Alvaro Cansanção
Alexandra Condé-Green
Editors

Gluteal Fat Augmentation

Best Practices in Brazilian Butt Lift

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To my wife Georgia and my children Davi and Isa whose love, sacrifices, understanding, and unselfish support have made editing and writing this book possible.

To my father, Dr. Alvaro Cansanção, for being a great example of character and professionalism, responsible for awakening in me the passion for plastic surgery. He has thought me everything I know, from how to hold a scalpel to the most refined plastic surgery techniques. Even today, 20 years after plastic surgery residency, I continue to learn from him daily in the operating room and it is a great honor to be practicing by his side.

Alvaro Cansanção

To my best friend and husband Joseph Louis Hogan whose love and unselfish support has made my academic and clinical work as a plastic surgeon possible for many years. To my daughter Anne-Isabelle Hogan for being patient, calm and an angel while I spend hours working at the office and even at home.

To my worldwide friends and colleagues in plastic surgery who have made me achieve so much more than I could have ever imagined by learning and listening to them, as so many have made remarkable contributions to our specialty.

Alexandra Condé-Green

Foreword

Gluteal augmentation through fat grafting, popularly known as the Brazilian Butt Lift or BBL, continues to gain in popularity and dare I say notoriety? Notoriety based on safety concerns related to massive fatal fat embolism. This work, including the words "best practices" in its title, is dedicated to patient safety, promoting best practices proven to reduce morbidity and mortality of this procedure which is increasingly sought after worldwide.

Despite safety concerns, demand for BBL has and will continue to grow. The International Society of Aesthetic Plastic Surgery's (ISAPS) international survey on aesthetic/cosmetic procedures reported over 45,000 such procedures for 2018, while the American Society for Aesthetic Plastic Surgery (ASAPS) Cosmetic (Aesthetic) Surgery National Data Bank Statistics for 2018 included over 25,000 cases of BBL in the United States, representing a 15% growth in the procedure from 2017 and 86% growth between 2014 and 2018 [1].

I commend Dr. Conde Green and Dr. Cansancao for this timely publication dedicated to the science and art of such a surgical technique and most importantly to the safety of BBL. Both have contributed to our understanding of fat grafting and body contouring. They have assembled an international group of authors each recognized as an expert on gluteal reshaping. Each of these experienced author surgeons has contributed to the safety and evolution of the procedures described.

The book is divided into four parts. Part I covers history and the basics including anatomy, aesthetics, and most notably three chapters on the art and science of fat grafting. Part II, comprising the major portion of the book, is dedicated to surgical technique, which includes a variety of fat harvesting, fat preparation, and fat grafting techniques. Parts III and IV are dedicated to alternate and ancillary procedures.

Each chapter is comprehensibly and beautifully illustrated with art work and clinical images outlining details of each technique, how to avoid pitfalls and complications including massive fat embolism. Clinical pre- and post-op images demonstrate the effectiveness of each technique.

This is a comprehensive work covering all aspects of buttock shaping which will be of great value not only to the novice just embarking on buttock contouring but also to the seasoned surgeon who will find valuable information to enhance results, reduce complications, and improve safety.

Foad Nahai, MD, FACS, FRCS (Hon)

Reference

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Preface

This book was written in order to inform and educate plastic surgeons who wish to perform gluteal fat augmentation in a safe manner, obtaining great long-term results. Even though gluteal fat augmentation has been performed since the early 1980s, it was somewhat marginalized. Thirty years later, the increase in demand and the popularity of the procedure have made it a hot topic in plastic surgery.

We first started to perform this procedure during our plastic surgery residency in Rio de Janeiro, Brazil, in the 2000s. There were two books on the subject at the time: *Buttocks Reshaping* from Raul Gonzalez and *The Art of Gluteal Sculpting* from Constantino Mendieta. However, these books described the personal techniques of each of these editors.

When Springer proposed to us to write this book because of our course at the annual meeting of the American Society of Plastic Surgeons, Plastic Surgery The Meeting, and our Best Cosmetic Surgery article awarded by *Plastic and Reconstructive Surgery* journal, we thought it would be interesting to not only show our concepts of gluteal fat augmentation but also share the techniques of several world-renowned plastic surgeons, so that the reader can appreciate the different techniques and apply the best to their practice and to their patients.

The book was carefully planned as we invited the masters of gluteal surgery from North America, Central America, South America, Europe, and Asia to share their extensive clinical and scientific experience. We are honored and grateful that the vast majority agreed to participate and contribute to our book.

The book contains 35 chapters divided into 4 parts: the basic concepts of gluteal fat grafting, the description of the procedure per se, other surgical techniques available for the treatment of the gluteal region, and ancillary techniques that can greatly improve the results of the procedure when used in conjunction with gluteoplasty.

This book was harder to write than we had imagined, especially with all the changes that came along since we started to write it: the cases of death from fat embolism, the identifying cause being intramuscular gluteal fat grafting that many plastic surgeons were doing previously; the statistics showing at some point that it was the plastic surgery procedure with the highest mortality rate; and the guidelines and restrictions to only inject fat in the subcutaneous plane. We were writing about a hot topic when all the concepts of this procedure were changing. Therefore, many chapters had to be rewritten and the information constantly updated. It took us more than 2 years to collect all the information and follow the new guidelines of the procedure. After all, we are offering our readers from around the world the most updated and current information in gluteal surgery, especially in gluteal fat augmentation. We hope to contribute to making gluteal fat augmentation a safer procedure, as education, dissemination, and sharing of knowledge are the best ways to increase patient safety, so that more plastic surgeons can perform the procedure safely with great long-lasting results.

Boa leitura – Bonne lecture

Rio de Janeiro, RJ, Brazil — Alvaro Cansanção
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Introduction

Gluteal Augmentation and Buttocks Reshaping: Two Different Concepts

Buttocks reshaping and gluteal augmentation are two slightly different concepts. The difference became apparent as gluteal contour surgery evolved. Reshaping aims at projecting the buttocks and making it rounder to achieve a nicer and more sensual shape that is in harmony with the rest of the body. For reshaping, some volume is added to selected areas of the buttocks that need more volume, or adipose tissue is removed from other areas such as the lower pole or close to the gluteal cleft, or large size buttocks can be reduced overall. It is, in principle, a very broad concept.

Augmentation is performed mostly to increase the volume of the current size of the gluteal region, based on the patient's request, without compromising the aesthetic aspect. It is of outmost importance to understand that it is not possible to use large filling volumes without losing the shape of selected areas of the buttocks. Also, when increasing the volume of the buttocks, the fine shape may be lost and the harmonious contour compromised.

Gluteal Augmentation or Reshaping? Or Gluteal Augmentation and Reshaping?

The indication of the procedure is based on the understanding of what the patient is looking for and what he or she is expecting. Asking them to bring pictures of gluteal contour that they like helps us understand what they want and which profile suits them best.

Many patients, especially Brazilians, are looking more for nicely shaped and contoured buttocks rather than for large sized buttocks. Small increases in selected areas, such as the trochanteric and ischiatic depressions, the superior aspect of the buttocks, will give the aspect of a lifted buttock. Patients who have lost projection due to sedentary life are looking to retrieve the shape that they had when they were young, and for those patients, selective reshaping or perhaps smaller gluteal implants may be preferred options instead of increasing the size of the buttocks.

Patients who are looking for a large increase in volume are usually more straightforward about what they want and most of the time they bring along pictures of their favorite models. Some of them are hard to please because they have high expectations and are often disappointed when the results fall short of what they had requested.

It is important not to confuse those two types of profiles and to identify exactly what patients are looking for. Successful indications and the right candidate result from clearly understanding those two different concepts.

Did Brazilian Surgeons Start Gluteal Contour Surgery by Reshaping or Augmenting the Buttocks?

Buttocks surgery started in the late 1980s and early 1990s in Brazil and Latin America. The first cases of fat grafting to the buttocks aimed at molding the buttocks were described in 1986, by this author, and were already popular in Brazil in the late 1990s. Raul Gonzalez, the pioneer, soon followed by Sergio Toledo, Paulo Matsudo, Luis Haroldo Pereira, Sergio Levy, and others were paramount in imparting fat grafting, first in Brazil and then abroad.

Brazilian surgeons very quickly adopted fat grafting as a procedure for *RESHAPING* the buttocks. At first, small volumes of fat were used by most surgeons (150–300 ml) especially in the trochanteric depression and on the superior aspect of the buttocks, where most patients need some filling to correct depressions and give the effect of a higher buttock. These volumes of fat are small when compared to those described in "*Brazilian Butt Lift*" (*BBL*), clearly an AUGMENTATION procedure, especially by American authors. After several years, Brazilian surgeons also started transferring larger volumes of fat to the buttocks, although most do not exceed 500 ml per side.

Why Has the Brazilian Fat Grafting Reshaping Technique Been Successful?

The procedure's success and popularity are based on two pillars: safety and good aesthetic outcomes. The fact that most Brazilian plastic surgeons inject fat in the subcutaneous layer, which is less vascularized than the muscular layer, has improved safety. When fat is injected in the intramuscular plane, it is placed in the superior aspect, the middle and thicker part of the muscle and not the lower aspect of the muscle and the tendinous part where it adheres to the sacrum. Injecting fat in these latter areas have a higher risk of injuring the gluteal vessels. This method of taking "*volume*" and "*area*" into account led to a low rate of complications of any nature such as infection, fat embolism, fibrosis, and retractions. As for the aesthetic results, experience has shown that using less volume in well-selected areas is more effective and achieves greater outcomes.

Creating a Market for Gluteal Reshaping in Brazil

One of the reasons why gluteal fat grafting became popular was the simplicity and the safety of the procedure, surgeons promptly began to offer it to patients who wished to have liposuction, as a means of "taking advantage of" and "reusing" the lipoaspirate to reshape the buttocks. Back in the mid-1990s, people assimilated this procedure as an "extra" advantage and part of the benefits of liposuction. This increased the demand for liposuction, since many patients knew that reshaping would be included "in the package" and it was easier for women who wished to have some improvement of the shape of their buttocks to take the decision to go forward with the procedure. To this date, the number of gluteal reshaping procedures with fat grafting is larger among patients whose main purpose is liposuction, but who are also looking for the reshaping that comes along with it, rather than the number of patients who specifically seek plastic surgeons to increase the size of their buttocks.

While buttocks reshaping with fat grafting grew in popularity, the use of gluteal implants also evolved, somewhat slower because of its complexity. On the other hand, thanks to the understanding of plastic surgeons of the superiority of the intramuscular techniques of gluteal implant placement and the need to respect the anatomical landmarks (XYZ) to achieve good results, in the year 2000, many gluteal implants were used in Brazil and became increasingly popular over the years.

Brazilian Buttocks Lifting Is Not Brazilian

It can be said that the Brazilian Butt Lift, as the term is used in United States, is not Brazilian. It is not properly a lifting procedure, but more of an augmentation procedure than a reshaping procedure. The true Brazilian way to improve gluteal contour was and has continuously been essentially a reshaping procedure. The demand for this type of procedure is continuously growing in this direction. Obviously, the concern with size exists also in Brazil and some patients are interested in larger buttocks. However, the interest for the majority of patients seeking this procedure is a great contour and shape of their buttocks rather than larger ones. Having perky and round buttocks is the most important request from Brazilian patients. On the other hand, BBL is the result of a market created for women who are looking for large-sized buttocks and an outstanding hourglass figure.

The Limit Between Buttocks Reshaping and Buttocks Augmentation Is Narrow

Both aspects are equally important and must be part of the armamentarium of every plastic surgeon that performs this procedure. To respond to the requests of some patients, some plastic surgeons obstinately give patients an hourglass figure, sometimes disproportionate to the waistline and hip measures. In order to achieve these results, aggressive liposuction is performed and large volumes of fat are transferred to the buttocks. On the other hand, the reshaping procedure is a delicate and thoroughly planned procedure with nice and more natural changes. Finding a balance between the two is important. The globalization of gluteal contour procedures has led to a fusion of local trends and cultures of the patients, with the experience of plastic surgeons around the world, each adapting to local preferences in order to obtain great outcomes.

Reshaping with Gluteal Implants

The major advantage of implants is that one can achieve projection at the center of the buttocks. Gluteal fat grafting provides a more scattered projection, which is not always desirable, and, therefore, gluteal implants in some patients is the only way to achieve the required remodeling. Nevertheless, the chosen technique is paramount to avoid two common problems with gluteal implants: asymmetry and visibility of the implants. The plane that will be used is of utmost importance to avoid such problems. The subcutaneous plane has shown to be impractical and should not be used. The sub-fascial plane in thin patients with saggy skin might make the implants more visible when the gluteal muscle contracts. Undoubtedly the best plane for gluteal implants is intramuscular as it provides more coverage in order to conceal the implants. The placement of the implant inside the muscle, as in a sandwich, leaves equivalent parts of the muscle in front and behind the implant and helps it stay in place when the muscle contracts, equally distributing the pressure exerted by the muscle onto the implant. During the undermining and split of the muscle, if one area is thinner than the other (this often happens on the lateral aspect of the muscle), with time, the continuous pressure on the implant by contraction of the larger and stronger (deeper) parts of the muscle on the smaller and weaker (more superficial) parts leads to gradual surfacing or even herniation of the implant. A guided technique such as the XYZ can help avoid this problem.

The Role of the Buttocks in Body Contouring

The buttocks are the center of the posterior part of the body and play a significant role in the beauty and harmony of the body. Their role in the posterior part of the body is similar to the one played by the breasts in the anterior part. The projection and round shape are common characteristics to both breasts and buttocks and are feminine features, undoubtedly important in the attraction between sexes.

Sexual attraction in most mammals is highlighted by the sense of smell, but for men sight and touch are more important. This explains the attraction that the visual differences in the male and female bodies cause. Undeniably, female buttocks play a significant role in sexual attraction. The posterior view, which represents three fourths of the posterior profile, is an alluring feature that intrigues and attracts the male sex. For all these reasons, the interest in improving techniques to value the shape of the buttocks is more than justifiable, and body contouring surgery is increasingly including the buttocks in its armamentarium.

The First Steps for Body and Gluteal Contouring

Before 1980, the posterior part of the body was rarely addressed. Surgeries involving the posterior contour such as trochanteric gluteal lifting, belt lipectomy among others, left extensive scars that were not attractive to patients. The term "Body Contouring" was introduced by John R. Lewis in 1980. The following year, Ivo Pitanguy, Bahaman Temourian and Bradford Fischer in different publications also used the term "Body Contouring." All the procedures described during that period were procedures that would address excess skin laxity and there were no appropriate procedures for small lipodystrophies which would results in minimal or shorter scars.

Liposuction Enters the Picture: The Body Contouring Dream Comes True

Liposuction was described in the early 1980s, and by the end of the decade, it was the most prevailing aesthetic surgical procedure in many countries. Liposuction of the trochanteric area performed in the prone position became popular, giving surgeons the power to act nearly on the whole posterior contour, not to say on the whole body. Concomitantly, patients became bolder in their requests, asking for liposuction in different parts of their body, including the posterior contour which expanded body surgery to a true "*Body contouring*." Later on, coinciding with the advent of liposuction and driven by it, the term "*body contouring*" became popular and turned out to be a key word to define a set of changes achieved through surgery, almost like sculpture, to attain beauty and harmony of the whole body, both front and back.

The Synergistic Effect of Liposuction and Gluteal Augmentation

Liposuction plays an important role in gluteal contour surgery. To perform a procedure on the gluteal region without completely and thoroughly evaluating the patient as a whole, especially the rear view, is to disregard the significant relationship between the buttocks and the posterior contour as a whole. Thus, liposuction of the area surrounding the buttocks, reducing the waist line, the fat deposits on the hips, and the saddlebag, achieves a synergistic effect that increases the buttocks' projection with much better results than simply augmenting the volume of the buttocks.

The Future of BBL and Gluteal Contour Surgery

The Brazilian Butt Lift opens new horizons on buttocks remodeling. All surgeons working with the body and the gluteal contour should learn the different methods, open their minds to these new concepts, and most of all understand the safety guidelines and use them. Nowadays, because of globalization, the preferences and beauty stereotypes created by social media are different and are influenced by race, culture, and many others factors. The concept of beauty is unique to each patient; therefore, plastic surgeons have to adapt to the different trends, and an individual approach needs to be used for each patient. These techniques helped broaden the reach of gluteal contour surgery and joined the other aesthetic procedures that are increasingly being carried out worldwide. Gluteal retractions, ptotic buttocks, extreme sagginess, and flat buttocks have now found a solution. BBL will not be the last procedure aiming at beautiful buttocks or to bring satisfaction to women and men in search of enhancing their body contour. Nevertheless, BBL is a recent, still evolving technique and it must be quickly taught to those who wish to use it.

At the right time, the editors of this magnificent book are conveying excellent information provided by an outstanding group of experienced plastic surgeons to guide the steps of those who wish to perform a great procedure with high rates of satisfaction while employing patient safety.

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Part I

Basics of Gluteal Fat Grafting

History of Gluteal Fat Grafting

1

Jose Abel de la Peña Salcedo and Guillermo J. Gallardo

1.1 The Female Figure in Art

There is no universal ideal female figure for each culture. The concept of female beauty has evolved with time; however the form and size of the breasts and the gluteal region have remained constant symbols of maximum femininity. In Art, the origins of human aesthetics go back to antiquity. Sculptures, paintings, and drawings show feminine figures that are voluminous, often to the point of deformity, and reflect human history's interest in fertility. Among the oldest discoveries that allude to the ancient ideal of feminine beauty is a painting found near Oslo, Norway, that reproduces the figure of a woman being daubed with reindeer fat. The well-known Venus of Willendorf (Fig. 1.1) was discovered in Austria, and it is perhaps one of the first sculpted female forms. It is the most famous of the "steatopygic" (i.e., fat in the gluteal area) type of Venuses. The Venus of Grimaldi found in the French Blue Coast area—with her protuberant breasts, prominent stomach, and plump gluteal area—is a symbol of fertility. In ancient Egypt, the refinement of the aesthetic ideal for women led to the images of Nefertiti, the beautiful queen who gained mythic stature.

The perception of beauty from ancient Greece has influenced many cultures. The Greeks initiated the concept of female aesthetics that spread throughout Europe (Fig. 1.2), and their beauty standards did not tolerate accumulation of fat in the trunk, but rather in the gluteal area.

The Middle Ages were characterized by little to no expression of the human body and physical aesthetics in Art. With a burst of artistic activity and understanding of human aesthetics, the Renaissance period in Europe made beauty

Fig. 1.1 The Venus of Willendorf is perhaps the earliest female form sculpted in history that still survives. (From: De la Peña de et al. [1])—Fig. 1)

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Fig. 1.2 The Venus de Milo (or Aphrodite of Melos) represents the ultimate beauty among the ancient Greeks. Although excess fat in the waist and trunk was not tolerated, we get a sense of plump buttocks beneath her drape. (Original collection of pictures from Alexandra Condé-Green, Le Louvre, Paris 2018)

embrace everything and be embraced by everyone. A clear example that the standards of beauty vary with the epoch and culture is the small feet held as a characteristic of feminine beauty by the Chinese, which would never appeal the eyes of an African. Instead, steatopygia and a narrow neck have been ideals in the model of beauty of many African cultures. Even with such differences within and between cultures, studies have demonstrated the presence of certain similar patterns of what humans find physically appealing, which could suggest universality for the appreciation of an aesthetic ideal. The standards of harmony, balance, and proportion have been used by artists, philosophers, and mathematicians of Western cultures for at least 2500 years.

The plastic surgeon and the sculptor both work in three dimensions and are accustomed to perceiving three-dimensional figures with the purpose of "sculpting" forms, sizes, and planes that are well balanced and harmoniously proportioned. The analysis of human beauty—harmony, form, balance, symmetry, proportion, tension, movement, force, color, and mass—has been studied via lines, axes, planes, and curves for centuries. In this day and age, we possess newer tools like holograms and radiology, combined with geometric, mathematical, and logarithmic models, as well as knowledge of the physiology and psychology of vision and perception. Such tools give us more resources for quantifying the aesthetics of the human form as our patients seek more harmonious proportions [1].

1.2 History of Gluteal Augmentation

Women innately understand the necessity of balance between the volume and the form of the thorax, breasts, waist, hips, and buttocks. Modification of the body to achieve balance and improve an individual's physical image may be accomplished by a number of methods, such as clothing, hairstyle, makeup, exercise, and surgery. The perception of the aesthetic ideal is undoubtedly influenced by trends in the mainstream media and marketing. Our modern lifestyle demands a harmonious figure from everyone so keenly that a lack of balance in proportions could have undesirable deleterious psychological implications, and its restoration can improve self-perception and self-confidence. However, judgement of harmony, beauty, and proportion is dictated by human perception [2].

Throughout history, special focus has been given to the female buttocks and breasts, which have served as a source of inspiration to many artistic disciplines: literature, painting, sculpture, and dance, among other expressions of the human form. In earlier times and different cultures, the concept of beauty of the gluteal region often involved a disproportionately large volume that—to our modern eyes—is now regarded as a lack of balance between the trunk and the extremities. It probably violates the golden ratio. Our current ideal of the female buttocks is composed of a small waist and an appealing buttock posterior projection, with a proportionate width. This is the exact opposite of the pre-Columbian beauty concept, which valued a large buttock width and small posterior projection. Today, we greatly prefer an athletic build, where the gluteal silhouette acquires a firm and round form that is in balance with the rest of the body.

Today's body-contouring surgery is directed at improvement of the aesthetic characteristics of the extremities, breasts, abdomen, flanks, upper and lower back, and gluteal region. The different procedures available for contouring these regions include augmentation, reduction, fixation and lifting (pexy), and skin resection. For cases of lipodystrophy or gluteal ptosis, the buttocks can be re-contoured in much the same way as the breasts, specifically augmenting or reducing the volume and lifting the skin and subcutaneous tissue.

Several factors have led not only to a dramatic increase in the number of patients seeking buttock enhancement but also to an increase in the volume they request:

- The greatest influence has been the media. With our increasing acceptance of cultural diversity, the popularity of Latina star Jennifer Lopez, African American singer Beyonce, and tennis star Serena Williams, these celebrities' ample derrières have become the goal of many young women of all ethnic groups. These are among the most frequent photographs that patients bring in to illustrate the buttocks' shape they would like.
- Clothing styles: Low-cut jeans and bare midriffs call attention to the buttocks. Thong style underwear and bathing suits have increased in popularity; they uniquely expose and draw attention to the "gluteal aesthetic unit."
- The widespread circulation of upscale intimate apparel catalogs and the appearance of the bare or almost-bare buttocks in the popular media and advertising industry use models with a flawless gluteal shape.
- The Internet: By simply typing in a phrase such as "buttock augmentation," a wealth of information is available (and misinformation) on various types of surgeries and patients' descriptions of their own experiences.
- An early influence was the exercise/physical fitness movements, which called attention to the development and shaping of the buttocks. A tight-fitting attire with compression technologies has kept the gym as a main gathering place for those trying to tone up their gluteal muscles.
- The gradually increasing awareness by today's society that buttock augmentation using the patient's own fat is possible bypasses concerns about foreign implant material. The huge surge of "reality" television shows on plastic surgery has been a prime factor here.

1.3 Gluteal Augmentation with Alloplastic Implants

Gluteal augmentation in clinical practice began with Bartels and colleagues [3] in 1969 to correct asymmetry caused by atrophy of the left gluteal muscle with a Cronin-style breast implant. The implant was inserted through the infragluteal fold with an impressive aesthetic result.

Four years later, in 1973, Cocke and Ricketson [4] used breast implants in the subcutaneous plane to correct lateral gluteal depressions. Dacron patches were initially placed on the base of these implants for better fixation, but other implants such as the Lise style were also used. Still, aesthetic results with these alloplastic implants did not achieve the best contouring of the buttocks. In 1977, González-Ulloa [5] designed an anatomic gluteal implant with fixation extensions to correct hypotrophic and ptotic buttocks. He also described placement of the implant in the subcutaneous plane; the supragluteal incision from both sides of the coccyx, which has thinner fatty tissue; the infragluteal fold incision, which facilitates drainage and helps hide the scars; and the intergluteal crease incision to avoid evident scars. Subcutaneous placement of gluteal implants has serious disadvantages, which were learned over time. The aponeurotic expansions that fix the skin to the deep tissues are incised, which lead to skin laxity; therefore, implants are prone to migration over time. In addition, the implants usually are more visible due to a lack of thickness in tissue coverage, and the complications include implant exposure, infection, and inferior displacement.

The second generation of implants had Dacron fixation patches at their base intended to keep the implants properly positioned postoperatively; however, implant migration still occurred. The next generation of implants was designed with an area that could be sutured to the deep tissues, similar to the 1977 implant description of González-Ulloa, but the results obtained did not look natural, and the implants were still visible. Because of all of these complications, this plane is rarely used today [5].

In 1984, Robles et al. [6], from Argentina, described placement of gluteal implants in a submuscular pocket beneath the gluteus maximus and medius muscles. Hidalgo presented his submuscular modification of the Robles' technique in 1992 along with the use of solid round elastomer gluteal implants [7]. This plane preserves the aponeurotic system of fixation between the skin and deep tissues and has the advantage of reducing capsular contracture. The submuscular position, however, has the disadvantage of being a small space limiting the use of large implants and carries the potential risk of impinging the sciatic nerve that emerges near the area of pocket dissection just below the inferior border of the piriformis muscle. Consequently, implants should not be placed below this level.

In 1996, Vergara and Marcos [8] described the placement of gluteal implants in an intramuscular space. The incision is made in the intergluteal cleft, the gluteus maximus aponeurosis is identified, and the muscle fibers are then separated to create a pocket. The pocket should be padded with 2–3 cm muscle thickness beneath the superior gluteal aponeurosis. Vergara also designed his own almond-shaped implants.

The reported advantages of this intramuscular position include avoidance of dissection around the sciatic nerve, coverage of the implant with a thick layer of muscle that maintains the implant in position, and prevention of ptosis and skin irregularities. The primary complication is seroma, which develops because of the extensive disruption of muscle fibers. Another disadvantage is the difficulty of knowing the precise thickness of the muscle overlying the implant. Since there still is debate on which plane is best for implant placement to create a reproducible intermuscular geometric plane, González published his XYZ method for augmentation gluteoplasty, which is a more precise dissection. The following three points, X (an imaginary point that corresponds to half the thickness of the gluteus maximus muscle at the level of its incision site), Y (an imaginary point within the gluteus maximus at its superior origin attachment, normally on the iliac crest 4–5 cm lateral to the posterior superior iliac spine), and Z (an imaginary point within the gluteus maximus muscle where it covers the trochanter), form a triangular plane which delimits a safe zone for implant placement [9].

As surgeons strived for better results, different anatomical planes for implant placement were developed, i.e., the subcutaneous, submuscular, intramuscular, and subfascial planes; but little was published. Also, gluteal implant design evolved similarly to that of breast implants to include anatomical shapes and textured shells. Gluteal implants are currently designed specifically for the gluteal region and come in round, oval, and anatomical shapes with a variety of dimensions, textures, densities, and profiles. They can be filled with cohesive silicone gel or made from a soft solid silicone elastomer to prevent silicone extravasation in case of rupture.

At the 1995 International Society of Aesthetic Plastic Surgery (ISAPS) meeting in New York, the primary author, from Mexico, described the subfascial plane for gluteal augmentation with implants in order to solve the complications and difficulties found in the subcutaneous, submuscular, and intramuscular planes (Fig. 1.3). He also developed a system for gluteal augmentation that included templates,

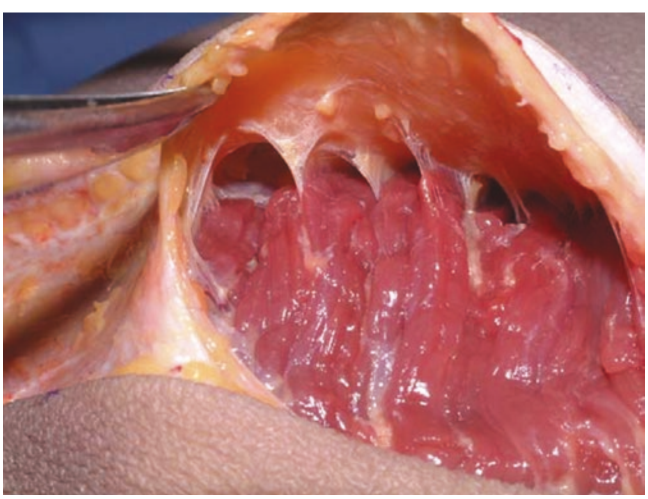

Fig. 1.3 The subfascial plane developed by De la Peña. The aponeurotic expansions are visible in this image. (From de la Peña [10]—Fig. 23)

sizers, and an anatomically shaped implant designed specifically for subfascial placement. His experience was originally published in 2004 [10]. Through diverse preoperative care and postoperative follow-up instructions, and surgical technique modifications, the complication rate has dropped dramatically.

In 2019, the first case of gluteal implant-associated anaplastic large cell lymphoma (GIA-ALCL) was published. This is an alert to physicians and patients alike, but definitive information is still lacking, and further investigation is warranted [11].

1.4 Gluteal Augmentation with Autologous Adipose Tissue

The history of fat tissue transfer or fat grafting to the buttocks is intermingled with the attempt to extract fat tissue from the body, and, therefore, the beginning of body sculpting through liposculpture. It appears that fat transplantation was first reported by Neuber [12] in 1893, followed by reports by Czerny [13], Lexer [14], and Rehn [15]. In 1911, Bruning [16] was the first to inject autologous fat into the subcutaneous tissue for the purpose of soft-tissue augmentation. Still, Charles Dujarrier, a French general surgeon and Chief of the Department of Surgery at Saint Antoine Hospital, performed the first recorded attempt to remove subcutaneous fat through a small incision in 1921. The procedure practiced on the dancer Folies Bergère resulted in necrosis and amputation, which culminated in the first lawsuit in the history of plastic surgery [17].

Adipose tissue extraction by curettage was carried out by the German physician Joseph Schrudde. He reported on practicing "lipexheresis" at the 1972 meeting of ISAPS in Brazil, which he then published in 1980 [18]. Arpad and George Fisher were pioneers in incorporating suction for adipose tissue extraction in 1977 [19]. Unfortunately, the complication rate was high. That same year, Illouz reported the removal of a large lipoma with a blunt cannula preserving the neurovascular bundles and using a hypotonic solution to decreased blood loss. He presented his technique in 1980 at the Shirakabe Clinic in Osaka, Japan [20]. Hetter then described the addition of epinephrine to the infiltration solution in 1984 further reducing blood loss to 4–8% of the lipoaspirate [21]. Illouz's technique is currently the most accepted liposuction method around the globe [22].

Brazilian plastic surgeons were introduced to liposuction by Illouz in 1980 and to liposculpture in 1983 by Fournier. Since then they began developing body sculpting with adipose tissue transfer. In 1984, Raul Gonzalez started to perform fat grafting to sculpt and augment the gluteal region, which he published in 1986, along with the development of the first sterile device to accumulate fat for transfer [23, 24]. He then started to use intramuscular implants since he did not achieve the results he expected [25]. In 1985, Luiz Toledo started injecting larger quantities of fat to the face and body, up to 450 mL to each buttock. He revealed his 18-month experience in 218 patients at the ISAPS congress in New York City in 1987 and published the results 1 year later [26, 27]. Toledo had developed a gluteal augmentation technique, which consisted on liposuction of the flanks, abdomen, and thighs with fat injection to the buttocks and trochanteric regions. He was injecting up to 500 mL of fat to each buttock intramuscularly and subcutaneously. Fat absorption was estimated by clinical evaluation to be between 20% and 50% of the transferred volume [28].

In the 1990s, Chajchir et al. [29] published their experience with gluteal fat augmentation, and other important contributions to the art of gluteal shaping through liposculpture have come from Guerroerosantos [30], Cárdenas-Camarena et al. [31], Peren et al. [32], and Pedroza [33] who have reported injecting 100–300 cc of fat per buttock. Toledo [34] in 1991 published his "syringe liposculpture" technique where he described some cases of buttock augmentation. He then performed surgical demonstrations of his technique at the University of Southern California (USC) in 1995, and the results were transmitted 6 months later at the Teleplast video-conference in the USA [35]. Fat grafting to the buttocks was initially met with skepticism in part due to Peer's theory of 50% cell survival rate [36], but slowly was adopted by the rest of the world.

In 2003, Mendieta published a classification of the gluteal shape which combined with Centeno's 2006 classification of the gluteal aesthetic units changed the way plastic surgeons understood the shape, anatomy, and surgical goals of the procedure [37, 38] as gluteal fat augmentation became a three-dimensional body contouring technique and not merely a buttock augmentation procedure. It is uncertain when and who coined the term "Brazilian Butt-lift (BBL)" to describe this technique, as it has been popularized in the English-speaking world. It has been deemed a mere marketing strategy by a plastic surgeon in California, USA, in 2006 [39, 40], but claims to this are still debated.

BBL as a body contouring technique including a circumferential lipoplasty of the whole region continued its evolution through modifications of Mendieta's technique [41]. Del Vecchio used "expansion vibration lipofilling" which decreased operating time and increased the volume of fat transferred to the gluteal region [42].

Gluteal fat augmentation was initially described to have the best outcome when fat was grafted into the intramuscular plane; unfortunately, an alarming number of complications arose, questioning this practice [43, 44]. This led to the establishment of recommendations from the multi-society gluteal fat grafting task force and other techniques in order to reduce the risks of related fat embolism [45–47].

Even with the changes in cultural perception, the advances in the analysis of gluteal aesthetics and the increased use of technology in everyday surgical practice have led to an increase in the amount of fat injected into the gluteal region, an overall shift toward safer infiltration planes, and improvements in patient selection and follow-up methods in order to achieve better long-term surgical outcomes.

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Biology of Adipose Tissue

2

Guy Magalon and Jeremy Magalon

2.1 Adipose Tissue

2.1.1 Human Adipose Tissue

Adipose tissue, present in large quantity in mammals, is best known for surviving episodes of limited caloric intake by storing excess energy in the form of lipids during periods of abundance. Adipocytes, the main cells that make up adipose tissue, are the only cells that are specialized and perfectly adapted to accumulate lipids without compromising their functional integrity, due to their appropriate enzymatic machinery [1]. There are two types of adipose tissues that are fundamentally different in their distribution, function, and histology: brown adipose tissue and white adipose tissue.

Brown adipose tissue plays an important role in the regulation of thermogenesis, due to its large amount of uncoupling protein-1 (UCP-1) or thermogenin. This protein, located in the mitochondria's inner membrane, acts as a proton channel. It eliminates the potential difference in the membrane, thus preventing the production of adenosine triphosphate (ATP) by ATPase. The residual energy is then released as heat. The large amount of mitochondria in the cell may be responsible for its brownish color. The adipocytes that make up the brown adipose tissue contain an abundant cytoplasm with lipid droplets of various sizes and have a 30–40 μm diameter [1].

White adipose tissue is the predominant adipose tissue in mammals. It represents 9–18% of the body weight in healthy men and 14–28% in healthy women with a body mass index (BMI) of less than 25 kg/m^2. It exceeds 22% in overweight men and 32% in overweight women. The distribution of white adipose tissue varies by species. In mammals, it is mainly found in two layers: subcutaneous (abdominal, gluteal, and femoral) or visceral (mesenteric, omental, and retroperitoneal) (Fig. 2.1). Although white adipose tissue does not actively participate in thermogenesis, its insulating effect and its distribution throughout the body help conserve body heat. Although there are only subtle differences in gene expression, there are significant variations between the different white adipose tissue deposits in terms of their structure, composition, and metabolism, as well as their impact on the surrounding organs. For example, morphological studies reveal the presence of more blood vessels and nerve fibers in omental fat than in subcutaneous fat, suggesting greater metabolic activity in the latter.

2.1.2 The Adipocytes

Adipose tissue is a loose connective tissue composed of several cell types and extracellular matrix (ECM) composed of collagen fibers, among others. Mature adipocytes comprise one third of the adipose tissue. They are surrounded by an enriched vascularized stroma with several distinct cell populations, including nerve fibers, lymph nodes, immune cells (leucocytes and macrophages), pericytes, fibroblasts, and pre-adipocytes (undifferentiated fat cells). Adipocytes of white adipose tissue are differentiated cells that possess the cellular machinery necessary for lipid accumulation. Their size vary from 60 to 100 microns on average and can reach up to 120 microns in obese individuals. The lipid droplets contained in the cell represent 85–90% of the cell mass, repelling the other components of the cytosol (organelles, nucleus) at the periphery of the cell.

Adipogenesis consists of two main phases:

- The first phase, called determination, consists of the proliferation of adipose mesenchymal stem cells (MSCs) and their commitment to the adipocyte differentiation pathway to form adipocyte precursors (pre-adipocytes). The cell phenotype changes during this step and pre-adipocytes

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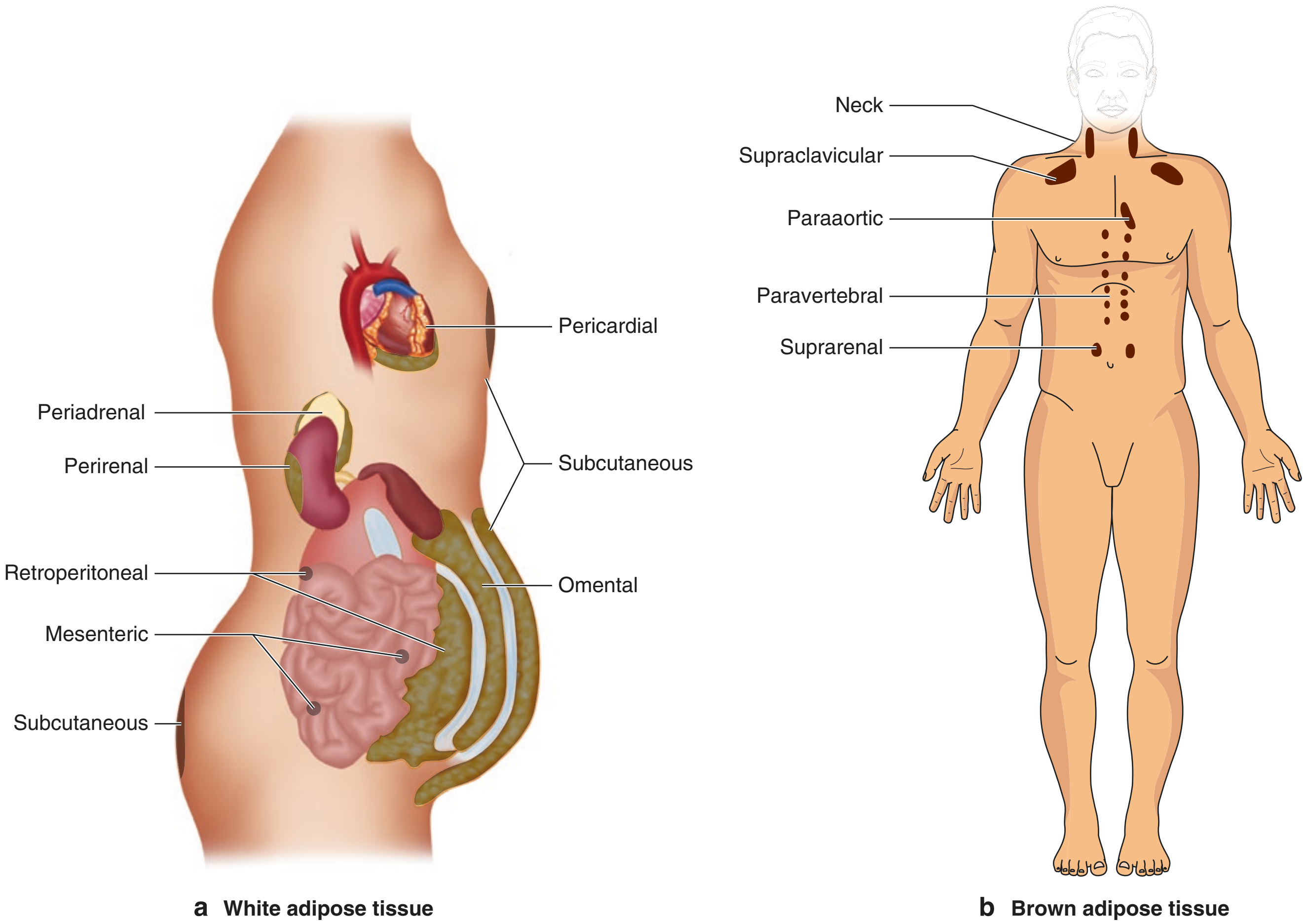

Fig. 2.1 Distribution of (**a**) white and (**b**) brown adipose tissues

begin to express early markers of adipocyte differentiation. The cellular processes responsible for determining stem cells toward this differentiation pathway are still uncertain. However, studies have shown the involvement of certain transcription factors such as Zinc Finger Protein 423 and 467 (Zfp423 and Zfp467), as potential regulators in the recruitment of pre-adipocytes by their action on the expression of key proteins of adipogenesis [2].

- The second phase constitutes the differentiation of pre-adipocytes into mature adipocytes. It is characterized by an increase in lipogenic activity, which requires an enzymatic machinery for lipid transport, insulin sensitivity, and the secretion of adipocyte-specific proteins.

2.1.3 Functions of the White Adipose Tissue

2.1.3.1 Physical Protection and Thermogenesis

Adipose tissue generally offers physical protection against cold. In fact, the conductivity of adipose tissue in the cold is about two times lower than that of muscle tissue, which reduces the body's heat loss when exposed to cold temperatures. Although the insulating properties of adipose tissue are essential and fully exploited by marine animals (whales, seals), its effectiveness and necessity are controversial in terrestrial animals and humans. Adaptation to the cold climate by humans appears to be related more to increased metabolism than to improved body insulation. Also, white adipose tissue provides essential body protection against various mechanical forces that it faces daily. For example, orbital fat provides mechanical protection to the eyes and the subcutaneous fat protects the internal organs and structures during a fall.

2.1.3.2 Lipid Metabolism

The adipose tissue consists mainly of adipocytes, specialized cells that store energy in the form of lipids, more particularly in the form of triglycerides. The latter consist of three esterified fatty acids linked to a glycerol molecule, with several characteristics that make them the molecules of choice for storing energy. In addition to their hydrophobic nature, they have a high caloric density and are poorly hydrated, compared to glycogen or proteins, which require up to five times their weight in associated water. Triglycerides, therefore, contain more energy while occupying less volume and weight.

Three major cellular processes participate in the metabolism of lipids in the adipocyte: the transport of fatty acids into the cell, lipogenesis (synthesis of fatty acids, glycerol, and esterification of fatty acids), and lipolysis (hydrolysis of triglycerides). Each of them can be modulated in response to extracellular signals such as insulin, cortisol, growth hormones, free fatty acids, cytokines, etc.

2.1.3.3 Endocrine Function

For a long time, adipose tissue was considered an organ whose main function was to store lipids. The discovery of leptin, a hormone that regulates satiety in the body and is secreted by adipose tissue, has changed the way we view this connective tissue. Interest in adipose tissue has continued to grow since an important endocrine function involving the secretion of several proteins and molecules has been associated with it. White adipose tissue accumulates cholesterol and is involved in the metabolism of steroid hormones. Although the tissue does not synthesize de novo hormones, it expresses enzymes involved in the conversion of glucocorticoids and sex hormones, which are subsequently secreted.

2.1.3.4 Vascular Function of Adipose Tissue

Adipose tissue is a highly vascularized organ. Its development is closely related to its vascular network. Indeed, as early as embryogenesis, we observe a complex vascular network in areas predestined to form adipose tissue deposits even before the appearance of adipocytes. Adipose tissue because of its high plasticity must be adequately nourished by its vascular network. Thus, when it expands, formation of new blood vessels ensure transport of nutrients and oxygen necessary for its survival. New blood vessels can form in two ways: by vasculogenesis during embryogenesis or by angiogenesis, which involves the presence of preexisting blood vessels.

Angiogenesis, unlike vasculogenesis, is the mechanism by which new blood vessels are formed from preexisting vessels. It occurs during embryonic and fetal development, but also later in development, during tissue repair following injury, bone growth, the menstrual cycle in women, and pregnancy.

2.1.3.5 Angiogenic Properties of Adipose Tissue

As mentioned above, the adipose tissue is an endocrine organ that secretes molecules, many of which demonstrate angiogenic potential:

- Leptin is a small 16 kDa adipokine produced mainly by adipocytes of white adipose tissue. It has a paracrine effect on endothelial cells and is a pro-angiogenic factor that stimulates the production of vascular endothelial growth factor.
- VEGF is produced by stromal cells and mature adipocytes.
- Angiopoietin-1 and angiopoietin-2.
- Hepatocyte growth factor (HGF).
- Type 1 plasminogen activator inhibitor (PAI-1).

2.2 Stromal Vascular Fraction

2.2.1 Adipose Tissue to Mesenchymal Stem Cells

In the 1990s, Coleman set the principles for the fat grafting procedure from harvesting fat to injection, passing through a step of purification before grafting. The lipoaspirate is centrifuged in order to discard the liquid of infiltration containing anesthetic solution and epinephrine. Because of its practicality, this technique became widespread and led to many advances. Fat grafting not only was used to fill defects and restore volume, but also had a trophic effect on the quality of the skin. This trophicity is attributed to the presence of multipotent stem cells within the adipose tissue, discovered in 2001 by Zuk et al. These adipose multipotent stem cells have similar properties as bone marrow multipotent stem cells. These cells must be isolated from the adipose tissue. The first step consists of liposuction to harvest fat and enzymatic digestion with 0.075% collagenase for 30 minutes at 37 °C. After neutralization of the enzyme, a centrifugation step separates the adipocytes on the surface of the tube from cells of the stromal vascular fraction (SVF), forming a cell pellet at the bottom of the tube. With culture of the SVF, a homogeneous population of fibroblastic appearance (initially called processed lipoaspirate (PLA) cells) is obtained. The multipotency of these cells is demonstrated by their differentiation into adipocytes, chondrocytes, osteocytes, and myocytes. They may be kept in vitro for long periods of time (until passage 13, approximately 165 days) with a stable population doubling (linear relationship between the accumulated population doubling and the number of passages) and a low level of senescence. PLA cells are thus presented as an alternative to the therapeutic use of bone marrow MSCs. They have many advantages: their extraction is less invasive and they provide MSCs in larger quantity [3].

Since their discovery, a precise definition of MSCs regardless of their tissue of origin, has been established:

- Ability to adhere to plastic and proliferate in culture
- A membrane phenotype determined by flow cytometry with a majority of cells (> 90%) positive for CD13, CD73, CD90 and at least 98% of the cells negative for hematopoietic markers CD11b, CD45
- In vitro differentiation potential in cell types derived from mesoderm (bone, cartilage, adipose tissue) [4, 5]

2.2.2 SVF: Definition and Composition

The use of SVF in the operating room has gained interest with the surge of approved medical devices to isolate SVF in a relatively short period of time to allow injection during the same procedure. The first clinical applications of SVF were reported in 2007 for breast reconstruction in patients with breast cancer who had received radiation therapy. Yoshimura's group coined the term cell-assisted lipotransfer (CAL) in 2008, to describe a technique in which adipose tissue grafts are enriched with SVF, in order to increase graft take. The use of SVF inside the operating room without quality control has limited its credibility and delayed its use in clinical trials, as well as its large-scale pharmaceutical development.

SVF represents a heterogeneous cell population readily accessible from adipose tissue, once separated from adipocytes by enzymatic digestion, centrifugation, washing, and filtration. According to the International Federation for Adipose Therapeutics and Science (IFATS) and the International Society for Cellular Therapy (ISCT), the distribution of viable nucleated cells in the SVF is as follows:

- 25–45% cells of hematopoietic origin
- 15–30% stromal cells including MSCs
- 10–20% endothelial cells and endothelial progenitors
- 3–5% pericytes

2.2.3 Stromal Vascular Fraction Properties

2.2.3.1 Angiogenic Properties

Since SVF is composed of cells involved in the composition of blood, it naturally has angiogenic properties based on a synergy between the different cell types. The use of combined adipose endothelial progenitor cells (EPCs) and MSCs leads to greater neovascularization than the use of EPCs or MSCs used separately. Other studies have shown that SVF cells gather rapidly to form new vessels in the recipient tissue. Neovascularization is further stimulated by stromal cells through the release of growth factors such as VEGF, HGF, and TGF-β98. Koh et al. showed that the macrophages found in SVF are also important to obtain appropriate structural organization within the new vessels [6]. Bora et al. hypothesized that adipose MSCs and EPCs found in SVF produced many bioactive soluble factors, and that a cross talk is established via VEGF and platelet derived growth factor (PDGF-BB) for neovascularization via endothelial cells for maintenance of a stable network with MSCs [7].

The fat grafting model is also used to study the angiogenic properties of SVF. The resorption of adipose tissue grafts may sometimes exceed 75%. Enrichment of fat with SVF has shown increased angiogenesis and revascularization of the graft. In particular, pericytes and endothelial cells contribute directly to vessel formation and angiogenesis in the graft. Zhu et al. showed that SVF-enriched lipotransfer in nude mice resulted in greater graft maintenance with improved angiogenesis and morphology, whereas the non-enriched fat grafts showed some fibrosis and less viable tissue. They noted a rapid growth of a vascular network in the SVF-enriched group that progressively extended from the periphery to the central region of the graft. There was also a significant increase in VEGF expression in the SVF-enriched group, which may influence the migration of endothelial cells and stromal cells to the neovascularized region. Additionally, the new adipocytes showed a similar tendency to congregate around the blood vessels in the interstitial tissue, indicating that the survival of adipocytes probably depends on this vascular network [8]. Condé-Green et al. showed similar results with their comparison study in rats of four differently processed fat grafts, where SVF-enriched fat grafts had more viable tissue, more vascularization, almost no fibrous tissue and calcifications in comparison to decanted, centrifuged, and washed grafts [9]. Furthermore, Paik et al. revealed that it was important to consider the amount of SVF cells implanted within the graft. In a mouse model, SVF was mixed with adipose tissue at concentrations ranging from 10,000 to 10 million cells for a total volume of 200 μ[mu]L. Their results indicated a dose-dependent inverse relationship, in which a dose of 10 million cells impeded graft retention by inflammation and low vascularity. These results suggest that spatial arrangements and nutrient availability for implanted cells need to be taken into consideration in our understanding of the regeneration process involving SVF [10].

SVF can also be used to improve the take of human dermoepidermal skin substitutes in the treatment of burns. These substitutes are generally not vascularized and their engraftment depends on the establishment of a vascular network. Immunodeficient rats with deep skin lesions treated with a SVF-enriched dermoepidermal substitute derived from human adipose tissue have shown vascularized tissue anastomosed to the rat vascular system in 4 days, effectively establishing tissue homeostasis. Due to the vascularity present in the tissue, the dermis presented no contraction. The composition of the capillaries that grew in the substitute was similar to that of normal human capillaries. The mechanism by which SVF forms capillary plexuses is still unclear, but it may be related to the secretion of growth factors such as VEGF and IGF. In addition, freshly isolated SVF had superior angiogenic properties compared with purified adipose MSCs.

2.2.3.2 Immunomodulatory Properties

The immunomodulatory properties of SVF are related to several cellular components. Stem cells and progenitor cells have anti-inflammatory and anti-apoptotic properties that contribute to the regeneration of the host tissue. Adipose tissue macrophages in healthy conditions belong to the anti-inflammatory M2 phenotype, which demonstrated differentiating ability in cells of the mesodermal lineage. SVF also contains T-regulatory cells that secrete high levels of immunosuppressive cytokines. These T-regulatory cells can maintain the M2 phenotype of macrophages in the SVF when appropriate. In some disease models, SVF tends to decrease inflammatory cytokines, interleukin 6, and tumor necrosis factor alpha [11]. In an experimental model of autoimmune encephalitis for multiple sclerosis, SVF has shown that it is more effective than adipose MSCs in reducing the secretion of interferon-γ and IL-12, which are two cytokines involved in the pathogenesis of multiple sclerosis. Thus, SVF modulates inflammation and the immune response by expression and suppression of various cytokines.

2.2.3.3 Antifibrotic Properties

SVF has shown some antifibrotic effects due to the presence of MSCs. Domergue et al. [12] compared the effects of human adipose SVF and MSCs in a hypertrophic scar model in nude mice. There was an attenuation of the hypertrophic scars, associated with lower total collagen content in the skins of treated mice, as well as a reduction in the thickness of the dermis. MSCs appeared to be more effective than SVF. The therapeutic effect of MSCs has been attributed to greater expression of TGFβ3 and HGF, which are important anti-fibrotic mediators, and the high levels of MMP-2 and the MMP-2 / TIMP-2 ratio, which reflect the remodeling activity responsible for the resorption of fibrosis. Our team also documented the antifibrotic effect of SVF in a murine model with skin fibrosis induced by daily injections of bleomycin. The efficacy of various cell therapy products (SVF, microfat, platelet rich plasma (PRP) concentrates) and their combination were evaluated. Microfat combined with SVF or PRP significantly reversed epidermal sclerosis. Areas treated with SVF showed a significant increase in local angiogenesis.

2.2.3.4 Regeneration Properties

Because of their natural ability to differentiate into lineages when placed in an appropriate environment, mesenchymal stem cells promote tissue regeneration. SVF also induces proliferation of host cells and can be used in various conditions (diabetic foot ulcers, nerve repair, burns) [11, 13, 14]. Zhu et al. suggested that adipose MSCs could differentiate into adipocytes after observing the CD34 expression in fat grafts enriched with SVF [8]. CD34 marker is specific to adipose MSCs and an increase in the amount of neoadipocytes was seen between 14 and 30 days. Fu et al. used GFP-labeled SVF to illustrate the dynamic changes that occur in mice treated with CAL [15]. Although a dramatic decrease in GFP-labeled cells occurred within 14 days of injection, they persisted for up to 56 days (17.3% compared to J1). SVF cells have shown to promote healing when injected into diabetic foot ulcers, by “awakening” senescent cells [14, 16]. Similar results have been observed with respect to burns in which SVF administered intradermally showed increased fibroblast activity and cell proliferation [17].

The specific mechanisms by which SVF promotes regeneration of nerve cells are not precisely defined, but studies using SVF for nerve repair have shown that treated animals exhibit faster recovery of regenerated axons and a greater number of myelinated fibers with a larger diameter. Nerve regeneration may result either from the differentiation of SVF cells or from their paracrine effect on the host tissue, possibly inducing surrounding Schwann cells to regenerate and migrate. Both mechanisms are likely to contribute to this process.

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3 Stromal Vascular Fraction Enriched Fat Grafting

Katarina Andjelkov and Ramon Llull

3.1 Background

Gluteal fat augmentation can be challenging, as it often requires a significant volume of fat to be transferred to satisfy some cultural and aesthetic requirements. Within the last decade, fat grafting has been a preferred method to increase volume-deficient areas of the body such as the gluteal region, the breasts, the calves, or as a hybrid approach in combination with implants [1, 2]. Conventional wisdom arising from transplantation and tissue grafting contend that constitutive stromal cell elements are critical to engraftment. Supplementation, enrichment, and addition of stromal cells to fat will result in the potentiation of cellular-mediated mechanisms underlying engraftment, the preservation of volumetric graft integrity, and an eventual improvement in clinical outcomes.

While the above postulate is sound, this strategy faces both conceptual difficulties and marred scientific records but most importantly opens a prolific field to answer fundamental questions about the ultimate design of cell-based therapies for the structural and functional reconstruction of soft tissue deformities.

3.2 Clinical Outcomes of Fat Grafting and Its Difficulties

Both volume restoration and long-term outcomes are much sought after clinical outcomes in body contouring surgery. Fat grafting procedures are highly variable as the long-term retention rates are unpredictable. The lipoaspirate is composed of tissue, aqueous, and oil fractions that are variable, depending on the liposuction equipment used, the techniques, and the patients. Shortly after grafting, a significant yet, inconstant volume of water fraction is reabsorbed by the recipient bed, and the oil fraction is later walled off by an inflammatory reaction which can lead to the formation of oil cysts. With all these changes affecting the fat graft, it is difficult to determine the actual tissue fraction responsible for the restoration of volume. The reactive, edematous, and third-space expanded recipient bed is transitory and does not impact on the intraoperative graft restoration capacity or its postoperative retention over time. Since estimating the final volume restoration is difficult with standard fat grafting, cell-enriched fat grafting has surfaced in order to improve graft take.

The lipoaspirate sample is stromal vascular cell-depleted when compared to excised adipose tissue [3]. Cannulas are designed to avoid areas where the perivascular matrix septae are most resistant, yet most densely populated in stromal cells. There is an unknown graft volume and a dwindling constitutive cell density within the graft, which also changes according to the patients' age [4]. The above findings further reaffirm the principle of increasing the stromal vascular fraction (SVF) pool by adding stromal vascular cells to otherwise cell-depleted lipoaspirate to improve fat graft retention.

Cell-assisted lipotransfer (CAL) is a processing method that increases the adipose-derived stromal cells (ADSCs)/adipocyte ratio of the lipoaspirate with enzymatically isolated stromal cells. The lipoaspirate is divided in two portions: one that is processed by standardized techniques to purify the adipose tissue, and the other is used to isolate the SVF. Freshly isolated SVF cells are mixed with the processed lipoaspirate that acts like a scaffold, and this enriched lipograft is used for reinjection. Cell-assisted lipotransfer (CAL) has been used clinically in humans since 2006 for aesthetic breast augmentation, breast reconstruction, and facial volume restoration [5] (Fig. 3.1).

