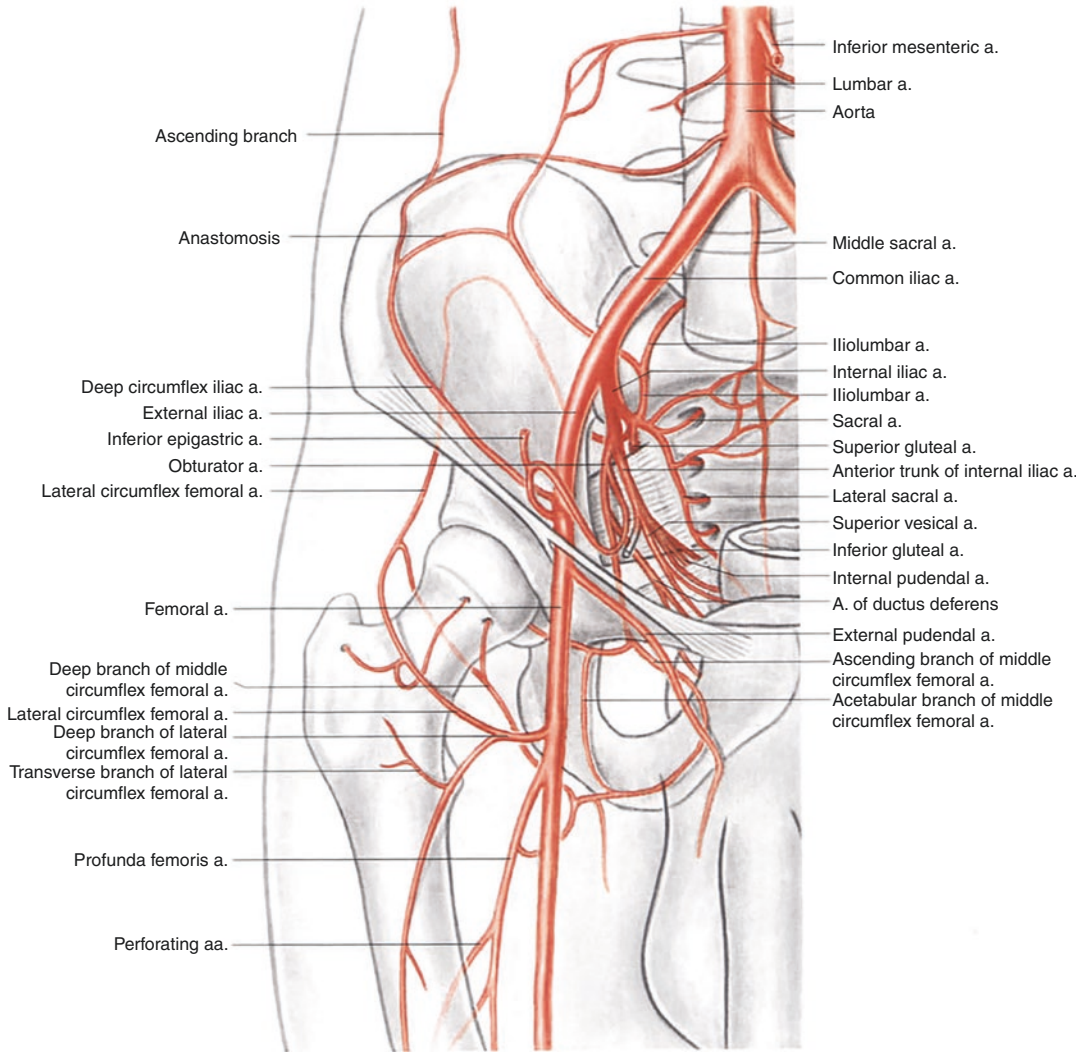


Fig. 36.17 Pelvic arterial blood vessels (adapted from Lierse W. Applied Anatomy of the Pelvis. Springer Berlin Heidelberg; 1987)

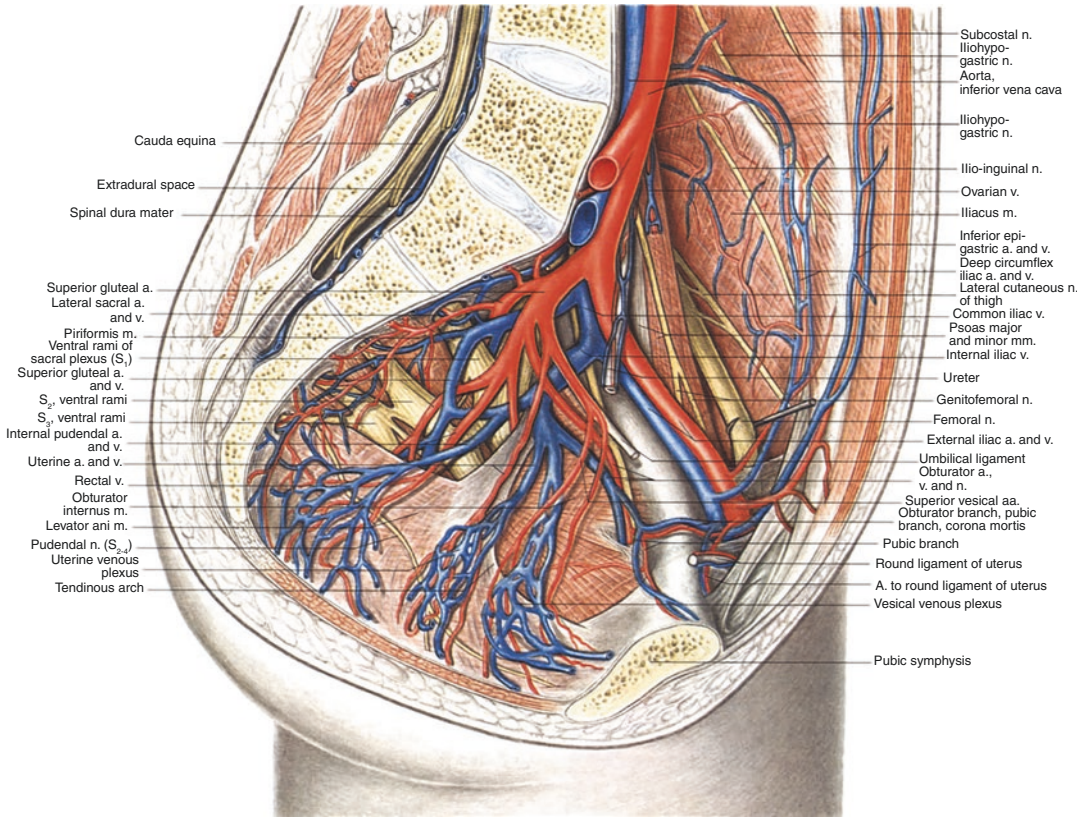


Fig. 36.18 Nerves and veins of the female pelvis: (Reprinted from Werner L. Applied anatomy of the pelvis. 1st Ed. Springer. 1987 with permission)

36.7.1 Aorta

Common iliac art

- External iliac:
  - Femoral artery
- Internal iliac:
  - **Posterior branch**
    - Superior gluteal a.
    - Superficial branch
    - Deep branch
    - Superior branch
    - Inferior branch
  - Iliolumbar a.
  - Lumbar branch (psoas major, quadratus lumborum and transversus abdominis muscles)
  - Spinal branch
  - Iliac branch (iliacus muscle ilium + gluteal muscles)
- Lateral sacral a.
  - Spinal branches

36.7.2 Anterior Branch

- Obturator a.
  - Pubic branch
  - Acetabular branch
  - Anterior branch
  - Posterior branch
- Inferior gluteal
- Internal pudendal a.
  - Inferior rectal a.

36.7.3 Visceral Branch

- Umbilical a.
  - Ureteric branches
- Superior vesical a.
  - Vesical branches
- Uterine a.
  - Vaginal a.
  - Ovarian branch
  - Tubal branch
- Middle rectal a.
- Perineal a.
  - Posterior labial branches

36.8 Innervation [3]

36.8.1 Somatic Innervation (Figs. 36.19 and 36.20):

- Lumbosacral plexus (T12–S3)
  - Lumbar plexus
  - Iliohypogastric nerve:
    Lateral cutaneous branch: skin of the superolateral región of the thigh
    Anterior cutaneous branch: skin from the inguinal region and over the mons pubis.

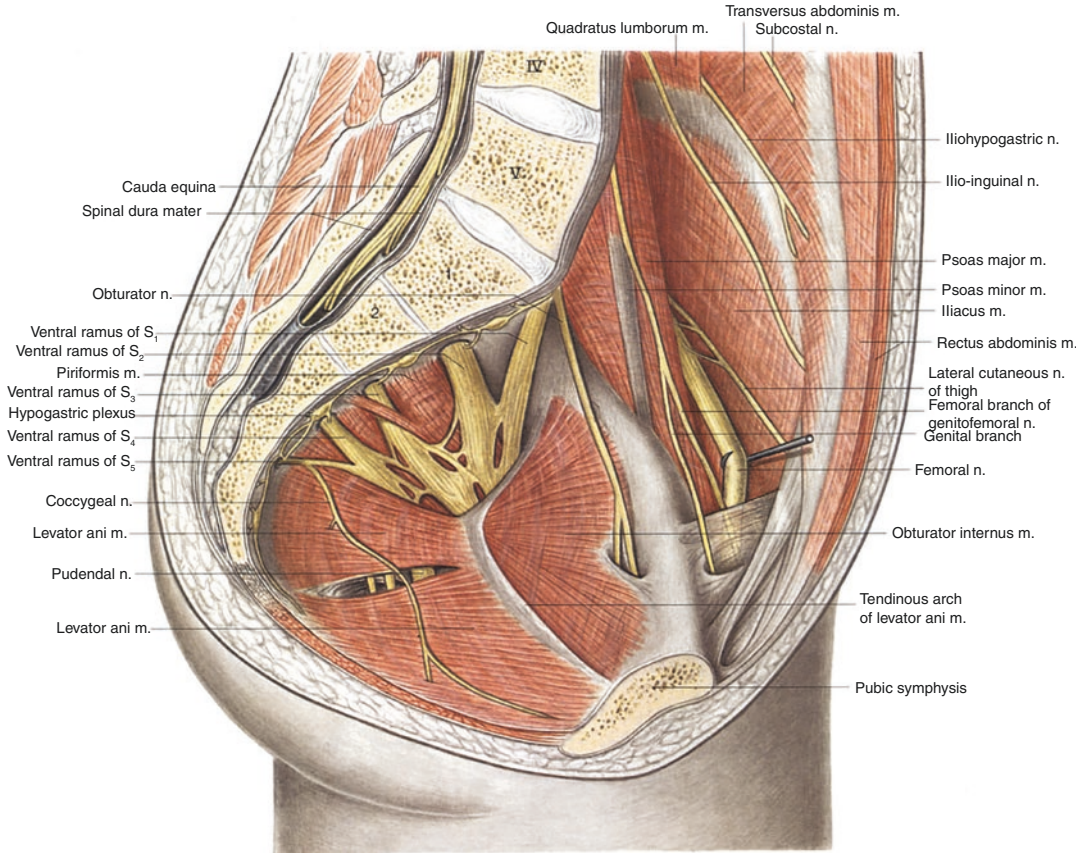


Fig. 36.19 Nerves of the pelvis. (Reprinted from Werner L. Applied anatomy of the pelvis. 1st Ed. Springer. 1987 with permission)

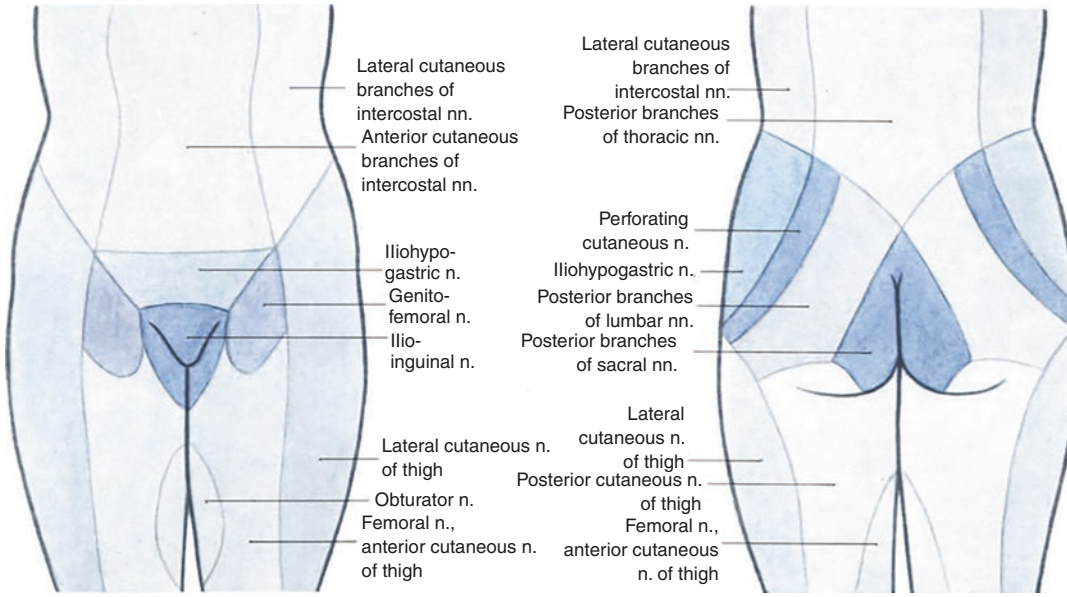


Fig. 36.20 Peripheral skin innervation. (Reprinted from Werner L. Applied anatomy of the pelvis. 1st Ed. Springer. 1987 with permission)

  - Ilioinguinal nerve (L1): skin of the superomedial part of the thigh, labia majora, and mons pubis.
- Genitofemoral nerve: (L1–L2) travels along the psoas major fascia and gives two branches:
  - The genital branch passes through the inguinal canal, the skin of labia majora, and the skin of the adjacent part of the thigh.
  - Femoral branch: skin adjacent to saphenous opening.
- Obturator nerve (L2–L4): It enters the lesser pelvis at the medial border of the psoas major, lateral to the internal iliac artery runs toward the obturator foramen, lying on the obturator internus muscle. And exits the pelvis through the obturator foramen. It can be pressured during pregnancy or labor, causing pain in the medial side of the thigh.
- Femoral nerve (L2–L4): starts at the lateral border of the psoas major, proximal to the inguinal ligament. Active flexure of the thigh.
- Lateral cutaneous nerve of the thigh (L2–L3): it runs over the lateral border of the psoas major, it innervates the anterior and lateral skin of the thigh
- Sacral plexus:
- Sciatic nerve
- Superior gluteal nerve: L4–S1 gluteus medius and minimus and the tensor fasciae latae.
- Inferior gluteal nerve L5–S1: gluteus maximus and piriformis.
- Gluteal branches of the posterior cutaneous nerve.
- Posterior cutaneous nerve of thigh: skin of the perineum, labia, inferolateral part of the gluteal region, and the posterior surface of the thigh.
- Pudendal nerve (S2–S4): it is a sensory and motor nerve. It enters the pelvis parallel to the pudendal artery and vein, through the greater sciatic foramen, goes over the ischial spine and sacrospinous ligament, and exits the pelvis through the lesser sciatic foramen to enters the perineum through the Alcocks canal. It gives three branches:
  - The inferior branch is the inferior rectal/hemorrhoidal nerve: external anal sphincter and anal skin.
  - The middle branch, the largest of the three, is the perineal nerve: skin of the perineum, labia majora and minor, levator ani, exter-

nal anal sphincter, ischiocavernosus, the bulbocavernosus,the transverse perineal muscles, the urethral sphincter, and the vestibule.
  - Superior branch: Dorsal nerve of clitoris: skin and gland of clítoris.
- Coccygeal plexus: skin over the coccyx.
- The **nerve supply** for the iliococcygeal and coccygeal muscles comes from the anterior branch of the ventral ramus of the third and fourth sacral nerves.

36.9 Functional Anatomy

Normal pelvic support is the result of the interaction between the muscles and its connective tissue attachments, the ligaments, and fascia. The forces resulting from the interaction of the different components give the organs the shape and position they have, which is essential for their correct functioning (Fig. 36.21).

Pelvic floor muscles are composed of type I **muscle fibers** (slow-twitch) and type II (fast-twitch). **Type I** fibers correspond to 90% of the composition of the pelvic floor muscles and are involved in maintaining tone and posture involuntarily in resting conditions, they have high resistance to fatigue and consume little energy. **Type II** fibers are recruited during voluntary muscle contraction or when intra-abdominal pressure increases, they contract rapidly with short latency consuming a lot of energy. When the integrity of the pelvic floor is altered, the function is altered too and clinical problems, such as pelvic organ prolapse, and urinary or fecal incontinence, may occur.

Connective tissue is mainly composed of **collagen** (provides rigidity) and **elastin**. Events like pregnancy, childbirth, and ageing change the structure of these components and weaken them, therefore affecting the structural integrity of the pelvic floor. Structure of collagen changes with age, resulting in a weakened and less elastic

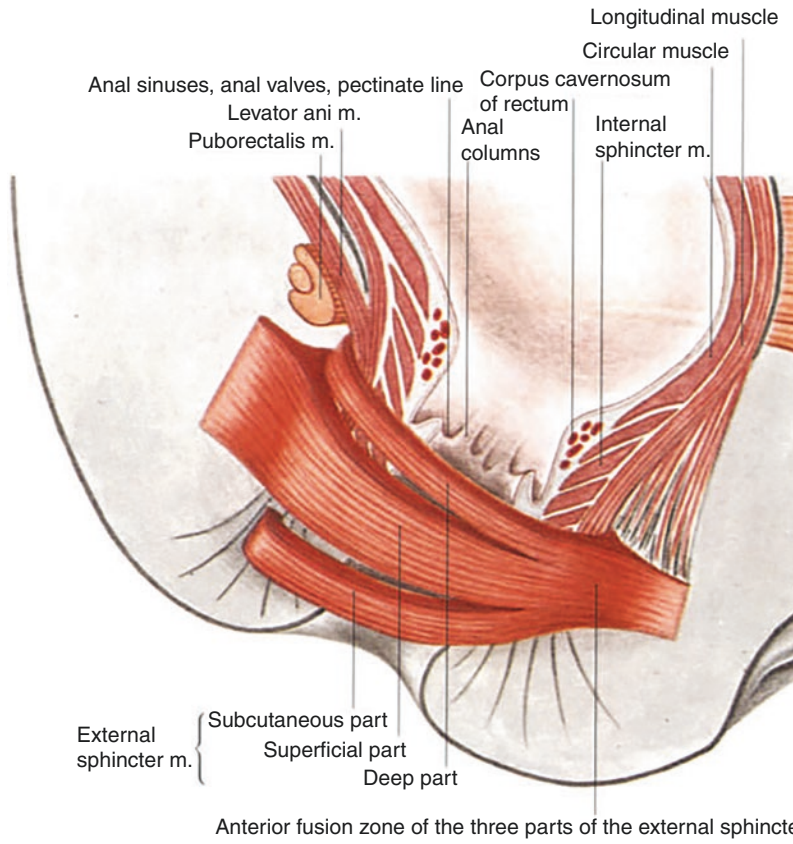


Fig. 36.21 Muscular closure mechanism of the rectum. (Reprinted from Werner L. Applied anatomy of the pelvis. 1st Ed. Springer. 1987 with permission)

structure, altering the mechanism of urethral support and causing urinary incontinence. Estrogens may prevent collagen loss and therefore have a role in the prevention of stress urinary incontinence [4].

The organs are suspended from the pelvis by the **fascia and ligaments**, which also serve as anchoring points for the muscles, and pull the organs downward and backward to help prevent their prolapse. If the ligaments are damaged or lax, the muscles will not be able to create the different forces that keep the organs in place.

The main function of the levator ani muscles is to close the urogenital hiatus, anchor the vagina and anus upward, and stretch the perineum toward the pubic symphysis [5].

As Petros and Ulmsten [6] described, the muscles of the pelvic floor can be divided into three layers, the upper one is horizontal and consists of the pubococcygeous muscle and the levator plate, the middle one contains the longitudinal muscle of the anus, and the lower one consists of the muscles sited over the perineal membrane (bulbocavernosus, ischiocavernosus and the deep and superficial transverse perineal muscles), the external anal sphincter and the postanal plate.

The pubococcygeous muscle creates a forward force that stretches the organs anteriorly; the levator plate creates the backward force anchoring the posterior wall of the rectum. These two components serve as support for the organs and participate in the opening and closure of the urethra, vagina, and anus.

The longitudinal muscle of the anus is a striated, vertically oriented muscle that contributes to urinary continence during effort by closing the bladder neck as a result of the downward force it creates when it contracts. When it stretches, it opens the outflow tract for micturition. Superiorly, it inserts in the levator plate and inferiorly in the external anal sphincter; when it contracts, it pulls from the levator plate and contributes to the angulation of the rectum, which is essential for fecal continence.

When the muscles of the lower layer contract, they stabilize the distal parts of the urethra, vagina, and anus and also help in containing the abdominal contents.

The deep transverse perineal muscle stabilizes the perineal body laterally, the bulbocavernosus stretches and anchors the distal part of the urethra, and the ischiocavernosus stretches the external urethral meatus laterally.

The puborectalis has an important role in anorectal closure, it is the voluntary muscle activated during contraction or "squeezing" of the pelvic muscles (i.e., Kegel exercises) [7].

The lower two-thirds of the urethra are attached to the anterior vaginal wall, which at the same time is densely adhered to the perineal body, and the anterior wall of the rectum. This keeps the distal part of these three organs firmly attached to each other, while in the more proximal part, they are not adhered, allowing them to stretch, which is essential for opening and closure.

Urethral closure is the result of the forward tension created by its attachments to the pubourethral ligaments and pubococcygeous muscle acting at the same time as the backward tension created by the levator plate and longitudinal muscle of the anus. When the forward component (pubococcygeous muscle) relaxes, the backward component stretches and opens the urethra for micturition.

Micturition is the result of the activation of a neurological reflex triggered by the stretching of pressure and volume receptors at the bladder base that cause the relaxation of the pubococcygeous muscle, stretching of the levator plate and longitudinal muscle of the anus and contraction of the detrusor. Connective tissue laxity may unbalance the peripheral neurological control mechanism, so that the stretch receptors are activated prematurely, causing manifestations of bladder instability such as urgency, increased frequency, and nocturia. Laxity in the anterior forces will cause stress incontinence symptoms or unconscious incontinence due to urethral closure defects.

The external striated muscle mechanism gives the ultimate control for opening and closure. If the external opening mechanism is altered, the flow rate will decrease and the patient will complain of emptying symptoms or incontinence.

Urethral closure during effort results from the closure of the distal urethra (forward force against

the pubourethral ligament) and closure of the bladder neck (backward force).

Normal micturition is the process of being able to open, expel all the urine, and return to a closed state rapidly. Damage in the pubococcygeous muscle or pubourethral ligaments will cause stress incontinence. Lax uterosacral ligaments may enable the backward force to open the urethra and will originate a functional obstruction with symptoms such as slow flow, difficulty in starting to expel the urine, or incomplete emptying.

Damage in the pubocervical or rectovaginal fascia contributes to the collapse of the vaginal walls, causing a prolapse.

Closure of the anal canal results from the interaction of three muscular structures: the smooth muscle of the internal anal sphincter, which contributes to 75% of the resting pressure and therefore plays a key role in maintaining continence [8]; the striated muscle of the external anal sphincter, which is voluntarily activated to generate additional closing pressure during increases in abdominal pressure such as during coughing, sneezing, or lifting heavy objects [9]; and the striated puborectalis muscle, which creates a 90° angle in the rectum. Contraction of the puborectalis induces the posteroinferior stretching of the posterior rectal wall reducing the anorectal angle and preventing the scape of its content secondary to involuntary intra-abdominal pressure increase. Defecation occurs secondary to the relaxation of the puborectalis that diminishes the anorectal angle favoring the evacuation of fecal content. Since defecation is a voluntary action, it can be inhibited by contracting the puborrectalis and the external anal sphincter.

As with urinary dysfunction, anal dysfunction (constipation or incontinence) will occur if any of the backward or forward components is not properly working due to a neurological or connective tissue defect. When the index finger is placed in the vagina and the woman is asked to bear down with her abdominal pressure, the contracted levator ani can be felt in the lateral vaginal walls. Contraction of the puborectalis approximates the anus to the vagina and the posterior wall of the vagina to the anterior vaginal wall.

36.10 Pelvic Floor During Pregnancy and Labor

During pregnancy, many changes occur in the women in order to satisfy the increased metabolic demand, allow the fetal growth, and prepare the body for childbirth. Concerning the bony pelvis, there is an increase in the anterior pelvic tilt and pelvic width, the center of gravity shifts anteriorly and joint laxity, especially at the sacroiliac joint and pubic symphysys increases [10].

As pregnancy reaches term, the increased intra-abdominal pressure relies on the anterior abdominal wall and pelvic floor, weakening the muscles (Table 36.2).

Connective tissue in the urogenital hiatus is sensitive to hormones and changes during pregnancy become more distensible in order to allow birth.

During pregnancy, the suspensory ligaments weaken and stress urinary incontinence or bladder instability may occur. This laxity causes a weakened support that may cause pelvic pain or the activation of the receptors of the bladder base triggering the micturition reflex and resulting in symptoms of bladder instability such as frequency, urgency, and nocturia [11].

One of the main risk factors for pelvic floor dysfunction is **vaginal delivery,** but pregnancy itself induces persistent changes in pelvic organ support [12].

Pelvic floor damage associated with labor is due to three main factors: **muscular** lesions, **nervous** alterations in the pudendal nerve, and damage of the **connective tissue.**

As the fetus passes through the birth canal and urogenital hiatus, an overdistension of the tissues

Table 36.2 Anatomic changes during pregnancy

Anatomic changes during pregnancy
Increase in the anterior pelvic tilt and pelvic width
Anterior shift of the center of gravity
Increased joint laxity (sacroiliac joint and pubic symphysis)
Increased hormonal sensitivity in connective tissue
Stress urinary incontinence and bladder instability
Increased genital hiatus and perineal body (POP-Q)
Cranial shift of vagina and cervix (POP-Q)

occurs as well as compression of the bladder, urethra, and rectum occurs, diminishing the vascular supply to these structures [13] (Fig. 36.22). The consequent damage of the structural support will end in an urethral hypermobility with stress incontinence and pelvic organ prolapse.

The perineal body may be ruptured during labor, favoring pelvic organ prolapse [10].

As Dietz concluded [14], the medial part of the pubovisceral muscle is the one that suffers most, since it is the one that supports more tension in a very short period of time. After vaginal

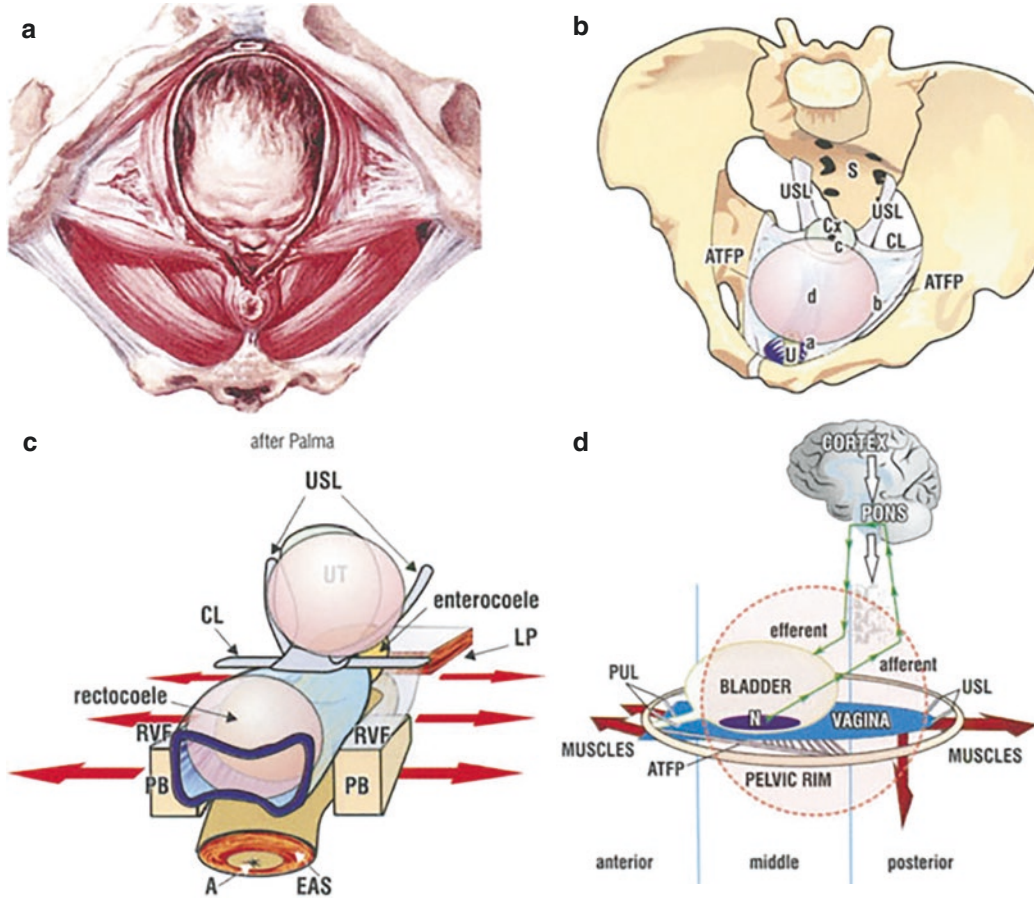


Fig. 36.22 Schematic representation of Childbirth. (**a**) Childbirth. Forcible lateral displacement of hiatal and perineal structures. The head has turned 90° and has descended below the ischial spines to distend the middle and distal parts of urethra, rectovaginal fascia, and perineal body. The A-P diameter of the pelvis is 12–13 cm, A flexed head measures 9.4 cm, and a deflexed head 11.2 cm. After Santoro, by permission. (**b**) Childbirth. Forcible lateral displacement of connective tissue structures by the fetal head (circle) at the level of the ischial spines may cause ligamentous laxity at 'a' (pubourethral), 'b' (ATFP), 'c' (cardinal/cervical ring), 'd' (pubocervical fascia) causing prolapse and incontinence. (**c**) Childbirth. Forcible lateral displacement of uterosacral ligaments (USL), perineal body (PB) and rectovaginal fascia (RVF) by the fetal head above and below the ischial spines (circles) causing connective tissue laxity, and protrusion of enterocoele and rectocoele. (**d**) Schematic representation of a fetal head pressing into the pelvic brim, against the vagina and its suspensory ligaments, uterosacral (USL), pubourethral (PUL), and Arcus Tendinous Fascia Pelvis (ATFP). There may be no major separation of ligaments. Even minor damage may cause urgency, as this symptom is neurologically determined; a lax vaginal membrane may not be able to support sensitive stretch receptors "N′: so that these activate the micturition reflex prematurely. The patient senses this as urgency and frequency, and at night, nocturia. (Reprinted from Petros P. The female pelvic floor: function, dysfunction, and management according to the integral theory. 3rd edition. Germany. Springer; 2010 with permission)

Table 36.3 Anatomic changes during delivery

Anatomic changes during delivery
Overstretching of levator ani avulsion
Damage of structural support: urethral hypermobility, pelvic organ prolapse
Perineal tears
External anal sphincter lesion: anal incontinence
Overdistension, stretching, and compression of pudendal nerve

delivery, lesions at this level have been described in up to 20–36% of primiparous women [15] and are not found after cesarean section [14]. The detachment of the puborectalis muscle from its insertion on the inferior pubic rami is called levator ani avulsion (Table 36.3) [16]. The risk factors for suffering a levator ani trauma are as follows: vaginal delivery, use of forceps, increased maternal age, lower maternal body mass index, fetal head circumference and position different to occipito-anterior, and a prolonged second stage of labor. Forceps delivery, especially rotational forceps, is the most important and best-established risk factor for avulsion, probably in relation to the shortened time to maximum distension and increased overall force [17].

Pelvic organ support can be assessed by the Pelvic Organ Prolapse Quantification (POP-Q) system, it is considered the gold standard for diagnosing anatomic POP. According to this system, it has been shown that the perineal body and genital hiatus become longer from mid to late pregnancy and shortened after 6 weeks postpartum, the vagina and cervix are pulled up as a consequence of uterine growth [18].

Another muscle, which is commonly damaged during vaginal delivery, is the **external anal sphincter** with an estimated incidence of 0.4–5%, contributing to anal incontinence.

Perineal tears and episiotomy are another cause of perineal damage associated with vaginal delivery.

Neurological damage associated with labor is due to damage in the pudendal nerve, which is responsible of the motor innervation of the anal sphincter and sensitive innervation of the genitalia.

Damage of the pudendal nerve is a common repercussion of childbirth. It results from overdistension, stretching, or compression, especially with prolonged second stage of labor and use of forceps. It results in a diminished strength of the levator ani and anal sphincter, which fail to reflexively contract in response to increases in abdominal pressure, favoring urinary and fecal incontinence. In a similar way, the resting tone of the levator plate and perineal body may be reduced, resulting in some grade of organ prolapse. This denervation is often temporal and improves with time [11, 19].

Epidural analgesia may have a protective effect against levator ani muscle avulsion although it may contribute to micro-traumatization of and development of ballooning [20].

Regarding sexual dysfunction, it is estimated to affect 63–93% [21] of pregnant women and up to 70% of women during the first year after birth [22] and it is associated with psychological and physical causes, being impaired pelvic floor muscle strength (levator ani avulsion) secondary to labor one of the main risk factors. Women with avulsion may complain of reduced contraction strength, increased vaginal laxity, and reduced tone on intercourse (Fig. 36.23) [23]. Perineal tears secondary to delivery may contribute to dyspareunia and have important effects on both the timing and quality of the resumption of sexual relations during the initial postpartum months [24].

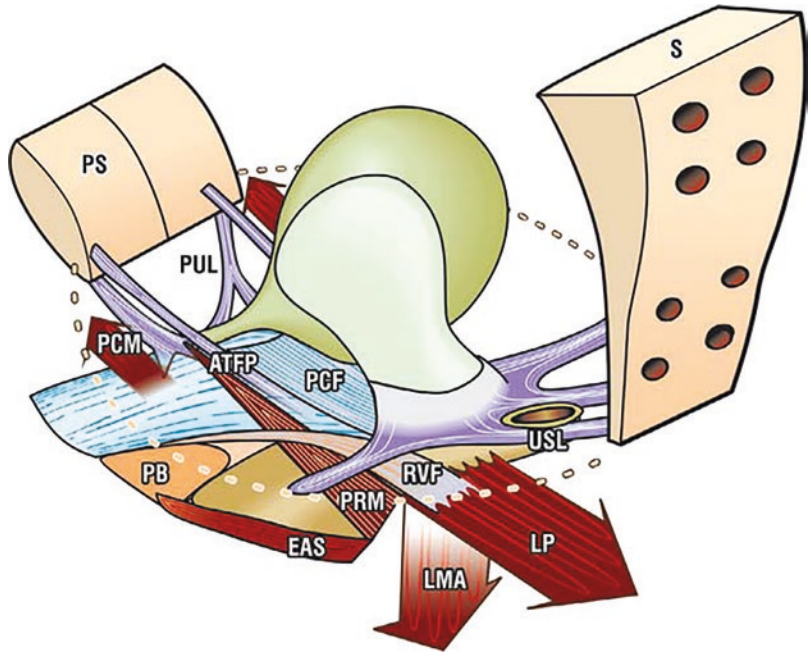


Fig. 36.23 Fascial attachments and tensioning mechanisms. *Anteriorly, vaginal fascia connects the vaginal membrane to the muscles and pubourethral ligaments (PUL), laterally to the Arcus Tendineus Fascia Pelvis (ATFP) and the cervical ring/cardinal ligament complex, posteriorly to the uterosacral ligaments (USL) and inferiorly, to the perineal body (PB). PB is tensioned by the external anal sphincter (EAS). (Reprinted from Petros P. The female pelvic floor: function, dysfunction, and management according to the integral theory. 3rd edition. Germany. Springer; 2010 with permission)

36.11 Pelvic Floor in the Puerperium

V**aginal delivery** increases the risk of having a pelvic organ prolapse in 4–11 times and 2.7 times the risk of having urinary incontinence [25].

Levator ani trauma may lead to avulsion and ballooning of the genital hiatus (hiatal area >25 cm^2) associated with a weaker and more distensible muscle, which may predispose to pelvic organ prolapse [26].

Studies that have evaluated the hiatala area at 3–6 months and 2–3 years after the first birth, found that there was no evidence of regression or healing, suggesting that overdistension of the puborectalis or levator "micro-trauma" may be irreversible [27].

Levator ani avulsion is a risk factor for genital prolapse and as Dietz [28] demonstrated, women with pubovisceral muscle avulsion were twice as likely to have cystocele and uterine prolapse of stage II or higher than those without. Levator trauma is also a risk factor for treatment failure [26].

It is estimated that 45% of women with a history of vaginal delivery will suffer a moderate pelvic organ prolapse in the following 20 years [29] and 50% will have urinary incontinence. This risk increases with maternal age and weight and use of forceps.

Urinary incontinence is not associated with levator ani avulsion [26]; it improves with time, and only 3% of the women, who refer symptoms during delivery or postpartum, refer those symptoms one year after. 92% of women referred recurrent stress urinary incontinence 5 years postpartum [11].

The pudendal nerve terminal motor latency recovers after 2 months, whereas functional dis-

turbance in the pelvic floor persists at least until 6 months [30].

Pelvic floor muscle strength is impaired shortly after vaginal birth, but for most women returns within 2 months [19].

POP-Q points, except for the cervix, return to baseline 12 months postpartum after vaginal delivery [18].

Although urinary and fecal incontinence has not clearly been associated with levator ani avulsion, pelvic floor muscle training has a positive impact on this morbidities, since they strengthen other muscle groups that are important for anal and urinary continence [26].

Fecal incontinence in parous women is associated with direct muscular [31] and indirect neurological damage to the anal sphincter that may occur during vaginal delivery. The reported incidence of fecal incontinence in primiparous women is 2–6%, which increases to 17–62% after third or fourth degree perineal tears [19]. Direct sphincter injury is more common after the first childbirth and use of forceps,whereas neuropathy may be cumulative with successive deliveries. Both injuries may remain asymptomatic until menopause, when estrogenic support of pelvic floor connective tissue descends and symptoms may appear [32].

36.12 Conclusions

Pregnancy is a predisposing factor to develop some degree of pelvic floor dysfunction regardless of mode of delivery. Vaginal delivery, and especially the use of forceps and maternal age, is an important risk factor for the development of pelvic floor dysfunction manifested as stress urinary incontinence, fecal incontinence, pelvic organ prolapse, and sexual dysfunction.

During labor, overdistension, stretching, or compression of the pudendal nerve may occur, resulting in a diminished strength of the levator ani and anal sphincter, contributing to urinary and fecal incontinence and pelvic organ prolapse. This denervation is usually temporal and improves with time.

Most women with postpartum stress urinary incontinence will recover within one year although they have a greater disposition for long-term recurrent stress urinary incontinence.

Understanding the anatomy and proper interaction among the support components is essential to diagnose and treat possible pelvic floor dysfunctions, present sometimes in pregnant and puerperal women.

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37 Pelvic Floor Muscle Exercises to Prevent and Treat Pelvic Floor Dysfunction

Sahar Sadat Sobhgol

Take-Home Points

- Research has shown that women who perform exercises during pregnancy and after birth have higher body image satisfaction, improved health, and also a better weight balance [1, 2].
- Thirty minutes of moderate general exercise for at least 3 days a week, if not daily, for pregnant women (in the absence of medical or obstetric complications) is recommended [1].
- Pelvic floor exercises must be one of the components of prenatal physical exercise [3].
- Supervised training by a trained health-care professional and adherence to a pelvic exercise program for at least 3 months is required to get the best results [1]
- Any exercise program will give better results when it is combined with a healthy lifestyle (such as healthy eating habits, cessation of smoking or alcohol, and preventing constipation to avoid straining on the pelvic floor) [1, 4].

37.1 Introduction

The aim of this chapter is to discuss the effect of pelvic floor muscle exercises (PFMEs) on pelvic floor dysfunction (PFD) and sexual function, particularly during pregnancy and postpartum, in the context of maternal body reshape techniques. This chapter has been divided into three parts. (1) The first section provides a definition and discusses risk factors of PFD and female sexual dysfunction (FSD), the role of pelvic floor muscle (PFM), and the effect of pregnancy and postpartum on the pathogenesis of PFD and FSD. (2) The second section provides a review of literature focused on the effects of pelvic floor muscle exercises (PFMEs) on PFD and FSD during pregnancy and postpartum, and (3) the last section provides information on treatment options of PFD and FSD with a specific focus on PFMEs and physical therapy and the mechanism of the effect of PFME.

37.2 Part 1. Definition and Risk Factors of Pelvic Floor and Sexual Dysfunction

- **Pelvic floor dysfunction (PFD):** Pelvic floor dysfunction (PFD) includes urinary incontinence (UI), fecal incontinence (FI), pelvic organ prolapses (POP), and female sexual dysfunction (FSD) [4, 5]. The incidence of

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/978-3-030-43840-1_37.

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© Springer Nature Switzerland AG 2023
M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_37

PFD is on the rise as life expectancy increases. Pelvic floor dysfunction significantly affects the quality of life of women [4, 6].

- **Urinary incontinence (UI):** Urinary incontinence is the most prevalent symptom of pelvic floor dysfunction. Defined by the International Continence Society, urinary incontinence is the complaint of any involuntary urine loss [4]. In pregnancy, the estimated prevalence of urinary incontinence ranges from 42 to 53%. Approximately 37–61% of primigravid women will develop urinary incontinence during their pregnancy, half of whom will remain incontinent at 8 weeks postpartum. For continent pregnant women, 34% will develop de novo incontinence after childbirth, and most will remain incontinent at 8 weeks postpartum [5].
- **Fecal incontinence (FI):** fecal incontinence is either the involuntary passage or the inability to control the discharge of fecal matter, gas (flatal incontinence) or solid or liquid feces through the anus [4, 5]. Flatal incontinence has been reported in 8.2% of primigravid women before or during pregnancy and ranges from 0 to 2.1% before birth. (1) In primigravid women, FI is almost always related to bowel diseases such as inflammatory bowel disease or irritable bowel syndrome. Studies have shown that 33% of women experience FI after vacuum-assisted delivery, and 44% after forceps delivery. Other studies have suggested that 1.2–4% of women develop fecal incontinence after spontaneous vaginal delivery, 3% after caesarean section, and 9% after forceps delivery [5].
- **Pelvic organ prolapses (POP):** Pelvic organ prolapse is the protrusion of the pelvic organs into or out of the vaginal canal [4]. Primiparous women can develop (mild) detectable prolapse during pregnancy and following childbirth. The rate of POP was reported to be 40% after vaginal birth, whether or not the delivery was instrumented. No data have been reported for women who delivered by caesarean section [5] (Fig. 37.1).

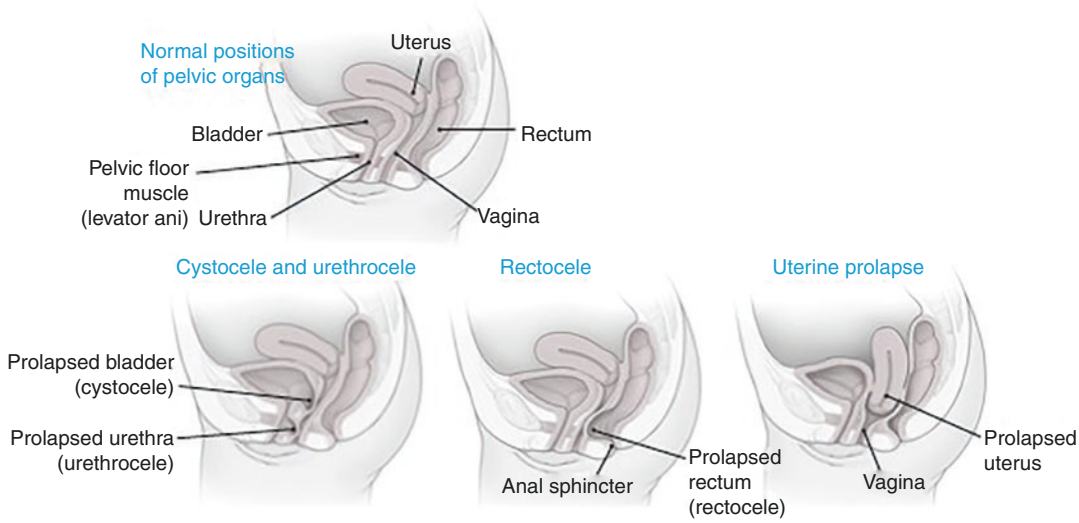

Fig. 37.1 Pelvic organ prolapses and normal pelvic organs positions (Retrieved from https://raincitymama.files.wordpress.com. Accessed February 2020)

37.3 Risk Factors of Pelvic Floor Dysfunction

Table 37.1 outlines the risk factors of PFD. Age, demographic factors (such as lifestyle, weight lifting, smoking, poor nutrition), menopausal age, previous history of pelvic surgery, pregnancy, and childbirth are considered the risk factors for pelvic floor dysfunction [4, 7, 8]. Pregnancy, obesity, and vaginal childbirth are important risk factors for PFD as they increase the burden on the pelvic floor structures, which contribute to weakening the pelvic floor muscles. The first birth seems to be the most harmful to the pelvic floor [4].

37.3.1 Female Sexual Dysfunction

Female sexual dysfunction (FSD) is a persistent or recurring reduction in sex drive, aversion to sexual activity, difficulty becoming aroused, inability to achieve orgasm, or dyspareunia [4]. According to the World Health Organization (WHO), FSD refers to the various ways in which an individual is unable to participate in a sexual relationship as he or she would wish [4, 9]. It is a complex neurovascular phenomenon that is under the control of psychological, neurovascular, and hormonal factors [10]. Women's sexuality is discontinuous throughout their life cycles and is dependent on personal and relationship variables as well as medical factors [4].

Table 37.1 Factors related to pelvic floor dysfunction

Factors related to PFD	
Predisposing factors	Gender, Race, Collagen, Neurologic, Muscular, Anatomic
Incite factors	Pregnancy and childbirth, Hysterectomy, Vaginal Surgery, Radical Surgery, Radiation Injury
Promoting factors	Constipation, Occupation, Recreation, Obesity, Lung Disease, Smoking, Infection, Medications, Menopause, life style
Intervening factor	Behavioral, Pharmacologic, Devices, Surgical
Decompensating factor	Disease, Environment Medications, Aging, Dementia, Debility

37.4 Risk Factors of Female Sexual Dysfunction (FSD)

Table 37.2 outlines the risk factors of FSD. The ability to express one's sexuality and engage in sexual activity requires multisystemic coordination involving many psychological functions as well as the integrity of the nervous, hormonal, vascular, immune, and neuromuscular body structures and functions [9, 11]. Women with PFD report higher rates of sexual dysfunction. It is recommended to ask open-ended questions about sexual function when evaluating women

Table 37.2 Risk factors of female sexual dysfunction

Risk factors of FSD	
Medical-surgical	Lower urinary tract problems, Voiding problem, Painful bladder syndrome, Urinary incontinence, Endometriosis, Uterine fibroids, Genitourinary cancer, Breast cancer, Arthritis Inflammatory or irritable bowel disease, Multiple sclerosis (MS), Neurological conditions, Spinal cord injury (SCI), Hysterectomy, ovariectomy, Diabetes mellitus, Coronary artery diseases, Heart diseases, Inflammatory diseases (rheumatoid arthritis and ankylosing spondylitis), Thyroid problems, Pelvic surgery
Obstetrics and Gynecology	Breastfeeding, Menopause, Hormonal imbalance, Hysterectomy Ovariectomy, Childbirth, Mode of delivery, Number of childbirths, Pelvic floor dysfunction
Psychological	Psychiatric conditions, Other mental health issues, quality of relationship, Depression, Anxiety, Obsessive compulsive disorder
Life style	Physical activity, Smoking, Drug abuse Alcohol consumption
Demographics	Genetic, Age, Education, Income Ethnicity
Other factors	Sexual orientation, Sexual abuse, Negative sexual attitude, Negative body image, Sex practice (penile-vaginal intercourse, anal sex, masturbation, and oral sex)

with PFD, in order to effectively identify the substantial number of women in need of help [4]. FSD in women with PFD was found to be correlated with age and pelvic floor muscle tone [11].

37.4.1 The Role of Pelvic Floor Muscles in the Pathogenesis of Pelvic Floor Dysfunction

The pelvic organs rest above the levator plate, formed by the pubococcygeus and the iliococcygeus muscles. During micturition or defecation, the puborectalis sling and levator plate relax, allowing the bladder (or rectum) to evacuate its contents. When contracted (whether reflexively with a cough or voluntarily), the puborectalis sling closes off the genital hiatus. Poor levator ani function may contribute to stress incontinence due to a lack of posterior support to the bladder neck, whereas a strong pelvic floor provides a backboard against which the bladder neck becomes "compressed" during increases in intra-abdominal pressure. Pelvic floor muscle exercises are devised mainly to strengthen this muscle group and thus promote urinary continence and pelvic organ support [5] (Fig. 37.2).

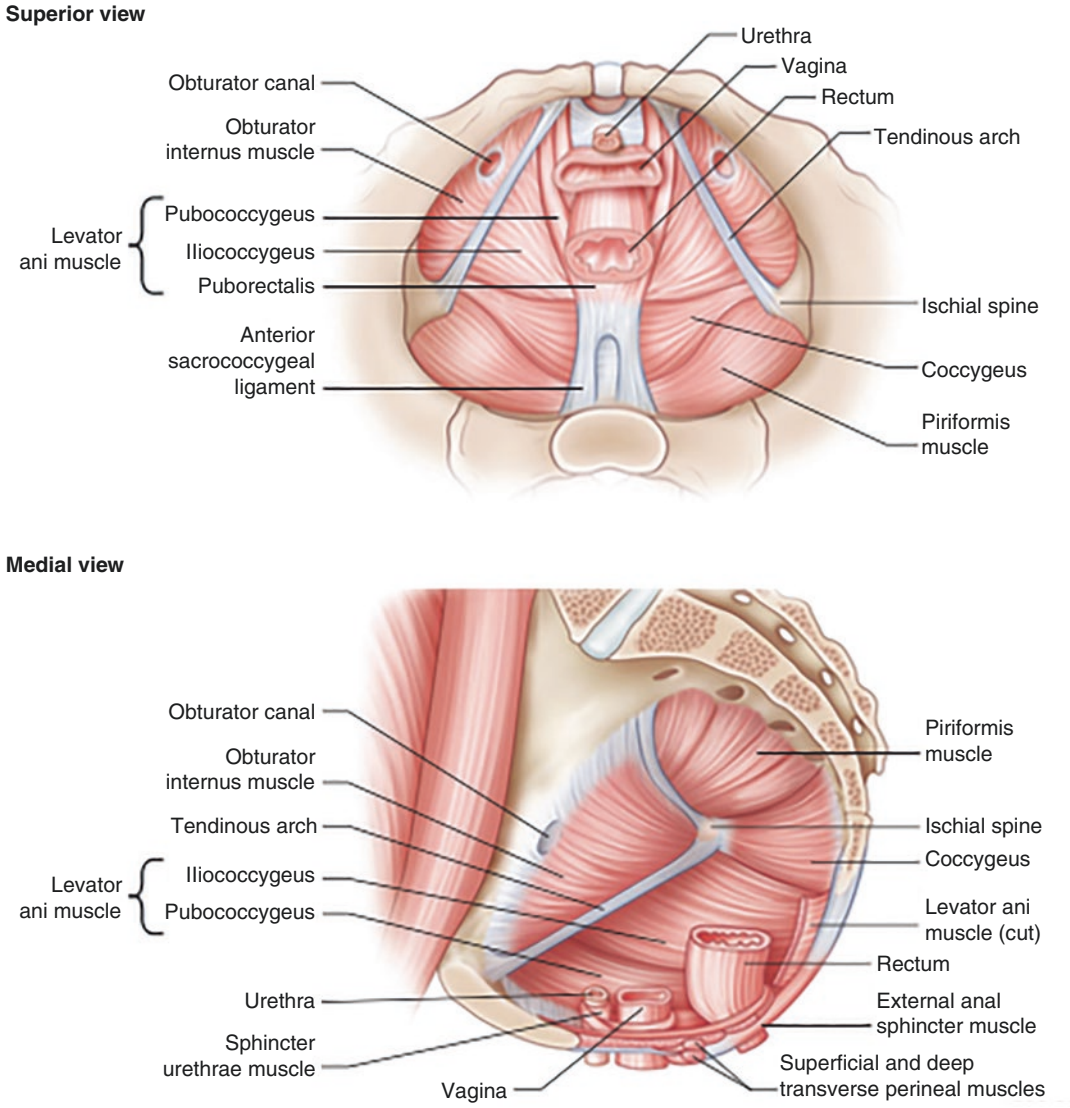

Fig. 37.2 Pelvic floor muscles (retrieved from https://media.springernature.com. Accessed February 2020)

Pelvic floor muscle strength (PFMS) is the single most important predictor of PFD. Pelvic floor muscle strength decreases with age and parity. An intact levator plate acts as a "flap-valve," keeping the walls of the vagina closed and supports the vagina over the levator muscles in the standing position, thereby preventing prolapse. Samuelsson reported that in a 35-year-old woman with two children, the probability of having prolapse was 25% if the PFMs were strong and 58% if the PFMs were poor [4]. Pathological and electrophysiological studies have shown that significant pelvic nerve damage and consequential denervation and reinnervation are associated with a weakened pelvic floor, POP, and stress incontinence [4, 8]. Collagen is a major component of fibrous tissue, basement membranes, bone, cartilage, and other specialized tissues, such as corneas and heart valves. Collagen is also the essential product of fibroblasts, which provide the tensile strength of the tissue. Collagenous changes related to childbirth, endogenous hormone changes, and the effects of increasing age occur in the pelvic floor. Interestingly, hormonal therapy does not appear to improve muscle tone or urodynamic performance due to denervation, which seems to significantly affect collagen metabolism [8]. Where there is neuromuscular dysfunction in the pelvic floor, the connective tissues supporting the pelvic organs are exposed to increased risk of injury and prolapse occurs [4]. Morphological studies have shown that muscle fibers increase in size (hypertrophy) under the stress of repetitive and sustained work. However, muscle fibers decrease in size (atrophy) when they are not active and they are deprived of the trophic influence of their innervation. Muscle hypertrophy associated with pelvic floor exercise is considered a preferential type 2 hypertrophy [8].

37.4.2 The Impact of Pregnancy on Pelvic Floor Function

While the majority of reproductive-aged women are in good health prior to pregnancy and remain in good health throughout pregnancy, many pregnant women experience important declines in functioning that may persist into the postpartum period [12]. The prenatal period is a unique physiological period in which a woman's body adapts to many changes to secure the well-being of the fetus and herself. The intra-abdominal pressure generated by the growing uterus, as well as the mechanical strain imposed by the delivery process, may cause partial denervation of the pelvic floor and injury to the muscle and connective tissue [13].

Obesity and childbirth are two important risk factors for PFD. Studies have shown that women who have had one live birth have an increased risk of becoming moderately overweight (60%) and obese (110%) [14]. Pregnancy weight gain is the strongest predictor for postpartum weight retention and the trend of weight gain starts in early pregnancy [1]. It seems that fat accumulation is highest during the second trimester and diminishes after birth [15].

As the controversy over elective caesarean delivery for protection of the pelvic floor grows, the relationship among pregnancy, parturition, and pelvic floor support remains poorly understood [2, 16]. The distinction between "normal" and "abnormal" pelvic organ support is still not clearly defined for the general population of women or the pregnant population. However, there are several indications suggesting pregnancy itself imposes significant changes to the pelvic floor, as outlined in Table 37.3.

The occurrence of PFD (including urgency, stress incontinence, discomfort/pain, and sexual complaints) has been reported in 52% of patients with pelvic lower back pain (PLBP) [21]. It has been suggested that PLBP is not associated with the Relaxin hormone; however, it is related to deficient pelvic stability [20] and asymmetric laxity of the sacroiliac joints (SIJs) [22–24]. Patients usually compensate for the pelvic instability by a higher level of activity in the pelvic floor muscles, since these muscles have the capability to stabilize the pelvic ring [20]. Therefore, it seems pelvic floor muscle exercises can also be effective in improving lower back pain in pregnant women [25] (Fig. 37.3).

Table 37.3 The effect of pregnancy on pelvic floor muscles

Effect of pregnancy on pelvic floor muscles
1. An increase in bladder and urethral mobility noticeable at early pregnancy [16]
2. A highly significant increase in the overall pelvic organ prolapse stage and the perineal body measurement from the first to the third trimester, due to collagen changes in pregnancy [17]
3. Vaginal distention associated with vaginal delivery conferring a 4- to 11-fold increase in the risk of the development of prolapse [17, 18]
4. Changes in the vaginal wall including increased distensibility and decreased stiffness and histomorphologic changes in the ratio of collagen subtypes and elastic fiber similar to those changes in patients with pelvic organ prolapse [18]
5. Increased episodes of stress urinary incontinence throughout pregnancy [2]
6. Downward displacement of the pelvic floor, a significant decrease in pelvic floor contractions, and a thicker pelvic floor muscle (PFM) in continent pregnant women as shown by perineal ultrasounds [19]
7. Increased joint laxity due to pregnancy hormones in addition to the intra-abdominal pressure due to a growing uterus and the delivery process, which can cause partial denervation of the pelvic floor and injury to the muscle and connective tissue [20]

37.4.3 The Impact of Pregnancy on Sexual Function

According to the WHO, healthy sexuality cannot merely be defined as the absence of sexual dysfunction, but as a state of physical, emotional, mental, and social well-being related to sexuality. Healthy sexuality during pregnancy appears to be a key stage in the evolution of a couple toward being parents [26].

It has been suggested that sexual function worsens during pregnancy and is not recovered by 6 months postpartum [27]. A study by Paul et al. (2008) reports that a low body image and urinary incontinence are associated with FSD during pregnancy and postpartum. This is due to the loss of urine or urgency to urinate during sexual activity, reduced lubrication, and dyspareunia. The protective effect of elective caesarean section for FSD remains controversial [27]. Impaired body image may occur with pelvic organ prolapse, which can also affect a woman's sex life [28].

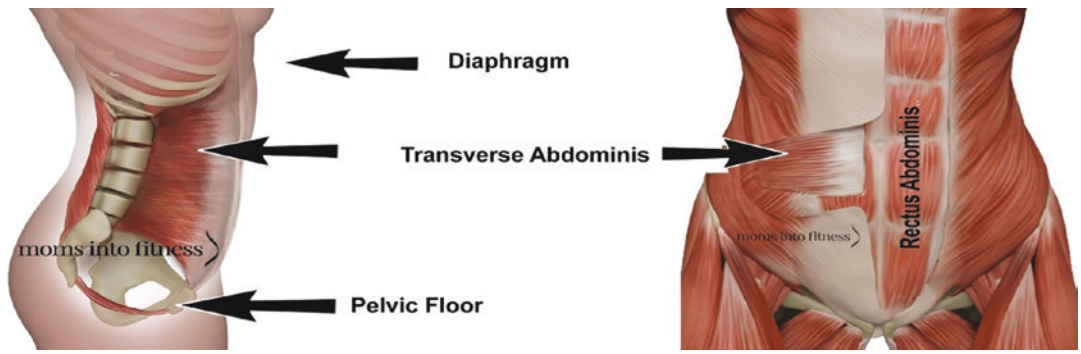

Fig. 37.3 The interconnected system of pelvic floor muscle and trunk (Retrieved from http://www.momsintofitness.com. Accessed February 2020)

37.4.4 Postpartum Period and Pelvic Floor Dysfunction

Women experience three stages of recovery in the postpartum period. The first acute stage is the first 6–12 h after birth. In the second stage, which lasts 2–6 weeks, the body undergoes major changes in terms of hemodynamic, genitourinary, metabolism, and emotional status. The third stage is the delayed postpartum period, which lasts up to 6 months. Changes during this phase are gradual. It is the time of restoration of muscle tone and connective tissue to the prepregnant state. Some changes to the genitourinary system are much longer in resolving, and some may never fully return to the prepregnant state [29]. Two third of primiparous women suffer from PFD symptoms [30] and women notice a significant reduction in pelvic floor muscle strength after birth, especially those who have sustained levator ani tears [31]. For many women, pelvic neuropathy will have no clinical consequences; for others, the nerve injuries initiate a pathophysiologic sequence eventually leading to incontinence, prolapse, and pelvic floor dysfunction [4]. Pudendal neuropathy due to vaginal birth, prolonged second stage, macrosomia, and assisted birth can persist and even worsen with time [32]. Surgical intervention should not be considered until 6 months postpartum (the length of time for complete restoration of connective tissue support). Pelvic floor muscle exercises (PFMEs) have been shown to be of benefit during this time [29].