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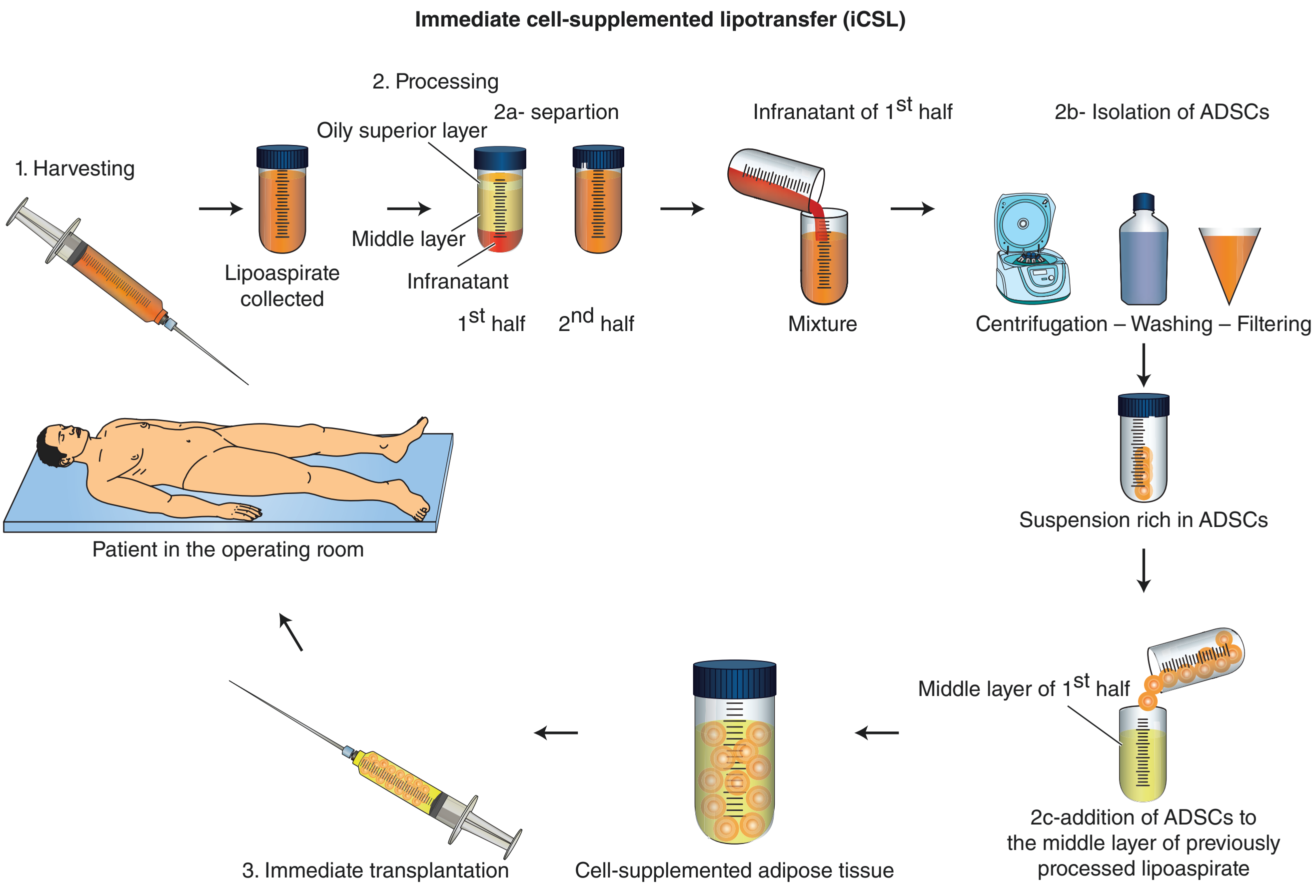

Fig. 3.1 The steps involved in cell-supplemented lipotransfer. (Modified image with permission from Condé-Green et al. [21])

3.3 Stromal Vascular Fraction: Mesenchymal Stromal Cells

White adipose tissue, apart from the adipocytes, contains stromal cells, identified as stromal vascular fraction (SVF), which is a heterogeneous cell population that includes not only adipose stromal, hematopoietic stem, mesenchymal and progenitor cells but also endothelial cells, erythrocytes, fibroblasts, lymphocytes, monocyte/macrophages and pericytes, among others [6].

The majority of SVF cells are located in the adipose tissue perivascular space confined to extracellular matrix axles and branching basement membrane that coat vascular networks. SVF cells can be isolated in a reproducible manner from the adipose tissue that is either resected or aspirated, on the basis of two fundamental biophysical properties: the differential enzymatic dissociation of parenchymal cells loosely attached to their extracellular matrix versus stromal cells, and the differential buoyancy of parenchymal oil-laden adipocytes versus the much denser stromal cells.

3.3.1 SVF Isolation

The perivascular space architecture explains the different cell populations that detach following digestion by protein catalysis. This enzymatic dissociation can be performed manually or utilizing semi or fully automated closed-system devices [7]. Automated closed-system isolation devices are easy to handle, have a reduced risk of infection and human error, and allow clinicians to isolate and re-administer stromal cells to patients within the same surgery. The lipoaspirate is washed, enzymatically digested by one or more of the following: conventional collagenase, dispase, trypsin, or related enzymes [6]. The digestion times range from 30 to 120 min. After neutralization of the enzyme, SVF cells are separated from mature adipocytes by centrifugation, concentrated, and ready to be used to enrich the adipose tissue that has been carefully washed and filtered (Fig. 3.2). Freshly isolated and resuspended adipose SVF cells are then combined with washed fat graft. For every 50 mL of processed fat, 1–2 mL of resuspended SVF cells are mixed in, using gentle back and forth transfer between the two syringes [8].

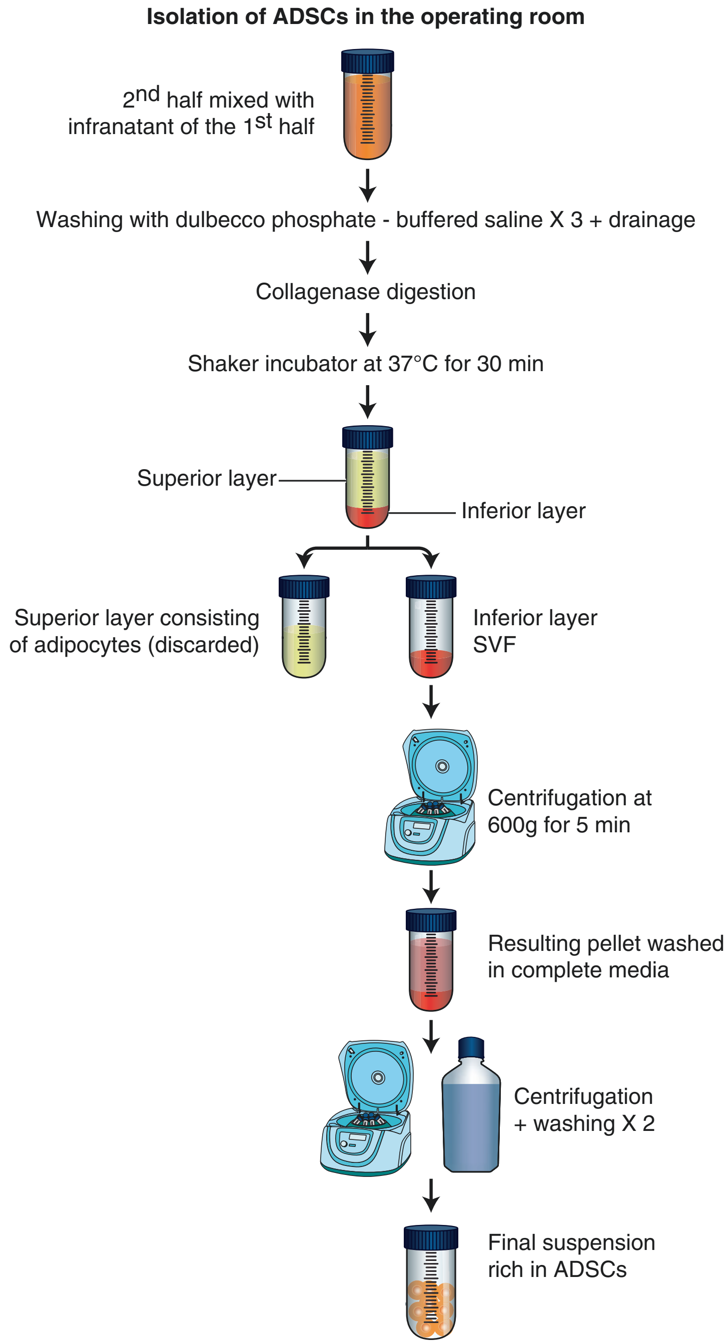

Fig. 3.2 The different steps of the enzymatic isolation of adipose stromal vascular fraction. (Modified image with permission from Condé-Green et al. [21])

Commercial cell separation systems differ in the total cell recovery, percentage of viable cells, identity, and safety profiles (residual collagenase levels) [7]. Other drawbacks of these systems are the elevated cost of the devices and disposable units. Collagenase preparations have also been shown to activate human complement, which could induce a local inflammatory reaction. Although the number of cells isolated by enzymatic digestion is significantly higher compared to isolation in the absence of enzymatic dissociating agents, the complexity of current regulatory issues in many countries have created obstacles to the translation of enzymatic SVF isolation protocols, whether manual or automated, to clinical scenarios.

Mechanically isolated SVF is a promising therapeutic strategy that can solve regulatory and safety issues that surround enzymatic SVF isolation. In the last few years, different nonenzymatic protocols have been attempted, consisting in mechanically dissociating SVF using different devices. Mechanical dissociation of SVF can be done with the use of centrifugation, inter-syringe emulsification with or without filtration, and through automated devices [9, 10]. The cellular composition of SVF obtained can differ according to the isolation protocols. Also, the cell yield is still far behind in comparison to the enzymatic protocols. Gentile et al. compared nonenzymatic and enzymatic

SVF-enriched fat grafting in patients who had breast reconstruction. The clinical outcomes and graft volume retention of patients who received mechanically isolated SVF fat grafting were not different from those who received enzymatically isolated SVF fat grafting after 1 year [11]. Mechanically isolated SVF cells have demonstrated clinical benefits in improvement of volume retention of fat grafts. However, there is a lack of literature comparing different mechanical isolation methods. Future studies should compare and refine these protocols to improve cell yield and quality and reduce the proportion of contaminating cell populations.

SVF cell suspensions have been subjected to plastic adherence and culture selection and expansion to increase the progenitor cell density. Expanded cultured cells have been the object of differentiation and trans-differentiation studies. When SVF cells are seeded in culture, this process allows the emergence of a population of adipose tissue-derived stromal cells (ASCs) (Fig. 3.3). ASCs are a homogenous population of cells that have the capacity to differentiate into adipocytes, chondrocytes, osteoblasts, among others [6]. They are an abundant, accessible, and reliable source with therapeutic applicability in diverse fields. They have rapidly gained importance in recent years due to their ability to readily be expanded and their capacity to undergo multi-lineage differentiation. However, the essential functions of initial stromal cells remain absent in the literature. With scant cell sorting studies, reports fall short with regard to functional assays that have not been developed, and no surrogate markers have been identified to predict function or therapeutic effect. Even despite increased graft survival of enriched fat grafts with ex vivo expanded adipose-derived stem cells over non-enriched fat grafts, the improvement of clinical efficacy and reliability remains noncompliant [12].

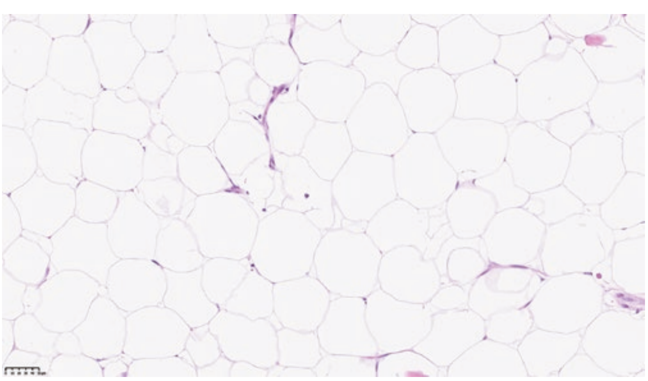

Fig. 3.3 Cells of lipoaspirate fat graft whole mount immunohistochemistry with contrast phase, light oil red O staining and 4′,6-diamidino-2-phenylindole (DPAI) binding to adenine-thymine regions of double-stranded deoxyribonucleic acid (dsDNA) to allow location of cell nuclei

3.3.2 Rational Behind CAL, Constitutive, and Therapeutic Dose

Most reports test SVF "stemness" as if stromal cells could exert their therapeutic benefit by calling upon adipocyte-committed progenitor cells and multipotent stem cells to differentiate and raise a new pool of parenchymal cells (mature adipocytes), thereby replacing injured parenchyma. This "substitutive mechanism," driven by the graft SVF progenitor pool, appears energetically demanding especially under ischemic conditions of injury. It is certainly subordinated to structural stability, vascular supply, and inflammatory control, all integral to the stromal pool. Alternatively, the differentiation potential of SVF precursor subsets could well be associated with cell-cell cooperation and the promotion of reparative functions executed by the terminally differentiated pool (fibroblasts, endothelial cells, lympho-epithelial and myelo-mononuclear cells /histiocytes), thus reconstituting the matrix, vessels, and histio-reticular control of tissue inflammation. This "cooperative mechanism" enabled by a cross-talk between progenitor and terminally differentiated SVF subsets has been supported by anecdotal evidence. However, it remains more plausible to focus on a "reparative mechanism," as the internal repair capacity of the abundant terminally differentiated pool relies on its intrinsic essential functions to enable engraftment and graft structural maintenance. Under this physiologic response to injury, three major fibroblastic, angioblastic, and histoblastic components of SVF are triggered to reconstitute and regulate the scaffold, vascular bed, and tissue homeostasis.

Under the equivalence group hypothesis, SVF comprises an enzymatically or mechanically selected sample of the total amount of stromal vascular cells which is distributed across a given tissue volume (namely the tissue's cell density). This constitutive cell density is required to support the tissue's functional activity in normal conditions. Under stress, however, the cell density requirements escalate several orders in magnitude [13]. The lipoaspirate differ in cell density and is cell depleted. It is likely that cell depletion below its constitutive density is a critical factor behind the precariousness of conventional fat grafting. The quantity of cells in a graft may have therapeutic effect.

The literature on transplant, engraftment, and wound healing supports the concept of therapeutic dose. The total mass of functionally specific constitutive, exogenous cells, and the recipient's mobilized cell populations congregate in response to implantation of stress, orchestrate all substitutive, reparative, and cooperative circuits within the stroma to eventually integrate the graft and recipient bed to healthy equilibrium. The cell quantity and quality of such a therapeutic dose are paramount in reaching the exquisite equilibrium between clinical graft fibrosis and necrosis. Unfortunately, neither the constitutive cell density nor the additional cell inoculum (fresh or expanded) does approximate such a therapeutic dose required to sustain the healing process observed in undisturbed wound healing. In fact, recent observations in animals venture a therapeutic dose far beyond any reported clinical cell-assisted fat graft studies.

3.3.2.1 Cell-Assisted Lipotransfer Effects on Subcutaneous Gluteal Volumetric Deficiency and Clinical Evidence

Autologous fat grafting is widely used for aesthetic gluteal augmentation and correction of soft tissue defects of the buttocks. Increased grafted volumes lead to higher incidence of liponecrosis, oil cysts, calcifications, and long-term unpredictability of the outcomes. Patients may be submitted to repeated procedures that additionally increase the costs and complication rates. Cell-enhanced fat grafting reduces the absorption rate of the graft and supports the formation of de novo adipocytes. The immunosuppressive potential of implanted SVF cells may also minimize the inflammatory reaction in the recipient site. They secrete different growth factors such as endothelial growth factor, hepatocyte growth factor, and transforming growth factor-β [beta] [13]. They promote angiogenesis, additional tissue growth, and at the same time decrease complications such as fibrosis, calcification, and cyst formation [5]. Additionally, the plasticity of preadipocytes and macrophages seems to promote healing secondary to enhanced immune response and removal of dying or defective cells, leading to permanent tissue remodeling.

Therefore, one of the indications of CAL would be for gluteal volume deficiency where large volume of fat is usually grafted because of the potential of high degree of resorption. CAL could minimize graft resorption and help avoid grafting large volumes of fat, decreasing complication rates, and leading to more predictable and long-lasting results. Until today, there are no published papers presenting clinical evidence in CAL for gluteal augmentation. On the other hand, the benefits of CAL over conventional fat grafting were reported in cases of facial volume restoration and breast augmentation [14, 15]. Such therapeutic effects are amplified whenever a greater number of cells are implanted. High-dose cell-enhanced fat grafts are capable to decrease early postsurgical breast edema and significantly improve long-term volume retention in human and murine studies [8, 12, 16]. Significant efforts have focused on the ability of regenerative cells to promote volumetric restoration potential for fat grafts. These cells have proven to increase the number of lymphatic vessels and vascularized lymph node transfers, which induce lymphatic flow drainage in the circulatory system [17]. Also, the use of CAL in patients with chronic wounds showed a reduction of the size of the ulcers and decreased healing time [18, 19].

The safety and efficacy of application of ADSCs (both solely and as enriched fat grafts) for tissue regeneration or reconstruction are still under investigation in clinical trials. Although the data on both positive and negative outcomes are largely lacking, early information from selected trials confirm the feasibility and safety and suggest efficacy in both site-specific and systemic delivery [20].

3.4 Conclusion

Collagenase digestion is still considered the standard practice for isolation of adipose stromal vascular fraction and the preparation of cell-enriched fat grafting. Preliminary results have suggested that CAL is an effective and safe technology for soft tissue augmentation and is superior to conventional lipotransfer. CAL can be standardized (ways to process fat and isolate the cells, cell quality and quantity of therapeutic dose, etc.) for patients having aesthetic or reconstructive surgery in order to obtain reproducible and efficient clinical results. Aside from several methodological obstacles, a conceptual hurdle lies ahead, which is the controversy surrounding additive cell therapies in general, and cell-assisted fat grafting in particular. Current clinical attempts fall short at simulating nature's powerful quantitative and qualitative cell-dependent healing mechanisms.

Only when we manage to concentrate the cell inoculum quantity and quality in like kind with nature's massive cell assembly at an injury will we design efficient cell-assisted therapies to seamlessly integrate fat grafts onto its recipient bed and capacitate the ultimate frontier to facial, breast, and body volumetric deficiencies.

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4 Cryopreservation of Fat Grafts for Future Clinical Applications

Shaili Gal and Lee L. Q. Pu

4.1 Introduction

Autologous fat grafting has grown in popularity since the 1980s, being utilized in both the aesthetic and the reconstructive arena as a filler and for tissue augmentation. Its popularity has risen due to its abundant donor availability, ease of harvesting, biocompatibility, as well as the added benefit of additional body contouring during its harvest [1]. These characteristics ultimately have made fat transfer well-liked by surgeons, as well as patients. The primary shortcoming to this procedure is its unknown long-term result due to its high rate of absorption, namely 70% reported in the majority of the literature [2]. This high absorption rate leads to overcorrection by some surgeons and more importantly repeated or serial procedures. These repeated and serial procedures lead to potential donor site morbidity due to contour irregularities, increased patient discomfort, as well as higher cost [1, 2]. For these reasons, the senior author has examined, with in vivo and in vitro studies, adipose tissue cryopreservation.

Currently, fat transfer is performed immediately post-harvesting procedures, and leftover adipose aspirate is discarded. As the concept of adipose tissue cryopreservation continues to develop, this will negate the need for future harvesting procedures and trend toward better patient satisfaction. Furthermore, as a practical and optimal technique of cryopreservation for adipose tissue becomes widespread, this will undoubtedly stand to benefit both patients and surgeons.

4.2 Previous Studies in Cryopreservation of Fat Grafts

As adipose cryopreservation has continued to grow out of its infancy, several articles have examined the role of frozen storage of adipose aspirates obtained by liposuction for short-term storage in relatively high temperatures (+1 °C–−18 °C). Shoshani et al. demonstrated that human adipose tissue obtained by suction-assisted lipectomy and stored in a domestic refrigerator at −18 °C for 2 weeks had no significant difference when compared to fresh grafts in terms of weight, volume, and histologic examination. After the two-week period, the grafts were thawed and injected into nude mice and compared 15 weeks postinjection [3]. Another article looked at an animal model with isogeneic Sprague-Dawley rats where fat grafting was performed in one group with specimens stored at −16 °C or 1 °C for a period of 1 or 2 weeks, and another group with fresh harvested fat. Histological comparison showed a decrease in viable adipocytes and an increase in signs of inflammation and fat cell necrosis in rats that received stored fat. These changes became more severe with increased length of storage and the use of refrigeration over freezing [4].

Long-term storage of fat grafts utilizing a simple freezing technique was examined as well. MacRae et al. demonstrated that fat grafts frozen in liquid nitrogen and stored at −195.8 °C for up to 8 days maintained their mitochondrial metabolic activity [5]. Wolter et al. showed that after simple freezing at −20 °C, up to 92.7% of metabolic activity of fat grafts was lost, but the addition of a cryoprotective agent led to preservation of 54% of baseline activity. Thus, they concluded that the widely used practice of simple freezing in a freezer leads to nonviable tissue, and that cell survival could be improved with a cryoprotective agent (CPA) [6]. Atik et al. found that fat grafts frozen in liquid nitrogen at −35 °C for 6 months had similar viability and histology to those of fresh grafts [7]. Li et al. demonstrated that fat grafts cryopreserved at −20 °C, −80 °C, and −196 °C along with a group stored in hydroxyethyl starch showed no difference in cell viability among the three temperatures or with the use of a cryoprotective agent [8]. However, these findings have been questioned and seem contradictory to other investigator's findings that to achieve optimal cryopreservation of adipose tissue, it is necessary to add a CPA before freezing and fat grafts

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mixed with a CPA should undergo controlled freezing and thawing during cryopreservation [9].

In the senior author's laboratory, an initial study was conducted to evaluate the effects of temperature alone on adipose tissue storage. The viability of adipose aspirates was assessed by a glycerol-3-phosphate dehydrogenase (G3PDH) assay at both 4 °C and −20 °C. After 2 weeks of storage at 4 °C, the viability decreased about 80% (Fig. 4.1); however, at −20 °C, the viability only decreased about 5% (Fig. 4.2). A series of experiments were conducted with different types and concentrations of CPAs and their combinations to delineate what would be the best CPA and its concentration for adipose tissue cryopreservation. In addition, a number of freezing and thawing protocols were evaluated [10].

Although a few of the aforementioned studies show encouraging preliminary results for cryopreservation of autologous fat grafts for possible future application, the techniques described can only be used for short-term preservation (a few days, weeks or months) and may not be optimal due to uncontrolled cooling/warming process, which can lead to damage of cells. If modern cryoprotective techniques are applied, a better long-term preservation of adipose tissue can be achieved. This will likely allow fat graft storage for months to years (below −85 °C) or for more than 10 years (at −196 °C in liquid nitrogen).

4.3 Development of a Cryopreservation Protocol for Fat Grafts

4.3.1 Modern Techniques in Cryopreservation

The modern technique of cryopreservation allows for the long-term storage of living cells and tissues that may have many potential clinical applications [11]. The major steps of cryopreservation can be summarized as follows:

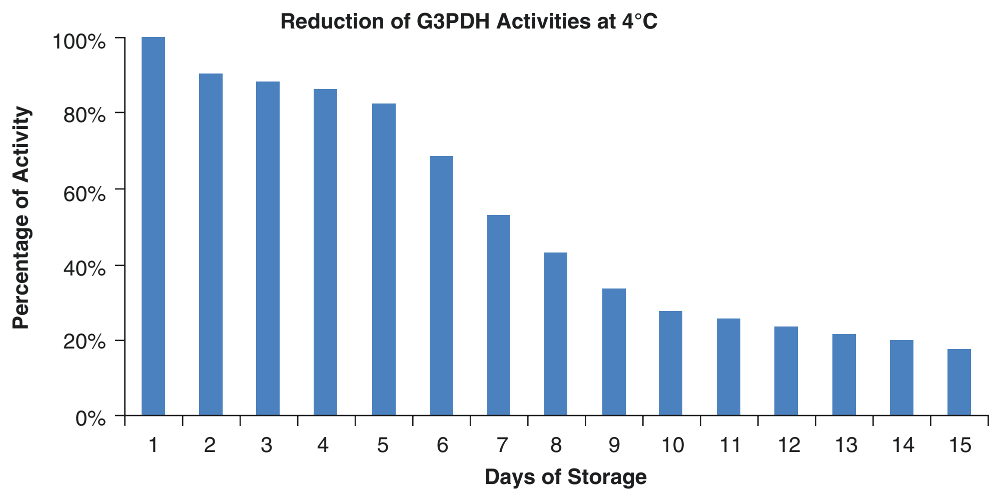

Fig. 4.1 After 2 weeks of storage at 4 °C, the viability of fat grafts decreased by about 80%

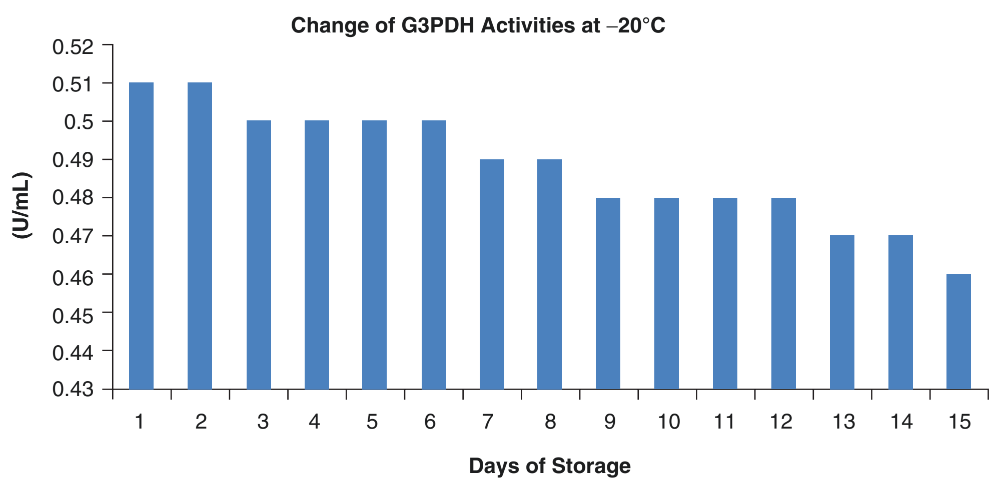

Fig. 4.2 After 2 weeks of storage at −20 °C, the viability of fat grafts decreased by 5%

Table 4.1 Modern technique and recommended protocol for cryopreservation of adipose tissue

Steps	Recommended protocol
CPA selection	Combination of permeable and nonpermeable CPAs; e.g., 0.5 M DMSO +0.2 M trehalose
CPA addition	Add CPA stock solution (precooled at 4 °C, 2× concentration) to adipose tissue stepwise at 4 °C or room temperature (with final volume ratio 1:1) Equilibration for about 30 min
Cooling	Controlled slow cooling to a temperature (e.g., −35 °C) at 1–2 °C/min Equilibration for about 10 min Put into −80 °C freezer or liquid nitrogen
Storage	Storage in −80 °C freezer or liquid nitrogen
Thawing	Fast thawing by stirring in 37 °C water bath until thoroughly thawed
CPA removal	Add isotonic medium slowly to fat tissue followed by equilibration and washing Repeated dilution/washing may be needed

CPA cryoprotective agent

1. Add CPA to cells/tissues before cooling
2. Cool the cells/tissues in a controlled rate toward a low temperature at which the cells/tissues are stored
3. Warm the cells/tissues
4. Remove the CPA from the cells/tissues after thawing [12]

Cell survival is based on the optimal cooling rate, which should be slow enough to avoid intracellular ice formation but fast enough to minimize cell damage. Table 4.1 reviews the modern technique and our recommended protocol for adipose tissue cryopreservation.

4.3.2 Choices of Cryoprotective Agents

The addition of CPAs can modify the freezing behavior of cells, which affects the rate of water transport, nucleation, and crystal formation. Cells that have survived cooling still face the trauma of thawing, which can lead to similar challenges as cooling. Additionally, recognizing the cell permeability to water as well as to the CPAs can allow one to predict minimal and maximal cell volume excursion during the addition and final removal of the CPAs to ascertain a quantitatively optimal approach to help avoid osmotic damage.

Dimethyl sulfoxide (DMSO) is a permeable agent that can reduce ice formation as well as prevent severe cell shrinkage during cell dehydration, thus reducing cell injury. For these reasons, it has been widely used as a CPA in cryopreservation of cells and tissues [11, 12]. The concentration of DMSO when used alone is usually 10%. However, because this agent is tissue toxic at normal body temperature, it needs to be removed from the previously cryopreserved cells or tissues once they are properly thawed. In a previous study, we attempted to decrease the concentration of DMSO further by the addition of another non-tissue toxic CPA such as trehalose. Trehalose, a non-permeable CPA, can dehydrate cells and reduce the amount of water present before freezing. It also functions as a cell membrane and protein stabilizer during freezing and drying. A combination of trehalose and DMSO may ultimately enhance the protective effect of adipose tissue during cryopreservation through a synergistic mechanism, which remains uncertain [13, 14]. Due to this effect, the concentration of DMSO can theoretically be decreased when combined with trehalose. The combination of these two CPAs may be valuable to help achieve optimal cryopreservation of adipose tissue along with other types of tissues.

We conducted preliminary studies to define whether the addition of a CPA would allow for better protection of cryopreserved fat grafts and subsequently to determine the optimal concentration and combination of CPAs used for adipose tissue cryopreservation. Checking for adipose cell viability counts, it became clear that the optimal combination was 0.5 M (3.3%) DMSO (Sigma, St. Louis, MO) and 0.2 M (7.6%) trehalose (Sigma) [14]. Furthermore, trehalose alone may be used for cryoprotection of adipose tissue. The highest viable adipocyte count was found in the trehalose group with a concentration of 0.35 mol/L versus the fresh control group ($p > 0.05$) and versus all other trehalose groups ($p > 0.001$). This concentration of trehalose appears to provide optimal protection of the lipoaspirate during cryopreservation in both in vitro and in vivo trials. Furthermore, this protection is similar to that provided by the aforementioned optimal combination of DMSO and trehalose as CPAs [15, 16].

4.3.3 Establishment of a Freezing and Thawing Protocol

The protocol of freezing and thawing described below represents the best possible approach developed for cryopreservation of adipose tissue [15–17]. Fresh adipose aspirates, after preparation, were mixed with DMSO (in 0.5 M) and trehalose (in 0.2 M) solution or trehalose only (in 0.35 M) in a 1:1 ratio. After addition of the CPAs, the mixtures were placed in room temperature for 10 min and then into a methanol bath (Kinetics, Stone Ridge, NY). The freezing system was programmed to cool at 1–2 °C/min from 22 °C to −30 °C without artificial ice formation. The mixtures were then transferred to liquid nitrogen (−196 °C) after they reached −30 °C for long-term preservation.

Prior to thawing, the cryopreserved adipose aspirates are removed from the liquid nitrogen tank and placed at room temperature for 2 min to allow the liquid nitrogen vapor out. Finally, the vials with the preserved adipose aspirates are placed into a stirred 37 °C water bath until they are thoroughly thawed.

4.4 Findings from Our Recent Studies

Samples of human fat grafts were obtained from female patients during liposuction and collected from the middle layer after centrifugation. First, in the in vitro study, trehalose only was used in its optimal concentration as described previously. Maximal recovery of adipocytes after cryopreservation was obtained using the slow cooling and fast warming as described above. The difference in the number of viable adipocytes between the fresh fat grafts and the cryopreserved fat grafts with trehalose (in 0.35 M) was not statistically significant ($p > 0.05$). G3PDH assay showed no statistical significance between the fresh control group as compared to all the cryopreserved groups (all $p > 0.05$). Finally, on histology, the basic structure of adipose tissue was maintained in most cryopreserved groups (Fig. 4.3). Therefore, trehalose serving as a CPA in its optimal concentration of 0.35 M seems to provide optimal protection of lipoaspirate during cryopreservation [15].

In the consequent in vivo study, maintaining the same freezing and thawing protocol, fat grafts (0.5 cc) were injected in an athymic nude mouse model. Group 1 (control group) received fresh fat grafts, group 2 received cryopreserved fat grafts with a combination of DMSO (in 0.5 M) and trehalose (in 0.2 M), and group 3 received fat grafts cryopreserved with the optimal concentration of trehalose (in 0.35 M).

Both cryopreserved groups showed equivalent maintained volume and weights, but they were both inferior to the control group. However, histologically, the basic structure of adipose tissue was maintained in all three groups. Thus, trehalose in its optimal concentration of 0.35 M/L can provide adequate protection of human fat grafts, similar to the combination of DMSO and trehalose [16].

4.5 Clinical Case Report for Gluteal Augmentation

Moscatiello et al. described a case of gluteal augmentation using cryopreserved fat in a 42-year-old man. He initially presented for abdominal liposuction and expressed interest in receiving gluteal augmentation in the near future. In the initial liposuction procedure, 600 cc of fat was cryopreserved with 10% DMSO as a CPA. Freezing to −80 °C was achieved slowly, at approximately 1 min per −1 °C. The day after the surgery, the 10 mL syringes of fat were transferred to liquid nitrogen vapor phase (−196 °C). Three months later, the gluteal augmentation was performed using the cryopreserved fat. On the day of the procedure, 14 bags containing sterile syringes with cryopreserved fat were quickly thawed by swirling them in a 37 °C water bath and the DMSO CPA was removed prior to injection. The results were maintained after 1 year. According to the authors, the factors that con-

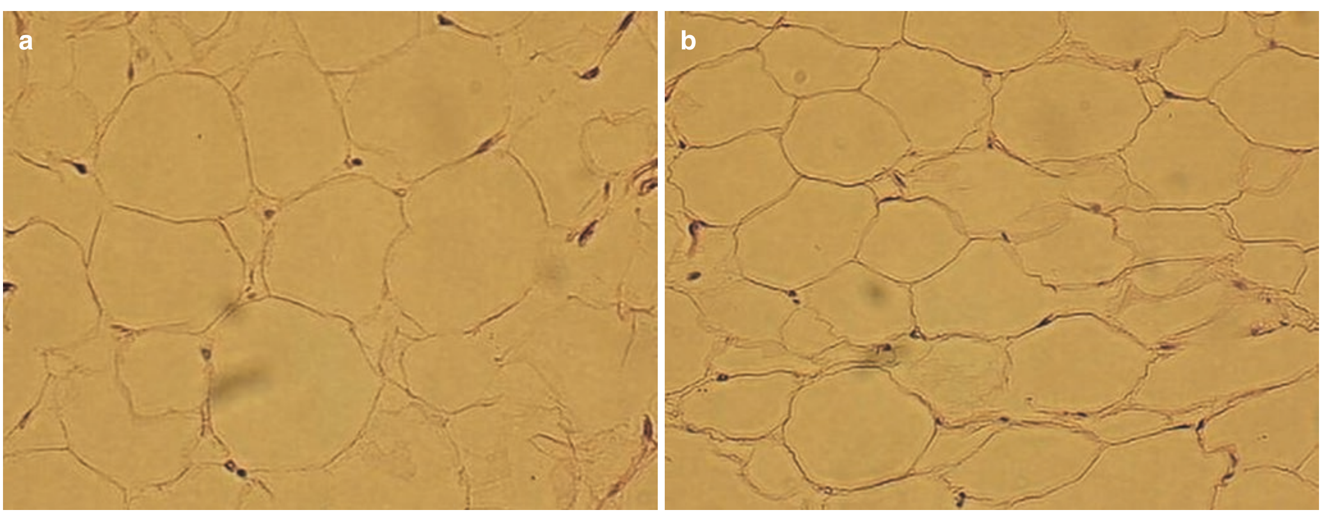

Fig. 4.3 Histological analysis of adipose aspirates (H&E staining, original magnification ×200). (**a**) Normal structure of fragmental adipose tissue from the fresh control group. (**b**) Near-normal structure of adipose tissue after optimal cryopreservation of adipose aspirates with trehalose (0.35 M)

tributed to these results were the use of an adequate cannula and pressure, slow freezing with the aid of a cryoprotectant, rapid thawing procedure, and good injection plane [17]. This is the only clinical case report in the English literature in which gluteal augmentation was safely performed with cryopreserved fat grafts.

4.6 Future Perspectives

Certainly, the development of a practical but optimal cryopreservation technique will benefit many patients who desire soft-tissue augmentation for both reconstructive and cosmetic purposes. Since repeated or serial fat grafting procedures are often necessary to achieve the best outcome for the patient, his or her banked lipoaspirate can be used, as long as the fat grafts are properly preserved and maintain their viability and structure (Fig. 4.4). In essence, no further harvesting procedures would be required, thus reducing operative time and cost.

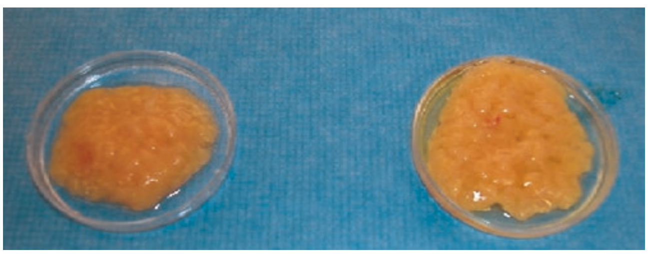

Fig. 4.4 Previously cryopreserved fat grafts with trehalose (0.35 M) with near-normal appearance, similar to freshly aspirated fat (left), readily available for use

Another facet to this concept is the ability to take adipose aspirates and process them in vitro to obtain a fibroblast-like population of cells, called processed lipoaspirate (PLA) cells [18]. Several studies have demonstrated that PLA cells can differentiate in vitro into different cell lines in the presence of lineage-specific induction factors [19]. Additionally, adipose tissue may represent an important source of adipose-derived stem cells (ADSC) [20]. The current proposed strategy for the use of PLA cells for cell-based tissue engineering would process adipose aspirates immediately for PLA cells after its collection from conventional liposuction and then store these cells by means of cryopreservation. The lipoaspirate obtained after cryopreservation with our described technique appeared to be a reliable source of adult human PLA cells since they could be processed later in good quantity [20] (Fig. 4.5). Thus, lipoaspirate as a "raw material" can be preserved using an optimal cryopreservation procedure to meet future needs of patients, in the form of subsequent fat transplantation or for ADSC-based therapy [19, 20] (Fig. 4.6). This may open a new era in plastic and reconstructive surgery, autologous fat transplantation, and ADSC-related tissue regeneration.

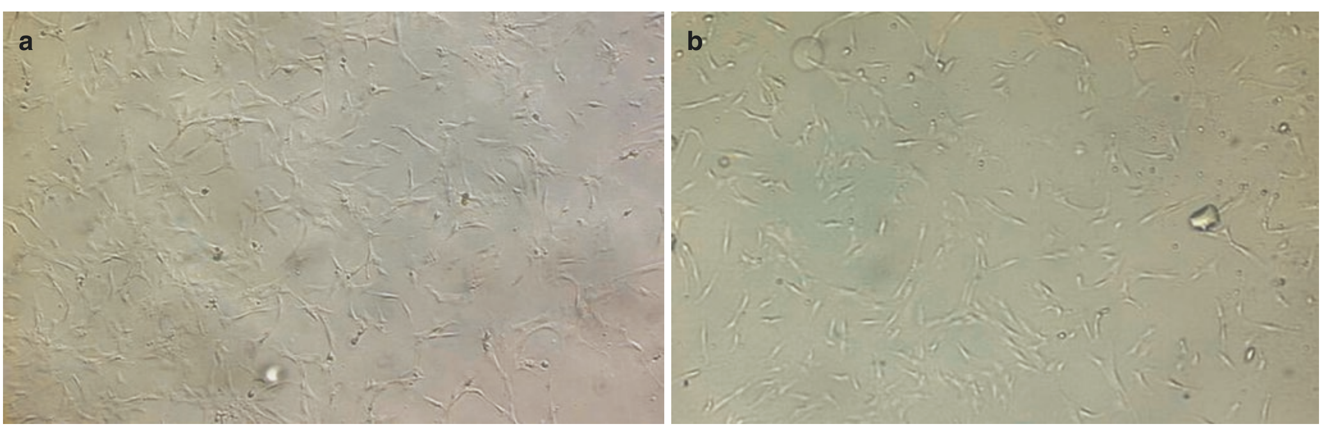

Fig. 4.5 Flat, spindle-shaped processed lipoaspirate (PLA) cells after 2 weeks of culture (**a**) from the fresh control group, (**b**) from the cryopreservation group. Phase-contrast microscopy was used with an original magnification of 100×. Both PLA cells appear to have normal morphology and may be used for cell-based therapy in the future

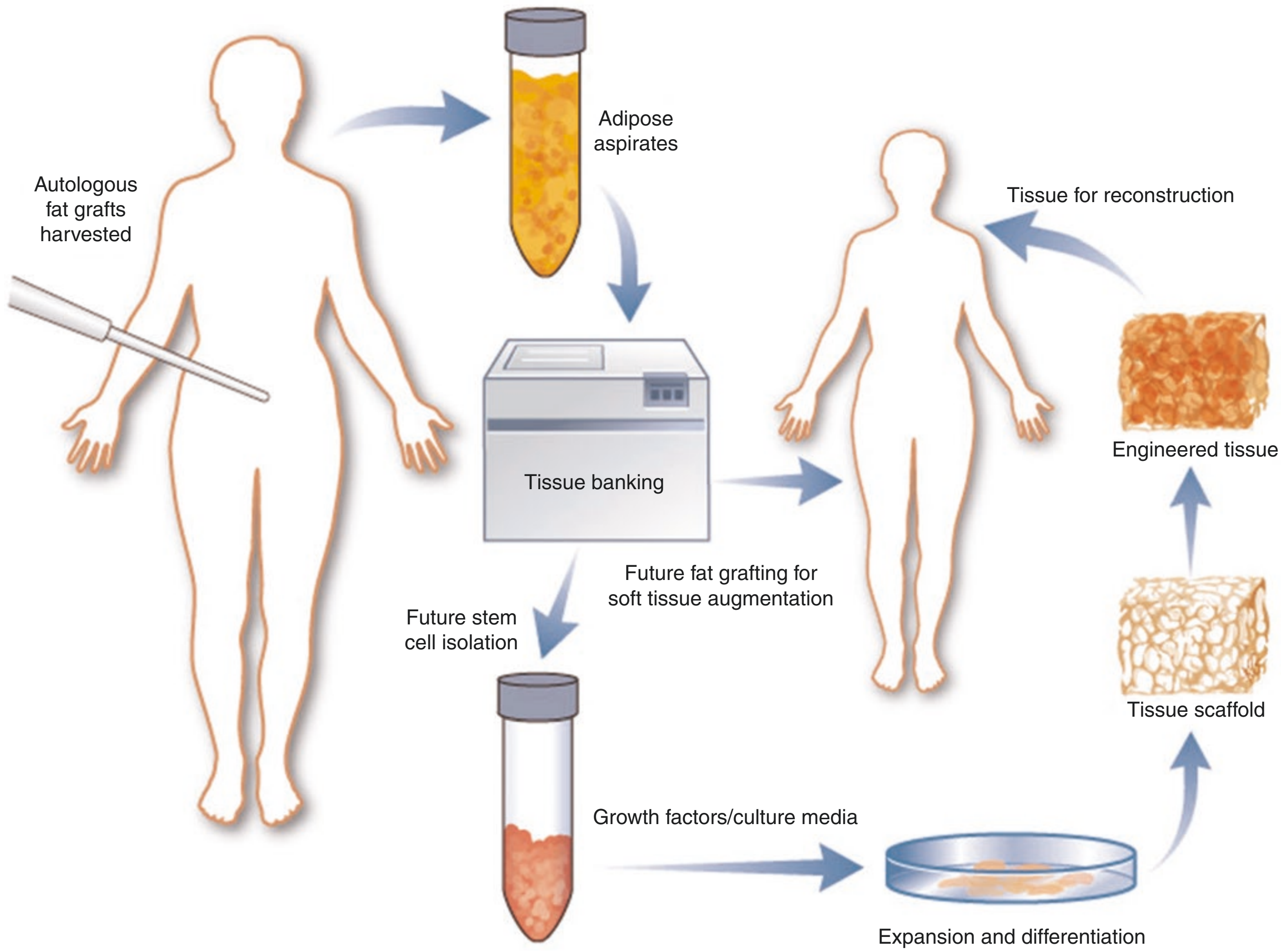

Fig. 4.6 Schematic diagram showing possible autologous fat grafting and ADSC-based therapy for engineered tissue reconstruction after successful cryopreservation of the patient's own adipose tissue collected from liposuction

4.7 Conclusion

Our cryopreservation method developed specifically for adipose tissue appears to provide good long-term preservation of fat grafts, but so far, the overall quality of the cryopreserved fat grafts is still less than ideal than the fresh ones. This might be true not only for adipose tissue but also for other types of tissues after an "optimal" cryopreservation. Because of its safety and effectiveness, trehalose only as a CPA with an optimal concentration along with our cooling and thawing protocol can possibly be used in patients for long-term preservation of their fat grafts. However, further studies are still needed in order to develop a reliable and clinically feasible cryopreservation method that can be used for successful long-term preservation of large volumes of adipose tissue.

Disclosure The authors have no financial interests in any of the drugs, products, or devices mentioned in this chapter.

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5 Anatomy of the Gluteal Region Applied to the Brazilian Butt Lift

Alvaro Cansanção, Alexandra Condé-Green, and Mauricio S. S. Viaro

5.1 Introduction

Detailed knowledge of anatomy is of great importance for the realization of any type of surgery. In the past, since gluteal surgery represented a very small portion of plastic surgery procedures, many surgeons were more familiar with the anatomy of the face, the abdomen, and the breasts and were not concerned with studying the anatomy of the gluteal region.

However, with the recent increase in demand for the aesthetic improvement of this region [1], and unfortunately the increase in complication ratio [2, 3], such as fat embolism, death [4], and GIA-ALCL (gluteal implant-associated anaplastic large cell lymphoma) [5], the quest for gluteal anatomy knowledge is becoming increasingly important.

It is imperative for any surgeon who performs gluteal aesthetic surgery, contour liposuction, fat grafting, implants, or gluteal lift to have extensive knowledge of the gluteal anatomy and learn the aesthetic standards for proper surgical planning. The correct technique or combination of techniques should be tailored to each patient in order to achieve the best aesthetic result without compromising patient safety.

For didactic purposes, we will discuss the anatomy of the gluteal region, the different layers including the bone frame, the musculature, the vascularization, the innervation, the cutaneous ligaments and the subcutaneous tissue, and the importance of each in regard to gluteal augmentation surgery.

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5.2 Limits of the Gluteal Region

The gluteal region is located at the back of the body, representing the transition point between the trunk and the lower limbs. Its limits are (Fig. 5.1):

- Medially: intergluteal crease, sacrum, and coccyx (sacral triangle, also known as V-shaped crease)
- Superiorly: posterior-superior iliac spine (PSIS), iliac crest
- Laterally: an imaginary line beginning at the anterior-superior iliac spine, passing through the greater trochanter and ending at the infra-gluteal fold
- Inferiorly: infra-gluteal fold

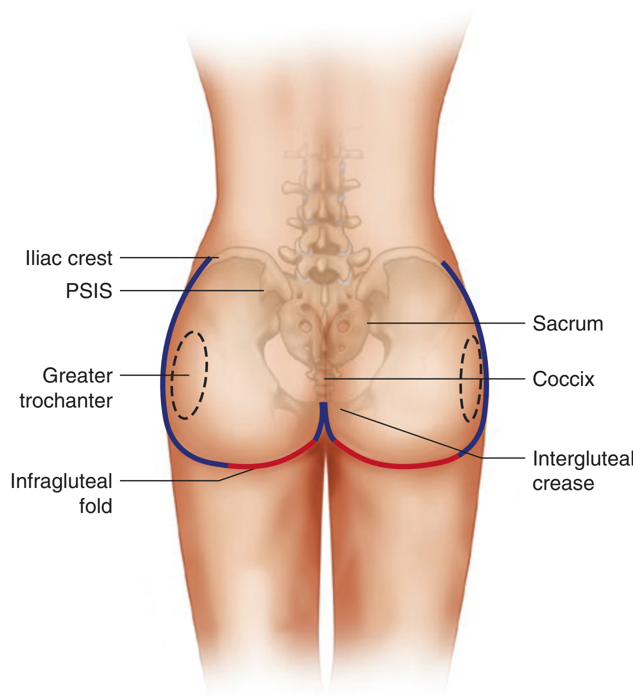

Fig. 5.1 Representation of the limits of the gluteal region (topography)

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The buttocks lie within this area, but does not fully occupy it, just as the gluteus maximus muscle is mostly located within the gluteal region but extends beyond it into its insertion at the iliotibial tract.

5.3 Bony Structure: The Pelvis

The bony pelvis is a structure that represents a frame for the gluteal region, supporting the entire region through a ligamentous system that strongly joins the bones, the muscles, and other tissues. It is formed by the hip bone, sacrum, and coccyx. The hip bone is made up of three bones, ilium, pubis, and ischium, which are welded at puberty forming a single structure (Fig. 5.2).

External landmarks of the gluteal frame are as follows: The v-shaped crease is an inverted triangle with the tip represented by the coccyx following the lateral borders of the sacrum until the PSIS that represents the cephalic borders of the sacral triangle. The PSIS are represented by two round depressions known as the sacral dimples. Lateral to the PSIS, the iliac crest represents the cephalic limit of the bone frame. The lateral limits of the bony frame are represented by the great trochanters as lateral depressions. Inferiorly, at approximately one-third of the medial part of the buttocks, the ischial tuberosity represents the most inferior part of the bone frame (Fig. 5.3).

A complex net of ligaments strongly joins the bones of the pelvis, creating a unique structure, allowing the pelvis to support the weight of the upper trunk and transmit it to the lower extremities when we are standing upright. Among these ligaments, the most important in regard to this procedure are the posterior sacroiliac ligament and the sacrum-tuberous ligament (Fig. 5.4) which form the major and minor sciatic foramen, through which important structures pass.

The posterior sacroiliac ligament also has a protective function in gluteal fat grafting. When we perform fat grafting through an incision in the sacral triangle, if we inadvertently penetrate the muscle with the cannula, it protects the gluteal vessels within the sciatic foramen, where the vessels are larger in size and could more easily be injured.

When fat grafting is performed through a lateral, superior, or inferior incision (with the cannula directed medially), in case of inadvertent intramuscular penetration, the cannula is pointed directly at the sciatic foramen and all its noble structures. Therefore, even when performing subcutaneous

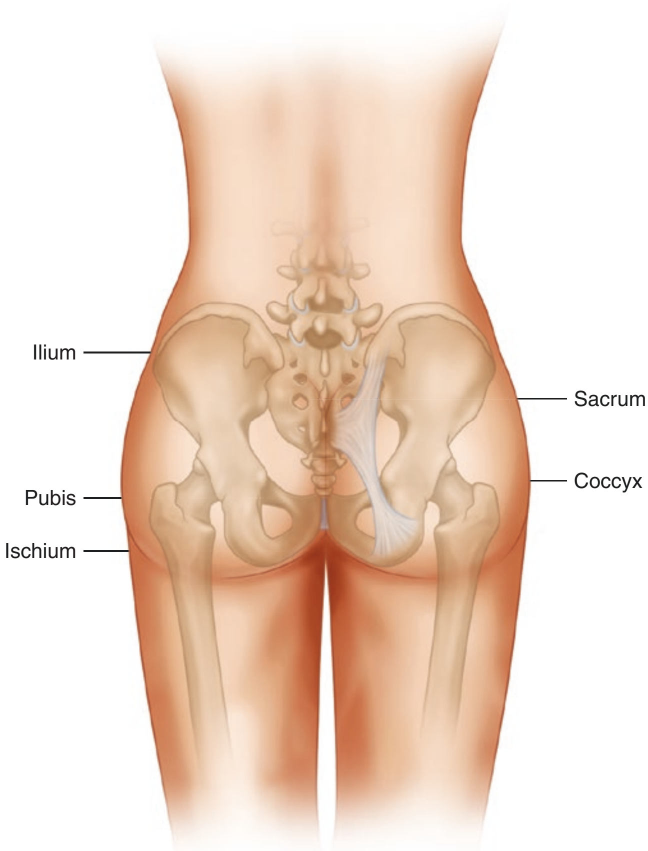


Fig. 5.2 The bone pelvis

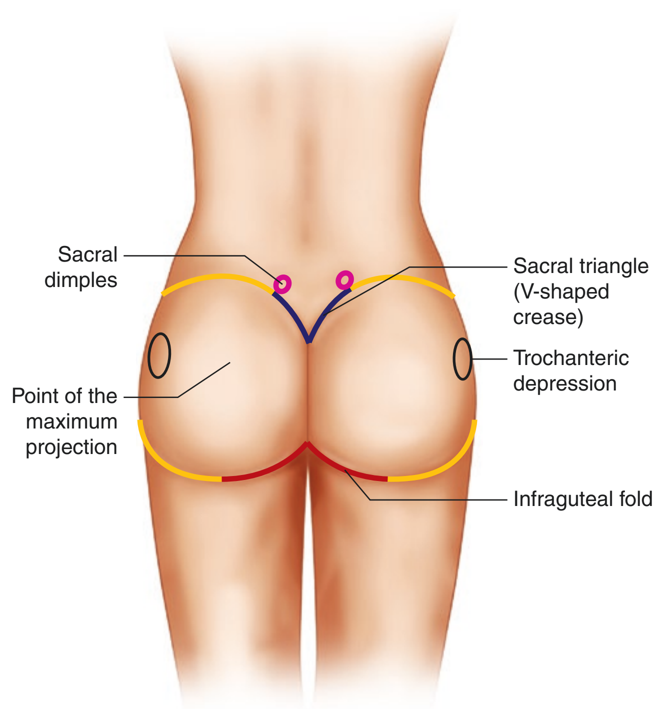


Fig. 5.3 External landmarks of the gluteal frame

fat grafting, we should avoid using the lateral incision as a port of access and pointing the cannula medially when using the upper and lower incisions [6] (Fig. 5.5).

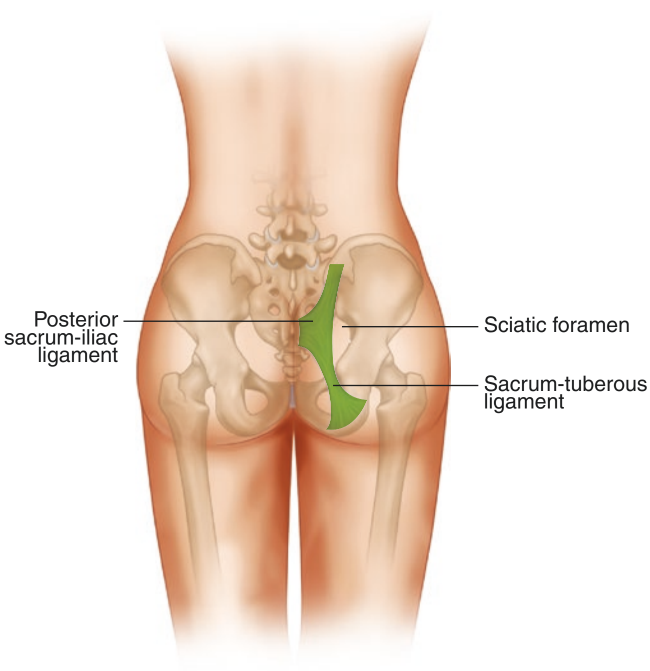


Fig. 5.4 Bone pelvis ligaments with clinical relevance to gluteal fat grafting

5.4 Muscles

The gluteal muscles can be divided into two layers, the deep layer (composed of the gluteus minimus, piriformis, superior gemellus, inferior gemellus, obturator externus, and obturator internus) and the superficial layer (composed of gluteus maximus and gluteus medius) (Fig. 5.6).

Among the deep muscles, the one with the most practical importance in gluteoplasty is the piriformis, as it is an important landmark for the identification of the pelvic neurovascular structures. It originates in the sacrum and passes over the sacrotuberous ligament to insert into the greater trochanter.

It crosses the sciatic foramen, dividing it in two parts:

- Superior: through which the superior gluteal nerve, artery, and vein emerge
- Inferior: through which the sciatic nerve, the inferior gluteal nerve, artery and vein, the pudendal nerve, and the posterior cutaneous nerve of the thigh emerge

At the superficial muscular layer, the gluteus maximus muscle is the thickest muscle of the human body ranging from 4 to 7 cm and is responsible for the buttocks contour [7]. It originates in the iliac crest, sacrum, coccyx, and the sacrotuberous ligament with insertions in the gluteal tuberosity of the femur and at the iliotibial tract.

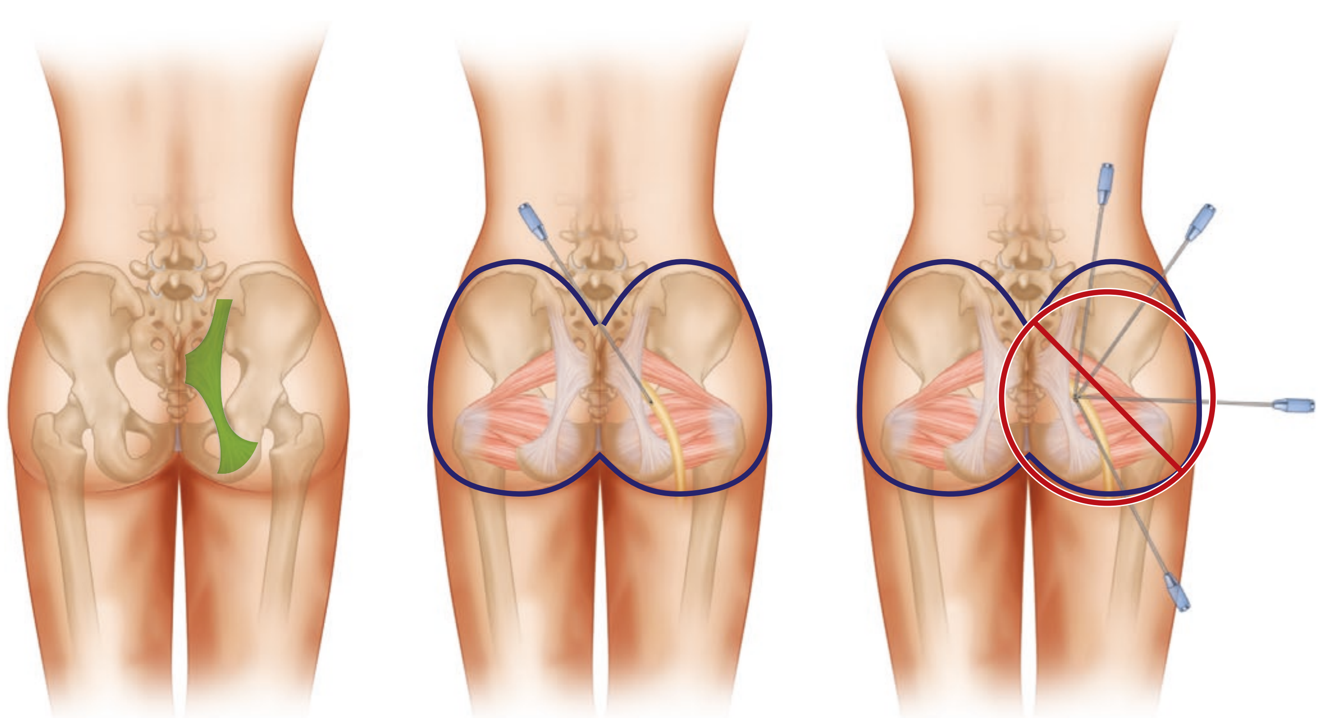


Fig. 5.5 Representation of how the cannula's entry port and the directing of the fat injection can influence the risk of fat embolism

5.5 Vascularization

The blood supply of the gluteal region comes primarily from the superior and inferior gluteal arteries, which are caliber branches of the internal iliac artery. They emerge from the sciatic foramen, respectively, above and below the piriformis muscle, penetrating the gluteus maximus and gluteus medius muscles through their posterior aspect, near to the sacrum. These vessels run perpendicularly and divide into branches that move parallel to the muscle fibers (Fig. 5.7). Therefore, dissecting the muscles for placement of gluteal implants may lead to bleeding [8].

Rosique and Rosique [9] described a triangular area, where all major vessels of the buttocks are located, except the superior gluteal artery and vein which are very deep and high in the iliac wing inferior edge and difficult to injure with a cannula. This area is known as a safety triangle with its apex between the sacral dimples and its base along the medial two-thirds of the infragluteal fold, on both sides.

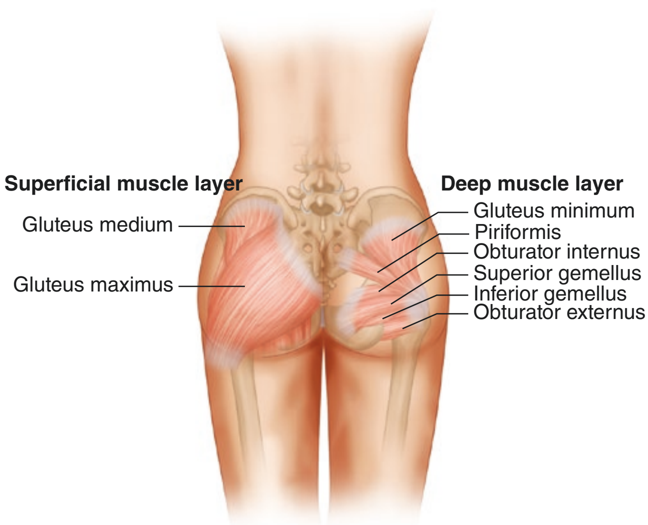
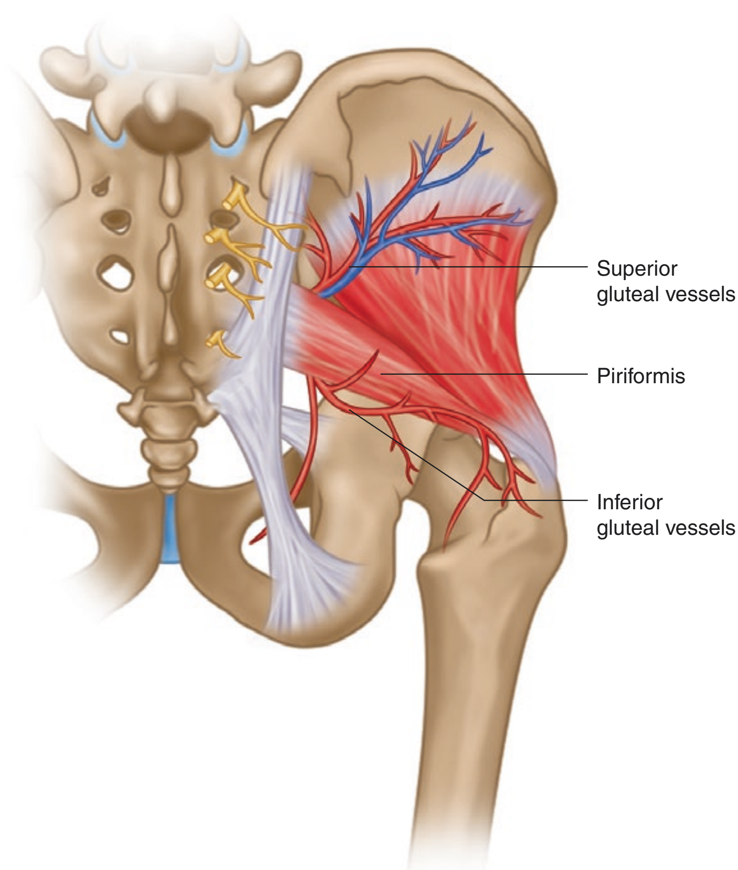


Fig. 5.6 Muscles of the gluteal region: right buttocks, deep muscle; left buttocks, superficial muscle

5.6 Innervation

The sciatic nerve is the largest nerve in the human body, measuring around 2 cm in diameter in adults. It emerges from the inferior sciatic foramen just below the piriformis, innervating the deep muscles of the gluteus and the

Fig. 5.7 Vascularization of the gluteal region. Superior gluteal vessels emerging above the piriform muscle, inferior gluteal vessels emerging below the piriform muscle



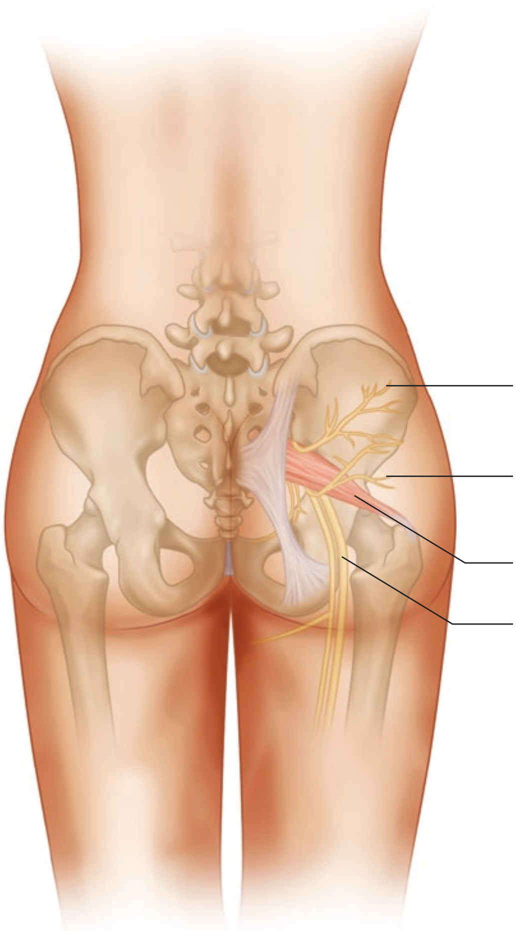


Fig. 5.8 Innervation of the gluteal region

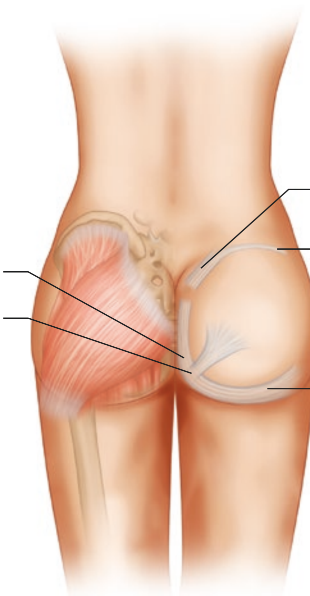


Fig. 5.9 The osseocutaneous and fasciocutaneous ligaments

posterior thigh. Its sensitive portion is prone to edema or bleeding, which may cause pain that radiates to the posterior thigh, thus the reason why some surgeons recommend avoiding the prone positioning in the first weeks post-op [10] (Fig. 5.8).

5.7 Cutaneous Ligaments

The gluteal region has ligaments and adhesion zones that have the function of supporting the skin and subcutaneous tissue and represent important landmarks for gluteal aesthetics. The knowledge of these ligaments and adhesions zones is important as their density can cause inadvertent misguidance of the cannula tip into deep planes increasing the risk of complications, such as fat embolism [11].

These ligaments can be classified into two groups: the osseocutaneous ligaments (sacrocutaneous, superior gluteal adhesion, and ischiocutaneous) and the fasciocutaneous ligaments (Natal cleft adhesion) (Fig. 5.9).

The sacrocutaneous ligament is consistently found at the superior border of the intergluteal sulcus and strongly attaches the skin to the lateral margin of the sacrum. This ligament is more adherent in males compared to females resulting in a pronounced angulation between the sacral triangle and the upper pole of the buttocks in males. It runs superolateraly with less dense adhesions from the iliac crest to the skin and receives the name of superior gluteal adhesion.

At the medial third of the buttocks, a fan-shaped ligament, the ischiocutaneous ligament, originates at the ischium and extends directly to the skin. It merges superiorly with the natal cleft fasciocutaneous ligament and inferolateraly with the gluteal crease fasciocutaneous ligament. The ischiocutaneous ligament is the most difficult ligament to pierce, and it can misguide the cannula directly to the minor sciatic foramen where the sciatic nerve and the inferior gluteal vessel are located.

The natal cleft fasciocutaneous ligament parallels and defines the natal cleft, extending from the gluteal fascia to the dermis. It merges superiorly with the sacrocutaneous ligament and inferiorly with the ischiocutaneous ligament.

The infragluteal crease is commonly misclassified as a fasciocutaneous ligament, but indeed it is a unique structure that can be classified both as fasciocutaneous and osseocutaneous ligaments. It originates from the dermis of the medial one-third of the lower buttocks, forming a strong septum that interdigitates with the gluteal fascia and also attaches to the ischium and sacrum, which explains the fixed and well-defined aspect of the gluteal fold.

5.8 Subcutaneous Adipose Tissue

Often overlooked, knowledge of the anatomy of the gluteal subcutaneous adipose tissue and how its different layers interact when injecting fat is extremely important in achieving good results in gluteal fat grafting. Localized between the skin and the muscular fascia, the subcutaneous adipose tissue is composed of two layers of fat, divided by a membranous tissue called fascia superficialis.

The superficial adipose tissue (SAT) also known as areolar fat layer is found above the fascia superficialis and is formed by fat lobules organized in single or multiple layers interspersed by fibrous septa, forming a honeycomb structure. These septa are composed of elastic and collagen fibers originating in the fascia and run in a well-defined and parallel fashion toward the surface strongly anchored to the dermis [12].

The SAT has different characteristics according to gender. In men, the fatty lobules are smaller, and the septa run in an oblique fashion, while in women they are larger and are oriented in a perpendicular fashion. These characteristics are present at birth; however after the puberty, the fat lobules become enlarged, and the interstitial fluid retention increases due to the hormonal changes, and the presence of cellulite (gynoid lipodystrophy) is seen in women [13].

The deep adipose tissue (DAT) also known as lamellar layer is located between the muscular fascia and the superficialis fascia. It has different characteristics than SAT and is composed of larger flattened and less defined lobules permeated by few and incomplete septa, in an oblique fashion [14] (Fig. 5.10).

It is important to understand the differences between these two fat layers to achieve the desired results in gluteal fat grafting. Injecting fat into any of the layers will increase the thickness (projection) and the consistency (hardness) of the buttocks. However, injecting fat into the SAT will increase the consistency more than the projection, as this layer has strong septa that do not allow for significant increase in the thickness. On the other hand, if more projection is desired, fat should be injected into the DAT, as this layer has incomplete septa that allow for more increase in thickness of the gluteal region. One needs to be cautious when injecting fat into the SAT since it has a limited volume capacity, and overfilling could lead to contour irregularities that can may mimic cellulite.

Careful understanding of all these different components of the anatomy of the gluteal region is important in order to perform fat grafting efficiently and safely while obtaining great long-term outcomes.

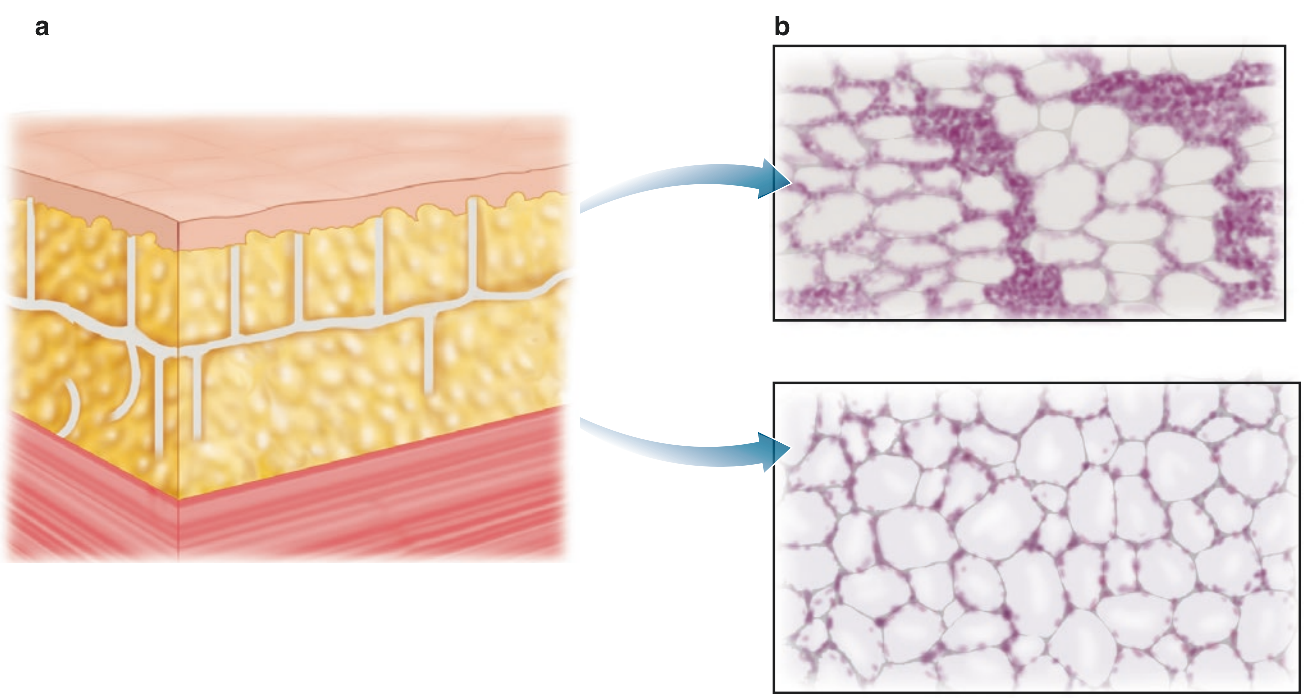


Fig. 5.10 The two layers of the subcutaneous tissue. (**a**) Superficial adipose tissue composed by small fat lobules interspersed by fibrous septa emerging from the fascia superficialis and anchored to the skin. (**b**) Deep adipose tissue composed by larger fat lobules, permeated by few and incomplete fibrous septa

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6 Aesthetics of the Gluteal Region

Aditya Sood, Samuel Kogan, and Robert F. Centeno

6.1 Introduction

While the demand for gluteal augmentation with fat grafting continues to grow, some plastic surgeons remain hesitant to incorporate the procedure into their practice due to safety considerations and a lack of understanding of gluteal aesthetics, the operative technique, and patient selection. The absence of accepted aesthetic gluteal classification systems that standardized the anatomic variations of the gluteal region was a significant hindrance to the adoption of the procedure. With the advent of such classification systems, gluteal fat grafting has become more standardized and approachable to many surgeons [1, 2].

6.2 Aesthetic Characteristics

6.2.1 Gluteal Zones and Aesthetic Units of the Buttock

Effective clinical evaluation of the buttock requires a consistent and systematic approach. The buttock may first be divided into three sections: upper, middle, and lower [3].

6.2.1.1 Upper Buttock

The upper buttock is composed of a lateral and medial zone. The aesthetic buttock contains fullness in the medial zone. Excess fullness in the lateral area creates a square and less attractive look but can be corrected with liposuction of the area [3]. Deficiencies of volume in the central zone may be corrected with fat grafting or gluteal implants. Implants add volume to the upper and middle buttock, but not the lower section.

6.2.1.2 Middle Buttock

The middle buttock is also divided into lateral and medial zones. The lateral zone may contain a depression, which significantly impacts gluteal shape. Excess fat in the lateral segments of the upper and lower buttock may worsen the appearance of the indentation, but liposuction may be used to improve the appearance. However, fat transfer to the depression is often necessary to significantly improve the overall gluteal shape and appearance.

6.2.1.3 Lower Buttock

The lower buttock is more difficult to augment, as it is divided into more segments and contains several important aesthetic structures. First, the lower buttock is divided into an inner, central, and lateral zone. The horizontal infragluteal fold, vertical intergluteal cleft, and outer leg skin fold are all within the lower buttock. The length of the infragluteal fold significantly impacts the appearance of the buttock, and a longer crease is a sign of buttock ptosis due to skin laxity [3].

Cuenca-Guerra and Quezada published the first systematic approach to gluteal aesthetic classification in 2004 [4]. The authors examined 1320 photographs of nude women and measured 132 female patients aged 16–62 years. They concluded that four characteristics determine the aesthetics of the buttocks.

1. *Lateral depression*. This is a hollow area on the lateral aspect of the buttock. This landmark is formed in its deepest point by the greater trochanter, superiorly by the insertion and belly of the gluteus medius, inferiorly by the insertion of the vastus lateralis, and posteriorly by the insertion of the quadratus femoris.
2. *Infragluteal fold*. This is a horizontal crease under the ischial tuberosity. The inferior border of the infragluteal

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fold is formed by the insertions of the semitendinous muscle and the belly of the biceps femoris. The superior border is formed by the lower border of the gluteus maximus.
3. *Supragluteal fossettes*. Also known as the Dimples of Venus, these are small hollow areas located on either side of the medial sacral crest. They are formed deeply by the posterior iliac spine and medially by the multifidus muscle.
4. *V-shaped crease*. These creases were observed in 45% of the analyzed photographs. They are formed by two lines arising in the proximal portion of the gluteal crease and are directed toward the supragluteal fossettes. They should measure no more than 1/3 the distance between the gluteal crease and the supragluteal fossettes.

Additionally, they observed that lumbar hyperlordosis contributed to an aesthetic buttock. They acknowledged that it was an ethnic feature, specific to those of African heritage. However, it served to give the impression of greater anterior-posterior buttock projection [4].

Centeno described the gluteal aesthetic unit classification system by dividing the gluteal region into eight aesthetic units [5]. From a posterior-anterior view, the gluteal region may be divided into two symmetric "flank" units, "sacral triangle" unit, two symmetrical gluteal units, two symmetric thigh units, and one "infragluteal diamond" unit. Each of these aesthetic units impacts the overall gluteal aesthetic and should be addressed when planning gluteal contouring.

Subsequently, Mendieta described a gluteal aesthetic unit classification system involving ten segments [2]:

1. Sacrum v-zone
2. Flank
3. Upper buttock
4. Lower back
5. Outer leg
6. Gluteus
7. Diamond zone: inner gluteal/leg injection
8. Mid-lateral buttock (point C)
9. Inferior gluteal/posterior leg junction
10. Upper back

In Mendieta's classification system, six aesthetic units contribute to the buttock frame/shape: zones 1–5 and 8. The mid-lateral buttock (zone 8) is unique in that it often requires fat transfer to improve contour. Additionally, this area does not contain muscle and thus requires special attention and precision when fat grafting. All approaches involve liposuction of zones 1–4 in all patients. Mendieta reports a decrease in the need to perform liposuction in the outer leg (zone 5), as many patients prefer to keep fullness in this area. It is important to note that excessive liposuction of zone 5 can also lead to an unnatural transition zone between the buttock proper and the lateral thigh.

6.2.2 Analysis of the Gluteal Frame

6.2.2.1 Gluteal Shape

Gluteal shape is determined by four anatomic variables and their relationships: (1) underlying bony framework, (2) gluteus maximus muscle, (3) subcutaneous fat topography, and (4) skin.

The "gluteal frame" is composed of the bony framework, subcutaneous fat, and skin—all structures other than the gluteus maximus muscle. Each of the individual components of the "frame" influences the overall shape, yet certain variables are more amenable to intervention than others. The underlying bony framework is used to classify pelvic height as tall, short, or intermediate. However, as surgery does not influence the bony structures, they do not play a role in the classification system. The skin determines whether a lift or skin excision is needed. Lastly, fat topography is the most important unit of the gluteal frame and the one most amenable to change.

6.2.2.2 Identification of Frame Types

Objective classification of the gluteal shape is accomplished by observing the amount of fat present in three specific zones of the gluteal region. The widest segment of the upper lateral hip is denoted as Point A, whereas the widest segment of the lateral thigh is established as Point B. The most lateral portion of the mid-buttock area is Point C (Fig. 6.1). Visually establishing a connecting line from Point A to Point B reveals four basic frame types: A-shape, V-shape, square shape, and round shape. Point C determines whether a buttock is square- or round-shaped. For example, excess fat in Point C is associated with a round shape, whereas deficiencies of fat in Point C result in a square shape. Point C is also used to determine the degree of fat deficiency in the A-shaped, V-shaped, and square buttocks. Typically, mild to moderate depression at Point C does not require fat transfer, as contour improvements are achieved via liposuction of the adjacent areas. Severe topographical depressions are corrected with fat transfer.

6.2.2.3 Characteristics of Frame Types

Square Shape The square shape is the most common of the four frames, accounting for approximately 40% of patients. Equal volumes at Points A and B characterize the square shape, such that a vertical line can be drawn to connect them. Point C may have varying degrees of fat deficiency, with a mild, moderate, or severe depression (Fig. 6.2).

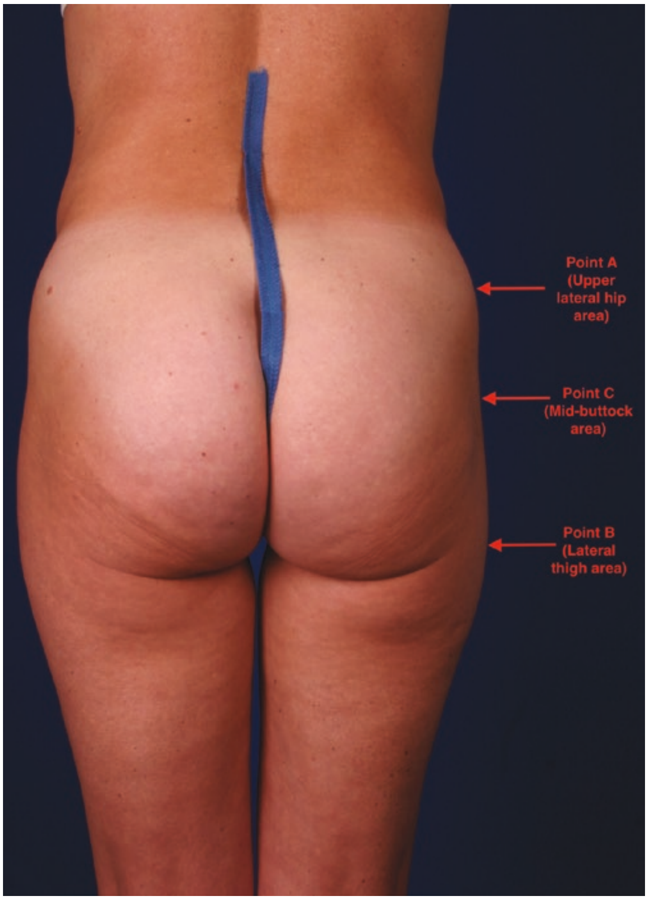

Fig. 6.1 Points A, B, and C, demonstrating areas to be considered in evaluating the frame type

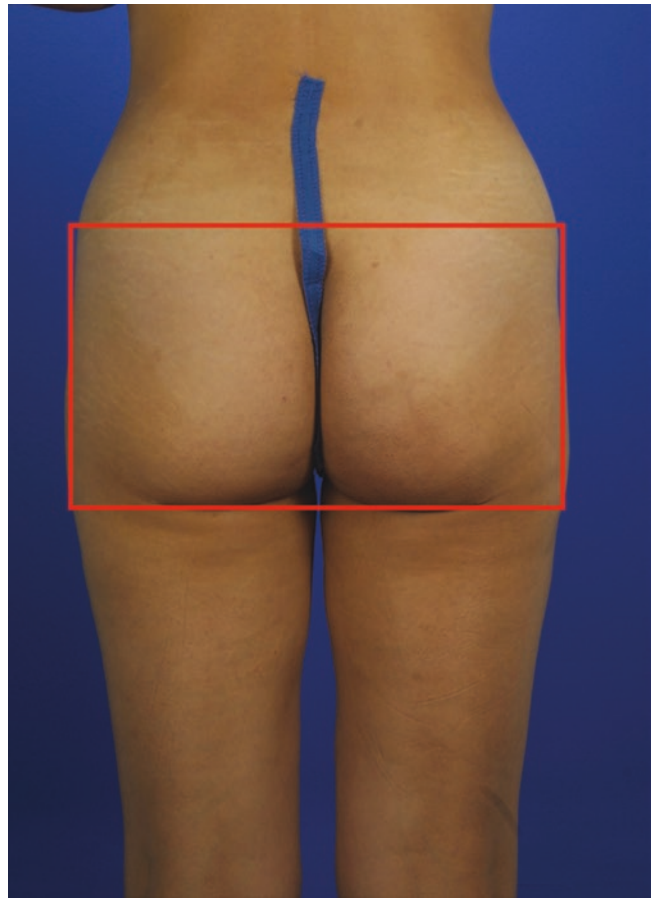

Fig. 6.2 Square-shaped buttock

The square shape can be further characterized as tall, intermediate, or short. A short buttock is defined by a gluteus maximus height-to-width ratio of 1:1. The tall square shape has a 2:1 height-to-width ratio, and the intermediate variant falls between the two others.

Liposuction at Points A and B improve the aesthetics of the square shape. Fat transfer to Point C may be needed, depending on the extent of depression.

Round Shape The round frame is seen in approximately 15% of patients. Excess fat at Point C is the differentiating factor between the round and square shape. When connecting Points A, B, and C, one can observe a C-shaped curve around the buttock (Fig. 6.3). The height-to-width ration is most often 1:1. Notably the round shape is sometimes associated with excess fat or skin in the lower inner gluteal fold area, which gives fullness to the buttock in an aesthetically unpleasing manner. An infragluteal diamond skin excision may be required to correct this deformity.

A-Shape (Pear Shape) The A-shape is seen in about 30% of patients. The A point is more medial than B, resulting in a shape of the buttock that resembles the letter "A" (Fig. 6.4). This shape is due to excess fat in the upper lateral thigh area compared to the upper lateral hip area. Liposuction of Point B improves the appearance of this shape, although excessive suction should be avoided as it can unnaturally mask the transition zone between the gluteal area and the lateral leg at Point B.

V-Shape (Apple Shape) The V-shape is an inversion of the A-shape, with the A point being wider than the B point (Fig. 6.5). It is observed in 15% of patients. These patients often have excess fat in the upper lateral hip area, with very little seen at the upper lateral thigh area. Patients with the V-shape often have a tall pelvis with thin legs and central obesity. The frame shape is the most difficult to re-contour. Liposuction of both the flank area and point A assists with reshaping the buttock. Additionally, fat transfer to the upper

Fig. 6.3 Round-shaped buttock

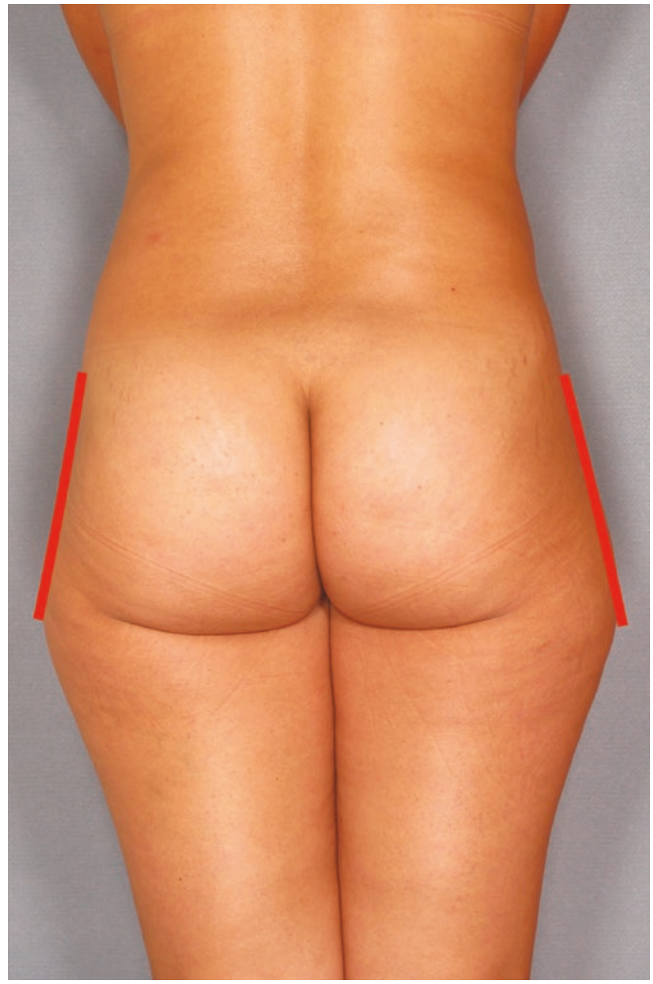

Fig. 6.4 A-shaped buttock

inner muscle area or the transition zone from the lower-outer gluteal muscle to lateral thigh may be used to improve the overall shape.

Intermediate Shapes While the majority of patients fall into one of the four frame types, others may not be as easily characterized. Asymmetry between the two halves of the body may result in the necessity of separately characterizing the patient's frame. In these cases, each buttock must be individually assessed and the approach modified accordingly.

6.2.3 Gluteal Projection

Gluteal projection is determined by both the gluteus maximus muscle and fat within the superficial fascia [1]. When viewing the buttock from the lateral view, it may be divided into three zones: upper, central, and lower [5]. The aesthetic buttock contains most of its volume in the central zone, with the remaining volume placed equally in the upper and lower zones. This distribution of volume in the buttock results in a C-shaped curve. The aesthetic buttock has a point of maximum projection at the level of the pubic bone [6]. Gluteal projection plays a role in ethnic preferences and will be discussed further in the following section. While fat grafting increase gluteal volume, contouring is necessary to achieve an aesthetic buttock, not just a large one [2].

6.2.4 Gluteal Ptosis

The final step in the evaluation of the buttocks is to determine whether any ptosis is present. The lateral view is used to categorize the patient into either no-ptosis or ptosis groups, both of which are subdivided into three groups. This categorization is useful for selecting the optimal buttock reshaping procedure for the patient [5].

Fig. 6.5 V-shaped buttock

Fig. 6.6 Buttock with no-ptosis (class C)

6.2.4.1 No-Ptosis Categories

No-ptosis is defined by the buttock volume being above the infragluteal fold and no dropping skin below the fold [5] (Fig. 6.6).

- Class A: Patients in the no-ptosis class A category have equal buttock volume in the upper and lower buttock zones, with a smooth C contour when viewed from the lateral view. Class A is the ideal shape, and only augmentation is necessary.
- Class B: In the no-ptosis class B category, there is a deficiency of volume in the lower part of the central buttock zone. Fat transfer to the depression should be performed alongside augmentation.
- Class C: In class C, there is no skin droop below the infragluteal fold, but the fold is not truly appreciated. Unlike class B, there is no depression in class C. Augmentation is typically sufficient to correct this group of patients.

6.2.4.2 Ptosis Categories

Patients are deemed to have buttocks ptosis when skin droops over the infragluteal fold and a skin fold is appreciated (Fig. 6.7). The angle of the skin fold is used to divide the ptosis into grades I, II, and III. The angle is less than 10° in grade I, between 10° and 30° in grade II, and greater than 30° in grade III ptosis [5].

Grade I ptosis: Grade I ptosis appears very similar to the no-ptosis class C; however, some skin droops below the infragluteal fold. From the lateral view, the skin fold appears as a horizontal line. Augmentation can correct the deformity, and an upper buttock lift is typically not necessary.

Grade II ptosis: In grade II ptosis, the skin fold is more angular than in grade I. There often is a depression in the upper segment of the lower gluteal region. Like grade I, grade II ptosis can often be corrected with augmentation alone.

Grade III ptosis: Grade III ptosis is the most severe, and the skin droops well below the infragluteal fold. There often is a depression in the lower segment of the central gluteal region. The skin has poor skin laxity and contains stretch marks. Whereas grades I and II ptosis may be corrected with

Fig. 6.7 Buttock with skin drooping over the infragluteal fold with an evident skin fold appreciated (grade II ptosis)

augmentation alone, grade III cannot be addressed without skin excision. A formal buttock lift or a circumferential thigh lift is required. If there is concomitant buttock and thigh skin laxity, excision of the infragluteal fold may be performed. Combining these procedures with fat transfer significantly improves outcomes.

6.3 Ethnic Preferences for Gluteal Region

It is imperative to be aware of ethnic preferences of the ideal gluteal region, as the differences among groups are significant [7]. Each patient will have their own specific requests, but a general sense of ethnic preferences may assist the surgeon in getting the patient toward their personal ideal shape.

With respect to buttock size, Asian women tend to prefer smaller but shapely buttocks. Caucasian women prefer a full buttock, but not as full as Hispanic or African American women. Hispanic and African American women prefer great lateral buttock fullness [8].

African American women have a preference for large buttocks, with lumbar hyperlordosis. Their unique desire for extreme prominence of the upper pole may result in a "shelf" appearance. They also prefer a smaller waist.

Asian women tend to request small-to-moderate-sized buttocks and avoid fullness in the lateral buttock or lateral thighs. They tend to be smaller than women of other ethnicities, and the shape and proportion of the buttock relative to the rest of the body is often a high priority for them.

Caucasian women request large full buttocks, but not extremely large. They do not request fullness in the lateral thigh. However, Caucasian women either prefer a more feminine look with rounded lateral buttocks, or a flatter, hollow shape with a more athletic appearance.

Hispanic women in the United States prefer very full buttock and some fullness in the lateral thigh, but less than that preferred by African American women.

While these generalizations are helpful during the consult with patients of different ethnic backgrounds about gluteal contouring, by no means should they serve as rules for categorizing patients. Changing ethnic demographics and popular culture continue to influence patient preferences dramatically. The skilled plastic surgeon will determine how each patient's personal preferences comport with or differ from these observed trends.

6.3.1 Waist-to-Hip Ratio (WHR)

Despite some empiric differences in ethnic preferences of gluteal shape, it has been argued that a waist-to-hip ratio of 0.7 is the "universal ideal female shape [9]." This ratio is measured at the narrowest portion of the waist and the point of greatest prominence of the buttocks. The ideal female shape is influenced more by the waist-to-hip ratio than by the overall body size. Singh presented study participants with six female figure outlines that differed in depiction of overall body weight and size of the WHR. Both male and female study participants used the WHR to determine attractiveness [10]. Achieving a WHR of 0.7 after buttock re-contouring is preferred regardless of the patient's ethnic background [8].

Wong et al. performed a population level analysis using digitally altered images of a range of WHR presented in posterior and lateral views [11]. From the posterior view, the 0.65 WHR was selected as most attractive (44.2% of respondents). The 0.60 WHR was the second most selected ratio (25% of respondents). Interestingly, only 5% of respondents selected 0.70 as the ideal ratio. From the lateral view, a WHR of 0.70 was most attractive (29.8% of respondents). These results may indicate a shift in preferences toward curvier buttocks. However, the authors point out that greater than 90% of respondents were American, with a disproportionate number of Caucasian responders. A study with increased global representation of respondents may better report ethnic preferences and uncover whether ideals have in fact shifted.

Heidekrueger et al. provided further evidence that the ideal WHR is 0.7 [12]. The authors used digital alteration to generate a series of images of a single woman with multiple buttock sizes. They created a questionnaire, translated it into multiple languages, and sent it out to over 9000 people in multiple countries. Responders of the online survey included the general public and plastic surgeons. They received 1032 responses from people in over 40 countries. The distribution of selected WHR ranged from 0.68 to 0.74. Thirty-nine percent of respondents (404/1032) chose the photograph with the 0.7 WHR as the ideal. Twenty-one percent (220/1032) chose 0.71, and 19% (191/1032) chose 0.69 as the ideal WHR. The other ratios (0.68, 0.73, and 0.74) were selected by less than 5% of participants. In concordance with other published data regarding ethnic preferences, non-Caucasians preferred a larger buttock than Caucasians [12].

6.3.2 Discussion

By applying a consistent approach to the characterization of gluteal appearance, a surgeon can help his or her patients achieve their aesthetic goals. The surgeon must first assess the patient's baseline gluteal characteristics and contour and only then progress to planning surgical intervention.

First, overall topographic characteristics of the buttocks should be assessed. A systematic analysis of the condition of each of the gluteal aesthetic units of the buttocks should be performed. Volume excess, deficiency, the point of maximum projection, and their impact on overall aesthetics of the gluteal region should be noted.

Next, the gluteal frame must be examined. After determining the pelvic height, the surgeon then defines the shape of the gluteal frame. By identifying the shape of the frame, the surgeon will be able to further assess where liposuction may improve the contour. Next, the degree of depression at Point C must be determined, which will dictate whether fat transfer is necessary. Subsequently, the sacral height should be compared to the length of the intergluteal [5]. Ideally, the sacral height should be less than 1/3 the cleft length. If the sacral height is greater than 1/3 of the cleft, the intergluteal cleft may be lengthened either by fat transfer to the upper inner buttock or with liposuction to improve the definition of the sacral triangle aesthetic zone.

Next, the gluteus maximus is evaluated. Depending on the height and projection of the muscle, fat transfer may be used to alter its height and shape. Typically this gluteal alteration is performed with different shaped implants, but fat transfer is also effective. Visually shortening or lengthening the muscle and buttocks proper with liposuction and fat transfer is a very effective strategy to improve buttock height. Attention is then turned to the lateral view of the buttock. Once the ideal point of maximum projection is identified, the other zones of the buttock can be treated with fat transfer and rarely liposuction to enhance the lateral profile. Lastly, the four quadrants of the gluteus maximus (upper inner, upper outer, lower inner, and lower outer) are evaluated for volume sufficiency or deficiency.

Further, the surgeon should evaluate the four transition zones between the gluteus muscle and the gluteal frame [5]. Liposuction may be used to define the upper border of the gluteal aesthetic unit. Contrastingly, if this area appears volume deficient, it may be due to excess fat in the sacral triangle aesthetic unit, lack of gluteal volume, or a combination of the two. The ideal shape of the transition zone from the horizontal infragluteal fold to the vertical intergluteal cleft and thighs is a diamond shape. If there is excess fat and skin at that transition zone, it can give the most caudal and medial aspect of the buttock a squared-off appearance rather than a gentle slope. While liposuction has been advocated for addressing this problem, it is rarely successful. Excision of excess skin is often necessary.

Lastly, the patient should be evaluated for ptosis. The grade of ptosis, along with an evaluation of skin laxity and wrinkling at Points A, B, or C, will determine whether an upper buttock lift or lateral excision of the inferior intergluteal fold will be of benefit to the patient. Next, evaluating whether fat transfer to the mid-lower gluteal area or liposuction of the infragluteal area is needed. The lateral view will determine whether liposuction of the sacral region is needed.

In summary, the combination of classification systems outlined in this chapter allows for a more systematic approach to the evaluation of gluteal shape and planning of gluteal augmentation with autologous fat transfer. This will assist the surgeon in answering the following questions:

1. How does the patient's presentation compare to ideal topographic landmarks of beautiful buttocks?
2. Which aesthetic units of the buttock region would benefit from liposuction?
3. Which buttock shape does the patient have? A, Square, Round, V?
4. What areas of gluteal volume deficiency may benefit from fat transfer? Where is the ideal point of maximum projection?
5. Given the patient's frame, can adequate buttock augmentation be achieved with fat transfer alone? Is there enough volume to address the deficient areas? Should the buttock be lengthened or shortened? Does the ratio of the sacral aesthetic unit to intergluteal cleft need to be changed? Do any of the four transition zones need to be enhanced or diminished?
6. Is the skin envelope less than ideal? Are accessory procedures needed to achieve the desired buttock aesthetic? If so, which are needed? Buttock lift, infragluteal diamond skin excision, thigh lift, or excision of the infragluteal fold excess?

6.4 Conclusion

Aesthetic preferences are inherently subjective, but applying a combination of well-described classification systems allows for a consistent approach and reproducible results. Each classification system has particular relevance to each of the various aesthetic gluteal contouring procedures but collectively yields a more comprehensive evaluation of the modifiable parameters. A thorough analysis of gluteal topography, aesthetic units, buttock zones, gluteal frame, projection, degree of ptosis, waist-to-hip ratio, and patient-driven aesthetic preferences is the hallmark of a sound approach to aesthetic gluteal contouring.

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Part II

Surgical Techniques of Gluteal Fat Augmentation

7 Strategy and Planning of Gluteal Reshaping

Alvaro Cansanção and Alexandra Condé-Green

7.1 Introduction

When patients present with complaints about the appearance of their gluteal contour, a comprehensive evaluation of the gluteal region and the surrounding areas must be done to determine the reasons for the patient's dissatisfaction and choose the appropriate technique or combination of techniques to address their issues.

7.2 Clinical Evaluation

A meticulous analysis of the gluteal region, back, posterior flanks, and sacral region are keys to individualize the strategy and surgical planning for each patient in order to achieve the best outcomes.

The patient must be examined while standing; in posterior, lateral and oblique views; and in static and dynamic positions. The following characteristics of the gluteal region must be documented: shape, projection, waist-to-hip ratio (WHR), skin quality, ptosis, asymmetry, depressions, scars, and lipodystrophy. It is important to ask patients about previous use of alloplastic material and fillers, especially non-approved fillers.

The buttock is divided into five subunits, according to the gluteal codes principle [1] to facilitate the exam and identify any localized deformity (Fig. 7.1).

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7.3 Surgical Techniques

The underlying concept of the gluteal reshaping approach is volume rearrangement, removing fat from areas in which it is excessive to augment areas that will benefit aesthetically [2]. One technique or combination of techniques can be used to augment the gluteal region and achieve harmonious results.

7.3.1 Liposuction of the Buttocks

Liposuction of the buttocks may be indicated in overweight or obese individuals who present with excessive and voluminous buttocks. In some cases, a gluteal lift may be necessary after liposuction in order to remove any excess skin laxity (Fig. 7.2).

7.3.2 Liposuction of the Gluteal Contour

Liposuction of the buttocks contour, such as the back, flanks, and sacral region, is indicated in individuals with an adequate gluteal volume and projection, who also present with lipodystrophy of the surrounding areas that mask the appearance of the buttocks, often give a fake impression of lack of projection and unaesthetic shape.

Performing liposuction of the gluteal contour will improve the hip-to-waist ratio, enhancing the projection of the buttocks, making it stand out, giving an impression of augmentation [3] (Fig. 7.3).

7.3.3 Gluteal Augmentation with Implants

Gluteal implants are used to add volume and improve the projection and consistency of the gluteal region [4]. It is especially indicated in individuals who do not have sufficient fat for gluteal fat augmentation such as thin, athletic, and some post-bariatric individuals.

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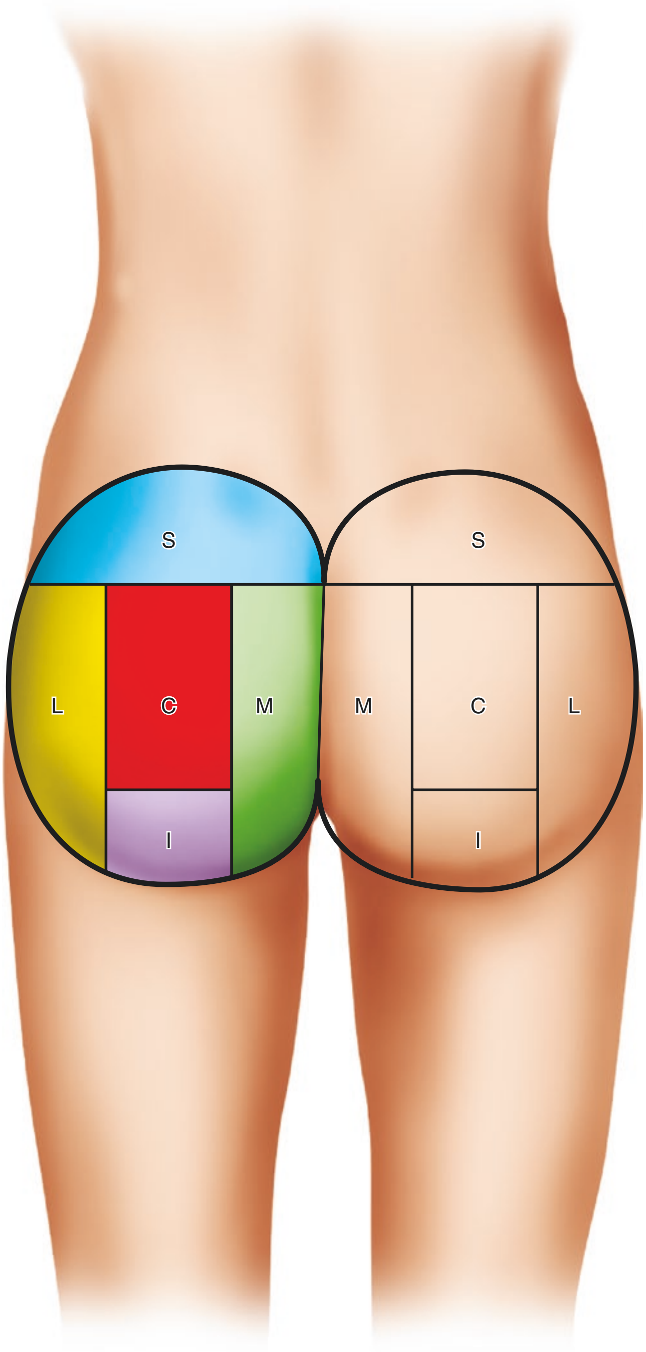


Fig. 7.1 Division of the buttocks in five subunits, according to the gluteal codes principles in order to facilitate the identifications of any localized deformity

7.3.4 Gluteal Augmentation with Fat

Fat grafting is used to increase the volume of the gluteal region, improve its shape, projection, consistency and skin appearance, as well as gluteal implants. In many patients, both techniques can be used, and the choice can be dictated by surgeon and patient preference rather than the advantages or disadvantages of the surgical technique itself [5] (Fig. 7.4).

7.3.5 Gluteal Lift

Gluteal lift is indicated in individuals who present with excess skin laxity. It can be performed alone or in combination with liposuction, fat grafting, or gluteal implants. This procedure has become popular especially in the post massive weight loss population.

Each procedure listed above has its indications; however, most patients have more than one complaint; therefore, a combination of the above techniques can be used to achieve better outcomes.

7.4 Surgical Planning

To standardize the surgical planning, we propose a classification of the gluteal region according to its different characteristics. Seven different body types were identified.

7.4.1 Type 0

The ideal buttocks. Individuals that have a good projection of the gluteal region (≥2:1) and a WHR ratio between 0.65 and 0.8. It is usually an individual with an athletic body type (Fig. 7.5).

- Surgical options:
  – Does not require any surgical procedure

7.4.2 Type 1

Individuals who are thin, have square-shaped buttocks, poor gluteal projection (<2:1), and a WHR ≥ 0.8 (Fig. 7.6).

- Surgical options:
- Gluteal implants
- Composite gluteal augmentation: Implants + fat grafting

Gluteal implants alone could appear unnatural, with the edges of the implant being noticeable. Patients with poor coverage (thin muscle and subcutaneous tissue), since a small amount of fat is available, a composite gluteal augmentation is the best option.

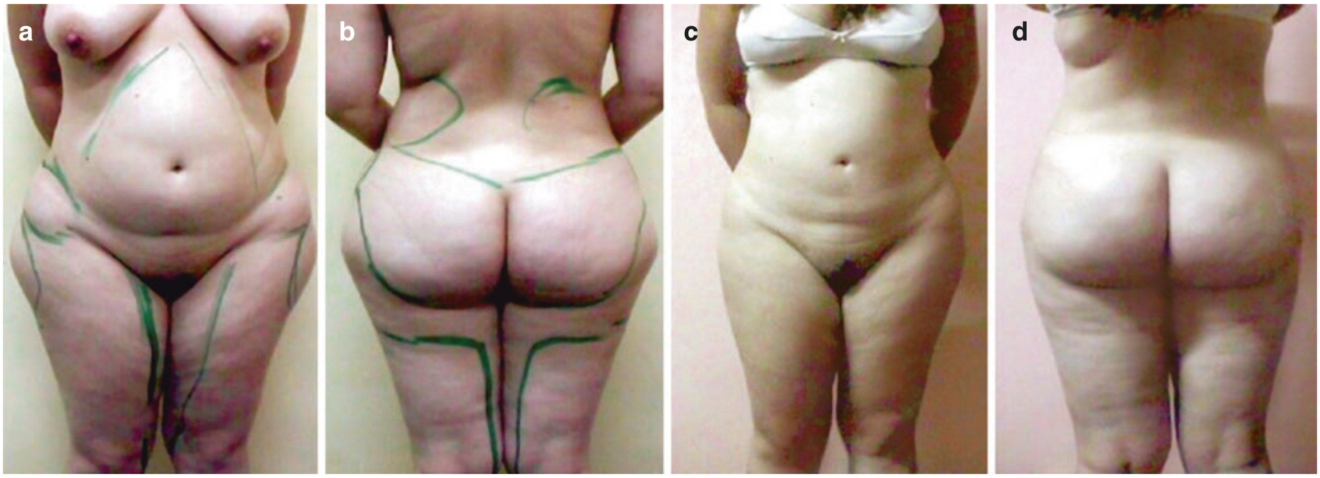


Fig. 7.2 Liposuction of the buttocks may be indicated in overweight or obese individuals who present with excessive and voluminous buttocks. (**a**, **b**) preoperative; (**c**, **d**) 6 months postoperatively

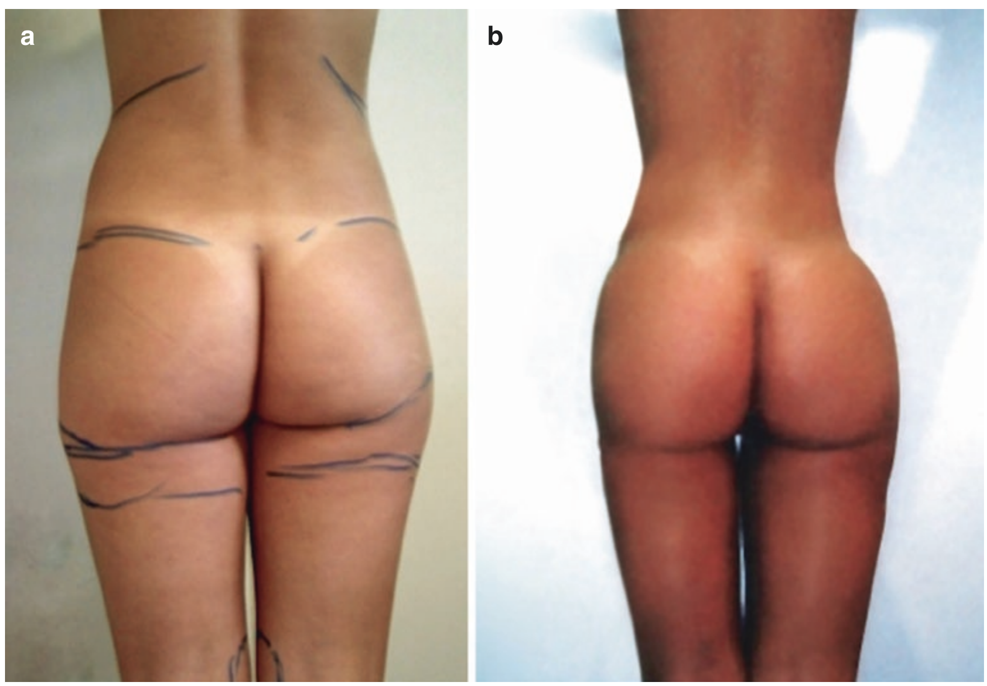


Fig. 7.3 In selected patients, liposuction of the gluteal contour will improve the hip-to-waist ratio and enhance the gluteal projection, making the buttocks stand out and giving the impression of augmentation. (**a**) preoperative, (**b**) 6 months postoperative. (Reprinted with permission from Cansanção et al. [3])

7.4.3 Type 2

Individuals who present with lipodystrophy of the surrounding areas of the buttocks, poor gluteal projection (<2:1), and lack of gluteal volume. Frequently, they have an "A"-shaped buttocks with a WHP ≥ 0.65 (Fig. 7.7).

- Surgical options:
  - Liposuction of the gluteal contour + fat grafting
  - Liposuction of the gluteal contour + gluteal implants
  - Liposuction of the gluteal contour + composite gluteal augmentation

7.4.4 Type 3

Individuals who have an ideal gluteal volume and projection (≥2:1), who also present with lipodystrophy of the surrounding

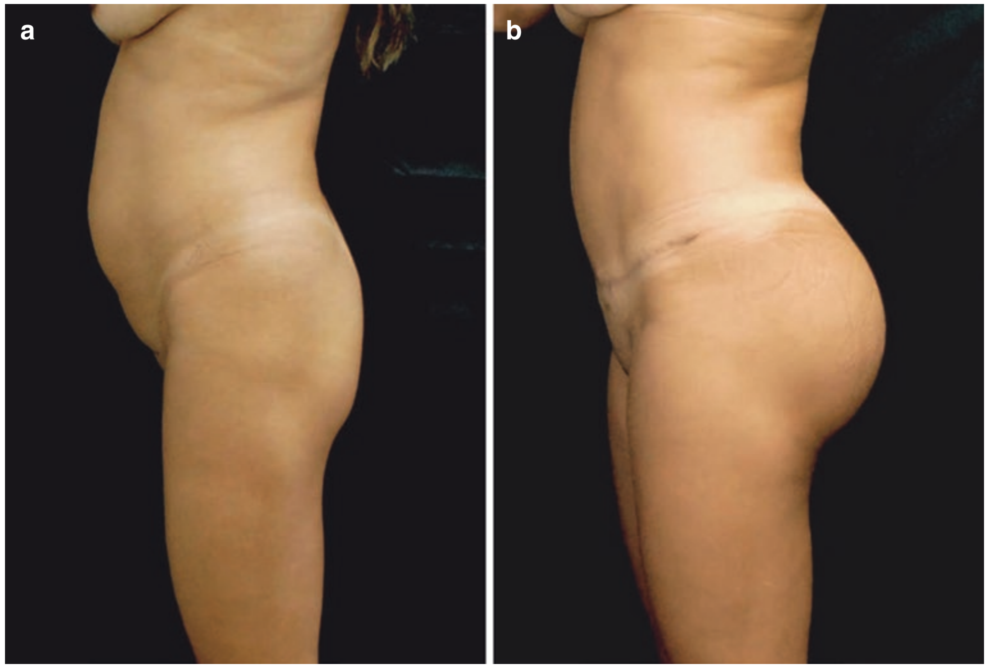


Fig. 7.4 Fat grafting is used to increase the volume of the gluteal region and improve its shape, projection, consistency, and skin appearance. (**a**) preoperative, (**b**) 1 year postoperative. (Reprinted with permission from Cansancao et al. [6])

Type 0

Body Shape	Athletic
Gluteus shape	Round
Projection	> 2:1
WHR	Between 0.65 and 0.8
Consistency	Muscle Hypertrophy Thin Subcutaneous layer
Ptosis	No

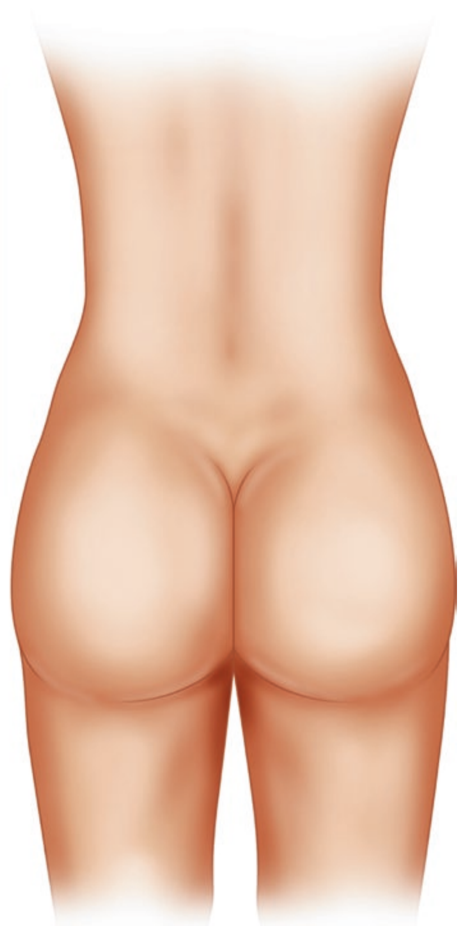


Fig. 7.5 Type 0 patient: the ideal buttocks

Type 1

Body Shape	Skinny
Gluteus shape	Square
Projection	<2:1
WHR	≥ 0.8
Consistency	Reduced Muscle Hypertrophy Thin Subcutaneous layer
Ptosis	Not

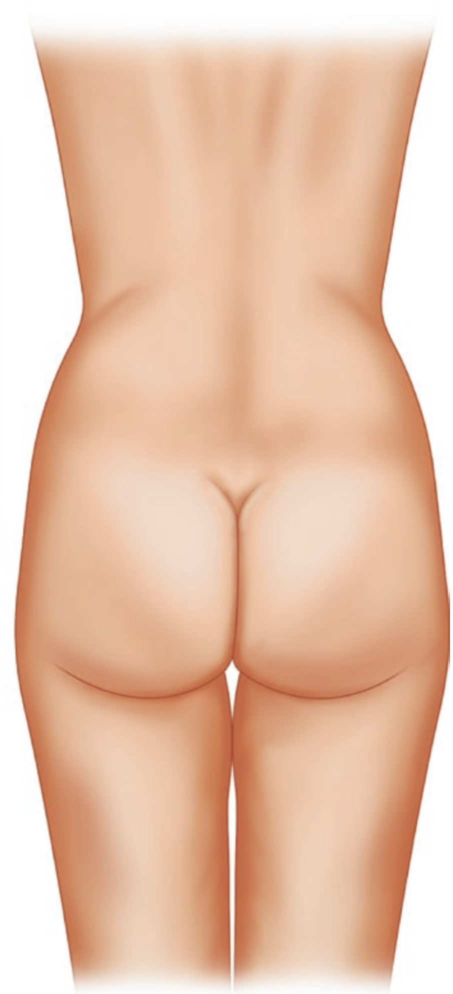


Fig. 7.6 Type 1 patient: thin individuals, presenting square-shaped buttocks, poor gluteal projection (<2:1), and a WHR ≥ 0.8

areas of the buttocks (back, posterior flanks, sacral region) giving the impression of lack of projection and volume of the buttocks (Fig. 7.8).