The presence of incontinence during pregnancy may be predictive of postpartum incontinence [29]. When stress urinary incontinence arises during the first pregnancy, the risk of stress incontinence occurring 15 years later is doubled [33]. Urge incontinence may occur in approximately 30% of postpartum women [29]. In one study, it was found that 4% of women developed fecal incontinence after childbirth. Fecal incontinence as an immediate consequence of childbirth is more common than previously realized, and medical attention is rarely sought. Forceps and vacuum extraction deliveries are risk factors, with no protection demonstrated from emergency caesarean sections [34]. Even an uneventful labor [35] can alter the vesical neck descent during a Valsalva maneuver and the ability of pelvic muscles to elevate the urethra in some women [36]. However, prolapse symptoms and objective prolapse may not always be in concordance [37]. Cesarean delivery during active labor and vaginal birth has a similar effect on the maternal pelvic support. Caesarean delivery appears to effectively prevent denervation injuries when performed electively but does not provide full protection if performed after the onset of labor [4]. This may indicate that prolapse developed during pregnancy and the first, but not the second, stage of labor [38].

Pelvic floor dysfunction is a hidden problem with a magnitude unknown to many [39, 40]. Abnormalities in the levator ani muscle have been observed on MRI after a vaginal birth [40]. One study suggested a computer model as a first step to understanding how obstetrical factors and interventions might influence levator ani injury, since experimental measurements of levator stretch in labouring women are not currently feasible for many clinical, technical, and ethical reasons [39].

37.4.5 Sexual Function During the Postpartum Period

In a study in Australia, it was found that almost two-thirds of women (64.3%) experienced sexual dysfunction during the first year after childbirth, and almost three-quarters experienced sexual dissatisfaction (70.5%) [41]. Available data suggests that more than 83% of women experience sexual problems in the first 3 months to 6 months postpartum. At 6 months postpartum, 18–30% of women experience dyspareunia [42]. Another study reported that primiparous women who delivered with anal sphincter laceration are less likely to report sexual activity at 6 months postpartum. Six months from delivery, one in five women report dyspareunia and up to one in nine may not have resumed sexual activity [43]. The effect of mode of delivery (vaginal delivery or elective caesarean section), episiotomy or perineal tears, concomitant urinary

symptoms or other pelvic floor dysfunction, breast-feeding, and dyspareunia prior to childbirth on sexual function after birth still requires more research [26].

It seems that childbirth has an impact on sexual function. Some results suggest that married women without children have higher mean scores of sexual satisfaction and higher marital satisfaction than women who have experienced childbirth [44]. Although physical problems experienced by women in the postpartum period are often considered temporary or minor, they influence women's physical and emotional health. Healthy sexuality is a positive part of being human; however, for postpartum women, pelvic floor dysfunction, vaginal dryness, difficulty in achieving orgasm, decline of libido because of the amenorrhea during breastfeeding, fatigue, lactation, and decreased lubrication due to hormonal changes could result in painful intercourse. In addition, painful and adhesive scar tissue secondary to assisted vaginal birth, spontaneous tearing, or episiotomy may contribute to pain with intercourse. For some women, dyspareunia can persist for longer than a year [45].

37.5 Part 2. A Literature Review on the Effect of Pelvic Floor Muscle Exercises (PFMEs) on Pelvic Floor Dysfunction (PFD)

Ageing, childbirth, and pelvic floor muscle strength (PFMS) play important roles in urinary incontinence symptoms [46]. Vaginal childbirth can be considered equivalent to a major sporting injury [47]. Urinary incontinence is a debilitating condition that can adversely affect physical and mental health, sexual function, and quality of life in women [48]. Pelvic floor rehabilitation has been shown to improve incontinence symptoms, quality of life, and sexual function significantly [48]. Table 37.4 summarizes the results of several studies on this topic.

As outlines in Table 37.4, several RCTs, systematic reviews, meta-analysis, and Cochrane reviews showed that PFMEs are effective in either prevention or improvement of PFD symptoms. The current data on the preventive effect of PFME on the prevention anal incontinence, and pelvic organ prolapse during pregnancy is limited [1, 3]. There is also a lack of knowledge concerning the long-term effect of postpartum pelvic floor muscle training [6].

In addition to the above studies, Pelaez et al. and Sangsawang et al. reported that antenatal PFMEs are effective in the primary prevention of urinary incontinence during pregnancy. Pelvic floor muscle exercise can modify overactive bladder syndrome and urge urinary incontinence (UUI) through both afferent and efferent stimulation of the detrusor muscle [19]. Morkved et al. (2003) reported that intensive antenatal PFME prevented urinary incontinence in about one in six women during pregnancy and one in eight women after delivery [6]. Pelvic floor muscle exercises (PFMEs) also improve pelvic floor muscle strength [19, 54, 55] during pregnancy and postpartum [56]. Wilson et al. and Sampselle et al. reported that the women who performed PFMEs in the antenatal period had a decreased prevalence of urinary incontinence in the third month postpartum [56]. Similarly, Morkved et al. (2000) found that 8-week (8th to 16th week) postpartum PFMEs were effective in increasing pelvic floor muscle strength and reducing urinary incontinence. The authors reported that 66% of women were cured immediately after sessions of supervised training. The benefits from PFME (specially designed eight-week PFME) were still present one year after birth [54]. PFMEs may also be an auxiliary tool for relieving the musculoskeletal alterations observed during pregnancy and the puerperal period [55, 56]. Gagnon et al. also reported that PFME alone could improve the symptoms of urinary incontinence, colorectal and pelvic organ prolapse symptoms in postpartum women [57]. Physical therapy is regarded as the first-line treatment option for PFD as evidenced by the diagnostic and therapeutic algorithms developed by a panel of experts and based on scientific evidence [10]. However, the success of pelvic floor muscle exercises depends on training frequency and intensity [6].

Table 37.4 The summary of available research on the effect of PFME on PFD

Reference	Study design and Population	Aim of study	Results
Woodley et al. (2017) [49]	Cochrane review, including 37 trials	To assess the effect of PFMEs on UI and FI in antenatal and postnatal women	Targeting continent antenatal women early in pregnancy and offering a structured PFME program may prevent the onset of urinary incontinence in late pregnancy and postpartum
Stafne et al. (2012) [50]	RCT, by including 855 women. Intervention included a 12-week exercise program	To assess the effect of PFME on urinary and fecal incontinence during pregnancy	The authors concluded that pregnant women should exercise and in particular do PFME, to prevent and treat urinary incontinence in late pregnancy. Thorough instruction is important, and specific pelvic floor muscle exercises should be included in exercise classes for pregnant women
Hay-smith et al. (2008) [51]	Cochrane review, 6181 women in 16 trials (3040 in PFME and 3141 in control group)	The effect of PFME to treat or prevent urinary and fecal incontinence in antenatal and postnatal women	It is possible that the effects of PFME might be greater with targeted rather than population-based approaches and in certain groups of women (e.g., primiparous women, women who had bladder neck hypermobility in early pregnancy, a large baby, or a forceps delivery)
Harvey et al. (2003) [5]	A systematic review, 12 studies were included	Effect of PFMEs on the prevention of pelvic floor problems [POP, UI]	Postpartum PFMEs appear to be effective in decreasing postpartum UI. Data regarding the effect of PFMEs on prevention of anal incontinence and POP are lacking
Mason et al. (2001) [52]	RCT, including 717 women at 34 weeks' gestation and 572 women at 8-week postpartum	The effect of PFMEs on postpartum stress incontinence	There is a relationship between ante-natal PFME and postpartum stress incontinence: women who regularly who received PFME per week are significantly less likely to report symptoms of stress incontinence
Sut KH and Kaplan PB (2016) [19]	RCT, 60 pregnant women study (n = 30) and control (n = 30)	Effectiveness of PFMEs on pelvic floor muscle activity and voiding functions	The authors concluded that PFMEs prevent deterioration of urinary symptoms during pregnancy and the postpartum period
Chunbo et al. (2016) [53]	Systematic review and meta-analysis, including 13 studies with 2340 patients	To assess the effectiveness of PFME as a treatment for POP and also as adjunctive therapy to prolapse surgery	Women had greater improvement in PFMS after PFME. Evaluating PFME as an adjunct to prolapse surgery was inconclusive. Overall, the results demonstrated women who received PFME showed a greater subjective improvement in prolapse symptoms and an objective improvement in POP severity

RCT randomized controlled trial, *PFME* pelvic floor muscle exercise, *POP* pelvic organ prolapses, *PFMS* pelvic floor muscle strength, *UI* urinary incontinence

The improvement of urinary incontinence and pelvic floor muscle strength in the postpartum period has been reported in control groups indicating that pregnancy, with its hormonal and mechanic effects, is a very important risk factor in urinary incontinence [19, 56]. The pelvic floor muscles distend considerably to allow the passage of the infant and then contract to resume normal functioning [58]. The meta-analysis by Du et al. (2014) found that PFMEs significantly shortened the duration of the first and second stages of labor in women who perform antenatal PFMEs [59]. Donmez et al. (2015) also found that PFME decreases the rate of severe perineal trauma and enhances the healing of the perineum after childbirth [60].

Harvey et al. (2003) reported that antepartum PFME, when taught by trained personnel with biofeedback, does not significantly decrease the incidence of postpartum urinary incontinence in the short term (3 months). However, postpartum PFME, when performed with biofeedback or with a vaginal device, decreases postpartum urinary incontinence in high-risk women.

Postpartum PFMEs, when performed with a vaginal device, result in increased pelvic floor muscle strength. Evidence shows that a reminder and motivational system without expert instruction is ineffective in preventing postpartum urinary incontinence [5].

37.5.1 A Literature Review on the Effect of Pelvic Floor Muscle Exercises on Sexual Function During Pregnancy and the Postpartum Period

Having a healthy functional body, particularly a healthy pelvic floor, is essential for healthy sexual function [61]. Female sexual dysfunction, especially sexual pain disorders, has been identified in patients complaining of symptoms related to urinary incontinence or pelvic organ prolapse [10, 11]. Weak pelvic floor muscle strength is related to sexual pain disorders and dyspareunia [62]. According to literature, physiotherapy treatment is appropriate for sexual pain disorder, due to its effect on reducing the anxiety related to penetration and pain by providing a range of treatments from PFME to behavioral and biofeedback therapy [63]. Although there appears to be no linear relationship between reduction of sexual pain symptoms and healthy sexual function, physical therapy may be a promising treatment option for women with lifelong vaginismus [64].

Table 37.5 outlines the results of several studies on the effect of PFMEs on sexual function. Most of studies including systematic reviews and meta-analysis, as well as several RCTs showed that PFMEs are effective to improve sexual function in pregnant, postpartum, and general female population. However, the effect is more prominent in targeted group with PFD at baseline.

It is suggested that chronic pelvic pain (CPP) and musculoskeletal factors are associated with sexual dysfunction. Physical therapy is an integral component of the multidisciplinary approach to CPP and associated sexual dysfunction. Chronic pelvic pain (CPP) specifically affects negatively on a person's body image and sexual self-esteem, and also affects both partners in the relationship [70].

Female sexual dysfunction (FSD) seems to be related to urinary incontinence [3] and body image [27]. Studies have shown that high exercising women are more satisfied with their bodies during pregnancy [2]. The effect of PFME on improving women's self-confidence has also been mentioned in the literature [45]. It has been suggested that female sexual function can be enhanced with Kegel exercise if the strength of two or more of the abdominal and pelvic floor muscles (measured using the electromyography technique) displays improvement [71].

Obstetric anal sphincter injury has been reported to be a strong predictor for both postponing coituses after delivery and for dyspareunia one year postpartum [72]. Some studies found no effect of PFME on sexual function in the postpartum period [73–75]. The long-term follow-up study by Morkved et al. found that postnatal PFME in women who performed antenatal PFME was associated with improved sexual function at 6 years after birth [45, 76]. Several studies (Table 37.5) report that PFME is successful in improving different aspects of sexual function such as sexual self-efficacy, arousal, body acceptance, desire, sexual satisfaction, orgasm and pain during pregnancy and the postpartum period [10, 45, 65, 67].

Table 37.5 A summary of results of studies on the effect of PFMEs on sexual function

Reference	Study design and Population	Aim of study	Results
Pourkhiz et al. (2017) [65]	RCT, 84 nulliparous women (Control = 82, Study group = 42)	To assess the effect of antenatal PFMEs on sexual function during pregnancy and postpartum	All domains of sexual function, sexual quality of life, and pelvic floor muscle strength improved significantly in women who received the PFMEs compared with the control group
Hadizadeh-Talasaz et al. (2019) [66]	Systematic review and meta-analysis including 12 papers	To assess the effect of PFMEs on sexual function during pregnancy and postpartum	A significant mean difference in sexual function score between study and control group by 0.462 [0.117–0.806], $P = 0.009$. and 1.294 [0.926–1.663], $P < 0.0001$ for sexual quality of life. PFMEs in primiparous and multiparous women can boost sexual function and quality of life in the postpartum period
Sobhgol et al. (2018) [45]	Systematic review including 10 papers	To assess the effect of PFMEs on sexual function during pregnancy and postpartum	The findings of this systematic review showed that the majority of included studies (seven out of ten) found that PFME alone improved sexual desire, arousal, orgasm, and satisfaction in the postpartum period. However, included studies carried several risks of bias
Willan et al. (2014) [67]	Literature review including 8 papers	To assess the effect of PFMEs on female sexual function including general female population	PFME can improve arousal, lubrication, orgasm, and desire in postpartum women and those with incontinence. However, the use of PFME to treat sexual pain disorders remains contentious
Ferreira et al. (2015) [10]	Systematic review including eight RCTs	The effects of pelvic floor muscle training (PFMT) on female sexual function (SF)	Most studies showed an improvement of at least one sexual variable in women with pelvic floor dysfunction, and one study demonstrated an improvement in SF in postpartum women; however, the results need to be interpreted with caution
Citak et al. (2010) [68]	RCT, 75 postpartum primiparous women (Control group = 37, Study group = 37) at seventh months postpartum	The effects of early pelvic floor muscle training after vaginal delivery on sexual function	All domains except satisfaction were significantly higher in the training group compared with the controls. Pelvic floor-muscle training improves pelvic floor-muscle function, and starting after the puerperal period, exercise appears to have positive effects on female sexual function
Tennfjord et al. (2016) [69]	RCT, 175 primiparous women at 6 weeks postpartum	Effect of PFMES on sexual matters, dyspareunia and coital incontinence	Results showed no difference between training and control groups in women having vaginal symptoms or symptoms related to sexual dysfunction 6 months postpartum. However, the subdomains of sexual function such as orgasm, lubrication, desire, and arousal were not measured in this study
Golmakani et al. (2015) [61]	RCT, 79 postpartum primiparous women at 4–8 weeks postpartum	To assess t the effects of PFMEs on sexual self-efficacy	The findings showed that 8-week pelvic muscle exercises increase the sexual self-efficacy in women after delivery

RCT randomized controlled trial, *PFME* pelvic floor muscle exercises

37.6 Part 3. Treatments of Pelvic Floor Dysfunction (PFD)

Table 37.6 briefly outlines the treatment options for pelvic floor dysfunction (PFD). The treatment ranges from noninvasive methods to medications, nonsurgical and surgical treatments.

Persistent leakage in the postpartum is more likely among women who more gain weight during pregnancy [4]. Optimal weight gain during pregnancy is a matter of continuous debate between obstetricians and specialists in nutrition. Women who increase more in total weight during pregnancy start to do so early on in the pregnancy. Body weight changes are much more determined by lifestyle changes during and after pregnancy than by body weight before conception. The return to prepregnancy weight seems to be more likely to occur in women who try to adhere to a generally "healthful" lifestyle, such as eating and exercise habits, and smoking cessation [1]. It seems women who exercise regularly throughout pregnancy retain a positive attitude toward their body as the pregnancy progresses [2]. A range of exercises, such as general fitness training, yoga, abdominal training, and breathing exercises, are recommended to women during pregnancy and postpartum [77]. However, there is not yet enough evidence to show that other general exercises are more effective than pelvic floor muscle exercises to improve pelvic floor health [77]. Given the prevalence of urinary incontinence, PFME should be incorporated as a routine part of women's exercise programs in general [47].

Table 37.6 A summary of treatment options for PFD

1. Noninvasive treatments
• Lifestyle modalities, behavioral therapy, exercise, and diet as the first line of treatment
• To avoid excessive weight gain in order to maintain general health, and to reduce the strain of pregnancy and childbirth on the pelvic floor
• To avoid constipation as gastrointestinal motility decreases during pregnancy. Valsalva straining during defecation increases stress on pelvic floor supports and should be discouraged as a chronic habit. Dietary fibers should be accompanied by adequate hydration, exercise, and stool softeners [4]
• Moderate levels of exercise to maintain health and weight balance. Exercises need to be tailored to specific considerations such as posture, balance coordination, and also considering joint mobility and vulnerability of the pelvic floor during pregnancy and postpartum
• Kegel or pelvic floor muscle exercises and physical therapy as the first-line treatment and prevention of PFD, Manual therapy (hands-on techniques to treat soft tissues—such as stretching, soft tissue massage, myofascial, and trigger—point release, also using heating/cooling pads, and through breathing and relaxation techniques
2. Surgical and nonsurgical treatments
• Medications based on the clinical symptoms and pathogenesis of PFD • Pessaries • Surgical options (will be discussed in the next chapters)

Pessary devices are also one treatment option and were found to provide immediate relief for prolapse symptoms. However, if nonsurgical treatments fail to provide relief, then surgery may be unavoidable. About 11% of women ultimately elect to undergo surgery to correct vaginal prolapse or incontinence [4]. However, it appears some restorative surgical procedures for pelvic organ prolapse (POP) have poor durability due to the changes in the vaginal wall (changes in the ratio of collagen subtypes and elastic fibers) in patients with POP, which are very similar to those changes that happen in pregnancy [18].

Eftekhar et al. (2014), in a randomized controlled trial (RCT) including 90 women aged 25–55, compared the effect of 8 weeks of physiotherapy (twice a week electrical stimulation, Kegel exercises) with surgery (rectocele repair and perineorrhaphy) on sexual function in women with PFD symptoms. They found that libido and arousal were improved in both groups. Orgasm and dyspareunia, however, were improved in the physiotherapy group and dyspareunia was more painful for the surgery group. They concluded that physiotherapy seems to be an appropriate method for the treatment of sexual disorder in pelvic floor disorder [78].

37.6.1 The History of Kegel Exercises (Pelvic Floor Muscle Exercises)

Kegel exercises are the most widely used method for improving pelvic floor muscle strength (PFMS) [19]. During the 1920s and 1930s, Minnie Randell, Sister-in-Charge of the Conjoint Massage and Remedial Exercises Training Course in London, UK, trained student physiotherapists to encourage women to contract their pelvic floor, as a means of preventing urine loss and prolapse. These exercises are thought to have originated from Swedish gymnastics. In 1948, Dr. A. H. Kegel, a gynecologist at the University of Southern California, first reported the use of voluntary exercise of the pelvic floor musculature. Kegel's work was inspired by personal communication with van Skolkvik, who noted unusually firm perinea in South African tribal native women: "Exercises by contraction of vaginal muscles on (the midwife's) distended fingers were begun several days after birth and were continued periodically for several weeks, until the desired result was obtained." Kegel was the first to report the effect of regular, specific strength training of the pelvic floor muscles on female urinary incontinence and pelvic organ prolapse. He claimed that 84% of a series of gynecological patients were cured of urinary incontinence after pelvic floor muscle training [19]. It was noted that injured muscle would regain most of its function when there was a demand for its use. On this premise, Arnold Kegel (1948) designed his perineometer, a biofeedback apparatus to exercise the pelvic floor [5].

The purpose of Kegel exercises is to strengthen weakened PFM structure and function. Strengthening the PFM through Kegel exercises may solve urinary incontinence problems without the need for surgical intervention. As a result, they can be used to prevent urinary incontinence during both pregnancy and the postpartum period [19] (Fig. 37.4). Several studies have shown that pelvic floor rehabilitation has led to a significant difference in urinary incontinence symptoms and improvement in patients' quality of life and sexual function [48]. Pelvic floor muscle training (PFMT) may also be an auxiliary tool for relieving the musculoskeletal symptoms during pregnancy and the puerperal period [55].

Fig. 37.4 Pelvic floor muscle exercises (Retrieved from https://au.images.search.yahoo.com. Accessed February 2020)

37.6.2 Treatments of Female Sexual Dysfunction (FSD)

Sexuality is one of the most important quality-of-life aspects. The potential for every woman to live an active, healthy, and fulfilling sexual life is possible, regardless of age [4]. According to the WHO revised definition, sexual health is a state of physical, emotional, mental, and social well-being, underpinned by human rights, in relation to sexuality [79]. However, the diagnosis of FSD can only be made if it causes marked distress [28].

Healthy sexual function requires physical, mental, and emotional well-being [80]. Relationship and psychological issues should always be assessed first to understand the underlying cause of FSD [4, 9]. The treatment options of FSD are outlined in Table 37.7.

There have been adverse side-effects of medication reported in the literature; thus, the main emphasis should be on nonpharmacological interventions, education, and behavioral therapies as a first-line intervention to treat FSD [4, 9]. Studies have also shown that no single androgen level is predictive of low female sexual function [81]. Although a great deal of attention is paid to new and expensive pharmacotherapy, scientific data suggest that pelvic floor exercises, behavioral therapy, and pelvic physiotherapy can be

Table 37.7 Treatment of female sexual dysfunction

Nonpharmacologic	Education, stress-relief activities, lifestyle changes, reduced daily alcohol consumption, reduced smoking, increased exercise, healthy diet
	Stress management activities such as yoga, meditation, mindfulness, cognitive behavioral therapy, and physical therapy
Psychological	Relationship and psychological issues such as depression, anxiety, etc.
Devices	Lubricants, devices (clitoral vacuum device), vibrators, and self-stimulators, dilators
Medications	Calcium plus vitamin D, vaginal cream estrogen, androgen therapy, prostaglandins, vasodilators, sildenafil, and herbal supplements
Medical & Surgical	Medical treatments based on the underlying medical conditions such as diabetes, Hypertension, infection diseases, heart disease, etc. Surgical options such as vestibulectomy (women with vulvodynia) and Bariatric surgery for obese women

equally, or even more, effective than drug therapy; the combination may even be more effective [4]. Cognitive-behavioral treatment (CBT) [82] and mindfulness [83] can also be used as first-line treatment. CBT includes a number of different interventions such as sexual and psychological education, behavioral sex-therapy exercises, or cognitive restructuring of sexuality-related thought biases [82].

As pelvic organ prolapses and pelvic floor muscle strength have a significant relation to dyspareunia [62], pelvic floor muscles should always be assessed for tenderness and strength in the assessment of FSD [84]. Kegel exercises and pelvic floor lifts that focus on the functional control of each muscle in the pelvis can be helpful for women suffering from dyspareunia, vaginismus, and pelvic pain [4, 9].

37.6.3 Physical Therapy for the Treatment of Female Sexual Dysfunction

Postpartum women are often distressed by changes that happen to their bodies after delivery, especially if these changes persist past what they perceive as an acceptable recovery time. There is a desire to "have my body back" as part of a fulfilling quality of life. Because surgery is often not the answer for a woman considering future childbearing, pelvic floor physical therapy has been proposed as a solution [85]. Nowadays, some women prefer caesarean section to prevent pelvic floor muscle damage and sexual dysfunction. However, Baytur et al. (2010) found that the mode of delivery did not affect sexual function after birth [86]. Moreover, sexual dysfunction after pelvic surgeries may happen due to the interruption of the vascular supply and neurologic innervation [10].

The puborectalis muscle is the main determinant of intravaginal pressures and has been termed the "love muscle." The avulsion of the pelvic floor muscle manifests itself as reduced tone and "vaginal laxity" [87]. It has been reported that women with major perineal trauma reported less desire to be held, touched, or stroked by their partners and reported fewer intimate relationships [42]. It has also been shown that PFME improved the sensation of vaginal laxity which could interfere with sexual function after birth [74].

The integrity and function of pelvic floor muscles are particularly relevant given that the role of this musculature was recognised as critical to sexual function by the middle of the last century by Kegel, Masters and Johnson, and Kaplan. The importance of pelvic floor muscle function has also been confirmed by studies using magnetic resonance imaging as well as surface electromyography [88] during sexual arousal and sexual intercourse. During penetration, this muscle is slightly stretched and widened to allow this act to occur, and it contracts during orgasm. High tone

pelvic floor muscles refer to a state of muscular tension or contraction when muscle realization is functionally needed. In contrast, pelvic floor muscles that cannot voluntarily contract are typically characterized as low tone musculature, and nonfunctioning PFM denotes the absence of any muscle activity [10, 11].

Kegel suggested that women possessed little awareness of their existence. He maintained that becoming aware of and strengthening the pelvic floor muscles could cure incontinence and improve sexual response [80]. Physical therapy and rehabilitation may be specially indicated if the pelvic floor is involved, especially when pain in the genital area is a chief complaint of FSD. Sexual function improves if other symptoms related to pelvic floor dysfunction are effectively treated. Physical therapy treatment needs to be considered for women who present with explicit complaints about sexual functioning, and also those who report symptoms such as urinary incontinence, pelvic organ prolapses, overactive bladder syndrome, fecal incontinence, constipation, and chronic pelvic pain syndrome. Sexual dysfunction could be present in all of these patients [10, 11].

Physical presentations such as decreased mobility, alterations in sensation, decreased genital circulation, and pain, as well as musculoskeletal symptoms such as joint, pelvic, or genital pain and decreased genital arousal, are best addressed by physical therapists [80, 89]. Physical therapy techniques such as biofeedback enhance sexual pleasure, decrease pain, and address specific conditions such as sexual dysfunction related to urogenital disorders or surgical complications, vaginismus, generalized and localized vulvodynia, pudendal neuropathy, and persistent genital arousal. Physical therapists use an array of techniques to treat PFD and FSD symptoms based on their clinical presentation [11, 80, 90]. Even though the issues presented, such as the effect on the relationship, lifelong or acquired low libido, and arousal can be treated by sex therapy, physiotherapists are in a unique position to provide adjunctive treatment for overcoming anxiety related to vaginal penetration [63]. Consistent with this, Diniosi et al. (2011) in an interventional cohort study, reported that 10 weeks of perineal massage, PFME, and transcutaneous electrical stimulation (TENS) have been successful in treating dyspareunia due to pelvic trauma and improving the perineum aesthetically in women within the first 3 years after birth [91].

37.6.4 The Kegel Exercises (PFME) Regimes

In 1951, Arnold Kegel published a landmark study of the effect of pelvic floor muscle exercises in 500 women with urinary incontinence. He instructed his patients to contract their pelvic muscles against a "perineometer," a cone-shaped balloon inserted into the vagina. They were instructed to alternately contract and relax the pelvic floor muscles, specifically the pubococcygeus muscles, for 20 min, three times a day, for a total of 300 contractions. Kegel reported an 84% success rate for stress urinary incontinence [4].

The purpose of PFME is to restore the tone and function of atrophied pelvic muscles, which helps control involuntary loss of urine during physical activities such as coughing, sneezing, exercising, or laughing [4]. An effective pelvic floor contraction is able to produce an increase in maximum urethral closure pressure. Whether this reflects the contraction of the levator ani or of the external striated urethral sphincter has not been clarified. Jones et al. concluded that PFMEs can improve a woman's "ability to voluntarily contract the external anal sphincter either by improving the strength of the sphincter and/or by increasing the patient's ability to perceive weak distension of the rectum" [5].

Pelvic floor muscle exercise is not a one-size-fits-all treatment [85]. Various PFMT protocols in nonpregnant women have been reported in the literature (Table 37.3); however, the number of repetitions, as well as the duration of contractions

and rest between series, has not been totally defined in any single protocol. A three-month timeframe for PFME is recommended as the amount of time necessary to obtain minimum hypertrophy and, consequently, muscle strength [55]. However, it remains to be determined which of these approaches is better, with respect to both efficacy and long-term compliance. Since not all women can hold a 10-s contraction at first, it is important to assess how long a woman can hold a contraction. It is important that the woman always rests her pubococcygeus for at least as long as she contracts it to avoid fatigue. After 2 weeks of daily pelvic muscle exercises, women may notice some improvement with urinary incontinence. Significant improvement can be expected after 12 weeks of training [4]. However, PFME is effective when supervised training is conducted [47].

Pelvic floor muscle exercise is a safe and effective technique during pregnancy, not only to improve pelvic floor muscle strength but also to help women control this musculature during pregnancy and also during the expulsive phase of labor (See Video 37.1) [55]. Improved tone and effective isolation of the pelvic floor muscles may help women to voluntarily relax pelvic floor muscles during labor and delivery. This is particularly helpful when women unconsciously contract the perineum during the expulsion of the fetus due to fear. The beneficial effects of PFME are, therefore, of great importance for pregnant women [4].

The development of an exercise program requires individual adaptation. Appropriate levels of individual training components should be regularly monitored and evaluated according to the observed progress. The most significant effects are typically observed during the first 6–8 weeks of an exercise program [92]. Morkved and Bo demonstrated that 8 weeks of structured group training combined with home exercises three times weekly were effective to reduce uirnary incontinence and the benefits were still present at one year postpartum [4]. Table 37.8 summarizes several recommended PFME regimes that can be used in practice.

Table 37.8 The recommended PFME regimes

	PFME regimes
1.	The recommended frequency of PFME, 2–3 times a week for up to a 3-month period [55]
2	A supervised training protocol following strength-training principles, emphasizing close to maximum contractions and lasting at least 8 weeks [47]
3	Ten-minute sessions and repeating the exercises 3 times per day [4]
4	Less intensive routine, with only 10–20 contractions per day [4]
5	2–5 daily sessions of 10–20 slow contractions holding for 10 s in the postpartum period [92]
6	8 slow pelvic floor muscle contraction holding 8–10 s, resting 8–10 s, followed by 5 fast contraction, to repeat this regime three times a day and every day for 3 months [93, 94]

37.6.5 Instructions on How to Perform Pelvic Floor Muscle Exercises

The currently available instructions on how to perform PFMEs are summarized in Tables 37.9 and 37.10. The basis of PFME is repeated pelvic floor muscle contractions. It is rarely sufficient to merely ask women to do "Kegels," because women frequently use abdominal, leg, or buttock muscles. Once the health-care provider is confident that the patient has correctly identified the pubococcygeus muscle, women can be provided with appropriate instruction. Women are asked to relax completely and empty their bladders before performing pelvic muscle exercises. Pelvic floor exercises can be done anywhere, anytime, and in any position, while the woman is relaxed. Pelvic muscle exercises are performed by tightening the pubococcygeus muscle and maintaining the contraction for 10 s, then relaxing for 10 s. The patient should feel a sensation of lifting around her vagina or of pulling around her rectum [4, 47, 93, 94].

As illustrated in Figs. 37.5 and 37.6, PFMEs can be done in different positions including standing, lying down, sitting position. Additionally, it can be combined with back and abdominal muscles strength training.

Table 37.9 The instructions for PFMEs

1. Start with the "stop test"[a]. Avoid leg and buttock contraction. Place a hand on the abdomen or thigh. Rest between contractions
2. Lift pelvic floor muscle (PFM) upward and inward around the urethra, vagina, and rectum, squeeze as hard as possible and hold it for 8–10 s before relaxing the muscles gently for 8–10 s
3. Relax and breathe with a slow, regular, and gentle rhythm in and out, both during and between the muscle contractions
4. Perform 8–12 repetitions in three sets. If this seems too difficult, start with fewer repetitions
5. Choose one or more of these starting positions:
• Sit with your legs apart and your back straight
• Stand with your legs apart, and check that the buttock muscles are relaxed while you squeeze the PFM
• Kneel on all fours with your knees out to the side and feet together
• To contract PFM before coughing, sneezing, lifting or bending [4, 47, 93, 94]

[a]The location of the pubococcygeal muscle may be identified using the "stop test," which refers to voluntarily stopping the urine stream while voiding. Women should not practice Kegel exercises repetitively during urination. If it is difficult to stop the initial flow, women can be asked to test themselves toward the end of urination, which is much easier. Women should not use urination for training, as this can interfere with the ability to empty their bladder. Alternatively, women may be instructed to squeeze the vagina around an inserted finger, providing a low-tech form of biofeedback [4]

Table 37.10 How to tell if contracting the pelvic floor muscles is done correctly?

1. Sit on the arm of a chair or the edge of a table
2. Lift the pelvic floor up from the sitting surface by pulling up and contracting around the urethra, vagina, and rectum so hard that a slight trembling in the vagina is felt
3. When squeezed hard enough, the lower part of the stomach is pulled in slightly at the same time
4. Release the contraction without pressing downward
5. Try to feel the difference between relaxing and tightening the pelvic floor
6. Try to stop the flow during urination. If these muscles are weak, it may be difficult to stop the flow. This can be tested toward the end of urination, which is much easier. Urination should not be used for training, as this can interfere with the ability to empty the bladder completely
7. If there is uncertainty about performing the exercises correctly, a doctor should be contacted and asked for a referral to a physiotherapist with special training in women's health [47, 93]

Different types of pelvic floor muscle exercisers are also available on the market. These include vaginal weights and cones, and feedback and electrical stimulation devices [4]. Pelvic floor biofeedback converts muscle activity into visual or auditory stimuli, allowing the woman to identify and amplify her "Kegel squeeze" efforts. A simple perineometer represents a "low tech" biofeedback device, whereas more sophisticated machines utilize electromyography (EMG) surface electrodes to enhance muscle isolation. Electrical stimulation therapy utilizes vaginal probes, which deliver mild stimulation to the pelvic floor nerves and muscles. Home units are available, allowing women an alternative for both stress and urge incontinence. "Neuromodulation" refers to an implantable "pelvic pacemaker" electrode, designed for women with overactive bladder symptoms that fail to respond to noninvasive therapy [4] (Fig. 37.7).

The mechanism of the effect of pelvic floor muscle exercises on pelvic floor dysfunction and female sexual dysfunction.

The theoretical basis for pelvic floor muscle exercise to treat and prevent stress urinary incontinence is based on the muscular changes that may occur after specific strength training. This change is supposed to be a neural adaptation during the first 6–8 weeks and muscle hypertrophy after a further period of strength training. A strong and well-functioning pelvic floor can build a structural support for the bladder and the urethra. In addition, a well-timed, fast, and strong contraction may prevent urethral decent and close the urethra during an abrupt intra-abdominal pressure rise [54].

The pelvic floor muscle is considered to have dual functions of providing trunk stability and contributing to pelvic floor organ supports. This synergy can be used for the rehabilitation of pelvic floor dysfunction, which may improve clinical outcomes [95]. Ten years ago, musculoskeletal physiotherapists would not have considered the PFM complex when treating patients with lower back pain or sacroiliac joint dysfunction and physiotherapists teaching PFME for the treatment of stress urinary incon-

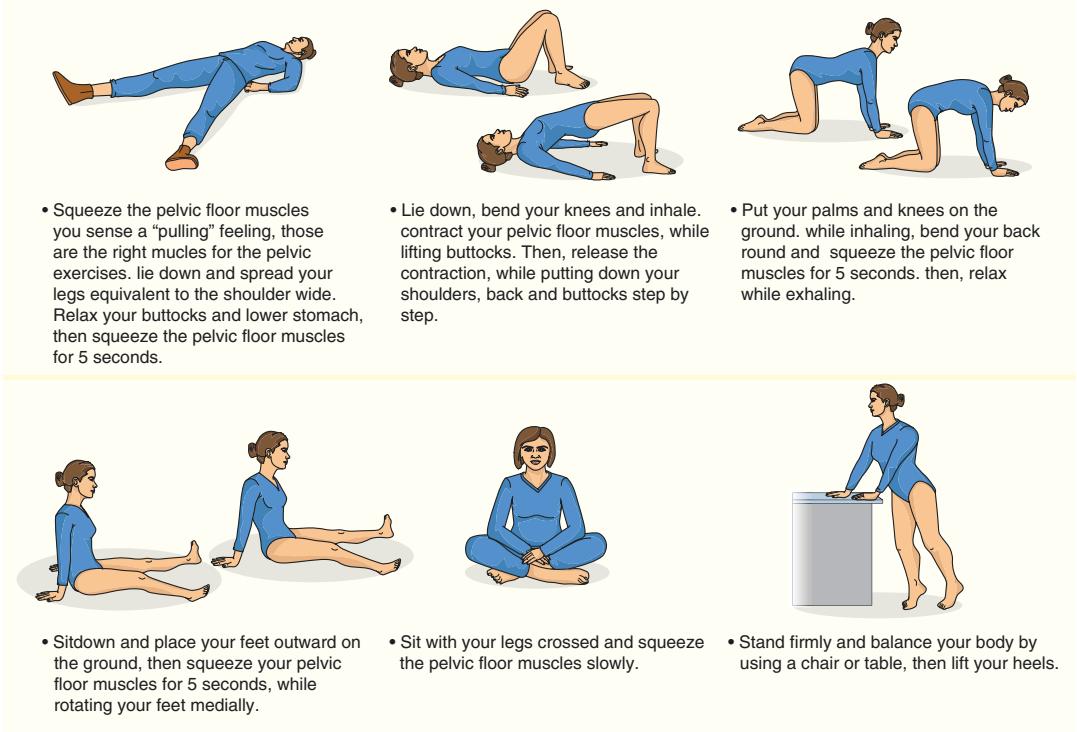

Fig. 37.5 Pelvic floor exercises in different positions (Retrieved from http://2.bp.blogspot.com. Accessed February 2020)

tinence discouraged the use of the abdominal muscles. These benefits are now changing [95]. Similarly, coactivation of the PFM and the deep fibers of lumbar multifidus has been observed clinically [21] (Fig. 37.8).

Pelvic floor muscle exercises strengthen the levator ani muscles through muscular hypertrophy, which leads to revascularization of damaged cells and tissue. This increases vaginal sensation and lubrication [45]. Successful PFME therapy facilitates greater self-awareness, self-confidence, improved body image, lowered anxiety, and feelings of empowerment—all of which encourage and affirm optimal sexual health [80]. Additionally, research has shown that pregnant women who exercise regularly during pregnancy are more satisfied with their body image compared with low exercising women [2]. Pelvic floor muscle training is considered both physical therapy and exercise behavioral therapy. As a result, physical therapy-informed and psychology-informed approaches in PFMT should be considered by therapists when designing a treatment for women [96].

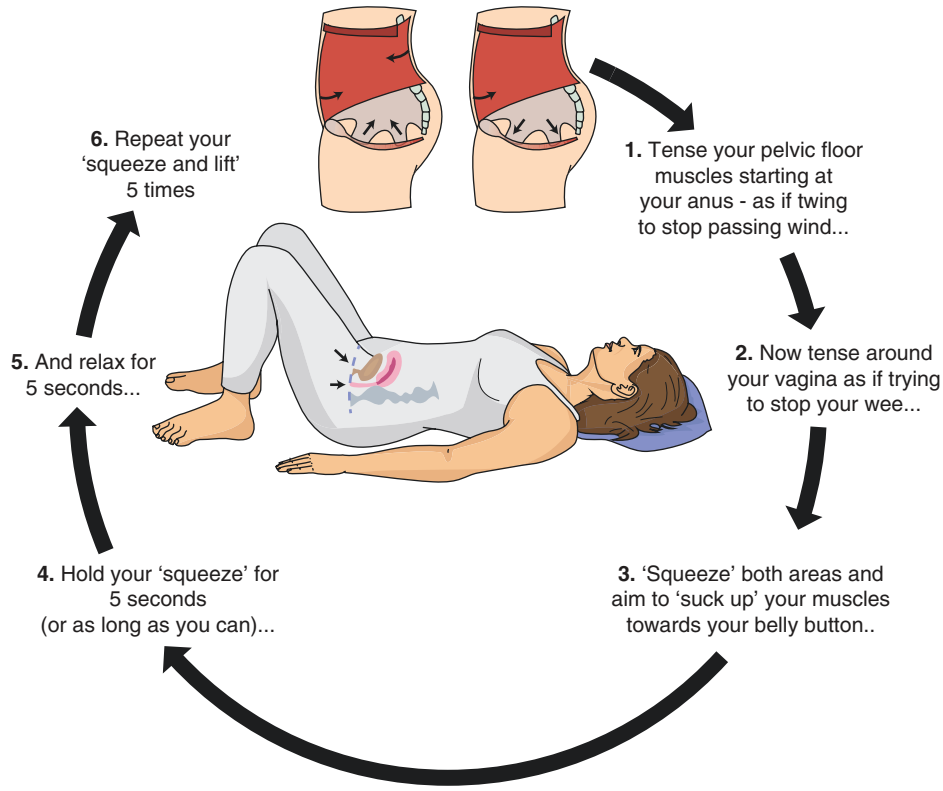

Fig. 37.6 PFMEs in lying down position (Retrieved from http://www.pelvic-healthcare.com. Accessed February 2020)

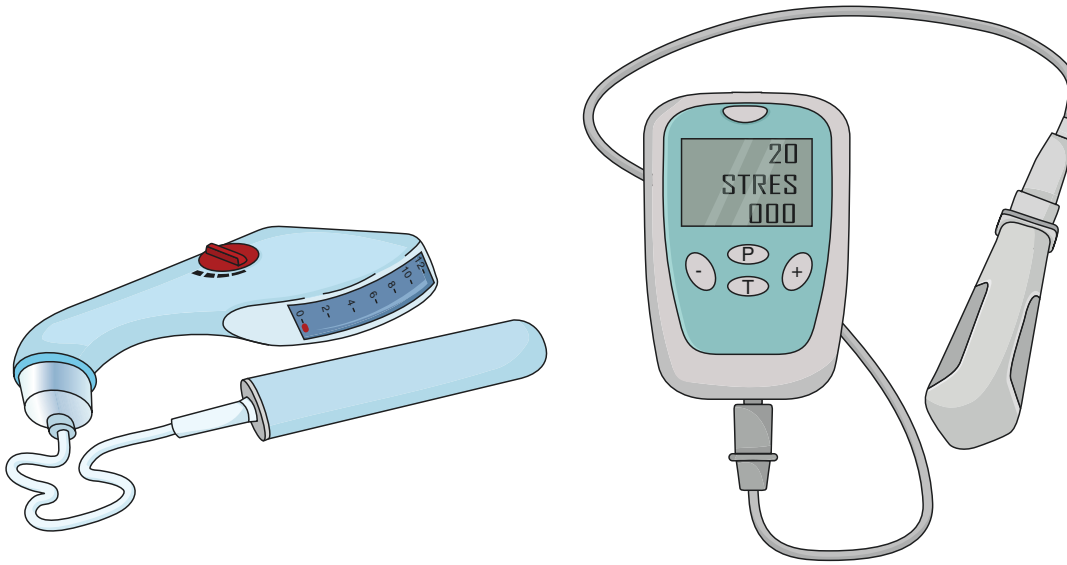

Fig. 37.7 Pelvic floor exerciser (Retrieved from https://www.pelvicfloorexercise.com.au. Accessed February 2020)

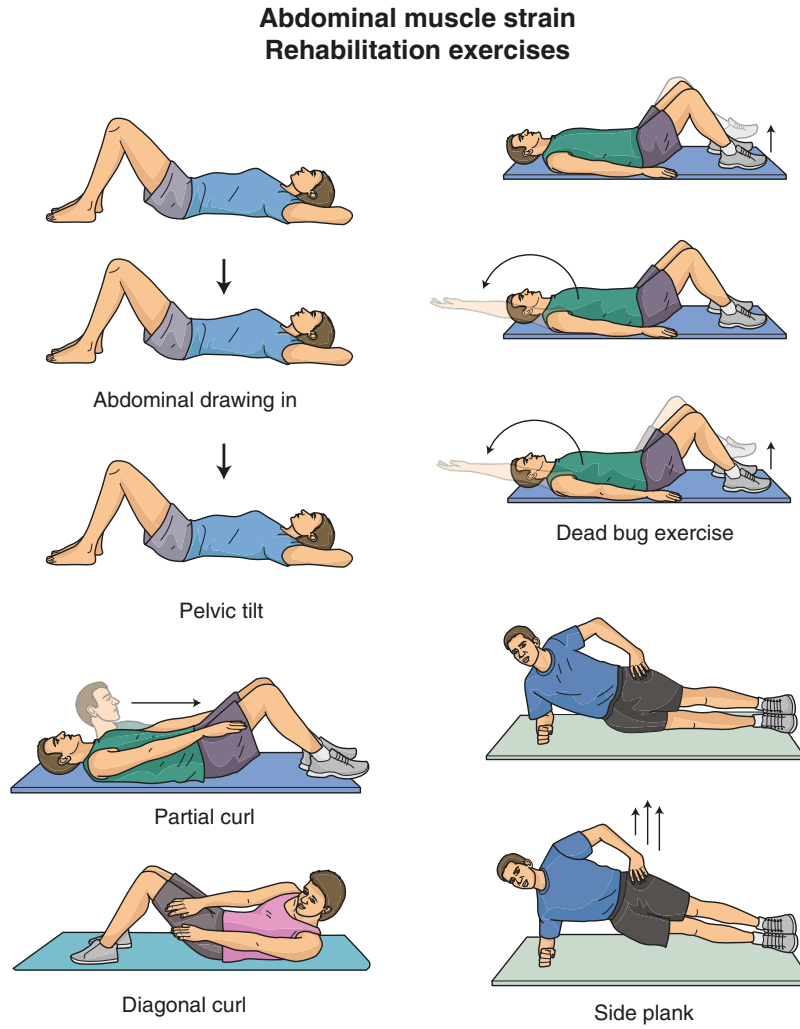

Fig. 37.8 Abdominal, back, and pelvic floor exercises in combination (Retrieved from https://au.images.search.yahoo.com. Accessed February 2020)

37.7 Frequently Asked Questions About PFMEs

- **How long should women do PFMEs?**

  There is an old statement that says "if you don't use it, you lose it." For a woman to maintain the result of PFMEs, she needs to become a lifelong kegeler [5]. The effect of any training program will diminish with time if it is not continued [97]. Research has shown that the initial improvement in PFD symptoms does not persist if women discontinue or decrease their PFMEs [5]. An estimated period of 8–12 weeks of PFMEs is necessary for muscle hypertrophy [54]. However, a 5–10% loss of muscle strength per week has been shown after training cessation. The majority of loss happens from 12 to 31 weeks after cessation of training. The rate of strength loss may depend on the length of the training period prior to detraining. There are few studies investigating the minimum level of exercise necessary to maintain the training effect [93]. Interestingly, a study by Cammu et al. (1995) showed that once a certain level of continence is established with pelvic floor muscle exercises, that level is maintained over 5 years. However, more studies are needed to investigate this [97].

- **What are the indications to start the exercises and when women should start them?**

  There is no census on the optimal indication to start PFMEs [4]. However, pregnancy and childbirth are known as major risk factors for injury to the pelvic floor [93]. Several studies indicated that PFMEs to be started from first pregnancy can prevent/or treat postpartum urinary incontinence. Additionally, pelvic floor rehabilitation should be strongly considered for postpartum women [4].

  PFME can also prevent or reduce PFD symptoms; therefore, it has both the therapeutic and preventive effect [98]. It is suggested that PFMEs are much more likely to work in women with mild-to-moderate symptoms of PFD and with urodynamic indices that are closer to normal [4]. However, in a study by Braeken et al. (2010), it was shown that women with stages of I, II, III prolapse who received pelvic floor muscle training showed elevated bladder (difference:3 mm; 95% confidence interval, 1.5–4.4; $P < 0.001$) and rectum (5.5 mm; 95% confidence interval, 1.4–7.3; $P = 0.022$) and reduced frequency and bother of symptoms compared with control groups [99]. Some studies also suggested that PFMEs have a higher rate of success among younger women with high motivation, less advanced pelvic floor dysfunction, without previous urogynecologic surgery, and less severe symptomatology [4].

  Overall, it can be suggested that PFMEs can be recommended for both pregnant and nonpregnant women with or without symptoms of PFD at baseline. Alternatively, it can be used as an adjunctive therapy with surgery to enhance the effect of prolapse repair [4].

- **What is the point to finish the exercise treatment and to indicate a surgical treatment?**

  PFMEs should be discussed almost for all cases of incontinence. PFMEs have been shown to improve mild and moderate cases of stress incontinence; however, more severe symptoms need additional treatment [4]. A study showed that a program of physiotherapy restored pelvic muscle to a degree that patients muscle thickness was comparable to continent group [4]. An aggressive pelvic rehabilitation program including biofeedback with vaginal Electrogalvanic stimulation had a high rate of self-reported subjective success and satisfaction and should be considered as nonsurgical treatment option in patients with pelvic floor dysfunction [100]. Similarly, in a study it was found that pelvic floor exercises, electrical stimulation, and vaginal cones are equally effective treatments and are far superior to no treatment in women with urodynamic stress urinary incontinence [101]. The meta-analysis by Chunbo et al. (2016) demonstrated that women who received pelvic floor training showed a greater subjective improvement in prolapse symptoms and an objective improvement in POP severity [53].

  However, it is estimated that 11% of women will eventually elect surgical treatments. Those women who fail an initial course of noninvasive management [including pelvic floor rehabilitation] may require referral for urodynamic evaluation in order to confirm or change the diagnosis and subsequent treatment plan. A study showed that of the women who initially failed pelvic floor muscle exercises, 62% had undergone surgery [4].

  In a study it was shown that the three independent predictors of PFMEs treatment failure were ≥2 leakages per day before treatment ($P < 0.0001$), the chronic use of psychotropic medication ($P = -0.002$), and a baseline positive stress test result at first cough ($P = 0.042$). The odds were only 15% for an individual patient to be treated successfully by PFMEs when these 3 predictors were present. The author concluded that pelvic floor muscle training was beneficial in one-half of the patients in their study. Two or more leakages per day at baseline and the chronic use of psychotropic medication significantly predicted therapy failure [102].

  Those women who fail to receive preventive measures and adhere poorly with the pelvic floor rehabilitation program and those with distressing symptoms may need to be reviewed for additional options including

pharmaceutical and surgical treatment. Although this has not been scientifically evaluated, one study demonstrated that reconstructive surgery that results in alterations in pudenal nerve terminal motor latency is more likely to fail. Pelvic floor rehabilitation can be used for optimization of the pelvic neuromuscular compartment to provide some enhancement to surgical prolapse repair [4].

Therefore, it can be suggested that pelvic floor rehabilitation can be used as a preventive or treatment measure. However, for those women who need surgery, pelvic rehabilitation can be suggested as an adjunctive therapy following surgery to enhance the effect of surgical treatment.

Key Notes

- The American College of Obstetrics and Gynecology recommends 30 minutes of moderate exercise on most, if not all, days of the week for pregnant women in the absence of medical or obstetric complications [1, 2].
- PFME should be one of the components of prenatal physical exercise [1, 2].
- PFME cannot, however, constitute the main content of prenatal exercises as pregnancy and childbirth are a complex process for the whole of the woman's body, involving more than just the reproductive system. Therefore, physical activity should be aimed at the whole body [1–4].
- Postpartum women returning to general fitness exercises should consider the vulnerability of the pelvic floor supports by limiting weight-bearing to reduce abdominopelvic injury [4].
- A knowledgeable fitness professional, working closely with the woman's physician, can make exercise a safe (for both the mother and the fetus), productive, and enjoyable endeavor [1–4].
- Lifestyle modalities such as dietary fiber stool softeners and occasional laxatives or suppositories can be used to avoid constipation to protect the integrity of perineal sutures and minimize stress against the pelvic floor [4].
- A PFME program may consist of 2–5 daily sessions of 10–20 slow PFM contractions for up to 10 s. A minimum of 8–12 weeks of adherence to PFME is essential to get the best result [4].
- Exercising in the recumbent position may help to minimize caudal traction on the pelvic floor supports before full involution of the uterine fundus in the postpartum period [4].
- When PFMEs are combined with biofeedback and electrostimulation, stress incontinence is reduced in up to 19% of women. PFME combined with transcutaneous electrical stimulation (TENS), and perineal massage can probably enhance the symptoms of dyspareunia due to perineal trauma in the postpartum period [48, 91].
- If incontinence or pelvic symptoms persist beyond 3–6 months postpartum, referral should be strongly considered [4].
- The therapist can use different methods to increase adherence and compliance to PFME program, such as individual supervised training followed by regular individual follow-up, regular group training and group training follow up, emphasis on motivation and benefits of PFME, using mobile applications, reminders, etc.
- Some practitioner uses digital palpations to teach PFME, while others use verbal and visual instructions. The method of training can be tailored individually depending on women's knowledge, learning capability, and experience. However, further follow-up is needed to monitor women's adherence to the program.

▶ **Important**

- Research has shown that long-term participation in high-impact general fitness exercise was associated with an increased incidence of stress urinary incontinence, which may be due to altered pelvic floor function [103]. As a result, general exercises should not yet be recommended for use in clinical practice for women with stress urinary incontinence [77].

- There is not yet strong evidence that general exercises are more effective than pelvic floor muscle exercises to improve pelvic floor muscle strength [77].

Attention

- It is important to consider that sustained symptom relief from PFD will require long-term daily commitment [4].
- The success of a PFME program depends on the quality of training and also follow-up [93].

Pitfalls

- There are various PFMEs teaching methods and there is no census on teaching method [4].
- There is no census regarding the optimal indication, application, or regimen of PFMEs [4].
- Many women are found to perform PFME incorrectly that could potentially promote incontinence such as using Valsalva maneuver when doing PFMEs [4].
- Patients' motivation and expectation as well as adherence to PFME play a major role in success [4].
- Isolation of the target muscle groups— an important principle in muscle strengthening—has been found to be difficult [4]
- Kegel exercises work for many people but not for everyone; it depends on underlying cause of pelvic floor symptoms [4].
- If there is already a pelvic weakness, women may not be able to perform PFME correctly on their own and they need expert training [4].
- A comprehensive training with a physiotherapist is essential for rehabilitation of the pelvic floor muscle and trunk stability for women with PFD symptoms. Therefore, performing solely PFME at home with no supervision is not always successful [4].
- No reliable predictors of successful PFMEs program has be found yet [4].
- There are no reported side effects of PFMEs; however, some patients may report pain during PFMEs [4].

Pearls

- PFMEs are free and can be done at anywhere and anytime.
- PFMEs, if done correctly, can prevent or treat mild-to-moderate PFD symptoms significantly.
- PFMEs has been shown to be of great benefit for pregnant women in terms of labor and birth as well as prevention and treatment of urinary incontinence.
- PFMEs can be used in different forms such as vaginal cones, electromyography, and biofeedback.
- PFMEs can also be used as an adjunctive therapy with other treatment options.
- PFMEs play an important role in increasing pelvic floor muscle strength and also trunk stability.
- PFMEs can be tailored individually based on women's clinical symptoms.
- PFMEs are the first line of noninvasive treatment to maintain and restore pelvic health, particularly for postpartum women.

37.8 Conclusion

Whether childbirth is short or long, easy or difficult, millions of women experience physical sequelae in the years and decades that follow. Strategies recommended to improve pelvic health include pelvic floor exercises, avoidance of routine episiotomy, avoidance of prolonged second stage of labor and instrumental birth, and attention to pelvic floor rehabilitation during the postpartum period [4]. Primary care clinicians are in a unique position to positively influence a woman's quality of life, either by preventing postbirth problems or by early recognition to avoid long-term sequela of incontinence and pelvic floor dysfunction—conditions that generations of women have suffered in silence.

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Pelvic Floor Trauma After Childbirth

38

Aubá María and Dietz Hans Peter

Take-Home Points

- Maternal birth trauma includes anal sphincter tears, levator avulsion, and hiatal overdistension.
- Training in the recognition of sphincter tears, correct intrapartum diagnosis, and adequate repair is important for the prevention of anal incontinence associated with childbirth.
- Forceps is an important risk factor for avulsion and should be avoided whenever possible.

38.1 Introduction

The pelvic floor is the set of structures located between the pelvic peritoneum and the skin of the vulva and perineum. It closes the abdominal cavity, prevents the expulsion of abdominal viscera, and plays a key role in physiological functions such as storage and evacuation of urine and stool. Condensations of fascial and fibromuscular tissue bind the soft tissues to each other and to the bony pelvis.

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Four planes or layers can be defined in the structure of the pelvic floor: the superficial perineum, the urogenital diaphragm, the pelvic diaphragm (i.e., the levator ani muscle) and the pelvic fascia (Fig. 38.1).

In this chapter, we will focus on muscle injuries that are associated with childbirth since injuries to fascia and nerve structures are much less well defined, very difficult to diagnose, and currently impossible to treat.

Pregnancy and childbirth are the most important risk factors for the development of pelvic floor pathology. The problems derived from effects of pregnancy and childbirth are urinary incontinence, fecal incontinence, and pelvic organ prolapse (POP). These conditions can appear early, during a woman's fertile years, or later, coinciding with effects of tissue aging.

Although birth is a physiological process, the passage of the fetus through the birth canal causes significant distension of the vaginal walls and of the levator ani muscle, as well as compression of the bladder, urethra, and rectum and decreased blood flow to these structures.

In the vagina and urethra, blood flow seems to recover quickly and without sequelae [1].

It has been claimed that stretching and tearing of the pubocervical fascia may lead to an anterior colpocele and also postpartum urinary incontinence, although proof of concept is currently lacking. Distension and/or tearing of the rectovaginal fascia may cause a rectocele [2].

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_38

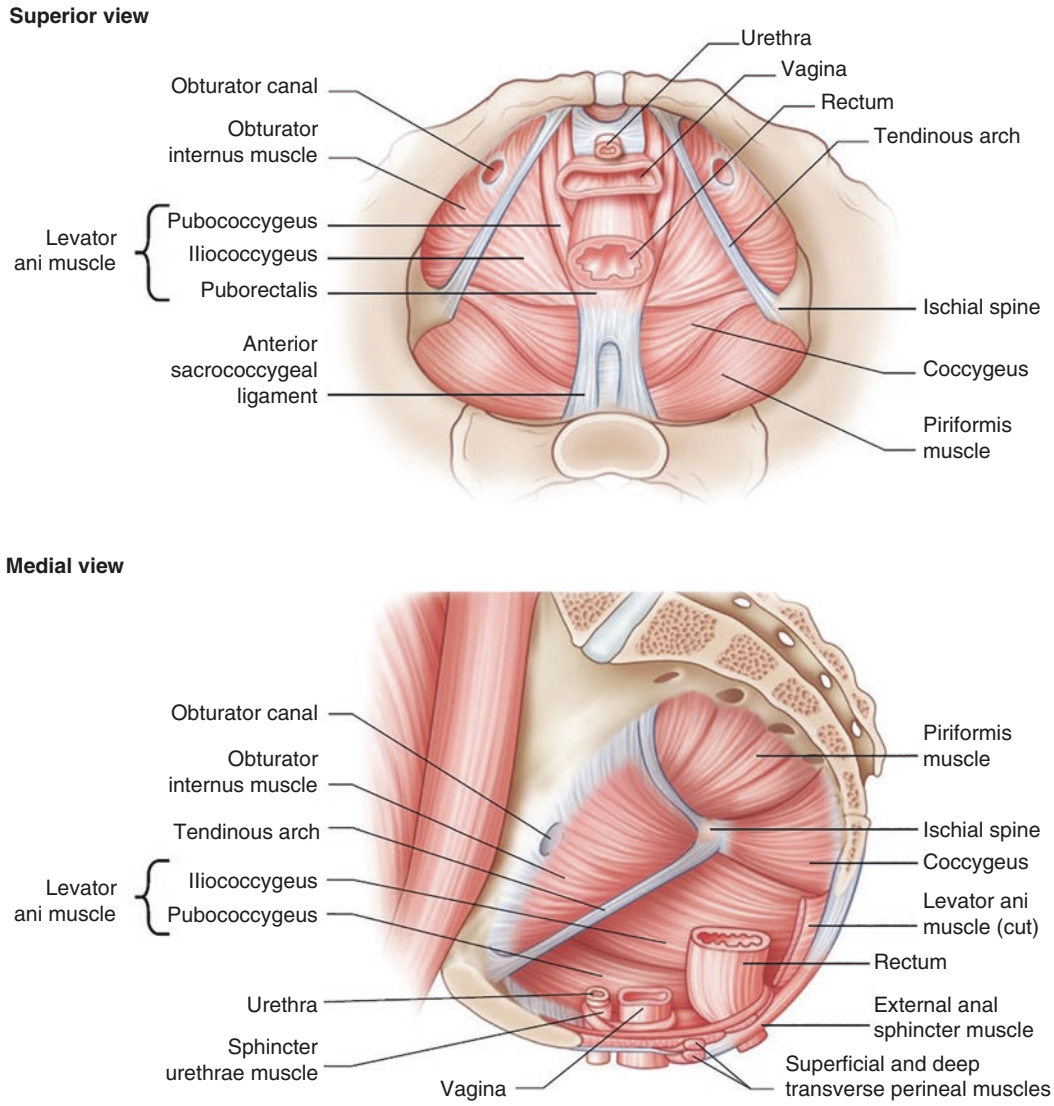

Fig. 38.1 Pelvic floor muscles (adapted from Firoozi F. Female Pelvic Surgery. Springer Science + Business Media. New York. 2015)

Elongation ("ballooning") and tearing ("avulsion") of the levator ani muscle (LAM) has been observed in up to 30% of primiparous women at 2–6 months postpartum [3, 4]. Both are independently associated with pelvic organ prolapse, especially cystocele and uterine prolapse [5, 6]. The effects of such alterations on urinary and anal continence are much less well defined [7–9]. The muscle that elongates the most, and is therefore most often injured, is the puborectalis muscle (Fig. 38.2) [10].

The pudendal nerve may also be affected during childbirth due to different mechanisms. The inferior rectal branch that innervates the external anal sphincter (EAS) and the perineal branch that innervates the external urethral sphincter may be the most affected by direct compression and by the descent of the fetal head, producing a proportional perineal descent with secondary nerve stretching [11–14]. However, long-term consequences of such trauma are not well understood.

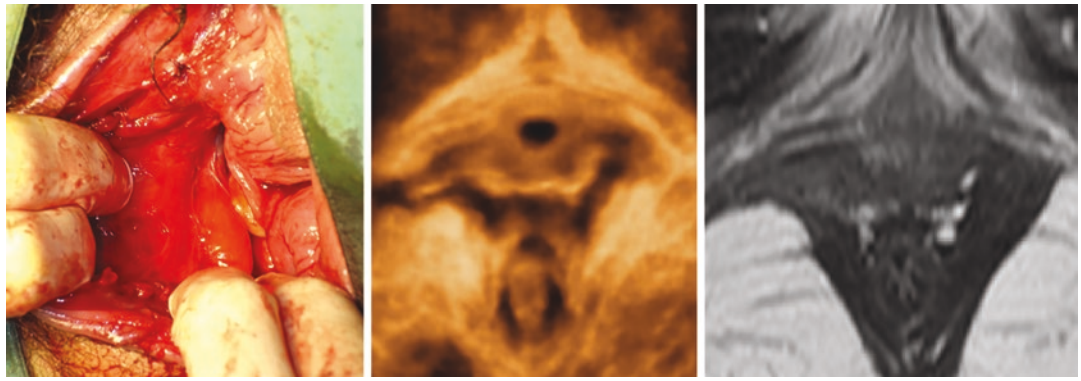

Fig. 38.2 Puborectalis muscle injury due to childbirth

Tears are classified according to their location and can be divided into:

- Perineal tears
  - Grade I
  - Grade II
  - Grade III (a, b, c)
  - Grade IV
- Vaginal tears
- Cervical tears
- Levator tears

In the context of vaginal tears, we will also discuss episiotomy.

38.2 Perineal Tears

38.2.1 Concept

Tears in the female genital area occur in about 85% of all first vaginal deliveries, the most frequent being first- and second-degree tears.

Perineal tears are further subdivided into first-, second-, third- (when they affect the anal sphincter complex), or fourth-degree (when they also affect the anorectal mucosa) tears.

First-degree tears are those that affect the perineal skin and vaginal mucosa, while *second-degree tears* are those that also affect the perineal fascia and muscles. ***First- and second-degree tears*** do not affect the anal sphincter.

38.2.1.1 Sphincter Injuries

This term refers to trauma that affects the anal sphincter complex in the context of vaginal childbirth. The prevalence of clinically diagnosed obstetric anal sphincter injuries (OASI) is 0.4–5%, with the majority (2.9%) occurring in primiparous women [15] [16] [17]. They affect the ventral aspect of the EAS; when partial, they seem to more commonly affect the proximal rather than the distal aspect of the sphincter complex [18].

Anal sphincter injuries are commonly underdiagnosed in delivery suite [15, 19, 20].

There is a strong correlation between the presence of sphincter injury and the appearance of fecal incontinence symptoms. Thus, 35% of primiparous women with an anal sphincter tear will have anal incontinence at 6 weeks postpartum [16], and about half complained of anal incontinence at an average follow-up of 6.6 years [21].

A number of risk factors for anal sphincter injuries have been identified in the literature, such as the following:

- Instrumented deliveries (greater incidence with forceps than with suction cups) [22]
- Primiparity [23]
- Fetal macrosomia [24]
- Occiput posterior presentation [24]
- Prolongation of the second phase of labor [25]
- Epidural analgesia
- Advanced maternal age
- Caucasian ethnicity

Fig. 38.3 Classification of anal sphincter injury

1st degree	Perineal skin injury.		
2nd degree	Injury to the perineal muscle without the affecting anal sphincter.		
3rd degree	Anal sphincter injury.	3a	Injury <50% of EAS thickness.
		3b	Injury >50% of EAS thickness.
		3c	Injury of both EAS and IAS.
4th degree	Injury of the anal sphincter complex and anorectal mucosa.		

Other risk factors are controversial, the most contentious one being episiotomy [26, 27]. This may be due to variations in the performance of episiotomy since it has recently been shown that a substantial number of episiotomies is not commenced in the midline and/or not cut at the correct angle.

38.2.1.2 OASIS Classification

The classification of sphincter lesions used by the Spanish Society of Gynecology and Obstetrics (SEGO) was described by Sultan in 1994 and endorsed by the Royal College of Obstetrics and Gynecology (RCOG). It offers prognostic value, as 3C injuries have twice the risk of developing anal incontinence than 3B injuries. These, in turn, have twice the risk of 3A injuries (Fig. 38.3).

38.2.1.3 Diagnosis

The original imaging method used in the diagnosis of anal sphincter trauma is endo-anal ultrasound, introduced in the 1990s. Its invasiveness and the need to specialized equipment has limited its use both in research and clinical practice, resulting in very limited impact on clinical care. While the method was first in traduced in the United Kingdom, this has not had any appreciable impact on clinical practice, given that the prevalence of anal sphincter tears and its main modifiable risk factor, forceps delivery, has been rising steadily in this jurisdiction [28] [29]. At present, this technique is still considered the gold standard in the diagnosis of sphincter injuries by many colleagues. More recently, however, exo-anal or translabial ultrasound has been shown to produce potentially superior images with commonly available 3D/4D ultrasound equipment used in general O/G imaging [30]. One of the many advantages of this approach is that it allows much improved standardization and an assessment of the perineum. The latter is particularly useful in the evaluation of episiotomy scars [31].

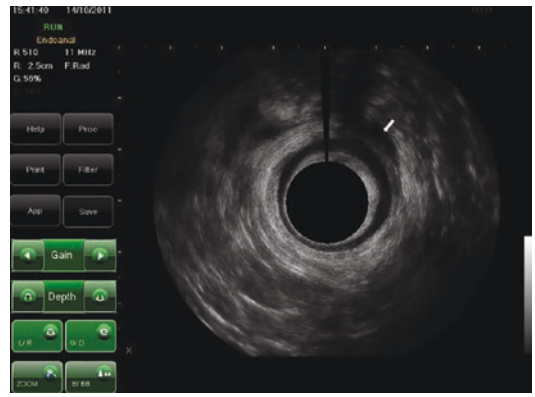

Fig. 38.4 Endoanal ultrasound performed at CUN. The arrow indicates an injury of the external anal sphincter

Regardless of the methodology used, an injury is detected when loss of continuity of the anal sphincter is observed (Fig. 38.4), accompanied by other signs such as the presence of irregular borders in the suspect area or a marked asymmetry.

Over the last 20 years, transperineal ultrasound has developed to become the main imaging method used in pelvic floor medicine [32]. Most gynecology services in developed nations have the necessary equipment. The use of 3D/4D transducers provides a fundamental advantage in the study of the pelvic floor in that axial plane imaging, and tomographic imaging is easily

accomplished, in real time. It also allows for multiplane are imaging, that is, the depiction of a structure in the three orthogonal planes at the same time. Volume data can be saved and analyzed offline with the help of proprietary software. The first author to use transperineal ultrasound for the study of the anal canal was Peschers in 1997 [33], although it is only since the introduction of 3D/4D imaging that the method has found more widespread use. In recent years it has been standardized and validated against symptoms (for an overview see [30, 34]).

The study of the anal sphincter with transperineal ultrasound is performed during contraction as abnormalities seem to be enhanced, but imaging may also be performed at rest [35].

With regard to the position of the probe, it is placed in a transverse position on the introitus and perineum, as shown in Fig. 38.5.

With a 4D transducer, a cine loop of volumes is obtained that can be analyzed on the system or offline. The following image shows such a volume, the first and last quadrant, is omitted so that only six intermediate ones are scored (Fig. 38.6).

An anal sphincter defect is diagnosed by transperineal ultrasound when 4/6 slices obtained as in Fig. 38.6 show a defect of ≥30° in the circumference of the EAS (Fig. 38.7).

38.2.1.4 Clinical Diagnosis

Identifying the type and degree of injury is essential to correctly repair the lesion, and this is not a trivial task, given that a large number of OASI seem to be missed on clinical examination [15, 19, 20].

For an examination to be accurate, a rectal examination with the index finger should be performed systematically with digital palpation of the sphincter mass between the finger lodged in the rectum and the thumb that is exploring the perineal wound.

The EAS may not be initially visible due to the lateral retraction that commonly occurs after rupture. It is composed of striated muscle fibers with circular morphology that are located around the IAS. The color of the EAS is similar to that of red meat, such as veal. The EAS is variously described as consisting of one, two, or three distinct fascicles, and there seems to be substantial interindividual variation. The bulk of the muscle varies greatly between individuals, which may result in the operator overlooking a fully ruptured deep fascicle, resulting in repair of only the superficial and subcutaneous aspects of the EAS. This may explain why residual defects after repair are more commonly found in the cranial EAS [31].

The IAS is identified as a whitish fibrous tube situated between the rectal mucosa and the EAS, the continuation of the muscularis layer of the gut. Its identification can be difficult during childbirth. The IAS is said to be responsible for 75% of the anal tone that maintains continence [36]. The color of the IAS is similar to white meat, such as chicken.

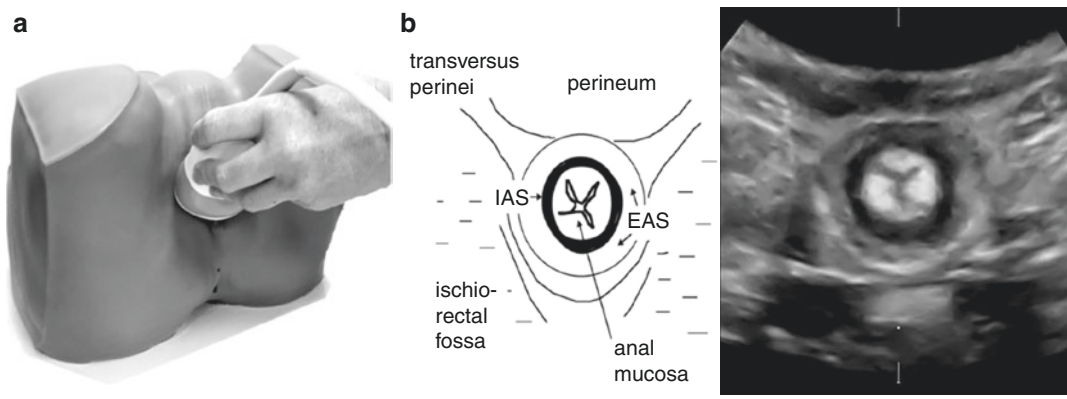

Fig. 38.5 Position of the probe over the introitus (**a**) and analysis of the IAS and EAS muscles (**b**)

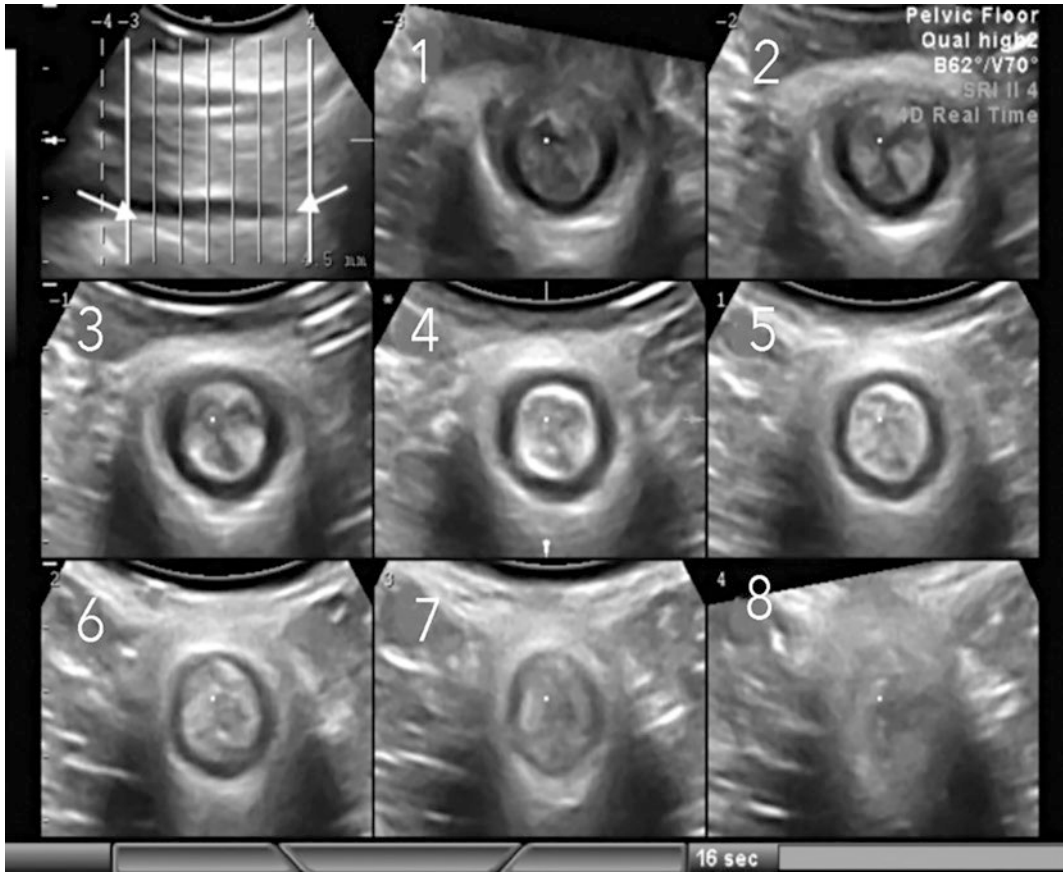

Fig. 38.6 Tomographic ultrasound showing an uninjured sphincter. The location of eight coronal slices is shown in the midsagittal reference plane in the top left hand corner. Slices 1 and 8 are cranial to the EAS and caudal to the IAS, bracketing most of the EAS for assessment of slices 2–7

Fourth-Degree Tears

Clinical diagnosis of a fourth-degree tear is quite straightforward since rupture of the anal mucosa should be evident as a full-thickness disruption of all tissue layers between vagina and anal canal. An exception is buttonhole tears of the upper anal canal, which may occur with a largely intact perineum. Missing such a tear usually results in an anovaginal fistula; hence, it is imperative to perform a full vaginal and, if there is any significant vaginal or perineal trauma, a rectal examination after every vaginal delivery.

On imaging, it is currently not possible to distinguish between 3C and fourth-degree tears, although the latter seem to show higher degrees of distortion, scarring, and residual defects.

38.2.1.5 Treatment

The IAS must be sutured separately and before repair of the EAS. Sutures should be placed without tension. EAS repair may be carried out by two different techniques: end-to-end suture or overlapping. In partial tears, the overlap technique cannot be used. The attempt to repair the IAS by means of the overlap technique is even more difficult than in the EAS, so the end-to-end suture is usually performed for this structure. A delay of less than 12 h in the repair of the anal sphincter does not worsen the functional results [37].

Repair of a fourth-degree tear should begin by suturing the rectal mucosa. It should be sutured with interrupted stitches, leaving the knot in the intestinal lumen. This practice is carried out in

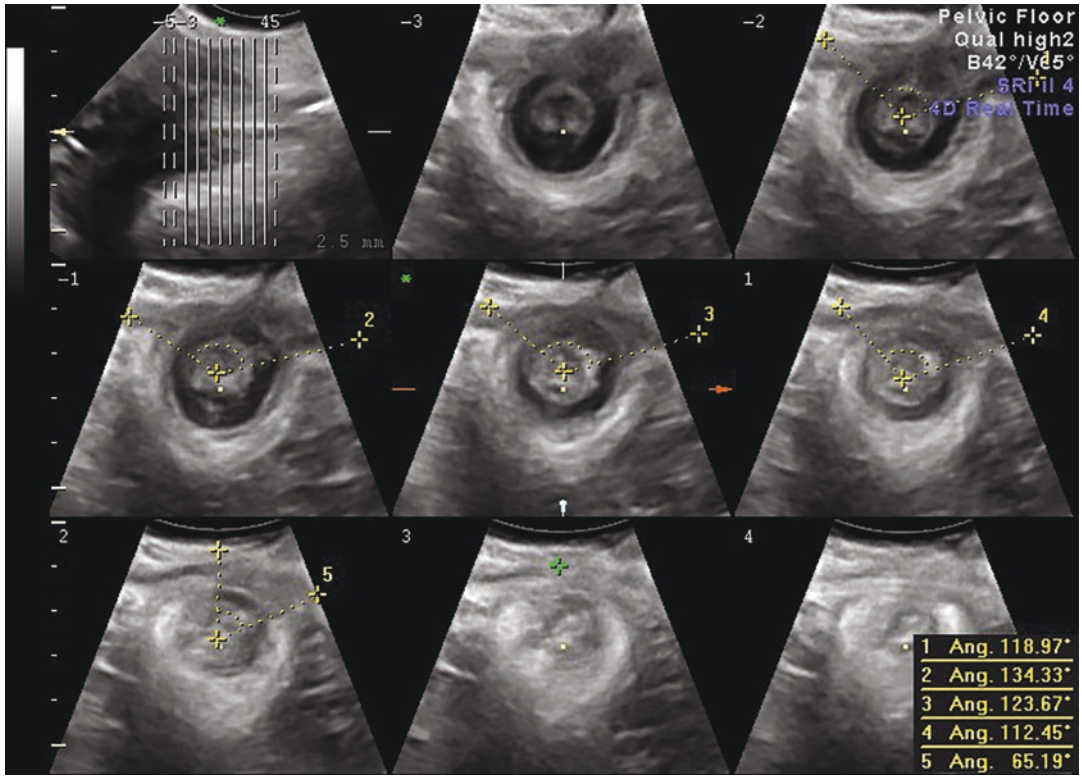

Fig. 38.7 Injury of the EAS in the presence of an episiotomy scar (arrow), which seems to aim toward the sphincter rather than away from it. The EAS defect suggests an unrepaired 3B tear

order to avoid a greater reabsorption of the suture material. An intramucosal continuous suture is also a valid option since the level of reabsorption of the material would be similar to that of interrupted stitches. It is necessary to ensure that a bowel movement occurs within a period not exceeding 5 days, even if the patient has already been discharged. The RCOG Green-top guideline suggests the use of laxatives. Intrapartum antibiotic therapy is indicated on suspicion of sphincter injury [38].

In recent years, workshops training medical professionals to identify and repair internal and external sphincter during childbirth have proliferated, commonly using pig sphincters as a model [39]. One would hope that such training will result in better diagnosis and treatment, thus improving future outcomes for the patient.

The following photographs show the anorectal complex of a sow, each one indicating the location of a particular muscle or structure (Figs. 38.8, 38.9, 38.10, 38.11, and 38.12):

Fig. 38.8 Internal anal sphincter. It has a smooth texture and a whiter color

The following clinical cases have been included to better illustrate what has been explained in this chapter.

Fig. 38.9 External anal sphincter

Fig. 38.10 Perineal muscles. It is important not to confuse them with the external anal sphincter

Fig. 38.11 Vaginal mucosa

Fig. 38.12 Internal anal sphincter with anal mucosa

Case 1

A patient presents to the physician's office complaining of occasional leakage of gas at 2 months postpartum. An ultrasound of the anal sphincter is performed, finding no evidence of anal sphincter injury (Fig. 38.13).

Comments on Case 1

There is no evidence of macroscopic sphincter trauma. At this point in time, we can only assume a neuropathic cause, but this cannot be ascertained with any certainty. Complete physiological recovery is likely to take more than 2 months. The patient is instructed to resume normal activity and advised to begin pelvic floor muscle training.

Case 2

Patient presents with gas leakage and occasional fouling of underwear at 3 months postpartum. This was her second delivery, and a 3100-gram baby was born through an instrumented delivery with forceps. An ultrasound is performed and reveals an anal sphincter tear that was not sutured after childbirth (Fig. 38.14).

Comments on Case 2

The ultrasound reveals integrity of the IAS and a wide, unsutured injury of the EAS in the presence of a poorly performed episiotomy. Recommended treatment would include electro-

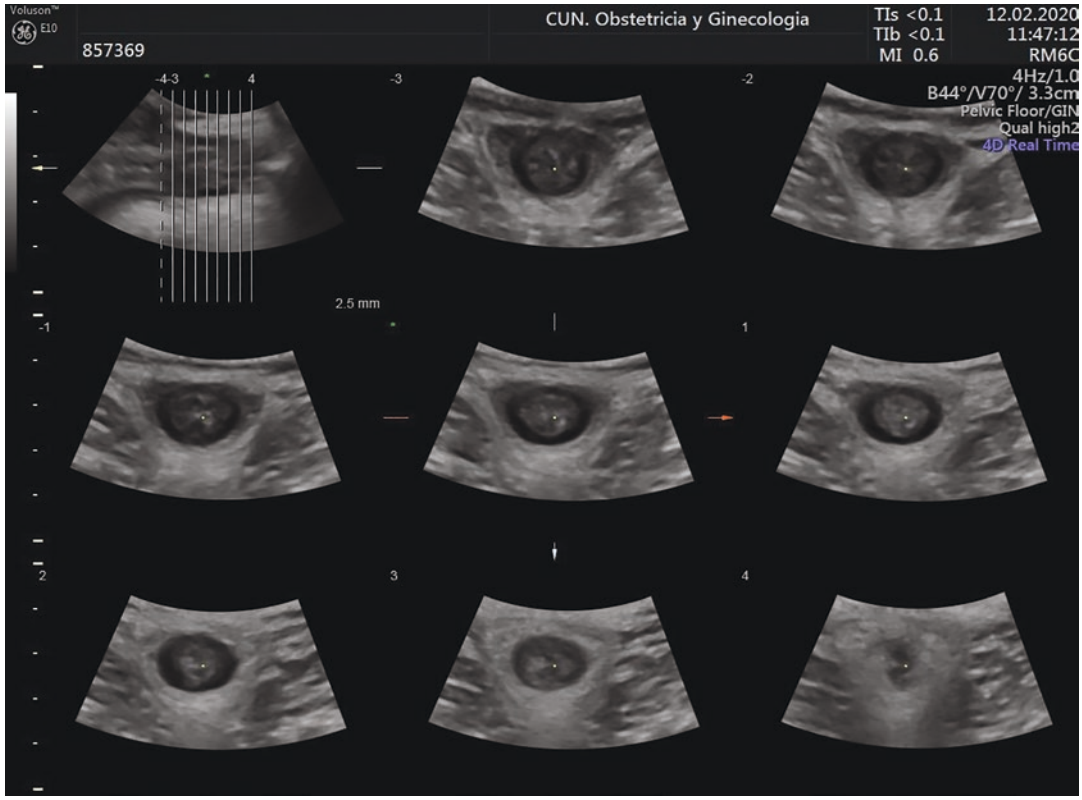

Fig. 38.13 Case 1

stimulation of both type I and type II fibers of the EAS, as well as and pelvic floor muscles training. If this was unsuccessful, one should consider a colorectal referral.

38.2.1.6 Prevention

A number of measures have been proposed with the aim of reducing the incidence of perineal tears, including the following:

(a) Perineal massage
(b) Ritgen and Hands-on maneuvers
(c) Episiotomy (we will explain later in Sect. 38.3)

(a) *Current Evidence for Perineal Massage*

The goal of perineal massage is to improve tissue quality and its hysteresis [40]. It is advisable to start at 32–34 week gestation. Each massage session should last no more than 20 min at a good pace. It is a low intensity massage. The frequency of the sessions should be one session per week until 37 weeks.

A Cochrane review published in 2013 included four trials (2497 women) comparing digital perineal massage with control. All were of good quality. Antenatal digital perineal massage was associated with an overall reduction in the incidence of trauma requiring suturing, and women practicing perineal massage were less likely to have an episiotomy. These findings were significant for women without previous vaginal birth only. No differences were seen in the incidence of first- or second-degree perineal tears or third-/fourth-degree perineal trauma [40].

(b) *Ritgen and Hands-on Maneuvers*

These two maneuvers are used in childbirth care in order to reduce the incidence of perineal tears.

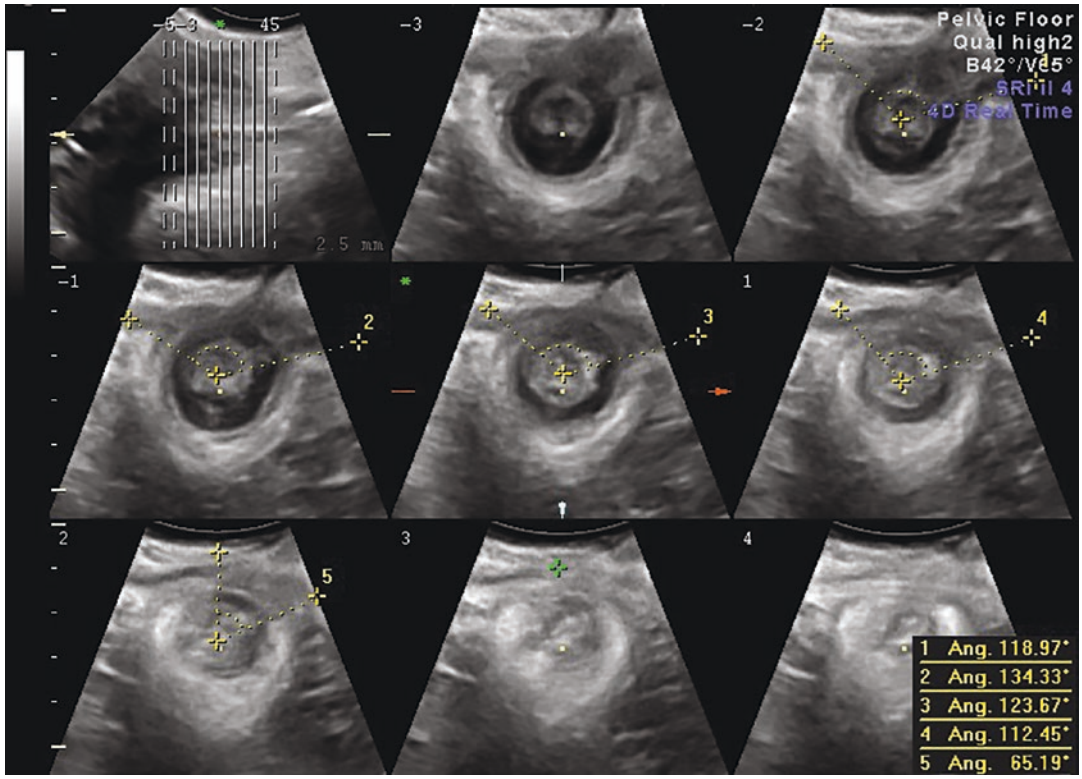

Fig. 38.14 Case 2

Fig. 38.15 The Ritgen maneuver

The Ritgen maneuver (Fig. 38.15) consists in holding the fetal chin when it reaches the plane formed by the maternal coccyx and anus, lifting the chin anteriorly and using the other hand to control the fetal occiput and the speed of labor. It mainly protects against an abrupt extension of the fetal head. It has been found to be effective in reducing first-degree tears, although not third- and fourth-degree tears [41].

The "hands-on" maneuver (Fig. 38.16) consists in controlling the fetal head with one hand, applying pressure to control the speed of labor, while controlling the maternal perineum with the other hand. This maneuver reduce the incidence of perineal laceration especially third and four degree [42, 43].

Fig. 38.16 Hands-on maneuver during an eutocic delivery

38.3 Episiotomy

This term refers to a surgical incision that is performed of the woman's perineum during the second stage of labor (Fig. 38.17). The goal is to widen the lower third of the vagina, the vulvar ring, and the perineum to prevent complicated tears [44].

Depending on the angle of the cut with respect to the perineal raphe, episiotomies are classified into three groups [45]:

- *Lateral*: The incision is made from a few centimeters above the midline at a 90° angle toward the ischial tuberosity. Bundles of the bulbocavernosus muscle are cut, bleeding is abundant, and the aesthetic result is poor. It is currently in disuse [46].
- *Mediolateral*: The incision begins in an oblique direction, at a 45° angle, from the posterior fourchette, toward the ischial tuberosity. The vaginal mucosa, skin, and muscle are cut, including the entirety of the puborectal fascia of the LAM. It can be extended to the ischiorectal fossa when deemed necessary. Bleeding is greater than with the midline episiotomy, but if done correctly, it can avoid the extension of tears to the anus and rectum. The rate of third- and fourth-degree tears is less than 1%, and it heals well, although retractions of the vaginal introitus and dyspareunia may remain present for a few months [47, 48].
- *Midline*: The incision is made on the fibrous perineal raphe preserving the LAM. If necessary, it can be extended around the anal sphincter. This incision reduces perineal tension symmetrically, and blood loss is low. In addition, it is easily sutured and causes little postoperative discomfort, and the aesthetic and functional result is usually excellent.

Fig. 38.17 Unsutured episiotomy

Despite these advantages and even when performed only under favorable circumstances, the tear rate, its length, the degree of complication, and the sequelae of anal incontinence are greater than with other incisions [49].

The evidence shows that episiotomies should be performed in a restrictive way, that is, only when the obstetrician considers it necessary [50] . However, it has to be said that there may well be a substantial detection artifact affecting all published studies on the impact of episiotomy. It is clear that many, if not most, third-degree tears are missed in delivery suite—either because they are truly occult, or because patients are not examined properly [19]. In addition, it is possible that performance of an episiotomy is in itself a confounder because there usually is a fuller examination after episiotomy and medical personnel are more likely to be involved. Hence, the role of episiotomy in the prevention of OASI has, in the opinion of the authors, to be regarded as uncertain.

An episiotomy should be performed once the perineum bulges in order to reduce bleeding and avoid trauma to higher structures such as the upper anal canal and rectal ampulla. During crowning, the vulva begins to distend considerably, and the anus dilates. In addition, making the incision at the acme of a contraction produces less bleeding. Usually, in assisted vaginal deliveries, any instrumentation must put in place before the episiotomy, although in some cases of vacuum extraction, performing the episiotomy first can facilitate the application of the suction cup.

Although the correlation between episiotomies and the development of prolapse is uncertain, in the 1980s, it was thought that this surgical incision produced pelvic floor disorders related to a greater subsequent relaxation of this structure. It is currently considered that pelvic floor disorders are not due to the episiotomy itself, but rather to other anatomical consequences of a prolonged second stage of labor or a more traumatic expulsion [51].

The episiotomy is usually sutured immediately after the placental delivery. The objective is to achieve an anatomical reconstruction as symmetrical as possible that can later facilitate function. Rapidly absorbed sutures are used. The use of threads derived from polyglycolic acid and the like is recommended [52].

The vaginal mucosa is sutured first. The apex of the tear is identified, and a first anchor point is placed 1 cm above it. The laceration is then repaired with a continuous suture from the apex to the hymenal ring. A locking stitch can be used to achieve greater hemostasis. The recommended suture material is a 2-0 rapid absorption suture.

Subsequently, perineal body is sutured and repaired with interrupted sutures of rapid absorption. It is important to suture in depth without leaving dead spaces where subsequent formation of hematomas could occur.

The skin should be properly approximated without tension, since the skin suture may increase the incidence of perineal pain in the first months postpartum. For this reason, two options are accepted: using a continuous subcuticular 2-0 or 3-0 rapid absorption suture without suturing the skin directly, or interrupted 2-0 or 3-0 sutures without tension (Fig. 38.18) [53].

Fig. 38.18 Sutured episiotomy

In the immediate puerperium, that is, the first 24 h after delivery, an episiotomy requires the following care:

- Observing the color and edema of the repair (to rule out the presence of hematoma or ecchymosis).
- Pain assessment: Persistent pain resistant to analgesia can be caused by a hematoma that may require drainage. Performing a vaginal and rectal examination will help rule out the presence of hematomas.
- Assessment of bleeding: An increase in bleeding, while usually due to uterine causes, may also be due to an unrepaired laceration or dehiscence of a suture.
- Placing an ice pack over the wound, wrapped in a cloth or towel because direct application can cause burns in the perineal area. The cold helps reduce inflammation and provides local relief [54].

During the early puerperium (within the first postpartum week), the patient should be assessed for signs of infection such as erythema, induration, heat, and suppuration. If the perineum continues to show inflammation, apply an ice pack two to three times day. The suture line should be assessed for signs of dehiscence. Monitor vital signs once a day during hospital stay and if the patient is symptomatic after discharge. Perform pain assessment, asking about the onset, duration, frequency, triggers, and intensity (using a Visual Analogue Scale or VAS).

The application of antiseptic once a day to prevent infection is controversial. Evidence indicates that the use of antiseptic has not been shown to reduce the rate of infection.

Health Education at Hospital Discharge

- Daily shower and wash the area with soap after a bowel movement.
- The use of antiseptics is not necessary.
- Use cotton or cellulose sanitary pads.
- Do not use vaginal tampons during the first 6 weeks postpartum.
- Avoid heavy lifting.
- Avoid sexual intercourse during the first 6 weeks postpartum.
- Use underwear made of natural fibers, preferably cotton.
- The sutures dissolve in 10–15 days. After that, it may be advisable to massage the scar with rosehip oil or aloe vera cream.
- Midwife visit or phone call 10 days after discharge or phone call.
- Call the midwife if:
  - There is redness, inflammation, heat, severe pain, or discharge from the suture line.
  - Temperature rises >38°.
  - There is a burning sensation when urine flows over the suture line.

38.4 Cervical Tears

Cervical tears occur as a result of the passage of the fetal head through the cervix. In general, spontaneous cervical tears are small (<1.5 cm), are not bleeding, and do not need to be sutured. The largest tears (<2 cm) are caused by precipitate births and macrocosmic babies. To prevent a cervical tear from going unnoticed, it is necessary to check with specula after delivery.

Cervical tears can be complicated by severe bleeding or a puerperal infection. Absorbable sutures of large caliber (0 or 1) are used. It may not be easy to locate the apex of the tear. In this case, and especially if bleeding is brisk, the two sides of the tear are gently grasped with large sponge holding (Rampley's) forceps, and a suture is placed as close to the apex as possible. After tying, this suture can then be used to apply further traction so that the next suture can be placed higher, until the apex is reached and bleeding arrested.

38.5 Levator Tears

38.5.1 Concept

The concept of LAM injury first appeared in the scientific literature in 1943 [55]. The term "avulsion" refers to the tearing of this muscle from its anchor point, which is the pubis.

In order to understand this form of pelvic floor trauma, it is necessary to recall the anatomy of the levator ani. While there is disagreement over its subdivisions, it is generally held to consist of three muscular fascicles: puborectalis, iliococcygeus, and coccygeus. On imaging, it is generally impossible to define the margins of those divisions.

- Puborrectalis muscle: It originates from the medial surfaces of the inferior rami of the os pubis bilaterally and embraces the urethra, vagina, and rectum at the height of the anorectal junction.
- Iliococcygeus muscle: It originates on the tendinous arch of the LAM over the obturator internus muscle and extends to the anococcygeal ligament and coccyx.
- Coccygeus muscle: It originates from the spine of the ischium and sacrospinous ligament and inserts into the coccyx and sacrum.

The main function of the LAM is to keep the urogenital hiatus functionally closed, thus maintaining organ support and enhancing urinary and anal continence. The puborectalis muscle forms the vaginal high pressure zone [56] and the hernia portal through which all pelvic organ prolapse develops. It also plays a role in sexual function, and it is the part of the levator ani that has to stretch the most and the fastest during vaginal childbirth [10, 57].

As the mechanical strain on the puborectalis muscle is bound to be greater than the strain placed on other components of the levator ani, it is not surprising that mechanical disruption of the muscle insertion is not uncommon after vaginal childbirth [22].

Risk factors associated with avulsion are advanced maternal age [58], instrumented delivery with forceps [22] prolonged duration of the second stage of labor, and the circumference of the fetal head [59]. Higher BMI and the use of epidural anesthesia may be protective factors for LAM injury [55]. Instrumentation with forceps carries the highest risk of avulsion (40–70%), followed by vacuum births (10–33%), and finally normal vaginal deliveries (10–15%). Overall, LAM avulsion prevalence is likely to be 10–30% depending on obstetric practice and population [3]. Since in avulsion injuries the muscle suffers a disconnection from its insertion, it is not surprising that most lesions diagnosed in the postpartum period seem to persist [60, 61].

Since 2006, we know that the main consequence of avulsion is prolapse of the anterior and central compartment [6, 62]. In addition, avulsion seems to be an independent risk factor for the recurrence of prolapse as shown in a recent meta-analysis [63]. On currently available data, the effect of avulsion on anal and urinary incontinence is likely to be minor [7, 64, 65].

38.5.2 Classification

LAM injuries are classified into macrotrauma and microtrauma, based on anatomical findings after delivery.

- *Macrotrauma* is a complete avulsion of the puborectalis component of the LAM. Only complete avulsion has been associated with signs and symptoms of pelvic floor dysfunction (see above). The diagnosis can be obtained at any time after a vaginal birth but is easier once local wound healing is complete, that is, at least 3 months after childbirth.
- *Microtrauma* is defined as hyperdistensibility of the LAM hiatus (ballooning), which has developed as the consequence of vaginal childbirth. This type of alteration is considered an independent risk factor for the appearance of prolapse and its recurrence [5]. At the moment, its effect on the functionality of the pelvic floor musculature is unknown [66]. The diagnosis requires both pre- and postnatal imaging as hiatal overdistensibility or "ballooning" may be congenital [67].

38.5.3 Diagnosis

LAM avulsion is diagnosed through clinical examination or by imaging.

38.5.3.1 Clinical Examination

On physical examination, LAM avulsion can be observed by placing the patient in the lithotomy position and performing a vaginal examination. The pubic arch is palpated on both sides, and an avulsion can be diagnosed when there is a lack of continuity in the musculature, with the bone of the inferior pubic ramus denuded. Asking the patient to contract the pelvic floor muscle will help clarify whether any muscle remains attached to the inferior ramus [68, 69].

38.5.3.2 Ultrasound Diagnosis

The levator ani can be imaged with 2D ultrasound—either with the help of a side-firing endocavitary probe or with an abdominal curved—array placed in a parasagittal orientation [70]. It is however more convenient to use standard 3D/4D abdominal/obstetric probes placed on the perineum in the midsagittal plane. A recent standardization document approved by six societies active in this field [34] suggests the use of 4D volume ultrasound and tomographic or multislice imaging, a method that is probably the most reproducible and valid [71–74], and it correlates well with MR for the diagnosis of levator trauma [75].

The distinction between incomplete and complete trauma, that is, the definition of a "full avulsion," is of crucial importance. Given the generally accepted 2.5 mm interslice interval for pelvic floor tomography, the minimal criterion for a full avulsion requires the three central slices in Fig. 38.20 to be abnormal. Slice location is very important, and this requires accurate location of the plane of minimal dimensions (Fig. 38.19) as well as adjustment of slices according to appearances of the symphysis pubis. The symphysis pubis is required to appear open in the center left slice, closing in the central slice, and it should be invisible due to acoustic shadowing in the center left slice (Fig. 38.20).

If appearances are equivocal due to partial trauma, scar tissue, limited image quality, or artifact, the "levator-urethra gap" (LUG) can be very useful in establishing a diagnosis; see Fig. 38.20 [76].

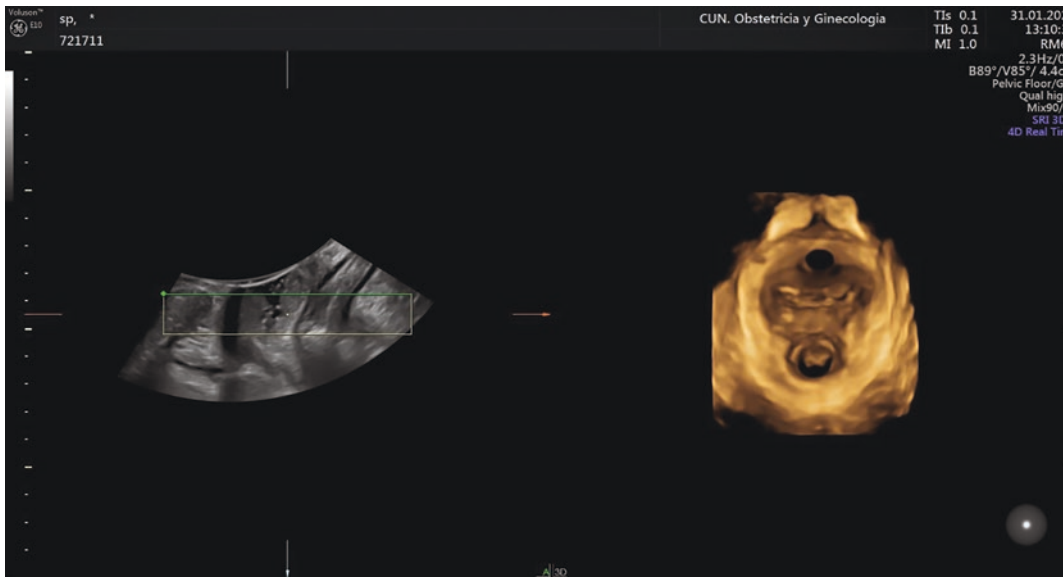

Fig. 38.19 2D ultrasound and 3D reconstruction of the axial plane (rendered volume technique). The left-hand panel shows the midsagittal plane, the right-hand panel is a semitransparent representation ("rendered volume") of all volume pixels in the box shown on the left

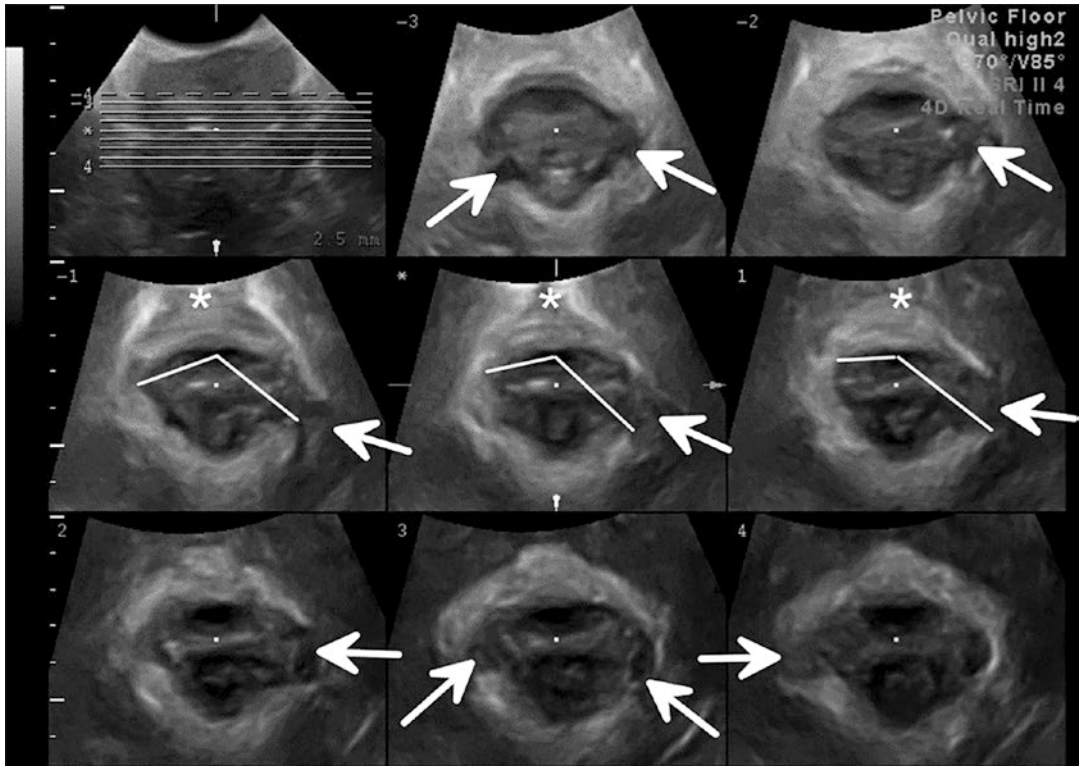

Fig. 38.20 Complete left-sided and partial right-sided avulsion. Oblique lines indicate the levator-urethra gap, arrows mark defects in single slices, and asterisks show the symphysis pubis. The patient's right-hand side is shown on the left of each panel

Usually, imaging for levator assessment is performed on pelvic floor muscle contraction as this seems to enhance tissue discrimination, but imaging at rest seems to be equally valid [77, 78].

38.5.4 Treatment

38.5.4.1 Prevention

Identifying risk factors and influencing those that are modifiable would be the first step to reduce the prevalence of this lesion. The most obvious modifiable risk factor is the use of forceps in childbirth, especially rotational forceps [22, 29].

There may however be opportunities to reduce the traumatic potential of forceps while retaining its use on principle. The degree of distension per se does not seem to be the major factor in the causation of trauma, and force and force over time are likely to be more important [79].

Biomechanical considerations would suggest that pulls should be steady and slow in order to reduce peak forces, and paralysis of the levator ani muscle via a pudendal nerve block or a dense epidural may reduce the work required for distension and hence trauma. Simulation workshops for obstetric specialists could be adapted to account for these principles. Of course, encouraging the use of vacuum for instrumental delivery is also likely to reduce maternal morbidity in childbirth.

Another approach is secondary prevention. This would require identification of women with major trauma in order to target pelvic floor rehabilitation treatment in asymptomatic women soon after childbirth. Pelvic floor physiotherapy will also strengthen other muscles such as external anal sphincter and urethral rabdosphincter. There is no contraindication to pelvic floor muscle training in the puerperium once acute pain

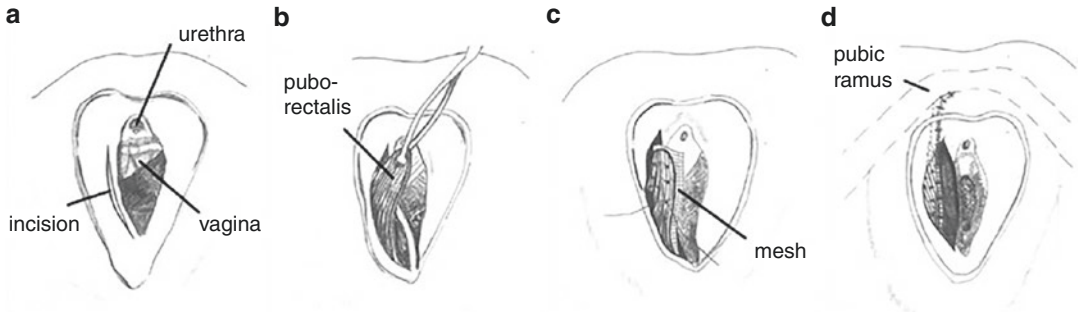

Fig. 38.21 Surgical repair of an avulsion of the puborectalis muscle through a distal lateral colpotomy (**a**). The muscle is identified and freed from the vagina medially (**b**). A 2 × 4-cm patch of polypropylene mesh is attached to the muscle using multiple single sutures (**c**). The reinforced muscle is sutured to the medial surface of the inferior pubic ramus (**d**). (With permission, from Dietz HP, Shek KL, Daly O., Korda A. Can levator avulsion be repaired surgically? Int Urogynecol J (2013) 24:1011–1015)

has settled, but diagnosis of avulsion by either palpation or imaging is best undertaken at least 3 months postpartum.

38.5.4.2 Surgical Treatment

Operative treatment of avulsion has to be regarded as experimental. The first description of a repair of an avulsion of the levator ani muscle dates to 2007. This repair was performed immediately after a vaginal delivery, with the muscle tear exposed by a large vaginal tear. The repair was unsuccessful as shown by MR and 4D US follow-up [80].

In 2009, Shobeiri repaired a unilateral avulsion with autologous "fascia lata," with access via the buttock, that is, via the ischiorectal fossa. The patient had a symptomatic avulsion of the right branch of the LAM. She presented with dyspareunia and anal incontinence. The authors did not provide data on integrity of the repair or medium- to long-term outcome.

The first report of a series of levator reconstructions in women suffering from pelvic organ prolapse was published by Dietz in 2013 [81]. It is a simple procedure performed concomitantly with prolapse surgery. A lateral colpotomy is performed at the level of the hymen, and the LAM is dissected off the vagina. A polypropylene patch is placed to reinforce the mobilized muscle, which is then sutured to the inferomedial surface of the inferior pubic ramus (Fig. 38.21). Despite this being a technically highly feasible technique, it may not be possible to significantly reduce the area of the genital hiatus, and the effect of such a reconstruction on prolapse recurrence remains unclear.

Attempts have also been made to reduce the area of the genital hiatus with the placement of a mesh sling that splints the puborectal muscles. The mesh is introduced through two perianal incisions that are then joined to form a postanal tunnel. The mesh sling is retrieved by passing a curved Stamey needle through the obturator foramen and the ischiorectal fossa to the perianal skin incision. The sling ends are then sutured to the inferolateral surface of the inferior pubic ramus [82] (Fig. 38.22). This technique may be able to reduce the area of the genital hiatus, with acceptable complications in patients after medium-term follow-up, but it will not lead to a re-attachment of an avulsed muscle.

The following clinical cases have been included to illustrate diagnosis of LAM injuries in a clinical setting.

Case 1

A 41-year-old primiparous patient who gave birth 3 months ago by forceps. She is asymptomatic and is there for a postpartum consultation. Her a priori risk of a full avulsion is likely to be well over 60%. An ultrasound is performed, and the following images are obtained (Fig. 38.23).

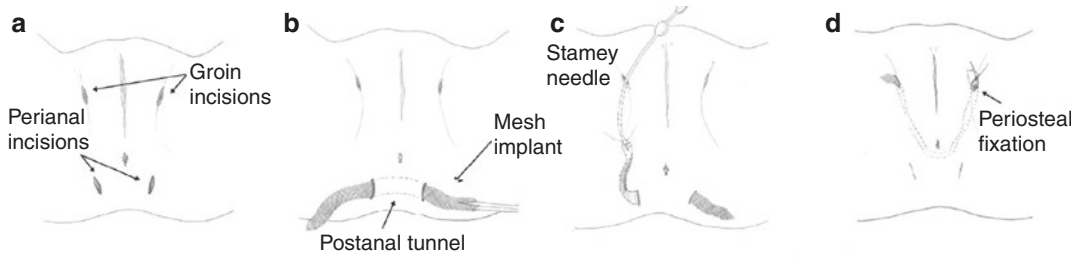

Fig. 38.22 Puborectalis sling procedure. (**a**) Incisions, (**b**) insertion of the implant, (**c**) its retrieval by curved needle, and (**d**) anchoring of the implant to the inferior pubic ramus. (From Wong V, Shek KL, Korda A, Benness C, Pardey J, Dietz HP. A pilot study on surgical reduction of the levator hiatus—the Puborectalis Sling. Int Urogynecol J. 2019 Aug 6. https://doi.org/10.1007/s00192-019-04062-0), with permission)

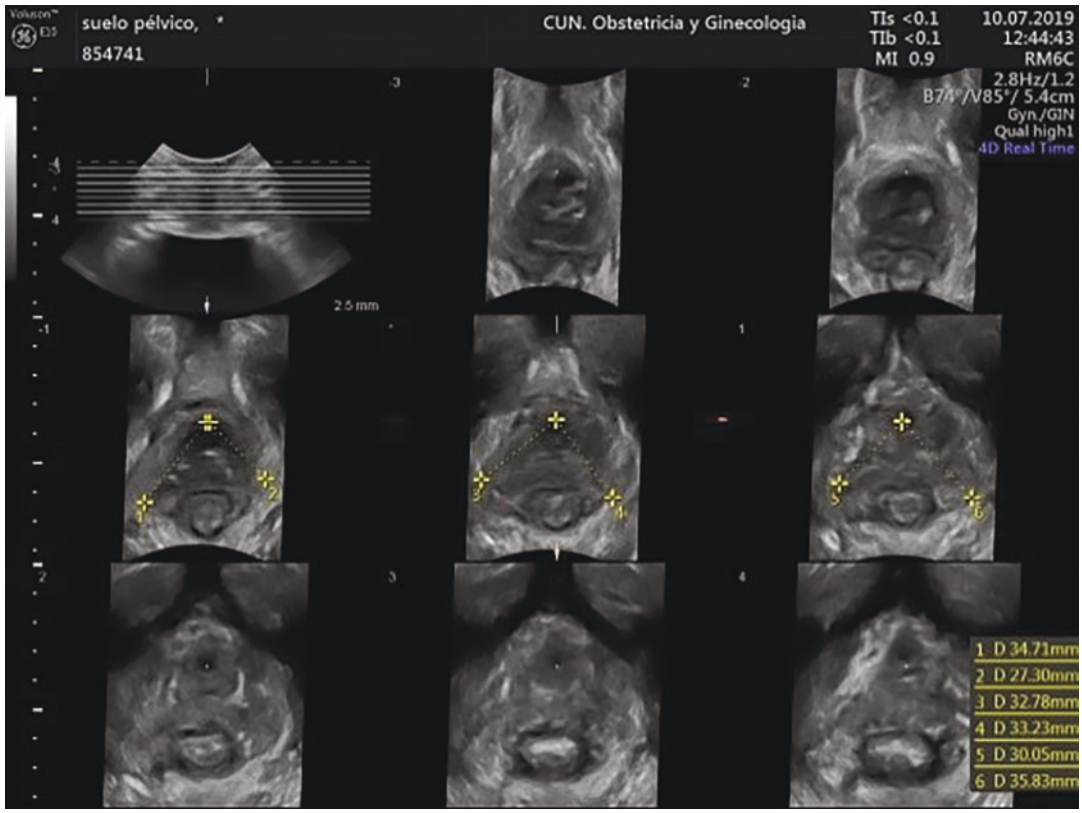

Fig. 38.23 Case 1

Comments on Case 1

An ultrasound of the pelvic floor has been performed, and bilateral avulsion of the puborectalis muscle is observed on tomographic imaging. The patient is currently asymptomatic, and hence, she does not require surgical treatment. We do know however that the likelihood of future pelvic organ prolapse is high and that a higher recurrence rate after surgery would have to be expected.

This lady would likely benefit from pelvic floor physiotherapy. As regards future vaginal births, she can be reassured that a second birth is likely to be easier and that further damage to the pelvic floor muscle is unlikely [83, 84].

Case 2

A 69-year-old patient presents to your urogynecology unit complaining of a vaginal lump. There is also nocturia three times with the sensation of incomplete bladder emptying, but no urinary incontinence and no bowel dysfunction. There is a history of three vaginal deliveries. On physical examination, the patient presents with grade 3 cervical descent as well as a third-degree cystocele during Valsalva maneuver.

On pelvic floor ultrasound, the following midsagittal and axial images are obtained (Figs. 38.24 and 38.25):

Comments on Case 2.

The images show us a bilateral avulsion of the puborectalis muscle, and abnormal compliance of the hiatus is observed, with a hiatus of 35 cm^2.

Given her symptoms, surgical treatment would be recommended for this patient. She should also be informed that the presence of a large hiatus is associated with a higher recurrence rate.

In this case, the affected compartments are the anterior and the posterior. The anterior compartment will be repaired either with its own tissues (anterior plasty) or with an anterior mesh. To repair the middle compartment, either a pexia or a vaginal hysterectomy is needed.

As previously explained, a pilot study showed that the puborectalis sling significantly reduced the elevator hiatus by almost 30% without major long-term complications [85]. Currently, a randomized controlled multicenter study of this procedure is about to be concluded.

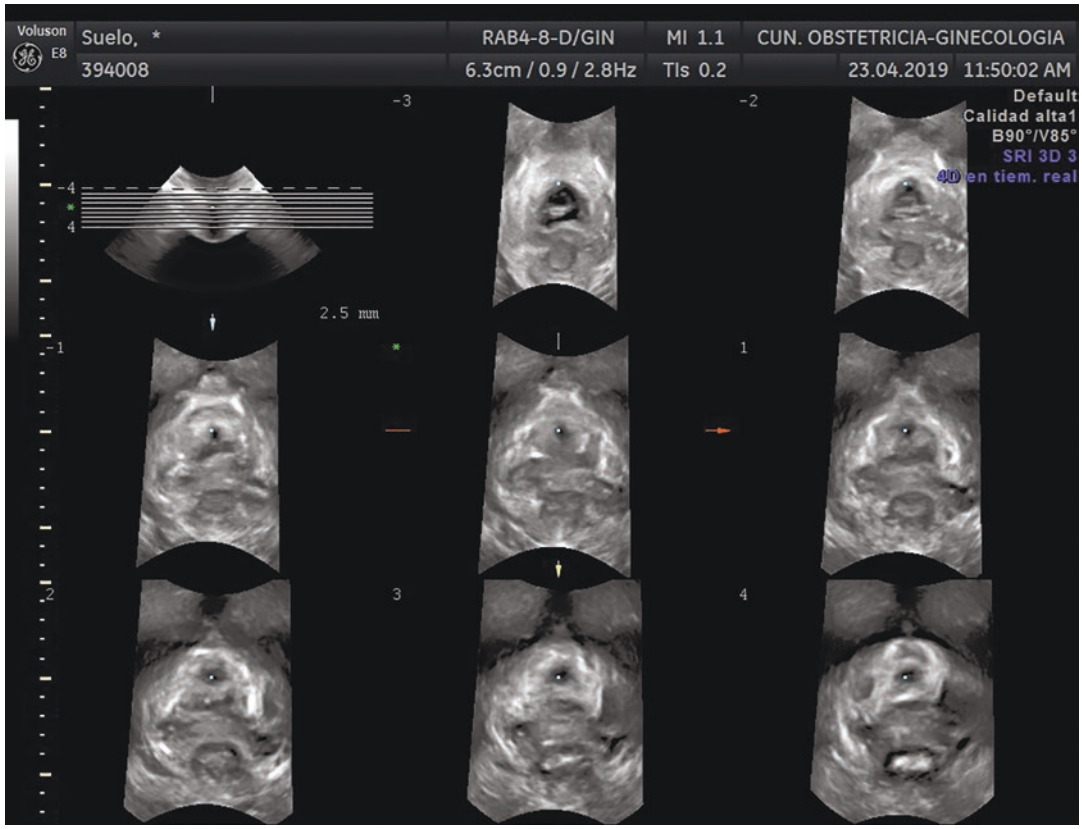

Fig. 38.24 Case 2

Fig. 38.25 Case 2

38.6 What Needs to Be Done in Clinical Practice and in Research Now? Prevention Rather than Cure

Although childbirth is a physiological process, it can have very substantial psychological and physical consequences for women. Pregnant women need to be treated as adults [86]. Informed consent is important so that the patient herself can be involved in therapeutic decision-making. In the same way as in the field of gynecology, we should inform patients of the risks involved in childbirth and potential long-term health consequences.

The literature now provides sufficient data to allow us to reduce the likelihood of obstetric trauma, acting on modifiable risk factors such as the use of forceps and perineal protection. Unfortunately, there are other nonmodifiable risk factors such as advanced maternal age. The current tendency to delay reproduction suggests that pelvic disorders will increase in the future.

In this situation, we must use the tools of evidence-based clinical practice. Training of medical personal and greater involvement of our patients in decision-making will be our best ally in the prevention of obstetric trauma.

Successful treatment relies on accurate diagnosis. In labor ward, this means concerted efforts to increase the detection rate for OASI and to ensure that, once detected, such trauma is repaired as well as possible. Imaging will allow much easier and more effective clinical audit of OASI, optimizing diagnosis and treatment, and helping to improve episiotomy practice.

Major trauma to the levator ani muscle, that is, avulsion, presents us with an even greater challenge. Diagnosis requires imaging. Ideally, all women at an increased risk of avulsion, such as women after a first delivery at age 30 or older, women after vaginal operative delivery, and those with clinically detected lateral vaginal tears and OASI, should have access to imaging services competent to diagnose or exclude avulsion. This would lead to greater awareness of trauma, hopefully with an increased clinical focus on primary prevention, while also allowing secondary prevention measures such as targeted pelvic floor re-education in women with major degrees of levator trauma. Ultimately, however, we will have to learn how to treat prolapse in women with avulsion, who are at a much greater risk of prolapse recurrence after surgery.

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39 Procedures After Dehiscence of the Pelvic Symphysis

Verónica Montiel Terrón and Pablo Díaz de Rada

Take-Home Points

- Pubic symphysis disruption is a rare condition but should be considered when anterior pelvic pain presents during pregnancy or labor.
- Pubic symphysis diastasis diagnosis must be suspected when the clinical signs are present and supported with radiological imaging showing a symphyseal separation over 10 mm.
- Pelvic symphysis dehiscence in pregnant women is usually considered Tile type B or open book injuries and are therefore partially stable.
- Most cases are mild, with a 4 cm or less widening, and can be treated conservatively.
- A prompt recognition of the symptoms is key, because when severe it could be followed by severe consequences.

39.1 Introduction

Pubic symphysis disruption is a rare injury during pregnancy. It causes an abnormal widening of the pubic symphysis.

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Pubic symphysis disruption is a rare injury with an incidence that ranges from 0.005 to 0.8% of live births [1–5]. This means it can sometimes go undetected because neither gynecologist nor orthopedic surgeons suspected. The early recognition of this injury is crucial to prevent complications and improve functional outcome. Therefore, it is important that when a pregnant woman starts having anterior pelvic pain, this injury is suspected and an appropriate clinical and radiological examination should be performed. Anterior pelvic disruption is more frequent in patients older than 35 years old; however, it has been reported in primiparous patients [6].