These are the ideal patients to perform liposuction of the contour only. However, mostly the patients become happiest with a gluteal augmentation.

- Surgical options:
  - Liposuction of the gluteal contour
  - Liposuction of the gluteal contour + fat grafting
  - Liposuction of the gluteal contour + implants

7.4.5 Type 4

Individuals who are overweight or obese and present with lipodystrophy of the surrounding areas of the buttocks give the impression that they have excess volume in the buttocks. They have an "A"- or "V"-shaped buttocks with a WHR ≥ 8.0 (Fig. 7.9).

- Surgical options:
  - Liposuction of the buttocks + liposuction of the gluteal contour
  - Liposuction of the surrounding areas of the buttocks

7.4.6 Type 5

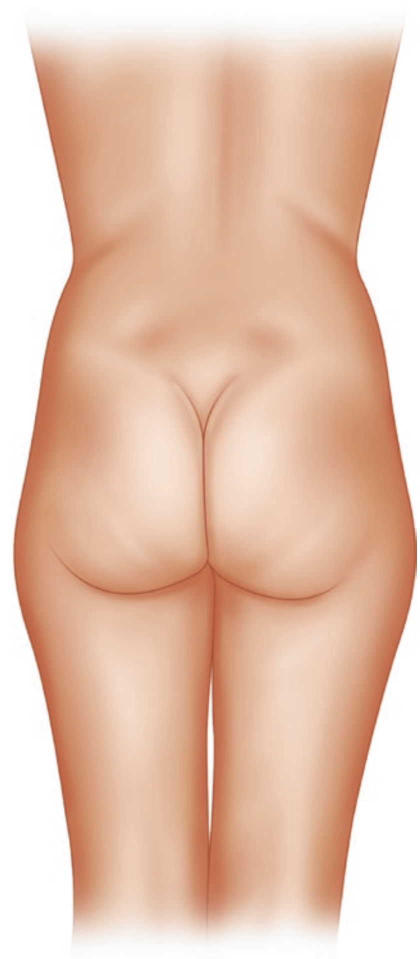
Older individuals with poor gluteal projection (≤2:1), gluteal ptosis, increased subcutaneous tissue, and muscle atrophy (Fig. 7.10).

- Surgical options:
  - Liposuction of the gluteal contour + fat grafting
  - Liposuction of the gluteal contour + fat grafting + gluteal lifting

Fig. 7.7 Type 2 patient: individuals who presents with lipodystrophy of the gluteal contour, poor projection (<2:1), and lack of l volume. Frequently, they have an "A"-shaped buttocks with a WHR ≥ 0.65

Type 2

Body Shape	Normal Or Overweight
Gluteus shape	A
Projection	< 2:1
WHR	< 0.65
Consistency	Reduced Muscle Hypertrophy Thin Subcutaneous layer
Ptosis	Indiferent



7.4.7 Type 6

Post-massive weight loss individuals present with square buttocks, poor gluteal projection (≤2:1), and a WHR ≥ 0.8 (Fig. 7.11).

- Surgical options:
  - Gluteal lift
  - Gluteal lift + gluteal implant
  - Gluteal lift + fat grafting

Type 3

Body Shape	Normal Or Overweight
Gluteus shape	A
Projection	Apparently little projection but in fact ≥ 2:1
WHR	Between 0.6 and 08
Consistency	Muscle Hypertrophy Thin layer Subcutaneous
Ptosis	No

Fig. 7.8 Type 3 patient: individuals with an ideal gluteal volume and projection (≥2:1), who also present with lipodystrophy of the surrounding areas of the buttocks (back, posterior flanks, sacral region) giving the impression of lack of projection and volume of the buttocks

Type 4

Body Shape	Obese
Gluteus shape	Indifferent
Projection	Exaggerated (Apparent Or Not)
WHR	> 0.8
Consistency	Severely increased Fat layer
Ptosis	Yes

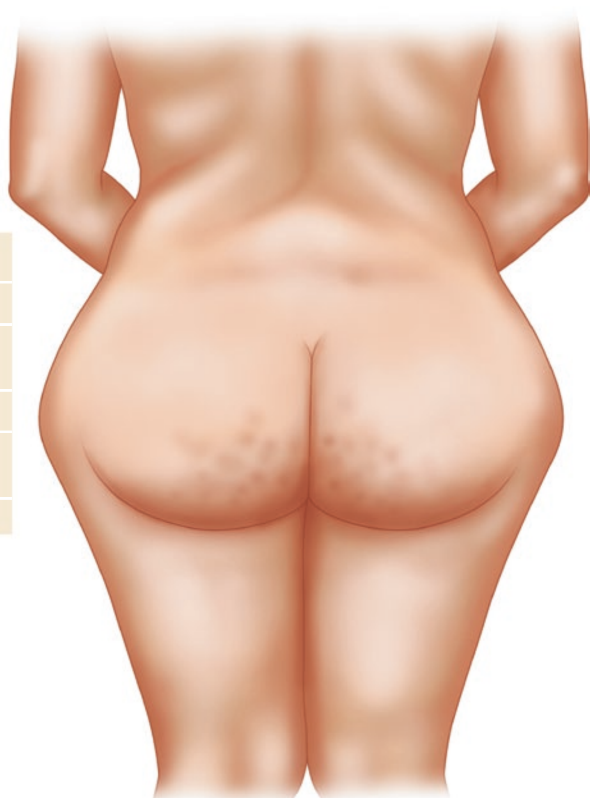


Fig. 7.9 Type 4 patient: individuals who are overweight or obese and present with lipodystrophy of the surrounding areas of the buttocks, giving the impression that they have excess volume in the buttocks

Fig. 7.10 Type 5 patient: older individuals with poor gluteal projection (≤2:1), gluteal ptosis, increased subcutaneous tissue, and muscle atrophy

Type 5

Body Shape	Senile
Gluteus shape	Indifferent
Projection	< 2:1
WHR	Indifferent
Consistency	Muscular atrophy Skin laxity
Ptosis	Yes

Fig. 7.11 Type 6 patient: post-massive weight loss individuals with square buttocks, poor gluteal projection

Type 6

Body Shape	Post bariatric
Gluteus shape	Square
Projection	< 2:1
WHR	>0.9
Consistency	Muscular atrophy Thin layer Subcutaneous
Ptosis	Severe

7.5 Conclusion

Plastic surgeons interested in performing surgery to enhance the gluteal region should understand the indications of each surgical technique, the advantages and disadvantages of each technique, in order to choose the adequate procedure or combination of procedures to reach pleasant and long-lasting results.

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Liposuction: Clinical Management and Safety Protocol

8

Alvaro Cansanção, Alexandra Condé-Green, Joshua A. David, and Bianca Ohana

8.1 Background

Liposuction, a surgical technique popularized by Illouz [1] in 1979, ushered in a revolution for body contouring surgery, both by improving results and facilitating diffusion of this technique across the world. In its infancy, however, high rates of complications and mortality [2] elicited concerns regarding the safety of this novel technique. Over time, with rigorous research and the introduction of safety guidelines, this technique has evolved to be extremely safe and reliable [3] and remains one of the most commonly performed plastic surgeries in the world [4]. Liposuction is one of the most commonly used techniques for improving gluteal contour and can be utilized alone or in conjunction with many other procedures such as fat grafting, placement of gluteal implants, and gluteal lifts. When combined with fat grafting, liposuction provides two major functions: modeling of the gluteal contour through the removal of fat from undesirable locations and providing volume in regions that are lacking.

Oftentimes, liposuction is treated as an addendum to gluteal fat grafting, serving as simply a means for harvesting fat. This oversight minimizes the fact that liposuction remains a surgical procedure with inherent risks. Moreover, as fat grafting is, by definition, a combined procedure, it generates significant surgical trauma and triggers an intense endocrine-metabolic response. Therefore, rigorous clinical support is highly recommended in order for this procedure to be carried out safely. Moreover, in light of current cultural and aesthetic trends that favor larger buttocks, increasing volumes of fat are being harvested during liposuction. In our practice, we have observed that liposuction of 150–200% of the fat graft volume is required in order to account for loss during processing of the lipoaspirate, in which fat is separated from blood and other contaminants.

Plastic surgeons interested in performing gluteal fat grafting must be properly trained in all aspects of liposuction and have a comprehensive understanding of the physiologic changes that can occur in the preoperative, intraoperative, and postoperative stages, in order to ensure patient safety and minimize risk.

8.2 Preoperative Assessment

The process of performing safe liposuction and, consequently, safe fat grafting starts well before the operating room. The first patient consultation gives surgeons a chance to perform a comprehensive medical history and physical exam, determine the need for laboratory tests or medical clearance, evaluate the risks of venous thromboembolism (VTE), and understand the patient's psychological state, as well as many other factors essential for a successful surgery [5, 6].

8.2.1 Medical History and Physical Exam

One of the most important steps in performing safe liposuction and minimizing the risk of unexpected intra- or postoperative complications is proper patient selection. This process begins with a comprehensive medical history, which addresses patient comorbidities, surgical history, medications, social history, family history, and possible

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allergies. It is also important to perform a thorough physical exam in order to determine potential sources of complications. This can include assessing signs of chronic or systemic disease, determining nutritional status and evaluating skin quality, as well as planning fat donor and recipient sites. Particular attention should be given to examination of the abdomen for surgical scars or diastasis recti as potential sources of hernia formation. The abdominal visceral fat component should be documented as well, in addition to total body surface area (TBSA), skin laxity, texture (e.g., wrinkles or striae), areas of lipodystrophy or fat hypertrophy, areas of skin depression or retraction, cellulite, varices, venous insufficiency, lymphedema, and scars (location and quality). Additionally, consideration of "zones of adherence" – the dense fibrous attachments of the underlying deep fascia – can help prevent postoperative contour deformities.

Surgeons should be mindful that informed consent is more than a signature and must follow a thorough explanation of the procedure itself, in addition to a frank discussion regarding the benefits, risks, alternatives, and expected outcomes. Simultaneously, the surgeon should strive to assess the motivations and concerns for surgery and gauge unrealistic expectations or underlying personality and psychiatric pathologies.

8.2.2 Age

Advanced age is not a contraindication to liposuction. Liposuction in an older, healthy patient may even pose less risk than a younger patient with comorbidities. It is important, however, to be aware that patients over 50 years old will develop worse skin retraction following surgery. Moreover, older patients have a significantly diminished capacity to adapt to the hemodynamic changes that occur during liposuction and thus may require a careful cardiac evaluation prior to surgery.

8.2.3 Body Mass Index (BMI)

Plastic surgery in the obese patient is controversial, owing largely to its perceived association with higher incidence of complications. This perception is likely due to the higher rate of comorbidities in this population and reiterates proper patient selection. However, in a retrospective study of 456 patients undergoing lipoabdominoplasty, Cansancao et al. [7] did not find any statistically significant difference in complication rates among normal, overweight, and obese patients. Therefore, elevated BMI alone should not be considered a contraindication to liposuction.

8.2.4 Nutritional Assessment

A thorough nutritional assessment is critical, as adequate caloric stores are essential for withstanding intraoperative tissue destruction and blood loss and for promoting normal wound healing. While there is no single test for reliably evaluating nutritional status, in our practice, we typically request albumin levels from all of our patients and do not operate on those with values <2.5 g/dL. In patients with recent weight loss (>10% of body weight in the last 30 days), the measured albumin level is not accurate, given the long half-life of this protein (18 days). In these patients, blood ferritin or pre-albumin can aid in determining true nutritional fitness.

8.2.5 Smoking

Smoking is a well-documented risk factor for patients undergoing surgery and has been shown to increase the risk of respiratory and cardiovascular compromise, infection, skin necrosis, wound dehiscence, and scarring, among others. During the first consultation, patients should be queried regarding smoking history, and smoking cessation should always be recommended. The optimal duration of cessation has not been fully elucidated, and various sources have reported ranges from 4 to 8 weeks before surgery through 7–30 days postoperatively. However, despite evidence that perioperative smoking cessation can drastically decrease complications, these risks nonetheless remain higher than those of a non-smoker, a fact that should be highlighted and included during the consenting process. A cotinine test, which evaluates nicotine levels in blood, urine, or saliva [8], may be ordered in case of suspicion of smoking, in order to ensure compliance with smoking cessation recommendations. Interestingly, a survey by Rohrich et al. [9] found that while 75% of plastic surgeons instructed their patients to abstain from smoking for at least 4 weeks preoperatively, only 17% confirmed compliance with cotinine testing.

Marijuana use should also be investigated and documented, as its frequency continues to rise, particularly among young adults. It is a psychoactive agent that contains approximately 340 chemical compounds, including carbon monoxide and many of the tars found in tobacco cigarettes, and its use can contribute to acute respiratory obstruction and bradycardia. It should be noted that elimination of delta-tetrahydrocannabinol (delta-THC, the most potent psychoactive agent in *Cannabis sativa*) from neural tissue takes approximately 30 days. Use of other illicit substances, such as cocaine, is also associated with cardiac, pulmonary, and vascular complications and should be elicited as well.

8.2.6 Medications

A list of the patients' medications should be obtained. It is also important to enquire about vitamins, minerals, or herbal supplements, as many patients do not consider these to be medications and may fail to mention their use. Tables 8.1 and 8.2 list common medications and supplements that should be suspended prior to surgery and the recommended timing of cessation.

8.2.7 Labs and Imaging

According to the American Society of Anesthesiologists (ASA) guidelines [6], there are no prerequisite preoperative diagnostic tests required for all patients. Rather, the decision to pursue laboratory tests or imaging should be patient-tailored, based on findings from the medical history and physical exam. In practice, however, routine blood tests such as a comprehensive blood count (CBC), comprehensive medical panel (CMP), coagulation studies, β-HCG (in women of reproductive age), albumin, and urinalysis are often requested prior to surgery, in addition to chest x-ray, abdominal wall ultrasound, or EKG for clearance in selected patients with certain underlying risk factors or diseases. Furthermore, there are additional tests that may be warranted in cases of known or suspected coagulopathies, endocrine disorders, cardiomyopathies, or other systemic or metabolic disorders.

Table 8.1 Prescription drugs requiring cessation prior to surgery

Drugs	Recommended timing of drug cessation
Tricyclic antidepressants	No need to suspend
Oral hypoglycemic	24 h
Estrogens	10 days
Amphetamines	15 days
Aspirin	15 days
Isotretinoin	180 days
Herbal supplements	15 days

Table 8.2 Over-the-counter supplements and vitamins requiring cessation prior to surgery

Coagulation disorders	Neurological disorders	Vascular disorders
Garlic	Kava kava	Ephedra
Ginkgo biloba	*Valeriana*	Ma-huang
Ginseng		Lithium
Omega 3/6		
Glucosamine		
Vitamin E		

8.2.8 Assessment of Risks of Deep Venous Thromboembolism

Venous thromboembolism is a group of diseases ranging from deep vein thrombosis (DVT) to pulmonary embolism (PE) and represents the leading cause of death following liposuction. Stasis, hypercoagulability, and endothelial injury – together referred to as Virchow's triad – are important contributors to the formation and evolution of VTE, and minimizing these elements can significantly diminish the likelihood of having a DVT or a PE. The Caprini Risk Assessment Tool is useful for stratifying patients to various risk levels of venous thromboembolism (VTE). Prophylactic measures can be divided into two categories: mechanical and chemical. Mechanical prophylaxis measures include the use of perioperative sequential compressive devices and early postoperative ambulation, in addition to elastic stockings, adequate hydration, and maintenance of body temperature above 36 °C (96.8 °F). Chemical prophylaxis instead relies on anticoagulation, the benefits of which must be balanced with the increase risks of hemorrhage and hematoma. This is particularly relevant for liposuction, which is not performed under direct visualization, and therefore does not allow for cauterization of blood vessels if bleeding occurs. It should be noted that even when basic preventative measures are taken, complications can still occur, so it is imperative to perform a critical evaluation of patient risk factors and formulate an individualized prophylaxis plan.

In our practice, all patients receive mechanical prophylaxis. Additionally, all patients are stratified by VTE risk according to the Caprini score, and when indicated they receive chemical prophylaxis with low-molecular-weight heparin (LMWH). For normal-volume liposuction (<5 liters), LMWH is given to high-risk patients (i.e., Caprini 5 and 6). For large-volume liposuction (>5 liters), LMWH is given to moderate-risk patients (Caprini 3 and 4) during hospitalization (typically 1 day) and to high-risk patients (Caprini 5 and 6) for 7–10 days postoperatively.

Furthermore, we use three others medications that theoretically act on Virchow's triad to decrease the risk of thrombosis, although there is currently no high-quality evidence for their efficacy:

1. Corticosteroids are anti-inflammatory molecules that decrease both endothelial lesions and edema by redirecting excess fluid to the intravascular space, consequently decreasing hemoconcentration and stasis.
2. Cilostazol augments both peripheral vasodilatation and capillary permeability, thus increasing blood flow and reducing stasis. Additionally, it possesses proper-

ties that inhibit platelet aggregation and help prevent hypercoagulability.
3. Diosmin + hesperidin is a flavonoid complex formula that has anti-inflammatory, vasculoprotective, and venotropic properties, which act to improve capillary resistance and venous tonicity, further increasing blood flow and decreasing stasis.

8.2.9 Preoperative Fasting

The commonly cited preoperative fasting requirement of 8–12 h was established in the mid-twentieth century, when anesthetic techniques were rudimentary in preventing pulmonary complications associated with vomiting and aspiration of gastric contents, such as bronchopneumonia. With modern improvements in anesthesia and airway management however, this has fortunately become a rare phenomenon. Nonetheless, aspiration of even a small volume of gastric fluid (pH < 2.5) or a solid particle can cause serious injury, justifying the persistence of this practice for all elective surgeries. We now know that prolonged fasting can potentiate the endocrine-metabolic response to surgical trauma by decreasing and increasing, respectively, levels of insulin and glucagon, the hormones responsible for regulating usage of hepatic glycogen reserves. Consequently, upregulation of gluconeogenesis promotes preferential delivery of glucose to tissues that rely on it as an exclusive source of energy (i.e., central nervous system, kidneys, and erythrocytes), thus intensifying the organic response to trauma. Therefore, abbreviation of preoperative fasting – especially with the use of carbohydrate-rich beverages (e.g., maltodextrose) – to 2 h before anesthetic induction may offer physiologic benefits such as reduction of insulin resistance, immunomodulation with lower inflammatory reaction, an increase in postoperative functional capacity, and a reduction in postoperative nausea and vomiting [10]. The most current preoperative fasting recommendations are listed in Table 8.3.

Table 8.3 Common preoperative fasting recommendations

Ingested material	Duration (hours prior to OR)	Examples
Clear liquids	2h	Water Fruit juice (without pulp) Carbonated beverages Carbohydrate-rich nutritional drinks Clear tea Black coffee
Non-human milk	6h	
Light meals	6h	Clear liquids + toast
Heavy meals	8h	Fried or fatty foods Meat

8.3 Intraoperative Considerations

One of the primary perioperative concerns during liposuction is the prevention of hypovolemic shock, which can occur from blood loss or water sequestration within the third space or "third spacing." In order to maintain an ideal fluid balance, one must be vigilant about intravenous (IV) hydration status, subcutaneous infiltration, blood loss, and hypothermia.

8.3.1 Anesthesia

The optimal choice of anesthesia during liposuction depends on many factors, including individual patient and procedural factors, as well as the judgement and experience of the surgeon and anesthesiologist.

Local anesthesia with lidocaine is ideal for small-volume liposuction or small anatomic regions. The approved limit of lidocaine use for infiltration is 35 mg/kg [11], owing to the poor vascularization and low absorption rate of adipose tissue, as well as the fact that much of the infiltrative solution will be aspirated with the fat before absorption occurs, and thus does not reach circulation. With large-volume infiltration, however, we must have a heightened awareness of the possibility of lidocaine intoxication, which can manifest as a variety of symptoms ranging from scintillating scotomas, perioral paresthesia, tongue contracture, and metallic taste to more concerning sequelae such as disorientation, somnolence, cardiac arrhythmia, seizures, and coma. It should be noted that at doses greater than 35 mg/kg, the liver reaches its maximum clearance capacity, and the concomitant use of substances that undergo hepatic metabolism may cause lidocaine accumulation and intoxication culminating in cardiorespiratory arrest and death.

General anesthesia or locoregional anesthesia is indicated for medium- and large-volume liposuction and/or multiple anatomic regions. In these situations, one should avoid the use of lidocaine in the infiltrative solution as it has not be shown to contribute additional analgesia, yet maintains its risk of intoxication.

Some authors reported that locoregional anesthesia decreases thromboembolic risk when compared to general anesthesia [12].

8.3.2 Intravenous Hydration/Fluid Management

Fluid management is undoubtedly one of the most important measures for preventing serious complications in liposuction. Patient hydration should be continuously evaluated – both during the procedure and postoperatively – via a combination of urine output, residual volume, lung auscultation, and vital signs. Low urine output can indicate either hypovolemia or acute kidney injury (AKI), which can be clinically differentiated by heart rate and blood pressure. Increased HR and decreased BP suggest hypovolemia, which can be corrected with IV fluids. In contrast, decreased HR and increased BP may indicate hypervolemia secondary to AKI and may necessitate a diuretic such as furosemide, in addition to consideration of a more serious etiology such as PE or congestive heart failure. Inadequate hydration, subsequent dehydration, and hemoconcentration can ultimately cause hypovolemic shock and increase the risk of VTE and fat embolism syndrome. In contrast, volume overload can precipitate pulmonary edema or cardiac arrest.

Various formulas have been described to aid in avoidance of under- or over-resuscitation, the majority of which are similar and based on the subcutaneous infiltration technique and expected lipoaspirate volume. One of the most commonly used protocols was described by Rohrich [13] in 2003 (Table 8.4). In our practice, we have developed an intraoperative hydration protocol that has proven to be reliably safe and efficient in more than 4000 liposuction procedures performed over the last 13 years (Table 8.5). In addition to the lipoaspirate volume and infiltration technique, this protocol also accounts for the volume of infiltration solution injected into the subcutaneous tissue. Additionally, it has the distinct advantage of tailoring the volume of fluid administered at different time points during the procedure. Briefly, we administer lactated Ringers (LR) solution at a ratio of 1:1 with the planned volume of lipoaspirate. This volume should be infused within the first 3 h of surgery, in the following proportion: 50% in the first hour, 25% in the second hour, and 25% in the third hour. However, there are some considerations and limitations when using this infusion protocol:

1. The total infusion volume should be limited to a maximum of 3500 ml.
2. Since approximately 30% of the volume used for subcutaneous infiltration will be absorbed, it must be deducted from the infusion volume (i.e., actual volume of IV fluids given = lipoaspirate volume – (0.3 × subcutaneous infiltration volume).
3. For large-volume liposuction lasting longer than 4 h, we maintain 250 mL/h IV hydration until the end of the surgery.
4. Ultimately, the volume should always be adjusted to the clinical parameters of the patient.

Table 8.6 illustrates two case examples of this fluid management protocol.

Table 8.4 IV fluid management in liposuction [13]

	Wet technique	Super-wet technique or tumescent technique
Liposuction < 5000 ml	1:1 IV volume Maintenance: 5–6 ml/kg/h	1:1 IV volume Maintenance: 5–6 ml/kg/h
Liposuction > 5000 ml	1:1 IV volume + 0.25 ml for each 1 ml aspirated over 5000 ml Maintenance: 5–6 ml/kg/h	1:1 IV volume Maintenance: 5–6 ml/kg/h

Table 8.5 Our protocol for intraoperative fluid management during liposuction

1. LR given at a rate of 1:1 (IV fluid: expected lipoaspirate volume)
50% – 1st hour
25% – 2nd hour
25% – 3rd hour
2. Total infusion volume limited to a max 3500 ml IV (over 3 h)
3. 30% of the subcutaneous infiltration is absorbed
4. Large-volume liposuction – length of the procedure > 4 h: maintain hydration at 250 ml/h of LR

8.3.3 Subcutaneous Infiltration

The use of subcutaneous infiltration prior to liposuction has multiple benefits, including the facilitation of fat harvest and hemostasis. The infiltration methods are classified according to the infused volume base and volume of lipoaspirate. With exception of the “dry” technique – which has been virtually abandoned due to high blood loss (20–50% of aspirated volume) associated with its use – the other infiltrative techniques are well accepted, and their use depends on surgeons’ preference, the volume of fat to be aspirated, and the clinical characteristics of each patient. Some of this volume, 30–70%,

Table 8.6 Intraoperative intravenous hydration

A. Case example 1
70 kg female patient
Expected lipoaspirate volume: 3000 ml
Subcutaneous infiltration volume: 3000 ml
Theoretical infusion volume: 3000 ml
Volume of subcutaneous absorption = 900 ml (i.e., 30% of 3000 ml)
Actual infusion volume = 2100 ml
Infusion schedule: 1st hour = 1050 ml
2nd hour = 525 ml
3rd hour = 525 ml

B. Case example 2
100 kg female patient
Expected lipoaspirate volume: 6500 ml
Subcutaneous infiltration volume: 4500 ml
Theoretical infusion volume: 6500 ml
Volume of subcutaneous absorption = 1350 ml (i.e., 30% of 4500 ml)
Actual infusion volume = 5150 ml (but maximum volume = 3500 ml)
Infusion schedule: 1st hour = 1750 ml
2nd hour = 875 ml
3rd hour = 875 ml
4th hour and beyond = 250 ml/h

will be absorbed in the subcutaneous tissue. This broad range is due to many factors, including the epinephrine concentration, the lipoaspirate volume, and the waiting time between infiltration and liposuction. For this reason, the volume infiltrated in the subcutaneous tissue should always be considered when calculating the water balance. Subcutaneous infiltration increases intravascular volume status and can lead to complications such as pulmonary edema and cardiac arrest, particularly in older patients or in those with cardiac disease. Several formulas have been described for the purpose of increasing safety and minimizing bleeding during liposuction. Wet or super-wet techniques using normal saline (NS) with epinephrine solution are the ideal choices for the majority of liposuction cases.

In our practice, we follow this routine:

- Small-volume liposuction < 1000 ml and few anatomic regions: use of local anesthesia in the infiltration solution of NS + epinephrine (1:500,000) + lidocaine (35 mg/kg), using a wet or super-wet technique.
- Normal-volume liposuction (1001–5000 ml): infiltration of a solution of NS + epinephrine (1:500,000), using a super-wet technique.
- Large-volume liposuction > 5000 ml: infiltration of a solution of NS + epinephrine (1:333,000) using a wet technique. This higher concentration of epinephrine is used in order to the decrease the infiltrate volume and avoid intravascular overload while maintaining the same amount of epinephrine.

8.3.4 Prevention of Blood Loss

Although hypovolemic shock in liposuction most commonly results from “third spacing” of fluids, prevention of blood loss – both intraoperatively and in the immediate postoperative period – remains an important consideration. Certain measures can be adopted to prevent excessive blood loss, including:

- Respecting the volume of lipoaspirate allowed: Many countries (and states) have legislation and recommendations regarding the amount of lipoaspirate that can be removed. While most of these limits were determined empirically, they are generally accepted by the surgical community and should be followed.
- Subcutaneous infiltration with a vasoconstriction solution in order to promote vasoconstriction.
- Hyper-hydration: Increasing intravascular volume results in a lower concentration of red blood cells per ml of blood via dilution.
- Anti-fibrinolytic agents: Tranexamic acid has been reported to be efficient in reducing blood loss by 56% during liposuction, allowing for aspiration of 114% more fat with comparable variation in hematocrit levels [14].

8.3.5 Hypothermia

Hypothermia is defined as a core body temperature below 36 °C (96.8 °F) and commonly occurs during surgery through both anesthetic inhibition of physiologic thermoregulation and body exposure. It is important to preserve normal body temperature during liposuction, as hypothermia is associated with many complications, some of which are listed in Table 8.7. Successful perioperative thermoregulation can be achieved through vigilant monitoring of core body temperature and the use of simple measures such as body warmers, warm blankets, warm fluid infusion, and coverage of the maximum possible body surface [15].

8.4 Postoperative Care

Immediate postoperative hydration refers to the volume given to the patient during the first 12 h following surgery. In our practice, we infuse LR at a ratio of 1:1 with the measured lipoaspirate volume and the physiologic fluid loss (1500 ml/12 h). Two-thirds of this volume is given in the first 6 h and one-third in the last 6 h. We limit this volume to a maximum of 4500 ml. If the patient remains in the hospital for longer than 12 h, the physiologic fluid loss is replaced intravenously at 100 ml/h, and oral intake is encouraged.

Table 8.7 Complications associated with hypothermia

Cardiovascular	Coagulation	Immune	Metabolic	Hormonal
Myocardial ischemia	Coagulopathies	Infection	Hypokalemia	Decreased steroids
Hypertension	Platelet activation	Seroma	Hypophosphatemia	Increased TSH
Tachycardia			Hypomagnesemia	Decreased insulin
DVT/PE				Hyperglycemia
				Hypoglycemia

DVT/PE deep vein thrombosis/pulmonary embolism

Late Postoperative Hydration Hemodynamic control is a priority, with continued monitoring of vital signs, urine output, and residual volume ((fluid received-fluid output)/patient weight) in kg. Prior to discharge, patients are counseled on the importance of adequate oral hydration to prevent further hypovolemia. They are instructed to drink 3–4 liters of liquids per day during the first 7 postoperative days. A balanced diet, composed primarily of protein-rich foods, such as meat, chicken, and fish, is highly recommended, as are dark, green vegetables, which are high in iron. Pain is managed with corticoids, nonsteroidal anti-inflammatory drugs (NSAIDs), and other analgesics, as needed. Antiemetics such as serotonin/5HT3 inhibitors and proton-pump inhibitors, adequate hydration, and glycemic control can help prevent nausea and vomiting which has been reported to occur in 35% of patients undergoing plastic surgery procedures.

Mild compressive garments are a mainstay of postoperative liposuction care and should be worn for the first 30 days over the donor sites. Highly compressive or overly tight garments should be avoided as they can cause hyperpigmentation, pain, edema, and skin necrosis. Compression socks (18–23 mmHg) are worn for 7–10 days, or at least until the patient returns to regular ambulation, in order to prevent DVT. Lymphatic drainage can be initiated in the fifth postoperative day in order to help decrease edema and smooth contour irregularities.

8.5 Conclusion

Technical and therapeutic advances in liposuction have revolutionized the safety and applicability of this procedure for body contouring. Despite relatively low rates of complications and mortality, the growing popularity of combined procedures such as gluteal fat augmentation [16, 17], as well as trends favoring increasing volumes of lipoaspirate, demands re-evaluation and reiteration of the surgical and patient-related factors necessary for a safe, outcome-oriented procedure.

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Anesthesia for Liposuction and Gluteal Fat Grafting

9

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9.1 Introduction

Anesthesiology has been accompanying the advances in liposuction techniques and fat grafting in the last years with more efficient patient monitoring, the use of new drugs and adjuvants helping make the procedure safer [1].

Liposuction and gluteal fat grafting can be performed under general, local, and central neuraxial anesthesia (spinal or epidural), associated or not with intravenous sedation. These three anesthetic techniques can be used individually or in combination. The choice of anesthesia should take into consideration the surgical procedure, the patient characteristics, and the experience of the anesthesiologist/surgical team, combining safety and comfort to the patient during the perioperative period.

All anesthetic techniques have advantages, disadvantages, indications, contraindications, and limits that must be respected; however, they are not be well defined [1, 2].

9.2 Anesthetic Techniques

9.2.1 Local Anesthesia

Procedures that are performed under local anesthesia can be done as outpatient with faster discharge of the patients. Local anesthesia allows a smoother arousal and less physiological changes, compared to general anesthesia and neuraxial blocks. However, this technique has the most limiting factors such as the toxic dose of each anesthetic drug that must be respected. Local anesthetic intoxication can range from lip numbness to severe arrhythmias that can reach irreversible cardiac arrest. These serious complications can happen in the perioperative period, immediate postoperative period, or, more tragically, in the late postoperative period, in which the patient is no longer under specialized medical supervision.

Liposuction and gluteal fat grafting are performed by a large number of plastic surgeons with the patients in the prone position [3], which can be uncomfortable for the patients. Therefore, it is often associated with intravenous sedation in order to make the patient more comfortable. However, using sedation for a patient in the prone position is a challenge, especially for the control of ventilation and for maintenance of airway patency. Preferably, overweight and obese patients should not be placed in the prone position while performing gluteal fat grafting under local anesthesia, as their physical characteristics can lead to ventilatory difficulty.

Local anesthesia, with or without sedation, is indicated for procedures that are relatively short and when small liposuction volumes or small volume fat grafting is performed. When a larger volume of gluteal fat grafting is indicated, it is best to perform multiple procedures to achieve the desired outcomes. Gluteal fat grafting with local anesthesia, with or without sedation, should be performed preferably in normal weight, cooperative patients with a low level of anxiety, injecting a limited amount of fat in the subcutaneous plane only.

9.2.2 General Anesthesia

General anesthesia is a well-established technique in which the patient hemodynamic status is under the control of the anesthesiologist. General anesthesia during liposuction and gluteal fat grafting allows great comfort for both the surgeon and the anesthesiologist, since it allows definitive airway control, independent of the patient positioning. However, despite these two important advantages, general anesthesia has some disadvantages.

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Minor disadvantages include prolonged fasting period preoperatively, poor pain control in the postoperative period, often prolonged awakening, and higher incidence of postoperative nausea and vomiting. Major disadvantages include higher incidence of deep venous thrombosis (DVT), pulmonary thromboembolism (PE), and greater intraoperative blood loss. These factors lead to greater morbidity and mortality with general anesthesia when compared to spinal anesthesia in these types of surgeries. Therefore, spinal anesthesia associated with intravenous sedation is our first choice for liposuction and gluteal fat grafting while taking into consideration the limitations of this technique and the individual characteristics of each patient.

General anesthesia is indicated for overweight patients that have a protruding abdomen, and patients with difficult airway. Even when general anesthesia is considered the first anesthetic option, a spinal or epidural blockage can be associated whenever possible, adding innumerable advantages for the patient, such as improvement of postoperative analgesia and reducing the incidence of major complications such as blood loss, DVT, and PE. It is important to note that the association of general and neuraxial anesthesia does not present similar incidence of major complications when compared to spinal/epidural anesthesia when used as a single technique.

No relationship was found in the literature between general anesthesia and the occurrence of macro or micro fat embolism [4]; the only advantage is the fact that the management of this complication is easier if the patient is already under general anesthesia, and an airway access is secured by orotracheal intubation [5].

9.2.3 Central Neuraxial Anesthesia

Central neuraxial anesthesia techniques (spinal or epidural) are efficient and safe for performing different surgical procedures and can be used alone or associated with other techniques, such as general anesthesia.

While prolonged, general anesthesia facilitates thrombus formation in the deep veins of the lower limbs [6], neuraxial anesthesia is a protective factor for DVT/PE through two mechanisms [7]: (1) it increases blood flow and decreases vascular resistance in the lower extremities as a result of the sympathetic block and (2) decreases coagulability. Blood flow in the femoral veins decreases by 40–50% during general anesthesia while it is increased by approximately 120% in loco-regional anesthesia, reducing venous stasis and clot formation [8] in the latter. Another advantage of neuraxial anesthetic techniques is the antifibrinolytic effect. The drugs used in spinal/epidural anesthesia inhibit platelet adhesiveness, increase fibrinolysis in the postoperative period, creating a prophylactic effect against DVT/PE [9–11]. Neuraxial anesthesia, as a single technique or associated with general anesthesia, reduces intraoperative and postoperative blood loss significantly. This can be explained by the reduction not only in the arterial and venous pressures but also in the central venous pressure resulting from the sympathectomy effect caused by loco-regional anesthesia [12].

The use of neuraxial blockage has advantages compared to general anesthesia such as softer awakening, better transition from the intra- to postoperative period, less postoperative nausea and vomiting, reduced endocrine-metabolic response to trauma, short fasting period preoperatively, early ambulation, better postoperative analgesia, besides being a protective agent against some major complications such as DVT, PE, and myocardial infarction.

9.3 Conclusions

Surgical techniques are evolving fast, and anesthesia has been following these surgical advances closely in order to allow a more comfortable and safer procedure for the patient.

All anesthetic techniques can be used in an efficient and safe way, alone or in combination, as long as technical standards and limits are respected. The recognition of the best anesthetic technique to be used is not an easy task as it depends on several factors such as emotional and physical characteristics of each patient, the surgical techniques, the expertise, and personal preferences of the anesthesiologist and the surgical team.

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10 Clinical Principles of Autologous Fat Grafting

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10.1 Introduction

Autologous fat grafting has become a common procedure for aesthetic and reconstructive purposes. It is widely accepted as an ideal soft-tissue filler, as fat is biocompatible, nonallergenic, nontoxic, easy to harvest, and synergistic with the skin [1]. From Neuber who reported one of the first cases of fat grafting in 1893 to Illouz who pioneered liposuction in the 1980s, and Coleman who standardized the procedure, fat grafting has become one of the fastest growing procedures in the United States [2, 3] and worldwide. However, fat grafting has been criticized over the years for having inconsistent graft take and seemingly surgeon-dependent outcomes [4, 5].

The variety of techniques for harvesting, processing, and injecting fat is likely the reason for the differences in graft take [6]. There is no consensus as to the best technique for each step of the fat grafting procedure. Consistently, new technologies are being developed in order to improve the long-term outcomes of the procedure.

10.2 Fat Grafting Physiology

Peer, in 1950, defined the fat graft biological behavior concepts. He presented handling technique, contraindications, clinical results, and he observed a 50% index from the transplanted adipose tissue absorption [7].

The fat take, as viable tissue, is deeply related to the fat grafting revascularization conditions. The decreased microcirculation, during the first postoperative week, is the most common reason for the reabsorption, because of the prolonged ischemia that causes necrosis and activates the mechanisms responsible for apoptosis [8].

The preadipocytes present an emphasized part of the fat grafting process understanding. It has a multiplication capacity, and when it finds a favorable place, it is able to gather fatting and differentiate in mature adipocytes, confirmed phenomenon by in vitro and in vivo studies [9].

Besides that there is a quantity of preadipocytes reservation present in the fraction of adipose tissue connective stroma. Therefore, when fat grafting is done, preadipocytes are also transferred, together with connective stroma [9].

The histological analysis of the grafted area, on the first days, shows the existence of a high index transplanted adipocyte breakage, evidencing that the mature adipocytes are very sensible to ischemia during the initial period [10].

This fact leads us to think that pre-adipocytes are perhaps more resistant to ischemia, being the biggest responsible for the mass of adipocytes that remain in the long term, into the grafted areas. Several studies have been performed, establishing the best clinical practices, in order to obtain a better adipose tissue integration and to decrease the morbidity of the process.

10.3 Variable Techniques That Interfere with Fat Grafting Integration

There are a variety of factors that interfere with fat graft take. The main factors are as follows:

- Fat harvesting methods
- Fat processing
- Fat injection methods
- The preparation of the recipient site

10.3.1 Fat Harvesting

10.3.1.1 Optimal Cannulas or Needle Diameter (Evidence Level IV)

Pu et al., in a comparative study about the adipose tissue viability, after conventional liposuction and tissue dissection with a scalpel, concluded that the fat that is aspirated keeps

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the same structure as the dissected tissue, with a reduced cell function, leading to less integration [11].

Erdim et al. noticed that the adipocytes obtained with cannulas of high caliber (6 mm) presented a better viability. However, if we considered all the factors involved in the graft integration, the diameter of the cannula would be an isolated factor. However, the trauma at the donor site is more significant when a larger cannula is used for harvesting [12].

In our clinical practice, we use cannulas of 2.5–3 mm diameter that create smaller fat lobes which are easier revascularized, it causes less lesion into the donor area, and less trauma during grafting (evidence level IV). As for the number of holes in the cannulas used for harvesting, cannulas with 6–12 lateral holes of (2 × 1 mm) diameter are recommended in order to obtain a high fat flow through the cannulas, with low pressures (evidence level IV). The diameter from the cannulas must preferably equalize the diameter of the graft in order to avoid rupture and injury to adipocytes (evidence level IV).

10.3.1.2 Negative Pressure

In order to collect fat through liposuction, negative pressure is generated by a suction device or a syringe. The proper suction pressure must be able to detach fat from the donor area, without injuring the fat cells. Har Shai et al. verified using a barometer that using a 60-ml syringe produces a vacuum pressure around 200–300 mmHg, provided the piston is not pulled to the maximum. Therefore, using a syringe or a vacuum suction device, the most important is to keep the negative pressure under 300 mmHg, in order to obtain adipocytes with high viability (Evidence level IV) [13].

10.3.1.3 Donor Sites

In 2008, Padoin et al. showed that the fat harvested from the lower regions of the abdomen and the inner aspect of the thighs contained a larger number of mesenchymal cells when compared to other regions. However, clinically, there was no significant difference in the results obtained whether using fat obtained from any other areas of the body (evidence level IV) [14]. The choice depends on the amount of adipose tissue needed to graft depending on the procedures that will be done.

Although there is no scientific evidence, it is recommended not to expose the lipoaspirate to the external environment (evidence level IV). It is preferable to use a closed system, in order to avoid contamination and viability lost. The infiltration with local anesthetic at the donor site does not interfere with the integration of the graft (evidence level IV).

10.3.2 Fat Processing: Tissue Preparation (Evidence Levels III and IV)

Smith et al. compared different fat preparation methods: decantation, centrifugation, washing with ringers lactate, washing with ringers lactate and centrifugation, washing with normal saline and centrifugation, and did not find statistical differences among these samples [15].

The three main fat processing methods are as follows:

- Washing with normal saline
- Decantation
- Centrifugation

Condé Green et al., in 2010, compared these three processing methods and concluded that centrifugation at 3000 rpm (1286 g) injured the adipocytes. However, with centrifugation, there was a higher concentration of mesenchymal stem cells in the pellet, the lowest layer resulting from the separation of components after centrifugation [16]. The washed lipoaspirate had the higher number of mesenchymal cells in the adipose layer (middle layer).

Manual centrifugation has also been introduced with the intention of not injuring the adipocytes.

Yoshimura et al., in 2008, showed high graft take and low complication rate when fat was enriched with mesenchymal stem cells [17].

Fraga et al., in 2008, compared the take and viability of the fat graft, autonomized or not, and observed a bigger number of viable adipocytes, lower rate of fibrosis, and graft necrosis in fat previously autonomized [18]. The substances used that are capable to increase the graft tissue integration are also constant sources of study. Fraga et al., in 2010, combined fat grafting with PRP and showed lower absorption rate and higher transplanted tissue integration [19].

10.3.3 Fat Injection (Evidence Level IV)

It’s recommended that fat should be injected with blunt tip cannulas of 1.5–2 mm diameter with side holes with equalized diameter related to the cannula used for harvesting in order to obtain create less trauma. Syringes of 1, 3, or 5 cc or “pistols” that allow the injection of a controlled amount of fat graft to be delivered (0.5, 1, 1.5 cc) can be used. The graft should not be injected in bolus or in a cavity as it must be in contact with the recipient area to integrate. It must be injected in tunnels in multiple layers and in a retrograde fashion.

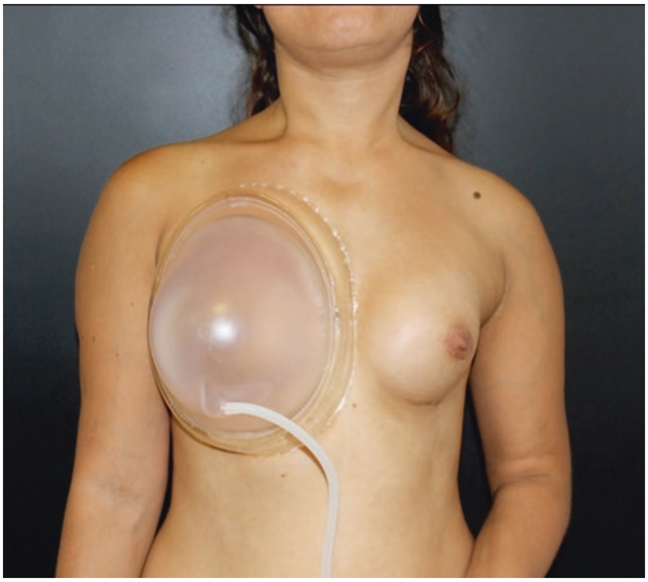

Fig. 10.1 The treatment of the recipient site with negative pressure has shown to increase the graft potential promoting angiogenesis and optimize surgery time

10.3.3.1 Recipient Site

The treatment of the recipient site with negative pressure became popular in the early decade (Fig. 10.1). It was shown to increase the graft potential, allow the expansion of areas with fibrosis and contracture, and reduce the adipocytes demand to work as an expander as the expansion would reduce tissue tension. It also showed to promote angiogenesis and optimize surgery time [20].

The fibrotic areas present in cases of radiotherapy can be released through a process named rigotomy, which consists of using a needle in order to create a multi-perforated mesh that allows expansion and placement of the graft under the scar or the fibrotic area. Studies that have shown the effects of the preparation of the recipient site were of levels of evidence III, IV, and V.

10.3.3.2 Gold Standard for Quantifying Fat Viability After Transplant

There is no standard test, or imaging modality, to determine fat viability or volume augmentation after grafting. Fat graft viability has been estimated through visual assessment, membrane integrity staining, conventional histology, special staining for apoptosis or mitochondrial function, histologic analysis for cell death, colorimetric salt viability assay, cell count per high-power field, and biochemical assays. Graft take has been measured by magnetic resonance imaging, computed tomography, three-dimensional laser scanning, and others.

10.3.3.3 Perspectives

The future of autologous fat grafting will be guided by research involving stem cells, especially stromal vascular cells, found in the lipoaspirate. These precursor cells are more resilient, resistant to trauma and ischemia, when compared to mature adipocytes. Furthermore, they have the capacity of differentiating. The development of technologies for cell expansion from adipose stromal cells will provide filling material for patients who do not have enough adipose tissue. The use of growth factors, platelet rich plasma, mesenchymal cells, hormonal manipulation, and preadipocytes transplant need to be further studied. Cell culture techniques and tissue engineering still need the scientific evidence and improvement, in order to have applicability in our clinical practice.

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11 Liposuction Techniques

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11.1 Introduction

The increasing demand for body contour surgeries has been favored by safe anesthesia and effective surgical techniques [1]. The advent of liposuction in the late 1970s has tremendously changed plastic surgery for it has become one of the most performed aesthetic surgical procedures worldwide over the last decades. Liposuction is mainly used to remodel the body contour by partially removing deep and superficial fat accumulation. Although liposuction is not a universal remedy for obesity, it is an important complementary technique to enhance the aesthetic result of dermolipectomies and other aesthetic and reconstructive procedures [2]. Given the numerous techniques and recent advances in liposuction, it is important to have the expertise with the chosen liposuction device taking into account the patient safety and the eventual use of the lipoaspirate for grafting [3, 4].

11.2 History

The first attempt to remodel body contour took place in 1921 when Charles Dujarrier removed great amount of tissue while trying to improve the ankles and knees of a dancer. The intervention was a disaster and resulted in necrosis and amputation. During the last century, several other techniques involving excision of skin and subcutaneous fat were developed in an attempt to improve body contouring. In the 1960s, Pitanguy published techniques involving the “en bloc” resection of cutaneous and adipose tissue to redefine the contour of the inferior limbs [1]. Although that technique has had a boost in the last years due to the increasing number of bariatric surgeries, large visible scars and possible complications are limiting factors. Consequently, several surgeons ventured into the endeavor toward an effective removal of subcutaneous fat in the 1970s. Schrudde, in 1972, published a less invasive technique, using a uterine curette [5, 6]. In 1975, Fischer developed a technique of liposuction using a blunt hollow cannula for thigh adiposity with more predictable aesthetic results and fewer complications [7]. Subsequently, Kesserling and Meyer in 1976 used a large cutting curette connected to a low-power device to aspirate the fat that was previously separated from the deep planes by scissors [2, 5].

Liposuction was defined as a technique in 1977, when Illouz introduced two important factors. The use of a modified high-suctioning power device connected to blunt-tipped cannulas of considerable diameter (10 mm) was important to reduce injury to blood vessels, nerves, and lymphatics. Second, the concept of harvesting adipose tissue after subcutaneous infiltration of normal saline and hyaluronidase was also important. The tunneling technique allowed the removal of localized fat throughout the body without extensive scars and complications commonly seen in dermolipectomies [3, 5, 8].

This standard technique was defined as classic liposuction and is known as suction-assisted liposuction (SAL). While the fundamental principle remains, liposuction has evolved from mechanical fat aspiration to sophisticated body contouring techniques, with the use of numerous technologies that have changed surgical outcomes. Since performing large volume liposuction can be labor-intensive, these novel technologies were developed to enhance lipolysis and minimize surgeon’s effort [5, 7].

11.3 Modern Concepts and New Technologies

Liposuction aims to remove excess fat and promote harmonious body contour and allow adequate skin retraction. Initially, the target was the deep fat in order to leave a sufficiently thick cutaneous flap that could conceal contour irregularities. Nonetheless, this concept has changed and a

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controlled subdermal injury, through direct mechanical trauma from the cannula itself, became an important objective. The current approach involves an all-layer liposuction with different caliber blunt cannulas to avoid damage to the delicate subdermal vascular plexus. It is known that liposuction outcomes are related to the degree of obesity and cutaneous laxity. The precise mechanism of skin retraction remains unclear while it is known that skin stretching and retraction are usually site-specific. Post-liposuction skin tightening seems to be related to genetics, patient's habits, skin quality, and the chronological age. Nevertheless, to a certain extent, skin retraction can be manipulated through conventional liposuction (SAL) that comprises partial removal of all subcutaneous layers or through thermal or mechanical subdermal injury [3].

After proving its efficacy, SAL was followed by energy-enhanced techniques. The first of these new technologies was ultrasound-assisted liposuction (UAL). However, unanticipated adverse consequences of the additional energy source have proven to be problematic and cutaneous burns and paresthesia were reported. Nonetheless, the goals were to decrease surgeon's fatigue, promote effective lipolysis, and obtain better skin retraction. Consequently, power-assisted liposuction (PAL), laser-assisted liposuction (LAL), and, more recently, the radiofrequency-assisted liposuction (RFAL) were developed [2].

11.4 Available Technologies

Table 11.1 compares the technologies available for liposuction.

11.4.1 Suction-Assisted Liposuction (SAL)

SAL is regarded as the classic technique using a vacuum source that can reach up to 760 mmHg (1 atm pressure) in

Table 11.1 Advantages and disadvantages of the different techniques of liposuction

Period	Developer/ technology		Advantages	Disadvantages
1976	Fischer	Sharp dissection combined with suction		
1980	Illouz	SAL – blunt cannula and wet technique	Most commonly used technique. Easily obtainable	Fatigue; more difficult in secondary procedures where fibrous areas are found; noisy depending upon the machine. Considerable blood content in the lipoaspirate
1989	Toledo	Syringe	Easily obtainable. Low cost. Precise for measuring the removed adipose tissue. Possibility of immediate fat grafting without risk of external contamination	Fatigue for larger areas
1992	UAL	Zocchi	Better penetration in secondary, fibrous areas; less surgeon's effort; some skin contraction can be expected due to the dermal stimulation by the ultrasonic energy	High cost; risk of burns and skin sloughs; larger incisions for the ports; two-stage procedure (extended surgical time)
	VASER	Fodor; de Souza Pinto; Zukowski	Contemporary device using advanced UAL technology; better penetration in secondary, fibrous areas; less blood content in the lipoaspirate; less ecchymosis	Risk of thermal injuries/skin sloughs; requires learning curve; cost and availability of the equipment can be a limiting factor regarding its use
1992	LAL	Apfelberg	More selective adipose damage, thus preserving surrounding tissues' integrity; skin contraction/ tissue tightening; enhanced hemostasis	Requires learning curve; risk of burn injuries / skin sloughs; extended surgical time; cost and availability of the equipment can be a limiting factor regarding its use
1998	PAL	Fodor	Better penetration in secondary, fibrous areas; less tissue trauma. Reduced vascular injury and swelling	Noisy, requires learning curve; surgeon's discomfort (pain, tendinitis); availability of the equipment can be a limiting factor regarding its use
2007	WAL	Man	More selective adipose damage, thus preserving surrounding tissues' integrity; enhanced hemostasis; allows for the immediate recollection of adipocytes	Requires learning curve; cost and availability of the equipment can be a limiting factor regarding its use
2009	RFAL	Paul	No strength required to produce lipolysis as the radiofrequency itself produces it; controlled temperature due to a heat limiter; skin contraction	Cost and availability of the equipment can be a limiting factor regarding its use; risk of burn injuries

order to harvest adipose tissue. The equipment is affordable and easily obtainable. As the cannula moves in the subcutaneous tissue, mechanical disruption and avulsion of adipocytes take place and the lipoaspirate is collected in a canister. SAL's main advantage is the relatively short learning curve, and despite all new advances in liposuction techniques, it remains the most used technique all over the world.

11.4.2 Syringe-Assisted Liposuction

In 1988, Luiz Toledo introduced the use of disposable syringes for liposuction. While still relying on vacuum inside the syringe to harvest fat, it allowed freer movement and more control to the surgeon. The technique is easy and convenient as the lipoaspirate can be kept inside the syringes without contact with the environment and directly injected in the desired sites after processing. However, it can be cumbersome and time consuming in cases of large volume liposuction [2, 3, 5].

11.4.3 Ultrasound-Assisted Liposuction (UAL)

Ultrasound-assisted liposuction (UAL) was introduced by Zocchi in 1992. This technique involves the application of ultrasound waves transmitted by the probe as high-frequency acoustic energy. The mechanical oscillations produced by the device pass through the tip of the cannula that emits waves. Sound waves have natural cycles of expansion and compression. The compression cycle exerts a negative pressure that creates interstitial cavitation. The resultant microbubbles implode causing cellular fragmentation and fat emulsification, and less physical exertion is required as the fat is dissolved with ultrasound [3, 9]. The action of ultrasound waves comprises both thermal and mechanical effects to the surrounding adipocytes. A selectivity and tissue-specificity of UAL destruction is expected as cellular rupture is faster in adipose tissue than in surrounding higher-density structures such as muscle and fascia. The thermal effects of ultrasound generate a significant amount of heat; therefore, generous amount of tissue infiltration must be done to dissipate the head and reduce thermal injury [3, 9]. Skin retraction is expected secondary to the stimulation of the dermis by the ultrasonic energy. The drawbacks include skin sloughs, burns, seromas, and the need for larger incisions to accommodate the incision protectors and a long learning curve. The original technique consisted of a two-stage process where the use of the ultrasound to treat the adipose tissue preceded the aspiration, prolong the operative time up to 40%. Consequently, a second generation of devices using a hollow cannula with simultaneous liposuction was developed. More recently a third generation ultrasound-based device was developed using internal ultrasound waves delivered via a solid grooved probe, which included two modifications: a pulsed energy, rather than continuous and concentric rings near a smaller probe tip. These modifications significantly reduced the levels of ultrasonic power for fat fragmentation with fewer adverse effects. The system was named VASER for Vibration Amplification of Sound Energy at Resonance (Solta Medical, Hayward, CA, USA). VASER-assisted liposuction is advantageous in fibrous areas, particularly the trunk and previous areas of liposuction. Studies have shown reduced ecchymosis, less blood loss, and less postoperative pain [10]. However, the high cost of the equipment hinders its ample use.

11.4.4 Laser-Assisted Liposuction

The first studies on the interaction between laser and adipose tissue were conducted by Apfelberg in 1992 [11].