39.2 Pelvic Anatomy

The bony pelvis is formed by be two innominate bones that join dorsally to the sacrum and anteriorly to each other at the pubic symphysis to form the pelvic griddle or ring. Each of the hip bones is composed of three bones, the ilium the ischium and the pubis (Fig. 39.1). The ilium is the most posterior; it articulates medial and posteriorly with the sacrum and lateral and distally forms the acetabulum that contains the femoral head. The ischium is composed of a body, a tuberosity, a superior ramus that joins the ilium through its posterior border, and an inferior ramus that joins the pubis. The pubis is formed by a body and two rami, an inferior one that joins the ischium and a

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_39

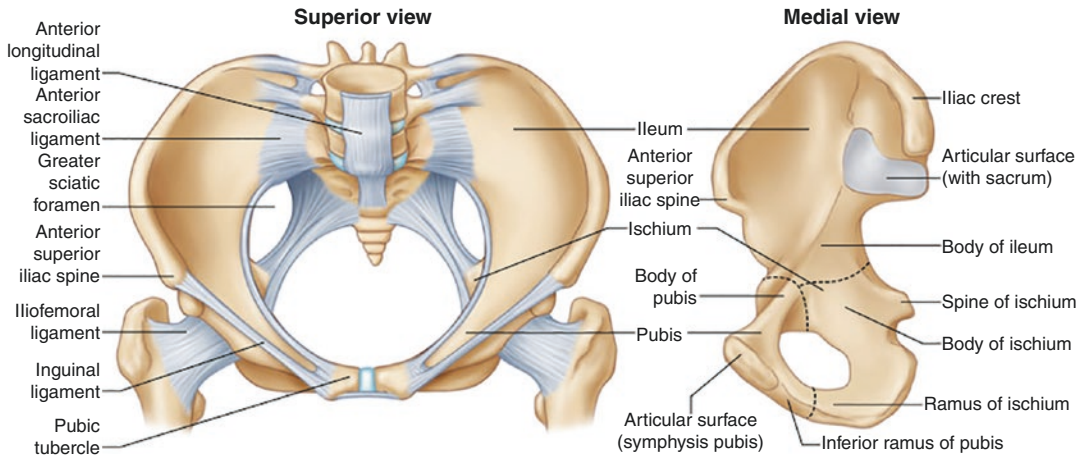

Fig. 39.1 The bony pelvis is composed of the ilium, the ischium, and the pubis (adapted from Firoozi F. Female Pelvic Surgery. Springer Science + Business Media. New York. 2015. Fig. 1.3 p. 4)

superior one that joins the ilium and the ischium. The sacrum in the middle of the two innominate bones is formed by the fusion of five or six sacral vertebrae. The sacrum articulates superiorly with the fifth lumbar vertebrae and inferiorly with the coccyx (formed by three to five fused caudal vertebrae).

The sacroiliac joint is a plane synovial joint in the anterior third and a fibrous syndesmosis in the posterior two thirds (Fig. 39.2). The joint space goes from 0.5 to 4 mm. The ligaments crossing the sacroiliac joint include the anterior sacroiliac ligament, the interosseous sacroiliac ligament, the posterior sacroiliac ligament, the sacrotuberous ligament, and the sacrospinous ligament.

- The anterior sacroiliac ligament is thin and not well defined. It is almost a thickening of the anterior joint capsule.
- The posterior sacroiliac ligament is divided into long or extrinsic dorsal sacroiliac ligament that runs obliquely and the short or interosseous ligament that is perpendicular to the joint and prevent distraction and opening.
- The sacrotuberous and sacrospinous ligaments limit the flexion of the sacrum.

The pubic symphysis is a midline non-synovial joint separated by a fibrocartilaginous disk and supported by four ligaments that connect the two superior pubic rami [5, 7]. The joint surface is not flat, and it has palpable elevations and depressions or ridges that increase contact area and theoretically increase the resistance to shearing forces. The fibrocartilage lamina varies in thickness in different subjects [8]. This joint has a limited movement of approximately 0.5–1 mm.

There are a number of muscles attached to the bony pelvis (Fig. 39.3). The medial side of the ilium or iliac fossa is where the iliac muscle originates. The external oblique, the internal oblique, the transversus abdominus, latissimus dorsi, and quadratus lumborum all insert in the iliac crest. The rectus femoris and the sartorius originate in the anteroinferior and anterosuperior iliac spines, respectively. The tensor fasciae latae, gluteus maximus, and minimus muscles attach the outer part (or lateral fossa) of the ilium.

Inside the pelvic ring the obturator internus muscle, transversus perineal muscle, coccygeus, and elevator ani muscles attach to the ischium and form a bowl that contains the pelvic floor (Fig. 39.4).

The obturator externus muscle, the adductor brevis, longus and magnus muscle, the rectus, and pyramidalis muscles arise in the pubis and extend to the lower limb.

Inside the ring lay the urogenital system, the distal part of the colon and the rectum, the large

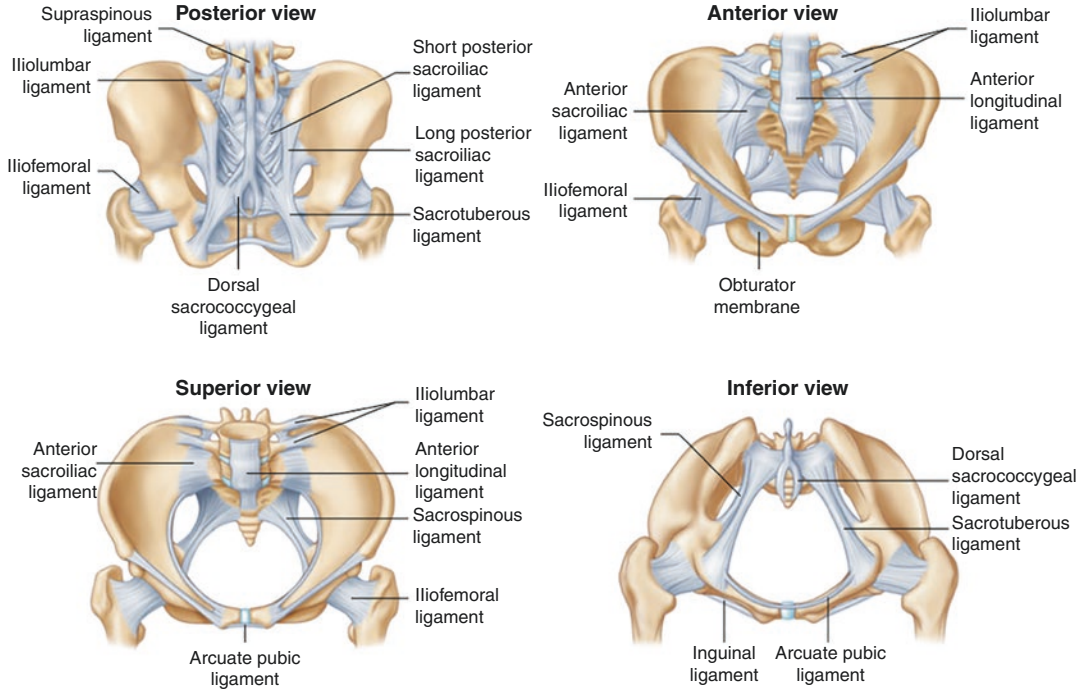

Fig. 39.2 Ligaments of the bony pelvis (adapted from Firoozi F. Female Pelvic Surgery. Springer Science + Business Media. New York. 2015. Fig. 1.6)

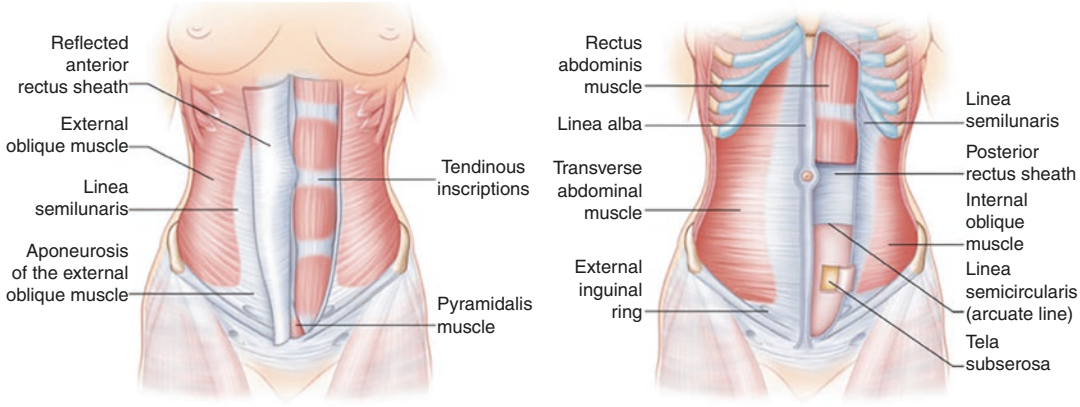

Fig. 39.3 Trunk muscles that attach to the bony pelvis (adapted from Firoozi F. Female Pelvic Surgery. Springer Science + Business Media. New York. 2015. Fig. 1.4)

vessels, and neve plexus that supply blood and innervation to the lower extremities. It also connects the trunk to the lower extremities. Therefore, it has to support important forces and weight.

The main arterial supply of the bony pelvis and ligaments is the internal iliac artery. The superior gluteal and the iliolumbar arteries also supply blood to the ilium. The external iliac artery runs anterior to the iliopubic ramus and supplies blood to the legs via the femoral artery. One of its branches, the obturator branch, also supplies blood to the pubic symphysis. A number of anatomical variations have been described for this branch (Fig. 39.5). The dense arterial and venous vessel distribution is show on Fig. 39.6. Before delivery, blood flows increase by 40% to

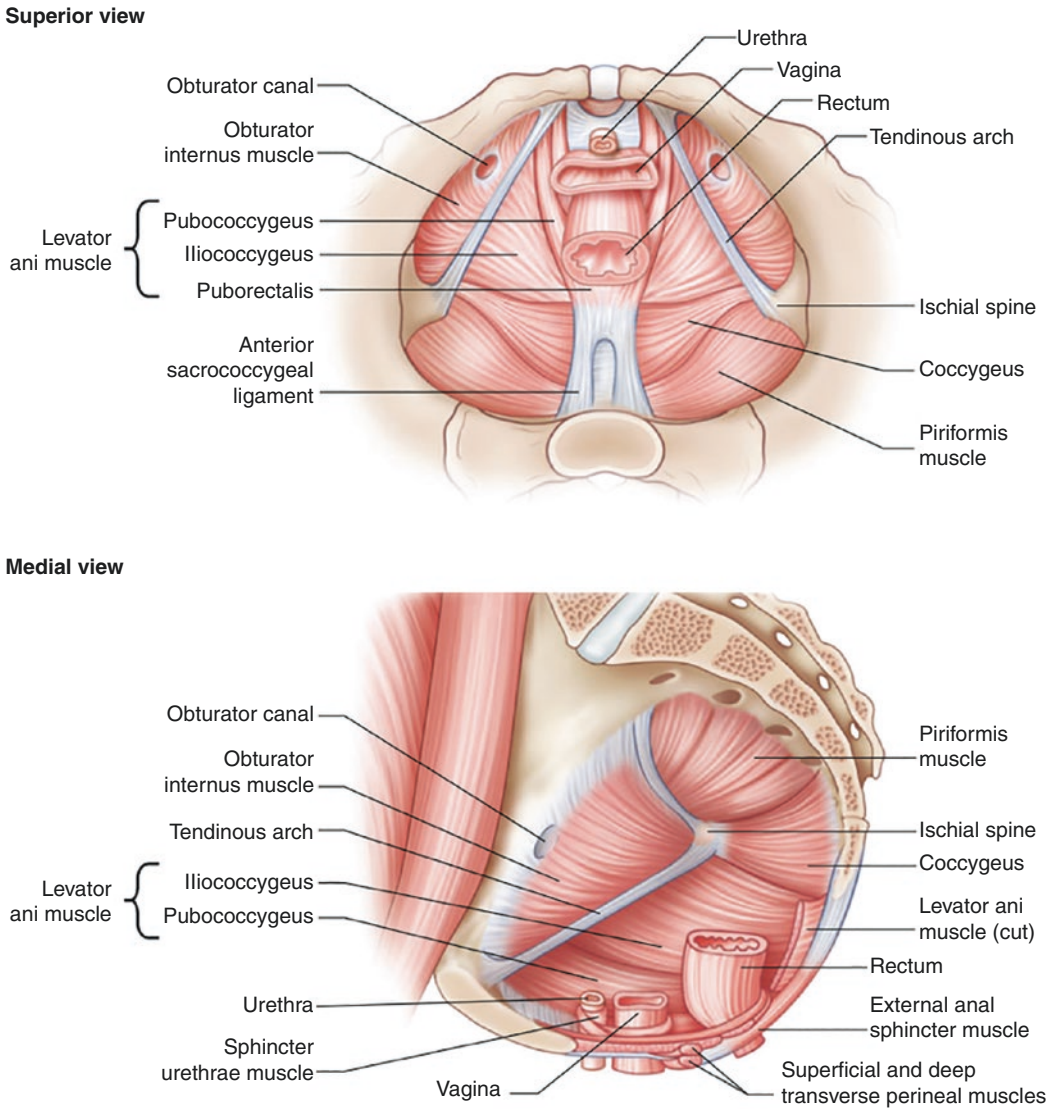

Fig. 39.4 Muscles forming the pelvic floor (adapted from Firoozi F. Female Pelvic Surgery. Springer Science + Business Media. New York. 2015. Fig. 1.8)

ensure extra oxygen for the fetus during delivery. Moreover, there are vaginal-uterine anastomoses that function as a "portal system" taking blood from the vagina to the uterus from venous plexuses toward arteries as a countercurrent transport. This leaks substances from veins to arteries. This means there are two systems bringing in oxygen during delivery. This means that small tears or damages in the tissues or vessels if a pelvic diastasis occurs can result in major blood loss and hemodynamic instability.

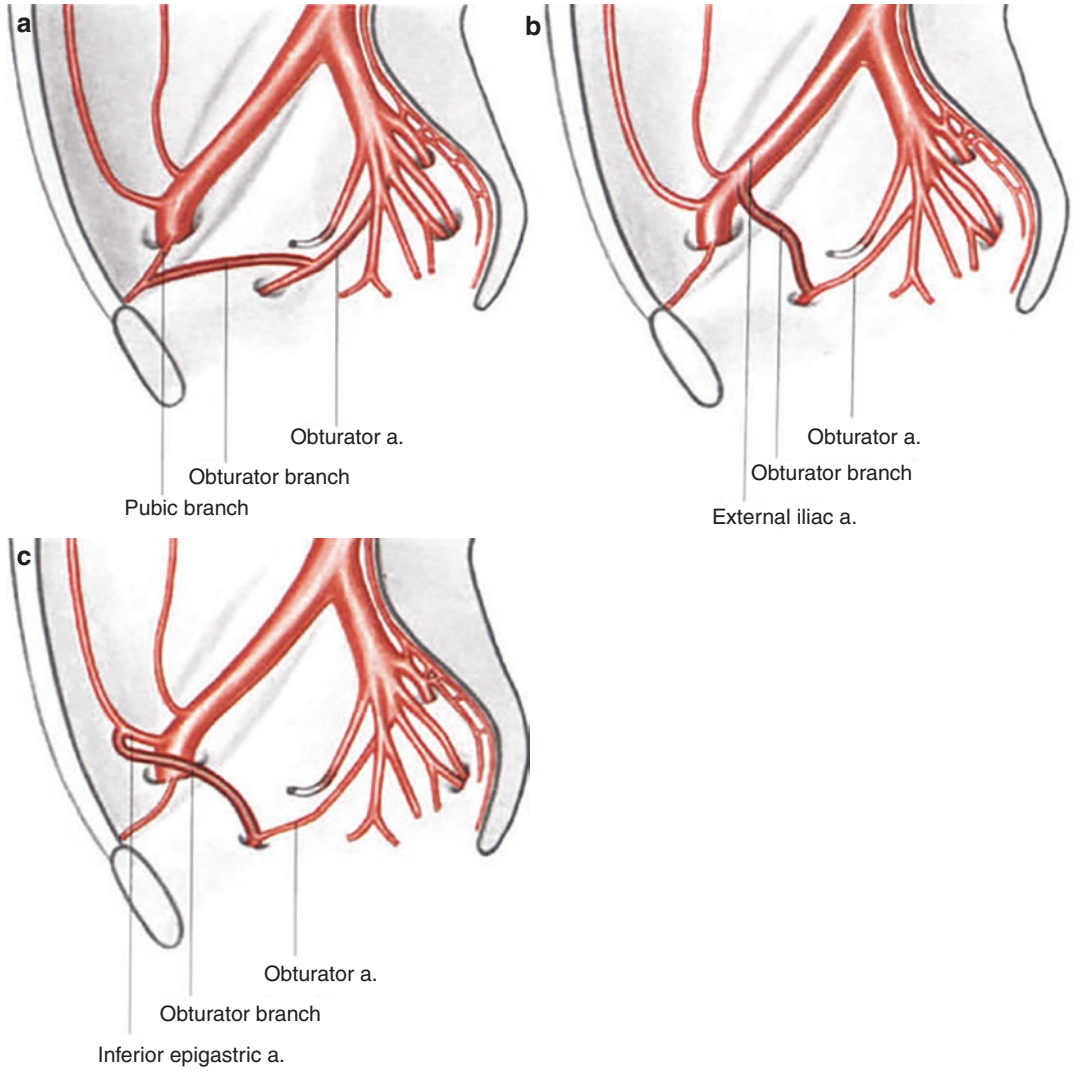

Fig. 39.5 Variations of the obturator branch. Origin of obturator branch from obturator a. and pubic branch (**a**). Origin of obturator branch from obturator a. and external iliac a. (**b**). Origin of obturator branch from obturator a. and inferior epigastric a. (**c**) (adapted from Lierse W. Applied Anatomy of the Pelvis. Springer Berlin Heidelberg; 1987)

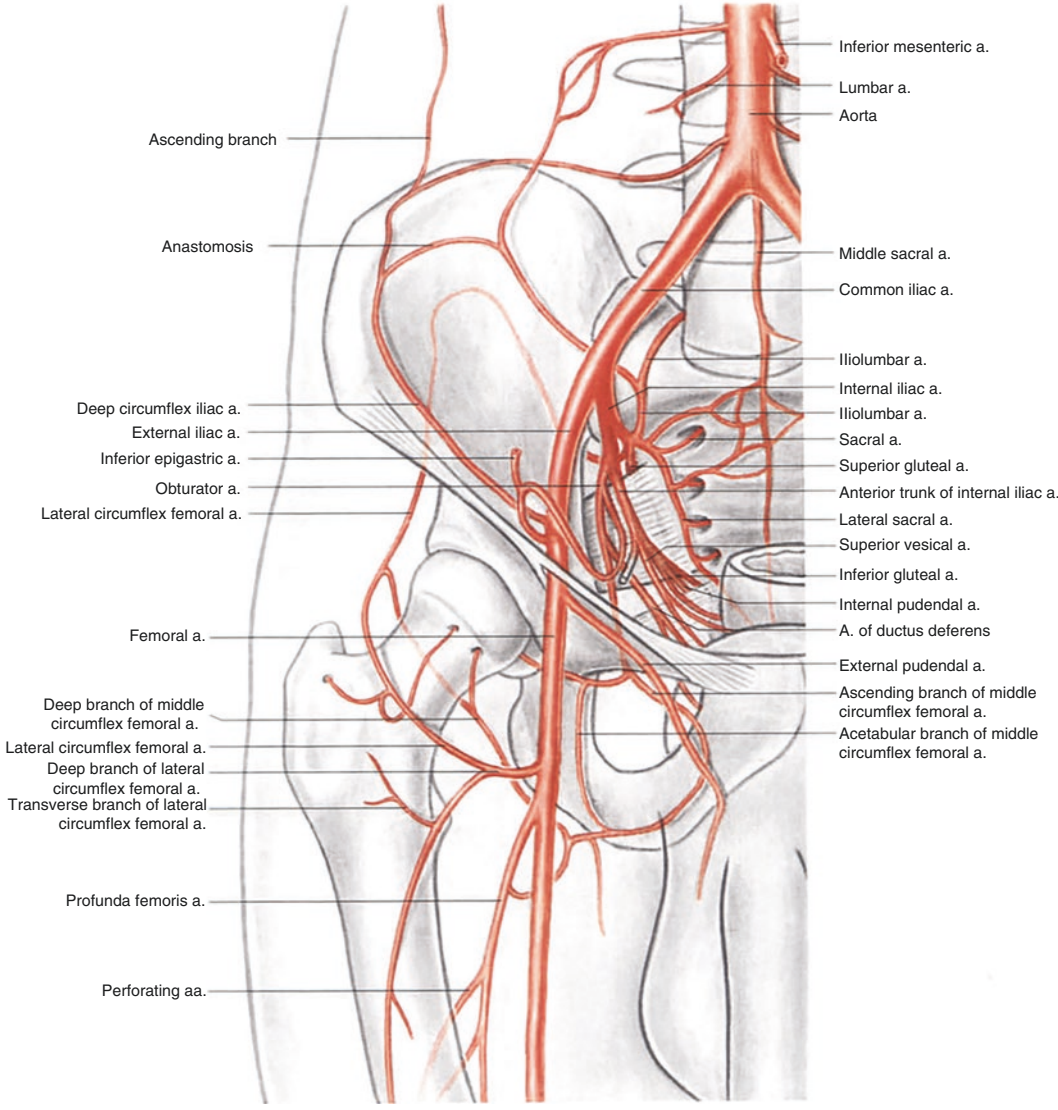

Fig. 39.6 Pelvic arterial (left) and venous (right) blood vessels (adapted from Lierse W. Applied Anatomy of the Pelvis. Springer Berlin Heidelberg; 1987.) (Figure 35 p. 49 and Fig. 38. P 53)

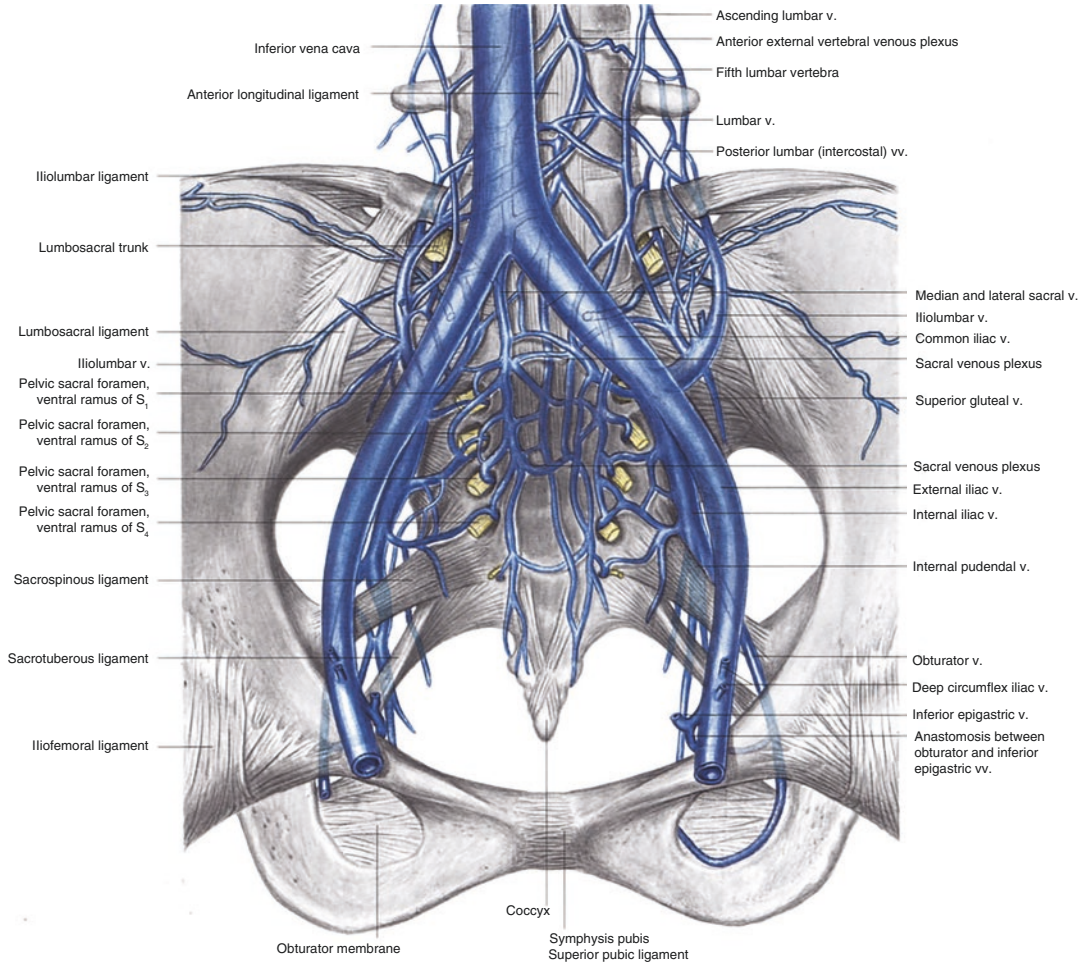

Fig. 39.6 (continued)

39.3 Pathophysiology

The increase in progesterone and relaxin levels cause a physiological ligament relaxation. This ligament relaxation can cause asymptomatic symphyseal pubic diastasis of up to 7 mm, which results in birth canal widening and is therefore physiological to facilitate vaginal delivery [5, 8–10]. Joint laxity increases during pregnancy starting surround the tenth gestational week and can last until 4–12 weeks postpartum. Therefore, symphyseal pelvic injury is not exclusively a delivery injury; it can also occur during the pregnancy [8]. Usually, there is normalization of the hormonal levels after delivery. A rapid and forceful increase in intrapelvic pressure due to fetal head descent combined with the increase laxity can cause spontaneous ligament rupture and symphysis diastasis [1, 2, 11–18].

39.4 Diagnosis

The clinical diagnosis of pubic symphysis rupture has been made antepartum, intrapartum, and even 48 h after delivery when typical symptoms appear.

39.4.1 Clinical Course

The mean time of onset of symptoms of some kind of symphyseal pubic dysfunction ranges from 14 to 26 weeks in the literature [8, 19, 20]. The most common symptom is pain in the symphyseal region that radiates to the lower back and thighs and is exacerbated by leg movement [3, 5, 21–23]. Sometimes a sudden "POP" can be heard during delivery by the patient and even the physicians [4, 24]. The diastasis can be evident on palpation of the pelvic symphysis, and vaginal examination can show a palpable gap and be associated with vaginal tears [21]. Some patients are unable to sit, stand or change decubitus, and develop waddling gait. Typical signs include the Trendelenburg sign [23]; Destot sign (hematoma in the labia majora), which indicates pelvic ligament injury and pelvic floor disruption [24, 25] (Fig. 39.7); and Patrick's Fabere sign (Fig. 39.8). Iliac crest compression and distraction maneuvers can denote instability and be painful, and an active straight leg raise test can cause anterior pain (Fig. 39.9) [3, 5, 22, 23, 26]. In severe disruptions, hemodynamic instability can be present due to pelvic venous plexus injury [24]. Spinal and epidural anesthesia can temporarily mask the symptoms during labor [5, 27].

Main symptoms	
• Pain at the symphyseal region • Inability to sit or change decubitus • Waddling gait • Trendelenburg sign	• "Pop" during childbirth Destot sign • Palpable gap on palpation • Pain on iliac crest compression and distraction • Hemodynamic instability

Key Points

The severity of the symptoms does not correlate with extent of symphyseal widening.

39.4.2 Differential Diagnosis

The differential diagnosis for anterior pelvic pain that can occur during symphyseal pubic disfunction includes nerve irritation due to an intervertebral disc hernia, pubic osteolysis and osteitis, osteomyelitis, tuberculosis, syphilis, urinary tract

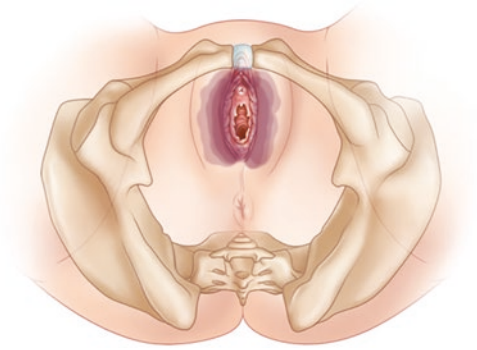

Fig. 39.7 Destot sign (hematoma in the labia majora): indicating pelvic ligament injury and pelvic floor disruption

Fig. 39.8 Patrick's Fabere sign: The tested leg should be placed flexed and the thigh abducted and externally rotated. It is considered positive for hip or pubic symphyses disorder when pain is elicited on the ipsilateral side. It is considered positive for contralateral sacroiliac joint disorder when pain is elicited on the contralateral side posteriorly around the sacroiliac joint

Fig. 39.9 Active straight leg raise test

infection, pelvic inflammatory pain, round ligament lesion, femoral vein thrombosis, and obstetric complications [7, 8].

39.4.3 Risk Factors

Risk factors for symphyseal diastasis during pregnancy include maternal medical history details such as joint laxity, connective tissue disorders that can affect ligament laxity [6, 8, 28]. Maternal hip dysplasia, osteomalacia, chondromalacia, rickets, and tuberculosis have also been related to pubic diastasis [6, 21, 28]. Some authors report that patients with a history of prior pelvic trauma or a history of active athletic pursuit have an increased risk of pelvic diastasis during pregnancy [3, 7, 29, 30]. Other authors report pelvic pain in previous pregnancies, early menarche, lack of regular exercise, paid employment, and breastfeeding as possible mother related risk factors [8]. However, there is not a clear consensus on the statistical significance of these risk factors in the literation. Primiparity and multiparity are the two most accepted risk factors across the literature: the first one may be due to the rigidity of the birth canal that causes increase intrapelvic pressure [4, 6], and the later because it is said that these patients suffer progressive weaken the pubic symphysis with each delivery [4, 7, 8, 28–35]. The literature is also in agreement that increase force on the pelvic rig due to increase uterine contractions and rapid second stage labor are common risk factors [4, 7, 14, 22, 27, 29, 30, 32, 33, 36–46],and McRoberts maneuver has been described in a number of case reports of pelvic diastasis [3, 25, 35]. Other risk factors considered by some authors include twin gestation, macrosomia, cephalopelvic disproportion, neonatal hip dysplasia, forceps delivery, precipitous labor or long-lasting labor, malpresentation, or post-term delivery [3, 8, 28, 30, 31, 33, 35].

Risk factors for pubic symphysis diastasis (in bold the "evidence-based risk factors")

Maternal medical history	Pregnancy characteristics	Birth characteristics
• **Primiparity** • **Multiparity** • Joint laxity • History of active and athletic pursuit • Prior pelvic trauma • Connective tissue disorders • Osteomalacia • Chondromalacia rickets • Tuberculosis	• Twin gestation • Macrosomia • Cephalopelvic disproportion	• Precipitous labor or long-lasting labor • Malpresentation • McRoberts maneuver • **Rapid decent of the fetal head** • **Rapid second stage labor**

Key Points
Both primiparity and multiparity are risk factors for pelvic symphyseal diastasis.

39.4.4 Imaging

A pelvic radiograph should be performed to assess the pelvic ring integrity and symphyseal widening [3–5, 7, 8, 23, 47]. A 4–5 mm gap of the pubis symphysis is normal in adults [47]. In pregnant woman, a gap of up to 9 mm is considered normal due to the ligament relaxation and widening during childbirth [8, 47]. Therefore, a widening of greater than 10 mm is considered pathologic and seems to correlate with anterior pain (Fig. 39.10) [4, 5]. However, the extent of symphyseal widening does not correlate with the degree of pain [5, 8, 35, 47].

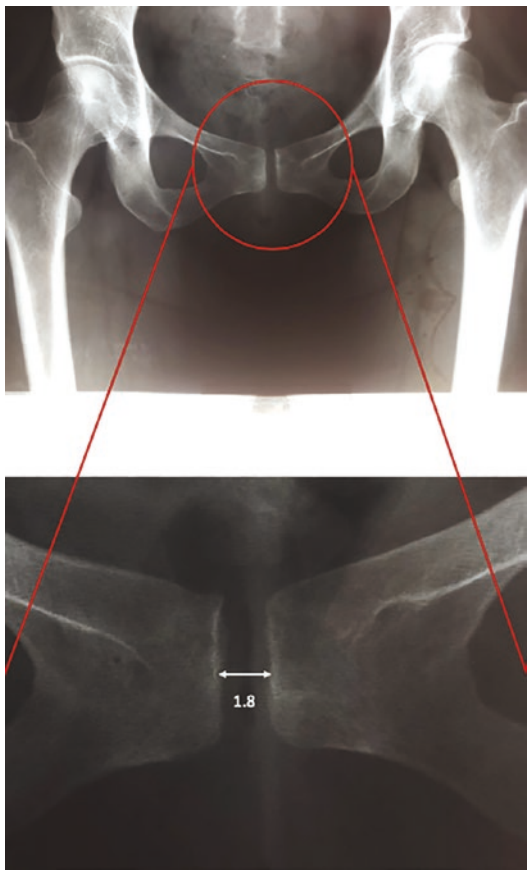

Fig. 39.10 Symphyseal widening of 18 mm in a woman that developed anterior pelvic pain during the third trimester. Vaginal delivery was possible. Anterior pubic pain was completely resolved by the sixth week after delivery

Ultrasound imaging may help confirm the diagnosis [3, 21, 23, 48]. A 7.5 MHz linear array probe has to be used [48]. Sevelato et al. suggest it is better than x-ray imaging because there is no ionizing radiation, it is easy to perform, it is reproducible and without side effect, and it is at least as accurate as x-ray imaging. They suggest scanning the upper margin of the symphyseal joint by placing the probe in a transverse plane to the pubic symphysis and with 30° caudal tilt [49].

Magnetic resonance imaging seems to be superior than radiographs or computer tomography in assessing the pelvic ring injury and associated soft tissue damages and has the advantage that it lacks ionizing radiation and can assess the injury in multiple planes [5, 8, 24]. Kurzel et al. concluded that MRI showed a bigger pubic gap than x-ray imaging [39]. Wurginger et al. found that small signal changes in the pubic cartilage could be found in asymptomatic patients [41].

The measurement of the pubic gap is useful for the diagnosis but does not correlate with the final outcome [48].

39.4.5 Classification [5]

From an orthopedic point of view, a pubic diastasis is considered a pelvic fracture, which are classified as:

- *Tile type A*: The pelvic ring is stable despite the fracture.
- *Tile type B*: The pelvic ring is partially stable. They result from external and internal rotation forces that lead to “open book” and “bucket handle” fractures.
- *Tile type C*: The pelvic ring is unstable due to its complete disruption. They result from high energy trauma.

From an obstetric point of view, pubic diastasis is usually classified as anteroposterior compression (APC) injuries in:

- APC I: when there is less than 2.5 cm separation

- APC II: when there is more than 2.5 cm separation but the anterior sacroiliac ligaments are intact
- APC III: when there is a total symphyseal and sacroiliac disruption

Pubic diastasis during pregnancy and birth are usually considered Tile type B or open book injuries APC-II, which are partially stable (Figs. 39.11 and 39.12) [5, 9, 40, 50]. This type of pelvic disruption is usually rotationally unstable due to the disruption of the anterior ligaments and vertically stable due to the integrity of the posterior ligaments. However, this classification was made thinking of high energy traumatic injuries. The difference between these high energy traumatic injuries and postpartum pubic symphysis diastasis is that the first one results from force applied anteriorly to the pubic symphysis, and the second results from force applied from a point posterior to the pubic symphysis [33].

Despite Tile type B APC-II being the most common pelvic disruption during pregnancy, APC III or Tile type C have been reported [16].

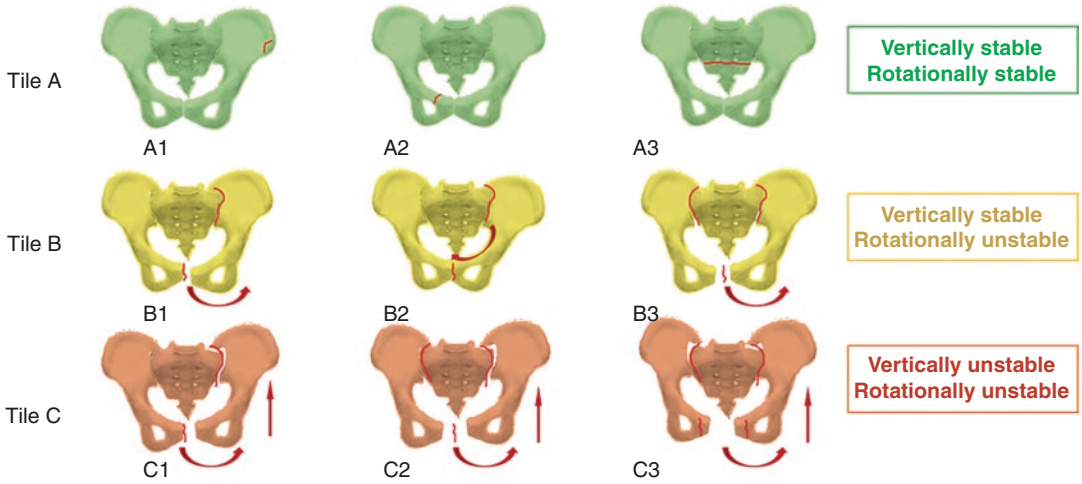

Fig. 39.11 Tile pelvic fracture classification

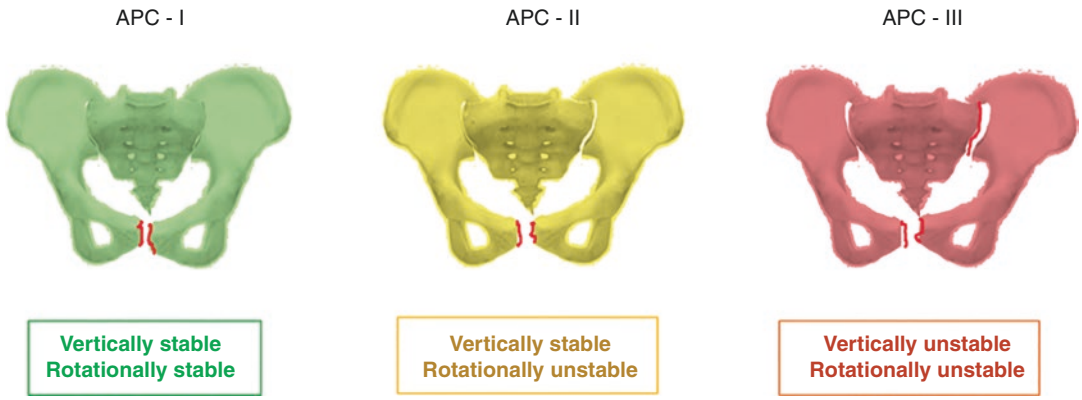

Fig. 39.12 Types of anteroposterior compression (APC) injuries

39.5 Treatment

39.5.1 Conservative Treatment

Conservative treatment is the first treatment choice in mild cases, with a 4 cm or less widening. The majority of cases resolve once hormonal levels are normalized, after delivery, and clinical and functional outcomes are satisfactory without surgery [4, 7, 8, 23, 26, 31, 51]. Meanwhile, bed rest, pelvis sling or binder, and intravenous or oral analgesia can be prescribed to manage the pain.

- ***Bed rest*** preferably in a lateral decubitus position is recommended. However, care should be taken that complications are not developed. These complications include muscle atrophy and joint stiffness, thromboembolism, pneumonia, urinary infections, and decubitus ulcers.
- ***Pelvic binders*** should be placed bellow the anterior iliac spines and compressing the mayor trochanter (Fig. 39.15). This can be used for short periods of time [24, 43]. The use of belts has been reported less effective during pregnancy than after childbirth [52].
- ***Crutches or walking frame*** is advisable for ambulation [8, 53].
- ***Analgesia*** includes oral and intravenous anti-inflammatory drugs (NSAIDs) and narcotics, if necessary, given according to the regular analgesic ladder. Moreover, symphyseal corticoid, chymotrypsin, and lidocaine injections can be given [24, 27]. Special consideration must be given to the fact that NSAIDs have significant teratogenic effects and are, therefore, not recommended during pregnancy.
- ***Spinal anesthesia*** with 1 mL, 0.5% bupivacaine, and 12.5 μg fentanyl can be used when inadequate pain relief is reported after well-functioning epidural anesthetic. Continuous infusion of 0.2% ropivacaine and 2 μg/mL fentanyl at 3–4 mL/h and be helpful in maintaining pain control. Chamchad et al. consider spinal anesthesia can have better pain control effects than well-functioning epidural anesthetics, because intrathecal anesthetic allows better access to the somatic fibers originating in the sacral plexus (S1–4) [54].
- ***Prophylactic low-molecular-weight heparin for thromboprophylaxis*** is suggested to avoid thromboembolic complications due to immobilization [7, 25].
- ***Physiotherapy sessions*** with massages and stretching exercise and muscle toning. Ultrasound, cryotherapy, and electrostimulation therapy can also be used to ease pain. Pregnancy causes and excessive lengthening of the abdominal and pelvic floor muscles, thereby reducing their contractility affecting both strength and temporal regulation during daily activities. The aim of the physiotherapy is to strengthen abdominal muscles and improve stabilization and normalization of the function of deep core muscles and improvement of functional mobility and providing a self-bracing effect to the pelvic ring [7, 19, 34, 55, 56].
- ***Acupuncture*** has even been reported as an alternative to reduce symphyseal discomfort and low back pain [23, 57].
- ***Avoiding*** weight bearing activities, activities that require hip abduction and standing on one leg [58].

Most patients achieve full recovery by 6–8 weeks, but some may have persistent pain for 6–8 months [7, 21, 59, 60]. The conservative treatment can be associated, in some cases, with persistent residual pain and perceptual instability at the symphysis, which can be very frustrating for the mother because she can't take care of the newborn [4, 9, 30, 36, 44]. Long-term outcome is generally excellent (Figs. 39.13 and 39.14).

Sometimes, residual sacroiliac pain can also be presented. Kharrazi reported SI pain when the pubic diastasis was greater than 60mm [14]. Major pubic symphysis separation (>25 mm for some authors and >40 mm for others) causes progressive injury to the posterior pelvic ring. This includes damage to the SI joint, sacral fractures, and injuries to the lumbosacral plexus [14]. This is why when the gap is greater than 40 mm symphyseal and sacroiliac examination is recommended along with anterior plate fixation.

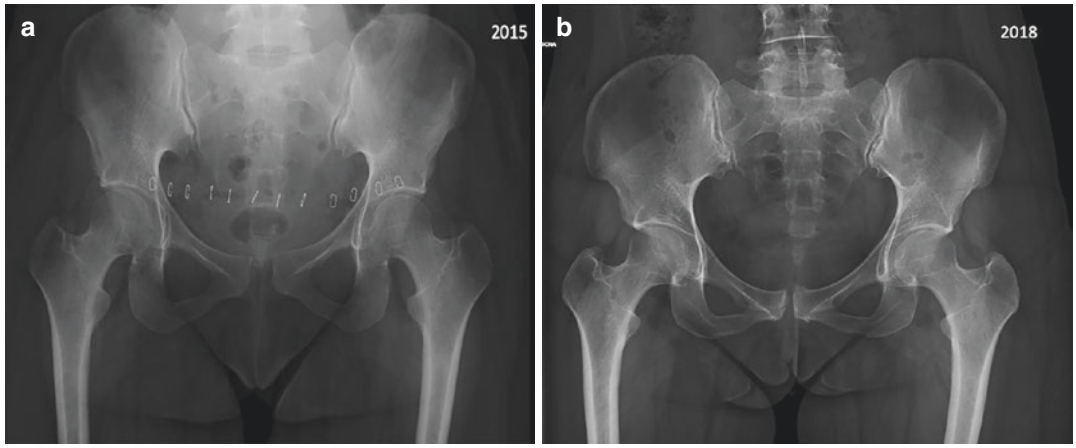

Fig. 39.13 X-ray images of spontaneous resolution of pubic diastasis. (**a**) Pelvic diastasis developed during childbirth in 21-year-old women. (**b**) 2 years later x-ray imaging shows spontaneous resolution of pubic diastasis

However, a number of authors have reported good results of conservative treatment for diastasis of more than 40 mm [6, 25, 26, 61].

A case has been presented in the literature of a patient with a 21 mm pubic gap confirmed on radiograph and ultrasound following vaginal delivery, showing developed chronic neuropathic pain and disability. After 3 months of conservative management and later surgical treatment with anterior plate fixation of the symphysis pubis, the patient still suffered severe burning pain, allodynia at the pubic symphysis joint, and hyperesthesia around pubic symphysis. She was successfully treated with a spinal cord stimulator with dual electrode leads was inserted at T10 level, resolving pain and improving quality of life [62]. The good response with the stimulator at T10 levels suggests that the pain may come from the main branches of the pudendal nerve.

39.5.2 Surgical Treatment

The four Hagen instability criteria that are an indication for internal fixation are public diastasis of more than 1 cm, vertical shift of more than 5 mm, widening of SI joint, and para-articular sclerosis of the SI joint [14]. Most authors recommend surgical treatment in severe cases with a widening greater than 40 mm; however, some authors recommended surgical fixation when the diastasis is greater than 25 mm and in cases of simultaneous soft tissue injury or failed conservative treatment [5, 42, 63]. Moreover, if there is no hemodynamic instability, there is no clear consensus as to the specific period of time to perform the surgical procedure. Given that in most cases this condition resolves with conservative treatment, most authors agree in waiting 2–3 months after childbirth to consider surgical treatment, if the patient is hemodynamically stable and the pain is manageable.

Hagen instability criteria
• Public diastasis >1 cm
• Vertical shift >5 mm
• Widening of SI joint
• Para-articular sclerosis of the SI joint

Surgery consists of open reduction, and plate fixation to restore the pelvic ring should be considered along with early functional rehabilitation [11, 13, 14]. Delaying the surgery can cause chronic instability, which may result in residual chronic pain [9].

Open reduction and fixation are usually performed via a Phannenstiel skin incision 3 cm above the pubic symphysis and a midline longitudinal rectus splitting anterior approach. Careful soft tissue dissection is completed until you reach the bone. Reduction with bone forceps is performed. Fixation can be done with a small single superior [64, 65] or anterior plate

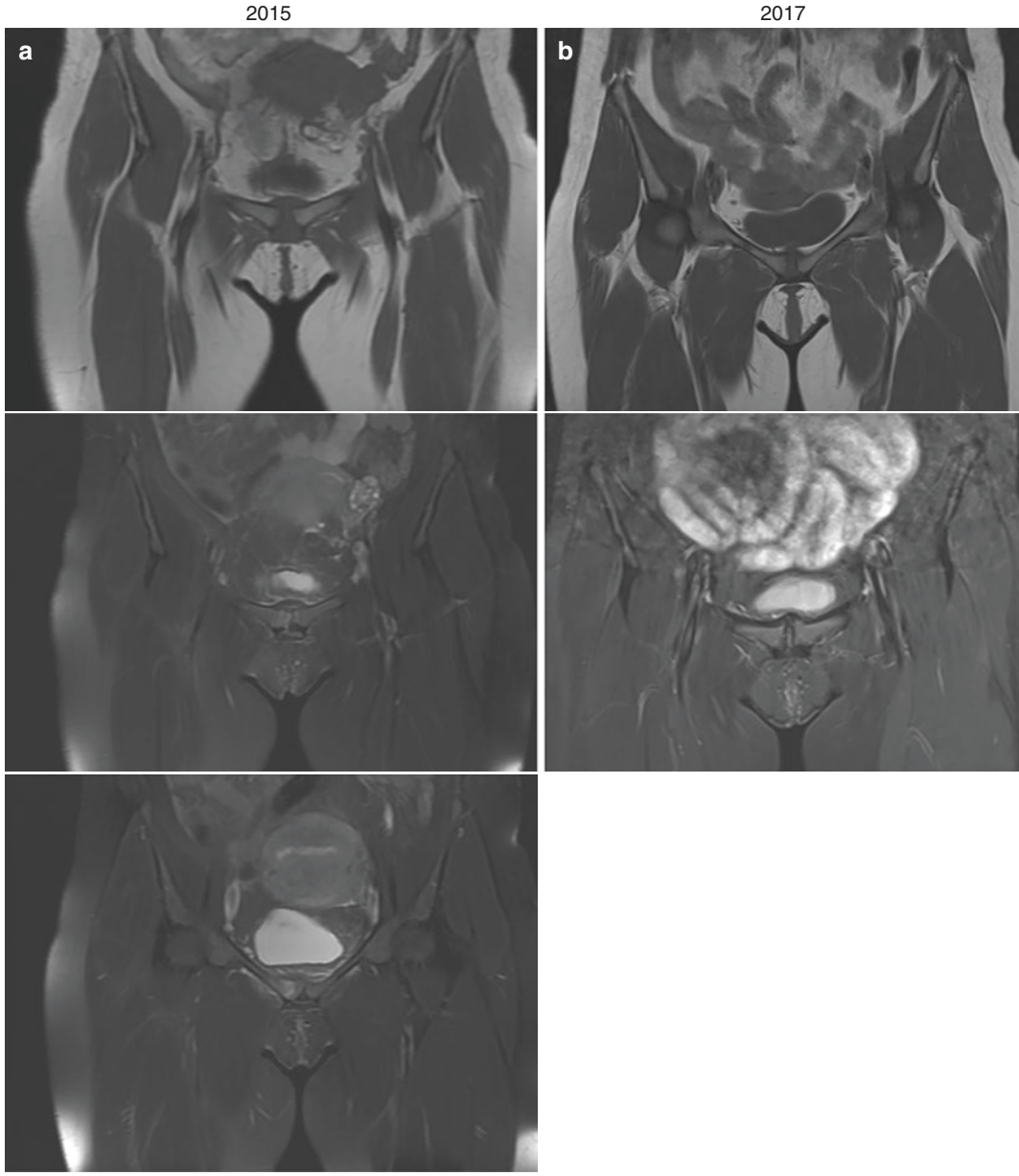

Fig. 39.14 RM images of spontaneous resolution of pubic diastasis. (**a**) Pelvic diastasis developed during childbirth in 21-year-old women. The MRI shows bone edema and widening of the pubic symphysis. (**b**) Two years later x-ray imaging shows spontaneous resolution of the bone edema and of pubic diastasis, which has a restored width

[23, 37]. However, some authors consider anterior and superior orthogonal plates when there is a severe instability or in obese patients. If there were to be a sacroiliac joint disruption, a percutaneous sacroiliac screw can be placed to reduce and stabilize this joint. After the surgery, a rehabilitation protocol is then started, allowing bed-to-chair and chair-to-bed transfers, with no ambulation allowed for 2 weeks [33]. Most authors forbid ambulation during the first

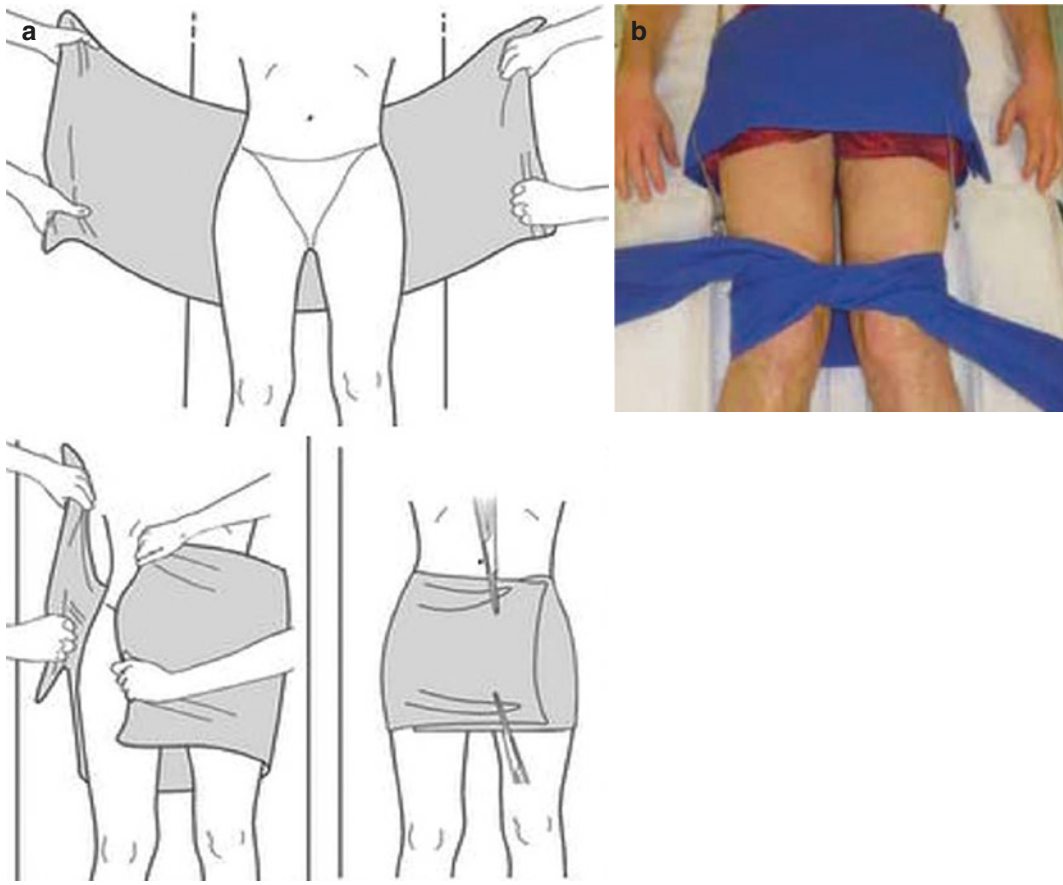

Fig. 39.15 Sheet compression at the greater trochanter. (**a**) Drawing of application of pelvic sheet. (**b**) Application of a pelvic sheet in the emergency room. (Adapted from Rommens PM, Hofmann. Fragility Fractures of the Pelvis. Springer. 2017. Switzerland. p. 15. Fig. 2.6)

4 weeks after surgery [6]. However, some allow walking on crutches for the first 6 months [16, 23]. Most patients notice significant pain release by the 12th month [16].

In subacute or chronic cases, symphysis fusion with autologous iliac bone graft and anterior plate fixation is recommended by some authors [9].

Surgery may shorten the hospitalization stay and allow for earlier ambulation. This must also be taken into because it decreases the risks of complications due to bed rest and allows the mother to cope with her new responsibilities earlier, decreasing stress [30, 44]. However, it is a major surgery that carries a risk of bleeding, damage to surrounding structures, and reaction to anesthesia and should therefore be avoided if possible [7].

Severe hemodynamic instability caused by pelvic venous injury is an indication for surgery [16]. It can be managed acutely with a pelvic binder or sheet compression at the greater trochanter (Fig. 39.15). Sheet compression over the iliac crests is insufficient to manage posterior ring injuries and provides inadequate hemostasis. A binder must remain until external fixation can be performed. Removal of the binder before surgery can lead to hemostatic instability due to bleeding when the pelvic ring reopens.

External fixation is rarely used in peripartum pubic diastasis. It is only considered temporarily in cases with severe hemodynamic instability when open reduction and fixation can't be performed, because it causes discomfort, loss of reduction, and pin-track infection [66]. One of the

reasons for choosing definitive external fixation over internal fixation can be the significant reproductive organ damage, because the vaginal field and surrounding tissues can be contaminated due to visceral rupture and can therefore increase the risk of soft tissue infection or osteomyelitis [30, 33]. One of the downfalls is that patients can develop partial loss of reduction, but the frame can be retightened [33]. If using definitive externa fixation, the frame has to be worn for 6–8 weeks.

Hardware removal is a controversial topic. Some surgeons consider it 1 year after the initial surgery if there are concerns about subsequent pregnancies [16, 17] and other discourage routinely hardware removal due to surgical and anesthetic risks.

39.6 Delivery

When symphyseal diastasis is detected before deliver, early deliver and cesarean section have been said to be helpful in reducing the pain, but vaginal delivery is not contraindicated [23, 34]. During labor, simple measures are needed to be taken to avoid further damage by:

- Keeping separation of legs to a minimum
- Discouraging excessive forced hip abduction and strain on pubis

Instrumental delivery can be possible in a lateral decubitus position to provide optimum comfort without compromising the delivery [8]. Care should be taken when the patient is under epidural or spina anesthesia because like mentioned before it can temporarily mask the symptoms during labor.

▶ **Important** Vaginal delivery is not contraindicated if symphyseal diastasis is detected before delivery.

39.7 Prognosis and Subsequent Deliveries

Separation of symphysis pubis has been associated to complications such as arthritis osteitis pubis, uterus and vaginal laceration or rupture, complete disruption of the external anal sphincter, severe hemorrhage, urethral injuries and infections, nonunion, or recurrence [18, 25, 28, 33, 67, 68]. If the diastasis is greater than 2 cm, the pelvic floor support is affected, and as a result, urinary incontinence can develop when the intraabdominal pressure increases [66].

Recurrence of some kind of symphyseal pubis dysfunction has been reported in 41–72% of the cases, with symptoms being less severe in 15%, similar in 15%, and more sever in 79% than the previous pregnancy [69, 70].

Some authors have reported that symphyseal pubis dysfunction can be prevented with regular exercise to increase pelvis stability [19, 69]. Measures against some occupational exposures have also been suggested by some authors [8].

In general, well-resolved symphyseal rupture is not considered an indications for cesarean section in subsequent deliveries [7, 16, 27, 36, 37]. However, most authors consider it is reasonable to offer cesarean section to the patient due to the paucity of knowledge regarding the risk factors involved [36–38, 43]. Internal fixation has been considered by some authors a reason to recommend cesarean section, but vaginal delivery is possible [24]. A previous treatment with pubic symphysis fusion is the only accepted recommendation for cesarean delivery [9].

39.8 Conclusion

Pubic symphysis diastasis is a rare injury during pregnancy or childbirth.However, physician should be aware of it, because it can cause both severe acute problems and chronic disability.

Pubic symphysis diastasis must be suspected anterior pelvic pain, and palpable pubic gap presents associated with a “pop” during childbirth, followed by inability to sit or change decubitus, waddling gait, Trendelenburg sign, Patrick’s Fabere sign, Destot sign, or hemodynamic instability (Table 39.1).

When a patient presents with pubic symphysis diastasis symptoms, the diagnostic technique of choice ranges from pelvic radiograph, ultrasound, and MRI. If the mother has not given birth, a nonionizing radiation technique should

Table 39.1 Summary of the articles published (systematic review; SC: series of cases; CR: case report) with their recommended diagnostic techniques and treatment suggestions

Literature review of the past 20 years on pubic diastasis during pregnancy or childbirth: diagnosis and treatment			
Author (year)	Type of article	Diagnosis	Treatment
Aslan (2007)	SR	• Clinical symptoms • MRI to evaluate adjacent tissues • X-ray >10 mm diastasis (not considered of choice due to radiation)	• Focuses on the conservative treatment
Bombaci (2017)	CR	Reports a case with >20 mm diastasis on X-ray	• Open reduction and fixation were performed after conservative treatment failure
Buitendyk (2018)	CR	Reports a case with >60 mm diastasis on X-ray	• Open reduction and fixation were performed after conservative treatment failure
Chang (2009)	CR	Reports a case with >77.5 mm diastasis on X-ray hemodynamically unstable	• Focuses on the surgical treatment with externa fixator due to severe pelvic organ damage
Chawla (2017)	CR	Reports 2 cases with a 15 mm diastasis on X-ray hemodynamically unstable	• Focuses on the conservative treatment • Surgical correction should be offered if the diastasis is more than 3 cm wide
Cowling (2010)	CR	Reports a case with 54 mm diastasis on X-ray following McRoberts' maneuver	• Focuses on conservative treatment
Dunivan (2009)	CR	Reports a case with 62 mm diastasis on X-ray following McRoberts' maneuver	• Focusses on surgical treatment with external fixation and concomitant repair of 7 cm anterolateral vaginal laceration
Fidan (2013)	CR	Reports a case with 5 mm diastasis on X-ray following McRoberts' maneuver	• Focuses on the conservative treatment
Gharoro (2001)	CR	Reports a case with 18 mm diastasis and posterior fracture dislocation of the left femur on X-ray following extreme thigh abduction and fundal pressure	• Surgical treatment of the femur luxation • Conservative treatment of the pelvic diastasis
Gillaux (2010)	CS	Reports 10 cases with >10 mm diastasis on X-ray	• Focuses on the conservative treatment • Presents early cesarean section to release pressure and pain
Herren (2015)	SR	• Clinical symptoms • Pelvic X-ray inlet, outlet, and Ap views • Ultrasound • MRI to evaluate adjacent tissues	• Focuses on the conservative treatment • Surgical treatment with anterior plate fixation: persistent pain, inadequate reduction, nonunion
Hierholzer (2007)	CR	Reports a case with 90 mm diastasis on CT	Focuses on the surgical treatment, performing temporary external fixation and definitive internal fixation
Idrees (2012)	CR	Reports a case with 21 mm diastasis on X-ray	Unresolved pain with both conservative and surgical treatment Had to treated with spinal cord stimulator for pain control
Joosoph (2007)	CR	Reports a case with 45 mm diastasis on X-ray	Focuses on conservative treatment
Laadioui (2014)	CR	Reports a case with 15 mm diastasis on X-ray	Focuses on conservative treatment
Lasbleiz (2017)	CR	Reports a case with 41 mm diastasis on X-ray	Focuses on conservative treatment

(continued)

Table 39.1 (continued)

Literature review of the past 20 years on pubic diastasis during pregnancy or childbirth: diagnosis and treatment			
Author (year)	Type of article	Diagnosis	Treatment
Moral (2004)	CR	Reports two cases with 20 and 30 mm diastasis on ultrasound	Focuses on conservative treatment
Omololu (2001)	CS	Three case diagnosed with 30 mm and 20 mm diastasis on X-ray	Focuses on conservative treatment
Parker (2009)	CR	Reports a case with 23 mm diastasis on X-ray	Focuses on conservative treatment
Pathak (2015)	CR	Reports a case with 43 mm diastasis on CT	• Focuses on conservative treatment • Surgical treatment in extensive anterior pubic symphysis separation, pelvic vertical instability, pelvic dislocation
Pires (2016)	CR	Reports a case with 80 mm diastasis on X-ray	Focuses on conservative treatment
Saeed (2015)	CR	Reports a case with 25 mm diastasis on X-ray	Focuses on conservative treatment
Scriven (1995)	CS	Reports nine cases with a mean 20 mm diastasis on ultrasound	Focuses on conservative treatment
Seth (2003)	CR	Reports a case with >70–80 mm diastasis on X-ray	• Conservative treatment: <40 mm diastasis • Open reduction and fixation or externa fixation: severe diastasis, inadequate reduction with pelvic binder, mal union, nonunion or persistent symptoms
Shim (2012)	CR	Reports a case with 22 mm diastasis on X-ray	Focuses on conservative treatment
Shippey (2013)	CR	Reports a case with 46 mm diastasis on x-ray	Treated conservatively initially and required surgical treatment due to pain and instability. Definitive 1 stage surgery was performed to address both the pelvic diastasis and a stress urinary incontinence postpartum complication
Shnaekel (2015)	SR	• Clinical symptoms • X-ray: >10 mm diastasis • MRI to evaluate adjacent tissues	• Conservative treatment: <40 mm diastasis • Open reduction and fixation: 25–40 mm gap, soft tissue damage, failed conservative treatment • External fixation: temporary
Svelato (2014)	CR	Reports a case with 15.2-mm diastasis on ultrasound	• Conservative treatment: <40 mm diastasis
Yoo (2014)	SR	11 cases diagnosed with >10 mm diastasis on X-ray	• Conservative treatment in eight patients with <40 mm diastasis. And 1 patient with >40 mm diastasis • Open reduction and fixation in 2 patients with >40 mm diastasis due to failed conservative treatment

be chosen. A separation of more than 10 mm in any of the test is considered diagnostic for pelvic diastasis.