According to the theory of selective photothermolysis, appropriate laser selection allows preferential targeting of tissues, since the wavelengths have different absorption coefficients for fat, water, and hemoglobin. These chromophores preferentially absorb laser energy on the basis of their absorption coefficients at specific wavelengths. Different wavelengths have been selected for laser-assisted liposuction (LAL) in an attempt to specifically target subcutaneous tissue. The most used device is the 1064 nm neodymium-doped yttrium aluminum garnet (Nd:YAG) laser. The laser system emits light in the form of a beam that is converted to heat energy in fat, collagenous tissue, and hemoglobin. The employed photothermal energy liquefies the adipose tissue by rupturing the adipocyte's membrane releasing oily content into the extracellular fluid. Since laser coagulates small blood vessels, hemostasis is obtained. Additionally, it induces collagenesis with remodeling of the reticular dermis promoting tissue tightening [11]. There is no evidence supporting LAL superiority over other liposuction techniques. The disadvantages include the high cost of equipment, prolonged surgical time, and thermal injuries.

11.4.5 Power-Assisted Liposuction (PAL)

Power-assisted liposuction (PAL) described by Fodor involved the use of power supplied by an electric motor or compressed air producing a rapid in-and-out movement or an elliptic movement to an attached liposuction cannula breaking down the adipocytes directly and suctions the avulsed fat globules [12]. Depending on the vibration mode chosen, linear or rotational cannula movements travel between 600 and 4000 cycles/min. PAL is an efficient technique that has the advantage of less tissue trauma, edema, vascular injury, and ecchymosis in addition to shorter recovery and diminished surgeon's fatigue. The mechanical energy releases less thermal energy than the UAL; therefore, infiltrating solution is required. The disadvantages include the long learning curve, the noise of the equipment, and the constant movement of the handheld cannula which can lead to surgeon's discomfort, possible tendinitis and joint pain, and movement of the associated with operation of the PAL cannula.

11.4.6 Water-Assisted Liposuction

Water-assisted liposuction (WAL) was described in 2007, and, as the name suggests, this system uses water to loosen fat cells from the connective tissue. A thin, hollow cannula intermittently introduces a wetting solution in a microthin fan-like water stream directed at 30° anteriorly. The water-jet pressure can be adjusted with the ranges of 30–120 kPa increasing adipose cell detachment while preserving cellular integrity and causing less damage to the surrounding blood vessels and nerves. The advantages are reduced blood loss, reduced risk of adverse volume-related complication due to volume overload, less postoperative pain, ecchymosis, and edema [3]. The main disadvantage is the cost of the equipment.

11.4.7 Radiofrequency-Assisted Liposuction (RFAL)

Radiofrequency-assisted liposuction (RFAL) comprises the use of bipolar radiofrequency energy to disrupt the adipose cell membrane and facilitate lipolysis. This electrical current, which flows from the tip of the cannula to an electrode, creates a contained thermal energy to maximize skin retraction and fat coagulation. During the procedure, no skin pinch or palpation guides the surgeon. Since the machine produces lipolysis, the end-point is determined by the loss of resistance to forward motion of the cannula. Comparing to LAL that produces a relatively uncontrolled and focal effect, the radiofrequency device automatically adjusts the temperature as needed, producing uniform heat throughout the layers of the skin. The temperature must remain between 40 and 42 °C so that optimal skin retraction can occur with no burn and skin necrosis. The cannula is inserted in the subcutaneous tissue, and an electrode is placed on the surface of the skin. The emission of radiofrequency radiation is cast between the internal and external electrodes, destroying adipose tissue and promoting coagulation. The internal electrode, placed in the subcutaneous adipose tissue, is used in the same manner as SAL, creating numerous tunnels as it passes without effort as the radiofrequency energy itself produces the lipolysis. RFAL has the advantages of creating less ecchymosis, pain, and edema [3], and promotes better skin retraction explained by the neocollagenesis derived from the controlled thermal injury at the subdermal surface. The disadvantages are the learning curve and the cost of the equipment.

11.5 Adipocyte Viability in the Lipoaspirate

Adipose tissue is used for soft-tissue augmentation and as an alternative source of large quantities of mesenchymal stem cells. Choosing the right liposuction technique to harvest fat for grafting is important for graft take. The number and viability of adipocytes and adipose regenerative cells comprised in the stromal vascular fraction can vary depending on the liposuction technique used.

Suction-assisted liposuction has been the gold standard, especially for gluteal augmentation which involves larger volumes of fat grafting. Some authors recommend the use of low-pressure syringe vacuum aspiration as the pressure parameters for harvesting adipose tissue influence the number and functional properties of the adipose-derived stem cells (ADSCs) [13]. Coleman's method, which makes use of a 3-mm blunt-head suction cannula connected to a 10-ml Luer-Lock syringe, is the current internationally recognized method for autologous fat transplantation. The viability and enzyme activity (glyceraldehyde-3-phosphate dehydrogenase) of the adipocytes harvested by this technique seem to be significantly higher than other techniques. Yet, the multimodality approaches for autologous fat transplant, including thriving technologies such as ultrasound-assisted, water jet-assisted, VASER system, and radiofrequency, need to be better evaluated [14]. Technically, the chosen device must be safe, easy to handle, time saving, low priced, and shall not impair the number and functional properties of the ASC [15].

Among the available technologies, no negative effect on ASCs seems to occur while using water jet-assisted, third-generation ultrasound and PAL devices [14, 15]. Similarly, viability of the adipocytes harvested using the VASER system is estimated by 85.1%, consistent with the outcome related to conventional suction-assisted liposuction technology [16].

The ASCs harvested with laser or SAL both undergo osteogenic and adipogenic differentiation; the impact on cellular yield and ASC biology makes SAL more advantageous for clinical applications where large numbers of viable cells are necessary for tissue repair and reconstruction [17].

Although there are unique advantages and disadvantages of each lipoplasty technique, in experienced hands, excellent results can be achieved with any of the techniques, including suction-assisted lipectomy, power-assisted lipoplasty, UAL, and laser-assisted lipoplasty [18]. Contour deformities resulting from liposuction are usually related to how the operator performs the technique rather than the technique itself.

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12 Fat Processing Techniques Used for Gluteal Fat Augmentation

Pietro Gentile

12.1 Introduction

The areas in which stromal vascular fraction (SVF) cells have been used include breast augmentation, breast reconstruction, radiotherapy-based tissue damage after mastectomy, Romberg syndrome, hemifacial atrophy [1], burns, Crohn's fistulas and complex perianal fistula, damaged skeletal muscle, scarring and gluteal soft tissue defect, pectus excavatus, dermatofibrosis, and vocal fold augmentation.

Visceral and subcutaneous adipose tissue has been demonstrated to contain progenitor cells able to differentiate in multiple cell lineages [2, 3]. After centrifugation of collagenase-digested adult adipose tissue, a heterogeneous cell population named stromal vascular fraction (SVF) is obtained [3, 4]. This population contains adult stem cells named adipose-derived stromal cells (ASCs) [4]. ASCs might improve tissue outcomes by increasing vascularity and through the secretion of growth factors that improve tissue survival. The author published works on the use of fat grafting in the lipostructure technique as described by Coleman [5] mixed with platelet-rich plasma (PRP) in plastic surgery [6], in lower chronic extremity ulcers [7], in hemifacial atrophy, and in breast augmentation [8, 9]. Now, in this chapter, the author describes his experience using engineered fat grafting with the SVF-enhanced in buttock augmentation, while reviewing the different fat processing techniques.

12.2 Techniques

SVF-enhanced (e-SVF) autologous fat preparation (based on filtration and centrifugation according to minimal manipulation).

The e-SVF is obtained by the centrifugation and filtration of autologous fat, according to the European Rules and EMA-CAT suggestions. The fat (80 ml) is subjected to automatic filtration and centrifugation cycles at 1300 rpm per 10 min, after which 40 ml of the suspension is extracted from the bag. The suspension is further filtered through 120 μm filter, and 20 ml of the e-SVF suspension is obtained. Subsequently, the e-SVF suspension is added and mixed with the centrifuged fat. A total of 0.2 ml of SVF is added to each ml of centrifuged fat.

This purified fat combined with SVF is collected in 1-ml syringes and aseptically re-injected [10] into the areas to be treated. Skin incisions of about 2 mm in length for the entry of the cannula are made using a no. 11 scalpel blade. The areas to be injected are carefully selected in order to make the necessary corrections [7, 11]. Fat tissue combined with PRP is implanted "gently" at different levels in small tunnels around the margins created earlier by introducing the cannula with precise controlled movements. A small quantity of fat cells is laid at a time in a retrograde manner creating a large grid to correct the vascular development around each fat cell.

This technique is of fundamental importance in allowing each single layer deposited to survive through the few days necessary for the growth of the blood vessels that can nourish them permanently [12]. The incisions are closed with 5–0 nylon sutures. No compressive bandage is applied.

Preparation of the SVF-enhanced autologous fat graft (based on enzymatic digestion, performed by the author until at the publication of the EMA-CAT suggestion).

The cell and tissue preparation procedure mainly exhibits two phases. Phase 1 starts with syringe liposuction (2706 ml average in all patients; range, 200–6300 ml) in the abdominal region using 3-mm cannulas. While aseptic technique is maintained, the plunger of the 60-ml syringe is removed, and the tip is closed with a cap. Half of the lipoaspirate (386.57 ml average) is placed into the tissue collection container. Blood and free lipid is removed from the tissue through a wash cycle, and the specific collagenase (product by a company owner of the collection container) is added to enzymatically digest the tissue, which releases the SVF. After additional

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washing and centrifugation cycles, 4–5 ml of the SVF suspension is extracted from the system. In the second phase, the remaining part of the lipoaspirate is added to the tissue collection container and a washing step is automatically carried out. Once completed, the 4–5 ml of SVF suspension is added and mixed with the washed fat graft resulting in approximately 434.5 ml (range, 140–750 ml) (217.25 per each side) of SVF-enhanced fat tissue for grafting. This newly processed cell-enhanced fat graft typically consists of 25–30% water, which is reabsorbed by the body in the postoperative period. This overall process is controlled through automated sensors and processing algorithms that ensures standard handling of the tissues and cells, and the process is completed within 160 min. The SVF-enhanced fat graft is transferred into 10-ml syringes and aseptically re-injected into the patient using specific micro-cannula for implantation.

The donor site region is infiltrated with a cold saline solution containing 1 ml of adrenaline per 500 ml of saline solution without lidocaine or carbocaine. Adipose tissue is removed after 5 min using a 3-mm-diameter cannula and a 60-ml Toomey syringe. The SVF-enhanced adipose tissue is injected using specific micro-cannula (1–2 mm diameter) for implantation.

12.3 Coleman Procedure

Adipose tissue from the abdominal region is harvested using a specific cannula of 1, 5, 2, and 3 mm diameter for grafting. The plungers of the syringes are closed with caps and positioned flat in the sterile centrifuge maintaining asepsis. The syringes are processed for 3 min at 3000 rpm/min. The purified fat layer is placed in 1-ml syringes and aseptically re-injected into the area to be treated.

12.4 Clinical Evaluation

Fat graft maintenance is evaluated by analytical comparison of pre- and postoperative images. In addition, two methods for the evaluation of outcomes are used: (1) team evaluation and (2) patient self-evaluation. The team evaluation is an evaluation method based on clinical observation, using a scale of six values (excellent, good, discreet enough, poor, and inadequate). The factors/variables considered are pigmentation, vascularization, pliability, thickness, itching, and pain. The patient-based self-evaluation is an evaluation method based on clinical observation, using a scale of six values (excellent, good, discreet enough, poor, and inadequate). Follow-up of patients is performed at the second and fifth weeks and at 3, 6, 12 months, and then annually.

12.5 Discussion

The works of authors like Mendieta et al. [13] and Nicareta et al. [14] have used lipofilling for buttock reshaping, that is the center of the rear figure of the body and plays the same role in rear body contour like the breasts in front of the body.

Buttock reshaping is done by combining liposuction of the areas with excess fat and fat grafting to restore volumes and fill depressed areas. The anatomical planes in which fat tissue is injected are the subcutaneous layers, superficial and deep. We have treated patients for aesthetic and reconstructive reasons related to HIV lipodystrophy and congenital or acquired asymmetries. This is the only procedure that has allowed us to obtain ideal results, appreciated by patients and with few complications. The limits of this procedure are essentially related to the amount of fat tissue available, to the long time intraoperative and the costs of the technique.

We have used PRP with fat grafting to improve graft take. Moreover, our in vitro data are in accordance with the hypothesis that PRP stimulates adipose tissue regeneration, as demonstrated in controlled animal studies for both soft and hard tissues [5]. In addition, compared to lipofilling [15] where fat cells are laid in rows without solution of continuity, implant survival is likely derived from reduction of fat necrosis due to improved neo-angiogenesis in the implanted area.

Guerrerosantos et al. [16] reported the use of fat tissue without PRP in patients affected by Romberg syndrome disease. In addition, they recently reported interesting cases of facelift combined with suspension sutures and fat grafting [16].

Recently, the authors described the use of fat grafting with PRP and with only lipostructure technique [12] in patients affected by Romberg syndrome.

Lipostructure evolved from lipofilling and is better known as Coleman's technique [15].

In addition, Yoshimura et al. [1] described new methods and technologies of the use of fat grafting. In fact, they perform cell-assisted lipotransfer (CAL) for cosmetic breast augmentation using adipose-derived stem/stromal cells in combination with lipoinjection. Stromal vascular fraction (SVF) containing ASCs is freshly isolated from half of the lipoaspirate and recombined with the other half. This process converts relatively ASC-poor aspirated fat to ASC-rich fat.

A new aim could be the use of SVF isolated from half of fat tissue mixed with PRP and recombined with the other half.

Currently, for automatic SVF extraction, it is possible to use enzymatic digestion or mechanical processing. With enzymatic digestion, cell viability by trypan blue exclusion was consistently more than 98%. The cell yield was ~50,000 ± 6956 nucleated cells per mL of adipose tissue. SVF can be obtained with mechanical processing, using centrifugation and filtration of fat. Through the use of commercial system, fat (80 mL) is subjected to automatic filtration and centrifugation cycles at 1100 g per 10 min, after which 40 mL of the suspension is extracted from the bag. The suspension is further filtered through a 120-μm filter, obtaining about 20 ml of SVF suspension. The latter is centrifuged at 600 g for 10 min and then pellet is resuspended in erythrocyte lysis buffer and incubated for 5 min at room temperature. After centrifugation at 600 g for 5 min, the pellet is resuspended in few microliters of growth medium and cellular population is counted using hemocytometer. Cell viability by trypan blue exclusion is consistently more than 98%. About 65,000 ± 3345 nucleated cells/mL from the lipoaspirate can be obtained.

Our purpose remains to enrich our graft with 50,000–70,000 cells for each mL of fat tissue. Therefore, the addition of SVF to fat graft (the authors actually prefer to use only SVF obtained by centrifugation and minimal manipulation) improves fat graft maintenance compared to traditional fat graft injection with obtained after washing or with the Coleman method, inducing neo-angiogenetic microcapillary network.

12.6 Results

In Vivo: Influence of SVF in fat graft maintenance.

We generally inject a maximum of 180–350 ml in each buttock. We observed that patients who received fat grafting and SVF at a concentration of 0.2 ml per each ml of fat tissue had a 58% maintenance of gluteal contour after 1 year, while there was 37% maintenance in patients who received fat that was processed with centrifugation according to Coleman's method (n = 10).

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13 Three Decades of Brazilian Buttock Lift

Luiz S. Toledo

13.1 Introduction

While attending the Brazilian Congress of Plastic Surgery in November 1980 in Fortaleza, in the sunny Northeast of Brazil, we were surprised to see a new technique, something revolutionary and rare in plastic surgery, a technique that, for the first time allowed us to change the shape of the body through minimal incisions.

The lecture by French surgeon Yves-Gérard Illouz was not included in the main ballroom where all the well-known plastic surgeons were presenting. Instead, we saw his lecture in a small room for an audience of only 50 members. Most presentations at the time used slide carousels, but Illouz preferred to show us a 16-mm film of his technique. This was before the era of video. It happened like this, in front of a mesmerized small audience, we saw for the first time yellow fat passing through a transparent tube and falling into a big vial. Liposuction, as the technique would later be known as, had just arrived in Brazil. The rest is history.

Brazil was one of the first countries to start using the new technique. Illouz had presented it only once before at the Shirakabe Clinic in Osaka, Japan. He would show it for the first time in the United States 2 years later, at the meeting of the American Society of Plastic Surgeons (ASPS), in Hawaii, in 1982. I was part of the scientific committee of the Brazilian Society of Plastic Surgery, Sociedade Brasileira de Cirurgia Plástica (SBCP), and we invited Illouz and his colleague Pierre Fournier, another pioneer in the field, to come to Brazil several times in the early 1980s to lecture and demonstrate their surgical technique. However, it was only in 1983 that Illouz and Fournier started talking about injection of aspirated fat and Fournier had just developed syringe liposculpture [1, 2]. He said that the idea came to him when he was doing an injection on himself and when pulling the plunger of the syringe to verify that it was not in a blood vessel, some fat came into the syringe. Eureka!

Many surgical instrument manufacturing companies worked on perfecting cannulas and devices, and so instead of performing only reduction of fat deposits, we could now use syringes and start injecting fat for augmentation.

I had started performing liposuction in 1982 and consequently my practice grew. In certain cases, I operated with an associate, Dr. Paulo Matsudo, and fat grafting became a big part of both our practices. We started in 1983 with small fat injections in the face and by 1985 we were injecting larger amounts of fat to improve body contour, breasts, buttocks, thighs, trochanteric regions, and hands. We used a liposuction aspirator connected to a sterile fat collector. We transferred fat to 60-cc syringes and injected in different areas of the body. We showed our 18-month results at the congress of the International Society of Aesthetic Plastic Surgery (ISAPS) in New York in 1987 and published these findings in 1988 [3].

By 1989, I changed my liposuction technique and started using only disposable syringes for aspiration and injection of fat [4]. I learned from Carlos Carpaneda that fat should be injected in 3-mm threads for better survival [5]. My results improved and I started lecturing about the syringe liposculpture technique in Brazil and abroad. From 1990, and for a period of 15 years, I gave courses on liposculpture for the face and body at the annual meetings of the American Society for Aesthetic Plastic Surgery (ASAPS), the Lipoplasty Society of North America (LSNA), ISAPS, and ASPS.

13.2 Preoperative Period

Very little has changed in these three decades in terms of patient marking (Fig. 13.1). We mark patients in the standing position immediately before the surgery, since the subtleties of the defects tend to disappear when the patient is lying on the operating table. I use two colors, black for donor sites and red for recipient sites. The incisions are marked 5 cm distant from the treated areas to avoid depressions and keep the negative

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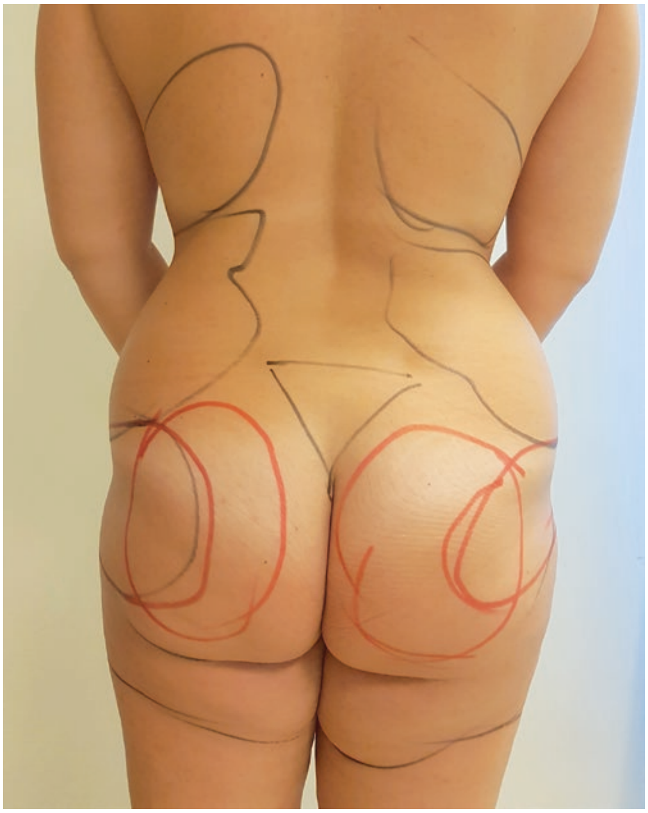

Fig. 13.1 Marking of the patients is done in a standing position. Two colors are used: *black* for the donor sites and *red* for the recipient sites

pressure inside the syringe. Depending on the body type, we harvest fat from different areas. In patients with the gynoid body type, excess fat is concentrated below the waistline and in the android type the excess fat is above the waistline.

We screen patients before surgery for complete blood count, glycemia, coagulation tests, human immunodeficiency virus (HIV), hepatitis B and C. We recently added Covid-19 test, which is now mandatory in all practices. For patients older than 45 years old, an electrocardiogram is performed. For surgeries that last more than 2 h, stockings and sequential pumps (pneumatic compression devices) are placed in the lower extremities for prevention of deep vein thrombosis. Low molecular weight heparin is sometimes required depending on the risk factors of the patient. The temperature of the patient is maintained by covering the body with an air warming blanket [6]. All the intravenous and infiltration fluids are warmed to 37 °C to prevent hypothermia and its dangerous consequences. Local anesthesia is injected, when we aspirate less than 1 L of fat, and intravenous sedation or general anesthesia when we aspirate more than 1 L of fat in certain areas. An anesthesiologist is always present to assist with the sedation that consists of a combination of midazolam, propofol, and fentanyl [7].

In 1989, we modified the infiltration formula and have been using a warm solution of 2% lidocaine (40 cc), epinephrine 1:1000 (2 cc) in 1-liter of Ringer's lactate and 3% sodium carbonate (10 cc) [4]. The amount injected varies from 1:1 to 2:1, that is, for each ml of fat aspirated we inject 1 or 2 ml of fluid. We use a multi-hole blunt 2 or 3 mm diameter cannula to harvest fat. The lipoaspirate obtained is decanted for 10 minutes before injection. We aspirate a maximum of 9 L of fat, keeping in mind that the safe volume of aspiration is up to 7% of the patient's weight, and 30% of the total body surface area. Some articles limit liposuction to 5 L, but it is not mentioned if this volume represents the total aspirate, or pure fat, and its relation with the patient's weight, which make those guidelines imprecise.

13.3 Positioning the Patient

When using local anesthesia, the patient is prepped in a standing position using an antiseptic spray. The table is covered with a sterile drape and the position can be changed as necessary. When the patient is under sedation or general anesthesia, we try to limit the position changes to prone and supine. Lateral decubitus position is also useful to treat the lateral areas of depressions or excess fat. Pictures of the patient in the standing position are displayed to help identify the body contour and irregularities during the procedure (Fig. 13.2).

13.4 Instruments

Almost every time a new cannula, device, or machine appeared on the market, we tested them to see if they would be of any benefit to our patients. For over 20 years, we have come back and stuck to the simplest technique: syringe liposculpture (Fig. 13.3). With the use of cannulas of 3–5 mm diameters and 15–35 cm length, and disposable syringes, we

Fig. 13.2 The patient is lying on the operating table in the position that best shows their problem areas. This patient is placed in lateral decubitus position

Fig. 13.3 Syringe liposculpture instruments

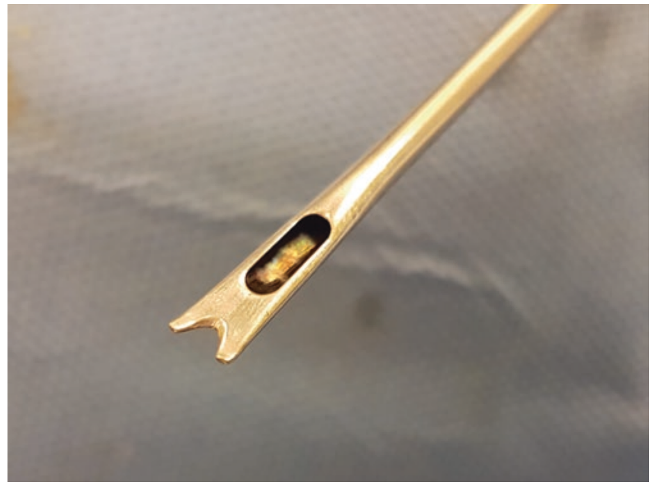

Fig. 13.4 The Toledo V-tip cannula

can modify the body shape safely, in an uncomplicated and cost-efficient way. For the last 5 years, I have used a device that warms the infiltration fluid and provides power-assisted liposuction (Möller Liposat, MöllerMedical, Fulda, Germany). The lipoaspirate is collected in an intermediary sterile container and transferred into syringes for injection.

In 1989, we developed the Toledo V-tip cannula that breaks fibrotic tissue, adhesions, treats retracted scars, skin deformities, buttock dimples, and "cellulite" while harvesting and injecting fat [8]. The tips of the V-tip cannula are blunt in order not to perforate the skin, only the inside of the V has a cutting surface. It comes in various lengths and diameters and is used for the face and body. We always have it ready on the operating table in case there is a depression or a zone of adherence that needs to be treated during liposuction or fat injection (Fig. 13.4).

Fig. 13.5 The lipoaspirate collected in a sterile container is decanted and transferred from one syringe to another syringe through an adapter

13.5 Fat Harvesting

We do not simply aspirate fat from the donor site for injection. We treat each area as a whole making sure to remove all excess fat and allow a smooth transition between treated and untreated areas. Finer cannulas are used at the end to feather the surface of the donor sites. For buttock augmentation, we need a great quantity of fat for injection therefore we harvest any excess fat from the flanks, thighs, abdomen, and other areas.

13.6 Fat Processing

In 1990, in collaboration with Alberto Hodara, a plastic surgeon from Porto Alegre, Brazil, we developed a manual centrifuge for 10 and 60 cc syringes. The manufacturer was a boat builder who produced a few of these instruments per month. I used this centrifuge for many years because it allowed me to separate fat from the infiltration solution in just 1 minute, instead of the 10 minutes necessary for decanting. Syringes of fat were centrifuged for 1 minute separating fat from the infiltration solution without breaking the fat cell membranes and keeping the cells viable for injection. Our manual centrifuge worked well in Brazil; however, some countries have health regulation rules mandating that the syringes inside the manual centrifuge had to be completely covered. This is the reason why when I left Brazil, I went back to decanting fat for 10 minutes. After separating the infiltration solution, we emulsify the fat by passing it from one syringe to another syringe through an adapter (Fig. 13.5).

13.7 Fat Injection

I use three incisions for injection: one subgluteal, one in the trochanteric region, and one in the sacral region. From these incisions, injection is done in a fan shape in different directions and planes with 3–4 mm diameter blunt tip cannulas with one hole, attached to a 60 cc Toomey tip syringe, keeping in mind not to inject "lakes" of fat, but "threads" of fat, like spaghetti.

I usually start injecting in a deeper plane and move superficially. For many years, I injected fat intramuscularly, but recently, due to the many reports of fat embolism [9], I now inject fat only subcutaneously (Figs. 13.6 and 13.7). The cannula must always be parallel to the skin and always inject fat as the cannula is being removed, in a retrograde manner, avoiding any possible high-pressure intravascular fat injection. The incisions are closed with a 4–0 nylon suture, which is removed on the seventh postoperative day. Some surgeons inject large volumes of fat in the gluteal region. I inject a maximum of 500 cc into each buttock and 200 cc into each trochanteric region. This might be because my patient population already has some fat in the gluteal region and does not require as much. In any case if more fat is needed, a second surgery is scheduled for additional fat grafting.

Fig. 13.6 Injection of fat subcutaneously via a subgluteal incision

Fig. 13.7 Injection of fat subcutaneously via a trochanteric incision

13.8 Postoperative Period

Patients receive 1 g of third-generation cephalosporin intravenously before the surgery and every 12 h for 24 h or while in the hospital. When discharged, they are prescribed amoxicillin and clavulanic acid tablets twice a day for 7 days. Analgesics such as non-anti-inflammatory steroids are taken in case of pain. Patients can shower after 24 h and are required to wear garments for 3 weeks in the postoperative period. Driving is allowed after 1 week, exercise and sunbathing after a month. Patients can sit up and sleep on the sides after surgery, but should avoid lying on their back for 3 days. Medication for prevention of deep venous thrombosis is given to high-risk patients.

13.9 Discussion

Buttock augmentation can be achieved with silicone implants, injection of fat or fillers. Initially, the results with gluteal implants did not look natural as they were placed too high. Complaints included long-term pain, implant misplacement, infection, and extrusion. I personally did not like my results with gluteal implants. The injection of hydrogel fillers was common in the Middle East over the last decade until complications started to surface. They included long-term infections, shift of volume with the force of gravity, adverse reactions, leading at times to open debridement, usually by general surgeons not familiar with the technique or the products used.

I believe that fat grafting is the safest technique to increase the volume of the buttocks in an efficient and aesthetic manner, provided the patient has enough fat. We have been through many phases in the three decades that we have been performing this procedure. In our initial technique in 1985, we used a traditional liposuction aspirator connected to a sterile container. We collected fat, let it decant and transferred it to 50-cc veterinary resterilizable syringes and cannulas as there were no medical 60 cc syringes available in Brazil at the time. In 1988, when we started performing syringe liposculpture [10], we used catheter-tip 50-cc syringes and custom cannulas adapting to that particular tip. However, these syringes were fragile, the tip would sometimes break.

In 1990 when I started lecturing in the United States, I bought cannulas from Tulip Medical Products designed to fit the body of 60-cc Toomey tip syringes. We immediately saw the difference in the negative pressure generated, since the diameter at the tip of the cannula is 3 mm and the Toomey tip syringe has an 8-mm diameter tip. They are zirconium-fused cannulas that are less traumatic to fat cells, which I use for fat injection.

In 1995, I used the ultrasound-assisted liposuction, and was soon facing complications such as skin burns, hypersensitivity, long-term postoperative pain and I was not convinced that the lipoaspirate extracted with the ultrasound was viable for injection. In 2006, Rodrigo Neira and I published our study on "Low-level laser-assisted liposuction" known as the Neira 4 L technique, where we used low-level laser to create a transitory pore in the cell membrane of adipocytes so that fat could move from inside the cell to the interstitial space without damaging them, while modulating the inflammatory response [11]. Liposuction and fat grafting were associated with many severe complications at the time including pulmonary embolism, hemorrhage, perforation, infection, lidocaine toxicity, epinephrine toxicity, third space fluid shifts, fat embolism syndrome, and death. Aesthetic complications included undercorrection, overcorrection, contour irregularities, persistent edema, hematoma, seroma, local infection, epidermolysis, hyperpigmentation, vasculopathies, and permanent changes in skin color. We published the methods of prevention and the management of those complications [12].

That same year, we published a 20-year review article on fat grafting [13], describing several techniques that we had used. There was not a standard technique adopted by all practitioners to ensure maximum graft take. During this time, emerging approaches to fat tissue engineering with the use of cultured autologous preadipocytes started being tested to improve the outcomes of fat grafting.

In 2007, I started using laser-assisted liposuction with the SmartLipo device (DEKA M.E.L.A. srl | Via Baldanzese, 17—50041—Calenzano (FI), Italy). I noticed an improvement in skin retraction in areas of flaccid skin such as the neck, arms, medial thighs, but the technique had no advantages for buttock augmentation. In 2012, I started using a combination of fat with platelet-rich plasma (PRP) and later adipose stem cells (ASC). These two techniques increased dramatically the price of the procedure in my practice. I am not convinced that the advantages of using them justify the increased cost for gluteal fat augmentation, as my results were similar with or without the use of ASC and/or PRP. Moreover, in general, two procedures are needed, one to harvest fat, and after isolation and multiplication of the ASC, another procedure is performed 15 days later to inject the mixture of fat and ASC.

Today I am back to the basics. I harvest and inject fat with an emphasis on patient safety. I am very pleased with the results of my patients and so are they (Figs. 13.8 and 13.9). It is interesting that a technique we developed more than 30 years ago, and the "Brazilian Buttock" a term that I coined for an ASAPS teaching course in 2000, has become internationally recognized as a new procedure. There has also been a shift in the patients' mentality. Twenty years ago, American patients were mostly concerned with the size of their breasts. There were no requests then for buttock augmentation.

According to the recent statistics, the Brazilian Buttock Lift generally attributed to the pioneering work of Toledo beginning in 1985 [14], took the top spot for the most significant increase in the number of procedures performed over the course of 1 year [15].

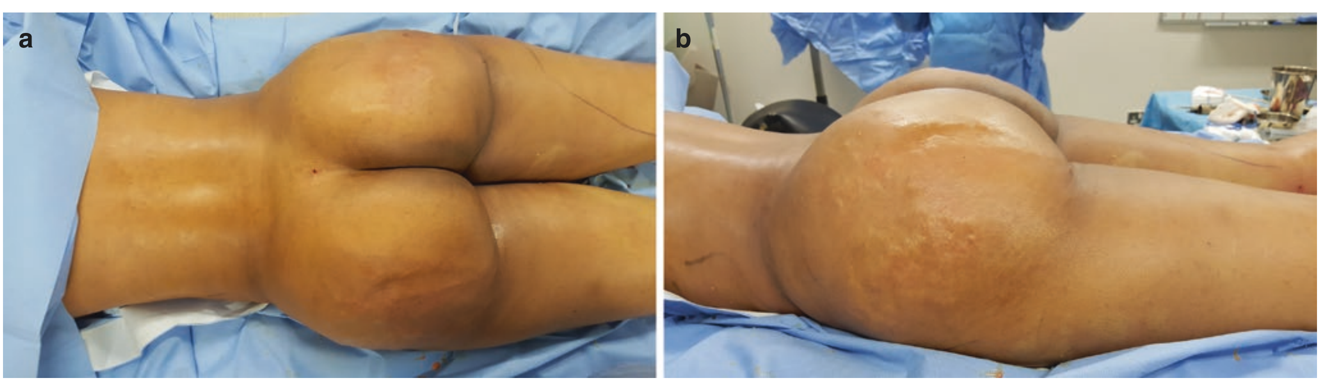

Fig. 13.8 Immediate postoperative "Brazilian Buttock technique" with injection of 500 ml of fat into each buttock and 200 ml of fat into each trochanteric region. (**a**) Posterior view and (**b**) lateral view

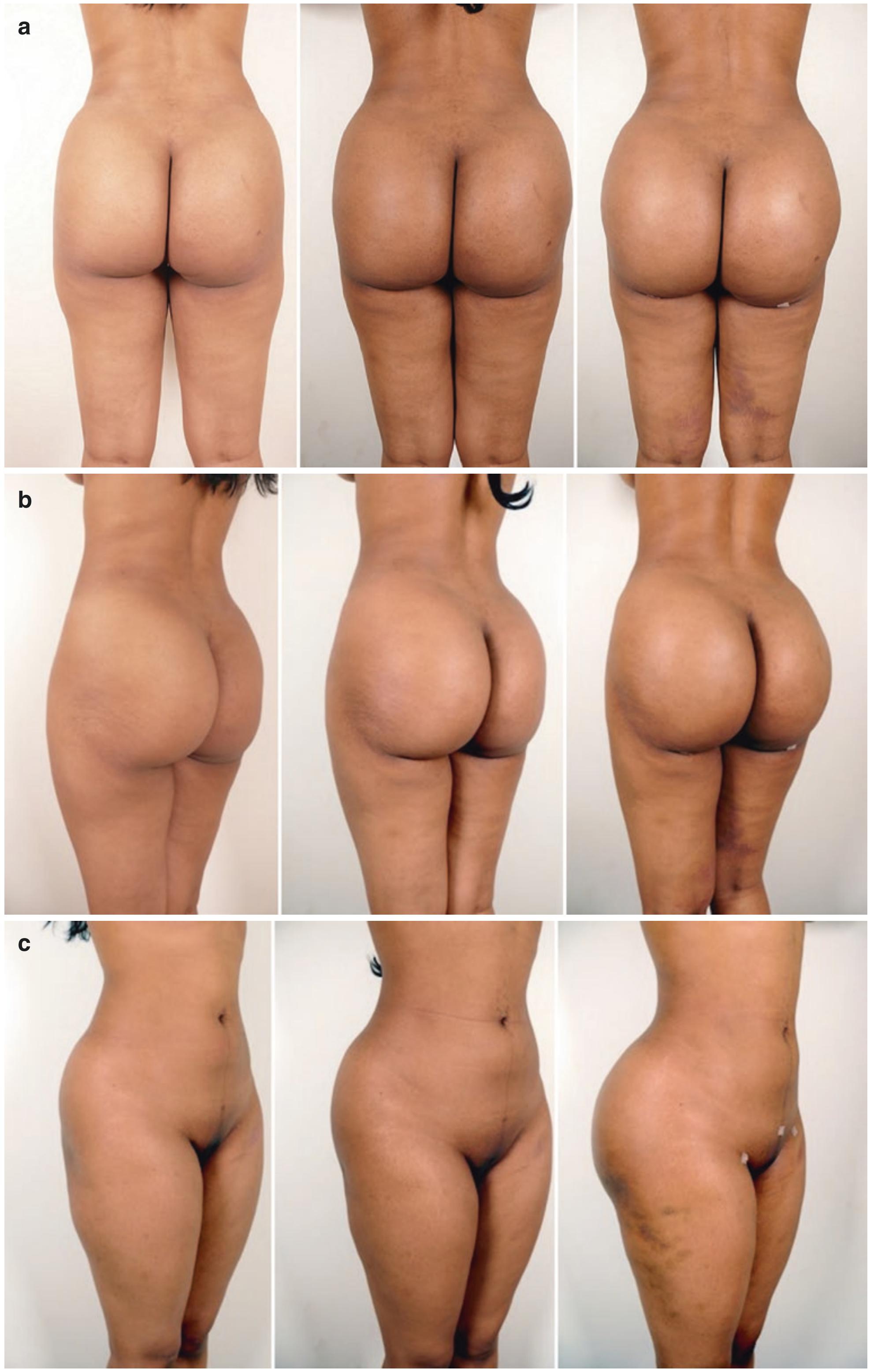

Fig. 13.9 Patient submitted to two procedures of the "Brazilian Buttock technique" at 6 months interval in order to avoid over-injection during the first procedure. Photos of the patient in Preop—6 months after the first procedure where 200 ml of fat were injected in each buttock and 300 ml of fat in each trochanteric region—2 weeks after the second procedure where 450 ml of fat were injected in each buttock and trochanteric region. Her hip circumference went from 95 cm to 112 cm. (**a**) Posterior views, (**b**) posterior-oblique views, and (**c**) anterior-oblique views at the different time points cited above

13.10 Conclusion

Fat grafting to the buttocks is an effective technique that achieves good results, with minimal postoperative pain and high patient satisfaction. We have performed this technique for over 30 years with good results and the international acceptance shows it is a reproducible procedure to improve body contouring.

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14 Strategy and Planning of Gluteal Augmentation with Lipotransfer

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and Natale Ferreira Gontijo-de-Amorim

14.1 Introduction

Buttock augmentation using fat grafting techniques is among the fastest-growing procedures performed in the United States with a 280% increase for the 5-year period from 2011 to 2015 [1]. Fat grafting for gluteal augmentation is an ideal autologous substitute for tissue deficiency. It is easily accessible in subcutaneous deposits, and can be molded to reconstruct defects. Despite over 100 years of clinical use, the clinical longevity of fat graft is variable, operator-dependent, has a high rate of absorption, and in particular large volume fat grafting decreases over time [2].

Adipose tissue has become one of the most interesting materials in bioengineered tissues of the human body because of its enormous potential to produce regenerative cells and its capacity to provide material for autologous volume replacement [3–7]. Fat grafting is widely used in plastic surgery, mostly for body contouring and facial rejuvenation. There are no standardized steps for the fat grafting procedure and multiple surgical techniques are used during the procedure. The techniques used to transfer fat significantly impact the survival of adipocytes, adipose mesenchymal stem cells (AMSC), and the longevity of the fat grafts. The long-term success of fat transplantation is dependent on several elements, including harvesting, processing methods, bioactivation, transplantation methods, and management of the recipient site [8–12].

Gluteal augmentation has gained acceptance among plastic surgeons in recent years. The main procedures to achieve this result are the inclusion of implants, autologous fat tissue sculpting, or a combination of both. The advocates for gluteal implants claim that fat grafting is not a long-lasting procedure and has variable degree of fat reabsorption. On the other hand, liposuction and autologous fat grafting to the buttocks for the purposes of contouring and gluteal augmentation have greater versatility, precision, larger area approach (implants do not allow treating different parts of the buttocks), and more rapid recovery with less cost and lower complication rates [4, 7, 8]. A meta-analysis of gluteal fat augmentation evaluated 4105 patients, where fat was harvested from the thighs and the back, and an average of 400 ml of fat was injected per buttock with 7% complications. A total of 46.7% of the articles found that fat was injected into both the subcutaneous and intramuscular planes, 26.7% into the intramuscular plane only, and 26.7% into the subcutaneous plane [13].

In this chapter, we present the planning of gluteal contouring and augmentation with liposuction and autologous lipotransfer. The clinical management, body mass index, postoperative care, and complications are not covered.

14.2 Evaluation of the Gluteal Region

A meticulous analysis of the gluteal region and patient cooperation during surgical planning are key to achieve pleasant results. The gluteal evaluation includes the back, the lateral, and oblique views in static and dynamic positions (Fig. 14.1). For an adequate and detailed analysis, the gluteal region is divided into four quadrants (Fig. 14.2). All the areas that will be addressed for liposuction and lipografting are marked in an orthostatic position in the preoperative period. The following parameters are evaluated:

- Skin quality
- Volume asymmetry
- Depression and bulging
- Scars
- The form of the gluteal region: round, oval, undefined
- Lipodystrophy of the surrounding region
- Presence of alloplastic material (e.g., polymethylmethacrylate, silicone liquid, and others)

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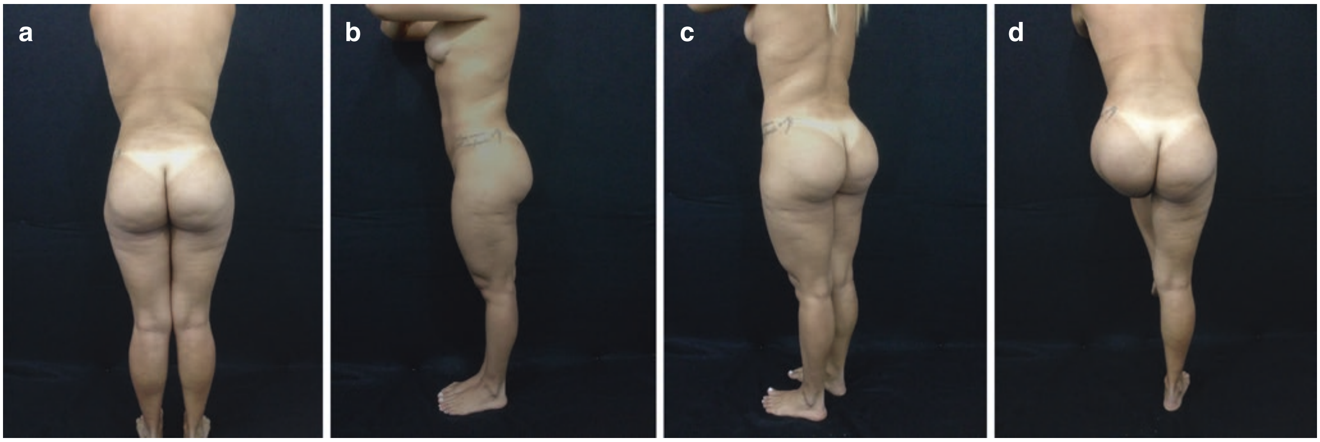


Fig. 14.1 Dorsal (**a**), lateral (**b**), and oblique (**c**) views in static and dynamic (**d**) positions to analyze volume, design, asymmetry, atrophy, scars, depression, bulging, gluteus muscle function, and other alterations

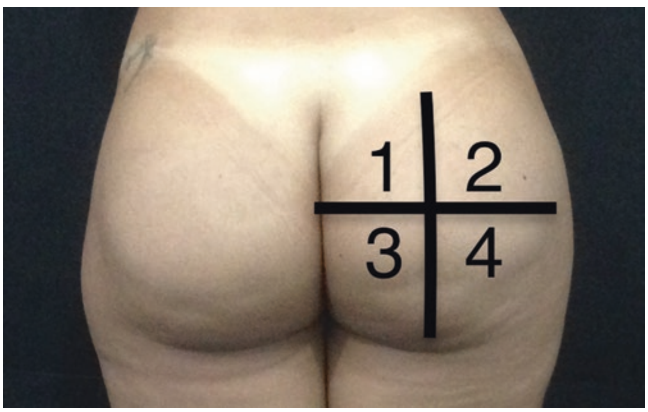


Fig. 14.2 The buttock is divided into four quadrants

There are objective and subjective methods for planning and postoperative results of gluteal fat augmentation. The results of fat-grafting procedures are assessed by observation, clinical examination, and photographs. Ultrasound, three-dimensional photography, magnetic resonance imaging (MRI), and computed tomographic imaging studies are more objective measurement tools [14]. Both CT and MRI acquire axial images of known thickness, usually 5–10 mm. Volumes are then calculated using geometric models based on the measured areas and the distances between adjacent slices [15]. Har-Shai et al. [16] suggested the use of CT scan to quantify the volume of fat and concluded that it could distinguish the density of fat from other tissues.

14.3 Protocol for Gluteal Surgery

Following preoperative analysis, there are different surgical approaches to address the gluteal region. There is not an established protocol; however, several procedures have been performed to improve gluteal contour. Considering the wishes of the patients and using the principles of fat removal where it is in excess and fat injection where it is needed, a harmonious contour of the buttocks can be obtained by a combination of different surgical procedures with excellent results in gluteoplasty in the same surgical time. A single technique or an association of techniques can be used to give the patient an ideal body contour by removing fat deposits with liposuction and injecting fat where it is needed:

- Liposuction of the surroundings of the gluteal region (Fig. 14.3)
- Liposuction of the surroundings of the gluteal region + autologous lipotransfer (Fig. 14.4)
- Gluteal implant + liposuction of the surroundings of the gluteal region (Fig. 14.5)
- Gluteal implant + lipotransfer of the surroundings of the gluteal region (Fig. 14.6)
- Gluteal implant + liposuction of the surroundings of the gluteal region + autologous lipotransfer (Fig. 14.7)

14.4 Surgical Technique

14.4.1 Fat Harvesting

Donor area. Preoperative markings are done to identify the areas of lipodystrophy (Fig. 14.8). After antiseptic cleaning of the skin with chlorhexidine, fat is harvested from the lower and superior back and the lateral thighs using the super-wet technique. A solution containing normal saline with 1:500.000 of epinephrine is injected through a 22-gauge spinal needle. A total of 700–500 ml of fat is harvested using blunt-tipped cannulas of 3 mm in diameter and 20 cm in length (tip model 3B, Richter®, Brazil) attached to a 60-ml

Fig. 14.3 In patients with a satisfactory gluteal volume (**a**), liposuction of the surroundings of the gluteal region (lower back and trochanteric regions) is recommended. In this patient, liposuction of the lower back and the trochanteric regions was done (**b**)

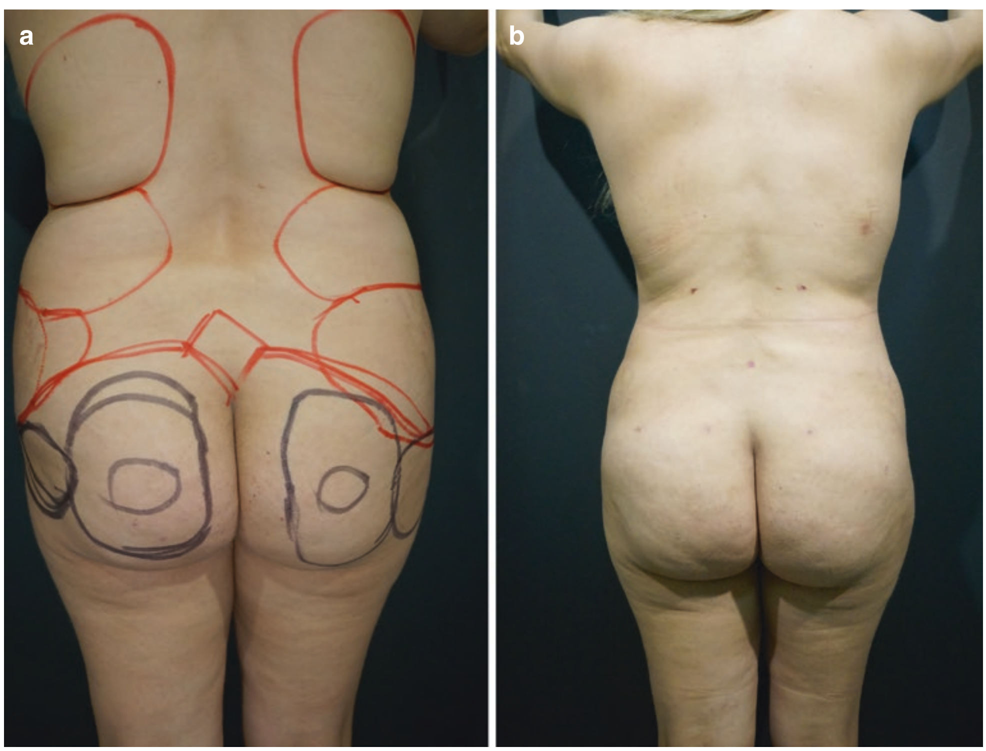


Fig. 14.4 Liposuction of the surroundings of the gluteal region + autologous lipotransfer. (**a**) Liposuction of the flanks and back (*red* areas) and lipotransfer in central and lateral gluteal regions (*black* areas) were performed. (**b**) Six months postoperative time shows a notable improvement of gluteal region

catheter tip syringe, creating a slight negative pressure by slowly withdrawing the plunger in a gradual manner.

14.4.2 Fat Processing

After collection, fat is washed three times inside the syringe with normal saline to remove blood and cell elements, then it is left to decant. This procedure is done employing the same 60-ml syringe used during fat harvesting, and the piston is not removed from the harvesting syringe during washing to avoid tissue exposure to air. In addition, to decrease the resorption rate, efforts have been made to enrich fat with stromal vascular cells. This practice has gained more popularity in the face [17, 18] (Fig. 14.9).

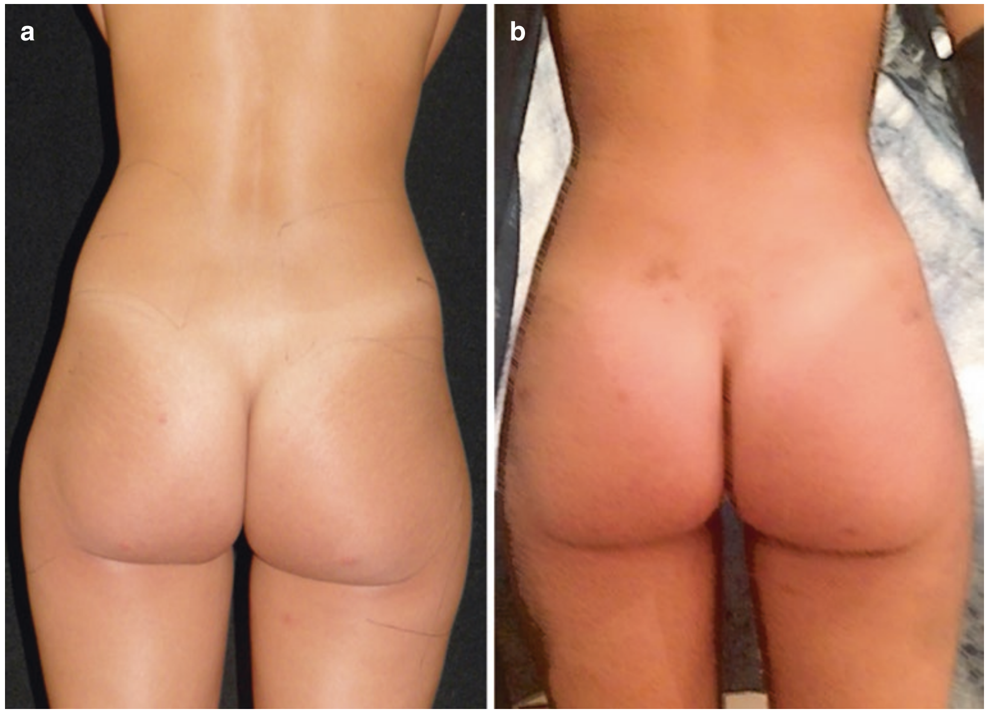


Fig. 14.5 Gluteal implant + liposuction of the surroundings of the gluteal region. (**a**) This patient had gluteal augmentation with implants (Oval-400 cc) and liposuction of the back and posterior flanks. (**b**) Six months postoperative follow-up

Fig. 14.6 Gluteal implant + lipotransfer of the surrounding gluteal regions. (**a**) The patient had buttock augmentation with gluteal implants and (**b,c**) lipotransfer in lateral and superolateral regions. The adipose tissue was collected from the abdomen and the back. (**d**) The gluteal implant is shown on the right side. (**e**) After both implants are positioned, (**f**) the lipotransfer is done in lateral and superolateral regions

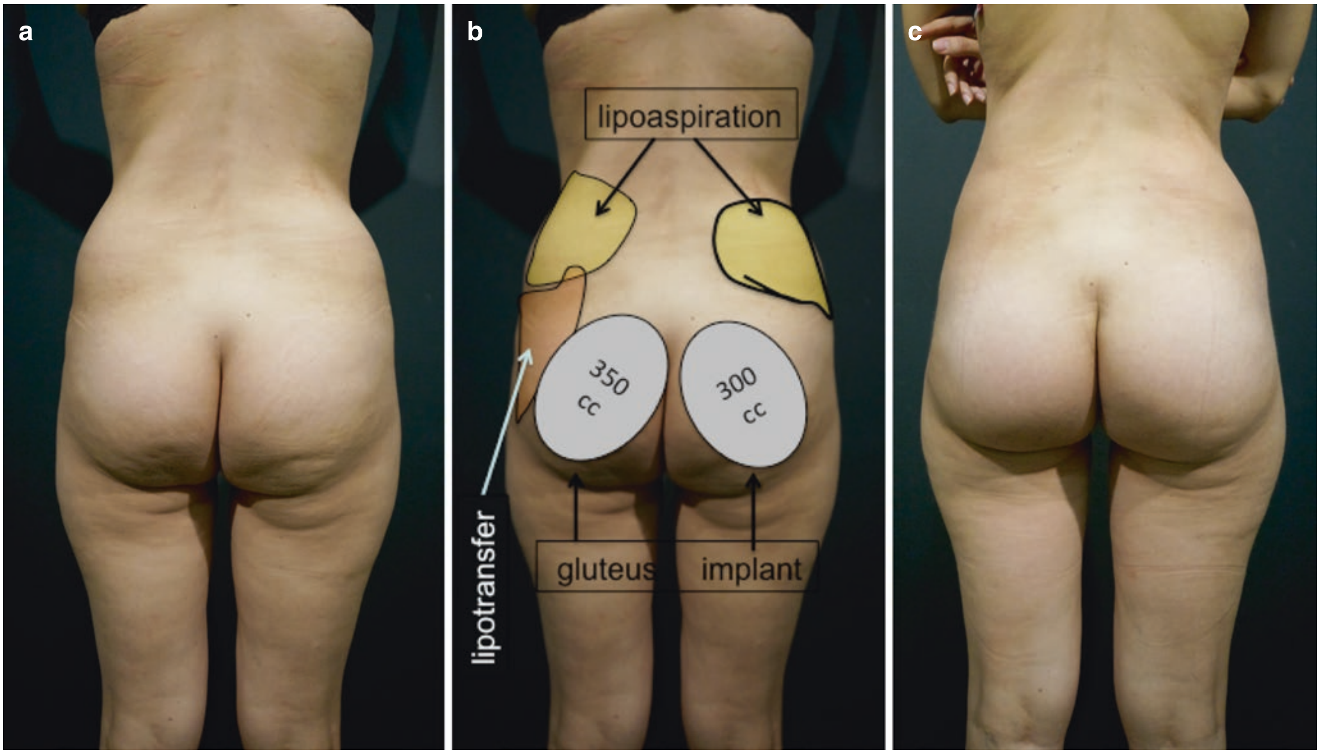


Fig. 14.7 Gluteal implants + liposuction of the surroundings of the gluteal region + autologous lipotransfer. (**a**) The patient presented an important asymmetry of the buttocks with lipodystrophy of the flanks and lipoatrophy of the lateral region of the left buttock in a disbalance hip. (**b**) The surgical plan has addressed different procedures to the each region. Gluteal implants of different volumes were placed associated with liposuction of the flanks and lipotransfer in the superolateral region on the left side. (**c**) Six months postoperative time

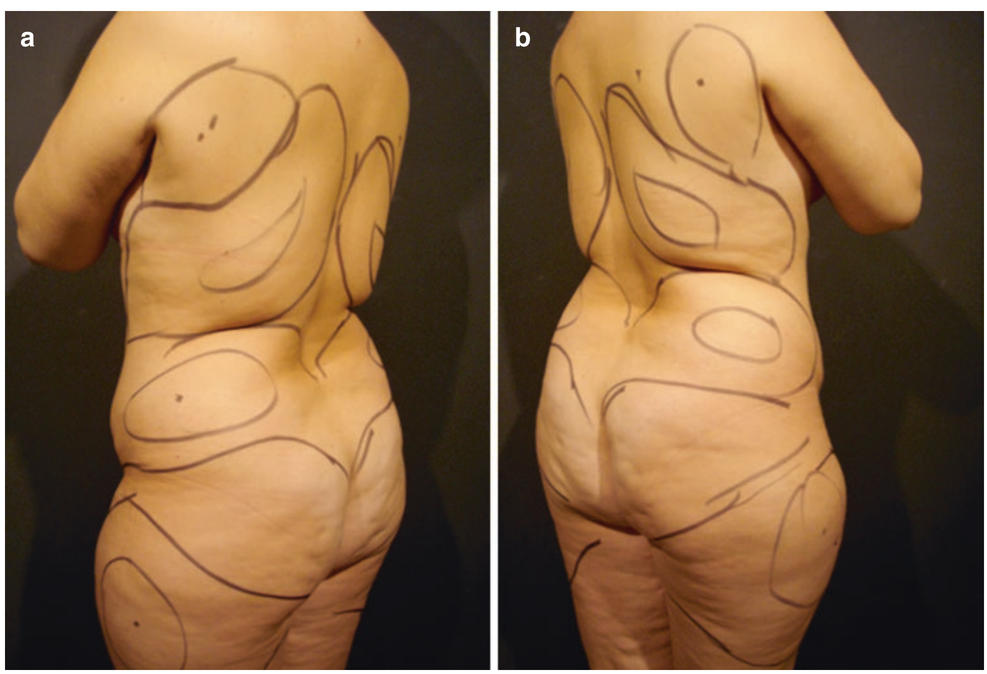


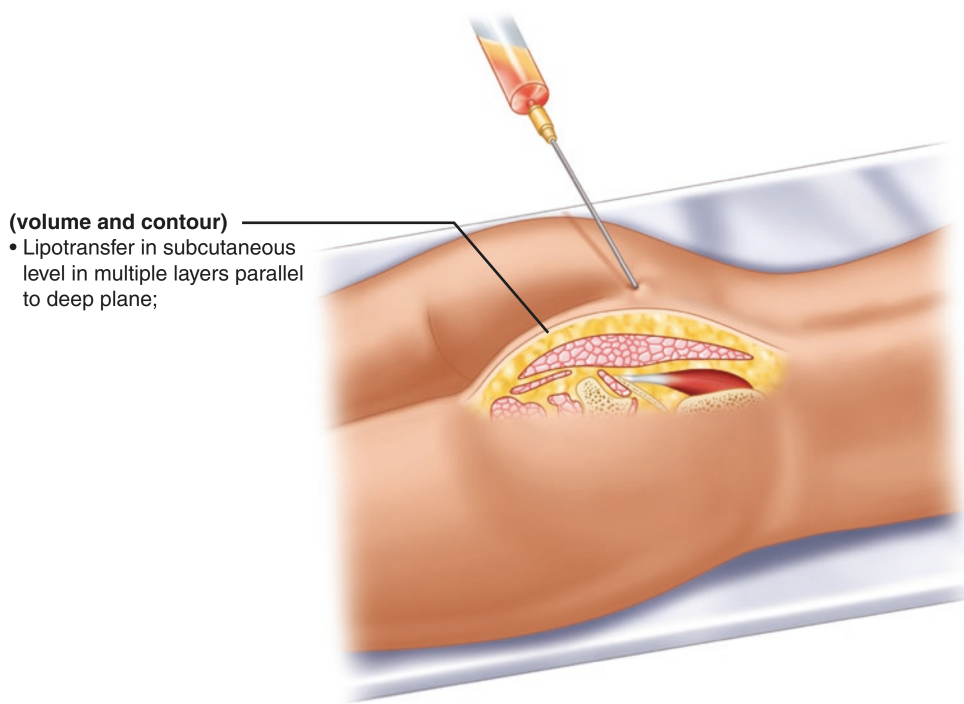
Fig. 14.8 Preoperative markings to identify areas of the volumetric dystrophy which will be lipoaspirate to harvesting adipose tissue

14.4.3 Lipotransfer

Preoperative markings are done to identify the areas of volumetric deficit (central or lateral). Small incisions are made with a #15 scalpel at three sites: superior, lateral, and inferior gluteal region. Fat is then injected using a 3 mm blunt-tipped cannula with a single hole connected to 60-ml catheter tip syringe using a multi-channel technique in a retrograde manner (Fig. 14.10). The amount of fat to be grafted is assessed based on the volume deficit, avoiding overcorrection and bolus injection. The parameter in the cases of asymmetry is the contralateral site. The volume of adipose tissue transferred to each buttock ranges from 150 ml to 600 ml. Fat is homogeneously deposited in the subcutaneous level in multilayers parallel to the deep plane to achieve volume augmentation, preventing the cannula tip to bend downward during fat grafting. The cannula access points are sutured with 5.0 nylon sutures.