Pelvic symphysis dehiscence in pregnant women is usually considered Tile type B or open book injuries and is therefore partially stable.

Most cases are mild, with a 4 cm or less widening, and can be treated conservatively. Making pain control with NSAIDs, physiotherapy, and the use of pelvic binders and crutches is the key to spontaneous resolution of the injury. However, surgical treatment with external fixation should be considered when presented with hemodynamic instability (as a temporary treatment) or severe pelvic organ disruption (as a definitive treatment). Open reduction and internal fixation

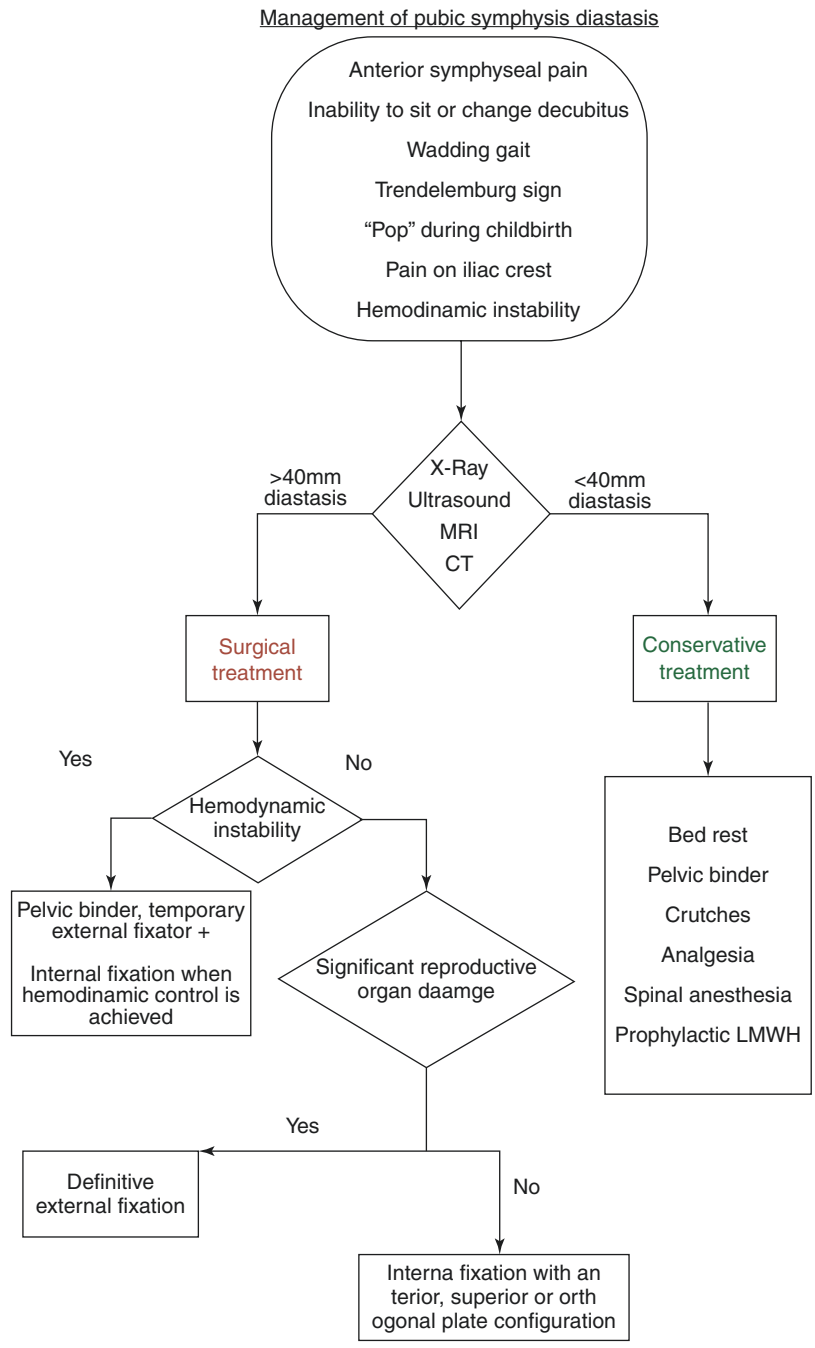

Fig. 39.16 Treatment protocol for pelvic symphyseal diastasis during childbirth

are the surgical treatment of choice when conservative treatment fails, in severe diastasis and when the pelvis is unstable (see Fig. 39.16).

The prognosis is good with most patients making full recovery with the first year after childbirth. However, some genitourinary complications can occur and should be diagnosed promptly and treated accordingly. Vaginal delivery is possible if the diastasis occurred during pregnancy and in subsequent pregnancies too taking special care not to overstress the pubic symphysis during birth.

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Part IX

Lower Body and Thigh

Physical Changes of the Lower Body and Thigh

40

Demetrios Rizis, Kaitlyn Enright, and Andreas Nikolis

40.1 Introduction

Childbearing is a period in the life cycle during which some women may gain weight, increase general circumference, and develop the appearance of cellulite in the buttocks area and lower extremities. It is estimated that up to 20% of women retain at least 5 kg (~11 lb) by 6–18 months postpartum [1]. Besides being a risk factor for several diseases, postpartum weight retention is associated with psychological and social consequences and is therefore considered to be a major health issue worldwide [2–4]. This chapter will discuss various physical changes of the lower body, during and after pregnancy.

40.2 Changes in Fat Distribution Throughout Pregnancy and the Postpartum Period

During childhood and puberty, females store approximately 25–30% of their body weight within the subcutaneous tissues of their hips and thighs, while males deposit much less [5–9]. This difference in the distribution of fat storage produces sexually dimorphic body shapes [6]. In the immediate postpartum period and continuing thereafter, the changes in maternal body composition during pregnancy impacts both maternal and infant health outcomes [10]. Although there is a plethora of research regarding predictors and outcomes [11, 12], studies are unable to properly differentiate the parameters of weight gain and how these influence both maternal and infant health. One of the main challenges in this field is measuring maternal body composition during pregnancy, given the dynamic shifts during this period and the lack of available methods to differentiate maternal and fetal components [10]. The most commonly used method to measure maternal body composition changes in the peripartum period is anthropometry via skin fold thickness [10]. As such, the body of knowledge on the component of weight changes during pregnancy and the postpartum period is very limited and shows considerable variations.

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© Springer Nature Switzerland AG 2023
M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_40

40.2.1 Changes in Weight and Fat Distribution

Changes in postpartum body weight and subcutaneous fat deposits vary with relation to energy intake and expenditure, as well as age, parity, and pre-pregnancy weight [13, 14]. Subcutaneous body fat is stored and utilized at different sites, at specific times during and after pregnancy. Additionally, the pattern of change varies based on factors related to the women and pre-pregnancy characteristics [15]. Subcutaneous fat stores are used to meet the demands of both mother and fetus, with the amount and timing of these changes having an influence on infant birth weight and health. Lipid metabolism in the peripartum and postpartum period is highly affected, to the point where it has been said that every aspect of lipid metabolism is affected by pregnancy [16–18].

There is a steady decline in mean maternal weight over the six-month postpartum period [19–21]. Weight loss appears to be greatest in the first three postpartum months. Breastfeeding, often thought to be an accelerating factor in postpartum weight loss, does not show long-term changes in postpartum body fat, but it does show increased relative losses in the first 6 weeks postpartum [22, 23]. Women with lower pre-pregnancy weights appear to have greater observed losses in the immediate postpartum period. These losses are influenced by a number of factors that include both metabolic factors that contributed to their maintenance of a lower weight as well as the greater desire to achieve their more ideal weight. Parity also plays an important role as primiparas appear to have faster and more significant weight loss in the first 3 months, than multiparas [21].

Fat stored in the hips and thighs appear to be protected from mobilization until late pregnancy and lactation, and these fat stores tend to remain relatively constant [6, 24, 25]. During the first 6 months of pregnancy, women tend to add an additional 3.5 kg (~8 lb) of fat to that stored during childhood and puberty [6]. As in childhood and puberty, this additional fat is also preferentially deposited to the hips and thighs [8, 11, 15, 24]. During the last 10–12 weeks of pregnancy, some stored fat is mobilized to meet the needs of the growing fetus [6, 8, 26, 27]. This process continues after birth with lactating women losing an average of 0.8 kg (~2 lb) of fat per month [8, 28–30]. During this period, previously protected fat is preferentially mobilized from hips and thighs [25]. Thigh and suprailiac skinfolds decrease, as does hip circumference [6, 26, 30–32].

Different patterns of weight loss can be seen based on pre-pregnancy nutritional status. In malnourished females, a phenomenon termed "maternal depletion" may occur, whereby the fat accumulated during early life depletes and causes them to become progressively thinner with each succeeding pregnancy [6, 33–35]. However in well-nourished women, although some fat is lost during late pregnancy and lactation, many women appear to lose less fat than they gained in early pregnancy and thus have a net gain in fat with each succeeding pregnancy [36–39]. As such, maternal prepregnant body mass index was found to be an important determinant factor in long-term weight gain during the reproductive cycle. Women with the highest prepregnant body mass index tend to gain less subcutaneous fat early, whereas primiparous women and women carrying males gain more in thighs and subscapular area [15].

When considering postpartum weight retention, important contributing elements seem to include gestational weight gain, maternal age, parity, lifestyle factors, and initial maternal weight [2, 40]. It is important to note that there is more of a tendency for patients with high pre-pregnancy body mass index to gain more central obesity and retain it in the postpartum period [41]. Central fat deposition provokes more disordered glucose tolerance than peripheral fat distribution in subjects with identical body mass index [42–44].

Central adiposity is generally of greater importance than overall obesity because visceral fat is associated with obesity-related insulin resistance, cardiovascular disease, lower high-density lipoprotein cholesterol levels, and progression toward type 2 diabetes particularly

among women [45, 46]. Centralized adiposity increases disease risk even among those not overweight. Visceral adipose tissue is more metabolically active and differs from subcutaneous fat in the production of adipocytokines that are thought to help regulate insulin sensitivity [46].

A higher pre-pregnancy waist circumference irrespective of body mass index shows an increased risk of diabetes and cardiovascular disease among women with gestational diabetes [47, 48]. Parity has also been shown to have a directly proportional correlation with larger waist girth many years after childbearing had ceased [49, 50]. Data shows that pregnancy preferentially promotes central obesity, which is an important risk factor for future metabolic disease [41, 49, 50]. Childbearing is associated with a threefold greater increase in visceral fat deposition from pre-conception to the postpartum period [41]. Longitudinal analysis of fat deposition has showed that 68% of gestational fat is distributed in the trunk, and excess fat that remained over one year postpartum tended to be maintained and localized centrally [51]. Several studies have shown evidence that increased central body fat persists for at least 5 years following pregnancy [1, 41, 49, 50]. This is of considerable importance because an increased central fat distribution represented by an increased waist-to-hip ratio is shown to be the most valid anthropometric index for identifying individuals whose obesity predispose them to glucose intolerance [52, 53].

It is important to note that visceral fat is more difficult to treat both surgically and with ancillary methods, and therefore, patients need to be properly informed of these risk factors. Peripheral fat on the other hand is easier to address with aesthetic methods.

40.2.2 Changes in Skinfold Measurements

Measurement of skinfold changes is one of the most accepted ways of measuring changes in maternal body composition in the peripartum period. The most significant observed skinfold thickness change occurs in the suprailiac region, with less significant changes seen in the triceps and subscapular areas [21]. However, the largest absolute gain in skinfold thickness from preconception to 35 weeks of gestation is noted to be in the thigh area, and this gain continues to be higher, relative to other areas well into the initial postpartum period [10, 15, 26]. Subscapular skinfold changes appear to occur at the slowest rate. Triceps area skinfolds act differently, with a relative increase in the first three postpartum months before a slow decline, albeit a rate faster than the subscapular ones [10, 54]. Peripheral fat stores in the thigh are used to a greater extent in the late pregnancy and early postpartum period than are central and subscapular stores [6]. The level of gain skinfold thickness and subcutaneous fat along with the differential utilization during the perinatal process may explain the observed residual central fullness and lower limb skin laxity in the postpartum period. This pattern seems to be accentuated with parity.

These abovementioned patterns suggest that a temporary redistribution of body fat occurs following pregnancy as the more central fat deposits are mobilized to meet the needs of lactation as the body attempts to return to its pre-pregnancy state. Many variables are at play, and as already stated, primiparas tend to lose more weight earlier on, and multiparas lose weight more gradually [1, 49, 50]. Body fat changes also differ with pre-pregnancy body mass index and infant gender [10, 55, 56]. Another accelerating factor in initial postpartum weight loss is breastfeeding [57, 58]. Although contentious, it has been stated that breastfeeding for a longer period may be necessary for older or multiparous women to achieve a return to pre-pregnancy weight [22].

It is important to note that changes in skinfold thickness correlate poorly with absolute weight changes during pregnancy [10, 15]. Weight begins to increase prior to expansion of subcutaneous fat stores and sees a progressive increase throughout the pregnancy and a sharp drop-off postpartum. However, skinfold thickness does not see the same sharp drop-off, and its increase is maintained [15].

Pregnancy weight change correlates poorly with skinfold thickness changes across the tri-

ceps, subscapular, suprailiac, and mid-thigh sites and appears to be a weak marker of subcutaneous fat change [15]. This is likely due to changes in weight being a sum of changes in body water content, lean tissue mass and fat stores, both visceral and subcutaneous.

In conclusion, fat storage patterns during pregnancy vary by ethnicity, parity, maternal nutritional status, preconception BMI, and several other factors.

40.3 Changes in Skin Structure and Biomechanics

The skin and related structures undergo changes during pregnancy, and the peripartum period can be separated into three categories: hormone-related, pregnancy specific, and preexisting. The physiologic changes are mainly of cosmetic importance. However, some pregnancy-specific skin diseases have associated symptoms. Although most skin conditions resolve postpartum and only require symptomatic treatment, some are associated with an increase in both fetal and/or maternal morbidity and mortality and cannot be overlooked. We will focus here on hormone-related and pregnancy-specific changes causing a cosmetic impact.

Pregnancy is a state of profound hormonal, immunologic, and metabolic changes. These changes contribute to the spectrum of physiologic changes seen in pregnancy. Normal hormonal changes during pregnancy may cause benign skin conditions, which include structural, pigmentary, vascular, and appendageal changes [59].

A woman's skin is dramatically affected by pregnancy with its biomechanical properties being critical for resisting highly stressed areas. Among all the modifications that occur (e.g., hormonal, immunological, vascular), the most evident change is in the body shape, especially the abdomen area, which grows significantly as the baby grows [60]. From a mechanical point of view, the change in body shape caused by pregnancy induces high mechanical stress on the skin.

Studies have demonstrated that skin becomes less elastic and less deformable on the abdomen during pregnancy [60, 61]. In addition to alterations in abdominal skin during pregnancy, mechanical changes are observed on the thighs, which are less subject to stretching during the childbearing process, with a loss of elasticity and firmness also being observed [60, 62].

40.3.1 Pigmentary Changes

Varying degrees of hyperpigmentation of the skin have been documented in up to 90% of pregnant women [36, 59, 63, 64]. It usually occurs in localized areas and may be due to regional differences in melanocyte density within the epidermis [59]. Pigmentary changes are caused by a prenatal influx of progesterone, estrogen, and melanocyte-stimulating hormones with histological examination showing an influx of melanin in the epidermal basal cell layer [65]. The presence of estrogen receptors on melanocytes indicates a hormonal responsiveness heightened with pregnancy [66].

Pigmentation can manifest in various ways, as in chloasma on the face or linea nigra on the abdomen, and tends to accumulate in areas that already have pigment, including preexisting nevi, freckles, scars, areolae, genitalia, axillae, as well as in the anal region. Melasma has been shown to occur in up to 50–70% of pregnant woman [67]. Occasionally, generalized hyperpigmentation occurs. These changes are more pronounced in women with darker hair and skin color.

Most of these lesions fade postpartum; however, the epidermal-type hyperpigmented lesions that do not fade can safely be treated with topical 5% hydroquinone cream or 0.1% dexamethasone cream with varying degrees of success [68].

40.3.2 Vascular Changes

Changes in maternal hormones (e.g., estrogen, human chorionic gonadotrophin, adrenocorticotrophic hormone-like substance, thyrotrophin-releasing hormone) greatly influence the vascular changes observed during pregnancy [59, 69]. These hormones result in an increase in cardiac output, vascular proliferation, congestion, and vasomotor instability [69].

Varicosities have been documented in up to 40% of pregnant women in western civilizations [70]. Varicosities are increased distension in the superficial venous vasculature of legs (varicose veins), vagina, vestibule, and rectum [36, 59].

The compounded effect of increased blood volume and obstructed venous return from the prominent gravid uterus produce varicosities. Elevated estrogen levels induce a nitric oxide-mediated vasodilation to enhance maternal and fetal circulation [71, 72]. Vessel distention and fragility result from relaxin-weakened collagen and elastin, whereas vessel hyperproliferation is mediated by an estrogen-induced surge of angiogenic growth factors [69, 73].

With advanced maternal age and parity, veins lose valve patency and vessel tone [74]. Eventually, the engorged veins are visualized as varicosities or telangiectasias. Varicose veins usually regress postpartum, but in severe cases, surgical intervention may be necessary. Regardless of aesthetic effect, if uncontrolled, varicosities of the legs can progress to deep vein thrombosis. Symptoms can be alleviated by leg elevation, cool water immersion, graded elastic stockings, reclining in a left lateral decubitus position, and light exercise.

Spider nevi (angiomas) occur in approximately two thirds of light complexioned, pregnant females. While dark-complexioned, pregnant females are less likely to develop angiomas, they occur in approximately 10% of this population. Angiomas typically appear on the face, neck, and arms and commonly appear during the first and second trimesters [63]. Postpartum, most angiomas regress, but a small percentage may persist. Angiomas can be treated with electrocautery or laser [59].

40.3.3 Structural Changes

Studies performing comparisons between non-pregnant, pregnant, and postpartum groups have enabled us to better understand the effects of pregnancy on skin properties. Results from such studies are as follows.

Skin extensibility decreases around the abdomen during pregnancy since the skin approaches maximum extension as the baby grows. This corresponds to a critical state where striae could occur. The viscoelastic behavior of the skin is also disrupted by pregnancy with a loss of elasticity. Not surprisingly, firmness increases as the abdomen becomes more inflated. However, the biological elasticity does not differ between non-pregnant and pregnant groups.

Skin extensibility in the abdomen of women after delivery exceeds that of the non-pregnant group suggesting that the skin is so extended during pregnancy that it does not return to its original state. Viscoelastic behavior of abdominal skin after delivery is the same as that of non-pregnant women, showing that pregnancy does not have a significant impact on this parameter. However, after delivery, we see a loss of firmness and elasticity. The effects of pregnancy on these parameters remained visible well beyond 4 months after delivery.

Within the thigh area, we see a loss of firmness and elasticity with higher extensibility. These results demonstrate a tendency that was opposite than that of the abdominal area for extensibility and elasticity parameters with a decrease in the biological elasticity and firmness. Because this area did not change shape like the abdomen, mechanical stress was most likely not the main cause of these alterations in skin properties. If mechanical stress on the abdomen is responsible for specific skin properties, the observed modifications during pregnancy could not be generalized to other areas, such as thighs, where physiological parameters other than tension may exert more predominant effects. Therefore, factors other than mechanical stress, such as hormonal changes, could be responsible for the modifications in skin mechanical behavior on the thigh. This is in line with previous studies that have suggested that hormonal changes during aging might induce alteration of skin elasticity and extensibility.

Data from these studies demonstrated that the modifications that occur during pregnancy continued after delivery, resulting in a loss of firmness and elasticity but higher extensibility, coupled with the changes in superficial fat distribution discussed earlier, these changes lead to the aesthetic changes we see within the lower body

with regard to skin properties, laxity, and fat distribution with the end result being loose, sagging skin, and localized fat deposits.

40.4 Stretch Marks

Striae distensae may result from numerous physiological and pathological conditions. They are widely known to occur during pregnancy, and due to frequency of occurrence, they are defined as striae gravidarum. They present as atrophic linear scars that represent one of the most common and disfiguring gestational change in connective tissue during pregnancy. Striae gravidarum can cause emotional and psychological distress for many women. They are a source of significant anxiety for women, impacting on their quality of life.

Rates of occurrence of striae gravidarum vary with reported rates ranging between 50 and 90% [75–77]. In primiparous women, incidences of 52% [78], 61% [77], and 87.7% [79] have been reported, while a rate of 71.1% [80] was found in a study involving both primigravidae and multigravidae.

Typically, lesions affect the abdomen and breasts and, less frequently, the thighs and buttocks. Initially, lesions appear as erythematous, and sometimes edematous, streaks. Over months to years, they mature into permanent, scar-like, hypopigmented linear bands displaying a crinkled shiny surface, laxity, and atrophy.

Research on risk factors, prevention, and management of striae gravidarum has been often inconclusive. The exact cause of stretch marks is unclear, and proposed hypothesis includes lateral stress in connective tissue and increased glucocorticoid levels due to elevated adrenocortical activity [75, 77, 79, 81–83].

40.4.1 Pathophysiology of Striae

Clinically, striae have been defined as "visible linear scars that first present as flat, pink-to-red bands that become raised, longer, wider, and violet-red." [84] Within a few months to years, this redness fades, and the lines appear as scar-like, wrinkled, white, and atrophic marks [84]. Striae vary in size and color and can fade to become skin-colored or become hypopigmented atrophic lines [77]. These benign skin changes commonly occur on the abdomen but are also seen on the breasts and thighs hips and buttocks and groin and axillae [85, 86]. Striae have been reported as ranging in severity and have been graded as mild, moderate, or severe by some authors, while others have developed numerical classifications systems that captured the severity of striae, focusing on the number of striae present and the degree of erythema, or redness [77, 81, 87, 88]. Striae gravidarum seem to affect all racial groups, although once considered to be more common in White than in Black or Asian women more recently non-White women were seen to be at greater risk [77, 89].

While much debated, the histopathological origins of striae are poorly understood [75, 77, 79, 82, 83]. However, the etiopathogenesis appears to involve a combination of genetic [90] and hormonal factors [89, 91–93], as well as increased mechanic stress on connective tissue [77, 79, 92, 94, 95]. For example, hormone changes during pregnancy can cause adhesion of the collagen and elastin fibers, while skin stretching may damage them, which may in turn causes dermal tearing [95, 96].

Striae gravidarum are common during the first pregnancy and usually present during the third trimester [84, 89]. However, there have been reports in women under 24 weeks' gestation and of women first developing them in a second pregnancy [89, 97]. This condition is described as a mild form of physiological, hormone-dependent changes in the skin, which develop during pregnancy [89, 91, 98, 99].

With regard to hormonal factors, twice as many estrogen receptors and elevated androgen and glucocorticoid receptors have been observed in striae compared with those in healthy skin [84, 91]. These findings indicate that the areas of skin that undergo greater mechanical stretching may express greater hormonal receptor activity [91]. Ultimately, abnormalities in a variety of extracellular membrane components [83, 94, 96, 100–105] are believed to underlie the pathogenesis of striae gravidarum [104]. However, how and to

what extent these extracellular membrane components become deranged is not clear. A recent study analyzing dermal elastic fibers in newly developed, erythematous abdominal striae gravidarum in pregnant women showed severe disruption of the elastic network, accompanied by the emergence of newly synthesized, disorganized tropoelastin-rich fibrils, which persist and fail to form normal-appearing elastic fibers [104].

Early striae gravidarum displayed severely disrupted organization of dermal collagen fibrils, with marked separation of bundles, especially in patchy to extensive areas of the mid-to-deep dermis [96].

Intense skin stretching that mechanically "pulls apart" the dermal extracellular membrane may disrupt the organization of collagen bundles, and the dermal membrane may lack the ability to accommodate to intense skin stretching [104, 106, 107]. Such a hypothesis helps to explain the observations that SG often appear on the abdomen during pregnancy [96]. Risk factors impacting the degree of stretching include maternal baseline weight, weight gain during pregnancy, and multiple gestation pregnancy [108]. Additionally, increased mechanical tension of the skin may prevent the formation of collagen bundles, a situation possibly analogous to impaired healing of surgical wounds under high mechanical tension [109]. Finally, hormonal changes may also contribute to the persistent disorganization of extracellular membrane constituents in striae gravidarum [91, 110].

40.4.2 Risk Factors for Striae

According to the reports in literature, there are a number of risk factors associated with striae gravidarum development. Identified risk factors include family history, race, skin type, birth weight, baseline body mass index, weight gain and inadequate nutrition, younger maternal age, increased pregnancy weight gain, use of corticosteroids, genetic susceptibility, and the presence of stretch marks on the hips and the breasts prior to pregnancy [75, 77, 89, 99, 111]. However, the pathophysiological explanation of the majority of these factors still remains unclear.

Confounding factors should also be considered, as studies have found that increased alcohol intake [112], decreased water consumption [112], decreased blood vitamin C levels [113], and expecting a male baby [114] are more common among women who develop striae gravidarum [84]. Unfortunately, the pathogenesis of striae gravidarum is currently unknown, and available studies tend to be limited by study type, size, and patient population [84].

Many pregnant women consult dermatologists in order to learn about the risk of SG formation and the ways to reduce it. They should be informed by their healthcare providers about the possibility of lowering the risk of striae gravidarum development by modification of previously mentioned factors. Prevention of striae gravidarum with topical creams and a daily massage seem the most supported treatment options by the literature, but further studies are necessary [81, 84].

40.4.3 Treatment of Striae

Throughout history, stretchmarks have always been a source of distress for pregnant women. Current data suggest that strategies aimed at promoting organization of collagen fibrils into densely packed bundles that provide structural support may be effective for preventing or treating striae gravidarum [86, 96].

The current, most effective therapies include tretinoin cream ≥0.05% and modalities such as non-ablative fractional lasers [83, 84, 115–121]. The main limitation of such a cream is that topical retinoids are typically avoided during pregnancy, and it remains unclear whether they can prevent new lesion development. Laser treatment appears to yield a greater mean improvement than topical retinoids, and in a much shorter time. Studies have revealed that laser treatments result in increased elastin content and collagen production in the treated lesions, which can partly explain the improvement observed [84].

Many studies investigating novel laser, microdermabrasion, and microneedling treatments are underway.

40.5 Cellulite

Cellulite (gynoid lipodystrophy) is the orange peel-type or cottage cheese-like dimpling of the skin on the thighs and buttocks that affects up to 80–90% of post-adolescent women [122, 123]. This condition, as far as we can deduce from the best evidence, can be conceptualized as a disorder of the subcutaneous fat layer and the overlying superficial skin.

Evidence has suggested that cellulite is a complex process that involves many mechanisms including microcirculatory dysfunction, local fat accumulation, hormonal factors, altered matrix metabolism, inflammatory changes, alterations in lymphatic drainage, and genetic factors [124–126]. The predisposing factors for cellulite lead to a reduction in the metabolic rate of the affected areas, ultimately resulting in congestion and alterations in the external aspect of the skin [127, 128].

Cellulite is separate from skin laxity and stria and should not be confused with obesity, in which a gain in adipose tissue mass results from an increase in adipocyte cell size and number [124]. Although these changes can be seen within areas of cellulite, additional structural alterations in the dermis and subcutaneous tissue exist.

Histologically, cellulite is characterized by the extrusion of underlying adipose tissue into the dermis, and the percentage of hypodermic invaginations (papillae adiposae) has been shown to correlate with the severity of this condition [126, 129–131]. Importantly, areas of cellulite are characterized by a complex network of hypodermal fibrous strands at an angle substantially perpendicular to the skin surface [130].

Formerly viewed as resting tissue storing excess energy, subcutaneous adipose tissue is currently regarded as an endocrine organ that secretes a wide variety of fatty acids, cytokines, and various hormones with profound paracrine and endocrine effects that influence metabolism, endothelial function, inflammation, and extracellular matrix deposition and may functionally affect the subcutaneous vascular and lymphatic circulation and possibly play a role in the formation of cellulite [126, 132, 133].

Only a limited number of studies on cellulite have been published in the literature, and it is not yet possible to reconcile the extreme differences of opinion, which have lingered on for years concerning the nature of this disorder, as well as its origin and even the most basic aspects of its histopathological classification.

Over the last few decades, three major conflicting theories have emerged in relation to the etiopathogenesis of cellulite. These indicate, the following causes:

1. Excessive hydrophilia of the intercellular matrix.
2. The “histochemical scenario” indicates an anomalous connective response, which, through the retention of liquids in the interstitial matrix, can result in new collagen deposition in the subcutaneous tissue. [123, 134]
3. Microcirculatory alteration.

The most popular theory, at least in Europe, explains cellulite as the consequence of a homeostatic alteration and dysfunction on a regional microcirculatory level [123, 135–137].

There also exists anatomical peculiarities of the female subcutaneous tissue. Histological modifications are different to those of the male morphology and to those commonly observed in the zones of macroscopically “normal” adipose tissue accumulation [123, 138–140].

These theories must all now be updated in the light of recent advances on the sophisticated and composite physiopathology of the adipose organ—which acts not only as a control device, which regulates the systematic equilibrium of energy and modulates the food intake and the metabolism of other tissue substrate through a multiple glandular secretion of hormones and parahormones [132, 133, 141–143].

Given the small number of studies on the subject, it is not yet possible to reconcile the substantial differences in opinion, which for years have

lingered on the nature of this disorder, as well as on the origin and even on the most basic elements of its histopathological aspects.

40.6 Psychological Impact of Lower Body Changes

Due to many contributing factors (e.g., pregnancy occurring at a later age than in earlier generations; multiple births becoming more common; the advancing age of a population with a keen interest in nutrition, fitness, and a desire to retain a youthful figure), patients have been increasingly concerned with their postpartum appearance and often hold their pre-pregnancy appearance as an ideal for post-pregnancy form. The psychological effects of postpartum body changes cannot be denied, but are often regarded as an aesthetic nuisance and overlooked by practitioners who consider them to be clinically insignificant. These changes, even though they are mostly aesthetic in nature, have a profound effect on the psychological well-being of the mother. The psychological impact can begin in the early or late postpartum period and can persist for multiple years following childbirth. They can take the form of depression, anxiety, and feelings of inadequacy or negative self-worth [144–146].

The abdominal region and the breasts represent the two regions subject to the most visible and disconcerting sequelae of pregnancy. Patients often consider the form of their abdomen a surrogate for good health and the appearance of their breasts a marker for youthfulness and vitality. These regions represent areas that cause the most concern in the early postpartum period, with changes in skin structure such as persistent hyperpigmentation, striae, and cellulite tending to manifest as subjects of concern much later in the postpartum phase [84, 85].

Negative body image has related to issues with women's weight status including greater postpartum weight retention, increased body mass index, and higher current weight in the postpartum [147, 148]. During pregnancy, women's attitudes toward their bodies may shift away from wanting to align with society's ideal thin shape, and women may prioritize the health of their baby over the aesthetics of their own body. However, after the birth of their baby, women often report dissatisfaction with their post-pregnancy body [147, 148]. Women may experience displeasure with the residual large size of their abdomen, changes to posture, and clothes they can no longer wear if they are not able to lose the weight they gained during pregnancy. All of these factors are associated with psychological distress [149, 150]. Additionally, these findings are consistent with established research, which has found that body dissatisfaction is also associated with the rate at which weight is lost in the postpartum. This research indicates that women with positive body image are more likely to lose the weight gained during pregnancy [151].

The relationships between depressive and anxiety symptoms, body image, and weight status in the postpartum period have been previously reviewed. Body dissatisfaction during pregnancy has been shown to be a significant predictor of postpartum depressive symptoms [152–156]. It is likely that body dissatisfaction contributes to decreased self-esteem, self-deprecation, and feelings of inadequacy, which can themselves lead to feelings of depression. In the studies reviewed, postpartum depression was found to predict body dissatisfaction. Postpartum depression has been described as symptoms of depression, such as overeating and weight gain/retention, which in turn can contribute to, or exacerbate, negative body perceptions. Other studies have found that women who are overweight or obese have a significantly greater risk of postpartum depression than women at a normal weight and that this relationship is even stronger in women with pre-existing body dissatisfaction [83, 157, 158]. It is possible that other factors, such as sleep, diet, physical activity, and body image, may play a role in the association between anxiety, depression, and weight in the postpartum period [159]. The direction of the causation between mood symptoms and body dissatisfaction remains unclear; however, it seems likely that the association is bidirectional. Therefore, depression may enhance negative body attitudes, and body dissatisfaction may contribute to psychological dis-

tress [147]. However, the exact causal pathways in the relationship between depression and weight remain unclear.

It is important to note that different cultures view body image very differently, particularly in the postpartum period. Cultural differences may contribute to some of the disparity in findings across studies, given their different approaches to pregnancy and postpartum weight management. This presents issues for making between-studies comparisons [149]. Other factors, such as lack of a spouse/live-in partner, lower income level, and parity, are also significantly associated with higher levels of depressive symptoms [152, 158, 160].

Healthcare providers need to be sensitive to factors affecting women's emotional well-being during the postpartum transition, such as body image distress, and provide culturally appropriate care. An important component of culturally appropriate care is to avoid making assumptions and to proactively discuss with women their expectations related to body weight and shape during postpartum.

Guidance regarding healthy diet and exercise may be particularly important for women dissatisfied with their body image. Information should be provided to discourage attempts at quick weight loss using fad diets and dietary supplements that may further exacerbate postpartum fatigue and exacerbate depressive symptoms.

40.7 Conclusions

Many changes can be observed in the lower body during and after pregnancy. Postpartum body changes relevant to the areas of the buttocks and thighs can include changes in weight and fat distribution, skin biomechanics and structure, and the development of pigmentary and vascular disorders and cellulite. Given the potential for these changes to influence psychological distress, physicians should proactively discuss and mitigate postpartum expectations with patients.

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Cellulite: Etiology and Treatment

41

Miriam Vicente-Ruiz

Take-Home Points

- Cellulite purportedly affects up to 95% of post pubertal women of all races.
- Cellulite is a multifactorial entity with skin architecture and connective tissue, inflammatory, vascular, endocrine, and genetic factors playing a major role.
- The appearance of cellulite worsens during high estrogen states, including pregnancy, nursing, and chronic use of oral contraceptives.
- Although no cure for cellulite exists, multiple treatments have been developed over the years to try to improve its appearance.
- It is not clear whether lifestyle modifications such as weight loss or exercise can improve the condition, but they may have some positive effects.

41.1 Introduction

Cellulite remains one of the most common dissatisfactions among women after puberty [1]. It has been estimated that up to 98% of females are concerned about their skin changes due to cellulite with a decrease in their self-esteem [2].

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Cellulite refers to the *orange peel-type*, *mattress-like,* or *cottage cheese-like* dimpling of the skin that appears on the thighs and buttocks of post-adolescent women and is considered a complex, multifactorial, cosmetic disorder of the subcutaneous fat layer and the overlying superficial skin [3]. Although the precise definition of cellulite is not clear and many different, and even conflicting, definitions for this entity have been proposed, it can be described as an esthetically disturbing, localized distortion of the skin architecture accompanied by a higher subcutaneous adipose tissue thickness in lower body fat depots like the buttocks and thighs, as shown in Fig. 41.1 [4].

Although its exact prevalence is unknown, it is reckoned to affect up to 80–90% of post pubertal females of all races [5]. It is known to accelerate during adolescence, pregnancy, and around menopausal age, and its incidence and severity are influenced by **sex**, being more common in women than men; **race**, being more common in Caucasians; and **biological type**, being found on the hips and thighs of Latin American women but not on the abdomen of European women [6].

Cellulite has been given many names including *gynoid lipodystrophy, nodular liposclerosis, edematofibrosclerotic panniculopathy, panniculosis, adiposis edematosa, dermopanniculosis deformans, and status protrusus cutis* [7, 8]. **The term "cellulite" should not be confused with "cellulitis,"** a term used in scientific English to

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_41

Fig. 41.1 Dimpled appearance of cellulite on the buttocks and posterior thigh of a 24-year-old female (Reprinted from MacGregor JL, LaTowsky B, Arndt KA, Dover JS. Cellulite. In: Evidence-Based Procedural Dermatology [Internet]. New York, NY: Springer New York; 2012) [54]

indicate an infection of the subcutaneous cellular tissue [9]. It should also be differentiated from *obesity*, which is characterized by hypertrophy and hyperplasia of adipose tissue that is not necessarily limited to the gluteal, femoral, or abdominal areas, as opposed to cellulite, which is most commonly found in these areas [8]. Moreover, cellulite can also be found in slim and active persons [10].

Whether cellulite is a real disease or only a disturbing aesthetic issue is still a matter of controversy [4]. There is no consensus about whether or not we can consider it a disease, or it is merely a physiological feature in women. Some experts argue that there is no mortality or morbidity associated with this condition, which makes it difficult to define as "pathologic." Also, given its ubiquitous nature, it is more appropriately thought of as a secondary sex characteristic rather than a disease [8, 11]. Others, however, state that cellulite is more and more often treated as an illness since it more and more often negatively influences the mental state of women [10]. Additionally, while cellulite is generally asymptomatic, the more severe stages can present with painful nodules and increased local temperature, which argues against the physiological nature of this condition [4].

Many studies have suggested the association of cellulite with age, smoking, estrogen use, poor physical activity, body mass index (BMI), and indexes of cardiac risk [4]. In relation to **age**, significantly higher cellulite scores have been described in older patients, with flaccidity playing an important role as it worsens with aging [12]. With respect to **BMI**, cellulite can affect individuals regardless of their body mass index, although it has been described that obese patients have a higher percentage of fat inclusion in the dermis in areas with cellulite, which correlated with higher cellulite scores [12–14]. Other authors suggest that cellulite is not a result of increased body mass, but rather that the waist-to-hip ratio may influence its appearance [15].

▶ **Important** *Cellulite is almost omnipresent in post pubertal women.*

It appears as an orange peel-type, mattress-like, or cottage cheese-like dimpling of the skin on the thighs and buttocks.

Cellulite should not be confused with cellulitis or obesity.

It is not clear whether we can consider cellulite a disease or a physiological feature in women.

Although cellulite scores are generally higher in older and more obese patients, young and slim persons can present cellulite too.

41.2 Etiology

Many studies have tried to clarify the origin of cellulite; however, its precise etiology is still unclear, and most authors consider it a multifactorial entity with skin architecture and connective tissue, inflammatory, vascular, endocrine, and genetic factors playing a major role [6, 7, 16, 17].

41.2.1 Skin Architecture and Connective Tissue

Nürnberger and Müller published the first scientific paper on cellulite in 1978. They were the first to describe the sex-typical differences of the skin and subcutaneous tissue. According to their findings, the subcutaneous tissue of the thighs is composed of three layers of fat with two planes of connective tissue, being the uppermost layer made up of "fat-cell chambers" separated by septa of connective tissue. In women, these septa run perpendicular to the skin creating large, standing fat-cell chambers. From these fat-cell chambers, "*papillae adiposae*" protrude into the thin dermis creating the external appearance of cellulite. They also observed these findings in men with androgen deficiency, which suggests a major role of sex hormones in the development of cellulite. In men, however, these septa run in a crisscrossing pattern creating small polygonal fat-cell chambers, and *papillae adiposae* are scarcer with a thicker dermis, which hinders the mattress phenomenon, as shown in Fig. 41.2. They therefore concluded that cellulite is not a disease, but it is rather the result of the sex-typical structure of the skin of women and the natural consequence of aging [18].

This extrusion of underlying adipose tissue into the reticular dermis has been confirmed by histological examination of wedge biopsy of the thighs, ultrasonography, and MRI [13, 19–21]. Some studies have observed the correlation between the range of these extrusions and cellulite grading, while others found no correlation between their extent and the clinical severity of cellulite [13, 21]. The extrusion of these *papillae adiposae* into the dermis forced by external compression (**pinch test**) causes the overlying skin to protrude, creating the **mattress phenomenon**, which is a major sign of cellulite [21].

While three principal orientations of connective tissue septa exist (perpendicular, parallel, and angulated at about 45°), women with cellulite have a higher percentage of perpendicular septa than unaffected women or men, which allow the underlying fat to protrude [8, 20]. These gender-related differences in septal orientation have been found in affected and unaffected women. This could explain the observation that the areas where dimpling is evident are highly variable depending on the position of the individual lower extremity and positions that tend to compress the adipose tissue in a specific area will enhance the dimpling in that same area [19].

Differences in connective tissue morphology have also been described. In patients with cellulite, connective tissue of the dermal-adipose tissue border of the thigh has been described as irregular and discontinuous, as opposed to smooth and continuous in unaffected patients, but this pattern was found to be diffuse, that is,

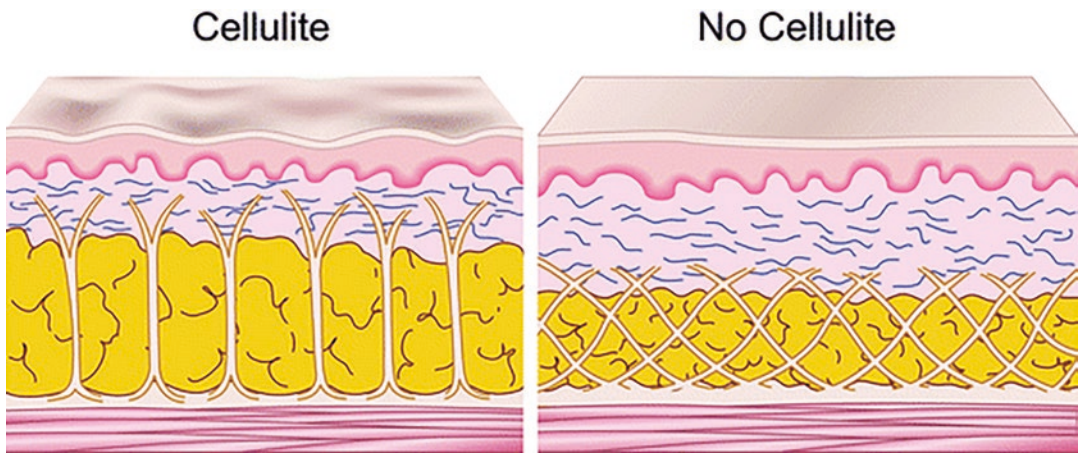

Fig. 41.2 The structure of cellulite (Reprinted from MacGregor JL, LaTowsky B, Arndt KA, Dover JS. Cellulite. In: Evidence-Based Procedural Dermatology [Internet]. New York, NY: Springer New York; 2012)

not localized to affected areas of the thigh [19]. One study that compared subcutaneous tissue in areas with and without cellulite showed that cellulite depressions on the buttocks were significantly associated with underlying thicker fibrous septa [22]. However, other studies have found no differences in the septa between raised lesions and control areas [12]. Another study found that women with cellulite and high BMI presented weaker and less dense connective tissue, thus linking connective tissue density with the degree of cellulite [13].

Other studies have linked cellulite with the characteristics and quality of the dermis and the biomechanical properties of the skin of women affected. One study found that the presence of cellulite corresponds to a thinning of the dermal layer, a greater length of the dermis–hypodermis interface, a decrease of dermal density, and the deterioration of biomechanical parameters of skin elasticity and extensibility, which are skin characteristics typical of older ages. The author therefore argues that the presence of cellulite is a cause of premature skin aging [23]. Another study observed that, women without cellulite had a better-quality skin—firmer, with less compliance, laxity, and capacity for deformation. By contrast, women with cellulite, presented greater laxity and weakness of the dermis and connective tissue. Adding to increased interstitial pressure and the negative effects of aging, this favors connective tissue weakening, making it more likely that fatty tissue may herniate into the dermis [17].

Lastly, the mechanical cause of the skin dimpling in cellulite has been linked to that of dermal stretch marks. While dermal stretch marks result from excessive tension applied in parallel with the skin surface, cellulite likely results from continuous and progressive tension vertically oriented [24].

Key Points

Cellulite is based on a sexual dimorphic skin architecture.

The external appearance of cellulite is caused by fat herniation into the dermis.

Women with cellulite have a higher percentage of perpendicularly running connective tissue septa.

Differences in the morphology and density of the connective tissue have been linked to cellulite.

Cellulite is associated with the presence of a thin dermal layer, bad skin quality, and abnormal mechanical properties of the skin.

41.2.2 Inflammatory and Vascular Factors

It is controversial whether localized tissue vascularity or inflammation plays a major role in the etiology of cellulite [8]. Some studies have found the presence of inflammatory cells in the fibrous septa of cellulite biopsies, which might be the cause of low-grade inflammation [7]. However, other studies found no evidence of inflammation [8, 18, 21].

Adiponectin is an adipocyte-derived hormone with anti-inflammatory, antifibrotic, and vasodilatory functions. In areas with cellulite, significant decreases in the subcutaneous expression of adiponectin mRNA have been found, with unaltered plasma levels, which suggests that it may act as a local paracrine factor that influences the appearance of the skin, through a microcirculatory dysfunction, inflammation, and disrupted extracellular matrix homeostasis [3, 7].

Glycosaminoglycans (GAGs) are polysaccharide chains found in the extracellular matrix. Through their water-attracting properties, they can create a swelling pressure to allow for the diffusion of water. Some authors have found increased concentrations of GAGs in the ground substance of dermis in cellulite skin, which could determine a rise for water retained in the skin and thus explain the edematous appearance of cellulite skin [25]. Other studies have failed to demonstrate increased water content in the adipose tissue of women with cellulite [20].

It has also been suggested that the process of cellulite originates with deterioration of the dermal vasculature, particularly in response to

altered precapillary arteriolar sphincters in affected areas, which would add to the deposition of GAGs and lead to elevated excessive fluid retention in the tissue. This edema can also lead to vascular compression, hypoxia, and capillary neoformation, resulting in microhemorrages. These findings have been supported by some studies but refuted by others [8, 19].

Key Points

It is controversial whether localized tissue vascularity or inflammation plays a major role in the etiology of cellulite.

A decrease of adiponectin expression in the subcutaneous tissue has been found in areas with cellulite.

Increased concentrations of GAGs have been described in the dermis of cellulite skin.

An alteration in dermal vasculature of cellulite areas has been suggested.

41.2.3 Endocrine Factors

The first scientific paper on cellulite, conducted by Nürnberger and Müller in the 1970s, described cellulite as being present only in women or in men with androgen deficiency, introducing the relationship between female sex hormones and cellulite [18]. Posterior findings have confirmed the major role of female sex hormones, notably estrogens, in the development of cellulite.

The first symptoms of cellulite appear in women during puberty, with the rise in sex hormones. In addition, progression of the skin lesions has been observed during high estrogen states, including pregnancy, nursing, and chronic use of oral contraceptives [6, 7].

Hormonal imbalances, rather than isolated hormonal peaks, are regarded as the crucial cause of the cellulite. More precisely, an excess in estrogen concentration in relation to progesterone causes a relative hyperestrogenism. These occur physiologically in the period of pregnancy, maturation, and menopause, or pharmacologically through systemic hormone contraceptive or in the course of the hormone replacement therapy [10].

Although there is no clear explanation for the topographic distribution of cellulite, it has been noted that the adipocytes in the gluteofemoral region are larger than in other areas and are greatly influenced by female sex hormones. In addition, they are metabolically more stable and resistant to lipolysis, which could partly explain the gynoid fat distribution in women, with a greater accumulation of fat in areas where cellulite is present [8].

Key Points

Female sex hormones play a major role in cellulite development.

Cellulite appears only in women and men with androgen deficiency.

The first symptoms appear in puberty with the rise in female sex hormones.

The skin lesions show progression during hyperestrogenic states.

Hormonal imbalances, rather than isolated hormonal peaks, are regarded as the crucial cause of the cellulite.

41.2.4 Genetic Factors

The distribution of two polymorphisms has recently been associated with cellulite [7, 26]. **Hypoxia-inducible factor 1 (HIF-1)** regulates gene expression in response to hypoxia. During hypoxia, it stimulates the production of the GLUT1 protein, erythropoietin, transferrin, and vascular endothelial growth factor (VEGF). In fat tissue, HIF-1 expression has been found to activate fibrosis and local inflammation. *T-allele polymorphism 11549465 for HIF1A* reduces the activity of this HIF-1A factor, and one study found that women presenting this polymorphism did not develop cellulite, or if they did, it was at a low level [6, 26]. The same study found that women who carry the *D allele of the angiotensin I-converting enzyme (ACE)* increase the risk of developing cellulite, which is related to the rise of production of angiotensin II in the subcutane-

ous adipose tissue. This growth provokes blood flow dysregulation and facilitates adipocyte hypertrophy, increased deposition at the extracellular matrix, and the formation of a complex mesh of subcutaneous fibrous tissue [26]. Another study found a significant synergism between this polymorphism and smoking for the risk of cellulite, suggesting for the first time that smoking might be a risk factor in the development of cellulite [27].

Key Points

T-allele polymorphism 11549465 for HIF1A is protective against cellulite development.

ACE rs1799752 increases the risk of developing cellulite.

Smoking might be a risk factor in the development of cellulite.

41.2.5 Other Factors

Various authors have suggested that limitation of fluid movement and impairment in lymphatic drainage may contribute and aggravate cellulite. However, studies have refuted the presence of enlarged lymph vessels in the dermis [21]. One study group described improvement in cellulite appearance after lymphatic drainage therapy [28–30], whereas another group found no significant improvement, concluding that manual lymphatic drainage is not effective as an isolated treatment of cellulite [31].

41.3 Cellulite and Maternity

As previously mentioned, it is known that cellulite may worsen during high estrogen states, including pregnancy, nursing, and chronic use of oral contraceptives [7]. However, the underlying cause appears to be a relative hyperestrogenism rather than an isolated increase of estrogens, which occurs physiologically in the period of pregnancy and menopause [10].

During **pregnancy**, the excess in estrogens causes excessive relaxation of the veins, causing blood stasis, resulting in swelling, ischemia, and hypoxia in the subcutaneous tissue, as well as increased wall permeability and swelling of surrounding tissues, which places pressure on small veins and arterioles, leading to abnormal blood flow within the skin and fatty tissue. This process exacerbates the fibrosis and formation of nodules in the subcutaneous tissue [6]. Pregnancy is also associated with an increase in certain hormones, such as prolactin and insulin, with an increase in overall fluid volume. Both of these factors promote cellulite by lipogenesis and fluid retention [8].

During **menopause**, a low estrogen concentration is responsible for increased vascular permeability and decreased vascular tone, which lead to microcirculation impairment and are important factors predisposing to the development of cellulite. The effects of estrogen deficiency on the skin connective tissue include a decreased production and topical content of both type I and III collagen and elastin fibers, which also contributes to cellulite [10].

41.4 Pretreatment Evaluation

Clinical examination with a focus on a palpable and visual medical examination is at the center of cellulite diagnosis and evaluation. However, some authors propose the use of complementary clinical and image tools.

The examiner should look for cellulite mainly in the outer thighs, posterior thighs, and buttocks. However, it can also be found in hips, periumbilical abdomen, breasts, posterior arms, and posterior neck [7]. Cellulite must always be evaluated with patients standing in anatomic position. Pinching the affected areas with the thumb and index finger (**pinch test**) as shown in Fig. 41.3, having the patient contract the underlying muscle group, and the use of tangential hard light can all help accentuate and visualize contour irregularities in affected areas [7].

Other clinical tools that may be useful in the office include *anthropometry, perimetry, scale of*

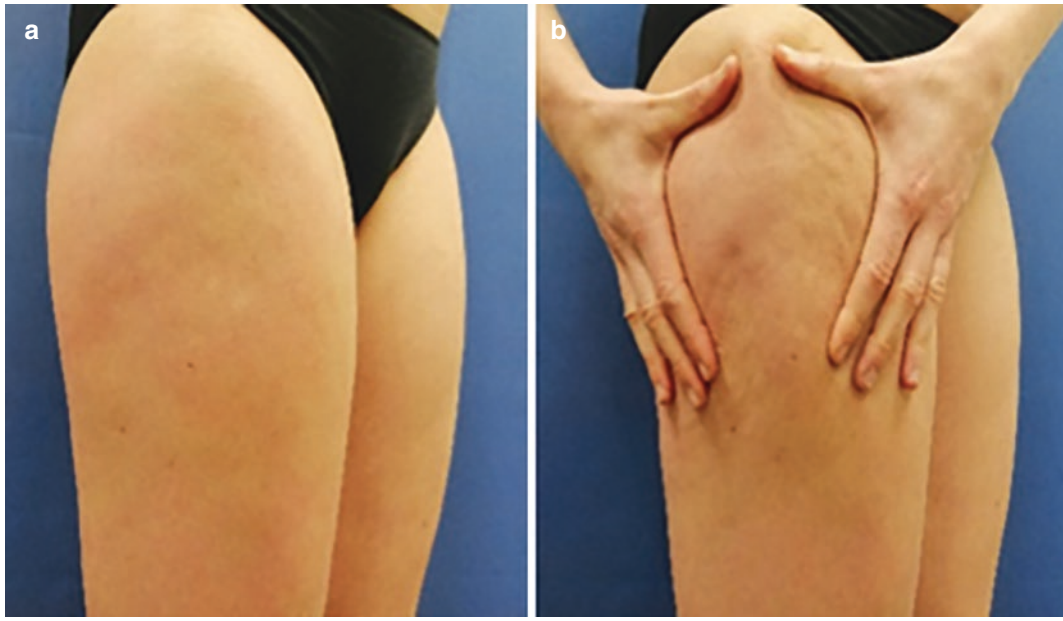

Fig. 41.3 Clinical examination of a healthy volunteer at rest (**a**), after applying the pinch test (**b**)

severity of cellulite (CSS), and quality of life by ***Celluqol questionnaire***, which evaluates the impact of cellulite on the choice of clothing, leisure, physical activities, relationship with partner, feelings, and changes in daily habits [1, 11, 32].

Some image tools that have been proposed as pretreatment evaluation methods include *Cutometer* to assess skin elasticity, *ultrasound* for thickness of hypodermis, *macrography*, *transepidermal water loss (TEWL) determination*, *videocapillaroscopy*, or *electric bioimpedance*. **CAT** and **MRI** have also proven to be useful tools, but they ought to be employed responsibly in account of their costs and radiation exposure [7, 10]. Recently, a study has shown the efficacy of thermal imaging using ***infrared thermography*** in the diagnosis of cellulite stage by analyzing the superficial temperature distribution, as shown in Fig. 41.4 [33].

41.4.1 Cellulite Classification and Grading

Cellulite may be divided according to clinical type (fatty, lymphatic, or alleged) or character of skin changes (tough type, slender form, or hydropic form) [10]. But most commonly, cellulite is characterized by the use of clinical scales.

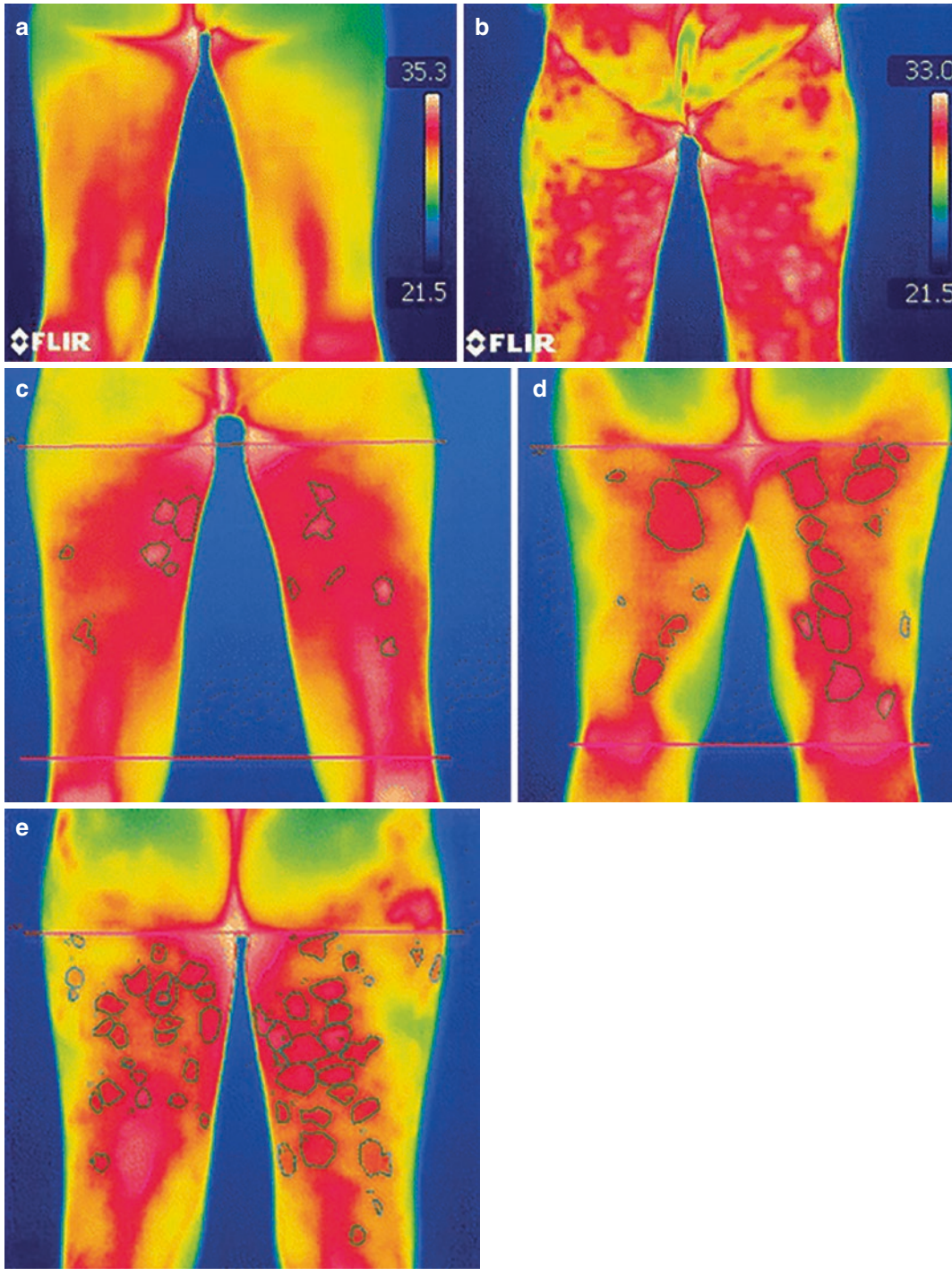

Fig. 41.4 Typical thermal images of thighs of a healthy volunteer (**a**), a volunteer with high occurrences of cellulite (**b**) and volunteers with cellulite of first stage (**c**), second stage (**d**), and third stage (**e**). Suspect areas were marked using ThermaCAM software (**c**, **d**). (Reproduced from Bauer, J., Grabarek, M., Migasiewicz, A. et al. Non-contact thermal imaging as potential tool for personalized diagnosis and prevention of cellulite. J Therm Anal Calorim 133, 571–578 (2018))

The first was described by Nürnberger and Müller [18] and included three grades:

- Grade I: Skin is smooth at rest.
- Grade II: Skin demonstrates a mattress or orange peel appearance at rest.
- Grade III: Skin has grade II features and nodules intermixed with raised and depressed areas at rest.

More recently, other scales have been proposed, being the **Cellulite Severity Scale (CSS)** (Tables 41.1 and 41.2) [34] the most commonly used, which has shown an excellent reliability and internal consistency when used to evaluate cellulite of the buttocks and posterior thighs [16].

Table 41.1 Photonumeric Cellulite Severity Scale [34]

Photonumeric severity scale	Score
Number of evident depressions	0 = None/no depressions 1 = A small amount: 1–4 depressions are visible 2 = A moderate amount: 5–9 depressions are visible 3 = A large amount: 10 or more depressions are visible
Depth of depressions	0 = No depressions 1 = Superficial depressions 2 = Medium depth depressions 3 = Deep depressions
Morphological appearance of skin surface alterations	0 = No raised areas 1 = "Orange peel" appearance 2 = "Cottage cheese" appearance 3 = "Mattress" appearance
Grade of laxity, flaccidity, or sagging skin	0 = Absence of laxity, flaccidity, or sagging skin 1 = Slight draped appearance 2 = Moderate draped appearance 3 = Severe draped appearance
Classification Scale by Nürnberger and Müller	0 = Zero grade 1 = First grade 2 = Second grade 3 =Third grade

Table 41.2 Scoring system of the Cellulite Severity Scale and Cellulite Classification [34]

Cellulite Severy Scale	Classification
1–5	Mild
6–10	Moderate
11–15	Severe

41.5 Treatment

Although no cure for cellulite exists, multiple treatments have been developed over the years to try to improve its appearance [1, 2, 11] (see Table 41.3). These treatments should have a multidirectional action, and patients should be informed that they will not eliminate the problem but rather offer a temporary improvement [10].

In light of its etiology, two criteria have been proposed to consider a treatment effective: it must both expel the fat protrusions back beneath the dermis and strengthen the dermis to prevent further protrusions [35]. The treatments available display these criteria in different degrees.

From the multiple studies that have aimed to analyze the effectiveness of different treatment modalities, most authors agree that the best effects are obtained by combined therapy [5, 10, 35–37].

41.5.1 Noninvasive Treatments

41.5.1.1 Topical and Oral Treatments

Numerous topical cosmeceutical ingredients have been reported to improve the appearance of cellulite, including caffeine, retinoids, and botanical extracts. Although it has been hypothesized that these ingredients cause the lipolysis of the adipose tissue, the stimulation of the peripheral

Table 41.3 Some devices available in the market with their proposed modes of action and advantages

Device	Mode of action	Advantages
THORK Shock Way®	Electromagnetic shock wave therapy	Energy is applied on target zones, avoiding damage to surrounding tissue
Utrashape®	High intensity-focused ultrasound	Energy is concentrated in selected subcutaneous areas, preventing excessive damage to surrounding tissue
Velasmooth®	Bipolar radiofrequency, infrared light, suction, and mechanical massage	Increase of deeper skin temperature without damage to the skin surface
Alma Accent®	Unipolar and bipolar radiofrequency	Increase of deeper skin temperature without damage to the skin surface
TriActive®	Low-dose laser, contact cooling, massage and suction	Combination of energy-based and mechanical stimulation techniques
SmoothShapes®	Laser, biostimulating light, massage, and suction	Combination of energy-based and mechanical stimulation techniques
VaserSmooth®	Ultrasound-assisted liposuction with a cutting cannula	Decreased bleeding compared to traditional liposuction, combines cellulite correction and fat removal
Smartlipo®	Liposuction with Nd:YAG (1064-nm) laser	Less invasive than traditional liposuction, combines liposuction with skin tightening
Cellfina®	Tissue-stabilized guided subcision system	Precise control of anesthesia infiltration and treatment depth and area
Endermologie®	Machine-assisted massage system that combines positive and negative pressure to the skin	Greater potency than manual massage
3DEEP®	Multisource radiofrequency system	Exact energy delivery customized in real time to individual patient's skin impedance

microcirculation to facilitate lymphatic drainage, and the reduction of edema, there is little evidence that topical treatments have a potential positive effect on the appearance of cellulite [7, 11, 38, 39]. Furthermore, given that cellulite is a condition that develops over years, several months may be necessary before the effect of any treatment may come apparent [5].

Topical treatments are most often used to treat mild-to-moderate cellulite and as an adjuvant treatment for severe cellulite. These substances can be divided into four groups according to their proposed mechanism of action [38]:

- **Increase microcirculation flow**: *Ginkgo biloba, Pentoxifylline, Centella asiatica, Ruscus aculeatus, Silicium, papaya (Carica papaya), pineapple (Ananas sativus), red grapes (Vitis vinifera), Cynara Scolymus, Ivy, Melilotus officinalis*
- **Reduce lipogenesis and promote lipolysis:** *Methylxanthines, B-adrenergic agonists, A-adrenergic antagonists*
- **Restore the normal structure of dermis and subcutaneous tissue**: *Retinol (vitamin A).*
- **Prevent free radical formation or scavenge free radicals**: *Alpha-tocopherol (vitamin E), ascorbic acid (vitamin C), Ginkgo biloba, red grapes (Vitis vinifera).*

Special attention should be given to three agents that appear to be giving some benefit:

- **Aminophylline** is believed to help in the breakdown of fat and cellulite by activating enzymes, which cause the release of fat stores and ultimately lead to a smoothing effect on the skin [35].
- **Retinoids** have a known effect of increasing dermal collagen fibers, thus strengthening the

dermis and improving the strength of the hypodermal septa [35, 39]. Retinol (vitamin A) can also act as an antiadipogenic agent by inhibiting the differentiation of human adipocyte precursor cells [38].

– **Methylxanthines**, such as caffeine, aminophylline, theophylline, and theobromine, are B-agonists and are the main category with documented action in the treatment cellulite. The most useful and safest is caffeine, which acts directly on adipose cells, promoting lipolysis. Caffeine also has a stimulating effect on the cutaneous microcirculation [38].
– **Peroxisome Proliferator-Activated Receptors (PPAR)** and their agonists, including petroselinic acid and conjugated linoleic acid (CLA), are a recently discovered family of nuclear transcription factors that have shown to enhance skin tightening and reduce adipose invagination into the dermis [5].

Many of the agents used in topical treatments are also used in oral supplements for the treatment of cellulite, such as PPAR agonists (notably CLA) or *Centella asiatica* extracts, which can also be found in combined formulations, such as **Cellasene**, which contains *Ginko biloba, sweet clover, sea weed, grape seed oil, and evening primrose oil*. Although their efficacy has not been proven, they appear to provide some relief from the symptoms of cellulite [5].

41.5.1.2 Mechanical Stimulation

Massage will reduce edema, there is also some evidence for increased collagen synthesis and stimulation of fibroblast (and keratinocyte) activity while decreasing adipocyte activity [5]. Mechanical stimulation of the skin is supposed to stimulate microcirculation as well as lymphatic drainage to improve lymphedema, which may improve the appearance of cellulite. Presumably, it causes damage to the subcutaneous fat cells that subsequently rebuild with an improved distribution that evens skin contour. It also enhances the presence of longitudinal collagen bands through the tensional stimulation of fibroblasts. However, its efficacy is not clear [11].

Mechanical stimulation can be carried out manually or through a device. Device-based modalities, such as **Endermologie**, deliver positive pressure to the skin and subcutaneous tissue via rhythmic folding and unfolding as well as negative pressure through aspiration. It has shown improvement in cellulite grading and a reduction in thigh circumference in some studies, although its long-term efficacy and the longevity of these effects is still questionable [5, 7, 11, 35, 39].

41.5.1.3 Noninvasive Body Contouring Devices

In the recent years, noninvasive body contouring devices have become one of the most widespread procedures and are growing fast in areas of esthetic medicine. Some have shown statistically significant effects on body contouring, removing unwanted fat and cellulite. However, the effect of such devices have been reported to be mild to moderate [2]. Plus, no long-term clinical studies have ever been carried out with these devices in the treatment of cellulite; therefore, maintenance therapy will be required for continued improvement in most patients [40].

– **Electromagnetic Shock Wave Therapy (ESWT)**. Although its full mechanism is not clear yet, it seems to be based on the conversion of electrical energy to mechanical energy on target zones, avoiding damage in the surrounding tissue, which can improve local blood circulation, mechanoreduction, induce lipolysis, and/or apoptosis of the adipose cell. Studies show improvement of degrees of cellulite severity as seen in Fig. 41.5, gross elasticity, and skin deformation ability, with improvement in the quality of life. Devices include *THORK Shock Wave* [1, 2, 7, 11, 41–43].
– **High Intensity-Focused Ultrasound (HIFU).** Ultrasound waves can induce adipocyte destruction by various mechanisms such as cavitation and thermal damage. Devices include *LipoSonix, Proslimelt, Medcontour, Ultracontour, Novashape, Accent Ultra, and Ultrashape*. Although the Federal Drug Administration (FDA) has not approved them for cellulite treatment, ***Ultrashape*** has shown

Fig. 41.5 Improvement of the Cellulite Severity Score in a female patient suffering from cellulite before and 3 months after six sessions of focused Extracorporeal Shock Wave Therapy (Reproduced from Knobloch, K., Joest, B., Krämer, R. et al. Cellulite and Focused Extracorporeal Shockwave Therapy for Non-Invasive Body Contouring: a Randomized Trial. Dermatol Ther (Heidelb) 3, 143–155 (2013)) [55]

to decrease subcutaneous fat tissue thickness [2, 35, 39, 44].

– **Cryolipolysis** is based on the sensitivity of adipocytes to cold in comparison with other water-rich cells. Therefore, the application of cooling panels on the target zone provokes the apoptosis of fat cells without damaging the circumambient tissue. It is usually carried out through cup-shaped applicators with two cooling panels, where a vacuum pulls the tissue and draws the target zone between cooling panels. It has been proved effective for patients with separate fat bulges. It presents the advantage of being operator-independent but the disadvantage of long-treatment sessions [2].
– **Radiofrequency (RF)** generates heat in different tissues by transforming energy from an electromagnetic field to the target tissue, in a monopolar, unipolar, bipolar, or multipolar modality. This results in an increase of deeper skin temperature without epidermal or dermal ablation, which leads to collagen denaturation and tissue tightening. In addition, the heat that is delivered to the subcutaneous layer is presumed to be absorbed by adipocytes inducing their apoptosis. Several RF devices are available, including V*elaSmooth and VelaShape, Thermage, Alma Accent and Accent XL, 3DEEP, Exilis, ThermaCool, TriPollar, Venus Freeze, Viora Reaction,* and *TiteFX*. Some of these devices combine RF with other modalities of treatment, such as ***Velasmooth*** that combines bipolar RF with infrared light, suction, and mechanical massage, or ***Alma Accent*** that combines unipolar with bipolar modalities. Some have been approved by the FDA for their use in cellulite treatment and have shown to be useful in the treatment of cellulite (Fig. 41.6), although more studies are needed [2, 7, 10, 11, 35, 39, 40, 45].
– **Laser and light-based devices**. Different laser devices using various wavelengths have been studied for the treatment of cellulite. Noninvasive long-pulsed 1064 nm neodymium-doped yttrium aluminum garnet (Nd:YAG) lasers would deliver thermal energy into the deep dermis and the hypodermis to generate a wound-healing response that promotes the for-

Fig. 41.6 Before and after five sessions of Alma Accent (RF–Accent – Alma Lasers). Improvement of the skin depressions in number and depth on the buttocks (Reprinted from ravo BSF, Torrado CM, Issa MCA. Non-ablative Radiofrequency for Cellulite (Gynoid Lipodystrophy) and Laxity. In 2018. p. 375–88) [56]

mation of new collagen. Minimally invasive pulsed 1440 nm Nd:YAG laser would smooth the uneven dermal-hypodermal interface by selectively melting the hypodermal adipocytes that protrude into the dermis. In addition, it would sever the hypodermal septa that connect the dermal and muscle layers by thermal subcision and heat the dermis from the inside out to increase dermal thickness and skin elasticity by stimulating neocollagenesis and collagen remodeling. While there is very little evidence that the noninvasive use of 1064 nm Nd:YAG lasers is effective, the minimally invasive 1440 nm lasers seem to significantly improve the clinical appearance of cellulite, decrease dimple depth, the number of dimples, and smoothen the contour of the skin. **Low-Level Laser Therapy (LLLT)**, which works at a 645 nm wavelength, is thought to stimulate collagen synthesis [2, 11].

One study showed that the subdermal application of the Nd:YAG laser combined with autologous fat transplantation is a safe and effective treatment for cellulite [46].

– **Infrared light (IR) and Intense Pulsed Light (IPL)** also have a role in the treatment of cellulite. They are supposed to promote microcirculation, lymphatic drainage, and collagen synthesis through the heating of the skin [35].

Devices that combine laser and light-based radiation with mechanical stimulation are frequently used.

– **TriActive** combines low-dose laser, contact cooling, suction, and massage and has shown results comparable to other available treatments.
– **SmoothShapes** combines laser, biostimulating light, massage, and suction and has also shown improvement in the appearance of cellulite although its results are short-lived [2, 10, 11, 35].

41.5.2 Invasive Procedures

41.5.2.1 Subcutaneous Injections

Mesotherapy involves the subcutaneous injection of compounds with the intention of inducing lipolysis and improving the appearance of cellulite. They usually contain a mixture of herbs, vasodilators, anti-inflammatory medications, or hormones, such as *methylxanthines (caffeine), aminophylline*, and *theophylline*, which cause lipolysis. The one ingredient most consistently used is *phosphatidylcholine*, which has proven to cause panniculitis with necrosis and lipoatrophy in the site of injection. However, the substances currently in use have not been thoroughly evaluated for safety or efficacy [35, 39, 47].

Carboxy therapy is a treatment in which carbon dioxide is injected into the subcutaneous tissue. This would create a hypercapnic environment, causing a rise in capillary blood flow, a drop in cutaneous oxygen consumption, or a right shift of the oxygen-dissociation curve (Bohr Effect),

which would facilitate the physiologic oxidative lipolytic process [5].

Collagenase injections can also be used to break the connective tissue septa that cause the dimpling [11].

41.5.2.2 Liposuction

Liposuction is not a unanimously accepted treatment for cellulite. Some authors argue that conventional liposuction reduces fat tissue content but does not directly act on the factors that cause cellulite and can increase skin irregularities. However, superficial liposuction exists, which is executed close to the dermis and can release subcutaneous fibrous septa. Its use on cellulite near the skin surface with only a thin layer of dermis dividing it from the epidermis often leads to increased dimpling of the skin and can cause skin necrosis from devascularization after extensive undermining, which constitutes an important limitation [35, 39]. However, some studies have showed some improvement in cellulite appearance after surgical treatment using liposuction and the release of the fibrous tissue bridges with blunt, thin cannulas [48].

Laser-Assisted Liposuction

Laser-assisted liposuction is often a preferred option for the treatment of localized adiposities and is a frequent treatment for cellulite. The Nd:YAG (1064-nm) laser such as ***Smartlipo*** targets selected areas of fat for destruction in addition to simultaneously tightening the skin. This technology is less invasive compared to conventional liposuction, as it employs a smaller cannula, and the application of laser pulses selectively damages adipocyte membranes while coagulating, promoting collagen tightening and hemostasis [39, 49].

Ultrasound-assisted liposuction (*Vaser)* has demonstrated increased skin retraction and, when utilized with a cutting cannula (VaserSmooth), may be an effective treatment for areas of cellulite, with decreased blood loss compared to traditional liposuction [49].

Recently, a new surgical technique has been proposed that combines liposuction, including wide areas of undermining and release of fibrous septa, with autologous fat grafting for smooth structural support of the subcutaneous tissue. Although more studies are needed, this technique appears to be a safe and effective treatment, with high level of patient satisfaction, sustained results after long-term follow-up, and a low incidence of surgical revision and post-treatment complications [49].

41.5.2.3 Subcision

Subcision is an invasive procedure in which, following local anesthesia, a 16 or 18 gauge needle or a blade is inserted parallel to the epidermis into the subcutaneous fat to shear the septa separating the fat lobules, interrupting the architecture of the protruding fat cells. Subcision is recommended for cellulite depressions present at rest, not for depressions visible only with muscle contraction. Depressions are marked immediately preprocedure with the patient standing in a relaxed position. The procedure may be carried out manually, combined with upward traction, or vacuum-assisted (**Cellfina system**), which provides a precise control of anesthesia infiltration, treatment depth, and area and has demonstrated long-term efficacy and safety. Post treatment recommendations should include avoidance of strenuous physical activity for 1–2 weeks and use of a compressive garment for 2–4 weeks. Post treatment adverse events include painful bruising and hemosiderin pigmentation in almost all patients. Therefore, repeat manual subcision should be avoided for at least 2 months from initial therapy or until all bruising or hemosiderin pigmentation from that first session has resolved. Subcision can temporarily improve the skin dimpling seen in cellulite-prone areas. However, its long-term efficacy remains controversial [7, 35, 39, 49–53].

No systematic tool exists to measure the outcomes after cellulite treatment, which makes it difficult to compare studies on the efficacy of dif-

ferent treatment modalities. Real-time scanning ultrasound image, three-dimensional optical skin surface measurement, clinical photographing, historical findings, or personal questionnaires are often used for this purpose [2].

Pearls and Pitfalls

- *Vacuum-assisted subcision, and more precisely the Cellfina device, has recently proven to be a long-term effective and safe treatment for cellulite.*
- *A new technique that combines liposuction with autologous fat grafting of the subcutaneous tissue has recently been proposed with promising results.*
- *No systematic tool exists to measure the outcomes after cellulite treatment, which makes it difficult to compare studies on the efficacy of different treatment modalities.*

41.6 Lifestyle

Lifestyle has been associated with the aggravation of cellulite appearance through different mechanisms [6, 10]. Therefore, all treatments should be accompanied by the control of aggravating factors, with a focus on a well-balanced diet and exercise.

41.6.1 Diet

An imbalanced diet, with excessive food intake and alcohol consumption, can exacerbate cellulite development and appearance in various ways. Excessive intake of food causes metabolic disorders including hyperinsulinemia, which can increase lipodystrophy. Alcohol consumption stimulates lipogenesis and causes body dehydration, resulting in the excessive and improper storage of fat. In addition, an overall excess in body fat causes adipocytes to become hypertrophic with a progressive reduction of microcirculation locally as individual cells constrict each other [6].

41.6.2 Exercise

A sedentary lifestyle or the lack of physical activity increases the severity of cellulite by weakening the muscle layers of blood vessels and causing local hemostasis, which leads to secondary hypoxia and ischemia of the adipose tissue [6].

41.6.3 Weight Loss

Weight loss has proven to have dual effects on cellulite appearance. Studies show that in the majority of subjects, cellulite severity decreases following weight loss, especially in those with higher body mass index. However, in some cases, it may have the opposite effect. This may be caused by septa acting as a tethering system, thus worsening the typical dimpling pattern or skin laxity with major weight loss, or an increase in skin looseness, which can adversely affect skin dimpling [11, 16, 39].

41.6.4 Smoking

Smoking provokes a greater amount of free radicals and contraction of small blood vessels responsible for local micro-circulatory impairments [6]. Also, as reported previously, smoking has been linked to the ACE gene polymorphism and an increased risk of developing cellulite.

41.7 Conclusion

Cellulite affects the majority of post pubertal women and remains a major cosmetic concern. Although its precise etiology is still not clear, it is considered multifactorial with sex-related differences in skin architecture, connective tissue, inflammatory factors, hormones, and genes playing a major role. Cellulite is known to worsen during high estrogen states, including pregnancy, nursing, and chronic use of oral contraceptives. No cure for cellulite exists; however, some treatments have shown to be effective for improving

its appearance with combined therapies having the best results. It is not clear whether weight loss or exercise can improve the condition, but they may have some positive effects.

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Gluteal Reshaping

42

Alexander Aslani and Miguel G. Bravo

Take-Home Points

- When approaching a post-pregnancy patient, attention should be payed to the gluteal region as an affected area that might need to be repaired as well.
- Different techniques can be used and the decision for the appropriate treatment should heavily consider patient goals and expectations.
- Both patients and surgeons should not underestimate the risks and potential complications of these procedures and specific training for plastic surgeons is encouraged.

42.1 Introduction

42.1.1 The Buttocks as a Secondary Sexual Character

Among the populations of Asia, Africa, and Europe, the buttocks are some of the most prominent features in the bodies of women. This is in combination with the hips, which are considered to be a feature of beauty among the people of these continents. Moreover, it is important to consider the manner through which these features are looked upon. Large hips and buttocks are a measure of beauty for a diversity of people, and this is to such an extent that it is an important feature in the body image of women [1]. Large hips and buttocks are what is used to differentiate men from women, and while it is a structural deviation of the female from the male, it also functions as a secondary sexual characteristic. It stands for the reproductive function of women in such a way that it inspires arousal from men. Thus, apart from being a feature of beauty, its characteristic as an aspect of sexual arousal means that the buttocks are a critical part of the process of natural selection [2]. Women with larger buttocks are more likely to attract mates than those who are less endowed, meaning that the buttocks are an aspect of beauty and sexual arousal that cannot be ignored. From a social and cultural perspective, the buttocks play an important role in the enhancement of the beauty of women and provide them with the means of making sure that they are able to attain a level of attractiveness that makes the men around them aroused. The buttock is therefore a necessary feature in women, and it is especially a matter of concern for women who are at the post-maternity stage following the considerable body changes that they have experienced.

A buttock that is properly developed is one of the most fundamental characteristics of the human body that is not seen in other creatures, especially primates. This is to such an extent that

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_42

it is one of the most important aspects of female beauty, because it involves a situation where it is viewed as a consistent cornerstone of the beauty found in women [3]. Thus, while the concept of female beauty has changed over time and it varies from culture to culture, there are two consistent major elements that have remained the same: the buttocks and the breasts. The definition of beauty based on the buttocks tends to vary from culture, ethnicity, and time, resulting in a scenario where a buttock type that is appealing in one part of the world may not have the same reception in another. In recent years, especially with new techniques in plastic surgery, there has been an increase in demand for buttock enhancement surgery. This process often involves the correction of either an irregularity or deformity, depending on the needs of the patient. Procedures such as buttock contouring have increasingly become a prominent procedure for many doctors, and this is the reason why a considerable number of women, especially those that have experience post-maternity body changes, are increasingly seeking to undergo the procedure. Over the last two decades, it has become common for individuals, especially women, to undergo procedures to improve their buttocks.

The gluteal region of the human body is one of the most significant secondary sexual characteristics, and it is considered a hallmark of beauty, especially among women [4]. Studies have been conducted with the aim of identifying the manner through which this region not only affects the way that individuals are perceived but also based on the characterization of the region based on such factors as weight gain and loss, as well as aging. The definition of beauty of the buttocks is one that is based on its perception, where it is seen as being well-rounded and symmetric with the greatest part of its projection being in the middle and upper thirds. The development of the buttocks varies from one individual to another, and because of this circumstance, women tend to have very different experiences, especially in the post-maternal period where they have considerable physical changes. Some may require some plastic surgery as a means of correcting any negative changes to the beauty of their gluteal region; a considerable number of women do not require it, and instead, they end up either adapting to their new look or maintaining the look that they had prior to having a baby. However, with the advances in plastic surgery, it has become common for women experiencing post-maternal changes to undergo surgery as a means of making sure they not only maintain the symmetry of their buttocks but also enhance its beauty. Thus, as a secondary sexual characteristic, the buttocks remain a critical part of the way women view themselves, and plastic surgery provides them with the means of greatly improving their look and their sexual appeal.

Any form of buttock restructuring, including contouring, is a complex process which requires that the surgeon undertakes a number of evaluations prior to doing the procedure. Among the most significant of these, especially in the modern world, it is to ensure the individualization of the patient evaluation in a manner aimed at the selection of the proper surgical procedure to undertake. The latter process is pertinent to the attainment of desired results. Buttock contouring, for example, is a procedure that is increasingly becoming popular based on the number of individuals demanding it [5]. There are a number of surgical modalities available for use in the procedure, and these can either be used independently or in a combination to ensure the attainment of the best results possible. Favorable results tend to come about mainly through the selection of the proper procedure or a combination of procedures. Good results also come about through undertaking an evaluative process that is thorough and involves the perfect selection of the patient and the procedure best suiting them, careful planning, and the refinement of surgical techniques. Through the careful handling of the entire procedure, the surgeon is better able to ensure that good results are attained and that the patients receives the buttock form that they desire.

42.1.2 Changes in Buttock Appearance After Pregnancy

The physical changes that take place in women following pregnancy are quite significant because they involve an increase in weight and a softening of some of the tissues in the body. Post-maternity physical changes tend to have a more negative effect on some women than on others to such an extent that they end up not feeling that their bodies are appealing. There are certain body parts that tend to be susceptible to changes that come about following the stress that is endured during the pregnancy. While the most obvious changes often appear in the breasts and abdominal areas, the buttocks tend to also be significantly affected to such an extent that they end up not having the shape that they had prior to the pregnancy. Buttock appearance after pregnancy is often a matter of concern for some women because of their desire to ensure that they not only look their best but also have the level of attractiveness that is only enhanced through the buttock being an essential secondary sexual character. Women are increasingly seeking avenues through which they can improve their buttock appearance following pregnancy, and this process can be considered essential because of the diversity of choices that they have to choose from including plastic surgery procedures. Post-maternity body changes, especially those in the buttocks, are extremely difficult to handle in the case of most women, and their desire to return as close as possible to their original buttock shape is based on this part of the body being greatly appreciated for its beauty by individuals from a diversity of cultures across the world. Therefore, there is the need to understand the processes leading to body changes in the buttock area in the post-maternity period.

Following pregnancy, the appearance of the woman involved tends to have changed considerably. The physical change comes about because during pregnancy, hormones tend to flood the body to such an extent that they not only alter certain behaviors, such as eating habits, but they also play an active role in bringing about the alteration of the body shape. These hormones are essential for the growth of a healthy baby while at the same time preparing the woman's body for the birth. However, a consequence is that it leads to the side effect of the body undergoing changes that greatly affect their appearance. One of the most significant hormones in the process of pregnancy is relaxin, which is produced to help the cervix and uterus for birth [6]. However, these hormones are also the main culprit when it comes to the alteration of the buttocks, because it causes it to sag. It is produced by the ovaries and placenta, and they play an important role in causing the relaxation of the muscles and ligaments. Thus, it ends up affecting the entire body and makes it possible for the woman involved to undergo the birthing process more effectively. It is however necessary to note that a considerable number of women do not recover their pre-pregnancy bodies after birth, a process that takes a lot of hard work and patience in order to achieve. This process is essential because the body takes some time in order for it to return to normal post-maternity. Despite the latter being the case, it is noteworthy that the buttocks tend to end up not going back to normal because during pregnancy, the soft tissue and skin tend to be the most affected by hormones that flood the body. An understanding of the physical changes that take place in this period and the processes that lead to the sagging of the buttocks is therefore essential.

The buttocks contain a trio of muscle groups, which allow it to determine its shape. Among these are the gluteus minimus, gluteus medius, and gluteus maximus [7]. Whenever changes occur to them, especially during pregnancy, they are immediately noticeable because these muscles are quite big. The noticeability comes about especially in slim women because they do not have any overly fat that might obscure any changes that occur to their buttocks. Furthermore, during pregnancy, the loosening of the skin and soft tissue often has an impact on the way that their buttocks look because the shape and at times size changes [8]. In certain circumstances, such as when the woman is approaching menopause, there is a significant drop in the levels of estrogen in their bodies, which result in a scenario where the fat distribution in their bodies end up shifting

in such a way that it moves from their hips toward their stomach. A consequence is that their buttocks end up appearing flatter to such an extent that they not only make their buttocks unappealing to look at, but there is also the alteration of their body shape. Pregnancy and the post-maternal body changes play a significant role in the process and make it difficult for the body to return to its previous shape. The body changes that take place among women in pregnancy and in the post-maternity periods and affect the buttocks tend not to take place in isolation.

Other secondary areas of the body such as the arms, thighs, lower legs, and labia minora are also adversely affected by the hormonal fluctuations in the body. The latter, along with changes in weight, often lead to these areas changing considerable because they end up losing their original shape [9]. Moreover, there is often a situation where there is a change to the skin of the mothers in such a way that they end up showing such features as stretch marks, cellulite, and skin thinning, which may occur because of the numerous hormonal changes in the body. Women undergo very different experiences during pregnancy, and it is mainly for this reason they end up attaining such different results following their period. Thus, as seen above, while some may regain their full buttocks and return to normal after the birth of their baby, the same is not often the case among others. These individuals require undertaking such measures as dieting and physical exercise as a means of achieving the goal of improving the esthetic aspects of their bodies, specifically the buttocks, which, following pregnancy, often loses its original shape. It leads to circumstances where it is necessary for external actions to be undertaken as a means of bringing about the attainment of the buttock shape that is desired by the woman involved.

42.2 Patient Selection

The gluteal region can be improved through a diversity of surgical techniques, and it can be combined with other post-pregnancy surgical procedures. These techniques include the use of silicone implants, liposuction, lipofilling, and the use of local flaps [10]. The aim is to restore and redistribute volume in the buttocks. The second important feature is restoration of a more feminine waist-to-hip-ratio (WTHR). Restoration of WTHR can be achieved by 360-degree liposculpture and fat transfer to the hips in properly selected patients, but in post-pregnancy bodies, liposculpture alone may not be able to restore abdominal wall firmness. Additional muscle repair with abdominoplasty is often warranted.

42.3 Preoperative Evaluation

During preoperative evaluation, as in other plastic surgery procedures, goals and expectations of the patients should be properly understood in order to provide the best solution for each specific case. See key points for most common indications.

Key Points

During preoperative evaluation, consider patient goals and expectations:

- To increase lateral view projection: Consider composite buttock augmentation using implants and fat transfer.
- To restore the shape and get an hourglass figure: Consider intense waist liposuction and fat transfer to the hips.
- To restore abdominal wall firmness: Consider fat transfer to the hips and buttocks in combination with an abdominoplasty.

42.4 Anesthetic Considerations

All surgical procedures involving gluteal reshaping in our practice are performed under general anesthesia. A combination with a spinal block should be considered as it provides a proper pain control during the early postop.

42.5 Surgical Techniques

42.5.1 Body Feminization Liposculpture

This procedure is commonly named "Brazilian butt lift."

We perform body feminization under general anesthesia. Patients are prepped all around standing up and placed on sterile sheets. The procedure is started in a supine position. Incisions are made in the bikini line and periumbilical. More incisions may be necessary depending on the torso length of the patient.

For liposuction, we favor a modified version of the SAFE liposuction technique as published by Wall with wetting solution typically used in a 1:1 or 1.5:1 ratio of infiltration to aspiration in primary cases [11]. The tumescent infiltration solution consists of 1000 mL of saline together with a 1-cc ampule of adrenaline.

We separate the fat with a 5 mm exploding tip cage cannula connected to a vibrating handpiece (Microaire, Inc. Charlottesville, Va.). Suction of the separated fat is then done with a 5 mm, 10-hole cannula.

Aspirated fat is collected in a sterile cannister.

Once liposuction is finished from the front side, patients are turned into prone position. Since all prepping has been done sterile, they are turned on sterile sheets, and no additional prepping is necessary.

In prone position, more bikini line incisions are made close to the posterior iliac spines and the apex of the gluteal cleft.

In the prone position, liposuction focusses most on the lower back area (love handles) to achieve circumferential reduction of the waist as possible.

The fat harvested during this 360-degree liposuction is not processed in any specific way except for decantation (Fig. 42.1).

In preparation for buttock-shaping fat grafting, we then change the 5 mm cage for a 4 mm cage cannula. With the 4 mm cannula providing excellent palpatory control, fat is grafted with continuous movements at 200–300 mL/min at 5000 vibrations strictly into the subcutaneous space. This technique is commonly named expansion-vibration lipofilling (EVL) first published by delVecchio [12] (Fig. 42.2a–d).

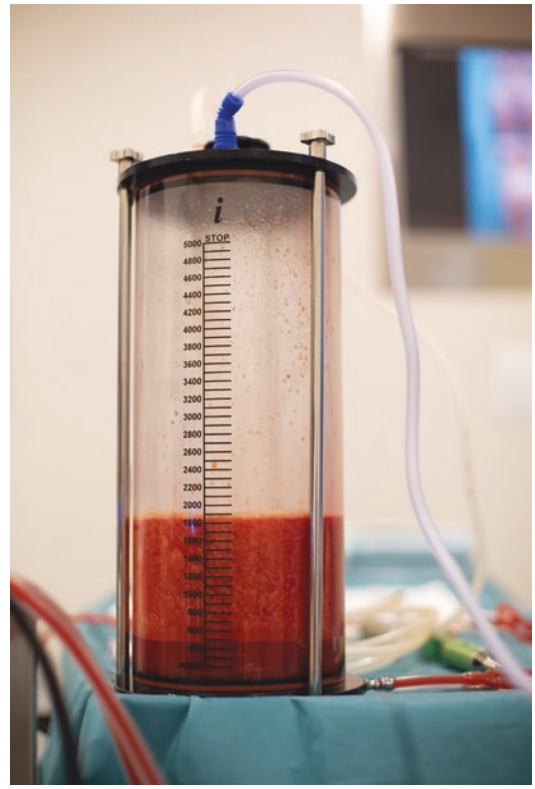

Fig. 42.1 Fat decantation

Intramuscular injection must be avoided by all means, since it has been associated with fatal fat embolism [13].

42.5.2 Supercharged (Composite) Brazilian Butt Lift

Not all patients have sufficient donor fat to deliver sufficient volume increase to the buttocks, or they have very little projection, in other words flat, buttocks.

Here, a combination of buttock implants and fat grafting can achieve good results. We favor a progressive blunt instrument dissection technique as it creates a pocket that is at the ideal

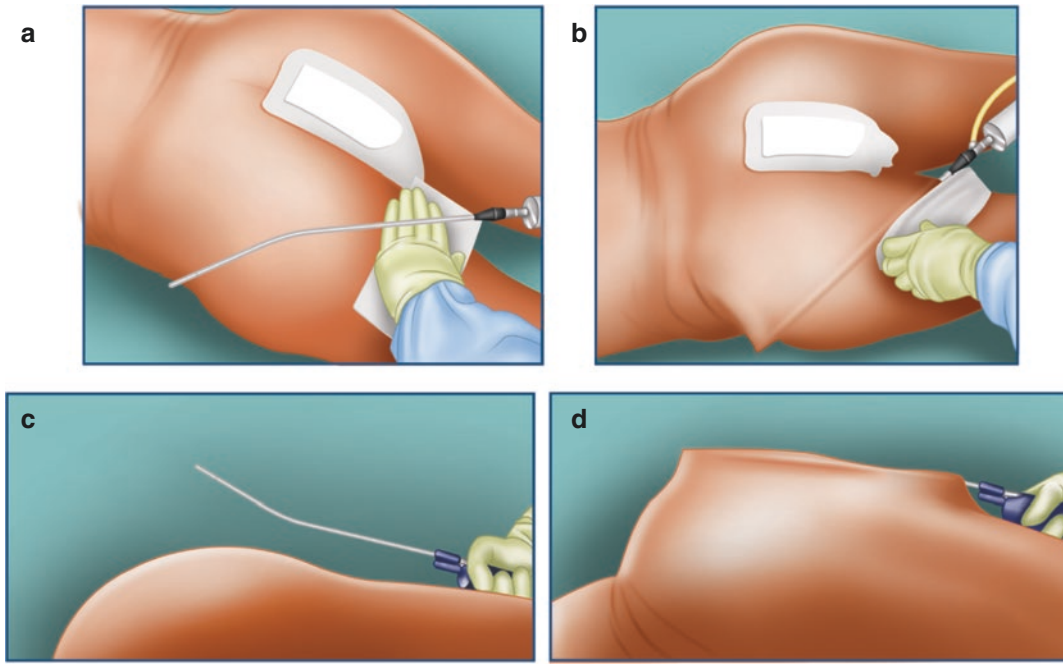

Fig. 42.2 (**a**–**d**) Expansion-vibration lipofilling steps

muscle depth and is just large enough to hold the implant with minimal tissue trauma through the dissection (Fig. 42.3).

The implants are placed into a deep intramuscular plane, and fat grating can be performed before or after implant placement (Fig. 42.4).

Supercharged buttock surgery does not carry any risk of fat embolism and provides very stable, consistent results [14].

42.5.3 The Brazilian Mommy Makeover

In post pregnancy surgery, patients often present with an abdominal bulging due to musculus rectus abdominis muscle distension and significant skin laxity or even overhang.

In these cases, abdominoplasty can be performed together with Brazilian butt lift.

The procedure is started similar to a conventional Brazilian butt lift, only should liposuction on the abdomen superior to the semilunaris line be limited to deep fat and avoid the areas of intercostal perforators.

Brazilian butt lift is performed as usual, and after completion of the Brazilian butt lift, the patient is turned back into supine position, and abdominoplasty is completed.

Abdominoplasty with BBL is a very powerful combination achieving great results in post-pregnancy surgery (Fig. 42.5).

Patients have to be nursed in supine position after surgery, which is not ideal for the grafted buttocks, but long-term experience has shown us that results are still very good and not sig-

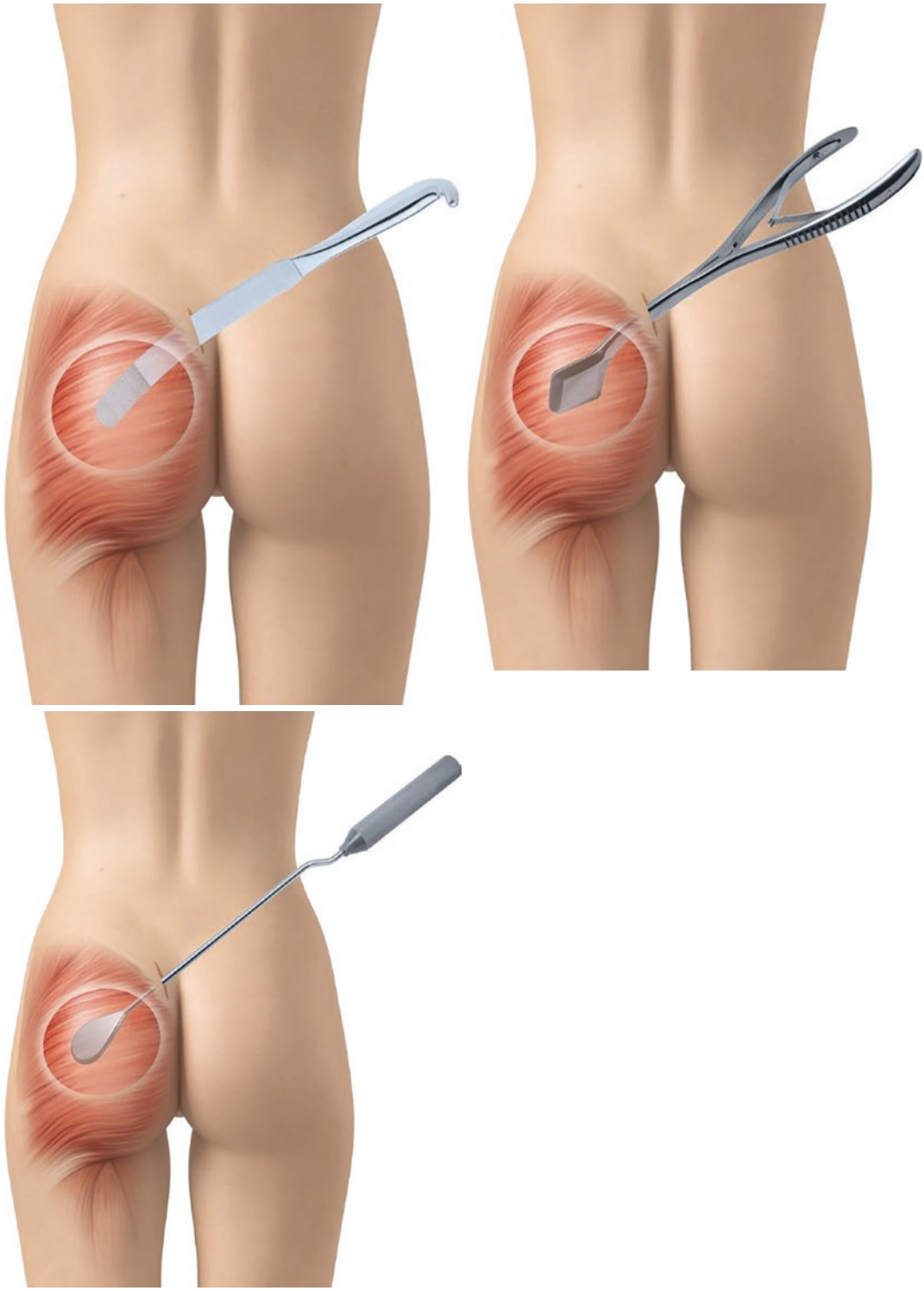

Fig. 42.3 The three steps of progressive blunt instrument dissection technique

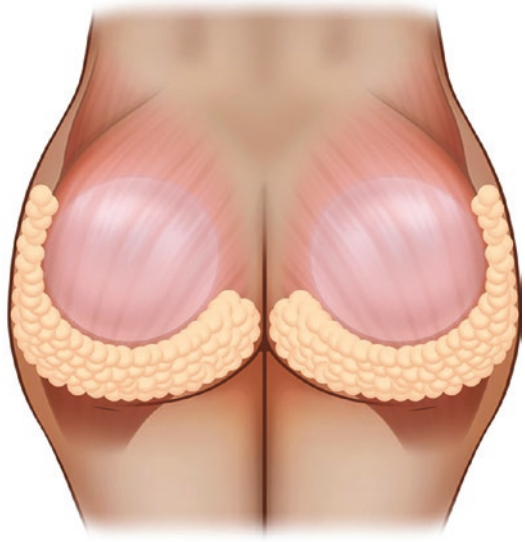

Fig. 42.4 Composited buttock augmentation using both implants and fat grafting

nificantly different to conventional Brazilian butt lift.

For safe performance of abdominoplasty combined with BBL, operating room efficiency is key. Full 360 prepping of patients, theater staff drilled in swift repositioning, and swift wound closure techniques such as running quill sutures or absorbable staples help to keep total surgery time within 3 h. Antithrombotic prophylaxis should be followed using the Caprini score, and perioperative antibiotherapy is given.

It is important to emphasize that we limit the indication for such combination surgery to abdominoplasty. We do not currently perform buttock implants together with abdominoplasty due to concerns of pressure distress to the gluteal muscle flap embracing the implants when patients are nursed in the supine position.

Fig. 42.5 Brazilian mommy makeover case. Before and 3 months after the procedure. Oblique view (**a**, **b**); Frontal view (**c**, **d**); Posterior view (**e**, **f**)

42.6 Complications [15–17]

Complications are listed in Table 42.1.

Table 42.1 Complications associated with gluteal reshaping

Autologous fat	Silicone implants
Skin irregularities	Wound dehiscense
Infection	Seroma
Seroma	Infection
Fat resorption	Paresthesia
Oil cysts	Implant exposure
Fat embolism	Chronic pain
Complication rate 8%	**Complication rate 20–40%**

42.7 Conclusion

The popularity of buttock surgery requires that surgeons are more careful in their handling of patients because, as with other surgeries, the complications, namely, fat embolism, might be fatal. The appearance of the buttocks changes after pregnancy, and patients often require an assessment of this area during the plastic surgery consultation. Provided high theater efficiency, we are able to combine surgical procedures in one surgery to better enhance the body contour of our after-pregnancy patients.

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Thigh Liposuction

43

Mónica Rubio Yanchuck
and Carlos del Pilar Bérniz Laborda

Take-Home Points

- During pregnancy, metabolic changes favor the accumulation of fat depots at the trochanteric level, which causes expected changes in the morphology of women.
- The incorporation of the diet and the exercise program will help to get better results of the surgery and will allow its maintenance in the time.
- Herbal medicines and certain foods may have an unfavorable interaction with surgery They should be abandoned 3 weeks before surgery.
- Knowledge of the regional anatomy and characteristics of fat at the thigh level is essential to carry out a correct procedure and achieve optimal results without complications.
- Liposuction in the superficial plane or crossing the adhesion zones can lead to irregularities in the contour, which should be avoided as much as possible.
- The access sites of the cannulas must be located in hidden sites asymmetrically and in places that allow the best access to all the areas that are going to be operated.
- Postoperative management through manual lymphatic drainage and pressotherapy will allow early recovery and improvement in results.

43.1 Introduction

The technique of suction-assisted lipectomy, more commonly known as liposuction, was introduced by Illouz in the early 1980s and continues to be one of the most popular body contouring techniques as well as one of the most requested procedures within the field of cosmetic plastic surgery [1]. According to the American Society of Plastic Surgeons and the American Society of Aesthetic Plastic Surgery, liposuction remains the second most performed cosmetic surgery (92%) and the first in the case of male cosmetic surgery and in the general population between 35 and 64 years [2].

Since its inception, modifications have been made to the standard liposuction technique with a progressive refinement of the procedure. Despite this, as an invasive method, it is not without risks. To carry out a body contouring procedure through liposuction in a controlled and safe manner requires a complete knowledge of the anatomy, as well as the patient's comorbidities and the technique's limitations and indications.

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© Springer Nature Switzerland AG 2023
M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_43

43.1.1 History

Before Illouz and Fournier set the foundations for an effective and safe liposuction technique, the use of a blunt-tip cannula, and the preoperative infiltration of tumescent solutions, and there were plenty of references in the literature aiming to improve body contour through the removal of redundant fatty tissue.

The first liposuction attempt dates back to 1921, when French surgeon Charles Dujarier used a uterine curette to extract fat from the knee of a French dancer. The excess of tissue removed, the vascular damage, and the tension applied by the sutures gave rise to a gangrene and the amputation of the limb. Such a disastrous result relegated this idea to oblivion until almost half a century later [3].

In 1964, Schrudde introduced the concept of "lipexheresis," which consisted of extracting the fat through a small incision in the lower leg by means of a curette. However, the poor esthetic scars, infections, bruises, and localized seromas hindered the progress in this field [4]. Kesselring and Meyer published the association of a suction system with curettes for fat removal; they also introduced the concept of applying the suction on the muscular fascia for a better result. However, his technique proved to be beneficial only in the trochanteric region. Goodstein and Hoefflin used a cannula with a scalpel as a curette for subdermal tissues, which resulted in lymphorrhea and cutaneous necrosis [5]. In 1975, two Italian surgeons, Giorgio and Arpad Fischer, developed a hollow suction cannula. This cannula had motorized cutting blades in its distal openings to ease the fat suction [6].

The final progress in instrumentation is due to the Frenchman Yves-Gerard Illouz who introduced the blunt cannulas and the tunnel theory: to practice many small diameter tunnels at different levels of fat causing tissue to collapse above them and reducing the risk of irregularities on the surface. This change allowed the liposuction technique to become something easily reproducible and minimized the incidence of associated complications, so today, it is still the reference with which to compare the alternatives that arise [1]. Later, Pierre Fournier modified the instrumentation and the "wet" technique reducing the amount of blood loss. Despite this, liposuction could only be carried out under general anesthesia, since it was not feasible to remove large volumes of fat under standard local anesthesia, because the required doses of lidocaine would surely have reached toxic levels [7].

The next big step forward came from the hand of dermatologist J.A. Klein, who introduced in 1987 an anesthetic technique for large areas of subcutaneous fat using a mixture of diluted local anesthetic and epinephrine [8].

The new techniques introduce mechanisms aimed to improve the effectiveness of the procedure, reducing surgeon's fatigue and surgical times and secondly providing firmness to treated tissues.

43.1.2 Physiopathology: Changes Associated with Pregnancy

Changes affecting the female body during pregnancy are clearly described in the literature [9]. However, those that refer to the different behavior of fatty tissue in each body region continue to be the subject of debate. It has been shown that specific areas such as fatty deposits in the femoral region show metabolic differences compared to others such as the abdomen [10].

Throughout life, women tend to gain weight following a ginoid pattern predominantly in the gluteal and femoral regions (including the trochanteric region and thighs) [11]. This fact is related to a greater activity of the lipoprotein lipase (LPL) in the adipocytes of these areas. In particular, LPL activity in the femoral region is higher than in the abdomen, something accentuated during pregnancy. After birth, there is a change with the onset of breastfeeding; the activity of the LPL significantly decreases in the femoral region allowing for lipid mobilization. These deposits would act as a source of energy and nutrients during the period of breastfeeding. This specialization of fatty tissues turns the postpartum period into a very unique moment, with its own characteristics and expected changes in skin and fat, which should be taken into account at the time of surgery and postoperative recovery [12].

Therefore, when considering the esthetic improvement of this specific anatomical area in this particular group of patients is imperative an individualized evaluation taking into account all these elements.

43.1.3 Anatomic Considerations

The thigh area extends from the posterior gluteal fold and laterally from the gluteal depression to the knee. From the esthetic point of view, it is of great importance to take into account the adjacent regions of this anatomical region, particularly the gluteal region. The gluteal fold extends to the lateral thigh creating a gentle curve. From a lateral view, the anterior and posterior silhouette of the thigh should form a convex arc slightly more evident anteriorly. In a coronal plane, the transition from the iliac crest to the thigh should be very subtle as a curve. The medial thigh also has a small convexity only flattened in the most distal area close to the knee [13] (Fig. 43.1).

Anatomically, the plastic surgeon must take several points into account during the preoperative planning. The skin of the thigh changes from the medial to the lateral area, being thicker in the latter. Analogously to Scarpa's fascia in the abdomen, the fatty tissue of the thighs is divided into a superficial and a deep layer (Fig. 43.2). However, when we propose a liposuction, we subdivide it into superficial, intermediate, and deep layer. The importance of this distinction is to know that the superficial layer should not be altered; otherwise, we may incur a vascular compromise (bleeding and bruising) and/or increase the risk of contour irregularities. Therefore, we anticipate that the intermediate level is the safest to achieve an optimal result [14] (Fig. 43.3).

In the thigh, the fascia lata defines the deep fascia that covers and groups the muscles. It thickens in the lateral region to form the iliotibial tract and under no circumstances should it be penetrated during the procedure. Although most important structures of the thigh are deep to this plane, we must bear in mind that the superficial

Fig. 43.1 The smooth transition from the iliac crest to the thigh from an anterior point of view (left). From a lateral view the thigh forms a convex arc slightly more evident in the front side (right)

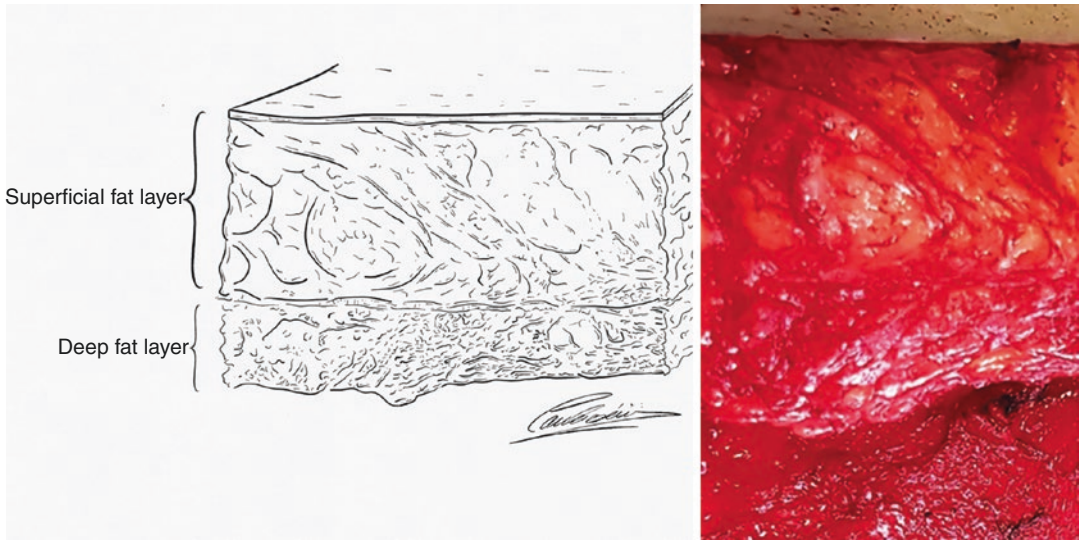

Fig. 43.2 Superficial and deep layers of fat. Differences in fat lobes size and distribution may be observed. Both layers are separated by a fascia analogously to Scarpa's fascia

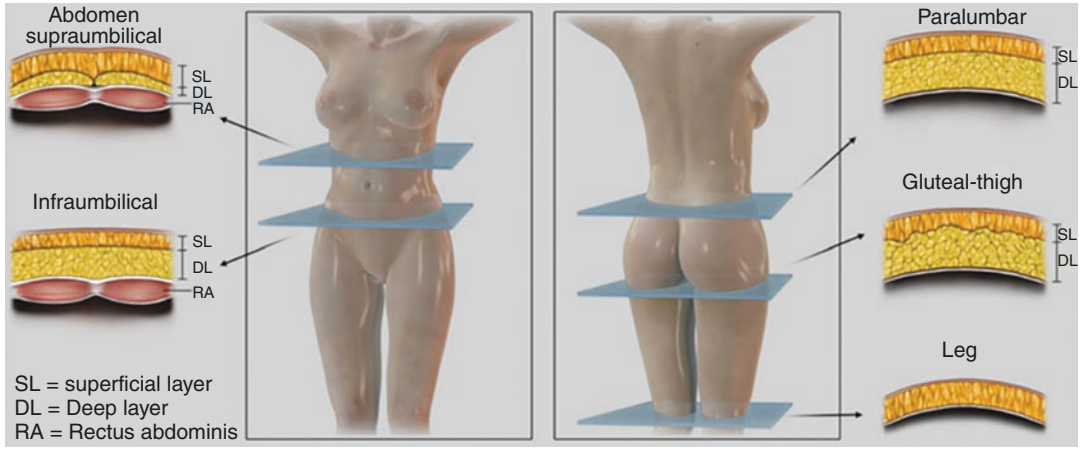

Fig. 43.3 Differences in the fat layers depending on the body region. In the gluteal-thigh region, specifically, the deep fat layer is thicker than the superficial layer that must be avoided during liposuction. (Reprinted from Hoyos)

venous system and some sensitive nerves run along the fatty plane. The greater saphenous vein runs along the medial aspect of the thigh until it pierces the cribriform fascia to join the femoral vein. The lateral femoral cutaneous nerve runs into the subcutaneous plane lateral to the sartorious muscle approximately 2 cm after passing under the inguinal ligament. It gives two branches: the anterior gathers the sensitivity of the anterior and lateral thigh and the posterior the back thigh (Fig. 43.4).

In the preoperative assessment, the most problematic areas referred by the patient are usually the lateral fat deposits in the trochanteric region and under the gluteal fold, commonly called "saddlebags" and "banana rolls," respectively (Fig. 43.5).

It is essential to take into account the particularities of the superficial fascial system in the thigh area, as it connects the dermis with the fascia that covers the musculature through fibrous tissue septa that wrap and compact fat lobes.

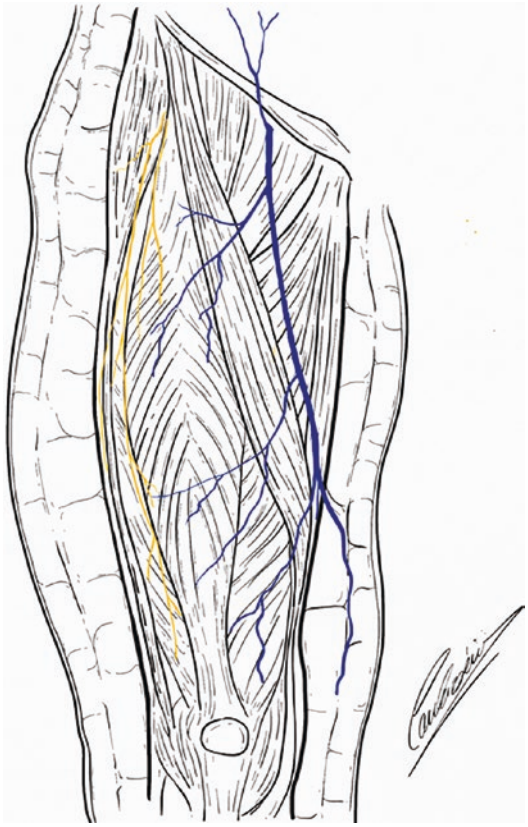

Fig. 43.4 Superficial anatomy of the thigh. The greater saphenous vein may be observed running along the medial thigh. In the lateral and front side of the thigh branches of the lateral femoral, cutaneous nerve provide sensation and must be taken into account during liposuction

There are five well-defined areas in which these elements become denser creating "zones of adherence": gluteal fold, gluteal lateral depression, distal area of the lateral thigh (iliotibial tract), the distal posterior region of the thigh, and the middle medial thigh. In these areas, the component of deep fatty tissue is smaller than the surrounding ones making them more likely to generate depressions or irregularities that alter the contour. Of these, the gluteal fold is undoubtedly the most problematic. In no case should it be crossed perpendicularly with the cannula, as it can result in a double fold or an elongation thereof. To prevent this, preoperative marking is important, and liposuction should be avoided with the exception of large volumes. In these particular cases, the surgeon should proceed with smaller caliber cannulas at low suction levels or "exploded tip cannulas" without suction in order to achieve smoother transitions [15] (Fig. 43.6).

Fig. 43.5 Most problematic areas referred by the patients commonly known as "saddlebags" in green (trochanteric fat deposits) and "banana rolls" in red (infragluteal fat deposits)

Finally, an element to keep in mind is the presence of skin cellulite. This is a skin condition that is often observed when we value patients for liposuction. It appears as irregularities of the skin, particularly in the buttocks and thighs. Its pathophysiology has a hormonal component being more frequent in females. Histologically, fibrous anchors may be observed from the dermis to the underlying fascia, surrounded by hypertrophied fat. Its long-term treatment is not predictable, so liposuction of these areas can soften or accentuate the deformity. Therefore, this condition must be assessed and informed to the patient [16].

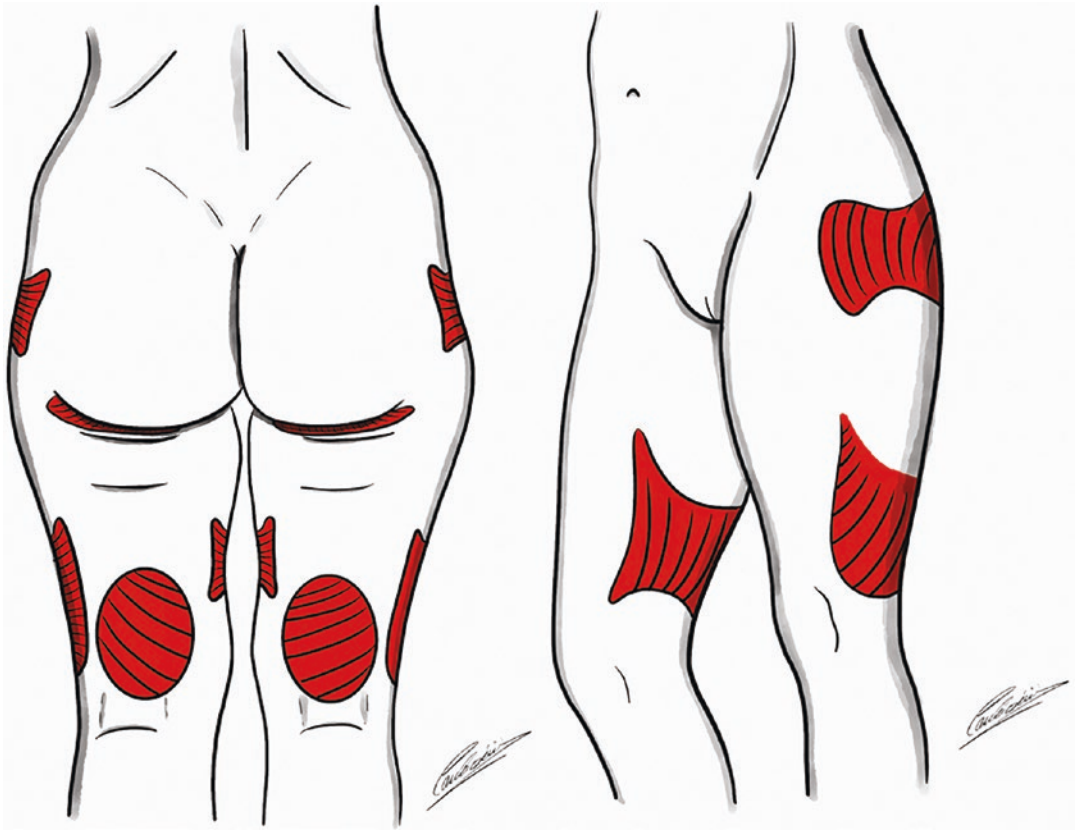

Fig. 43.6 *"Zones of adherence"*: Gluteal fold, gluteal lateral depression, distal area of the lateral thigh (iliotibial tract), distal posterior region of the thigh, and middle medial thigh

43.2 Patient Selection

As a general rule, liposuction should be performed in patients with realistic goals and expectations. It is also necessary for the patient to have a stable weight and raise awareness of the need for a change in her lifestyle if she did not practice it previously, eating a healthy diet and exercising regularly. In their study, Rohrich et al. concluded that patients who maintained healthy style life in the postoperative period had higher post-liposuction satisfaction scores [17].