Fig. 14.9 (**a**) After adipose tissue is collected, it is washed inside syringes with normal saline to remove blood and cell elements, and left to decant in the same 60-ml syringe used for fat harvesting. (**b**) The inferior layer, comprising blood, infiltrating fluid, and washing solution, is discarded. The *yellow* layer containing adipose tissue is prepared for grafting. (**c**) We prefer to use the catheter tip syringe for large lipotransfer volume due to the bigger tip diameter. We have measured the nozzle diameter of 60 mL syringe (Luer Lock tip): Nozzle **diameter** = 1.96 mm. Radius = 1.03 mm. Perimeter: 6.47 mm (form error: 0.020 mm; misunderstanding: 0.040 mm). The measure of the nozzle diameter of 60 mL syringe (catheter tip): Nozzle diameter = 3.60 mm. Radius = 1.87 mm. Perimeter: 11.37 mm (form error: 0.020 mm; misunderstanding: 0.040 mm) (*data from author*) [19]

Fig. 14.10 Fat is injected into the target sites using a 3 mm blunt-tipped cannula with a single hole connected to 60-ml catheter tip syringe using a multi-channel technique in a retrograde manner. The cannula movement must be parallel to the deep plane to achieve volume augmentation and prevent the cannula tip's downward movement during fat grafting. We prefer the subcutaneous plane for buttocks augmentation in most of the cases. In specific, cases could be injected in a superficial intramuscular plane to reach more volume and projection. The schematic way to lipotransfer into each layer in the gluteo



14.5 Final Considerations

To reach pleasant and long-lasting results, several factors must be considered in the pre-, intra-, and postoperative periods, in regards to the surgeon, the surgical technical approach, as well as the patient cooperation during the whole process [19]. Some potential limitations must be considered, such as a thin patient, severe gluteal flaccidity, demand for more than one surgical time, absorption index control, accuracy evaluation methods, and others. A comparative study among diverse surgical approaches to analyze the absorption rate and clinical results must be encouraged in order for this procedure to become a reproducible surgery with long-lasting results and maintenance of volume and normal gluteal characteristics. The adequate surgical planning must aim toward a safe and effective procedure, with all patients showing aesthetic improvement after a single lipotransfer surgery, without overcorrection and requirement of the additional procedure after years of follow-up. In the future, new treatments and technologies will be available to more suitable approaches to gluteoplasty.

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Gluteal Fat Augmentation with Vacuum-Assisted Liposuction

15

Rodrigo G. Rosique and Marina J. F. Rosique

15.1 Introduction

Vacuum-assisted liposuction (VAL) was the first method published of adipose tissue harvesting for gluteal fat augmentation [1] and is still widely used after more than 30 years. It is a straightforward technique that allows good tactile control while harvesting fat. In this chapter, we describe our personal experience with gluteal fat augmentation.

15.2 Preoperative Period

Proper patient selection is pivotal to ensure good results. The four main points to consider during the preoperative consultation are:

- Body fat percentage (BFP)
- Body mass index (BMI)
- Body shape
- Skin quality

When the patient has a low BFP, under 20%, there is usually not enough fat to work with. If the BFP is high, above 30%, we often ask the patient to lose weight and exercise to increase the muscle mass, ensuring more athletic results. A BFP between 20 and 30 allows good results with the use of fat.

If the BMI is under 20 kg/m^2, there might not be sufficient fat to achieve good results. Due to safety reasons in Brazil, the volume of fat that can be harvested is limited to 7% of the body weight. Therefore, if the BMI is above 30 kg/m^2, some fat will be left behind leading to less optimal results. With a BMI between 20 and 30, the excess fat can be safely removed and we can achieve great results.

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Patients are instructed to avoid losing weight 4 weeks before surgery, in order to prevent trans-operative anemia and low protein conditions.

Certain body shapes are difficult to work with and may be challenging to obtain the desired hourglass figure. Patients with banana or apple body shapes are advised preoperatively of the limitations of their body frames, and the expectations should be lowered (Fig. 15.1).

Lastly, the skin must be of good quality and elasticity, otherwise there will be flaccid skin and laxity, requiring skin excision procedures, especially in massive weight loss patients.

15.2.1 Marking

With the patient standing, the donor and recipient areas are marked. The donor sites vary with each patient, but usually comprise the flanks, the torso, the sacral region, and occasionally the arms, saddlebags, and inner thighs.

It is important to build a transition zone between the lower torso and the buttocks, in a wide-opened arc shape over each buttock beginning at the apex of the intergluteal cleft. This 1-inch wide line should not be suctioned or grafted.

The area to be grafted is usually a transverse oval shape, pointing outward and slightly displaced toward the superior part of the buttocks (to lift) and the lateral part (to fill the lateral curve). This area overlaps the gluteus maximus and the fossa between the gluteus maximus, gluteus medius, and tensor fasciae lata, from the lateral border of the sacrum to the femoral neck. In some patients, we also perform fat grafting in the greater trochanter depression to achieve a harmonious contour (Fig. 15.2).

15.2.2 Positioning of the Patient

The patient is placed prone as we think that this position is more stable than the lateral decubitus. This prevents an extra

A. Cansanção, A. Condé-Green (eds.), *Gluteal Fat Augmentation*, https://doi.org/10.1007/978-3-030-58945-5_15

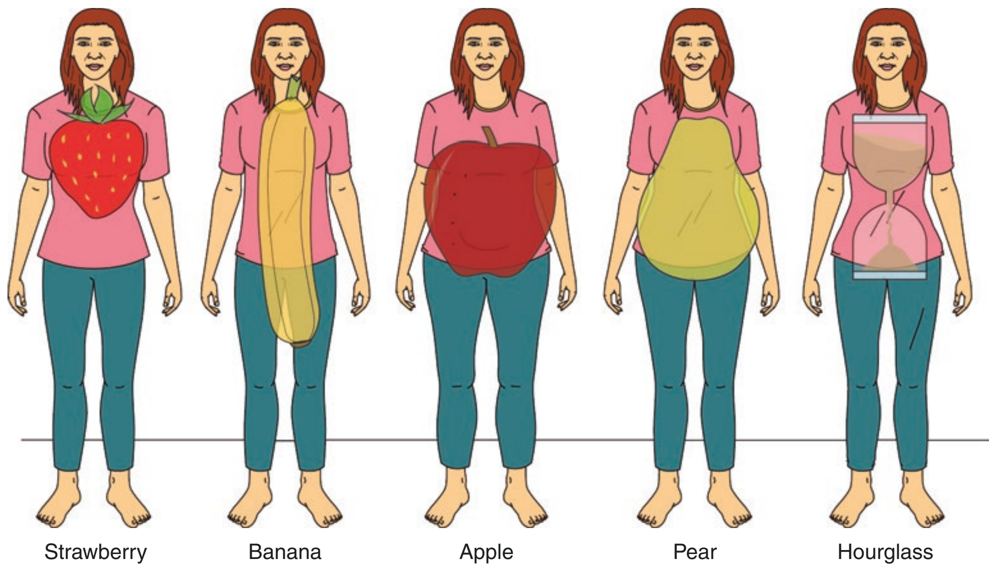

Fig. 15.1 Most common female body shapes

Fig. 15.2 Transition zone between the lower torso and the buttocks. With the patient in standing position, we mark the most pronounced points or lines to be suctioned or grafted and draw concentric areas around them. Fat harvesting sites upper body (*green*), fat harvesting sites lower body (*yellow*), grafted areas (*black*). The *blue line* is the transition area, or "no touch" area. Most of the fat is grafted over the gluteus maximus muscle (*black*). In some patients, fat is also injected over the great trochanter (*red*), especially if this area shows some depression during hip flexion

change in position and allows the placement of entry ports for the cannulas in well-defined anatomical landmarks. When the amount of fat required to achieve the desired outcomes is greater than the amount of fat available on the back, we place the patient supine to harvest some fat from the abdomen and the thighs.

15.2.3 Anesthetic Technique

We perform gluteal fat augmentation under epidural anesthesia due to its longer postoperative analgesia and proven beneficial effect in preventing thromboembolic events [2]. When the procedure is associated with an abdominoplasty or breast surgery where more than one intraoperative change of position is necessary, we use general anesthesia with an epidural block to avoid acute hypoxic cardiac arrest, which may occur during decubitus changes with a spinal block [3].

15.3 Intraoperative Period

15.3.1 Fat Harvesting

15.3.1.1 Infiltration

Infiltration is performed with the same cannulas used for liposuction with a solution of normal saline and epinephrine at 1:500,000 according to the wet technique. We avoid using local anesthetics in the solution as there have been reports of decreased adipocyte viability [4] and since the patient already has a neural block, local anesthetics are not necessary.

15.3.1.2 Donor Sites

We minimize the ports of entry for the cannulas as much as possible. In the back, we use one port in the center of the bra line and one at the apex of the intergluteal cleft. The fat is harvested from the whole back in a fan-shape fashion, criss-crossing the liposuction trajectory from the upper and lower cannula ports.

We use one port in each infra-gluteal fold and aspirate fat from the saddlebags in a deep plane, leaving an intact superficial layer of fat, in a continuous line starting at the lateral aspect of the knees to avoid any contour irregularities. From these same ports, the posterior inner thighs and the sub-gluteal fat is harvested as needed.

15.3.1.3 Equipment Used

An electrical vacuum pump set at approximately -400 mmHg is connected by a flexible silicone tube to a sterile glass canister covered with a rubber cap that will store the lipoaspirate. A second flexible silicone tube connects the canister to the cannula (Fig. 15.3). Cannulas of 4 and 5 mm diameter are used to harvest fat as some studies have shown greater adipocyte viability when larger diameter cannulas are used [5, 6]. To avoid clots within the lumen of the cannula, we use blunt cannulas with three holes.

15.3.2 Fat Processing

The lipoaspirate is decanted in a closed circuit. We open the canister only when ready for fat grafting. At this point, the supernatant fat is collected and injected.

15.3.3 Fat Injection

With the patient in prone and flat position, fat is injected in a superficial plane in order to give contour and shape to the gluteal region, beginning laterally in multiple planes, delivering small amounts of fat at each pass of a single-hole, 3.5-mm cannula attached to a Toomey tip 60 cc syringe. After the most lateral part is filled, we proceed medially. If there is hypoplasia at the medial buttock area, fat is injected near the intergluteal cleft in a centrifugal mode, always in the subcutaneous plane using the intergluteal incision site [7]. Fat is then injected deeper into the subcutaneous plane toward the lateral aspect of the gluteal muscles to increase projection, always keeping the cannula parallel to the sacral plane with a maximal angle of 30° to avoid injecting inside the muscles. Approximately 20–30% of the fat is grafted in the deep subcutaneous plane laterally and never in the central parts, in order to avoid inadvertently damaging or exerting pressure on the gluteal vessels [7] (Fig. 15.4). Cannulas with an internal diameter of 3 mm are preferred based on the classic theory of lipograft survival [8] or the recent substitution theory [9] which states that fat threads should be at most 1.5-mm radius to achieve long-term retention rates. Toledo published his 30-year experience showing that injecting 500 ccs of fat in each buttock is sufficient to achieve good results while keeping the incidence of complications low [10]. We also avoid injecting more than 500 ccs of fat in each buttock

Fig. 15.3 The vacuum-pump aspiration system in the operating theater

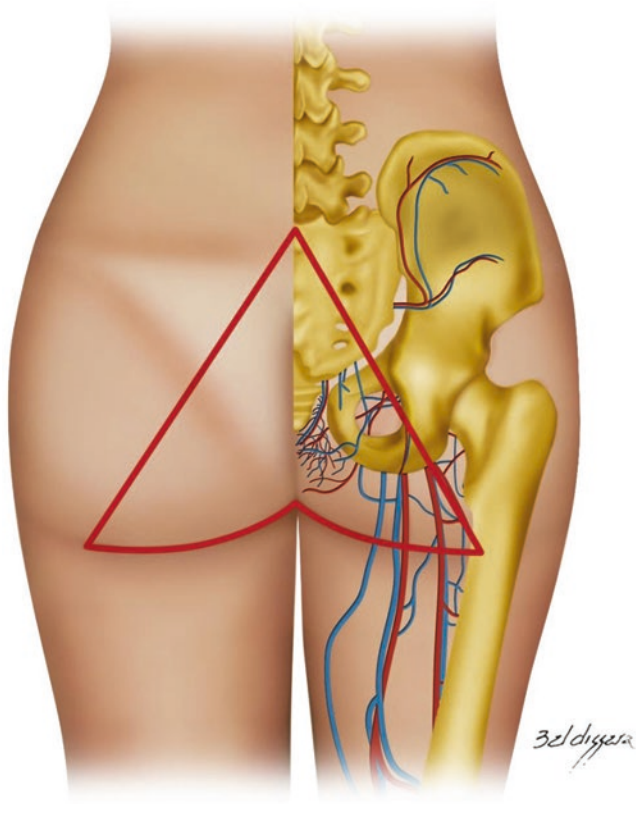

Fig. 15.4 Danger zone: Superficial (*left side*) and bone (*right side*) landmarks. The danger zone for deep fat grafting to the buttocks has a near pyramidal shape with its apex in the middle point between sacral dimples. Its base goes along the gluteal fold compromising the thighs' medial two-thirds and the lateral lines connect the apex to its base passing over the ischial spine. (Reprinted with authorization from Rosique and Rosique [7])

Fig. 15.5 Preop and 6 months postop of a 29-year-old female with BMI 20.5 Kg/m^2, who underwent liposuction (4L lipoaspirate) and injection of 540 cc of fat in each buttock. Note the lifting and augmentation effects by the lengthening of the intergluteal cleft (**a**, **b**, **c**) preoperative view, (**d**, **e**, **f**) postoperative view

(Fig. 15.5). If the patient needs or desires more volume, a second procedure can be done.

15.4 Postoperative Period

We routinely administer an intravenous dose of a first-generation cephalosporin at anesthetic induction and prescribe the same orally for 7 days in the postoperative period. Analgesics and multivitamins are also prescribed.

Following the deep venous thrombosis (DVT) risk factor assessment [11], we administer a standard dose of low molecular weight heparin subcutaneously daily for 7 days after the procedure. Patients also remain with intermittent pneumatic compressive devices for 12 h [12, 13]. They are encouraged to ambulate as soon as possible and drink lots of liquids during the first week.

15.4.1 Garments, Compression Socks, Massage

Compression socks and garments are used immediately postop and continued for 1 month and 2 months respectively. The garments compress the liposuctioned areas but also stabilize the grafted areas. A possible explanation why some pressure over the graft does not affect its viability clinically is based on the prevention of pressure sores using air or liquid mattresses by Pascal's principle, which states that when an enclosed liquid is directed to an external force, this force will be broken into several small forces spread all over the enclosed surface. Thus, when we enclose the grafted fat using compression garments, the force applied by lying over the buttocks will be broken into several minor forces that are not strong enough to prevent graft take, not to mention the graft stabilization effect promoted by the garment.

Massages over the grafted areas are avoided during the first 6 weeks because it can vigorously rupture the grafts' ongoing vascular reconnection process. Massages over liposuctioned areas are allowed and patients often fill much comfort.

15.4.2 Recommendations and Restrictions

Starting in the recovery room, patients rest over their buttocks. Pereira and Radwanski [14] showed in 1996 that, clinically, anterior body procedures can be associated while letting the patient lie over their buttocks without jeopardizing the grafted areas. Most of our buttock augmentations are performed concomitantly with abdominoplasty and breast surgery, and we observed that the supine position does not jeopardize the final outcomes of the procedure.

15.5 Follow-Up, Casuistic, and Complications

Between January 2011 and January 2016, we performed 845 gluteal fat augmentations either isolated or combined with other procedures. Patients had a mean age of 34 years old, a mean BMI of 25 Kg/m^2, and the mean volume of fat injected per buttock was 498 cc (Fig. 15.6). Minor complications included seroma in the sacral region (4%) and major complications included two cases of DVT confirmed by CT angiogram, and symptomatic hypovolemia requiring prolonged intravenous hydration (8%). The symptoms in the cases of DVT appeared at 7 and 9 days postop. There were no cases of mortality.

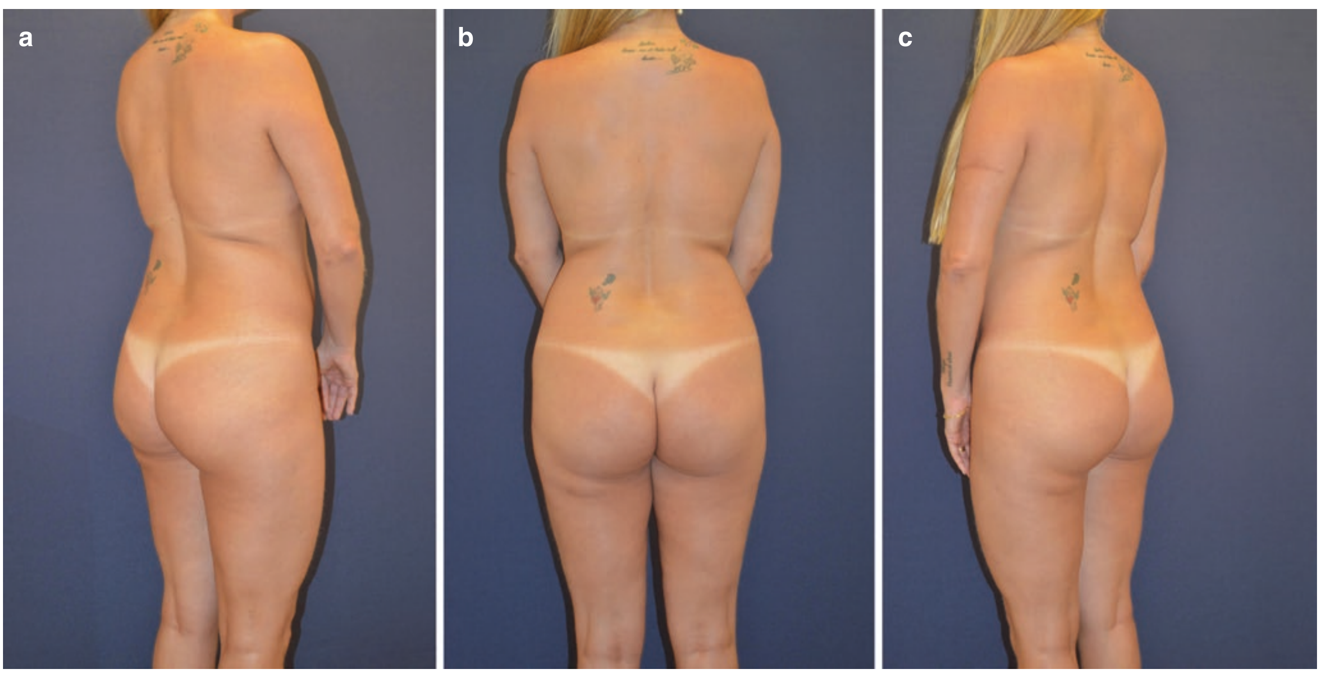

Fig. 15.6 Preop and 1 year postop of a 37-year-old female with BMI 24.2 kg/m2, who underwent liposuction (4.4L lipoaspirate) and injection of 540 cc of fat in each buttock. Note the improved contour and projection of the gluteal region. (**a**, **b**, **c**) preoperative view, (**d**, **e**, **f**) postoperative view

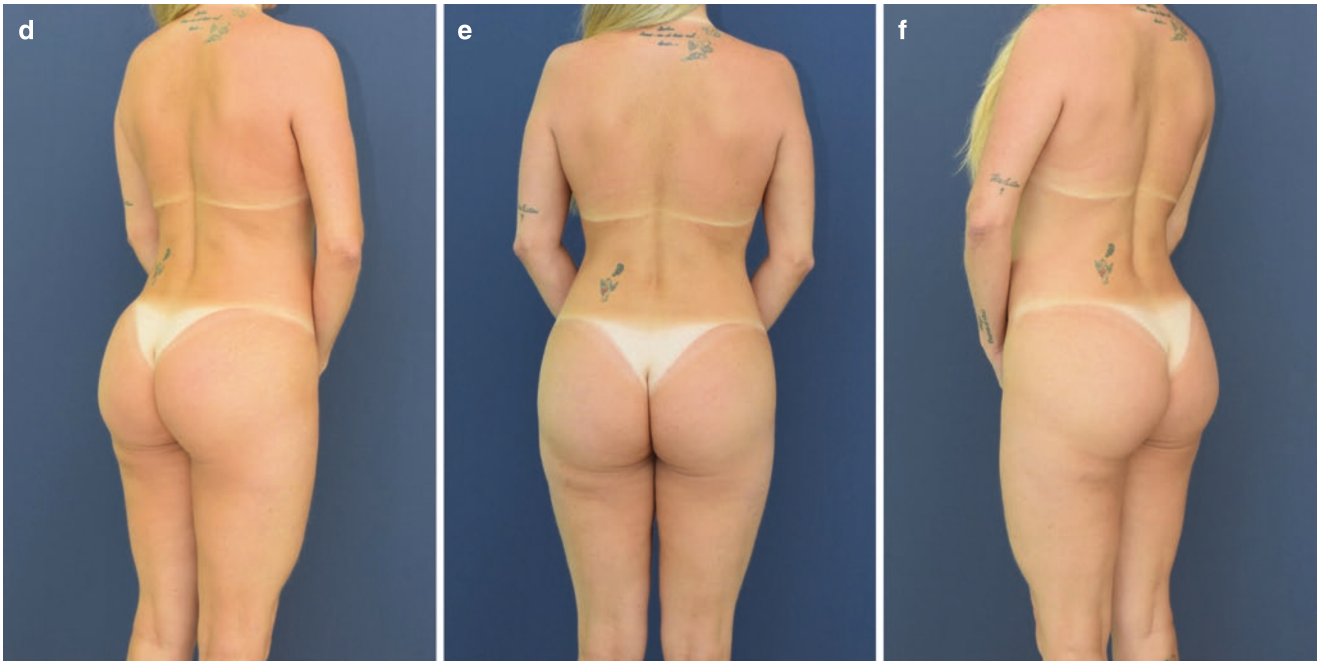

Fig. 15.6 (continued)

15.6 Discussion

The best technique to harvest fat is one that collects a great amount of viable cells, ensuring better and long-term results [15]. Concerning the negative pressure used to harvest fat, it was thought that syringes generated less negative pressure than the vacuum. Rodriguez and Condé-Green showed that syringes can generate as much negative pressure than a vacuum if the plunger is pulled completely [16]. Vacuum pumps can be set at a minimal pressure to harvest adipose tissue generating less cell damage and less surgeon fatigue.

15.7 Conclusion

Gluteal fat augmentation is a trend that will continue as long as we are able to deliver great results with maximal patient safety. Focus should be made to develop fat processing techniques that can extract infiltration solution, blood, and free oil from the lipoaspirate with minimal loss of viable cells and regenerative constituents.

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Gluteal Fat Augmentation with Power-Assisted Liposuction

16

Marwan H. Abboud, Hiba El Hajj, and Nicolas M. Abboud

16.1 Introduction

Proportion and symmetry have always been a cornerstone in body morphology and have always been emphasized in gluteal aesthetics. Curves, convexities, and concavities taking the shape of the letter *S* are the mainstay of female beauty. Liposuction and lipofilling are the most vigorous ways to bring about these curves and enhance buttocks projection. The power-assisted gluteal augmentation with fat grafting aims to improve body contour and emphasize the patients' appealing curves and proportions. Because shaping the buttocks is much more complex than increasing its volume, achieving an aesthetic gluteal contour is more than just a matter of adding fat and giving more volume.

In our previous experience, the technique was based on power-assisted liposuction of the buttocks surroundings and large-volume fat grafting, but it recently shifted to extensive liposuction and moderate fat injection volumes to achieve an aesthetic gluteal contour. This technique of gluteal augmentation is based on power-assisted liposuction lipofilling (PALL).

The key elements of power-assisted gluteal augmentation are:

- Preoperative evaluation and markings that are crucial to the planning of the procedure.
- Liposuction of the buttocks surroundings following axes and zones using a power-assisted device.
- Subcutaneous tunnelization to expand the recipient site, releasing the ligamentous attachments, and providing a larger space capacity (matrix) while allowing adequate contact between the grafted fat and the recipient site. Tunnelization is essential to dissociate the skin from the subcutaneous tissues as well as the subcutaneous tissues from the underlying fascia, to reduce any tensile force, and facilitate matrix modeling and fat injection.
- Simultaneous vibration and tunnelization in the recipient site during fat grafting, optimizing diffusion of the fat in the recipient site and thus increasing the volume of fat transfer.
- External vibration following fat transfer to further enhance the diffusion of fat in the recipient site.

16.2 Preoperative Period

The human body resembles a cylinder, therefore the gluteal contour cannot be dissociated from the abdomen, and a circumferential liposuction should be performed in order to obtain an S shape contour. One day prior to the surgery, patients are examined thoroughly in the standing position, where asymmetry, excess fat deposits, skin laxity, ptosis, hernia, muscle diastasis, and contour irregularities such as dimpling, cellulitis, banana rolls, and areas of adherence are pointed out to the patients and marked. Patient expectations regarding the outcomes of the procedure and the postoperative recovery are discussed in detail. Thrombosis risk factor assessment is performed using the Caprini score [1], and venous thromboembolism (VTE) prophylaxis is applied accordingly.

16.2.1 Posterior Preoperative Markings

Posterior preoperative markings are done with the patient in the standing position (Fig. 16.1). The posterior midline, the sacral dimples, the posterior axillary, the midaxillary, and the anterior axillary lines are marked. The two lines joining the posterior aspect of each axilla to the coccyx define the sacral triangle, and the line joining the medial aspect of the knee defines the inner posterior thigh zone of liposuction. Similarly, the line joining the posterior aspect

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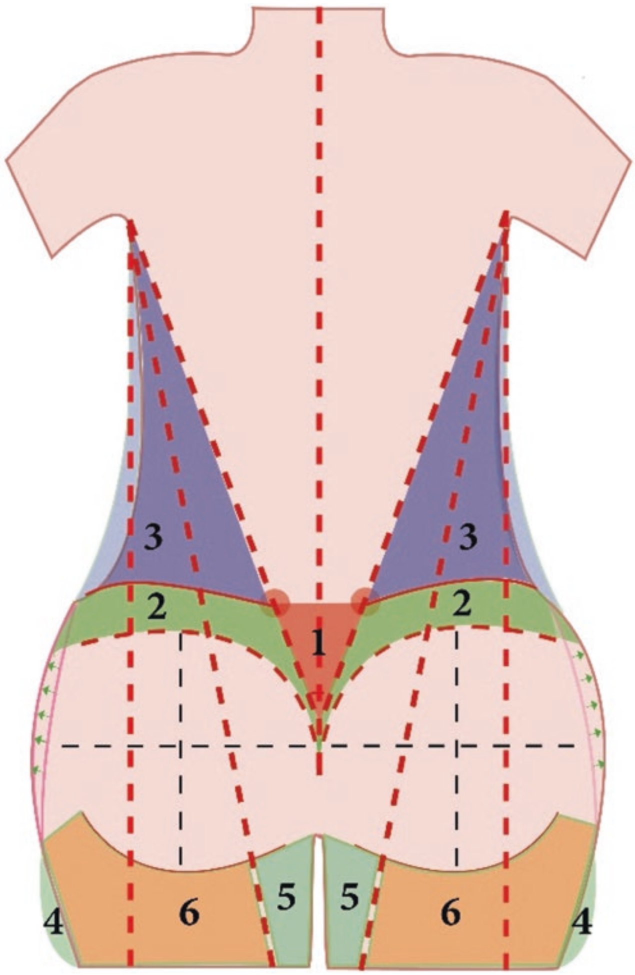

Fig. 16.1 Zones of liposuction. Zone 1: the sacral triangle; zone 2: the upper borders of the buttocks and flanks; zone 3: the upper lateral back; zone 4: the lateral thigh; zone 5: the inner thigh and the diamond zone; and zone 6: the inferior gluteal region

of the axilla to the lateral aspect of the knee determines the lateral thigh zone of liposuction. The infragluteal folds are marked. The upper limit of the buttocks is defined by a line joining the inguinal crease anteriorly to the coccyx posteriorly. The waistline is defined by drawing a horizontal line passing through the umbilicus and joining the dimples posteriorly.

Together, these axes outline six specific liposuction zones that delineate the technique of liposculpting to obtain the hourglass body shape: zone 1 is the sacral triangle; zone 2 consists of the upper borders of the buttocks and flanks; zone 3 is the upper lateral back; zone 4 is the lateral thigh; zone 5 includes the inner thigh and the diamond zone; and zone 6 is the inferior gluteal region. Then, the zones of lipofilling are marked according to the presence of depressions and contour deformities located at the lateral and upper aspects of the buttocks.

16.2.2 Anterior Preoperative Markings

With the patient in the standing position, the anterior midline is marked. The width of the pubis is defined by drawing a horizontal line at the level of the anterior vulvar commissure and extending laterally to the inguinal crease. The breast axis is marked and joins the lateral borders of the pubis to define the shape of the pubis. The line joining the posterior aspect of the axilla to the pubis defines the oblique lines, and the line joining the anterior aspect of the axilla to the medial aspect of the knee defines the inner thigh liposuction zone. The inguinal crease is also marked. The different zones of liposuction are marked in order to achieve liposculpture of the abdomen with better definition of the waistline, the costal margins, the linea alba, and the pubis. Preoperative photos are taken in eight basic views: posterior and anterior, right and left laterals, right and left posterior three-quarter profiles, and right and left anterior three-quarter profiles.

16.2.3 Patient Positioning

Following the administration of general anesthesia, the patient is placed prone for fat harvesting of the previously marked posterior areas of the body. The head is rested on a foam pillow with cutouts for the eyes, nose, and mouth. Proper positioning of the head and neck must be checked, with careful attention to the position of the eyes. The arms are placed on arm boards, abducted to less than 90 degrees at the shoulders and flexed at the elbows. All of the bony prominences are padded. Thoracic and hip bolsters are placed. The patient's abdomen must not be compressed, the breasts should be placed medial to the thoracic bolsters, and the buttocks surroundings should be well exposed. Pneumatic compression stockings are connected before the induction. A total of 10 ml tranexamic acid (Exacyl) 0.5 g/5 ml is routinely administered to all patients except in the case of a history of venous or arterial thrombosis [2]. Preoperative antibiotics with a first-generation cephalosporin is administered 30 minutes before starting the procedure.

16.2.4 Skin Incisions

Symmetrical access incisions along different axes are done as follows: (1) supine with one incision in the superior aspect of the umbilicus, one on each side of the lower abdomen, one on each side of the inguinal creases, one on each side of the lateral thighs, one on each side of the lateral flanks, and one on each side of the midlateral abdomen; (2) prone with one incision at the level of each posterior superior iliac spine, one or two in the posterior flanks, one on each side of the midlateral back, and one on each lower gluteal crease.

16.2.5 Infiltration

Superwet infiltration is performed using a solution containing 5 ml of tranexamic acid (Exacyl) 0.5 g/5 ml and 1 ml of epinephrine (11000) per liter of normal saline using a power-assisted liposuction system (Lipomatic Eva SP, EUROMI SA, Verviers, Belgium) connected to a 3 mm diameter blunt tip multi-hole cannula. The addition of tranexamic acid (Exacyl) to the infiltration helps reduce the amount of blood loss and has been used in our practice for over a decade. While waiting for the vasoconstrictive effect of epinephrine, tunneling is performed to enhance the diffusion of the infiltration solution, releasing the tethering attachments that will facilitate the liposculpture.

16.3 Fat Harvesting

Fat is harvested through the incisions mentioned above with a 3-mm diameter blunt tip multi-hole cannula attached to a power-assisted hand-piece, set at three bars vibrating pressure and 0.7 atm suction pressure. Power-assisted liposuction is performed in the previously described six zones, in their respective order starting at the sacral triangle, followed by the waistline, the flanks, the inner and outer thighs (Fig. 16.1). In order to avoid contour irregularities, two main principles are applied: the use of multiple access points to reach the same region in a crisscross pattern with the cannula passing at various depths; and the initiation of the liposuction with a larger cannula (4- or 5-mm diameter) in the deeper subcutaneous zones. Subsequently, a smaller cannula (3-mm diameter) is used in the superficial subcutaneous zones. Liposuction is also performed along the axes, maintaining the cannula's holes facing the dermis to better define the aesthetic lines, enhancing the sacral triangle and the upper border of the buttocks. Finally, the oscillating cannula, detached from the suction system, is passed in the deep and superficial subcutaneous planes and in the matrix to further release the fibrous bands, facilitating molding of the matrix and recipient site expansion, obtaining a smoother surface. Through these multidirectional and multilayered subcutaneous tunneling, a matrix for subsequent fat grafting is prepared at the recipient site.

16.4 Fat Processing

The authors use decantation of harvested fat in a closed system to encourage its diffusion into the recipient site. The lipoaspirate that is kept dilute has shown a relatively higher resorption rate; therefore, to account for the volume lost to resorption, a larger volume of fat must be injected. The injection of diluted fat with simultaneous tissue vibration increases the grafting capacity of the recipient site by expanding the subcutaneous space, dispersing the fat, and preventing the coalescence of fat lobules [3–5]. Fat grafts become vascularized on day 7 after transplantation [6]. This is a sufficient amount of time for fluid in the dilute lipoaspirate to be absorbed so that it does not interfere between the graft and recipient site.

In our previous experience, fat was allowed to decant and transferred to 60-ml syringes. Over the past 4 years, we have been using a closed system to harvest, collect, and transfer fat, which has shown to be more practical. The system consists of a canister with a built-in filter where fat is collected; the extra liquid remains at the bottom of the container.

16.5 Fat Injection

A matrix for fat grafting is prepared at the recipient site by performing multidirectional and multilayered subcutaneous tunneling with the power-assisted system through several access incisions. With the hand-piece disconnected from the suction system, fat is injected through a custom-made cannula (V-shaped base; 3-hole, blunt tip 3-mm diameter) that enables simultaneous vibration at the recipient site (Fig. 16.2).

Lipofilling is achieved in a multiplanar and multiaxial fashion in the subcutaneous planes to improve gluteal projection, volume, and fill any existing irregularities. The upper, lateral, and lower zones of the buttocks typically require fat injection in the superficial and deep subcutaneous planes to achieve sufficient volume. In contrast, injection into the superficial plane is sufficient to correct contour and

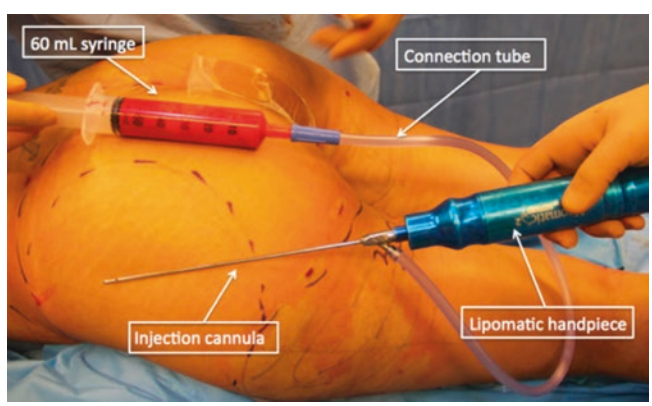

Fig. 16.2 Intraoperative views of a 32-year-old woman depicting the assembly of the power-assisted device for fat injection into the gluteal region. A tube is connected to the tip of a 60-mL syringe and to the base of the V-shaped cannula. The cannula, in turn, is connected to the power-assisted hand-piece, and suction is disabled. (Figure used with permission from Abboud et al. [3])

volume concerns in the medial zone of the buttock. No intramuscular or submuscular injections are performed. Injection is performed from superior and inferior incisions with the cannula remaining parallel to the muscular fibers, in order to minimize the risk of intramuscular fat injection. Combining tunnelization and vibration during fat transfer disperses the maximal amount of fat in the recipient site and avoids crowding and overloading scattered zones of fat to ensure maximal contact between the fat and the recipient site, optimizing revascularization and graft survival.

In some patients, we place an absorbable barbed suture around the buttock, guided through a 3-mm, 3-hole cannula using the skin stab incisions. This barbed suture allows better definition of the upper gluteal border and delineates the transition between the back and the buttocks units. Moreover, it can be placed to enhance the infragluteal fold and the definition of the diamond zone.

16.5.1 External Vibration

Following the completion of fat injection, additional external vibration is achieved by applying the power-assisted handpiece, set at 6 bars vibrating pressure on a vaseline gauze placed over the recipient site, and passing it over the complete area to further enhance the diffusion and distribution of fat. This maneuver is continued until the recipient site feels soft. Finally, the incisions are closed with simple sutures, and dressings are applied.

16.5.2 Supine Position

The patient subsequently is moved from the prone to the supine position for sculpting and fat harvesting along the preoperative markings on the thighs, the medial abdomen, and the lateral abdomen along the external obliques and inguinal creases. Liposuction with the patient supine enabled definition of the linea alba, the obliques, the medial and lateral thighs.

Similar to posterior liposuction, deep liposuction is performed using a 4-mm diameter cannula, superficial liposuction is performed using a 3-mm cannula, and excessive liposuction is performed using a 4-mm cannula with holes along the axes facing the dermis to better mark the aesthetic lines.

16.6 Postoperative Period

The dressings are changed after 3–4 days. Patients are instructed to wear compression garments at all times for 6 weeks. Sitting is allowed. Large-volume procedures may require 7–10 days before returning to work. Full activities are resumed in 3–4 weeks as tolerated. Postoperative massage and lymphatic drainage are important in the harvested sites beginning at 3 days postop, for a period of 2–3 weeks, as fluid tend to accumulate in these areas. Pressotherapy is also recommended during these sessions to further stimulate interstitial fluid reabsorption and lymphatic drainage. Postoperative radiofrequency may be used to achieve better skin tightening starting at 1 week postop, one session a week for 5 weeks.

16.7 Results

We have performed power-assisted gluteal augmentation since 2009 in a total of 442 patients. The mean age of the patients was 35 years old (range, 21–55 years), and the mean body mass index was 29 kg/m^2 (range, 25–36 kg/m^2). The mean liposuction volume was 2700 mL (range, 1400–5000 mL), and the mean injected volume of fat was 500 mL per side during a single session (range, 280–900 mL) (Figs. 16.3 and 16.4). At the beginning, we injected large volumes of fat to achieve gluteal augmentation. Since 2014, we have been injecting less volume (average 350 cc per side) and performing more liposuction of the buttocks surroundings. The mean operating time was 90 minutes (range, 60–120 minutes) when no liposuction of the abdomen was performed and when there is no change in position of the patient. A total of nine patients (2%) underwent a secondary procedure to achieve the desired outcomes.

The mean follow-up period was 20 months (range, 12–48 months). A total of 22 patients (5%) experienced intermittent burning sensation in the flank. This sensation was attributed to aggressive liposuction in this area and resolved spontaneously in all patients by 6 months postoperatively. Six patients (1.35%) experienced edema of the sacral region and lower back that resolved after 6 months. Two patients (0.45%) had mild erythema of the buttock, 10 days after injection of 600 mL of fat to each buttock. These patients did not present any sign of systemic infection and were effectively treated with oral antibiotics. No patient developed seromas or hematomas postoperatively, and there were no major complications such as VTE or fat embolism. The absence of fat embolism is related to the safety factors, well described in the literature, that we adhered to in our practice, namely injecting fat only in the subcutaneous plane using large cannulas, in a slow and continuous motion, from superior and inferior incisions, in a direction parallel to the muscle fibers and avoiding high graft fill pressure [7].

Of the 442 patients, 358 (81%) completed a questionnaire to assess the satisfaction rate of the procedure at 6 months postoperatively. A total of 87% of patients indicated that they would undergo the same surgical procedure or recommend it

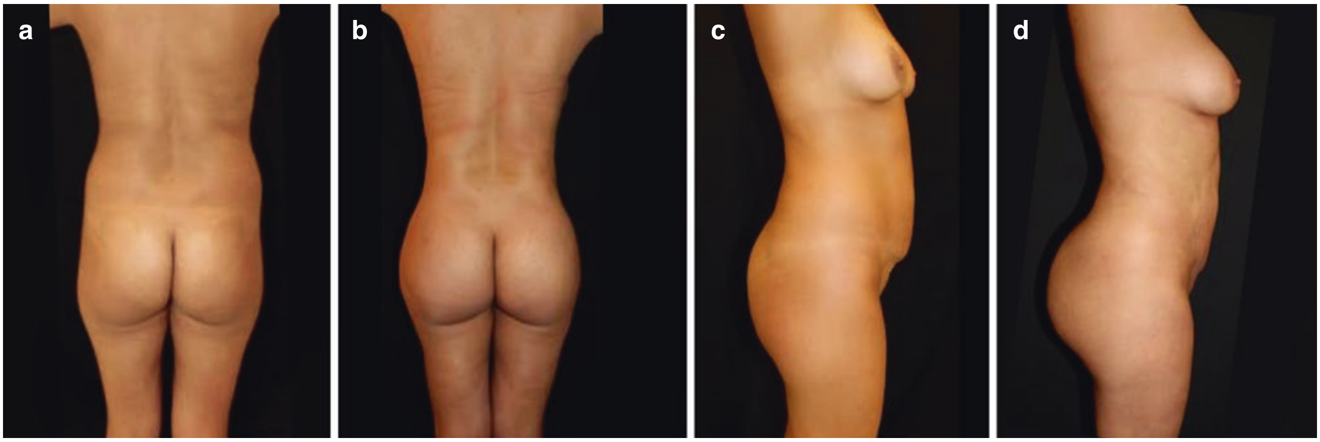

Fig. 16.3 (**a**–**d**) This is a 40-year-old woman presented with a waist-to-hip ratio (WHR) of 0.84 preoperatively. She underwent liposuction of the back units, abdomen, flanks, inner and outer thighs. Lipoaspirate volume 3000 mL, gluteal lipofilling with 450 mL per side. Patient at 1 year postop with a WHR of 0.65

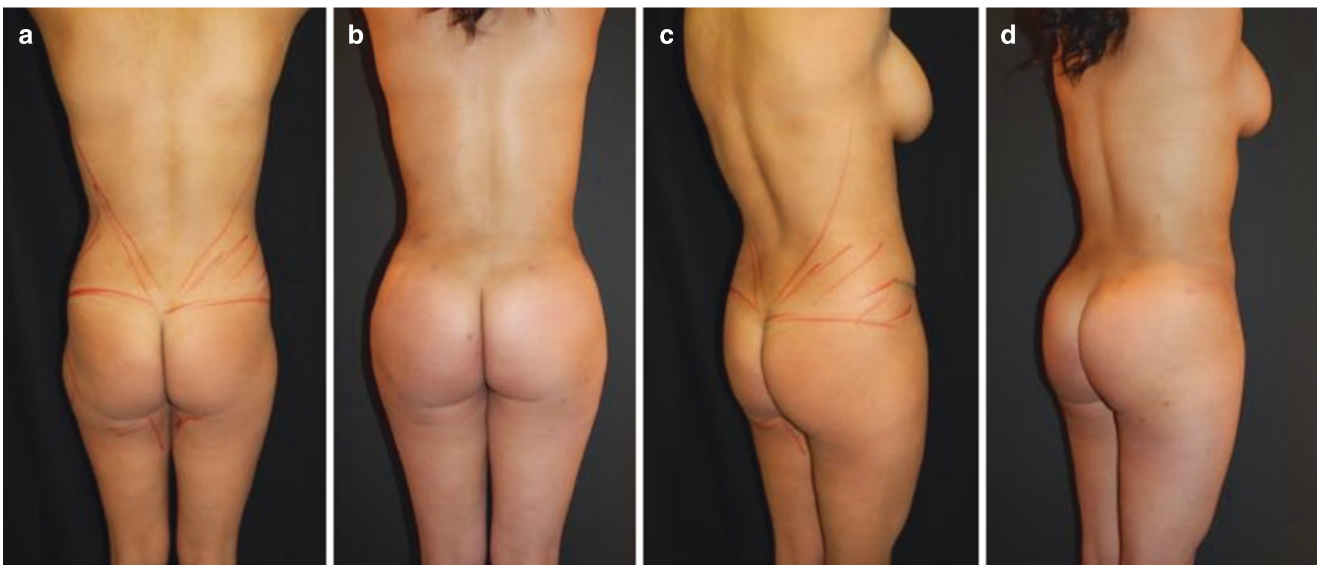

Fig. 16.4 (**a**–**d**) This 35-year-old woman presented with WHR of 0.90 preoperatively. She underwent liposuction of the back units, abdomen, flanks, inner and outer thighs. Lipoaspirate volume 3100 mL, gluteal lipofilling with 350 mL per side. Patient at 1 year postop with a WHR of 0.78

to a friend, 86% were satisfied with the final gluteal shape, and 85% reported improved psychological well-being as a result of the gluteal fat augmentation.

16.8 Discussion

Gluteal augmentation using fat grafting has the main advantage of providing patients with not only gluteal augmentation but also improving body contouring. Mendieta established a classification system for the buttocks describing 10 aesthetic units, six of which are crucial for defining the frame and shape of the buttocks [8]. Gluteal implants provide a localized projection of the buttock, whereas gluteal liposculpture addresses all the aesthetic subunits in order to achieve the best aesthetic results [8]. Furthermore, the risks inherent to gluteal implants include rotation, capsular contracture, seroma, extrusion, displacement, and more recently anaplastic large cell lymphoma [9–11].

However, gluteal fat transfer has also been associated with several minor and major complications, including fat necrosis, granuloma formation, abscess, contour irregularities, sciatic nerve injury, and the most feared one, fat embolism with possible fatal outcome [11]. Although autologous fat transfer is associated with the lowest rate of complications (10.5%), many plastic surgeons still fear fat embolism [12–14]. This has motivated us to develop our surgical technique in order to reduce the amount of fat injection, while achieving better buttock contour and projection. Combining power-assisted liposuction according to specific axes with moderate autologous fat transfer is the cornerstone of this technique.

We have used the PALL technique for gluteal augmentation since 2009 [3] and recently published the same technique for breast and arm reshaping [4]. This technique consists of the preparation of a matrix by means of power-assisted vibration and tunnelization to increase the recipient site capacity, allowing for large-volume fat grafting without compromising the safety of the procedure or significantly increasing the operative time. The keystone of this procedure relies on making preoperative markings that simplify and expedite the identification of zones of liposuction and sculpting the gluteal region. Preoperative evaluation of the body is crucial to detect any asymmetry, identify zones of excess fat, as well as volume-deficient aesthetic zones in order to achieve a harmonious body contour.

The operating time is reduced with the use of the power-assisted system, allowing liposuction, sculpting, tunnelization of the recipient site, and fat transfer to proceed swiftly. The ideal candidates for gluteal fat grafting are patients who are normal to slightly overweight, with mild to moderate body fat excess and flat buttocks. The final gluteal shape is more dependent on liposuction of the gluteal surroundings than lipofilling of the buttocks. Liposuction of the lateral flanks, sculpting the cylinder shape, and defining the waistline are key elements in gluteal liposculpture. Even if a portion of the injected fat is resorbed over time, meticulous sculpting of these surrounding zones offers long-term aesthetic changes to the gluteal shape. Power-assisted liposuction compared to manual aspiration was associated with viable adipose-derived stem cells and was considered a valid tool for fat harvesting. Moreover, cells harvested with power-assisted liposuction expressed significantly higher levels of differentiation markers when compared with manual aspiration, suggesting that the fat transferred from the products of power-assisted liposuction could develop into mature adipocytes more rapidly [15, 16].

We used a 3-mm cannula for liposuction and fat grafting. Erdim et al. [17] found that using a large cannula yields more viable fat cells. However, the 3-mm cannula allows for precise shaping around the buttocks and prevents contour irregularities. Furthermore, applying a suction pressure of 0.7 atm is safe and does not diminish the viability of the fat graft.

16.9 Conclusion

Optimal gluteal augmentation by autologous fat grafting relies on meticulous preoperative planning and consists of a synergistic approach between extensive liposuction of the buttocks surrounding and injection of moderate volumes of fat to create an aesthetically pleasing projection and contour. The incorporation of the power-assisted system maintains the safety of this procedure while enabling the surgeon to perform gluteal augmentation within a reasonable operating time, achieving pleasant aesthetic outcomes.

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17 Gluteal Augmentation with Stromal Vascular Fraction-Enriched Fat

Luiz Haroldo Pereira, Beatriz Nicaretta, and Aris Sterodimas

17.1 Introduction

Over the past decades, the demand for a better definition of the body and the gluteal region has increased [1]. Augmenting the buttocks by placement of silicone implants is a commonly performed procedure. The relatively high incidence of implant-related complications, for example, infection, malpositioning, nerve compression, delayed wound healing, or unnatural aesthetic appearance, lead to the quest for alternative techniques [2]. With the advent of liposuction in the 1980s, it became possible to aspirate and reinject fat, allowing transplantation of small volumes for soft-tissue augmentation and correction of contour irregularities [3]. In the last 25 years, different techniques of lipoinjection were developed to correct soft tissue defects for aesthetic and reconstructive purposes [4, 5]. A significant proportion of the engrafted fat undergoes resorption and necrosis due to the non-vascularized nature of the graft. The unpredictable degree of resorption of the transplanted fat may require repeated fat grafting sessions in order to obtain the final result, leading to increased cost and risks for patients [6]. On the other hand, injecting large volumes of fat may result in complications such as seroma formation, liponecrosis, cysts, infection, and fat embolism syndrome. As in every surgical procedure, the success of gluteal fat grafting is dependent upon many factors: the techniques and instruments used to harvest fat, fat processing, the volume of fat injected, the recipient sites, and the individual patient [7]. The concept of refining techniques for liposuction and lipoinjection according to individual anatomical zones is essential to the evolution of the procedure. Efforts to improve fat grafting have been made in the last 10 years. The addition of stromal vascular fraction (SVF) that contains regenerative cells including adipose-derived stem cells (ADSCs) to fat has shown to increase graft take. We describe our protocol of Stromal Enriched Lipograft (SEL™) for gluteal fat augmentation.

17.2 Patient Selection

Healthy adults presenting with mild to moderate excess fat and who desire more projection and improved contour of the gluteal region are candidates for gluteal augmentation with SEL™.

17.3 Surgical Technique

Marking of the donor and recipient sites is done with the patient in a standing position (Fig. 17.1). Loco-regional anesthesia and intravenous sedation are administered. Depending on the amount of fat needed, the patient may be placed supine first to access the anterior trunk and lower extremities or prone to access the posterior trunk and inject fat in the gluteal region. Subcutaneous infiltration of the donor sites with a solution of normal saline and epinephrine (1:500,000) according to the wet technique is done with blunt small-bore cannulas. After 15 minutes, liposuction is performed with a 4 mm diameter blunt cannula attached to a 60-cc syringe through the intergluteal cleft, two superior incisions near the iliac crest, and two inferior incisions in the gluteal folds.

In the SEL™ technique, the lipoaspirate once collected is treated in the following manner (Fig. 17.2). In general, two-thirds of the lipoaspirate are digested with 0.075% collagenase (Sigma, St. Louis, MO) in buffered saline solution and agitated for 30 minutes at 37 °C in order to isolate the SVF. The solution is then transferred in 10 ml syringes that are centrifuged at 1200 × g for 5 min (IEC Medispin Tabletop

There are no disclosures or conflicts of interest to be made.

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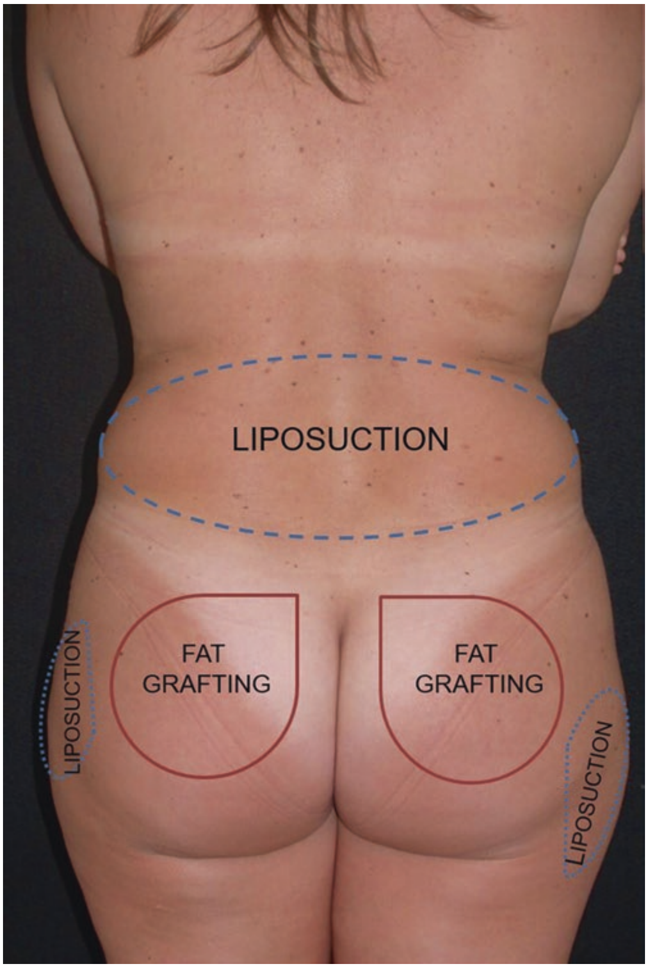

Fig. 17.1 Marking of the areas of liposuction and fat grafting with the patient in a standing position

Centrifuge, Needham, MA). The pellet derived from the centrifuged solution is located at the bottom of the syringes and represents the SVF. This procedure is done in the operating room theatre by two laboratory personnel manually, and the time required is about 90 min. The remaining one-third of the lipoaspirate is maintained in syringes held vertically with the open-end facing down in order to separate the fat and the bloody fluid. Normal saline is added to the syringes in order to wash the fat and after decantation the bloody fluid is discarded. The procedure is repeated until the fat is free of blood and other contaminants (Fig. 17.3). Mixing of the SVF containing ADSCs and the washed and decanted fat is done and transferred in 10 ml syringes for injection. The SVF-enriched fat is injected subcutaneously in the gluteal region, in multiple tunnels, in a retrograde manner using 3–4 mm diameter blunt cannulas through an intergluteal cleft incision. Additional incisions may be used for fat injection in order to treat the whole gluteal region (Fig. 17.4). The patient remains hospitalized for 24 hours. Antibiotics, analgesics, and anti-inflammatory medications are prescribed during the following 7 postoperative days. A fitted compression garment is used starting on the second postoperative day up to 4 weeks after, exerting more compression in the lower back and donor sites and no compression in the buttocks and thighs where fat was grafted. There are no specific position limitations as patients are allowed to sit or remain supine after the surgery. Return to mild physical activities is allowed after the third postoperative week.