This intervention is contraindicated during pregnancy and in patients with any major illness. It is not recommended to carry it out during breastfeeding due to the lipodystrophic changes that this region undergoes, as we have previously mentioned.

Tips

A successful body contouring patient must satisfy four key elements to achieve and maintain optimal results:

1. **Lifestyle change**
2. **Regular exercise**
3. **Well-balanced diet**
4. **Body contouring**

43.3 Preoperative Evaluation

43.3.1 Physical Evaluation

There are seven key elements to determine before performing liposuction:

1. Size, weight, and body mass index (BMI)
2. Areas of lipodystrophy and deformities in the body contour
3. Asymmetries
4. Cellulite areas
5. Myofascial support
6. Adhesion zones

We can distinguish three types of patients based on lipodystrophy and skin redundancy: [18]

- Type I: Localized lipodystrophy. Generally, young patients with good skin tone and minimal or no superficial irregularities.
- Type II: Extended lipodystrophy. These patients present loss of skin turgidity with minimal irregularities and lipodystrophy that includes trunk and extremities.
- Type III: Skin redundancy and lipodystrophy. Patients with significant skin redundancy that could be susceptible to excisional techniques to improve shape and contour, with liposuction being an adjuvant tool to achieve an optimal result.

▶ **Warning!**
Special attention should be paid to the adhesion zones. Between them, there is a union of the superficial fascia with the deep fascia, immediately below the subcutaneous fat layer. This makes these areas, particularly prone to irregularities, so they should be avoided. At the time of preoperative marking, it will help if these areas are indicated with a different color

43.3.2 Preoperative Marking

Marking should be done prior to surgery with the patient in standing position. Areas of liposuction and adhesion zones should be marked to know that they are areas to avoid. Boarding lanes should also be marked at this time. Generally, two incisions per area to be treated are necessary and should be located close to it, so that it allows to direct the cannula in multiple directions, taking special care not to place them in the areas of adhesion. The incisions must not be longer than 3–4 mm in length and should be located in hidden areas, such as the midpoint of the posterior infra gluteal fold and the groin fold per anterior (Fig. 43.7).

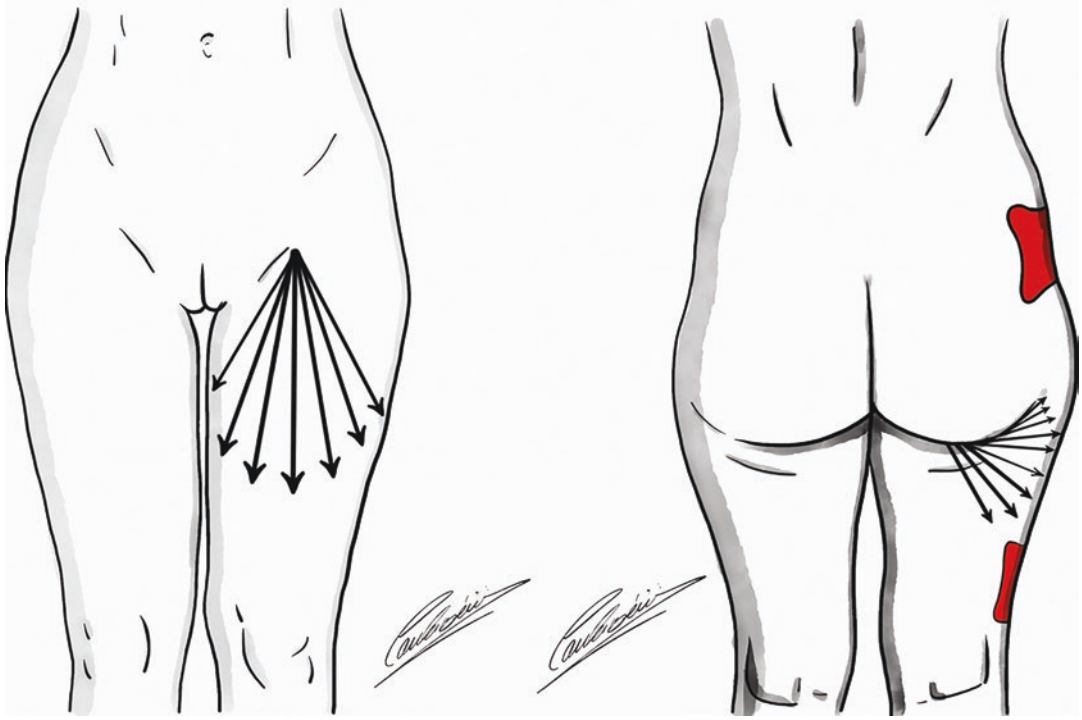

Fig. 43.7 Surgical technique: Liposuction of the posterior thigh from gluteal fold incision avoiding the adhesion zones. For the anterior thigh, incision may be hidden in the inguinal fold, from here the surgeon may reach the whole surface adding more effort to the lateral intermuscular space for better muscle definition

43.4 Anesthetic Considerations

It is up to the surgeon to determine the optimal surgical setting for each patient undergoing liposuction. Factors that influence this decision are: the amount of expected lipoaspirate, length an extend of procedure, patient positioning, anesthesiologist preference, and overall health patient.

As a general rule, small-volume liposuction cases can be performed with local anesthesia, with or without mild sedation. Complex, large-volume liposuction and combined cases should be performed under general anesthesia. In general, we think thigh liposuction usually requires a 360 degrees approach to get the result expected by the patient, being a complex procedure during which a great volume of fat and fluids are removed. For this, general anesthesia is our preference to perform liposuction for thigh contour improvement. In all cases as prone position is used, endotracheal tube is required for good control of the airway and breathing. We usually choose inpatient hospital setting for the first night for postoperative observation, which is thoroughly explained to the patient during preoperative evaluation.

Before the procedure, warming blankets are applied as soon as the patient is in the OR, and during it, all the body regions not meant to be suctioned are kept covered and warmed. Wetting solutions are also warmed before being infiltrated to avoid a sudden decrease in body temperature.

43.5 Surgical Technique

43.5.1 Patient Positioning

The author's preferred technique is to start in prone position to treat the posterior and lateral thighs (Fig. 43.8a and b). Once these are completed, the patient is changed to a supine position to treat the anterior region of the thighs (Fig. 43.9).

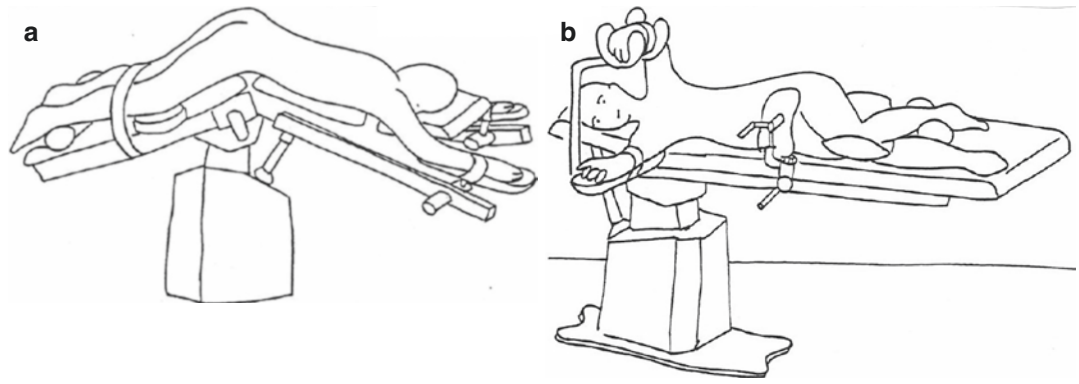

Fig. 43.8 (**a**) Representation of the prone position in the operating room. (**b**) Lateral position in the operating room

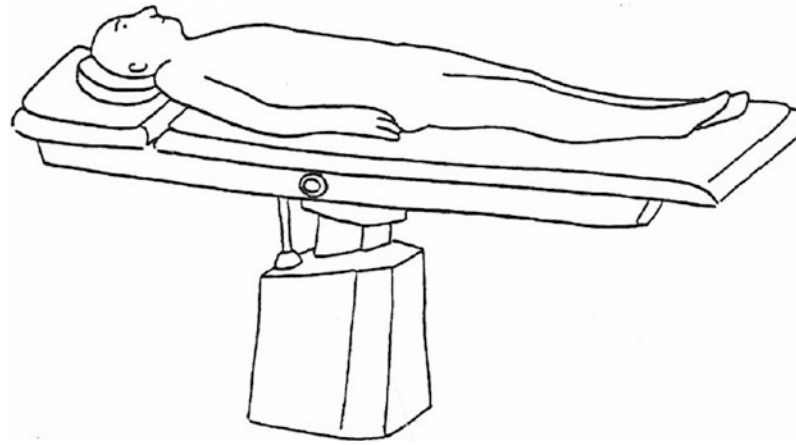

Fig. 43.9 Representation of the supine position in the operating room

43.5.2 Step-by-Step Procedure

- Infiltration: Before Illouz introduced the importance of using wetting solutions, the blood loss of liposuction procedures was inadmissible [19, 20]. Different solutions may be created depending on the amount of each component, but usually wetting solutions are classified based on the ratio of infiltrated volume and suctioned volume: dry, wet, superwet, and tumescent. Dry technique has almost no indication today. Wet technique uses the same volume per area regardless of the volume aspirated, which always is more than the infiltrated. Superwet liposuction establishes a 1:1 ratio for infiltration and aspiration. Tumescent technique as described by Klein uses a 3:1 ratio; enough volume infiltration is reached when tissues get pale and turgid. Today, superwet and tumescent techniques are the most popular as the blood loss that entails is insignificant, but after comparing both, Rohrich et al. found no differences between superwet and tumescent infiltration being the superwet safer as it avoids the fluid overload of the latter [21, 22] (Table 43.1).

  Wetting solutions are basically a different combination of fluid, anesthetic, and vasoconstrictor; the one we prefer to use in our practice is Klein's formula that consists of the following:
  - 1000 mL of normal saline
  - 50 mL of 1% lidocaine
  - 1 mL of 1:1000 epinephrine
  - 12.5 mL of 8.4% sodium bicarbonate

Table 43.1 Wetting solutions. The numbers are the percentage of volume aspirated

Technique	Estimated blood loss*	Infiltrate	Volume aspirate
Dry	20–45	No infiltration	Treatment endpoint
Wet	4–30	200–300 mL	Treatment endpoint
Superwet	1	1:1 (Infiltrate:aspirate)	1:1
Tumescent	1	Skin turgor	2–3 mL aspirate/mL

  - In addition to the vasoconstrictive properties of epinephrine, it also allows for higher doses of lidocaine. Although the maximum dose for lidocaine is 7 mg/kg, as Klein established in the literature, up to 35 mg/kg would be safe in liposuction procedures, especially because wetting solutions are infiltrated in a fatty layer only [3].

    In our opinion, the deep plane and then the surface plane must be infiltrated, using a standard tumescent solution. Uniform distribution must be achieved in order to perform liposuction on a regular basis and predict uniform skin retraction.
- Emulsification: If we want to preconditioned localized fat, then an emulsion treatment of it will be carried out well using ultrasonic or laser techniques (described above).
- Aspiration: First liposuction of the deep plane is carried out, which will be carried out in those areas with the greatest fat deposit, always avoiding the adhesion zones. We will use long cannula between 3 and 4 mm. Then, you can proceed with liposuction of the intermediate plane with a cannula of 3 mm, to regularize the contour and transition zones, being able to place more emphasis on lateral intermuscular space, between the iliotibial tract and the femoral biceps muscle. This gives some muscle definition and a toned appearance of the thighs.

43.5.3 Description by Zones

- Lateral side: It is likely the site of the most contour irregularities in our experience. Extreme caution is advised in the superficial plane for fear of worsening preexisting contour irregularities. Incisions are often placed in the lateral gluteal crease. Occasionally, a midlateral incision may be beneficial. Commonly cannulas in the 3–4 mm range are used. Often, final contouring or transitioning from lateral to anteriorly is performed in the supine position to remove any shelf that may exist following the prone position.
- Posterior thigh: It is usually carried out in prone decubitus, as it allows to work both sides and objectify the symmetry at all times (Fig. 43.10). We will put the stretcher in V shape position if we are going to take advantage to perform flank liposuction as well (Fig. 43.11). Incisions are usually made in the side area of the buttock fold. This region is especially susceptible to surface irregularities because in many patients, the skin is adherent to the underlying tissues with a

Fig. 43.10 Intraoperative photography of liposuction of the posterior region of the thighs

Fig. 43.11 Photography inside operating room. Position of the patient in prone position to perform liposuction of the posterior and lateral region of thighs. If we also want to perform flank liposuction, we can put the stretcher in a V shape to facilitate the intervention

paucity of fatty tissue. Overzealous suctioning in this area results in the loss of the adherent zone and rolling and redundancy of the skin. Special care should be taken when addressing the proximal posterior thigh, because problems in this area can be very difficult to correct, requiring either autologous fat transfer or skin excision. In fact, in females, the overtreatment of this area may elongate the gluteal fold, masculinizing the female silhouette. Commonly 3 mm and 4 mm cannulas are usually used for liposuction of the intermediate and deep plane, respectively [23].

- Medial side: At this level, the fat is usually soft, and the skin is usually thin and lax. The liposuction plane should be the middle layer, using small cannula (3 mm generally). The approach of this area can be done in supine and pronous decubitus or in supine decubitus with the legs "frogged." The patient should be warned of the possible outcome of redundancy and skin laxity, with the consequent need for secondary surgery [24].
- Anterior: This region is characterized by more compact fat. There is often thicker in the proximal area. Remodeling this region eliminates the transition of the medial and side regions and helps decrease the projection in the profile view. The boarding will be done through a proximal incision, and a fine cannula should be used.

43.5.4 Surgical Modifications

43.5.4.1 Cannulas

Despite all the different options and techniques for liposuction, the cannula remains a key element. The standard cannula has a blunt tip and a variable number of ports in the distal part but no ports at the very tip. Tip shape, diameter, and length affect the rate of fat suction. Aspiration is directly proportional to cannula diameter and inversely proportional to the length. For this reason, shorter cannulas allow better control and a higher aspiration rate but require more incisions [25]. The tip shape affects little to the aspiration rate; instead, different shapes like the exploded tip cannula allow to shape problematic areas such as the adherence zones. Careful treatment of these areas is mandatory to avoid postoperative cutaneous laxity. Fodor et al. published one of the most detailed studies about liposuction physics. Suction cannulas avulse fatty tissue depending on diameter, number, and size of tip ports. For cannulas with same length, diameter, and total port cross-sectional area, the one with greater number of smaller ports proves to be more effective and faster than the one with smaller number of larger ports [26]. Beck et al. later evidenced this after comparing multiport cannulas with the classic Mercedes cannula, being the former more effective [27]. From our experience for the thigh region liposuction, we advise to use a number 4 multiport cannula given the anatomical area and a number 3 for reshaping procedures given the better control it provides.

43.5.4.2 Liposuction Techniques

We may classify the different techniques in two categories: those based on a mechanical effect and those that add a source of energy to get a thermal effect.

(a) **Mechanical Techniques**

- Suction Assisted Liposuction (SAL): It is based on the mechanical effect that the liposuction cannula exerts. The energy comes from the surgeon's forward and backward movements along with an external source of suction. This movement disrupts the fat lobes that are aspirated and extracted. The established pressure should be around 300–600 mmHg, below the value of one negative pressure atmosphere established at the beginning by Illouz. These levels of suction may achieve the same results while minimizing tissue damage [28, 29].
- Power-assisted liposuction (PAL): One of the biggest drawbacks of liposuction is the fatigue associated with the procedure; some of the first improvements introduced were oriented in this regard. The PAL is based on a cannula that moves forward and backward at high speed (2000–4000 cycles per minute) replicating the surgeon's movement in a small space of 2 mm [30]. Besides requiring less physical effort, a decrease in surgical time associated with their use has been reported, showing the best cost-benefit ratio compared to the SAL and UAL [31, 32].
- Water-assisted liposuction (WAL): WAL employs a particular infiltration system: a pulsed fan-shaped jet instead of the continuous fluid jet of traditional liposuction. This releases the adipocytes facilitating subsequent liposuction and minimizing tissue damage. Values such as infiltrate flow and pressure may be altered depending on each body region avoiding a "tearing up" effect. WAL allows the use of a pre-infiltration that achieves enough analgesia to perform liposuction with the patient awake making possible he can stand up during the procedure [33]. In addition, WAL has demonstrated significantly greater postoperative pain control compared to traditional liposuction. The minor tissue trauma results in a lower postoperative ecchymosis [34]. A particular indication of this method would be in those patients affected by lipedema, as a minimally traumatic technique WAL would preserve the lymphatic vessels in the treated tissues [35]. This study also shows another advantage of this technique, the increased survival of adipocytes compared to traditional fat harvest. This is most important for fat grafting procedures and has been subsequently endorsed in the literature [36, 37]. As a disadvantage compared to other techniques, as WAL does not use any energy source, it has no effect on tissue retraction.

(b) **Thermal Techniques**

- Ultrasound-assisted liposuction (UAL): First published by Zocchi in 1980, this technique uses a modified cannula that emits ultrasound at a frequency of 16 kHz. The ultrasonic waves have little effect on the tissues, and the ability to liquefy the fatty tissue is mainly given by the increase in temperature and, above all, by the cavitation phenomenon. This consists in the passage of waves through holes present in the cell membranes, and these waves produce the expansion and contraction of this space. When these waves reach a specific frequency, contraction may not occur, and the expansion grows until a critical size results in the disruption of the membrane and cell lysis. Ultrasound leads to an increase in the local temperature, and to avoid tissue damage, it is necessary to use tumescent solutions and keep moving the cannula back and forth. This technique gives a supposed advantage in areas of fibrosis or previously liposuctioned, but it requires a longer surgical time and greater incisions in the skin. As a difference with the conventional technique, the objective is not the decrease of the pinch test but the loss of resistance to the passage of the cannula [28] (Fig. 43.12).
- Vibration amplification of sound energy at resonance (VASER): The VASER liposuction system appears as a refinement of

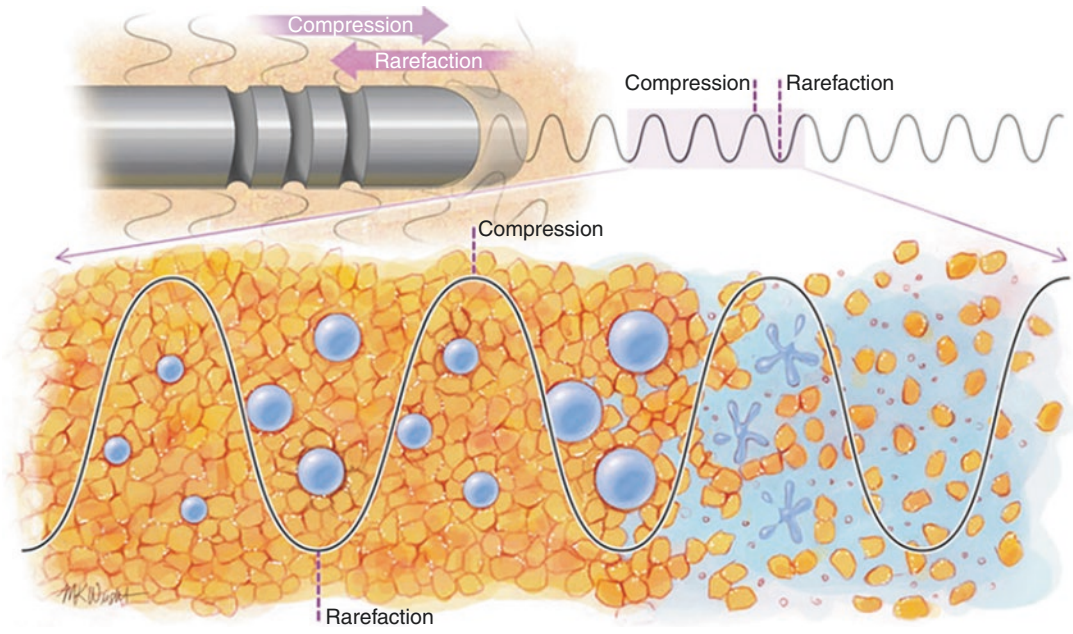

Fig. 43.12 Cavitation effect during ultrasound assisted liposuction. Gaps in the cell membrane get bigger until it collapses

UAL systems. VASER cannulas have modifications that allow focusing energy into a very specific area near the tip. The second key to its greater effectiveness is in the concept of resonance; the frequency of the VASER system (36 Hz) is close to that of adipocytes, facilitating fat cell lysis. This way equal results may be obtained using less energy [38].

- Ultrasonic liposuction technology has demonstrated, through prospective randomized trials, superiority over SAL in terms of tissue retraction, which was always offered as one of its greatest advantages over other techniques [39].
- Laser-assisted liposuction (LAL): In the 1990s, first papers were published trying to apply the advantages of laser technology to liposuction. The mechanism of action of laser on fatty tissue is a photothermal effect; light is selectively converted to heat on a specific chromophore (in this case water, which is the main component of fatty tissue) causing adipocyte disruption. In theory, using different wavelengths would allow to act selectively on collagen, hemoglobin, fat, or water molecules, achieving better hemostasis or greater tissue retraction [40]. However, the first studies that used a 1064 nm Nd-YAG laser (neodymium yttrium aluminum garnet) did not achieve results to get FDA approval, something that would not occur until October 2006 [41]. Since then, laser technology has been introduced in liposuction systems, either simultaneously (liposuction cannulas that incorporate a laser fiber near the hole) or in two different procedures (LAL followed by SAL). Despite the expected benefits of incorporating laser technology into liposuction, the 2006 randomized, prospective, and double-blind study conducted by Prado et al. showed no clinically significant differences when comparing LAL versus SAL in terms of esthetic outcome or skin retraction [42]. However, more recent publications that combine wavelengths of 1064 nm and 1320 show significant effects in terms of

skin retraction. The Nd YAG 1064/1320 laser has greater selectivity for collagen, which would explain these results [43].

- Radio frequency-assisted liposuction (RFAL): One of the most recent technologies applied to liposuction is radio frequency due to its ability to contract collagen fibers. The liposuction device consists of a "bipolar RF handpiece" that is inserted into the tissues. At the tip of the liposuction cannula, there is an internal electrode that emits the radio frequency current; on the outside, there is a second electrode with a wider surface to which the current is directed. The external electrode has a larger size to decrease energy density in the skin, making it lower than in the subcutaneous tissue, thus avoiding burn damage [44]. The device that generates the energy allows to establish safety parameters in such a way that when a certain temperature is reached on the skin the device stops. Energies of 40–50 W result in subcutaneous tissue temperatures between 60 and 80 °C and between 40 and 42 °C in the skin. With these levels of heat neocollagenesis processes take place [45]. The main advantage over other techniques is the ability to produce a retraction of the tissues in a controlled manner avoiding burns or cutaneous necrosis. It has been shown up to 31% of contraction significantly greater than other techniques that associate energy sources with liposuction [46]. As for the procedure, given the mechanism of the technique, adequate tissue tumescence is essential to facilitate cannula navigation and increase the conductivity of the radiofrequency current. Within the liposuction of thighs, one of the main indications would be the treatment of the inner thigh and specifically the recreation of the "thigh gap." This area, not being an area of adhesion, is very susceptible to exhibit excessive laxity after liposuction, something potentially preventable by RFAL liposuction [45].

43.5.5 Technical Tips to Improve Outcomes and Avoid Complications

The best results will be obtained from the correct indication of liposuction. We should practice it in those patients who are aware of making changes in their lifestyle in terms of diet and exercise. We must also delay surgery until the end of lactation. We must carry out a correct quantification of fluids, tumescent infiltration, and stop the surgery if true blood content is observed through the liposuction cannula. To avoid contour irregularities, we must avoid liposuction in the most superficial plane as well as in the adherence areas. Finally, the postoperative indications that we will cite later must be correctly followed.

43.6 Postoperative Care

A compression garment is required 24 h a day for 4–6 weeks. You will be encouraged to walk in the early postoperative period to avoid deep vein thrombosis. The administration of low molecular weight Heparin as the latter's prophylaxis shall be carried out according to the Caprini Test score (Table 43.2) [47, 48]. Murphy et al.'s study on the evidence of thrombosis prevention from the American Society for Aesthetic Plastic Surgery (ASAPS) thromboembolism working group established that liposculpture operated patients through general anesthesia with a duration of more than 60 min, having a Caprini Score of 3–6 points thromboprophylaxis, should be administered by low molecular weight heparin (LMWH) or unfractionated heparin. It was also evident that the combination of LMWH or unfractionated heparin together with mechanical prophylaxis using pneumatic compression boots was more effective than the use of each of them separately (Table 43.3) [49].

It is advised to start with physical activity 2 weeks after surgery. Edema begins to go down at 3–5 days, and bruising should be minimal at 7–10 days. We will start to see changes in the contour of the thighs from 2 weeks. The end result can be seen at 3–6 months, depending on

Table 43.2 Risk factors for venous thromboembolism based on the 2005 Caprini Risk Assessment Model [47]

1 point for each risk factor	2 points for each risk factor	3 points for each risk factor
Age 41–60 years	Age 60–74	Age over 75 years
Minor surgery planned	Malignancy (previous or present)	History of DVT/PE
History of prior major surgery (<1 month)	Major surgery (<45 min)	Family history of thrombosis
Varicose veins	Patient confined to bed (>45 min)	Positive factor V de Leyden
History of inflammatory bowel disease	Central venous access	Positive prothrombin 20210A
Swollen legs (current)		Elevated serum homocysteine
Obesity		Positive lupus anticoagulant
Sepsis (<1 month)		Elevated anticardiolipin antibodies
Serious lung disease (<1 month)		Heparin-induced thrombocytopenia
Abnormal pulmonary function		Other congenital or acquired thrombophilia
Oral contraceptives or hormone replacement therapy		
Pregnancy or partum (<1 month)		
History of unexplained stillborn infant, recurrent spontaneous abortion, premature birth with toxemia or growth-restricted infant		

the patient's characteristics [23] (Figs. 43.13, 43.14, and 43.15).

There are a number of techniques that, performed synergistically, will improve patient comfort, will optimize surgical results, and may reduce complications. These techniques include

Table 43.3 Measures to prevent venous thromboembolism in patients undergoing high-definition body contouring performed under general anesthesia lasting more than 60 min [49]

Points	Recommendations
2	Moderate risk: intermittent pneumatic compression device and elastic compression stocking on patient at all times while not ambulating
3	High risk: intermittent pneumatic compression device and elastic compression stocking on patient at all times while not ambulating
>4	Highest risk: intermittent pneumatic compression device and elastic compression stocking on patient at all times while not ambulating and use LMWH postoperative prophylaxis

manual lymphatic drainage, ultrasound, pressotherapy, diathermy, and radiofrequency, among others.

Manual lymphatic drainage plays an important role in the postoperative liposuction. Current techniques are based on the technique advocated by Emil Vodder in 1930, seeking to mobilize retained fluid, increase lymphatic flow, and soften fibrosis hotspots [50]. Among the many benefits of this technique, we find the following: [51].

- Microcirculation stimulation: avoids complications such as skin pain and improves postoperative pain, inflammation, and ecchymosis.
- Stimulation of the immune system by facilitating lymphatic drainage to the lymph nodes.
- Improves pain by reducing perineural edema and steadily stimulating type C mechanoreceptors. It also stimulates the parasympathetic nervous system with consequent relaxation and antispasmodic effects.
- Reduction in fibrosis: The fluid cumulus of protein-rich fluid (lymph) produces your organization resulting in fibrosis. Manual lymphatic drainage will reduce fluid buildup and soften tissues.
- Improvement of cellular nutrition and tissue recovery. Inflammation increases the distance between blood and different tissues, so the reduction in swelling increases the ease with which cells are oxygenated and receive vital nutrients.

Fig. 43.13 (**a**) A 32-year-old patient preoperative. Three years since last pregnancy. (**b**) Six months postoperative

Fig. 43.14 (**a**) A 40-year-old patient preoperative. Five years since last pregnancy. (**b**) Six months postoperative

Fig. 43.15 (**a**) A 37-year-old patient preoperative. Two years since last pregnancy. (**b**) Six months postoperative

The session schedule will be at 2–3 days the first massage to remove the residual tumescent liquid. Thereafter, it will be held one or two times a week, depending on the needs of each patient. Each session lasts approximately 45 min and must be performed by a professional trained in the technique, otherwise the results could worsen [52].

External ultrasound exerts their action through cavitation, mechanical disruption, and local heat. It can be performed within 48 h of surgery, always combined with manual lymphatic drainage and pressotherapy, allowing to reduce pain and inflammation, as well as the formation of fibrosis [53].

Pressotherapy carries out an activation of the venous and lymphatic systems, allowing the reabsorption of interstitial fluids. It does not replace manual lymphatic drainage, but complements it. It is usually done three times a week with a duration of 30–35 min per session. It is recommended to use ultrasound first, followed by manual lymphatic drainage and end with pressotherapy [54].

There are other techniques based on the use of energy such as radiofrequency or shock wave therapy that can be good complements from 4 to 6 weeks after surgery, especially if there is any area of fibrosis, skin sagging, or cellulite [55].

▶ **Warning! Pressotherapy should not be performed in the following cases:**

1. **Recent thrombophlebitis or phlebothrombosis**
2. **Significant or tortuous varicose veins**
3. **Skin infections**
4. **Cardiac failure**
5. **Uncontrolled hypertension**
6. **Acute inflammation**
7. **Neoplasm**
8. **Significant renal or respiratory failure**

43.7 Outcomes and Prognosis

Although results can be seen imminently, especially in case with more severe lipodystrophy, the patient may not be aware of them due to inflammation of the area. This inflammation will last up to 6 months after surgery. We must warn the patients that the most obvious results will be subject to one month after surgery. The ecchymosis will last from 2 to 4 weeks. All the aforementioned measures carried out during the postoperative period are aimed at achieving an earlier recovery as well as improving skin flaccidity.

43.8 Complications (Table 43.4)

- Bleeding: Using the tumescent technique, the solution causes vasoconstriction, so removal of fat is occurring in an almost bloodless field. If the aspirate is excessively bloody aspirate, the aspiration should be stopped, and more tumescent solution should be infiltrated. It is essential to exclude patients who have clotting problems, and it is advised to avoid the administration of medicines (aspirin, nonsteroidal anti-inflammatory drugs), vitamin E, ginseng, ginger, *Ginkgo biloba,* or garlic, as well as supplements that have effects platelet aggregation for 7–10 days before surgery. The aftermath of bleeding will depend on volume, the patient's precondition, and compression measures. Compression is essential in the immediate postoperative period to facilitate hemostasis and compression of small vessels. Ecchymosis is normal in decreased areas. In the face of small bruises, we can maintain an expectant attitude, but large bruises will have to be drained because, if they are not organized and form a mass, seroma, and chronic pseudocysts that will have to be operated openly [56].
- Infection: It is an unusual complication since the technique is done in a sterile way, and in addition, the components of the tumescent solution have an antimicrobial effect on bacteria, mycobacteria, and fungi. However, cases of infection have been reported, so prophylactic antibiotherapy with cephalosporin 2 g is recommended during nesthetic induction or half an hour before surgery and continue for 5 days. In case of penicillin allergy, clindamycin 600 mg is recommended every 8 h [57–59].

Table 43.4 Complications, prevention, and treatment

Complications	Prevention	Treatment
Bleeding	– Use tumescent technique – Avoid medicines and foods that have effects platelet aggregation	Compression
Infection	– Sterile technique – Prophylactic antibiotherapy	Antibiotherapy
Necrosis	– Avoid superficial plane if subdermal plexus is compromised – Advise smoking cessation	Debridement
Seroma	– Compression garment	Compression garment Drain
Thromboembolism	– Identified risk factors – Low molecular weight heparin – Pneumatic compression stockings	Anticoagulation
Pulmonary edema	– Correct fluid balance – Avoid in patients with comprised preload	Hemodynamic support
Lidocaine toxicity	– Avoid P450-3A4 metabolism drugs 2 weeks before – Respect limit dose of lidocaine	Ventilatory support Lipid emulsion 20%
Perforation		Surgery
Fat embolism		Ventilatory support
Aesthetic complications		Corrective surgery

- Necrosis: This complication can occur when going across a superficial plane, and the subdermal plexus is compromised. It is more likely to occur in smokers, in secondary cases, and with the use of sharp cannulas. With thermal emulsion techniques or with ultrasound, it can also occur if the cannula is not moved continuously or if it is performed with dry tissues (before having performed tumescent infiltration) [60].
- Seroma: This is a collection of liquid in the subcutaneous tissue, secondary to the friction of the tissues. It usually disappears over time using compression garments, but if it persists or is high in volume, it should be drained by needle aspiration [61].
- Thromboembolism: Risk factors for deep vein thrombosis (DVT) should be identified in the consultation. If the procedure is done under local anesthesia, no prophylaxis will be required. Patients should walk as soon as possible. Otherwise, prophylactic measures should be taken, such as the administration of low molecular weight heparin (40 mg/24 h) and the use of pneumatic compression stockings.
- Pulmonary edema: It is produced by the administration of a large amount of both intravenous and subcutaneous fluids. To avoid this, a correct fluid balance should be carried out, and this procedure should not be performed in patients with compromised preload (heart failure, congenital heart disease) [62].
- Lidocaine toxicity: The limit dose of lidocaine is 55 mg/kg [63]. Lidocaine toxicity is clinically manifested by perioral paresthesias, tongue numbness, dizziness, nausea, and vomiting, which may lead to cardiac toxicity. It should be noted that lidocaine is slowly absorbed from the fatty compartment, so that maximum plasma concentrations occur within 12–18 h of administration. Likewise, drugs that are metabolized through the enzyme P450-3 A4 compete with lidocaine and can increase the toxicity, so they should be discontinued 2 weeks before [64, 65].
- Perforation: While it is an uncommon complication, even less is at this location. Unless vascular perforation occurs, the transcendence will be less.
- Fat embolism: It is due to the mobilization of fat droplets into systemic circulation. It mani-

fests by dyspnea, fever, tachycardia, and petechial rash [66]. Pathophysiology is due to the inflammatory reaction of the endothelium secondary to the release of fatty acids from adipocytes [67].

- Aesthetic complications: Contour irregularities are usually due to the realization of the technique on a very superficial plane and constitute the most common late complication [68]. Asymmetries may not be seen during surgery or in the immediate postoperative period due to infiltration and inflammation, respectively. Therefore, when it happens, we must review it in the operating room and in case of fat deficiency in some area resort to autologous fat infiltration. Significant ecchymoses may result in hemosiderin deposition and ultimately hyperpigmentation.

43.9 Conclusion

Fat deposits at the thigh level during pregnancy cause a morphological change in a woman's anatomy, which can often be susceptible to psychological harm. Over the past three decades, liposuction procedure has become increasingly popular, being one of the most common procedures worldwide, especially in these patients. However, although it is a technique that is touted as a simple procedure, this intervention requires the combination of the surgeon's experience, combining art and science. Thus, with the precise knowledge about the morphology of the patient, we will be able to achieve safe and esthetically optimal results.

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Thigh Lift

44

Joseph Michaels

Take-Home Points

- If there is skin laxity in the abdomen and mons (pubic) region, this needs to preferably be addressed first or at least at the same time as correction of the inner thigh.
- The degree and location of the medial skin laxity will dictate which type of medial thigh lift is needed to optimize the result.
- Laxity of the inner thigh must be differentiated into vertical and horizontal vectors.
- Correction of the upper one-third of the thigh can often be corrected with vertical vector thigh that leaves a groin crease incision.
- Laxity of the inner thighs that extends to the middle and lower one-third of the thighs has both vertical and horizontal vectors of skin laxity and requires a vertical excision of skin to correct the loose skin. A vertical skin excision is often also performed to excise any residual skin within the groin crease.
- Proper evaluation and understanding the patient's scar tolerance and expectations is critical to obtaining optimal outcomes in medial thigh lifting.

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44.1 Introduction

Following pregnancy, there can be changes to the medial thigh that include changes in fat content, as well as changes to the skin laxity. In patients that have residual adiposity in the medial thigh with good skin tone, liposuction alone may be able to correct the issue. Liposuction of the medial thigh will be covered separately in Chap. 44. In patients with poor skin tone or laxity of the inner thighs, they will require a skin excision to tighten the inner thigh. Liposuction is often used as an adjunct procedure to remove any residual fat and optimize contour.

In addition to inner thigh laxity, the postpartum patient may also have laxity of adjacent areas that contribute to loose skin appearance of the thighs. These include the abdomen, mons (pubic) area, and the buttocks. Correction of these areas first (preferably) or at the same as medial thigh lifting will result in the best possible contour for the inner thigh. I will not correct the inner thighs alone unless the patient had a previous abdominoplasty or has no abdominal skin laxity.

Patient education and managing patient expectations are the two most critical components of your consultation. Many patients will stand in front of the mirror and pull up their thigh skin like stockings and say, "this is what I want." Unfortunately, there is no procedure that mimics that maneuver. They also want to correct this area

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_44

with the minimal amount of scarring preferring to have a groin only incision.

When evaluating the patient, it is best to do so in front of a mirror. There are both vertical and horizontal vectors to thigh laxity. The vertical vector is a skin that is loose in the plane parallel to the groin crease. Vertical skin excess can be corrected by excising a horizontal section of skin and closing the incision within the groin crease. The problem with this procedure is that the groin crease has a fixed distance. The more skin that is excised vertically, the more mismatch there will be upon skin closure, and there can be bunching of skin in the groin crease. There will also be increased tension on the closure that may lead to wound dehiscence, scar widening, inferior scar migration, labial distortion, and pain. When there is laxity that extends beyond the upper one-third of the thigh, there will be horizontal vector skin excess that will require a vertical excision of skin to correct. This will tighten the leg like a cylinder. It will allow for more skin removal and also tighten the leg more than a vertical only excision. This incision is placed on the inner aspect of thigh where it can't be seen from the front or the back when the patient is standing. I often find it helpful to draw the incision on the patient's thigh so that they can see it. Some patients may not want a vertical incision and elect to only have a groin incision. In these cases, the patient must understand that they will still have loose skin in the middle and lower one-third of the thigh. This discussion should be documented in the medical record.

Medial thigh lifts are also challenging for plastic surgeons. Of all the body contouring procedures, medial thigh lifts have one of the highest complication rates [1–3]. The groin crease is a high moisture area, and the bacterial counts in this region tend to be higher than others. Wound tension and sheering forces are also common in this area. This can lead to a higher incidence of wound dehiscence and infection predominantly in the groin incision.

Medial thighplasty was originally described as a horizontal and vertical skin excision by Lewis in 1957 [4]. Lockwood later popularized the medial thigh lift where the lower flap of the horizontal skin excision was anchored to Colles' fascia [5, 6]. This key aspect helps limit scar widening and skin tension on the closure. This procedure is what many refer to as a classic medial thigh lift. Additional variations of this technique have been described that combine this classic medial thigh lift technique with the addition of a vertical component [7–9].

For patients that may have had large weight fluctuations following pregnancy, a horizontal skin resection may not be sufficient to correct the inner thigh laxity. This is because this procedure does not generate enough force to affect the middle and lower one-third of the inner thighs. For patients with laxity in these two areas, a vertical medial thigh lift is more effective. This variant uses a vertical skin incision with a horizontal vector of pull to tighten the thigh like a cylinder. This allows the skin to be maximally tightened down the length of the leg. This is the preferred treatment for patients with significant weight loss after pregnancy with skin laxity in the middle and distal aspects of the inner thigh [1–3, 10–13].

It is the author's preference to correct the abdomen, including the mons (pubic) region first. This will correct some of the horizontal laxity present in the medial thighs, and this will also allow the groin crease position to become set. A thigh lift can then be performed in the future. For patients whose only concern are the abdomen and thighs, an abdominoplasty can be performed in conjunction with a medial thigh lift. The downsides of this combination are patient discomfort, prolonged recovery, and potential inferior scar migration since the groin crease position was not yet fixed by a previous tummy tuck.

44.2 Patient Selection

The post-partum patient can present varying degrees of skin laxity and residual adiposity in the inner thighs. It is best to wait at least 9–10 months to allow patients to get back to their goal weight and to let their bodies readjust. As breastfeeding mobilizes fat from the gluteal-femoral region, we wait at least 3–4 months after breastfeeding ends to make sure that there are no further changes to these areas. As with every patient, a complete history and physical examination should be performed. Any history of lower extremity trauma, surgery, edema, and venous thromboembolism should be elucidated. Questions about exercise tolerance, pain in the legs with exercise, and also smoking history should be noted.

Physical examination should focus not only on the degree of laxity in the medial thighs but also on any adjacent areas that may be contributing to this laxity. These areas include the abdomen, mons (pubic) region, lateral thighs, and buttocks. Assessment of lower extremities for signs of lymphedema and peripheral vascular disease should be noted.

Performing a tummy tuck (standard or extended) or a lower body lift prior to medial thigh lifting will correct the vertical laxity component that these adjacent areas and allow for a better medial thigh contour. We recommend standing the patient in front of a mirror and pulling vertically upwards on their skin similar mimicking the results of an abdominoplasty or lower body lift. The author will combine abdominoplasty and medial thighplasty together when these are the only two areas the patient desires correction [14], but it depends on their preference to stage these procedures if possible. The main reasons are recovery time and also staging allow time for the groin crease position to settle. This minimizes inferior scar migration onto the visible part of the inner thigh. In patients that have undergone significant weight loss that need a lower body lift, we will stage the medial thigh lift if a vertical skin component is needed.

When medial thigh laxity is limited to the upper one-third of the thigh with or without residual adiposity, a classic medial thigh lift (groin crease incision) can be performed (Fig. 44.1). Patients that have laxity extending in to the middle and lower one-third of the thigh will require both a horizontal and vertical skin excision. This procedure is known as a vertical medial thigh lift (Fig. 44.2). The length of this vertical incision will extend to a point just distal to the skin laxity. In cases of significant weight loss, this will often end below the level of the knees.

Fig. 44.1 (**a**, **c**) This 29-year-old woman, (6′0″, 199 lbs., BMI 26.9), complained of skin laxity in the upper on-third of her medial thigh. She had good abdominal skin tone and did require an abdominoplasty. (**b**, **d**) Postoperative views 10 months following medial (groin crease) thigh lift

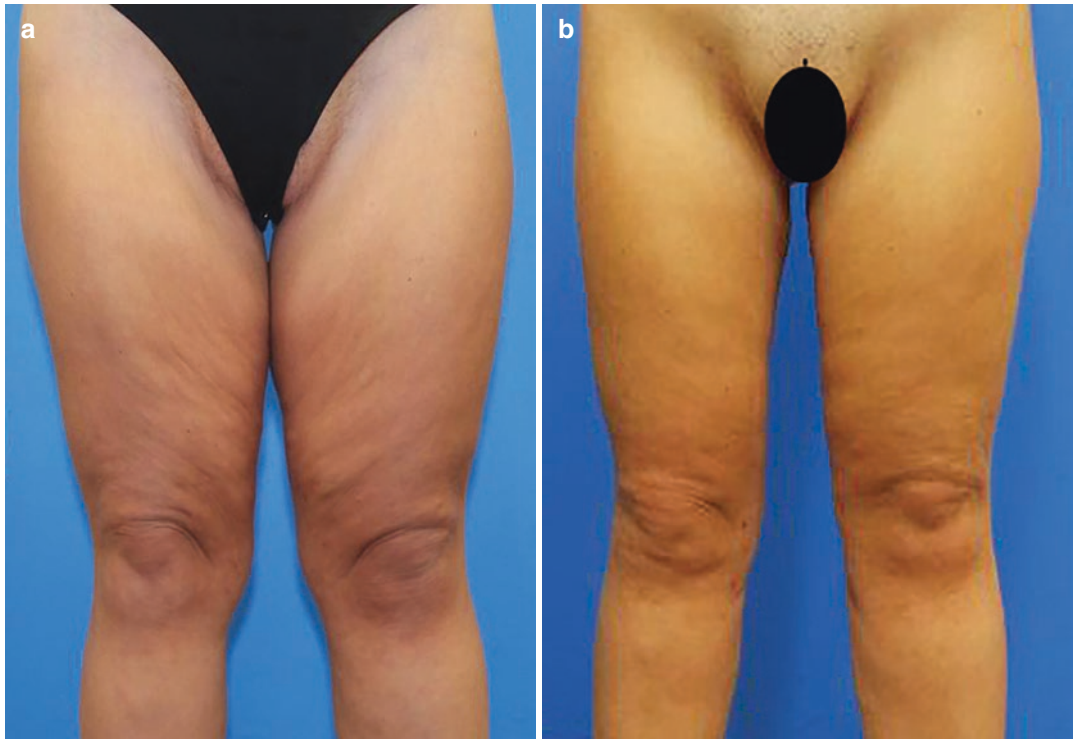

Fig. 44.2 (**a**) This 33-year-old woman, (5′2″, 144 lbs., BMI 26.4) lost over 135 lbs. following two pregnancies and after having bariatric surgery. The patient had undergone previous lower body lift and mastopexy/augmentation. (**b**) Postoperative views 4 months following vertical medial thigh lift

44.3 Classic Medial Thigh Lift (Groin Crease Only)

44.3.1 Patient Marking

Standardized pictures should be taken prior to procedure in the office. The patient is first marked in the standing position (Fig. 44.3). Gentle caudal traction is placed on the inner thigh to account for any potential skin migration, and the superior aspect of the skin excision is marked in the groin crease. Anteriorly, this will extend up to a previous abdominoplasty incision if necessary, although we try to keep this incision distinct if possible. The posterior aspect of the excision can extend into the gluteal crease as needed. We estimate the amount of skin excision with a pinch test. Residual fat deposits for liposuction are also

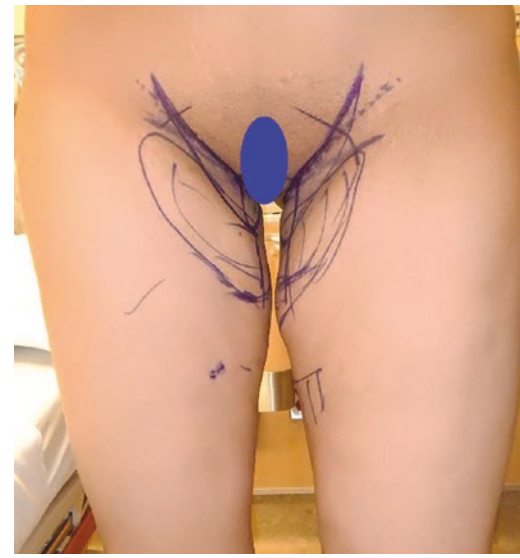

Fig. 44.3 Patient markings in the standing position

Fig. 44.4 A vertical line from the insertion point will mark the point of maximum excision, which is no more than 8 cm from the insertion

marked. The patient is then asked to lie down in the supine position and frog-legged. The insertion of the adductor longus muscle is identified. A vertical line from the insertion point will mark the point of maximum excision, which is no more than 8 cm from the insertion (Fig. 44.4). The amount of skin that can be resected is once again confirmed with a pinch test elevating the inner thigh skin to the groin crease with minimal tension. This point of maximum excision is then tapered to the to the anterior and posterior landmarks mentioned above to minimize skin bunching and dog-ear formation. The location of the femoral triangle is also noted.

44.3.2 Patient Positioning and Preparation

The operating room is pre-warmed, and a warming blanket is placed beneath the patient to minimize the risk of hypothermia [15, 16]. The patient is positioned supine on the operating room, and sequential devices are placed on the feet or legs prior to anesthesia induction. All dependent areas are padded prior to final positioning to minimize the risk of paresthesias or neuropraxia. If just a classic medial thigh lift is performed, a foley may or may not be required. Intravenous antibiotics are given prior to incision. The thighs are circumferentially prepped, and the abdomen, pubic, and groin regions are included within the sterile field.

44.3.3 Operative Technique

Tumescent solution is infiltrated into the areas of residual adiposity, and liposuction is then performed. The amount of infiltrate should estimate the amount of lipoaspirate. Excessive infiltration can result in edema. Following liposuction, the proximal incision is made first. Dissection over the femoral triangle and anterior to the adductor longus muscle is superficial to help protect the lymphatics. Posterior to the adductor muscle, dissection is down to the deep fascia. Dissection proceeds in a caudal direction to the estimated line of resection. Care is taken to preserve the saphenous vein. Once the amount of resection is confirmed, the skin is excised. The skin is temporarily closed with staples, and a similar procedure is performed on the contralateral leg. Once symmetry is confirmed, the inner thigh incisions can be closed. A 10F round drain is placed prior to closure if liposuction has been performed. Colles' fascia is identified adjacent to the adductor longus tendon insertion, and the flap is first anchored to the fascia with 0-Vicryl sutures. The superficial fascia is then closed with 0-Vicryl sutures. The skin is then closed in layers with a 3-0 Monocryl in both the deep dermis and subcuticular position (Fig. 44.5). The procedure is similarly performed on the contralateral side. Marcaine 0.25% with 1:200,000 is injected into the incision line to help with postoperative comfort. The incision is then sealed with Dermabond.

44.3.4 Postoperative Care

Postoperative care for the classic medial thigh lift is similar to the vertical medial thigh lift and is described below in the next section.

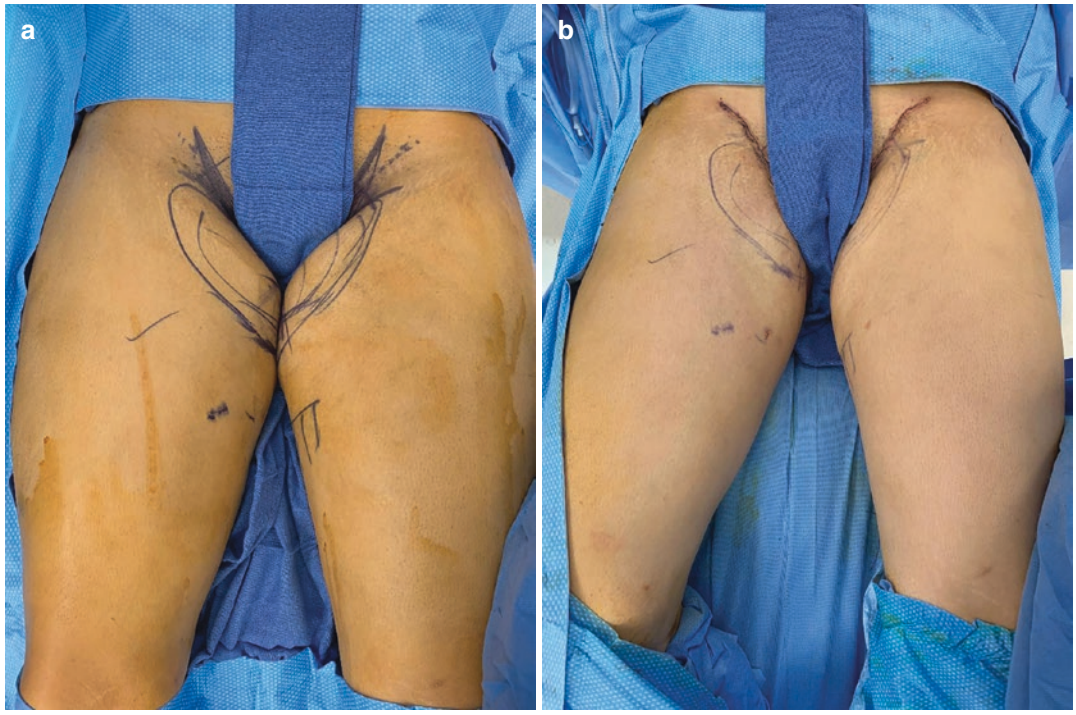

Fig. 44.5 (**a**, **b**) The skin is closed in layers with a 3-0 Monocryl in both the deep dermis and subcuticular position (preoperative and postoperative pictures)

44.4 Vertical Medial Thigh Lift

44.4.1 Patient Marking

Standardized photographs should be taken in the office prior to the procedure. Patients are first marked in the standing position. The adductor muscle insertion is first palpated. A vertical line is drawn posterior to the muscle insertion and extends down the length of the inner thigh and most commonly ends in a curvilinear fashion just below the knee (Fig. 44.6). This line should not be able to be seen from the front or back views. This line will represent the final scar position. A shorter vertical scar can be drawn if the laxity ends in the middle-third of the inner thigh. In rare cases, the incision will extend onto the medial calf crossing the knee adjacent to the medial condyle of the tibia.

The patient is then asked to lie down supine in the frog-leg position. Based upon the line demarcating the final scar position, a skin displacement technique is used to mark the anterior and posterior skin resection (Fig. 44.7a–f). This is done in

Fig. 44.6 The placement of the final incision is marked in the standing position on the medial aspect of the thigh, so it cannot be seen from the anterior or posterior when the patient is in their normal resting stance

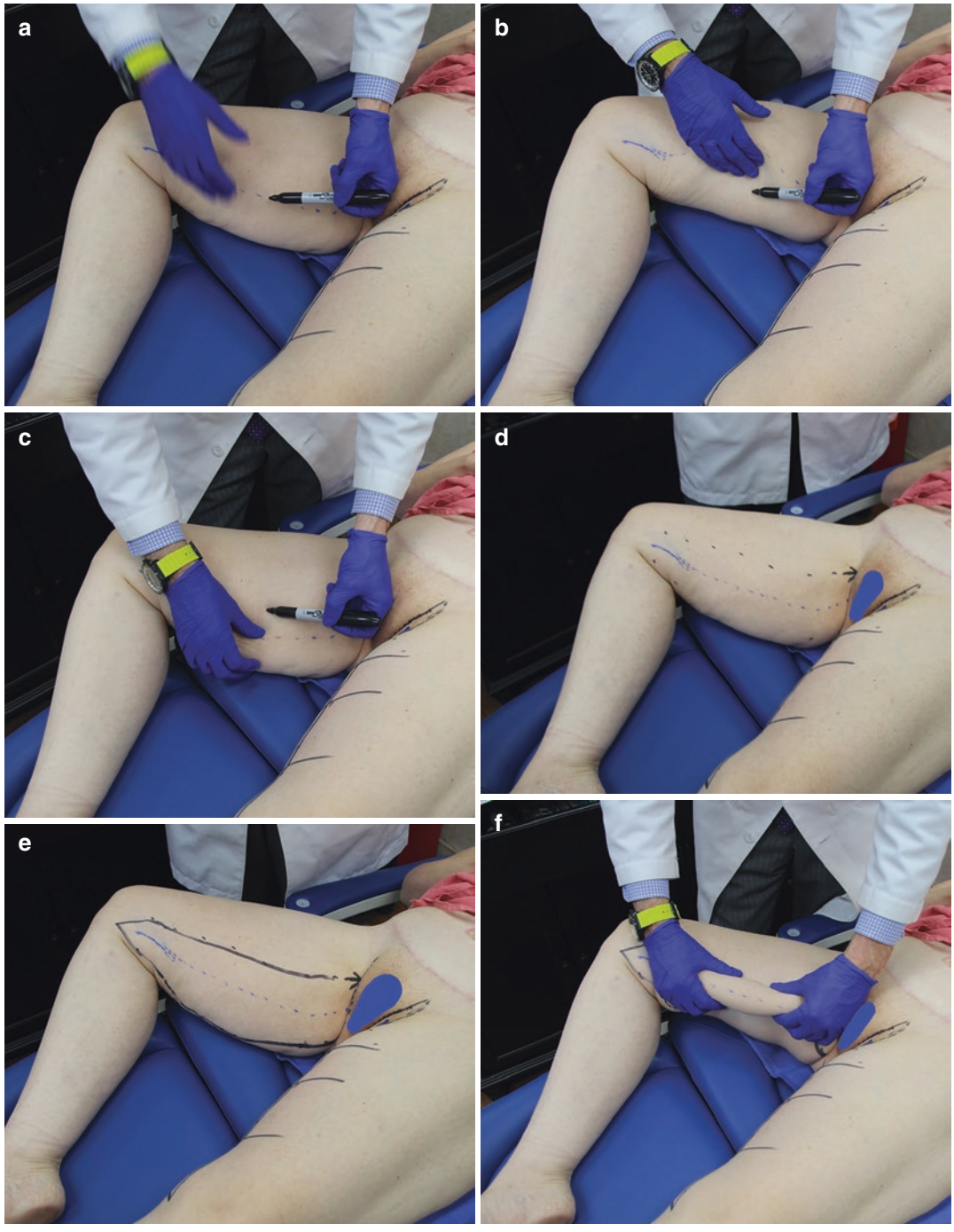

Fig. 44.7 (**a**–**e**) To determine the anterior and posterior extent of the excision, a displacement method is used. This is based on the desired final scar position (blue line). (**f**) A pinch test is used to confirm that these marks can be reapproximated with minimal tension. (**g**) Any excess skin that remains at the cephalad aspect of the thigh is excessed as a dog ear parallel to the groin crease under minimal tension. (**h**) Final markings. (The arrow points to the adductor muscle tendon. insertion)

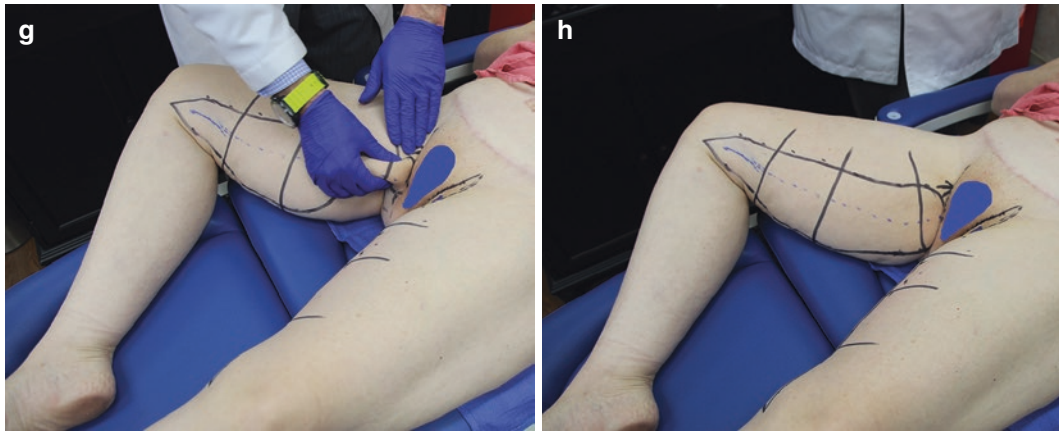

Fig. 44.7 (continued)

several places along the vertical inner thigh marking. A best fit line is made between the markings to outline the anterior and posterior extent of the inner thigh skin excision. Horizontal references lines are made to help guide closure. This vertical skin excision allows the leg to be closed like a cylinder optimizing the tightness of the thigh.

There will often be some residual vertical excess skin in the anterior and superior aspects of the thigh. This excess runs in parallel with the groin crease. This skin is excised as a dog ear along the groin crease leaving minimal tension in this region (Fig. 44.7g). This will minimize the risk of scar widening and scar migration. The femoral triangle is marked. Areas of residual adiposity that fall outside of the estimated lines of resection are marked for liposuction. The final markings are shown in Fig. 44.7h.

44.4.2 Patient Positioning and Preparation

These are similar to the classic medial thigh lift with the exception of that the sterile field extends lower. All vertical medial thigh lift will get a foley catheter following anesthesia induction.

44.4.3 Operative Technique

Areas of excess residual adiposity are infiltrated, and liposuction is performed. The amount of tumescent solution should estimate the amount of lipoaspirate. Excessive infiltration may contribute to increased swelling postoperatively. Liposuction is not performed in patients with a low BMI or that have significantly deflated inner thighs. Liposuction can be used to debulk areas outside of the resection zone to optimize contour. It is also used within the area of resection to help allow for optimal skin resection and also to help delineate the planes of dissection (Fig. 44.8a).

When performing a vertical thigh lift, the skin on one side is excised and temporarily closed before proceeding to the contralateral side to minimize the risk of excessive swelling. Following liposuction, a pinch test is used to confirm the area of resection (Fig. 44.8b). We prefer not to commit to both the anterior and posterior excision lines at first to minimize the risk of over resection and failure to close the leg. The anterior thigh incision is made first, and the incision is carried down to a plane just deep to the superficial fascia. In the area of the femoral triangle, only superficial dissection is performed to minimize injury to the lymphatic system. Dissection

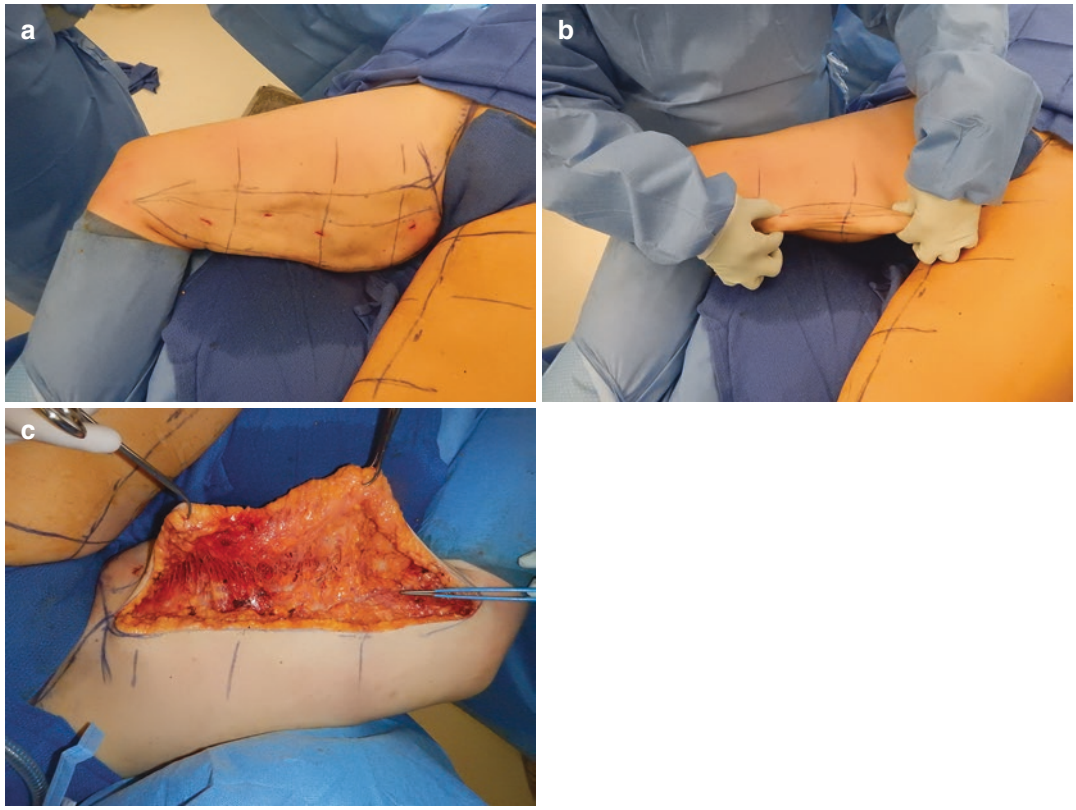

Fig. 44.8 (**a**) Liposuction is performed within the area of resection. This maneuver helps with dissection of the skin flap and also helps maximize skin resection. (**b**) The anterior and posterior lines of resection are confirmed with a pinch test. (**c**) Flap dissection is facilitated by the honeycomb appearance left following liposuction. It also allows for easy identification and preservation of the saphenous vein (adjacent to forceps)

is performed in an anterior to posterior fashion to the estimated line of resection. If liposuction was performed, a honeycomb appearance will result that will facilitate dissection. Care is taken to preserve the greater saphenous vein (Fig. 44.8c).

The excess skin is excised using serial resections to minimize the risk of excess tension and over resection. After each section is excised, the skin temporarily closed with staples. This helps facilitate closure by minimizing swelling. This process starts distally and works its way proximally (Fig. 44.9a–c). There is frequently a dog ear at the proximal aspect of the thigh. A pinch test is performed, and this skin is excised under minimal tension parallel to the groin crease (Fig. 44.9d). Once the resection has been completed and temporarily closed with staples on one side, the contralateral side is completed (Fig. 44.10).

Prior to closure, a 15F round drain is placed. We close the vertical section first and then the groin crease component. Since the skin of the medial thigh is often thin, it is difficult to get a three-layer closure on the inner thigh. For this reason, we close the superficial fascia system and the deep dermis together with 0 Vicryl. Interrupted 3-0 Monocril sutures are used as needed followed by a running 3-0 Monocril intracuticular stitch. At the "triple point," the skin flaps are anchored to Colles' fascia with 0-Vicryl sutures. The groin incision is closed in a similar manner as the classic medial thigh lift. The incisions are sealed with Dermabond. Marcaine 0.25% with 1:200,000 is injected into the incision line to help with postoperative comfort.

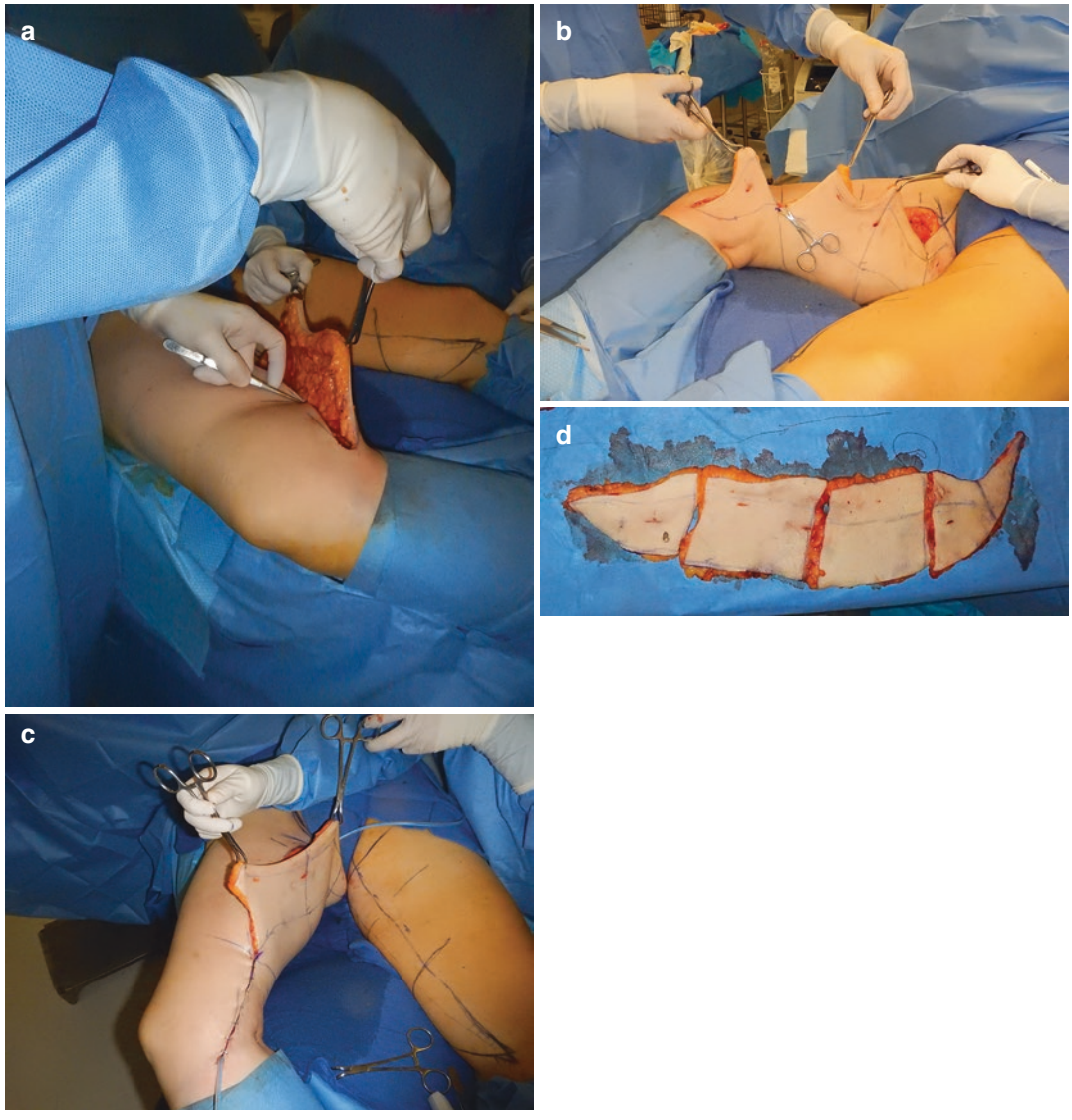

Fig. 44.9 (**a**–**c**) Serial resections are performed in a distal to proximal fashion to minimize the risk of over resection and the inability to close the incision. A drain is placed, and each section is then temporarily closed with staples to minimize swelling prior to excision of the next area. (**d**) Serial resection specimens shown with the small dog ear of redundant tissue that was excised parallel to the groin crease (right side of picture)

44.4.4 Postoperative Care

Vertical medial thigh lifts are performed on an outpatient basis when performed as a stand-alone procedure. When combined with other procedures, we keep the patient overnight for observation and discharge the patient home the following morning. To minimize the risk of venous thromboembolism, all patients must ambulate the evening of surgery. We start all patients on daily low molecular weight heparin (LMWH) chemoprophylaxis beginning 8 h after surgery for 2 weeks [17, 18]. High-risk patients are given a preoperative dose of unfractionated heparin (UH) [19]. We prefer UH for the preoperative dose because of the reversibility in the event there are any bleeding concerns.

Fig. 44.10 (**a**) Preoperative views of the medial thigh laxity. (**b**) Side-by-side comparison following excision of the right thigh skin excess and temporary closure compared to the left side. (**c**) Final result after closure of both medial thighs

Patients are placed in elastic wraps that can be adjusted after surgery. They are instructed to shuffle step for the first week to minimize tension on the incisions. Groin dressings are changed frequently to minimize moisture buildup. Patients are allowed to shower after 3 days. Compression wear is fitted on at their first postoperative visit and continues for 6 weeks.

Drain removal occurs when the output is less than 30 mL per day. Antibiotics are continued, while the drains remain in place. Oral narcotic pain medications are used for patient comfort. Our typical postoperative visit are at 1 week, 4 weeks, 3 months, 6 months, and at one year.

Care must be taken not to place excessive tension on the groin crease incisions. No lower body exercises are permitted for 6 weeks. Once the Dermabond adhesive falls off, scar treatments may begin. Patients are told that their scar will continue to fade and mature for up to 2 years.

44.4.5 Complications

Of all the body contouring procedures, medial thigh lifts have one of the highest overall complication rates. Recent published data showed complication rates ranging from 45 to 68% [1–3]. The most commonly observed complications are wound dehiscence (17–51%), seroma (10–25%), and infection (1–15%). The majority of these issues can be dealt with in the office.

Wound separation is the most common complication seen and generally happens after one week. It is most common along the groin incision in the medial thigh lift and where the vertical incision meets the groin crease in a vertical medial thigh lift. It is most commonly managed with local wound care that may require some minor debridement in the office. We don't recommend re-suturing these areas as they often fail due to the tension or shearing forces that caused them to occur in the first place. If the area is large, we will pack with wet to dry dressings using gauze and 0.9% normal saline. If the area is small, we prescribe Mupirocin 2% ointment and daily application area daily.

The second most common complication seen is seroma. It is often seen 2–3 weeks after surgery after the drains have been removed. It is more common in the vertical thigh lift and occurs around the knee. We perform needle aspiration twice per week until it resolves along with compression. If this fails, we will make a small incision through the existing thigh incision and into the seroma cavity, and a wick is left for 2 days to allow decompression (Fig. 44.11a, b). We also will have the patient place additional compression on the area. Antibiotics are given for the time the wick is in place. If the incision and drainage fail, the seroma cavity is excised in the office under local anesthesia.

The reported literature varies in terms of infection rates. Patients remain on antibiotics, while the drains are in place, either a first-generation cephalosporin or clindamycin in penicillin allergic patients. Cellulitis can occur along the incision line. In these instances, we cover for both *Streptococcus* and *Staphylococcus* species and place patients most commonly on cephalexin and doxycycline. Wound cultures are performed if there is any drainage from the incisions. In rare cases, admission for intravenous antibiotics is needed.

Up to this time, we have had no cases of venous thromboembolism in our thigh lift patients, but it is a reported risk. We place all of our patients on postoperative LMWH for 2 weeks. For high-risk patients, we give a dose of preoperative FH and then postoperative LMWH for 4 weeks.

Lymphedema is a risk that all patients need to be counselled about. It is higher in the vertical medial thigh lift patients and also patients with pre-existing edema or a previous history of edema. Although the incidence has been very low in our experience, some reports show it can occur in up to 30% of patients [20, 21]. Patients that

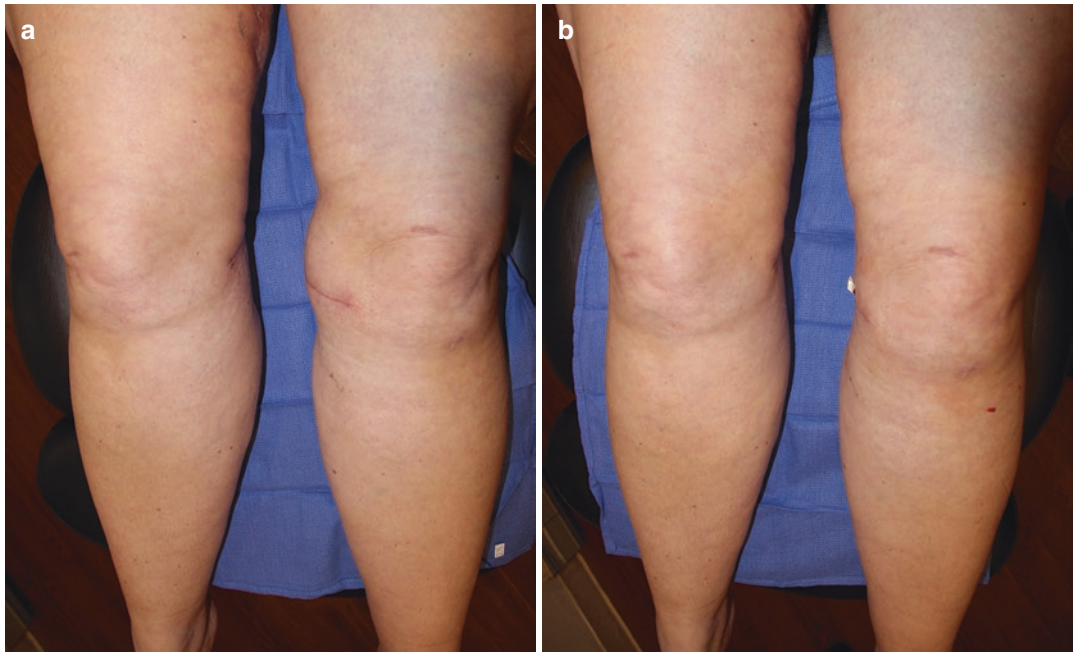

Fig. 44.11 (**a**) Postoperative seroma seen at the distal incision on the left leg. (**b**) This patient had a recurrent seroma despite conservative management with several needle aspiration attempts. A stab incision was made into the seroma cavity through the previous thigh scar any visible seroma capsule is excised. A wick is left in place to allow the area to drain and removed after 2 days. Compression is worn and the incision is allowed to close on its own

have pre-existing edema should be told that this might worsen after medial thighplasty, and deferral of medial thighplasty should be considered on case-by-case basis.

Pearls and Pitfalls

- Do not perform a medial thigh lift prior to an abdominoplasty or lower body lift as adjacent areas contribute to the laxity in the thighs.
- Patients need to be optimized medically and nutritionally prior to surgery.
- Make sure the patient understands the results they will achieve from the two types of thigh lift options. Make sure they have realistic expectations.
- To minimize tension and over resection, perform serial resections.
- Minimize undermining to reduce the risk of seroma.
- When performing liposuction be conservative with the amount of infiltrate to avoid excessive swelling. Perform liposuction on one leg at a time followed by immediate excision to avoid swelling and difficulty closing the thigh.
- Anchor the horizontal skin flap to Colles' fascia to minimize scar migration and labial spreading.
- To minimize the risk of chronic swelling/lymphedema perform only superficial dissection in the femoral triangle and preserve the greater saphenous vein.

44.5 Conclusion

The postpartum patient may present with skin laxity of the inner thighs in addition to other areas of concern, including the abdomen and breasts. Surrounding areas contribute to the laxity of the inner thighs, so it is important to address these first or at the same time as the inner thighs to achieve the optimal esthetic tech-

nique will give the patient their desired outcome. Preoperative evaluation, patient education, and managing expectations are critical to optimize results.

Disclosure Nothing to disclose.

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Varicose Veins After Pregnancy: Prevention and Treatment

45

Javier Rangel

Take-Home Points

- The most common risk factors for varicose veins include family history of venous disease, advancing age, increased body mass index, smoking, a history of lower extremity trauma, prior venous thrombosis, and, in women, pregnancy.
- The diagnosis of chronic lower extremity venous disease is predominantly clinical.
- The diagnosis of chronic venous disease is confirmed by the presence of venous reflux, which is diagnosed by duplex ultrasound by duration of retrograde or reversed flow.
- Static compression therapy is an essential component in the treatment of chronic venous disease.
- Sclerotherapy is used primarily in the treatment of telangiectasias, reticular veins, and small varicose veins, but it can also be used to treat saphenous and perforator reflux.

45.1 Introduction

Chronic venous disease refers to a wide spectrum of morphologic (i.e., venous dilation) and/or functional abnormalities (e.g., venous reflux) of long duration [1–3]. Vein-related problems may or may not be symptomatic and include a wide range of clinical signs. This full spectrum of signs and symptoms is associated with classes CØ to C6 of the clinical-etiology-anatomy-pathophysiology (CEAP) classification, but the term "chronic venous insufficiency" is generally restricted to disease of greater severity (classes C4 to C6) [4].

Chronic venous disease is a common disorder that affects the veins of the lower limbs. These veins carry blood from the legs to the heart. Normal veins have a series of valves that open and close to direct blood flow from the surface of the legs to the deep leg veins, from which calf muscles pump blood back to the heart.

During pregnancy, due to increased intra-abdominal pressure, as well as the estrogen-related hormonal changes that affect the walls and valves of the veins, the possibility of a slow-down of venous blood flow is present. If the calf muscles cannot pump properly, blood can flow backward in the veins causing venous hypertension.

Venous hypertension is associated with histologic and ultrastructural changes in the capillary and lymphatic microcirculation that produce important physiologic changes, which include capillary leak, fibrin deposition, erythrocyte and leukocyte sequestration, thrombocytosis, and inflammation. These processes impair oxygenation of the skin and subcutaneous tissues. The clinical manifestations of severe venous hyper-

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1_45

tension and tissue hypoxia are edema, hyperpigmentation, subcutaneous fibrosis, and ulcer formation.

Chronic venous insufficiency is associated with chronic disability, diminished quality of life, and high health care costs [5–9].

45.2 Epidemiology

A large proportion of patients with chronic venous disorders of the lower limbs do not consult, which skews many studies carried out on series of consultants. The epidemiology of varicose veins has been the subject of recent reviews, and some main facts should be noted:

The prevalence of varicose veins is high in the general population of industrialized countries, affecting 30–60% of the subjects.

The saphenous trunks or their first-order collaterals are affected in around half of the cases. The two lower limbs are also affected.

Age is a major risk factor: exceptional during the first decade, varicose veins reach a prevalence of 15% at 35 years and 65% at 75 years.

The predominance of women is evident in the series of consultants, but this is undoubtedly the result of recruitment bias. However, the impact of hormones on venous tone is well known. The veins in the small pelvis and lower limbs (great saphenous vein) have receptors for estrogen and progesterone. In addition to their role in water retention, estrogens and progesterone modify venous distensibility and parietal tone. Natural progesterone has a relative corrective effect on the effects of estrogen than synthetic progesterone does.

Environmental factors play an important role in the occurrence of varicose veins. The advanced explanations (diet, overweight, footwear, position at work) are still in the realm of the hypothesis. Pregnancies have a favorable role. The influence of the history of deep vein thrombosis remains difficult to assess epidemiologically because studies lack power on this point; their contribution is in any case small in view of the prevalence of varicose veins.

The prevalence is increased in families with varicose veins, which is more than just family habits, since a recent study of twins demonstrates the existence of a plurigenic genetic factor.

45.3 Venous Anatomy and Physiology

45.3.1 Venous Anatomy

There are three major vascular pathways responsible for draining blood away from the superficial vessels of the skin and subcutaneous fat of the legs: (a) superficial veins, a network of subcutaneous veins that are superficial to the deep muscular fascia; (b) deep veins, veins located deep to the muscle fascia; and (c) perforating veins, veins that communicate deep and superficial venous systems.

The axial veins of the venous system of the lower extremity are divided into the superficial and deep systems. Veins that traverse between the same system (superficial to superficial or deep to deep) are termed communicating veins, whereas veins that connect the superficial to the deep system are called perforating veins. Eighteen named venous segments are used as locators of pathology and classified anatomically as superficial veins (As), deep veins (Ad), perforating veins (Ap), or venous location not specified (An).

45.3.1.1 Superficial Venous System (As)

The superficial venous system is contained in the subcutaneous tissue of the lower extremity within a superficial space that is bounded superficially by the dermis and deeply by the muscular fascia. The major axial superficial veins of the lower extremity include the great and small saphenous veins. Other lower extremity superficial veins with more variant anatomy include the anterior, posterior, and superficial accessories of the great saphenous vein; the superficial accessory of the small saphenous vein; intersaphenous veins (communicating veins between the great and small saphenous veins); and the lateral venous system.

– The great saphenous vein (GSV) is one of the axial superficial veins in the lower extremity. It is the longest vein in the body, originating from the dorsal venous network of the foot and crossing anterior to the medial malleolus and coursing medially in the lower leg and thigh. Just below the inguinal ligament, it enters the fossa ovalis and terminates in the common femoral vein at the confluence of the superficial inguinal veins at the saphenofemoral junction, the anatomy of which can be quite variable. The anatomy of the saphenofemoral junction is highly variable [10]. The great saphenous vein also drains into the deep venous system through both calf and thigh perforating veins (Fig. 45.1).

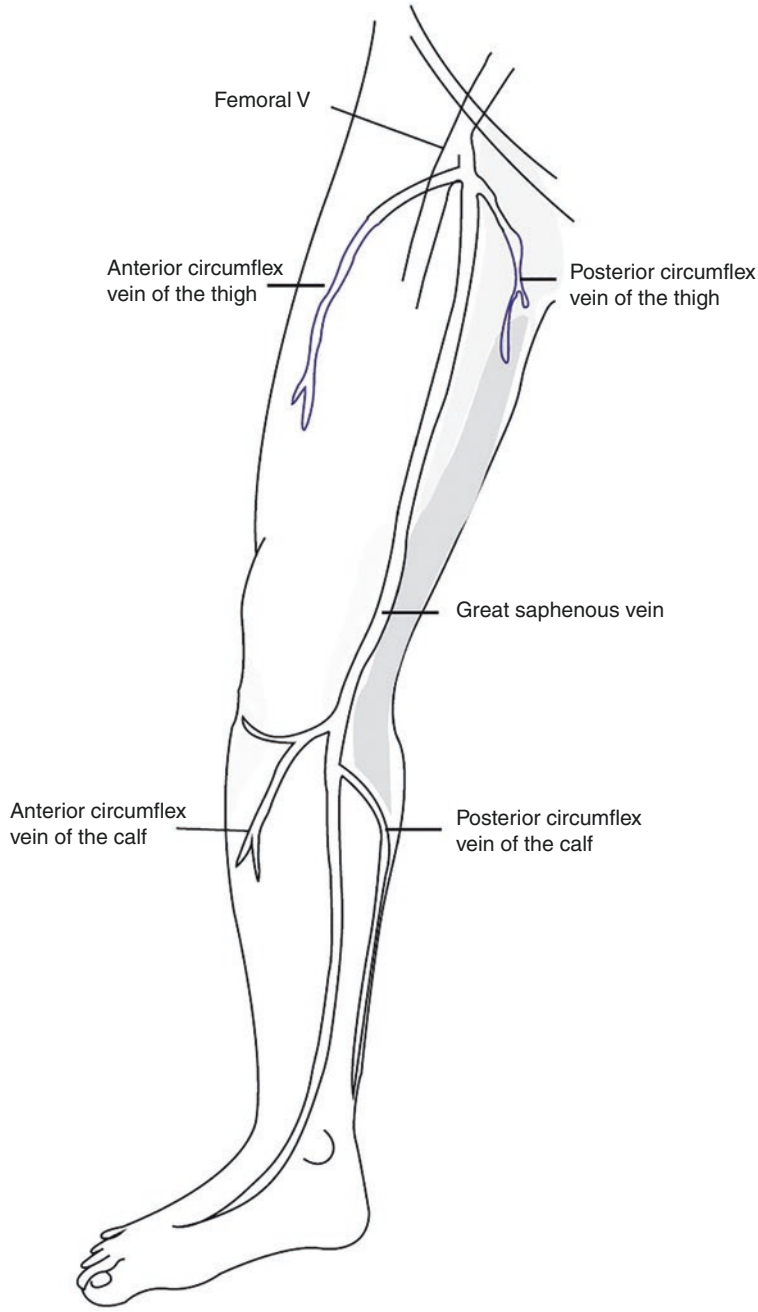

Fig. 45.1 The GSV and its primary tributaries. The vein segments shaded in gray in the saphenous compartment. Those shaded in blue are superficial to the superficial fascia. (Reprinted from John Bergan M.D. (auth.), Neil S. Sadick, Neil Khilnani, Nick Morrison (eds.) Practical Approach to the Management and Treatment of Venous Disorders-Springer-Verlag London (2013))

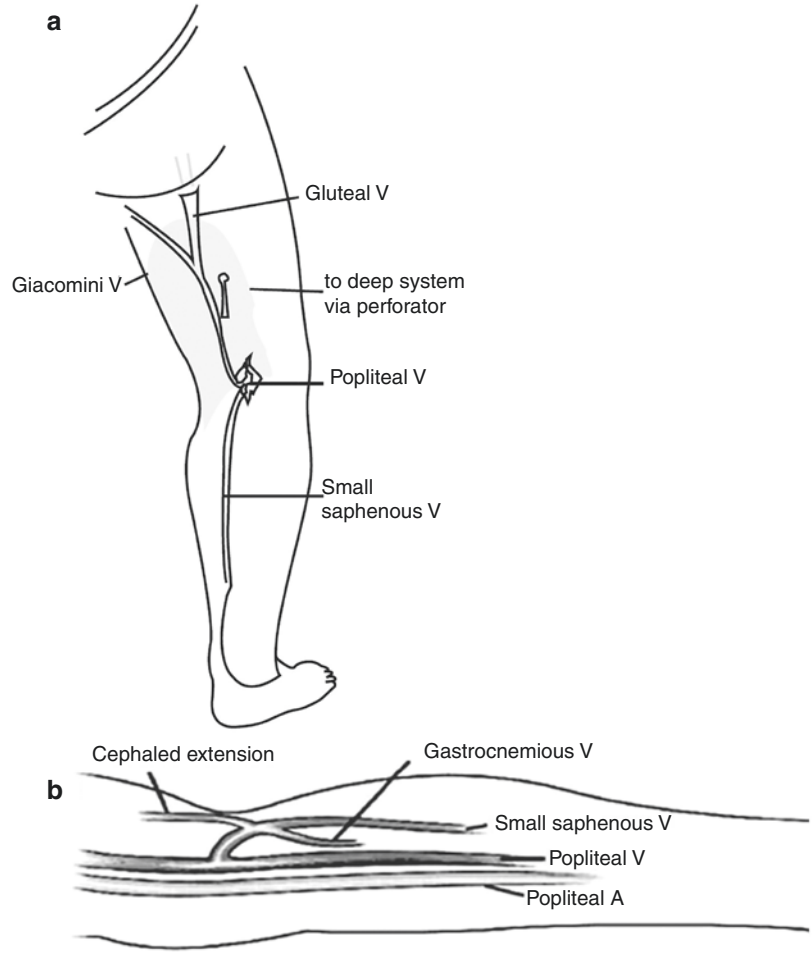

Fig. 45.2 (**a**) Posterior view of the lower extremity demonstrating the SSV and its primary connections. (**b**) Lateral view of the lower extremity, with the head of the patient to the left of the page, demonstrating the SSV and its central connections. (Reprinted from John Bergan M.D. (auth.), Neil S. Sadick, Neil Khilnani, Nick Morrison (eds.) Practical Approach to the Management and Treatment of Venous Disorders-Springer-Verlag London (2013))

– The small saphenous vein (SSV) is another of the axial veins, and it originates laterally from the dorsal venous arch of the foot, crosses posterior to the lateral malleolus, and ascends posteriorly along the midline of the calf overlying the fascia between the heads of the gastrocnemius muscle. In the upper calf, the SSV passes through the deep muscle fascia and terminates in the popliteal vein at the saphenopopliteal junction (SPJ), which also has highly variable anatomy [11–14]. The SSV can join a superficial cephalad extension in the posterior thigh (vein of Giacomini), connect to both the popliteal vein and the posterior thigh vein, or join the popliteal vein with no major tributaries near the junction. Anatomic variations in the SSV have implications for SSV ablation [14] (Fig. 45.2).
– Accessory saphenous veins (ASVs) are any of several venous segments that ascend parallel to the GSV. Anterior ASVs are located anteriorly and can be found in the thigh or leg [15]. The accessory saphenous veins can become more prominent after saphenous ablation procedures and are a potential source of recurrent varicose veins.

45.3.1.2 Perforating Veins (Ap)

This group of veins traverse the muscular fascia to connect superficial veins with the deep veins. They are located anteriorly, posteriorly, laterally, and medially in both the thigh and calf. The nor-

mal flow in the perforating veins is from superficial to deep; however, many perforators demonstrate bidirectional flow. When the perforating veins are incompetent, flow is from deep to superficial. The most clinically significant perforating veins connect the posterior arch vein to the posterior tibial vein. These veins, termed posterior tibial perforators, were formerly known as Cockett's perforators.

45.3.1.3 Deep Venous System (Ad)

The deep venous system is contained within the deep muscle compartments bounded by the muscle fascia (Fig. 45.3). The deep veins of the lower extremity are classified as intramuscular (within the muscle) or intermuscular (between muscle groups). The intermuscular veins are more important in the development of chronic venous disease [16].

In the leg, the intermuscular veins of the leg include the popliteal veins and crural veins (paired anterior tibial, posterior tibial, and peroneal veins). The intramuscular veins include the gastrocnemius and soleal sinus veins.

The three paired crural veins are named after the artery they accompany. The posterior tibial veins originate from the medial foot at the medial malleolus, the anterior tibial veins from the dorsum of the foot, and the peroneal veins from venous collaterals originating between the distal tibia and fibula. The popliteal vein originates in the popliteal space as the confluence of the crural veins. The popliteal veins transition to be renamed the femoral vein at the level of the adductor canal in the thigh. Duplication of the femoral vein in the thigh is a well-recognized anatomic variant. The popliteal vein may also be duplicated.

In the thigh, the intermuscular veins include the femoral vein, deep femoral vein, and common femoral vein. The femoral vein is joined just below the saphenofemoral junction by the deep femoral vein to form the common femoral vein.

In the pelvic, the veins draining blood away from the lower extremities can, when narrowed or thrombosed, contribute significantly to the development of chronic venous disease. The main collecting veins of the pelvis include the external iliac veins, internal iliac veins, and common iliac veins.

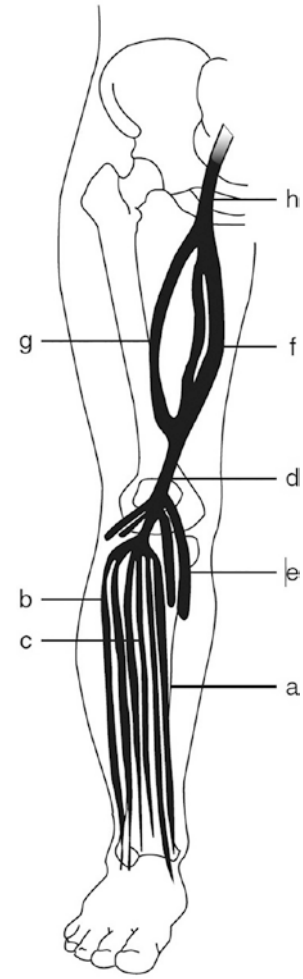

Fig. 45.3 Deep veins of the lower extremity, frontal view. (**a**) Paired posterior tibial veins. (**b**) Paired anterior tibial veins. (**c**) Paired peroneal veins. (**d**) Popliteal vein. This vein is often duplicated partially or completely. (**e**) Medial gastrocnemius veins. (**f**) Femoral veins (this vein is often duplicated; it is duplicated in this diagram). (**g**) Deep femoral vein (this vein can occasionally be large and continuous with the popliteal vein as in this illustration). (**h**) Common femoral vein. (Reprinted from John Bergan M.D. (auth.), Neil S. Sadick, Neil Khilnani, Nick Morrison (eds.)-Practical Approach to the Management and Treatment of Venous Disorders-Springer-Verlag London (2013))

After passing beneath the inguinal ligament, the common femoral vein becomes the external iliac vein, which is joined by the internal iliac veins to form the common iliac veins. The common iliac veins merge at the level of the umbilicus to form the inferior vena cava. Because the inferior vena cava is usually located to the right of the spine, the left common iliac vein is longer with a less vertical path to the cava. The left common iliac vein is crossed anteriorly by the right common iliac artery, and this results in variable degrees of compression of the left common iliac vein by the right common iliac artery. When associated with left lower extremity edema or iliac vein thrombosis, this is referred to as May-Thurner syndrome.

45.3.1.4 Anatomy Not Specified (An)

In clinical studies, if an anatomic location is not identified, "An" is assigned.

45.3.2 Venous Physiology

There are two major determinants of venous flow: the venous valves and "venous pump."

- Venous valves direct flow from distal to proximal and from the superficial system to the deep system except in the foot, where flow is directed from the deep system to the superficial system. Venous valves increase in number in direct relation to the hydrostatic pressure; in the distal deep veins, for example, they may occur every 2 cm [17]. Venous valves are typically bicuspid. Competent valves serve two main functions: they prevent the transmission of sudden rises in venous pressure in the superficial veins and capillaries during muscular contraction, and at the end of muscle contraction, the valves prevent retrograde flow back into the superficial system.
- The "venous pump" refers to the effect of calf muscles on venous flow as by increasing subfascial pressure above intramuscular vein hydrostatic pressure. The effectiveness of the pump is dependent upon the presence of adequate muscle contraction and competent venous valves [18].

When this system is functioning appropriately, the ambulatory venous pressure in the superficial system is maintained between 20 and 30 mmHg.

45.4 Pathophysiology of Chronic Venous Disease

45.4.1 Venous Hypertension

The level of venous pressure can reach 60–90 mmHg in the presence of venous obstruction, incompetent venous valves, or inadequate muscle contraction, constituting this venous hypertension initiating the anatomic, physiologic, and histologic changes associated with chronic venous insufficiency [10–13].

45.4.1.1 Genetic Factors

There is evidence suggesting the influence of genetics in the etiology and pathology of venous disease [19]. Genome association studies have identified strong candidate genes and gene-related proteins responsible for matrix metalloproteinases, vascular endothelial growth factors, and vascular development. Other genes responsible for abnormal iron metabolism (hemochromatosis C282Y gene mutation) and the development of collagen have also been implicated in the development of chronic venous disease and ulceration [20, 21].

45.4.1.2 Anatomic Changes

The primary anatomic abnormality associated with venous hypertension is the inability of valve coaptation, resulting in the increase in pressure, which is transmitted backward into the superficial venous system; thrombosis also destroys the valves, resulting in the persistence of venous hypertension even if the thrombosed veins are recanalized. Chronic venous insufficiency is also associated with fewer valves per unit length, which contributes to higher venous

pressures [14]. As deep and superficial veins become distended with excess volume, anatomic distortion of the vessel wall produces further valvular incompetence and an excess in wall pressure. It is the transmission of this excess pressure that is responsible for most of the skin changes [22].

45.4.1.3 Physiologic Changes

Standing is normally associated with reflex constriction of the precapillary arterioles; by diminishing the transmission of arterial pressure to the capillary bed, this response protects the capillary bed from surges in venous hydrostatic pressure when assuming an upright posture. Patients with venous hypertension may lose this reflex; as a result, large increases in venous pressure are transmitted directly to the superficial capillary system [23–25].

Venous hypertension is associated with a reduction in shear stress, which promotes the release of inflammatory cells into the vein wall and valves promoting local inflammation. Endothelial cells are capable of detecting reduction in shear stress and changes in the microenvironment and respond by releasing nitric oxide, prostacyclin, and anti-inflammatory substances [26, 27]. However, unchecked local inflammation can lead to endothelial cell dysfunction with reduced production of vasoactive mediators and anti-inflammatory properties; thus, this cascade of events ultimately leads to venous wall and valvular damage with abnormal venous wall remodeling characterized by venous dilation and insufficiency [26–29].

45.4.1.4 Histologic Changes

Sustained venous hypertension is associated with changes in the venous wall, including variation in wall thickness, increases in type 1 collagen, decreases in type III collagen, degradation of extracellular matrix, and reductions in the number of smooth muscle cells [4, 30]. These changes weaken the vessel wall and may lead to abnormal venous dilation, including tortuous (e.g., telangiectasias, varicose veins) and nontortuous segments [31]. The chronic release of inflammatory mediators is a fundamental cause for the trophic skin changes associated with venous insufficiency such as lipodermatosclerosis, atrophie blanche, and ulceration.

45.5 Signs and Symptoms of Lower Extremity Chronic Venous Disease

The diagnosis of chronic lower extremity venous disease is predominantly clinical. Initial evaluation consists of a thorough history and physical examination, with clinical classification of disease severity according to the clinical-etiology-anatomy-pathophysiology (CEAP) criteria [32]. The CEAP classification is helpful in documenting venous disease severity both at initial presentation as well as in documenting changes over time.

Up to one half of patients, even some with very large varicosities, have no specific symptoms [4]. Symptomatic patients may or may not correlate certain lower extremity symptoms with the presence of abnormal veins; alternatively, the patient may erroneously attribute symptoms that are more consistent with orthopedic or arterial vascular disease to their visible veins.

45.5.1 Risk Factors for Venous Disease

The most common risk factors include family history of venous disease, advancing age, increased body mass index, smoking, a history of lower extremity trauma, prior venous thrombosis, and, in women, pregnancy.

The patient who has no identifiable risk factors may have suffered a remote lower extremity trauma they do not recall, or an undiagnosed deep vein thrombosis (DVT). Duplex ultrasound in these patients may identify valvular insufficiency, chronic vein wall thickening, or chronic thrombosis indicative of post-thrombotic syndrome [33–35].

45.5.2 Symptoms

The clinical presentation of symptoms varies widely; however, the most common symptoms reported by patients with chronic venous disease are limb discomfort (i.e., tired, heavy legs), pain, and limb swelling [36]. Pain and limb discomfort were reported as a significant symptom for each of the six clinical-etiology-anatomy-pathophysiology (CEAP) [4]. Pain may be generalized or localized to specific veins, areas of lipodermatosclerosis, or ulceration.

Pain associated with venous disease, as well as extremity swelling, is typically worse when standing, or when seated with the feet dependent for prolonged periods of time, and improves with limb elevation and walking [37]. The pain associated with venous disease is typically directly associated with the affected veins, skin changes, or ulceration; it does not radiate as with radiculopathies and is not exacerbated by joint movement as in arthritis. In women, exacerbation of symptoms can occur with the menses or pregnancy, due to increased fluid volume and/or higher circulating levels of estrogen.

Other symptoms include limb aching or generalized fatigue, skin discoloration or redness, muscle cramping, numbness, tingling, or itching. Numbness and tingling due to chronic venous disease can become chronic and may be difficult to distinguish from other causes of peripheral neuropathy that affect the lower extremity [38–40].

45.6 Physical Assessment

The patient should undergo a complete physical examination with a detailed lower extremity examination that includes assessment of clinical signs of venous disease, pulse examination, and neurologic assessment. The femoral and pedal pulses (i.e., dorsalis pedis and posterior tibial pulses) are usually palpable in younger patients. In older patients, a handheld Doppler ultrasound may be necessary to assess pedal arterial flow.

45.6.1 Clinical Signs by CEAP Classification

45.6.1.1 No Clinical Signs

Approximately 20% of patients with clinical symptoms consistent with a chronic venous disorder have no visible clinical signs [4]. Duplex examination identifies functional disease (i.e., venous reflux).

45.6.1.2 Telangiectasia/Reticular Veins

The most frequently encountered manifestation of venous disease is mild venous dilation. Telangiectasias are a confluence of dilated intradermal venules less than one millimeter in diameter. Telangiectasias are more common in women [4]. Reticular veins are dilated, bluish subdermal veins, one to three millimeters in diameter, and are usually tortuous.

45.6.1.3 Varicose Veins

Varicose veins are subcutaneous dilated, tortuous veins greater than three millimeters in diameter. They may involve the saphenous veins, saphenous tributaries, or nonsaphenous superficial leg veins.

45.6.1.4 Edema

Long-standing venous disease associated with venous reflux is characterized by the development of dependent ankle edema, which may progress over time to include the calf region. In the early stages of chronic venous insufficiency, edema may be present only at the end of the day; however, with time, it can become persistent throughout the day.

45.6.1.5 Skin Changes

Individuals with functional venous disease due to venous reflux are prone to develop stasis dermatitis, which is one of the most common and earliest dermatologic signs of chronic venous insufficiency.

Pigmentation changes are initially most prominent at the medial ankle but subsequently may encroach upon the foot and lower leg. Brown and

blue-gray hyperpigmentation on the anterior lower leg is a common finding and is known as lipodermatosclerosis. The pigmentation is due to hemosiderin deposition, which derives from the breakdown of red blood cells that have extravasated through damaged capillaries into the dermis.

Atrophie blanche manifests as atrophic, hypopigmented patches with focal red punctate dots or telangiectasias, surrounded by hyperpigmentation. These are most often seen on the medial distal leg near the malleolus, or can occur within lipodermatosclerotic skin, where they correspond to points of avascular fibrosis. These areas do not represent healed venous ulcers, but they are vulnerable to future ulceration because of poor perfusion.

45.6.1.6 Venous Ulceration

Chronic venous disease is a common cause of lower extremity ulcers [41–45]. In addition to venous reflux and prior deep vein thrombosis, other risk factors associated with venous ulcer formation include older age, low physical activity, arterial hypertension, lipodermatosclerosis, obesity, and family history of venous ulceration [46–48]. They are usually located low on the medial ankle over a perforating vein, or along the course of the great or small saphenous veins; ulcers may be multiple or single and are exquisitely tender, shallow, and exudative and have a granulation base. The ulcer borders are usually irregular but not undermined. They can extend circumferentially around the leg if left untreated [4].

45.7 Diagnostic Evaluation of Lower Extremity Chronic Venous Insufficiency

Severe clinical manifestations of chronic venous disease, including pain, edema (which can be unilateral), skin changes, and venous ulceration, are often sufficient to establish a diagnosis of chronic venous insufficiency. However, objective testing is needed to confirm the diagnosis, determine the etiology (reflux, obstruction, or reflux and obstruction), localize the anatomic site and severity of disease, or identify coexisting peripheral artery disease.

45.7.1 Diagnostic Tests

45.7.1.1 Duplex Ultrasonography

Duplex ultrasonography is only justified in the case of visible varicose veins or symptoms of superficial venous thrombosis. It must always follow a complete arterial and venous clinical examination.

Duplex ultrasonography is the standard for assessing venous reflux in the great and small saphenous veins (SSVs) as well as accessory saphenous veins, posterior thigh extension of the SSV, intersaphenous vein, deep veins, and perforator veins, each of which needs to be evaluated by duplex to fully treat the patient [49–51].

Methodologically, two examinations must be carried out with a high frequency sensor (7.5–10 MHz):

- First, lying down, looking for obstructive thrombotic sequelae or active deep vein thrombosis.
- Second, standing, exploring both the continence of the deep venous network at the femoral, popliteal, and leg level and the permeability and continence of the superficial venous network.

The diagnosis of chronic venous disease is confirmed by the presence of venous reflux which is diagnosed by duplex ultrasound by duration of retrograde or reversed flow (>0.5 s for superficial or perforating veins, >1 s for deep veins) [32, 52, 53].

Duplex ultrasonography is more sensitive and specific than descending venography in predicting the clinical severity of venous insufficiency [54].

45.7.1.2 Air Plethysmography

Air plethysmography (APG) is a noninvasive physiologic examination that measures relative volume changes in the limb in response to

postural changes and muscular activity. The test is more typically used by clinicians who perform large numbers of interventional venous procedures as a means to assess the hemodynamic results of venous interventions, or as a research tool.

45.7.1.3 Transillumination

It uses a cold light source in contact with the skin to identify superficial venous network under the skin, which is little or not visible to the naked eye. Its principle is to highlight, thanks to the difference in refraction and absorption of light in the tissues, a large part of the intradermal venous network located in the first 3 mm below the epidermis. Reticular varicose veins are particularly clearly visible as well as the varicose branches under dermis most often little or poorly identifiable by Doppler echo. Guarantee of safety, it improves the practice of sclerotherapy of these small vessels and facilitates the precision of the marking of small varicose veins intended for surgical phlebectomy.

45.7.1.4 Venography

- Cross-sectionally, the role of multidetector computed tomographic (MDCT) venography and magnetic resonance (MR) venography in the management of chronic venous disease is not well defined, and their impact on patient outcomes has not been documented [55–60]. For patients who have signs of venous insufficiency but normal or equivocal Doppler ultrasonography findings, MDCT and MR venography should be considered.
- Catheter-based conventional catheter-based venography (ascending, descending) is rarely needed to make a diagnosis of chronic venous disease but is performed to confirm a diagnosis of venous outflow obstruction prior to intervention.

45.7.1.5 Ankle-Brachial Index

The ankle-brachial index (ABI) is also often needed to exclude arterial disease in patients with ulceration or symptoms compatible with peripheral artery disease (e.g., claudication). Concurrent arterial disease is important to identify because compression therapy, which is the standard treatment for venous ulceration and is contraindicated in the presence of significant arterial occlusive disease [61].

45.8 Medical Management of Lower Extremity Chronic Venous Disease

45.8.1 General Measures

45.8.1.1 Leg Elevation

Elevating the feet to at least heart level for 30 min three or four times per day can improve cutaneous microcirculation and reduces edema in patients with chronic venous disease and also alone may be sufficient to relieve symptoms in patients with mild venous disease.

45.8.1.2 Exercise

Progressive resistance exercise such as heel lifts and prescribed physical activity (walking and/or cycling 30 min per day three times per week) appeared to be the most effective. The efficiency of the calf muscle pump in pushing venous blood up the legs is usually impaired in patients with chronic venous insufficiency [62–64]. The addition of exercise to usual care (mostly compression) is associated with increased venous leg ulcer healing at 12 weeks [65–71].

45.8.1.3 Compression Therapy

Static compression therapy is an essential component in the treatment of chronic venous disease [72, 73]. Many patients with varicose veins report rapid symptomatic improvement with use of compression hosiery although there are few high-quality data that demonstrate the effectiveness of compression hosiery for managing symptomatic varicose veins.

The principle of compression is to restore as normal a transmural pressure as possible by increasing the extravascular tissue pressure.

In orthostatism, the distal venous pressure of 90 mmHg gradually decreases to the right atrium (5 mmHg), and the venous pressure at the root of the thigh is 45 mmHg. To respect this

physiological degression, the pressure exerted by the device must be degressive from the tip of the foot to the root of the member. This will be done naturally for bands under Laplace law enforcement.

Effect of Compression on Venous Hemodynamics

Resting

- Reduction in venous size: 50% twin veins and 34% popliteal vein, peroneal veins.
  - Corollary increase in the speed of venous flow.
  - Decrease in venous stasis.
  - Maximum anti-edema effect when the transmural pressure is zero.

In Orthodynamism

- Reduction in venous size, less than at rest.
  - Improvement of the functioning of the musculo-venous pump.
  - Decrease in ambulatory venous pressure measured in direct venous pressure.

45.8.2 Pharmacologic Therapy

45.8.2.1 Venoactive Drugs

Venoactive drugs are a heterogenous group of agents of natural or synthetic origin including flavonoids, rutosides, and other less studied agents such as aminaphthone, calcium dobesilate, Centella asiatica (gotu kola), naftazone, and chromocarbe [74, 75].

Most venoactive drugs have been shown to increase venous tone by a mechanism related to the norepinephrine pathway [76]. Other actions include reduction of capillary hyperpermeability, improved lymphatic drainage, anti-inflammatory effects, and decreased blood viscosity [77]. These agents may be useful for managing any class of venous disease. Their effectiveness is mostly related relieving symptoms such as extremity heaviness and pain [74, 78].

Flavonoids include rutin, rutoside, diosmin and hidrosmin, disodium flavodate, pycnogenol, French maritime pine bark extract, grape seed extract, and various combinations of these. These agents appear to be safe when administered during pregnancy [79].

45.9 Liquid, Foam, and Glue Sclerotherapy Techniques for the Treatment of Lower Extremity Veins

Sclerotherapy is a minimally invasive percutaneous technique using chemical irritants to induce fibrosis within the vein treated. Sclerotherapy is used primarily in the treatment of telangiectasias, reticular veins, and small varicose veins, but it can also be used to treat Saphenous and perforator reflux.

45.9.1 Indications

Candidates for sclerotherapy are patients with persistent symptoms (pain, aching, swelling) or signs (e.g., telangiectasias, reticular veins, varicose veins, pigmentary changes, and ulceration) of venous disease.

Sclerotherapy may be used to treat superficial telangiectasias, reticular veins, and varicose veins. Sclerotherapy techniques to achieve perforator and saphenous closure are also available for patients with documented reflux as a source of their symptoms.

While telangiectasias and reticular veins may be asymptomatic, patients often find the cosmetic appearance of their veins distressing. Sclerotherapy can be performed following physical examination without further diagnostic studies, as these patients are not as likely as symptomatic patients to have underlying venous reflux [9, 80].

45.9.2 Contraindications

Patients who have signs of acute thrombosis/phlebitis, due to the increased risk of deep venous thrombosis.

Pregnant patients should defer treatment until after delivery.

Diabetes and peripheral arterial occlusive disease (ankle-brachial index <0.9) are relative contraindications to a risk for wound complications.

A history of migraine headache and patent foramen ovale are relative contraindications to sclerotherapy due to a risk for microembolism [81–86].

45.9.2.1 Sclerotherapy Agents (Figs. 45.4 and 45.5)

The most common agents used in the treatment of lower extremity telangiectasias, reticular veins, and small varicose veins are sodium tetradecyl sulfate, polidocanol, glycerin, and hypertonic saline. These substances cause endothelial damage by their actions as either osmotic or detergent agents. Osmotic agents achieve their effect by dehydrating endothelial cells through osmosis. Detergents are surface active agents that damage the endothelium by interfering with cell membrane lipids.

Fig. 45.4 Marking of a reticular vein with patient in a standing position. (Reprinted from John Bergan M.D. (auth.), Neil S. Sadick, Neil Khilnani, Nick Morrison (eds.) Practical Approach to the Management and Treatment of Venous Disorders-Springer-Verlag London (2013))

Fig. 45.5 Traction on the skin directly over reticular vein with rapid cannulation of the skin surface and subsequent endothelium (puncture feel technique) is the technique of choice in treating reticular veins. (Reprinted from John Bergan M.D. (auth.), Neil S. Sadick, Neil Khilnani, Nick Morrison (eds.) Practical Approach to the Management and Treatment of Venous Disorders-Springer-Verlag London (2013))

Systematic reviews of randomized trials of injection sclerotherapy for telangiectasia or varicosities found no evidence to support the use of one sclerosant over another in the short-term success of sclerotherapy [87, 88].

Sodium Tetradecyl Sulfate

Sodium tetradecyl sulfate is the most commonly studied sclerosant [87]. The maximum recommended dosage is 10 mL of a 3% solution in the United States and Canada; the volume used varies worldwide depending on formulation. Dilutions between 0.1 and 3.0% are used depending upon the size of the vein treated (Fig. 45.6).

Polidocanol

Polidocanol, also known as aethoxysklerol, is also a detergent. The maximum dosage is dependent upon the weight of the patient. Dilutions between 0.25 and 5% are used depending on the size of the vein treated. In a

Fig. 45.6 Pre/post sclerotherapy of reticular veins employing sodium tetradecyl sulfate 0.25% (4 cc total injection). (Reprinted from John Bergan M.D. (auth.), Neil S. Sadick, Neil Khilnani, Nick Morrison (eds.) Practical Approach to the Management and Treatment of Venous Disorders-Springer-Verlag London (2013))

systematic review comparing various sclerotherapy agents for the treatment of telangiectasias, polidocanol was no more painful than placebo [88].

Glycerin

Chromated glycerin (e.g.,Scléremo, Chromex, Skermo) is a potent osmotic with dilutions that range from 25 to 72%. The maximum recommended amount per session is 10 mL [89]. While very popular worldwide, it is not commercially available in the United States.

Hypertonic Saline

Hypertonic saline is the most commonly used osmotic agent for lower extremity sclerotherapy. The dilution used to treat lower extremity vessels ranges from 11.7 to 23.4%. Hypertonic saline (20%) mixed with heparin 100 units/mL constitutes Heparsal. Hypertonic saline is frequently mixed with local anesthetic to reduce the pain associated with injection (e.g., 20% saline plus 2% lidocaine).

45.9.2.2 Liquid Sclerotherapy

Liquid sclerotherapy can be used to treat telangiectasias, reticular veins, small nonsaphenous varicose veins (<5 mm), residual or recurrent varicosities following endovenous ablation or surgery, and perforator veins [87, 90].

Liquid injection sclerotherapy is the gold standard for the treatment of the majority of lower extremity telangiectasias and reticular veins. Due to the risk of long-standing hypopig-

mentation from laser and light treatments, liquid sclerotherapy is a more appropriate choice for patients with Fitzpatrick skin types IV, V, and VI.

45.9.2.3 Foam Sclerotherapy

Sclerosant foam was developed from the detergent sclerosant agents to increase the surface area of exposure and is more commonly used for the treatment of larger veins.

45.9.2.4 Preparation

The foam can be produced manually just prior to injection using the Tessari method [91]. Foam prepared according to the Tessari technique has a half-life of approximately 90 s. An alternative consists of a product that dispenses a low-nitrogen gas and sclerosant liquid under pressure to produce a polidocanol foam with appreciably smaller and consistently sized bubbles compared with a foam/air mixture made by hand [92].

Sclerosant foam is echogenic due to the tiny air bubbles in the foam, which are easily seen with duplex ultrasound. In principle, all vein calibers are suitable for foam sclerotherapy; however, a minority of practitioners would use it for treatment of telangiectasias or reticular veins because there is no significant advantage over liquid sclerotherapy in small vessels [93].

45.9.2.5 Cyanoacrylate Glue

The use of glue was initially described for treatment of saphenous incompetence in 2013 [94]. The procedure is performed like radiofrequency and laser ablation, but without the need for tumescent anesthesia. In a randomized trial comparing this system with radiofrequency ablation, short-term outcomes at 3 months were similar [95]. Longer-term follow-up is needed to determine the durability of the results.

45.10 Techniques and Follow-Up

There is no consensus on specific aspects of sclerotherapy technique, including type of sclerosing agent, use of local anesthetic, use or type of local compression pad, and use or duration of compression dressing (bandage or elastic). Serial injections are often needed to address the veins of interest. Typical sessions last from 15–60 min.

A light dressing and graduated compression stockings or bandages can be applied depending on the physician.

The patient is discharged, providing he/she has experienced no adverse reactions. The patient is counseled to ambulate normally and may return to work.

Many physicians recommend the use of compression stockings or elastic bandages after the sclerotherapy with liquid. After treatment with microfoam, patients should wear compression stockings continuously for 24 h and afterward during the day (off at night and to bathe) for the next 2 weeks until a month depending on the vein treated.

If the procedure was performed in telangiectasias, patients can exercise after 24 h. Exercise should be avoided for at least one week if the procedure was performed with microfoam. Treated areas should not be exposed to the sun during this time period. Alternatively, sunscreen with a high sun protection factor (≥SPF 50) may be applied to the treated areas if the patient is going to be exposed to sun light. The patient must be instructed to contact the physician immediately if he/she is experiencing increasing pain or if any ulcers after the treatment at the injection sites or if they experience any visual, sensory, or motor disturbances, especially after treatment with microfoam.

Repeat sessions of treatment are frequently needed, especially in the treatment of telangiectasias. The next session can be performed after 2 weeks from the prior one.

45.10.1 Adverse Reactions

Common local adverse reactions to sclerosing agents include pain, ulceration, urticaria, hyperpigmentation, and telangiectatic matting, vasovagal reactions [96]. Most local reactions are transient and resolve within minutes/hours (pain,

urticarial), weeks (ulceration) or months (hyperpigmentation, telangiectatic matting) following the procedure.

45.10.1.1 Minor Pain

Pain is common at the sclerotherapy injection site. Significant pain during injection may be an indication that the sclerosing agent has extravasated into the tissue around the vein. Polidocanol is associated with the least amount of pain upon injection, whereas hypertonic saline and glycerin are the most painful, especially when used without lidocaine [97].

45.10.1.2 Ulceration

Ulcers may occur when the sclerosing agent extravasates from the vein into the subcutaneous tissue. The reported incidence is 1–5% of patients treated. When ulcers occur, they are usually small and most often heal with local care in 4–6 weeks. However, they may result in scarring.

45.10.1.3 Thrombus

Thrombus forms within the vessel if blood comes into contact with the sclerosing agent. The resulting mild inflammatory reaction is a source of post-treatment pain and is more common with treatment of reticular veins and small varicose veins than telangiectasias.

Microthrombectomy, which removes clot, significantly reduces postsclerotherapy pain and inflammation. It is typically performed within 2–3 weeks following treatment by making stab incisions (21- to 27-gauge needle) along the length of the thrombosed vein.

45.10.1.4 Telangiectatic Matting

Telangiectatic matting consists of multiple, fine dilated vessels in the area of the injection site. It is relatively common, occurring in 15–24% of patients, and usually resolves within 3–12 months [98].

In one retrospective review of 2120 patients, significantly more patients in the matting group were overweight, on female hormones (estrogen, progesterone) during sclerotherapy treatment, and had both a family history and a longer duration of abnormal veins compared with the non-matting group [98].

45.10.1.5 Hyperpigmentation

Hyperpigmentation occurs in up to 30% of patients following sclerotherapy. It is caused by deposition of hemosiderin in the skin as a result of extravasation of red blood cells. It usually becomes noticeable within one month following sclerotherapy and resolves spontaneously in 80% of patients within 2 years [99]. It occurs more commonly with treatment of veins greater than one millimeter in diameter.

It is important for patients who experience hyperpigmentation to avoid sun exposure to the treated areas.

45.10.2 Complications

A mild inflammatory reaction is expected within the treated veins; however, intense superficial thrombophlebitis can occur, and deep venous thrombosis, while uncommon, has been reported. Other complications include microembolic events (i.e., coughing, migraine-like headache, visual disturbances, paresthesias, and stroke), and anaphylaxis.

45.10.2.1 Superficial Thrombophlebitis

A mild inflammatory response is expected after sclerotherapy, and some patients may have urticaria at the site of injection. A more intense superficial thrombophlebitis with erythema, warmth, and pain can extend to veins neighboring the injection site.

45.10.2.2 Deep Vein Thrombophlebitis

A systematic review of foam sclerotherapy reported deep vein thrombosis occurring in 0.02–5.7% in the included studies [100]. Deep venous thrombosis is more likely to occur after sclerotherapy of the saphenous veins [101]. Popliteal vein thrombosis has been reported with foam sclerotherapy of the small saphenous vein [102,

103]. That is the reason why physicians should perform proximal compression of the saphenofemoral junction or the sapheno-popliteal junction depending on the case.

45.10.2.3 Visual and Other Neurologic Disturbances

Neurologic disturbances are usually transient. Symptoms include visual disturbance (scotoma), migraine-like headache, and neurologic deficits. These appear to be more common with foam compared with liquid sclerotherapy [104, 105]. During foam sclerotherapy of the great saphenous vein, microbubbles can be detected in the right heart and pulmonary circulation, in patients with a patent foramen ovale (PFO), and in the left heart as well [85, 106]. Coughing following foam sclerotherapy has been attributed to air microembolization into the pulmonary circulation. Because visual and neurologic disturbances have been reported with non-foamed sclerosant solutions and have occurred in the absence of a PFO, an alternative theory has been proposed involving neurologic symptoms the release of endothelin, a potent vasoconstrictor.

45.10.2.4 Anaphylaxis

Anaphylaxis can occur with any of the sclerosing agents with the exception of hypertonic saline.

45.11 Sclerotherapy Results and Success Rate

Clearance of 60–80% of treated telangiectasias, reticular veins, and small varicose veins can be expected [100, 107–112]. Vein clearance rates and overall patient satisfaction favor sclerotherapy over cutaneous laser [107, 108, 113].

Rates of saphenous closure with ultrasound-guided foam sclerotherapy (UGFS) appear to be lower compared with endovenous methods [114–117]. In a prospective study, significantly higher rates of great saphenous occlusion were seen in patients treated with endovenous laser compared with foam sclerotherapy (93.4 vs 77.4%) [114]. Other studies have reported higher long-term success with one or more treatment sessions [118–120]. In one of these studies, 90% of great saphenous veins were free of recanalization with two sessions over a mean 39 months of follow-up [118]. For the small saphenous vein, closure rates of 91–94% at 12 months follow-up have been reported [103, 121].

Recurrence of telangiectasias and reticular veins is uncommon if the treated veins have disappeared. The development of new veins (i.e., neovascularization) and telangiectatic matting are more typical [122].

45.11.1 Venous Clinical Severity

Sclerotherapy of telangiectasias, reticular veins, varicose veins, and incompetent perforator veins is effective in reduction of signs and symptoms in the treated veins with high rates of patient satisfaction [87, 123].

45.12 Conclusions

During pregnancy, the possibility of a slowdown of venous blood flow is present.

The diagnosis of chronic lower extremity venous disease is predominantly clinical. However, the diagnosis of chronic venous disease is confirmed by duplex ultrasound.

Static compression therapy has an important role in the prevention of chronic venous disease.

Treatment includes minimally invasive techniques as sclerotherapy.

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M. Gomes-Ferreira, J. Olivas-Menayo (eds.), *Post-maternity Body Changes*,
https://doi.org/10.1007/978-3-030-43840-1