17.4 Results

17.4.1 Patient 1

A 28-year-old healthy woman with a body mass index (BMI) of 22.1 kg/cm^2 presented to our clinic complaining of lack of projection and contour of the buttocks and thighs. She presented lateral depressions of the buttocks, lack of projection, and excess localized fat in the flanks and thighs (Fig. 17.5a, b). Extensive liposuction of the back, flanks, and upper thighs was performed (2100 cc lipoaspirate). A total of 350 cc of SVF-enriched fat was injected per buttock with no complication. The contour of the entire body improved significantly. Figure 17.5c, d shows the results 3 years postoperatively.

17.4.2 Patient 2

A 36-year-old healthy woman with a BMI of 19.38 kg/cm^2 presented to our clinic complaining of lack of projection and contour of the buttocks and excess fat in the lower back and thighs. On physical examination, she presented an A-shape buttock and localized fat in the lower back and thighs (Fig. 17.6a, b). Extensive liposuction of the abdomen, thighs, back, and flanks was performed (2700 cc lipoaspirate). A total of 410 cc of SVF-enriched fat was injected per buttock with no complication. The contour of the entire body improved significantly. Figure 17.6c, d shows the results 1 year after the procedure.

17.5 Discussion

A standardized technique of combining liposuction of the back, flanks, and hips with fat grafting in the upper-middle buttock to improve gluteal contour and projection was first described by Pereira et al. [5]. For predictable results, the surgeon should process the fat, using sterile conditions and avoid external contact, preventing contamination of the fat. Transplanting a high percentage of nonviable components such as blood and other contaminants reduces the potential for accurate volume estimation. In contrast to the facial

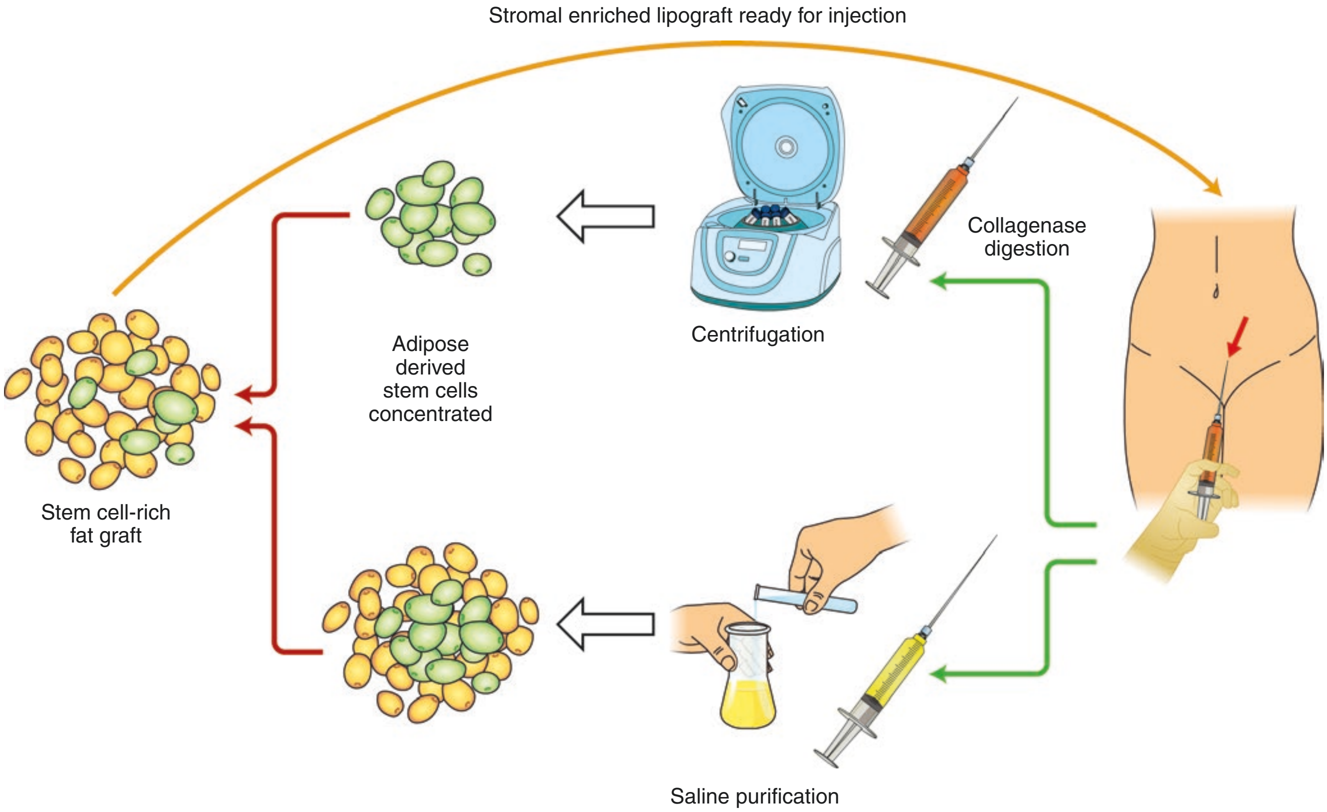

Fig. 17.2 Schematic representation of the Stromal Enriched Lipograft™

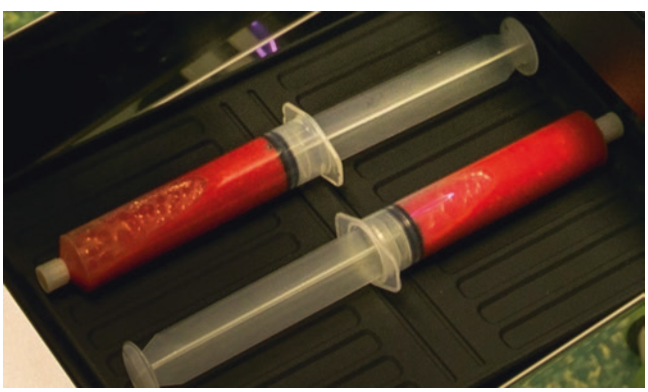

Fig. 17.3 The lipoaspirate are kept in syringes held vertically with the open-end down allowing the fat and bloody fluid to separate

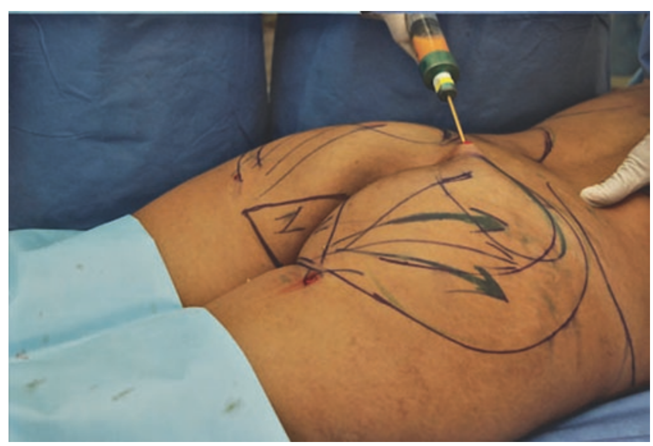

Fig. 17.4 The fat is injected via an intergluteal cleft incision in different tunnels in the subcutaneous plane of the buttocks

region, where graft absorption is notoriously high, the rate of volume loss in the gluteal region and thighs is known to be much lower. The average tissue loss because of reabsorption after lipoinjection in the buttock varies between 24% and 36% [8]. The present study confirms the senior author's clinical observation of over 18 years, producing high patient satisfaction and a low rate of complications after autologous gluteal lipograft. In a study by Nicaretta et al., a high patient satisfaction is reported in the short and long term after the surgery [9]. The limitations of fat grafting are well known, particularly the long-term unpredictability of volume maintenance [10]. Increasing the volume of fat grafting in one area may lead to complications such as liponecrosis, infection, and life-threatening fat embolism syndrome [11]. Regenerative cell-based strategies such as those encompassing the use of regenerative cells hold tremendous promise for augmentation of the soft-tissue space. Lipoaspirate, an other-

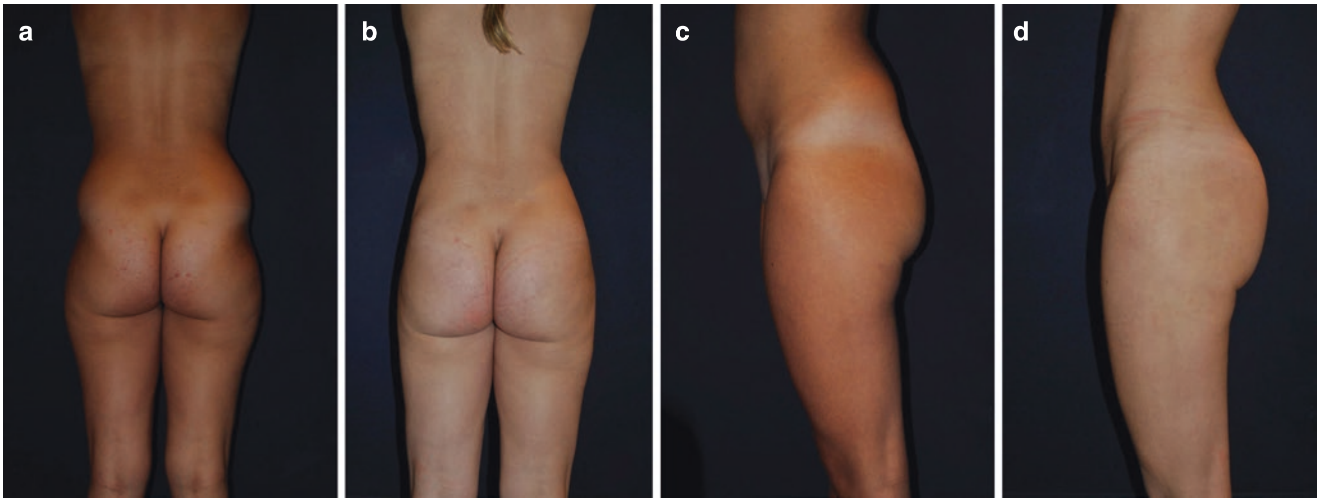

Fig. 17.5 (**a**, **b**) Preoperative photos of a 28-year-old woman, BMI 22.1 kg/cm^2 presenting with lateral depressions of the buttocks, lack of projection, and excess localized fat in the flanks and thighs. (**c**, **d**) Photos at 3 years postoperatively, after injection of 350 cc of SVF-enriched fat per buttock

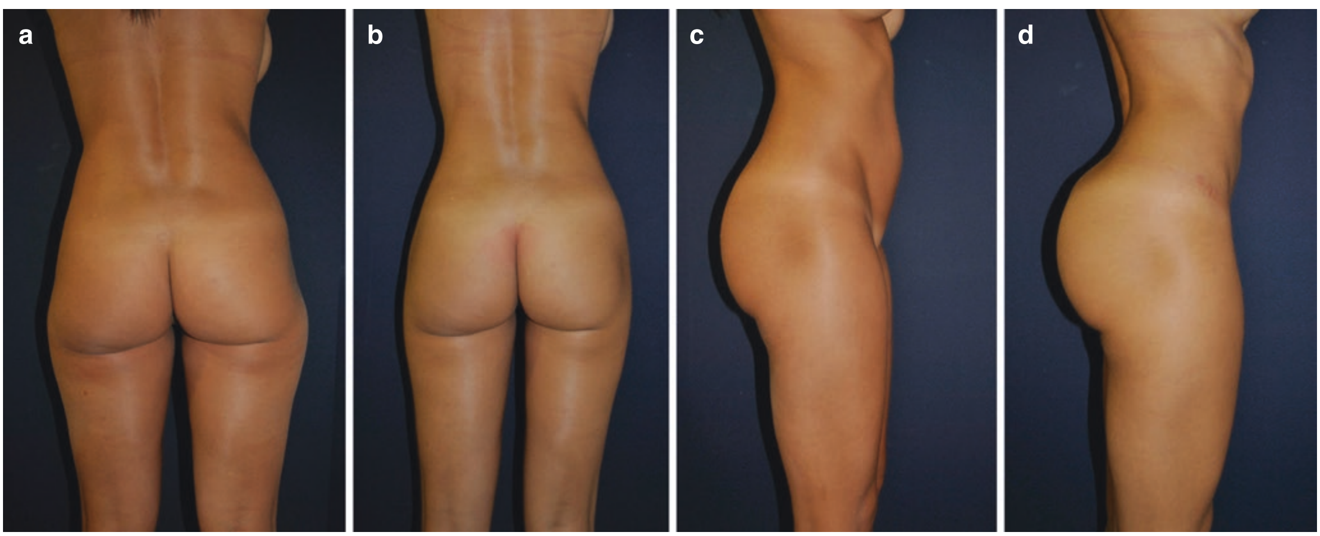

Fig. 17.6 (**a**, **b**) Preoperative photos of a 36-year-old woman, BMI 19.8 kg/cm^2 presenting an A-shape buttock and localized fat in the lower back and thighs. (**c**, **d**) Photos at 1 year postoperatively, after injection of 410 cc of SVF-enriched fat per buttock

wise disposable by-product of aesthetic surgery, has shown to contain a putative population of stem cells, termed ADSCs that reside within the adipose SVF which is thought to harbor cells that display extensive proliferative capacity and multilineage potential [12]. With better understanding of fat biology and more clinical experience, it becomes obvious that survival of transplanted fat is influenced by various factors such as the characteristics of patients, methods of fat processing, and the recipient bed [13]. According to recent studies, adipocytes existing within 300 μm from the surface of transplanted adipose tissue survive, but most adipocytes located deeper die within 24 hours. Some ADSCs survive in the deeper part of the transplanted fat and play an important role in regenerating adipose tissue. The regenerative features of SVF are attributable to its paracrine effects. SVF cells secrete vascular endothelial growth factor, hepatocyte growth factor, and transforming growth factor-β in the presence of stimuli such as hypoxia, and strongly influence the differentiation of stem cells, promoting angiogenesis, improving wound healing, and potentially aiding new tissue growth and development [14]. In Stromal Enriched Lipograft™, autologous ADSCs are used in combination with fat. SVF containing ADSCs is freshly isolated from two-thirds or half of the lipoaspirate and recombined with the other third or half. This process converts relatively SVF-poor aspirated fat to SVF-enriched fat. SEL™ has been shown to survive better than conventional fat graft and microvasculature can be detected more prominently in SEL™, especially in the outer layers of fat [9]. Future fat grafting may not be a only fat tissue grafting. It may be more like fat cell grafting or fat tissue engineering incorporating adipocytes, SVF, ADSCs, and adequate scaffold materials. SEL™ could be upgraded by enrichment with adequate number of cultured ADSCs which may significantly improve graft take. Full-scale clinical application of stem cell therapy is delayed by legal control to ensure patient safety, but the effect of stem cell therapy has been proved through scientific verification during the past decade.

17.6 Conclusion

The key for successful fat grafting is familiarity with the technique, knowledge of the gluteal topography, and understanding the patients' goals and explaining the outcomes. With experience, the surgeon can predict the amount of volume needed to be grafted in order to obtain the desired results. SEL™ to the buttocks is ideal to correct finite asymmetries and volume deficiencies in patients who have limited donor sites for harvesting fat. It may reduce the need for additional sessions of fat grafting and avoid the risk of major complications.

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Gluteal Fat Injection Standardization: The Gluteal Codes

18

Alvaro Cansanção, Alexandra Condé-Green, Rafael A. Vidigal, and André Cervantes

18.1 Introduction

Gluteal fat grafting, also known as Brazilian Butt Lift, gluteal fat augmentation, and gluteal reshaping, has grown in popularity in the last years [1]. Despite the popularity and considerable increase in the number of gluteal fat grafting procedures around the world, our meta-analysis on gluteal fat grafting a few years ago [2] showed that there were different harvesting techniques, processing methods and planes of fat injection, and there was no standardized gluteal fat injection technique in order to obtain symmetry and consistent augmentation of the different areas of the buttocks. This lack of standardized fat injection technique to the gluteal region can lead surgeons, especially those who are beginning to perform this procedure, to have doubts on how to perform gluteal fat grafting and can lead to complications, such as those that have been occurring in the last years. Our objective with the gluteal codes technique was to describe a standardized and reproducible gluteal fat injection technique in order to obtain a harmonious and symmetric contour of the gluteal region without compromising patient safety.

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18.2 The Gluteal Codes Technique

18.2.1 Inspiration to Create the Gluteal Codes Technique

When we started performing gluteal fat grafting, precisely because of the lack of standardized techniques, we had some doubts on how to perform the procedure:

- Where should fat be injected to improve the aesthetic appearance of the buttocks?
- In which plane should fat be injected: intramuscular, superficial subcutaneous, deep subcutaneous planes?
- The volume of fat that should be injected?
- How to reproduce the same procedure in the contralateral buttock to obtain symmetry?

We first started to inject fat in the central region of the buttocks, in the same area where gluteal implants are placed [3]. This strategy worked for a while as patients were satisfied with the results; however, the long-term outcomes could be better. There was not a global augmentation of the buttocks, and there was still a lack of contour and projection; it was clear that the other areas of the buttocks needed to be filled as well.

- The lack of volume in the superior aspect of the gluteal region gives the impression of gluteal ptosis with the buttock pointing downward. When fat is injected in this area, it gives a lifting effect.
- The lack of volume in the lateral gluteal region gives a square shape buttock that needs to be filled in order to obtain a harmonious contour.
- The volume deficiency in the inferior buttock may accentuate the infra-gluteal fold, giving the impression of ptosis or pseudo-ptosis, according to Gonzalez classification [3].
- The volume deficiency in the medial aspect of the buttock gives the impression of flat buttocks with a large distance

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between each buttock, with one side being far apart from the other.

Therefore, we observed that besides the central region of the buttocks, where the point of greatest projection is located, four other areas of the buttock needed to be filled as well, since the loss of proportion in these regions resulted in an unaesthetic appearance of the buttocks. We then started to analyze the buttocks as five regions and created the five gluteal aesthetic subunits.

18.2.2 Concepts of the Gluteal Codes Technique

The basic principles of our technique are similar to the MD Codes™, a standardized technique used to inject fillers to the face [4] where the volume of fillers, the planes of injection, and the areas of the face are well explained and provides a practical and standardized framework for physicians to perform safe and effective aesthetic treatments using a multimodal approach.

Our standardization of the gluteal fat augmentation technique consists of two basic steps: (1) division of the buttock in subunits and (2) systematization of the fat injection technique.

18.2.2.1 Gluteal Aesthetic Subunits

When a large surface such as the buttock is divided into small regions, surgical planning is easy as the desired outcomes can be easily reproduced in the contralateral side. We followed the same principles used by Centeno [5] and Mendieta [6], which divided the posterior trunk and thighs into aesthetic units with relevant interest to the gluteal contour, showing how preservation, augmentation, or reduction of these units can impact directly the gluteal contour. Both authors described the gluteal region as a single aesthetic unit, which is appropriate when gluteal contour surgery is planned. However, when gluteal augmentation with fat is planned, a more detailed segmentation of the regions should be considered.

Therefore, we introduced the concept of "Gluteal Aesthetic Subunits" dividing the gluteal region into five subunits according to its characteristics in terms of concavity and projection: central (C), superior (S), lateral (L), inferior (I), and medial (M) (Fig. 18.1).

To determine the five gluteal aesthetic subunits, five steps should be followed:

1. Considering a vertical line representing the height of the buttock and a horizontal line passing through the mid gluteal region representing the width of the buttock, two points are drawn along each line dividing them into three segments with the following proportions: 1/4, 2/4, and 1/4 (Fig. 18.2a).
2. A horizontal line is drawn from the medial to the lateral limits of each buttock passing through the superior point (Fig. 18.2b).
3. A vertical line is drawn from the superior line to the inferior limit of the buttock, passing through the lateral point (Fig. 18.2c).
4. A vertical line is drawn from the superior line to the inferior limit of the buttock, passing through the medial point (Fig. 18.2d).
5. A horizontal line is drawn from the medial and lateral vertical lines passing through the inferior point (Fig. 18.2e).

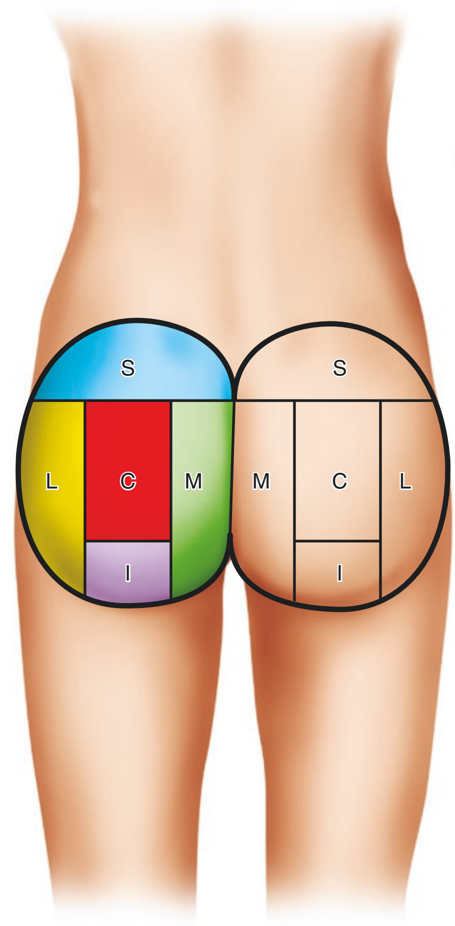

Fig. 18.1 The gluteal region is divided in five gluteal aesthetic subunits: subunit C (central) in red, subunit S (superior) in blue, subunit L (lateral) in yellow, subunit I (inferior) in purple, and subunit M (medial) in green

Each buttock is then divided into five subunits: central (C), superior (S), lateral (L), inferior (I), and medial (M) (Fig. 18.2f).

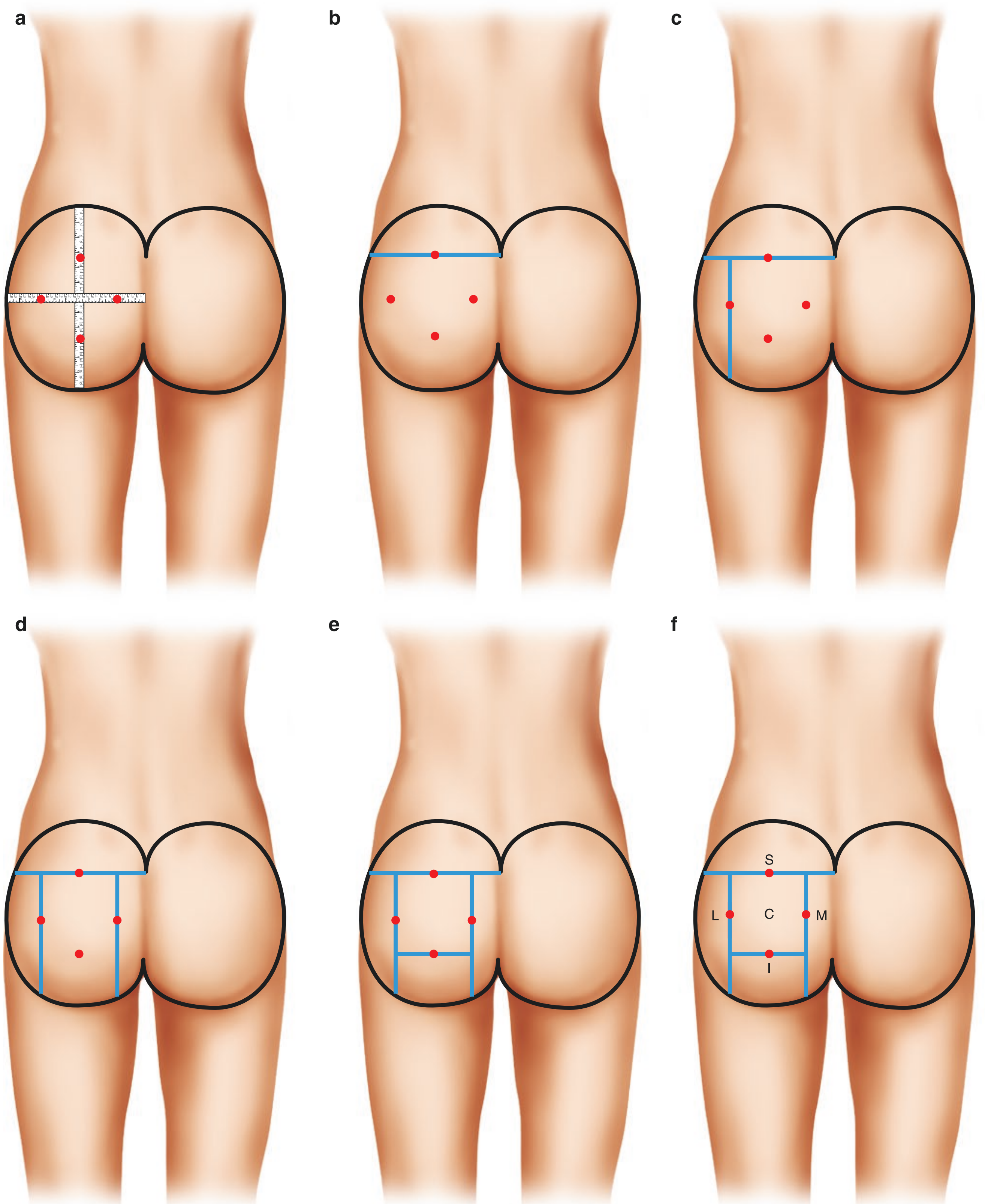

Fig. 18.2 Marking the five gluteal aesthetic subunits. (**a**) Determining the four points that will divide the buttocks into three vertical and three horizontal segments with the following proportions 1/4, 2/4, and 1/4 respectively. (**b**) Marking the superior horizontal line. (**c**) Marking the lateral vertical line. (**d**) Marking the medial vertical line. (**e**) Marking the inferior horizontal line. (**f**) The five gluteal aesthetic subunits: central (C), superior (S), lateral (L), inferior (I), and medial (M)

18.2.2.2 Fat Injection Technique

We maintain the concept of proportion when injecting fat, creating a standardization where each subunit is filled according to the buttocks' characteristics of the patients and their desire. The plane where fat should be injected is also important to obtain the desired outcomes. Fat injected in the superficial and deep subcutaneous layers will lead to different improvements in the projection and consistency (hardness) of the buttocks.

Proportions of Fat to Be Injected The most relevant aspect of our technique is to respect the proportions of fat to be injected in each gluteal subunit in order to preserve the harmony between the five gluteal subunits. Taking into consideration that ethnicity and cultural differences can lead patients to desire different buttocks shape [7] (Table 18.1), we created pre-established proportions that can be used according to the characteristics and shapes desired by each group of patients, as described by Roberts et al. [7], serving as a guide to obtain consistent and reproducible results (Fig. 18.3).

Caucasian Women There are two groups of Caucasian women according to gluteal aesthetic preferences: those who prefer a more athletic shape (type I) and those who prefer a more rounded buttocks (type II). Both groups have preference for full and projected buttocks with a 60/40 volume ratio between the upper and lower halves of the buttock [7].

For the Caucasian type I women, we perform gluteal fat injection using a ratio of 3:2:1:1:1 in the different subunits (3 volumes in C, 2 volumes in S, 1 volume in L, 1 volume in I, and 1 volume in M).

For the Caucasian type II women, we perform gluteal fat injection using a ratio of 3:2:2:1:1 in the different subunits (3

Table 18.1 Main characteristics of each buttocks shape according to patients' ethnical and cultural preferences [7]

Buttocks: characteristics X shape	Buttock size	Lateral buttocks fullness	Lateral thigh fullness	Gluteal volume distribution superior/inferior	Proportions of fat between gluteal subunits
Caucasian (Type I)	Full Projected Not extremely large	Athletic shape Lightly rounded	No lateral thigh filling	60/40%	3:2:1:1:1
Caucasian (Type I)	Full Projected Not extremely large	Rounded	No lateral thigh filling	60/40%	3:2:2:1:1
African descent	As full as possible	Very full	Lateral thigh very full	50/50%	3:2:2:2:1
Hispanic	Very full Not as much as African descent	Very full Not as much as African descent	Slight fullness	60/40%	3:2:2:1:1
Asian	Small Shaped	No	No	60/40%	3:2:1:1:1

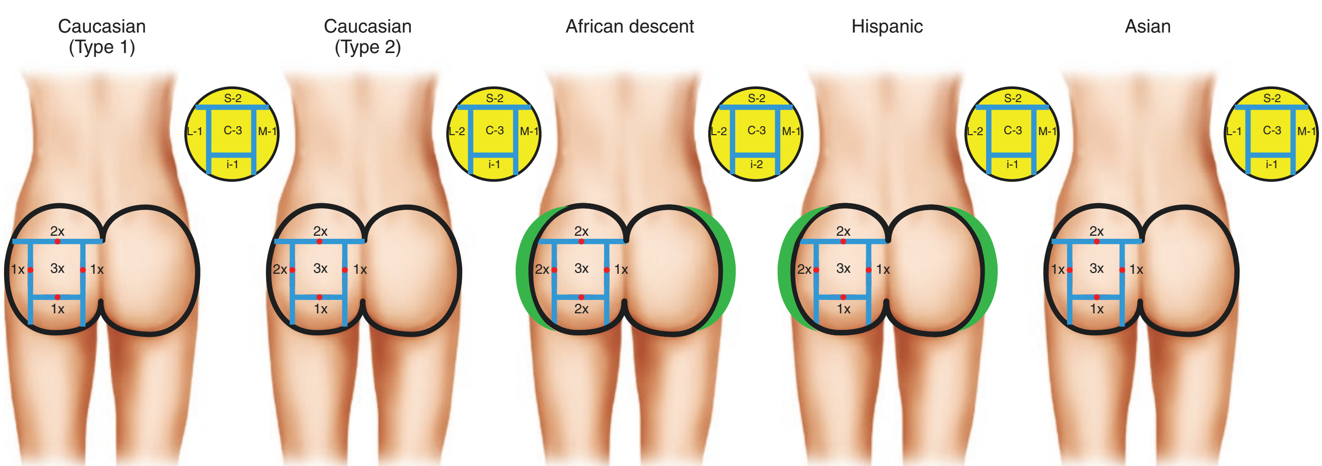

Fig. 18.3 Schematic representation of the four pre-established proportions for each buttocks shape: Caucasian type I (athletic buttocks), Caucasian type II (rounded buttocks), African descent, and Hispanic

volumes in C, 2 volumes in S, 2 volumes in L, 1 volume in I, and 1 volume in M).

African Descent Women The patients generally have preference for very full and well-projected buttocks posteriorly and laterally with a 50/50 volume ratio between the upper and lower halves of the buttock, as well as full hips and outer thighs [7]. For this group, we inject a higher volume of fat at a ratio of 3:2:2:2:1 in the different subunits (3 volumes in C, 2 volumes in S, 2 volumes in L, 2 volumes in I, and 1 volume in M).

Hispanic Women They have preference for very full and well-projected buttocks posteriorly and laterally, less than the African descent women, with a 60/40 volume ratio between the upper and lower halves of the buttock, as well as full hips and outer thighs [7]. For this group, we inject fat using a ratio of 3:2:2:1:1 in the different subunits (3 volumes in C, 2 volumes in S, 2 volumes in L, 1 volume in I, and 1 volume in M). This formula is similar to the preference of the Caucasian type II women, with the addition of fat to the hips.

Asian Women They have preference for a smaller, full, and projected buttocks without additional volume to the hips or thighs [7]. We use the same formula as the Caucasian women type I, a ratio of 3:2:1:1:1 in the different subunits (3 volumes in C, 2 volumes in S, 1 volume in L, 1 volume in I, and 1 volume in M).

Brazilian Women Independent of their ethnicity, they have preference for the Caucasian buttocks; therefore, we use the same ratio as for the types I and II of the Caucasian women. Patients who present with a depression or asymmetric buttocks should have more fat injected in order to correct those defects. This added volume does not count in the gluteal codes proportion (Fig. 18.4).

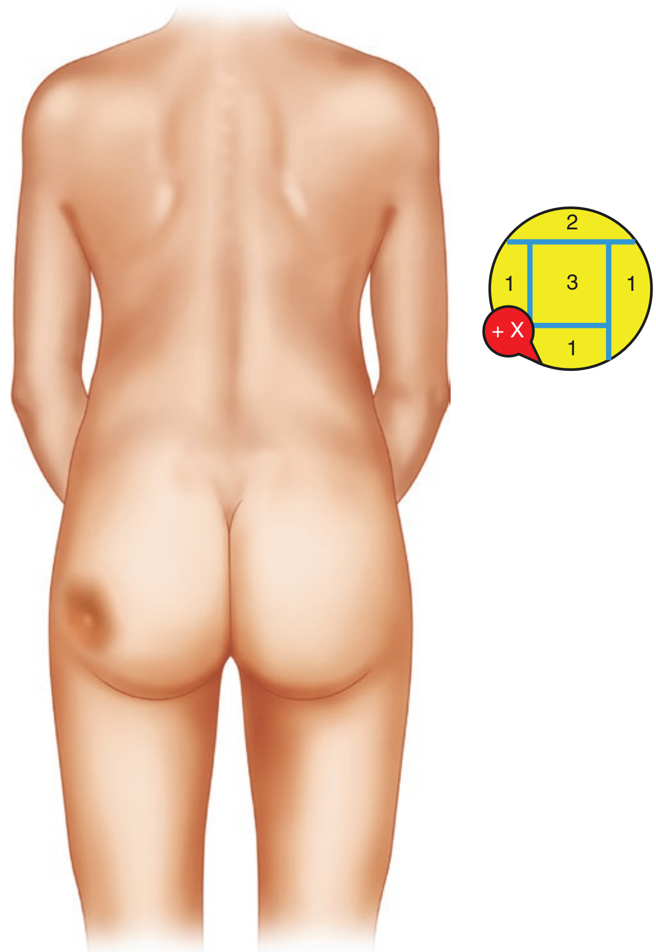

Fig. 18.4 When patients present with an asymmetry, depression or skin retraction of the gluteal region, an additional volume should be injected to correct these defects. This extra volume (represented by the +X in the green circle) does not count on the gluteal codes proportion

Plane of Fat Injection Following the recommendations of the multi-society gluteal fat grafting task-force safety advisory [8], we perform subcutaneous only gluteal fat grafting, due to the extremely high risk of fatality from fat embolism when fat is injected in the intramuscular plane [9–11]. In our recent survey among board-certified Brazilian Plastic Surgeons, the risk of death following gluteal fat augmentation (from any cause) was 16 times greater when fat was injected intramuscularly [11]. In large part due to studies by Guerrero-Santos, fat grafting injected into the muscle was widely recommended as a mean of increasing fat retention [12]. Nowadays with all the knowledge in the harvest processing and injection steps, we are able to achieve similar results with injection of fat into the subcutaneous plane only, with the added safety benefit of avoiding major gluteal vessels [13]. In order to increase the contact of the grafted cells with the recipient site [14], fat should be distributed throughout the whole thickness of the subcutaneous tissue, in both superficial and deep subcutaneous layers.

Regardless of the subcutaneous layer in which fat is injected, the thickness of the adipose tissue will be increased as well as the consistency (hardness) and the projection of the gluteal region. However, due to the anatomical characteristics of these two subcutaneous layers, the increase in consistency and projection of the gluteal region will be different according to which layer will receive more fat.

The superficial subcutaneous layer (SSL) situated between the dermis and the superficial fascia is composed of small fat lobes interspersed by large amounts of fibrous septa with high structural stability and tensile strength, oriented in a perpendicular fashion from the fascia to the dermis. These characteristics impart a high elastic resistance to this layer making it less expandable. The deep subcutaneous layer

(DSL) lies between the muscular fascia and the superficial fascia and is composed of larger fat lobes and incomplete fibrous septae. It is less resistant and expands more than the SSL [15]. Therefore, performing fat grafting in the SSL will mostly increase the consistency (hardness) and performing fat grafting in the DSL will mostly increase the projection of the buttocks.

When analyzing the patient in a standing position, it is important to determine whether more projection or more consistency is needed or desired by the patient in order to plan accordingly. Due to the limited expansion capacity of the SSL, injecting a large volume of fat in this layer may reduce graft take due to the excessive pressure on the cells and result in irregularities on the surface of the skin (peau d'orange effect) or fat necrosis (Fig. 18.5).

18.2.3 How Do We Perform Gluteal Fat Grafting Using the Gluteal Codes Technique?

18.2.3.1 Fat Harvesting

After subcutaneous infiltration is performed according to the wet technique using a solution of normal saline with epi-

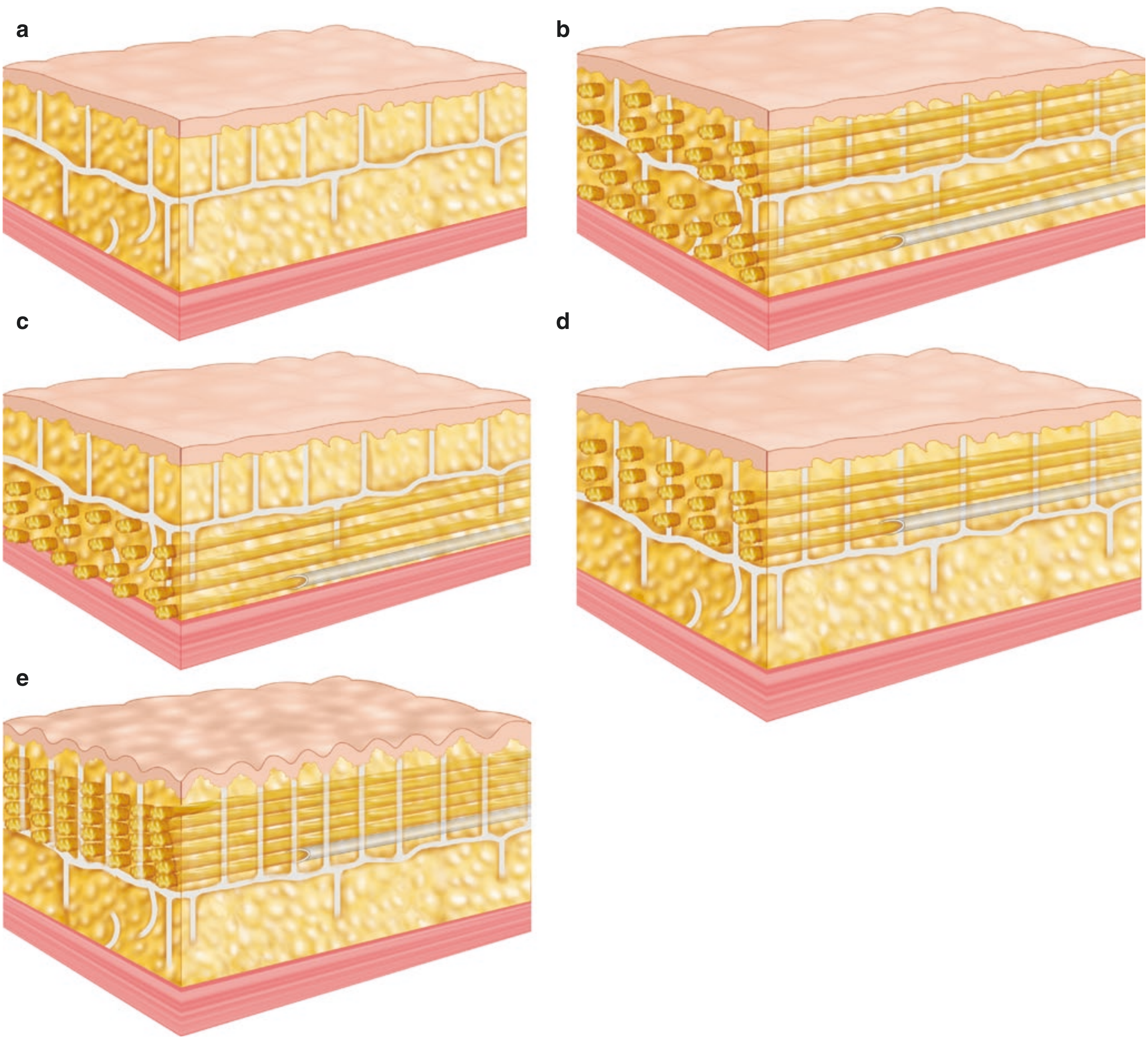

Fig. 18.5 Anatomic difference between the superficial subcutaneous layer (SSL) and deep subcutaneous layer (DSL). (**a**) Normal aspect of the subcutaneous tissue. (**b**) The correct way to inject fat, distributing it into both planes to improve the contact of the grafted fat with the recipient bed. (**c**) Injecting fat into the DSL will mostly increase the projection of the buttocks. (**d**) Injecting fat into the SSL will mostly increase the hardness (consistency) of the buttocks. (**e**) Excessive fat injection in the SSL can lead to irregularities on the surface of the skin

nephrine at 1:500,000, fat is harvest using power-assisted liposuction (Lipomatic; Euromi AS, Verviers, Belgium) with a 4-mm diameter blunt-tipped cannula with nine holes followed by another 4-mm diameter blunt-tipped cannula with three holes.

18.2.3.2 Fat Processing

Fat is collected in a sterile cannister and processed by decantation or washing in a closed system. When fat is too bloody, it is washed with normal saline, the superior and inferior layers of the lipoaspirate are discarded, and the middle layer consisting of adipose tissue is kept for grafting.

18.2.3.3 Fat Injection

With the patient in prone position, fat is injected subcutaneously using the expansion vibration lipofilling (EVL) technique [16]. A 3 mm diameter three-holes blunt-tipped cannula is introduced through an incision above the intergluteal cleft, and the tip of the cannula is kept parallel to the gluteal muscles. No drains are used. The average time for fat injection to the buttocks is 30 min (± 5 min).

In our casuistic, the Caucasian type I proportion (3:2:1:1:1) was used in 78.13% of patients and the Caucasian type II proportion (3:2:2:1:1) in 21.39% of patients. The volume of fat injected ranged from 400 ml to 810 ml of fat in each buttock.

Fat is injected into the SSL or the DSL according to the desired effects in terms of projection and consistency. In our pre-established fat injection formulas, we follow these rules:

- *Central subunit*: 3 volumes are injected, the first one into the DSL, the second one into the SSL, and the third one is distributed between both layers.
- *Superior subunit*: 2 volumes are injected. The first one into the DSL and the second is distributed between both layers.
- *Lateral and Inferior subunits*: 1 volume is injected and distributed between both layers. When 2 volumes are injected, the first volume is injected in the DSL and the second distributed between both layers.
- *Medial subunit*: 1 volume is injected and distributed between both layers.

We recommend the use of an entry port that allows the cannula to go from medial to lateral whenever possible, preferably above the intergluteal cleft. The inferior incisions (in the infra-gluteal fold) and superior incisions can be used safely for grafting the lateral portion of the buttock, the trochanteric depression, and the hips.

By remaining subcutaneously, fat can be injected in the whole gluteal region, even in the area described as the "danger zone" where major gluteal vessels are located in the deeper planes. When EVL is used, the proprioception of the vibration of the cannula under the skin helps confirm that it remains subcutaneously [16]. The use of real-time ultrasound-assisted gluteal fat grafting technique is a good option for identifying the plane in which the cannula is at all time when fat is being injected [17] (Fig. 18.6).

18.2.3.4 Postoperative Period

Ciprofloxacin was administered intravenously 1 h before the skin incision and every 12 h until discharge, and maintained orally for 7 days [18]. There is no position restriction after gluteal fat grafting. Venous thromboembolism risk stratification is performed using the Caprini risk assessment model [19]. All patients use sequential compression device (SCD) during their hospital stay and compression stockings up to the knees for 7 days. Patients who present risk factor scores 3 and 4 of the Caprini risk assessment module receive anticoagulation with one dose of low molecular weight heparin subcutaneously at 12 h postoperatively. Patients with scores 5 and 6 receive anticoagulation for 7 days.

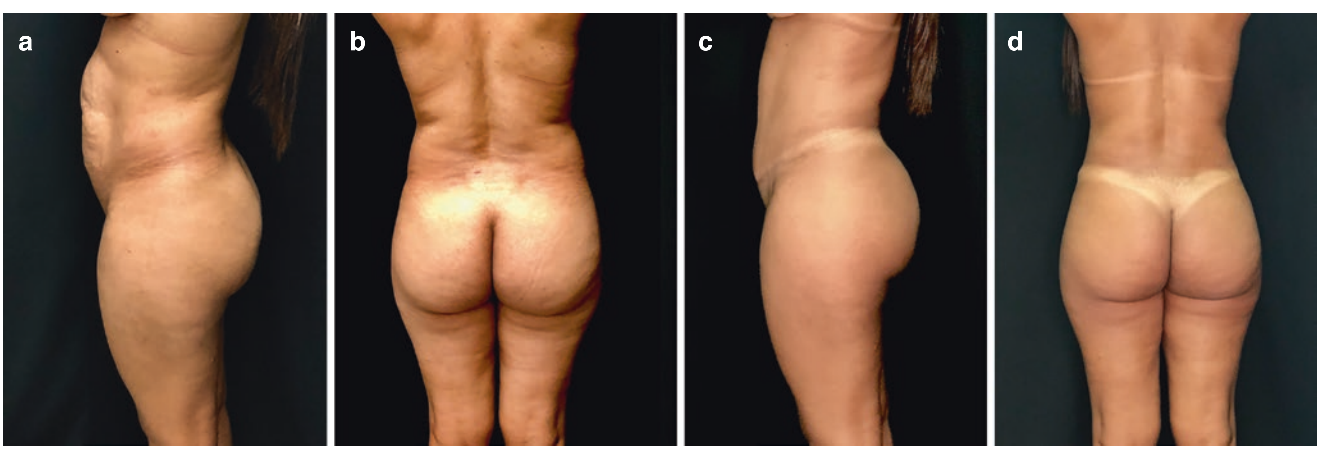

Fig. 18.6 A 36-year-old female patient with poor gluteal projection and excess skin laxity of the buttocks. A total of 560 ml of fat was injected per buttock with the proportion of 3:2:1:1:1. (**a, b**) Preoperative view. (**c, d**) Postoperative view

18.2.3.5 Complications

From January 2015 to September 2018, 416 patients were submitted to gluteal fat augmentation using the gluteal codes technique. There were no major complications in this series, no fat embolism, no DVT/PE, no infection or death. A total of 2.4% of patients complained of lack of gluteal volume and 1.92% of persistent areas of skin retraction. Patients who had combined surgeries such as lipoabdominoplasty and mini-abdominoplasty associated with gluteal fat augmentation presented minor complications such as contour irregularities in the donor sites (3.37%), hypertrophic scars (4.57%), hyperchromia of the flanks (0.96%), and persistent excess skin in the upper abdomen (1.92%).

18.2.3.6 Fat Retention

We performed ultrasound of the gluteal region in the immediate postoperative period and showed an average increase of 56.5% of the gluteal subcutaneous thickness (range: 39.5–108.6%) ($p < 0.0001$). At 12 months postoperatively, there was an average decrease of 18.2% (range: 6.8–24.8%) of the increased volume ($p < 0.0001$) [13].

18.2.3.7 Patient Satisfaction

A questionnaire evaluating patient satisfaction was distributed to 85 consecutive patients at 12 months postoperatively. The majority of patients rated their results as very good (57.65%) and good (41.18%) ($p > 0.05$). All patients claimed that they would have the procedure done again and would be willing to refer a friend to our practice [20] (Fig. 18.7).

18.3 Conclusion

Gluteal codes are a great and versatile technique which aims to enhance the buttocks, improve its contour and projection, with low complication rates, when performed following safety principles just like any other procedure. The gluteal codes technique allows the injection of fat uniformly to the gluteal region obtaining comparable proportions on each side. The technique is reproducible, has a short learning curve, especially for beginner plastic surgeons, as they are able to follow the proportions and planes of injections of the gluteal region in order to obtain good long-term results without compromising patient safety.

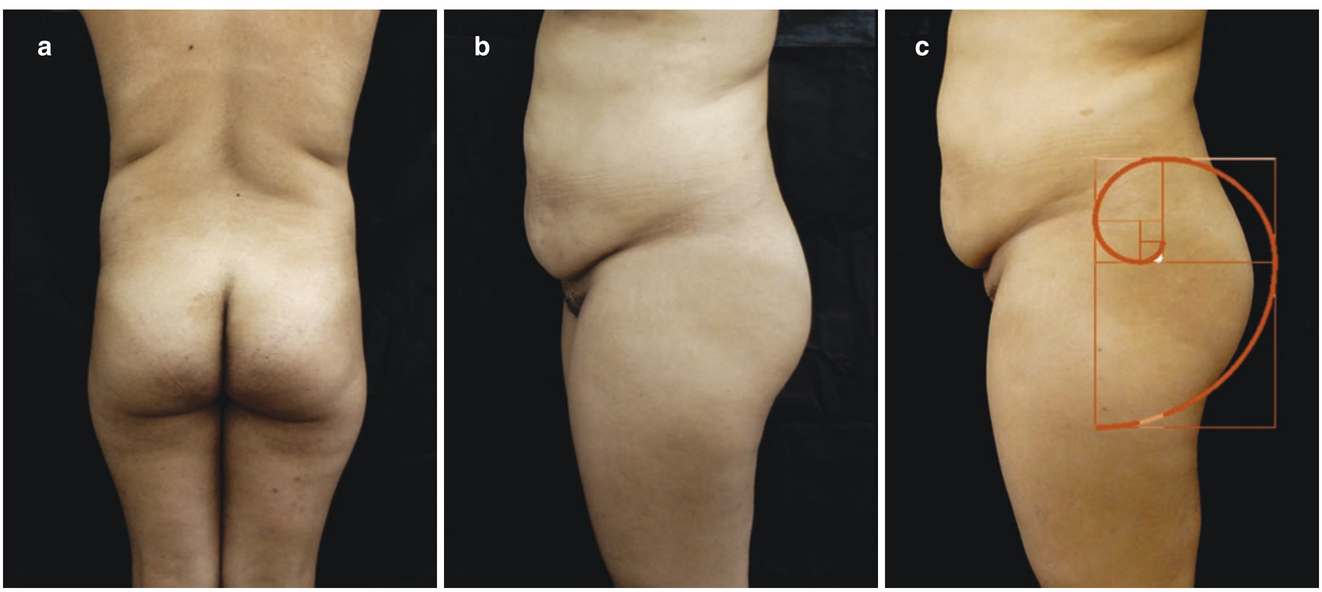

Fig. 18.7 A 32-year-old female patient, BMI = 27.9, with a square shape buttocks and poor gluteal projection. Injection of 560 ml of fat per buttock with the proportion of 3:2:1:1:1 was performed. (**a**, **b**) Preoperative view. (**c**) The Fibonacci golden proportion applied over the preoperative lateral view, identifying the areas that need gluteal contour improvement. (**d**, **e**) Postoperative view. (**f**) The Fibonacci golden proportion applied over the postoperative lateral view, identifying the areas of gluteal contour improvement with the proportions of the gluteal codes technique

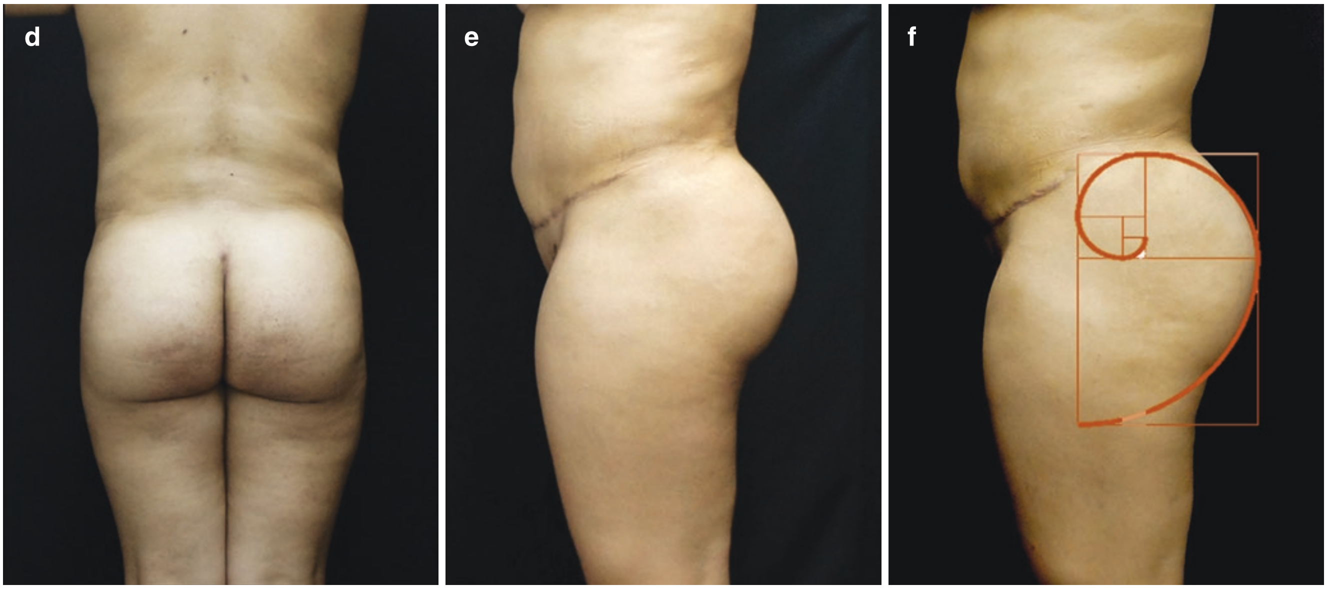

Fig. 18.7 (continued)

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Ultrasound-Assisted Gluteal Fat Grafting

19

Alvaro Cansanção, Alexandra Condé-Green, and Rafael A. Vidigal

19.1 Background

Gluteal fat augmentation has become increasingly popular and a preference of many surgeons and patients because of the rapid recovery and great results. In the last 4 years (2014–2017), there has been a 103% increase in gluteal fat augmentation procedures in the United States [1]. However, reports of fatal complications have surfaced, making us aware that this procedure is not without its risks. Recent studies [2, 3] have shown that morbidity and mortality risks are increased when fat is injected intramuscularly. In light of the multiple complications reported recently, a 2017 survey performed by the Aesthetic Surgery Education and Research Foundation (ASERF) reported that some patients have died when their surgeon said that they had injected fat into the subcutaneous layer, when all autopsies of deceased Brazilian butt lift patients had found fat in the gluteal muscles [4]. Therefore, not knowing where fat is being injected is of concern. In order to avoid inadvertent intramuscular fat injection, we created a surgical technique that allows us to identify the plane in which fat is being injected by using real-time ultrasound guidance [5], improving the safety of this surgical procedure.

Real-time ultrasound-assisted gluteal fat grafting can be used with any gluteal fat grafting technique. It consists in the use of an ultrasound probe placed on the skin of the gluteal region, to identify the different layers (skin, superficial subcutaneous layer, deep subcutaneous layer, gluteus maximus muscle) and the position of the cannula in real time, in order to avoid misplacement and consequent fat injection in an unwanted plane (Fig. 19.1).

Fig. 19.1 Real-time ultrasound gluteal fat injection: Ultrasound image generated by a probe placed on the skin of the gluteal region, transmitted to a screen during fat injection to identify the layers of the gluteal region and the positioning of the cannula. The surgeon is injecting fat (right hand) while following the cannula with his left hand (tactile) and with ultrasound (on the screen) held by the assistant

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19.2 Principles of Ultrasonography

Ultrasonography is one of the most widespread diagnostic methods in medicine and is being used by different specialties including cardiology, emergency medicine, gynecology, orthopedics, and, nowadays, plastic surgery [6]. The basic concepts of ultrasonography are important to understand before describing the actual technique. It consists in the formation of images through the physical properties of sound. Ultrasound is defined as a mechanical wave with frequency vibration greater than 20 kHz, inaudible to humans. However, in the ultrasound exam, frequencies ranging from 2 to 18 MHz are used, generating a sound wave in the transducer that travels through tissues. Low frequencies (2–5 MHz) are used to increase the field of vision when we need to study deep structures, such as in an abdominal ultrasound. Higher frequencies (7–11 MHz) are used for examination of superficial structures. As the sound passes through media of different densities with different speeds, it allows the identification of tissues according to the time that the sound wave takes to return to the transducer. The frequency of the sound is directly proportional to the resolution of the image and inversely proportional to the depth of the image.

There are different types of transducers and the choice of the transducer should be made based on the type of exam and the organ or region to be evaluated:

- Convex transducer: The scan is sectorial with a 60° angle and frequencies between 3 and 6 MHz. It has a broad field of vision and is mainly used in abdominal and obstetric exams to evaluate deep organs.
- Linear transducer: The scan is linear with frequencies ranging from 5 to 11 MHz. It is used to evaluate superficial structures, such as in exams of the breast, thyroid, and peripheral vascular structures.
- Convex endocavity transducer: The scan has an angle of 120° and 150° with frequencies ranging between 5 and 11 MHz. It is used for prostate and female genital exams.
- Sectorial transducer: The scan has a 90° angle and the frequency ranges from 2 to 8 MHz. It has a small area of contact and is used in cardiovascular exams.
- Annular transducer: The frequencies range from 6 to 10 MHz. It is used for orthopedic and soft tissue exams.

To visualize the layers of the gluteal region, we can use a convex or linear transducer. Since our aim is to evaluate the positioning of the cannula and make sure that it remains in the subcutaneous plane, we use a linear transducer as it has a better resolution than a convex one and we do not need a deep field of vision. The great interest in the real-time ultrasound technique is because it allows to see the images in real time and follow the cannula through the desired plane where fat should be injected. It is relatively safe (no radiation) and has a low cost; however, it is operator-dependent and may be subject to misinterpretation.

19.3 Ultrasound Image of the Gluteal Region

19.3.1 Gluteal Anatomy

One needs to be familiar with the ultrasound images of the gluteal region and recognize the important anatomical landmarks. The gluteal region is composed of planes separated by fasciae. The fasciae are represented on the ultrasound image by two horizontal white lines, the superficial fascia (top) and the muscular fascia (bottom) (Fig. 19.2a, b). The superficial fascia divides the subcutaneous tissue into two layers: the superficial subcutaneous tissue above the superficial fascia and the deep subcutaneous tissue between the two horizontal lines. The muscular fascia separates the deep subcutaneous tissue above, from the muscular layer represented by the gluteus maximus below (Fig. 19.3a, b).

19.3.2 Positioning of the Cannula

Once the cannula is introduced in the gluteal region, it is important to follow its position in order to inject fat in the adequate plane. The ultrasound does not directly show the cannula as it is made of steel and the ultrasonic energy does not pass through. However, a black shadow, called acoustic shadow, is generated from the tip of the cannula down through the planes.

- If the acoustic shadow starts above the first horizontal white line (superficial fascia), then the cannula is positioned in the superficial subcutaneous tissue (Fig. 19.4a, b).
- If the acoustic shadow starts between the two horizontal white lines (superficial and muscular fasciae), then the cannula is positioned in the deep subcutaneous plane (Fig. 19.4c, d).
- If the acoustic shadow starts below the second horizontal line (muscular fascia), then the cannula is positioned in the muscular plane (Fig. 19.4e, f).

19.4 Surgical Technique

When fat is being injected, an ultrasound is performed with the probe placed on the skin of the gluteal region following every move of the cannula. The images are projected in real time on a screen, so that the surgeon and assistant can follow

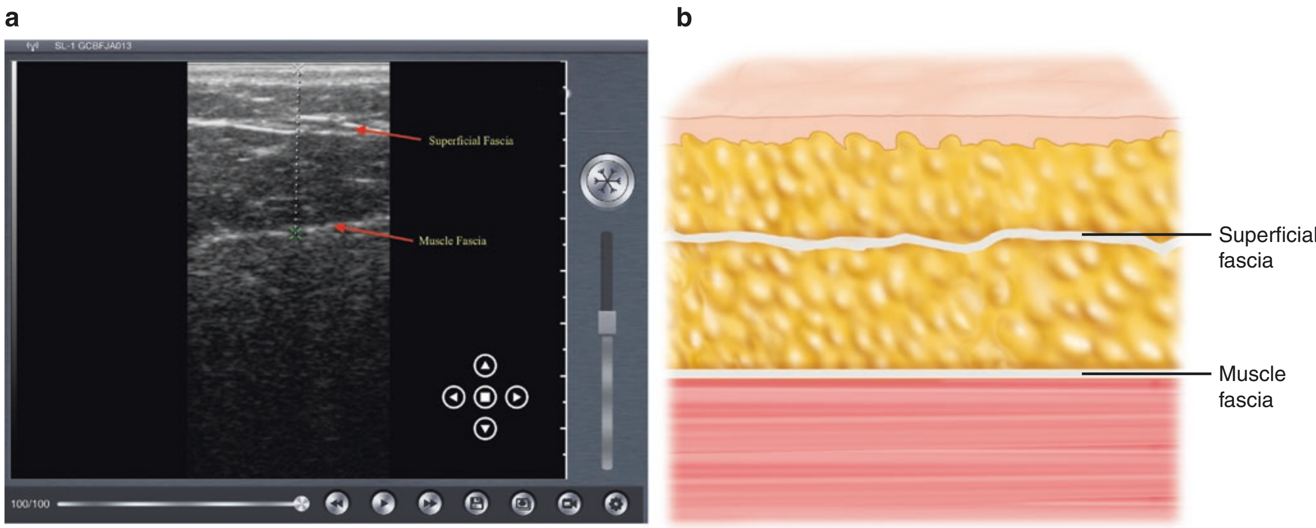

Fig. 19.2 Recognizing anatomical landmarks and layers of the gluteal region. The *two horizontal white lines* represent the superficial fascia and the muscular fascia (from *top* to *bottom*). (**a**) Ultrasound image of the fascia of the gluteal region; (**b**) illustration of the fascia of the gluteal region; Part **a** from Cansancao et al. [5]; used with permission

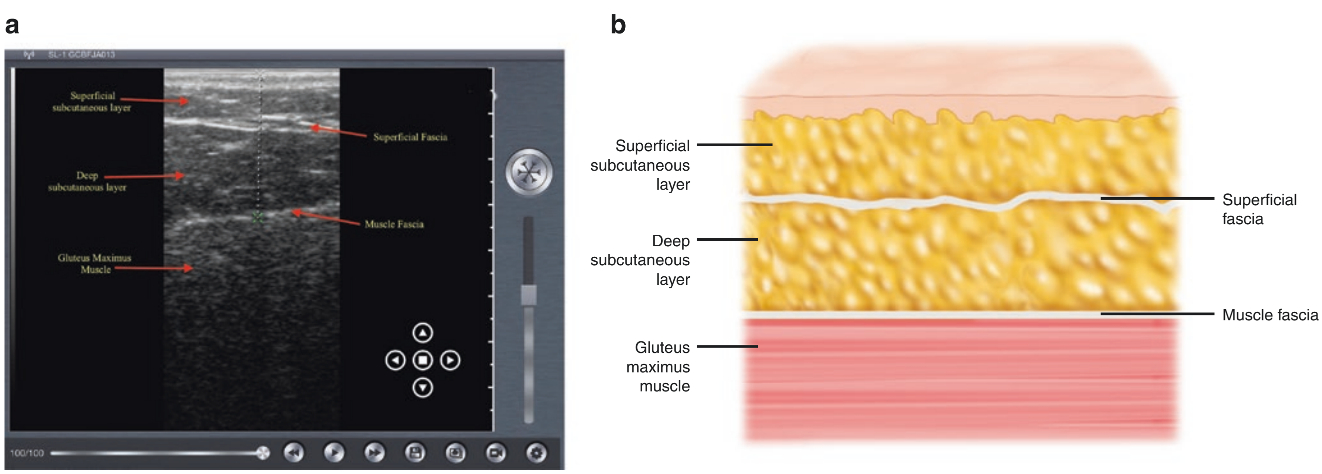

Fig. 19.3 Identifying the planes where fat should be injected on an ultrasound image. Above the superficial fascia in the superficial subcutaneous tissue; between the two horizontal lines in the deep subcutaneous tissue. (**a**) Ultrasound image of the planes of the gluteal region; (**b**) illustration of the planes of the gluteal region. Part **a** from Cansancao et al. [5]; used with permission

the planes in which the cannula is being introduced and the fat being injected (Fig. 19.1). We are able to evaluate in real time the location of the cannula and control its depth as fat is being injected. The simultaneous use of ultrasound while injecting fat in the gluteal region may add 25–30 min to the procedure as both the surgeon and assistant must follow the cannula by tactile sensation and with the ultrasound while injecting fat. We routinely use a 7.5 MHZ linear transducer, model C10 wireless probe scanner (Konted Co, Beijing, People's Republic of China) connected to a Wireless US for IOS software (Sonoptek Co., Beijing, People's Republic of China), and the images are transmitted to an IOS or Android mobile phone or tablet.

19.5 Discussion

The understanding of the mechanisms that lead to pulmonary fat embolism in gluteal fat augmentation has enabled us to identify surgical strategies capable of avoiding or reducing its incidence [7]. One of these strategies is to inject fat in the subcutaneous plane, avoiding the intramuscular plane where intravascular injections or migration of fat particles is more likely to happen. Many plastic surgeons familiar with gluteal fat augmentation feel that it is possible to remain in the subcutaneous layer based on tactile feel and proprioception alone. Recent complications discussed in the ASERF study [4] suggest that this may not be the case. We therefore pro-

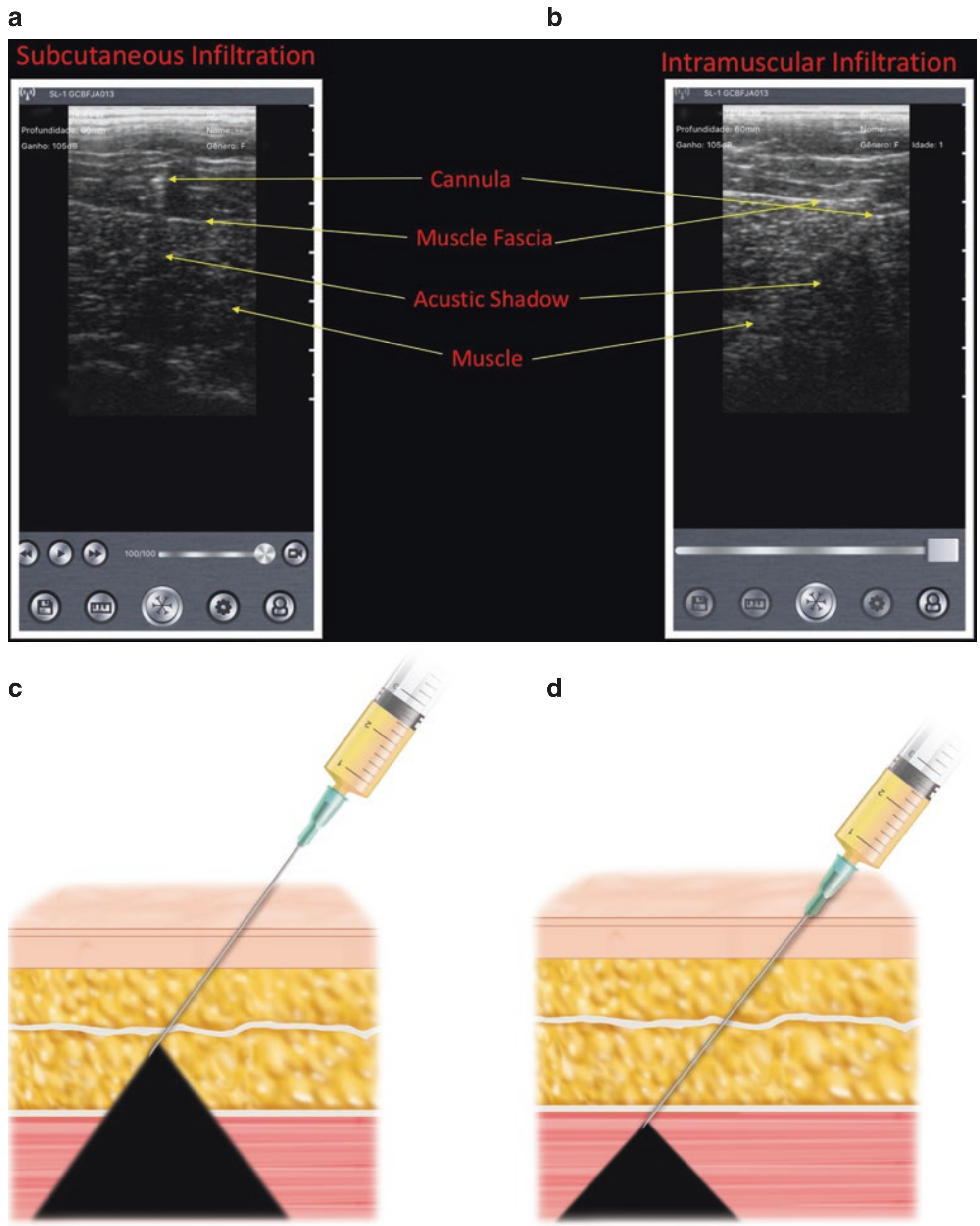

Fig. 19.4 Identification of the position of the cannula. The beginning of the acoustic shadow represents the position of the cannula. (**a**) Ultrasound image showing that the acoustic shadow is above the muscular fascia; therefore, the cannula is in the subcutaneous plane; (**b**) ultrasound image showing that the acoustic shadow is under the muscular fascia; therefore, the cannula is in the intramuscular plane; (**c**) illustration of the ultrasound image with the cannula in the subcutaneous plane; (**d**) illustration of the ultrasound image with the cannula in the intramuscular plane. Parts **a** and **b** from Cansancao et al. [5]; used with permission

pose the use of ultrasound to objectively identify the different planes of the gluteal region and avoid injecting fat in an undesired plane. We use a high-frequency 7.5 MHZ probe that provides better image resolution in the superficial soft tissue planes, as our objective is to follow the cannula in a the subcutaneous plane during fat injection. The downsides of this technique are the one-time cost of the ultrasound machine, the need for an assistant to hold the ultrasound probe while injecting fat, and the added operative time as mentioned above. There is a learning curve for both the surgeon and assistant, as they need to follow the cannula's trajectory on the patient and on the screen where the image is being projected in order to ensure the adequate plane of fat injection. The movements of the cannula and the probe must be coordinated constantly to follow the plane of injection in real time, thus increasing the surgical time.

19.6 Conclusion

Real-time ultrasound-assisted gluteal fat grafting is a reliable technique that allows to adequately follow the plane in which the cannula is placed when fat is being injected in the gluteal region. By making sure that fat is injected in the subcutaneous plane only, we may avoid injuring the deep vascular structures, further decreasing the risk of major complications.

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20 Postoperative Evaluation of Gluteal Fat Augmentation

Eric Swanson

20.1 Introduction

Despite its popularity, until recently [1] the efficacy of buttock fat injection had not been well documented by measurement studies. To meet the requirements of evidence-based medicine, surgeons must be able to measure their results. Otherwise, treatments may be based on clinical impressions alone, which are notoriously unreliable. Evidence-based medicine is largely synonymous with measurement-based medicine [2]. Ultrasound imaging has been previously used to assess the thickness of the subcutaneous fat layer [3, 4]. This modality has been compared to anthropometric measurements and computerized axial tomography and found to be similar in accuracy and sensitivity for measuring changes in gluteal projection [5]. Measurements on standardized photographs may also be used to assess changes in fat thickness. Computer assistance may be used to assist in matching photographs and performing measurements [6]. Most surgeons already own a software system for their digital photographs that provides archiving and can be used to simplify photographic comparisons. Without computer-assisted photographic matching for size and orientation, small differences in focal distance or the patient's position at the time they are photographed could easily compromise numerical comparisons. This matching is done by placing a cursor on body landmarks that are not included in the treatment area. A ruler is included in one of the photographs for calibration. The software adjusts the image to match orientation and size (Fig. 20.1). In the author's practice, 20% of women undergoing liposuction also have buttock fat injection [2]. To what degree does the fat survive the transfer? This question is a common one asked by patients. Little information has been available on which to base an answer. To learn more about the efficacy of buttock fat transfer, the author undertook a measurement study, using both photographic measurements and ultrasound measurements [1].

Some operators are concerned that large-volume syringes, such as 60 cc, used by many operators today, may deposit too much fat with each injection stroke, leading to nonviable fat and the formation of oily cysts. Ultrasound imaging offers a method to evaluate this possible problem [1].

20.2 Anatomical Landmarks

Buttock shapes include the A-shape, V-shape, square shape, and round buttock [7]. A sacral triangle is defined by the sacral dimples (posterior superior iliac spines) and the coccyx. The upper border of the buttock is at the level of the iliac crest and the lower margin is defined by the gluteal fold. The lateral gluteal (or trochanteric) depression is labeled the C-point. Many patients wish to have this depression filled in at the time of buttock fat transfer. Patients sit on the ischial tuberosities, located below the buttocks [8]. Buttock projection is measured along a horizontal plane that connects the mons pubis with the point of maximum buttock projection. Relative buttock projection is a measurement that relates the buttock projection to the vertical plane of the lumbar lordosis (Fig. 20.1) [1].

20.3 Liposuction

Like gluteal fat injection, liposuction was a popular procedure for many years before it was subjected to rigorous measurements [9]. Before accurate measurements were made in calorically neutral patients, many investigators subscribed to the false notion that fat redistributes after liposuction, returning to untreated areas [10]. Measurements showed that fat redistribution does not occur [6]. The body has no known inventory mechanism that keeps track of the distribution of subcutaneous fat and assigns areas for fat accumulation. Adipocytes respond to the caloric balance by either

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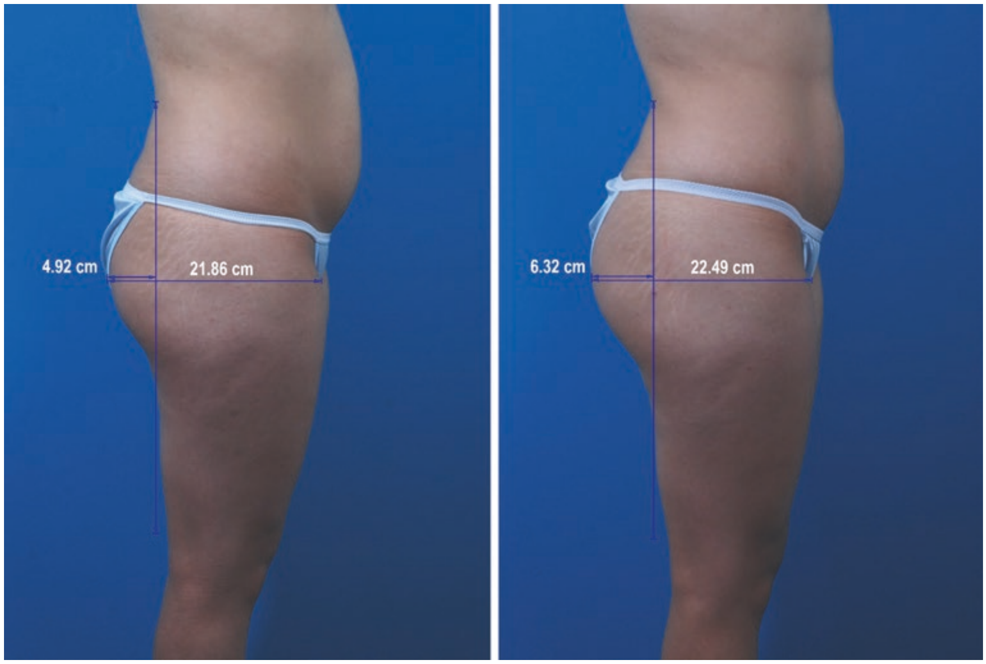

Fig. 20.1 Lateral photographs of a 25-year-old woman before (left) and 6 months after (right) liposuction of the abdomen, flanks, inner thighs, arms, and axillae. A volume of 285 cc of lipoaspirate was injected into the subcutaneous tissue plane in each buttock. This patient's fat injection volume was similar to the mean injection volume (287 cc) for study patients. The photographs were matched for size and orientation using the Canfield 7.4.1 imaging software (Canfield Scientific, Fairfield, N.J.). This patient's posterior photographs are provided in Fig. 20.5. Buttock projection is defined as the horizontal dimension connecting the mons pubis with the point of greatest buttock projection. This measurement increases approximately 0.6 cm. Relative projection is measured from the level of the lumbar lordosis to the same point of maximum buttock projection. The difference is 1.4 cm in this patient. An increased relative projection is provided by simultaneous liposuction of the flanks and lower back. (Reprinted from: Swanson [1]. With permission from Wolters Kluwer Health)

increasing or decreasing in size. The absolute number stays the same, barring extreme weight gain [6]. The body topography does not change after liposuction except in the treated areas. If it did, this confounder would be very difficult to control in any study of liposuction or fat transfer. It is important to consider weight gain or loss after surgery when evaluating changes in the fat thickness because such changes will affect the thickness of the fat layer and therefore the measurements. It is possible to statistically control for changes in body mass index [1].

Liposuction can improve the appearance of the buttocks by reducing excess fat from adjacent areas. For both women and men, reduction of the flanks and lower back accentuates the buttocks, giving the appearance of buttock enhancement even without fat injection. Relative buttock projection takes into account the post-liposuction decrease in volume of the flanks and lower back, which contributes to the apparent improvement in buttock projection (Fig. 20.1) [1].

20.4 Selecting a Measurement Device

Although several studies provide clinical data and subjective evaluation of buttock fat transfer [11–17], objective measurements are seldom reported. The first step in studying changes in fat volume is to select a valid measurement device. The simplest device is a measuring tape. Unfortunately, this method is limited by variability between operators in how much tension is applied to the tape, the level of the tape, and reading the tape measurement. Nonradiologic methods have overall errors in the range of 3–15%, which may exceed the magnitude of the expected treatment effect.

Magnetic resonance imaging is known to be accurate [6, 9], but this method is inconvenient and costly, and cannot be done in the office. Consecutive patients and sample size are important methodological considerations. A series of consecutive patients is unlikely to consent to the extra time commitment and inconvenience of magnetic resonance imaging. Murillo [16] used magnetic resonance imaging to document a qualitative increase in buttock fullness in six patients undergoing intramuscular buttock fat injection. Magnetic resonance imaging was also used by Wolf et al. [13] in a quantitative study of 10 patients undergoing gluteal muscle injection, but only muscle areas were measured, not subcutaneous fat thickness, despite fat injection in both locations. Neither study controlled for postoperative changes in body mass index.

Unlike laborious tape measurements or other radiological methods, ultrasound scans are highly practical and accepted by patients. They are quick and easy to perform in the office. A minimum follow-up time of 3 months is based on previous studies of fat injection using magnetic resonance imaging that reveal little change in the fat layer thickness beyond 3 months [18, 19], suggesting that swelling has resolved at that time. Although longer follow-up times are generally preferred, this advantage needs to be balanced against patient attrition that occurs at longer follow-up times, and in some cases, more potential for weight change. Ideally, the same operator performs both the before and after measurements to avoid inter-observer error [1].

One-dimensional measurements on standardized photographs have been used successfully to assess changes in fat thickness. Photographs are inexpensive and require only a few minutes of patient time, maximizing patient participation. Inclusion rates exceed 80%, adding to the reliability [1]. Large sample sizes are feasible, and permit statistical analyses with a low risk of type I or II errors. Linear measurements on standardized and size-matched photographs have an intraclass correlation of 0.98 on repeated measurements, sufficiently precise to be clinically useful. Because an increase in fat volume accounts for about 80% of increased body mass in nonobese adults, change in physical dimensions correlates closely with expansion or reduction of subcutaneous fat volume [6]. Of course, the change in external body dimensions is the relevant issue from the patient's perspective.

A limitation of the ultrasound measurement method used is that it is one-dimensional, providing a depth estimate at a fixed point on the buttock. Similarly, the photographic comparisons of buttock projection and relative projection are also one-dimensional. Nevertheless, one-dimensional measurements can provide reliable data when evaluating standardized images of consecutive patients. Simplicity can be a virtue.

20.5 Prospective Controlled Study of Gluteal Fat Augmentation

In the author's study, 25 consecutive patients underwent buttock fat injection [1]. The eligibility criteria were simply patients having buttock fat injection and returning for follow-up ≥3 months after surgery. The inclusion rate was 84%. A separate group of 30 patients undergoing cosmetic surgery without buttock fat transfer during the same study period served as a control group for ultrasound measurements. Twenty-five control patients returned for follow-up ≥3 months after surgery (inclusion rate, 83%). Eight of the control patients underwent liposuction. These eight patients served as controls for the photographic analysis. Liposuction donor sites always included the abdomen, lower back, and flanks. The outer thighs were treated in six patients. The expected degree of fat retention is related to the surgical technique. Therefore, the details of surgery are needed in any discussion of fat transfer. The author's technique is briefly described here, followed by the study findings.

20.6 Surgical Technique

20.6.1 Preoperative Marking

Patients are marked in a standing position before surgery, outlining both donor and recipient sites. The recipient area is contained within the lateral gluteal border laterally and the intergluteal cleft medially, superiorly to the transitional area between the buttock and the flank and inferiorly to the gluteal fold (Fig. 20.2). Many patients prefer lateral gluteal (trochanteric) fullness to accentuate the hourglass shape [8, 11, 12] and this area is routinely treated with the rest of the buttock during lipoinjection.

20.6.2 Anesthesia and Patient Positioning

The author prefers total intravenous sedation using a propofol infusion. Patients are prepped with warmed chlorhexidine solution circumferentially in a standing position. They are first positioned supine on the operating table and are then turned from side to side to perform the infiltration using a superwet (approximately 1:1 ratio of infiltration:aspirate volume) technique (Figs. 20.2, 20.3, and 20.4). The wetting solution consists of 1 L of normal saline with 500 mg (0.05%) of lidocaine and 2 mg of epinephrine (1:526,000). Prone positioning is never used. The sequence is repeated for liposuction, giving the lidocaine and epinephrine at least 15 minutes to work and providing movement of the lower extremities. This method reduces the likelihood of venous stasis and deep venous thrombosis [2].

20.6.3 Fat Transfer

Liposuction is performed using a 4 mm diameter blunt three-hole ("Las Vegas tip") cannula and a 4 mm one-hole spatula-tipped cannula. No other devices such as ultrasound, laser

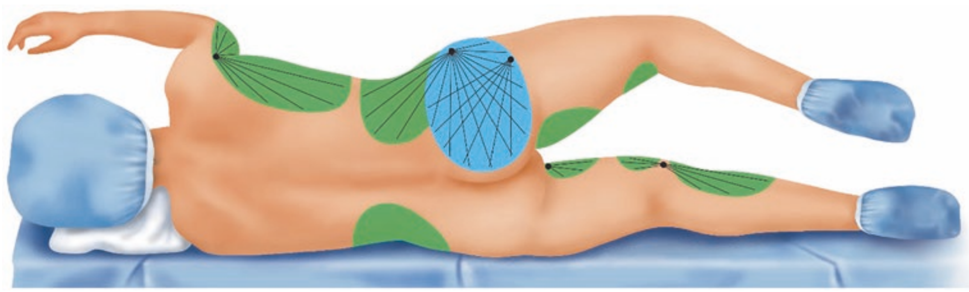

Fig. 20.2 Illustration of liposuction (*green*) and fat injection treatment areas (*blue*) with the patient positioned on her left side for liposuction of the right flank, arm, axilla (including the scapular area), and left medial knee. The abdomen and inner thighs have already been treated with the patient in the supine position. In some cases, the left medial calf and right lateral calf are also treated while the patient is on her side. The outer thigh may be treated if desired. The patient is then turned onto her right side and the contralateral areas are treated in the same sequence, completing the liposuction. Fat is then injected subcutaneously into each buttock using two access incisions located laterally, with cross-hatching over the central buttock. (Reprinted from: Swanson [1]. With permission from Wolters Kluwer Health)

Fig. 20.3 This 43-year-old woman is positioned on her left side. She has already undergone a breast reduction and abdominoplasty while in a supine position. She is breathing spontaneously using a laryngeal mask airway and total intravenous anesthesia. Fat is injected subcutaneously into the lower right gluteal area using radial passes and a lower lateral gluteal incision. (Reprinted from: Swanson [2]. With permission from Springer Nature)

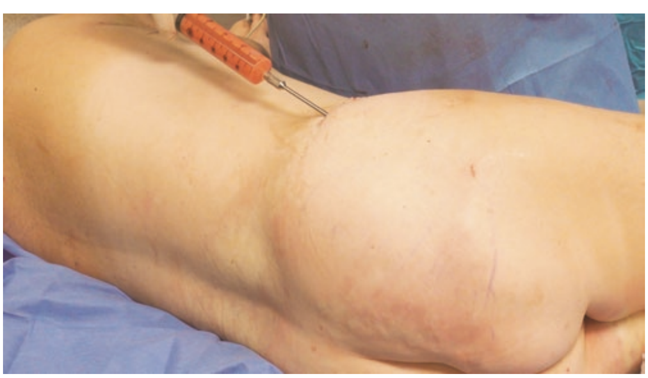

Fig. 20.4 The last area to be injected is the lateral gluteal area. The lower gluteal incision is sutured prior to injection so that fat does not escape during lipoinjection. (Reprinted from: Swanson [2]. With permission from Springer Nature)

assistance, or radiofrequency are used so as to maximize adipocyte viability.

The author presently uses a Tissu-Trans Filtron 500 closed inline filtration system (Shippert Medical Technologies, Centennial, Colo.) to collect the fat without centrifugation [1, 2]. There is no fat handling, improving efficiency and optimizing sterility. The lower abdomen can be treated aggressively to maximize fat harvesting if the patient is simultaneously having an abdominoplasty because this skin will be discarded.

The fat is then injected into the buttocks and lateral gluteal regions using a blunt 4-mm cannula with a side hole (Genesis Biosystems, Lewisville, Tx) attached to 60 cc syringes (Figs. 20.3, 20.4). This is a large cannula that will not bend and enter unintended tissue planes. The same incision used for liposuction of the flanks is re-used for fat injection (Fig. 20.4). A separate incision is made inferolaterally to allow cross-hatching (Fig. 20.3). Care must be taken when using Luer lock connections to secure these snugly so that the cannula angle does not inadvertently angulate during injection passes. To avoid injury to the gluteal veins, fat injection is performed only in the subcutaneous plane. No incision is made inferiorly in the gluteal fold [2]. No drains are used.

20.6.4 Postoperative Care

Patients wear a compression girdle postoperatively for 1 month. They return to full activities including exercising in 1 month. They are not instructed to avoid sitting but rather to minimize sitting, bearing weight preferentially on the ischial areas and getting up frequently. Patients sleep supine.

20.7 Photographic Standardization and Measurements

Strict photographic standardization is mandatory in any plastic surgery study using photographic measurements. The same examining room, lighting, focal distance, Nikon D80 digital camera, and fixed 60 mm lens (Nikon, Tokyo, Japan) are used for all patients. The horizontal distance from the anterior margin of the mons pubis to the point of greatest buttock projection is recorded (Fig. 20.1). In addition, the horizontal distance from the level of maximum lumbar lordosis to the point of greatest buttock projection is measured. This measurement represents the relative buttock projection.

Patient photographs are matched using the Canfield 7.4.1 imaging software (Canfield Scientific, Fairfield, N.J.). The surface area of each buttock within the treatment area is measured (Fig. 20.5). This area includes the region marked preoperatively, extending from the lateral gluteal border to the intergluteal cleft, superiorly to the transitional area between the buttock and the flank and inferiorly to the gluteal fold. This area measurement is used to calculate fat retention.

20.8 Ultrasound Measurements

A single linear depth measurement is made in the central gluteal area with patient positioned prone (Fig. 20.6), at the point of greatest fat thickness of each buttock [1]. All ultrasound measurements are made in the office by the same full-time sonographer. This consistency eliminates inter-operator error. The caliper function is used. Numerous diagnostic ultrasound systems are available. The author uses the Terason t3200 system (Terason Ultrasound, Burlington, MA) (Fig. 20.6). Ultrasound measurements are recorded at the time of the preoperative appointment (usually 2 weeks before surgery) and at a follow-up appointment ≥3 months after surgery. The plane of injection of fat was verified on postoperative ultrasound examinations (Fig. 20.7). Patient weights are recorded simultaneously using the same hospital scales. Analysis of covariance controls for this important variable. Fat retention is calculated using the following formula:

Fig. 20.6 Buttock fat thickness is measured at the point of greatest fat thickness of each buttock with the patient lying prone. This measurement is made before surgery and at ≥3 months after surgery. (Reprinted from: Swanson [2]. With permission from Springer Nature)

Fig. 20.5 Posterior photographs of the same patient depicted in Fig. 20.1 before (left) and 6 months after (right) buttock fat injection. Photographs are matched for size and orientation. The treated gluteal area was measured on both sides using the area measurement function of the imaging software. The surface area (247 cm^2) is indicated for the left buttock. There is no contour deformity of the flank donor sites. (Reprinted from: Swanson [1]. With permission from Wolters Kluwer Health)

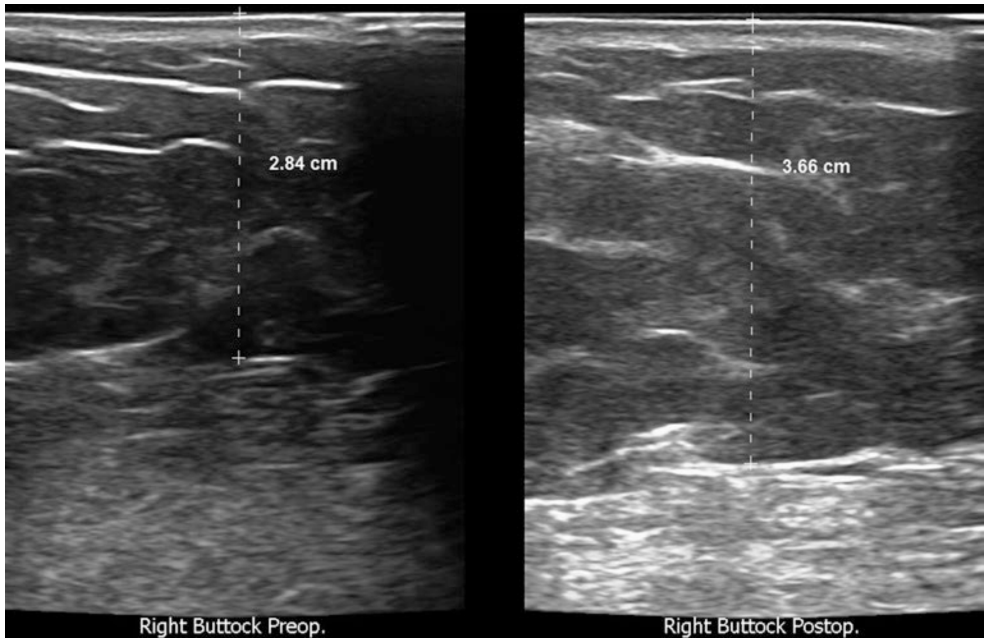

Fig. 20.7 Preoperative ultrasound image of the right buttock for the patient depicted in Figs. 20.1 and 20.5 (*left*). The thickness of the fat layer, measured from the muscle fascia to the skin surface, is 2.84 cm. Ultrasound image of the right buttock in the same patient 6 months after surgery (right). The thickness of the fat layer is 3.66 cm, a gain of 0.82 cm. (Reprinted from: Swanson [1]. With permission from Wolters Kluwer Health)

$$\frac{\text{Fat retention} = \text{buttock area}\left(\text{cm}^2\right) \times \text{difference in buttock fat thickness}\left(\text{cm}\right)}{\text{Fat injection volume}\left(\text{cc}\right)}$$

In the author's practice, patients routinely undergo Doppler ultrasound scans of the lower extremities as part of surveillance for deep venous thromboses. Patients scheduled for liposuction of the abdomen or abdominoplasty are also screened preoperatively for abdominal wall defects to reduce the likelihood of abdominal penetration with the cannula [2].

20.9 Study Findings

There was one male patient in the treatment group and two males in the control group; other patients were female [1]. Age, sex, smoking status, and body mass index were similar for the treatment and control groups. The mean follow-up time for treated patients was 5.8 months (range, 3–15.5 months). The mean fat volume injected per buttock was 287 cc (range, 70–550 cc). Photographs of the patient with lipoinjection volumes (285 cc per buttock) closest to the mean are provided in Figs. 20.1 and 20.5.

Ultrasound measurements detected a significant change in the thickness of the subcutaneous fat layer after surgery ($p \leq 0.001$), with a mean increase of 0.66 cm for the right buttock and 0.86 cm for the left buttock, corrected for a slight postoperative decrease in body mass index. The mean calculated fat retention was 66%. Photographic measurements revealed a significant increase ($p < 0.01$) in buttock projection (right, 0.44 cm; left, 0.54 cm) and relative buttock projection (0.69 cm and 0.73 cm respectively) for treated patients, corrected for change in body mass index. There were no significant changes for control patients [1]. An increase in fat thickness of <1 cm is admittedly modest, but is complemented by fat reduction of the flanks, as demonstrated by the increase in relative buttock projection. Even if fat retention were 100%, one could expect only about 1 cm of increased projection from 287 cc of fat distributed over an area of 250 cm^2. Accepting a lesser degree of augmentation is preferable to donor site deformities, seromas, and paresthesias caused by overly aggressive harvesting. Of course, it is possible to return later for additional fat injection if desired.

20.10 Complications

No infections were encountered among the 25 consecutive patients. No patient developed symptoms or signs of fat necrosis and no evidence of fat necrosis (oily cysts) was detected on any of the ultrasound examinations. This was a welcome finding in view of the large syringes used. There were no seromas or hematomas. There were no cases of fat embolism. No deep venous thromboses were detected at any of the ultrasound examinations. No patient required hospitalization or a blood transfusion. All patients were treated with fat injection once. There were no cases of sciatic neuropathy or painful paresthesias. Importantly, there were no donor site complications and no contour deformities [1].

20.11 Realistic Patient Expectations

At their consultations, prospective patients often show photographs of dramatic results that they have found on the internet. These photographs are different from those published in our journals, often demonstrating exaggerated results [2]. There is often no indication of how many fat injection and liposuction treatments were used or the postoperative time interval. Sometimes adhesive strips and bruising reveal that the photographs were taken shortly after surgery, at the time of maximum edema. Photographs are seldom standardized, so that different body positions (e.g., the patient flexed at the hips in the after photo and the waist rotated) contribute to the appearance of a reduced waist-to-hip ratio, even less than the idealized 0.70 figure. Exaggerated results promote unrealistic patient expectations and make good outcomes appear inadequate. Nowhere is the mantra of underpromising and overdelivering more applicable [2].

20.12 Conclusions

Photographic and ultrasound measurements are effective tools to evaluate changes in gluteal volume. The findings confirm that fat transfer effectively and safely increases buttock projection. Fat retention is about 66%. This method may be used to compare buttock fat transfer methods in future studies.

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Part III

Other Gluteal Augmentation Techniques

21 Mortality Following Gluteal Fat Augmentation: Physiopathology of Fat Embolism

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21.1 Introduction

Surgery for gluteal contouring with fat injection has significantly increased in the last 5 years [1]. Historically, aesthetic procedures for the gluteal region were limited to gluteal lift that left unsightly scars. Subsequently, the placement of gluteal implants was implemented, which initially did not provide great results. Additionally, the rate of complications and the prolonged learning curve limited their use. With the advent of liposuction and later the use of fat for aesthetic improvement of various parts of the body, fat injection in the gluteal region became the procedure of choice for gluteal augmentation. The concept of body contouring through gluteal lipoinjection consists of performing two combined surgical procedures: liposuction to remove fat from around the gluteal region to improve the contour and shape, and fat injection in the gluteal region to achieve gluteal augmentation and desired shape [2, 3].

Despite the excellent results obtained with gluteal fat injection, there has recently been a considerable increase in complications secondary to this procedure. Initially, the complications were minor and were solved in a simple manner [4]. However, there have been many severe complications mainly, due to the entry of fat into the bloodstream, that have increased the morbidity and mortality of this procedure [5].

In the mid-1980s, Dillerud reported the first cases of fat embolism syndrome secondary to liposuction [6]. Initially, these cases were isolated and uncommon. However, reports of similar conditions secondary to liposuction and gluteal lipoinjection have increased. Fat embolism syndrome is a complication inherent to the surgical procedure of liposuction and gluteal lipoinjection [7–9]. It is similar to the fat embolism syndrome described in the medical literature, with characteristic signs and symptoms that have been reported by Gurd for decades [10]. Recently, a different pathology with clinical characteristics different from the classic fat embolism syndrome began to appear with severe morbidity and mortality.

Therefore, we sought to determine the specific problems associated with gluteal lipoinjection. We identified two completely different pathologies in terms of etiopathogenesis, clinical presentation, prognosis, and treatment, secondary to the same causative agent: the introduction of fat into the bloodstream [5]. These two pathologies are referred to as microscopic fat embolism (MIFE) and macroscopic fat embolism (MAFE).

21.2 Clinical Presentations

21.2.1 Microscopic Fat Embolism (MIFE)

MIFE commonly known as fat embolism syndrome is typically seen in patients who present with long bone fractures and polytrauma [11, 12]. Secondary to the traumatic process, fat is introduced into the bloodstream in the form of fat micro-emboli, although larger fat particles may also be introduced (Fig. 21.1). These fat micro-emboli are degraded into free fatty acids by the action of serum lipase and can cause tissue damage inducing a systemic inflammatory response. This systemic inflammatory response affects the microcirculation of the body with involvement of the central nervous system, the respiratory system, and the skin [11, 13]. Clinical manifestations consist of disorientation with alterations of consciousness, dyspnea with hypoxemia, and petechiae. All these manifestations have been described by Gurd and Schonfeld, as previously indicated [10, 14]. Schonfeld was given the task of awarding scores to the various clinical manifestations, whereas Gurd classified the manifestations

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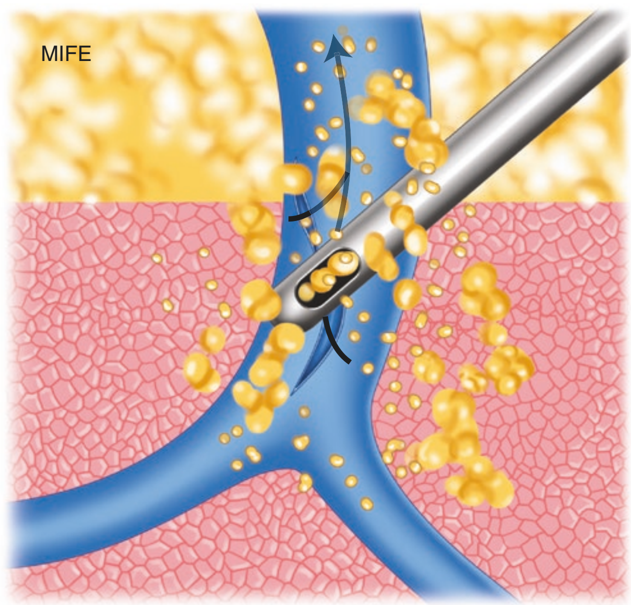

Fig. 21.1 Micro fat embolism (MIFE). Even when large vessels are not injured, injecting fat in highly vascularized areas can lead to absorption of microscopic particles of fat into the circulation

Table 21.1 Gurd's criteria for diagnosis of fat embolism

Major criteria	Minor criteria
Axillary or subconjunctival petechiae	Tachycardia >110 bpm
Hypoxaemia $Pa_{O2} < 60$ mm hg; $FI_{O2} = 0.4$	Fever >38.5 °C
Central nervous system depression disproportionate to hypoxemia	Emboli present in the retina on fundoscopy
Pulmonary edema	Fat present in urine
	Sudden inexplicable drop in hematocrit, hemoglobin or platelet values
	Increase ESR
	Fat globules present in the sputum

into major and minor criteria. The total score obtained by Schonfeld and the sum of major and minor criteria proposed by Gurd help us describe and subsequently diagnose the clinical picture (Table 21.1). The typical clinical picture of these patients usually begins between 24 and 72 hours after the surgical procedure. If the patients present with respiratory and neurological manifestations, it is imperative to perform pulmonary radiological diagnostic tests. Chest axial computerized tomography revealing ground glass opacities and pleural effusion provides diagnostically useful data [15, 16]. Once the diagnosis of a microscopic fat embolism has been established, the treatment is aimed at providing aggressive hemodynamic and respiratory support to facilitate cardiologic and respiratory function and stabilize the patient's acute state [17, 18]. The acute inflammatory state produced by fatty acids lasts approximately 7–10 days. Then, with adequate treatment, the patient becomes stable and improves gradually. With early treatment, the mortality of these patients is less than 10%; however, if the diagnosis and treatment are delayed, mortality reaches 30%.

Given that any substance injected in the body is absorbed easily and intensely when placed in highly vascularized tissue, such as the muscle, a few years ago, we had started to inject less fat intramuscularly. Nowadays, we inject fat only in the subcutaneous plane in order to avoid any entry of fat into the vessels. Similarly, to reduce the concentration of free fatty acids in the bloodstream, we require that patients remain hospitalized for a minimum of 12–24 hours after surgery, with the goal of ensuring proper hydration as it helps in elimination of fatty acids through the kidneys. In our surgical experience of almost 30 years, we have experienced two cases of MIFE that are reported as fat embolism syndrome in the literature in 1998 and 2000 [3, 4]. We have adopted the same prevention and treatment in these cases as in the orthopedics literature with good results. With the implementation of these measures, in more than 17 years, we have not experienced another case of MIFE since these maneuvers help reduce the introduction of fat into the bloodstream and facilitate its elimination.

21.2.2 Macroscopic Fat Embolism (MAFE)

In other cases of gluteal lipoinjection, clinical presentations were different from the classical MIFE and included sudden deaths. Currently, gluteal lipoinjection is the main cause of death approximating 30% during liposuction in countries such as Mexico and Colombia where this procedure is highly requested and performed. It is important to emphasize that the introduction of macroscopic fat into the bloodstream is due to injury of the gluteal vessels during the surgical procedure, thus the term MAFE [5] (Fig. 21.2). Autopsies of patients who died from this procedure showed direct lesion of the gluteal vessels, which allowed fat to enter the bloodstream in the form of macroscopic fat particles rather than microscopic fat particles as noted in MIFE. These gluteal vessels are located below the gluteus maximus and gluteus minimus muscles adjacent to the pyramidal muscle (Fig. 21.3). The injury does not necessarily have to involve a complete laceration or rupture of the vein or a tributary of the vein with a liposuction cannula. A cannula that scrapes the vein and tears it during the surgical procedure is sufficient for the problem to occur. When tearing of the gluteal vein occurs, the greater negative pressure of the vena cava causes the fat surrounding the gluteal vein to be absorbed. Analysis of these autopsies revealed macroscopic fat at the level of the vena cava, cardiac cavities, and pulmonary vessels due to injury of the gluteal veins [5] (Figs. 21.4 and 21.5). The gluteal veins may be damaged near the pyramidal muscle when deep lipoinjection is performed in the glu-

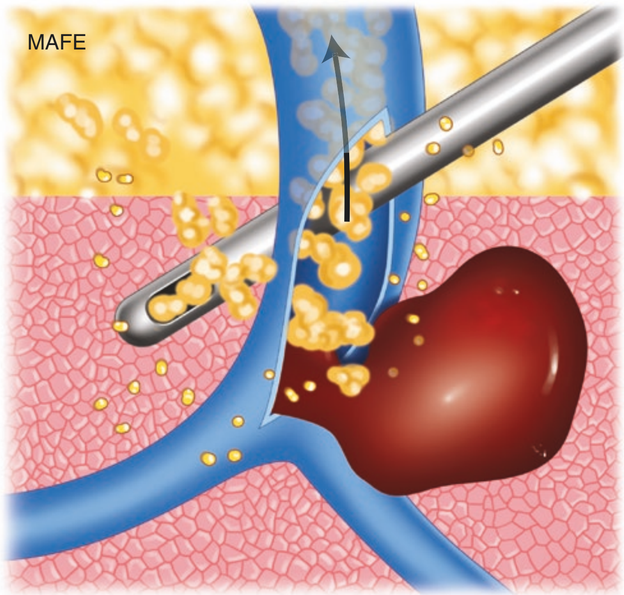

Fig. 21.2 Macro fat embolism (MAFE). Fat particles may be introduced into the circulation directly by the cannula or via a laceration in the vessel

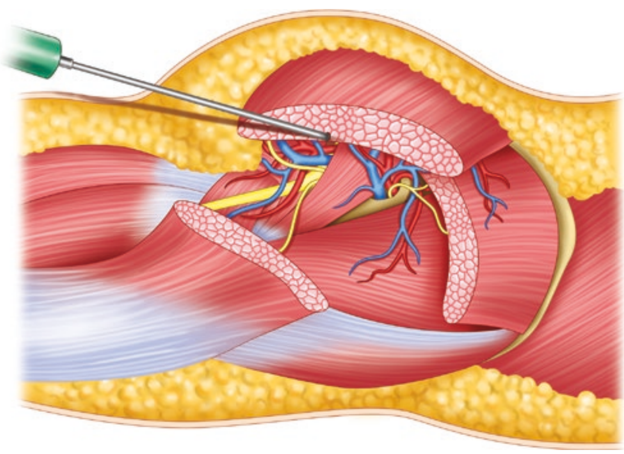

Fig. 21.3 Intramuscular injection of fat is the most common cause of fat embolism due to the risk of injuring the gluteal vessels

teal region. According to the topography of the region, the vessels are located in the deep medial portion of the gluteal region. Numerous factors can promote entry of fat into the bloodstream, including inappropriate positioning of the cannula, intense manual pressure at the time of infiltration, sharp cannula tip, thickness of the cannula less than 3 mm, and aggressive movements when injecting. However, the most important factor that determines the possibility of injuring the veins is the location where it is injected. Therefore, intramuscular deep injection of fat, especially in the medial portion, is the determining factor for injuring the vessels and causing problems [19] (Fig. 21.6). The easiest way to injure

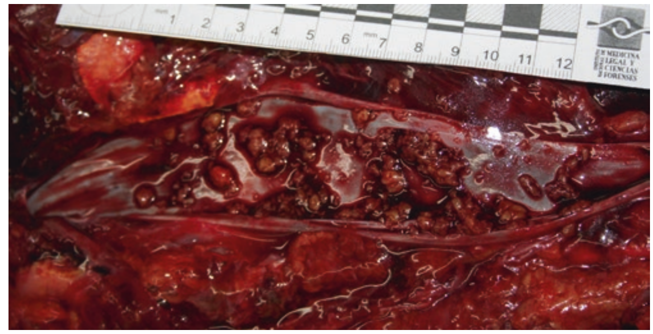

Fig. 21.4 Presence of macroscopic fat in the vena cava. (Reprinted with permission from Cardenas-Camarena et al. [5])

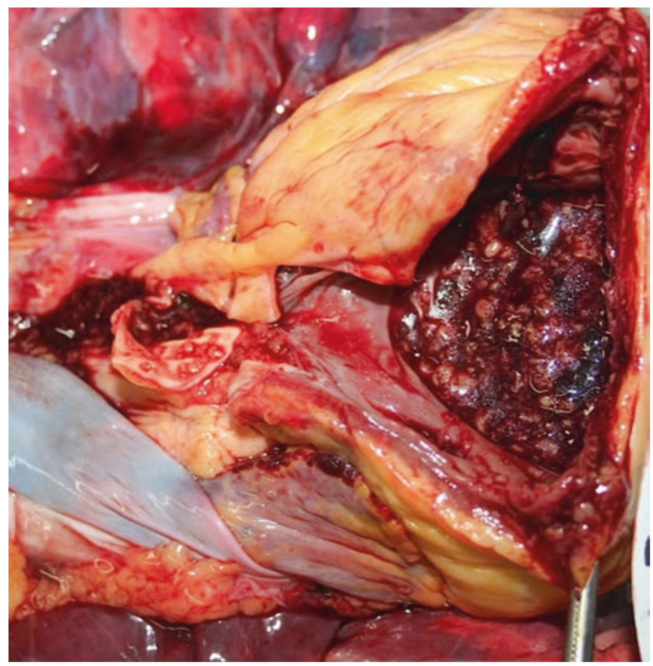

Fig. 21.5 Presence of macrosocpic fat in the right ventricle. (Reprinted with permission from Cardenas-Camarena et al. [5])

Fig. 21.6 Section of gluteus maximus muscle showing the presence of fat placed deep in the muscle. (Reprinted with permission from Cardenas-Camarena et al. [5])

Table 21.2 General characteristics of micro fat embolism (MIFE) and macro fat embolism (MAFE)

	Micro fat embolism (MIFE)	Macro fat embolism (MAFE)
Causal agent	Microscopic fat usually in liquid form or micelles that can form microembolism	Macroscopic fat which groups into clots forming macroembolism
Pathophysiology	Due to the effect of lipase, fatty acids are released from micro-emboli, producing alveolar and capillary irritation with hemodynamic alterations	Fat cells clot immediately obstructing the venous blood vessels and heart by a mechanical effect
Start	24–72 hours postop	Almost always intraop, usually when injecting fat, with sudden cardiac involvement
Clinical presentation	Gurd's criteria Alterations in microcirculation affecting the lungs, skin, and central nervous system	Mechanical effect on the heart producing sudden cardiac arrest similar to thromboembolism
Diagnosis	ClinicalComputed axial tomography: Ground-glass opacity and pleural effusion	Clinical Sudden onset, beginning when fat is injected Cardiac failure
Prognosis	Mortality between 10% and 30% depending on how fast the treatment is implemented	Almost always causes death
Treatment	Respiratory and hemodynamic support in the intensive care unit	No specific treatment Aggressive cardiovascular support Experimental: Ciclesonide, Rosuvastatin, percutaneous embolectomy
Prevention	Avoid liquid fat injection Adequate hydration Avoid fat injection in highly vascularized areas	Avoid injecting fat into the intramuscular plane

these gluteal vessels is when the cannula is introduced in the gluteal fold. Thus, it is highly recommended that the cannula be placed parallel to the thighs and directed upwards at all times to reach the gluteal surface, if injecting through gluteal fold incisions. Both vision and palpation allow proper steering of the cannula.

The presentation of the clinical picture of MAFE is very different from MIFE. Unlike MIFE, which starts 24–48 hours after surgery, the manifestations of MAFE occur at the same time of fat injection when there is injury to the gluteal vessels and subsequent entry into the bloodstream. The patient begins to exhibit signs and symptoms, including sudden onset of hypoxemia, hypotension, and bradycardia that do not respond to cardiovascular support maneuvers. These symptoms are similar to those encountered during a massive pulmonary thromboembolism, except that the etiopathogenesis is not a blood clot but a fat embolus. Unfortunately, the majority of patients with this clinical picture die within a few minutes of onset [20].

The general characteristics and the most important differences between MIFE and MAFE are presented in Table 21.2.

21.3 Conclusions

Plastic surgeons who perform gluteal lipoinjection must know that liposuction and/or lipoinjection can produce two different clinical pictures: MIFE and MAFE. The causative agent in both is the same: the introduction of fat into the blood stream. MIFE is caused by the introduction of micro fat particles and free fatty acids into the bloodstream and MAFE by the introduction of macro fat emboli. Intramuscular fat injection and dehydration are risk factors for triggering MIFE. Thus, adequate hydration and limiting or avoiding injection of fat intramuscularly are factors that help prevent these complications. Deep gluteal fat injection especially via incisions in the infra gluteal fold directed towards the medial aspect of the gluteal region exhibits increased risk of injury to the gluteal vessels. Therefore, maintaining the cannula parallel to the thigh, upwards and towards the surface of the gluteal region, will prevent injuring the gluteal vessels. To prevent injuring the gluteal vessels, our main recommendation is to avoid intramuscular injection of fat.

Dr. Guerrerosantos demonstrated years ago that fat injected into the muscles of rats survived in much greater proportions than if injected subcutaneously, as the muscle is highly vascular. This was corroborated by injection of fat into the face in intramuscular planes where high integration was observed. The complications of macroembolism started when attempting to generalize these findings and injecting fat into larger muscles, such as in the gluteal region. This concept has been changed when treating the gluteal region, as we now inject the greatest amount of fat in the subcutaneous plane, decreasing injections in the intramuscular planes. Overall, the paradigm must change, and we must always take into consideration the safety and life of the patient instead of achieving greater fat graft take.

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22 Complications of Gluteal Fat Augmentation

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22.1 Background

The gluteal region has always played an important role in female sexuality and beauty. With the increase in the demand for gluteal augmentation, there has been an evolution of the different surgical techniques. From 2001 to 2010, the demand for gluteal augmentation with implant was higher than with fat grafting. Since 2011, fat grafting has been the preferred procedure and the demand is increasing exponentially. A survey performed among board-certified Brazilian plastic surgeons [1] revealed that 80% preferred fat grafting for gluteal augmentation. According to the 2016 statistics of the American Society for Aesthetic Plastic Surgery (ASAPS) [2], 92% of the gluteal augmentation procedures performed in the US were with fat grafting while only 8% were with gluteal implants.

The increase in gluteal fat augmentation procedures is due to the fact that this procedure uses the patients' own fat tissue, there is a faster recovery, and the reported overall complication ratio was low 7.2% compared to 21.6% when gluteal implants were used [3, 4]. Recently, there has been an increase in the number of fatal complications related to gluteal fat augmentation [5]. We present the minor and major complications related to this procedure.

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22.2 Fat Resorption

Fat resorption is not considered a complication, since it is expected to occur in all cases of fat grafting in any region of the face and body. The amount of fat that will be absorbed varies according to several factors, the patient, or the technique used. Cansancao et al. [6] reported a mean fat absorption ratio of 18.2% at 1-year post gluteal fat grafting performed in the subcutaneous plane only. When there is more resorption of fat in one buttock in comparison to the other, it can result in severe asymmetry of the gluteal region and can be considered a complication, as it will most probably require a secondary fat grafting procedure.

22.3 Seroma

The occurrence of seroma is multifactorial and can be related to lymphatic disruption, non-viable tissue, or fat debris [7]. It occurs in 3.5% of cases [4], and is more common in the donor sites where fat has been harvested [8, 9]. The use of compression garments and lymphatic drainage can help decrease its incidence.

22.4 Fat Necrosis and Oil Cysts

Fat necrosis may occur independent of the amount of fat injected in a specific area of the body. The incidence reported for this complication is 4% [4]. The fat that does not integrate within the recipient bed will not survive and will remain oily and most will get reabsorbed in the body. The higher the volume of fat injected in an area, the higher the incidence of possible fat necrosis and oil cysts. They are usually asymptomatic and the incidence not reported unless diagnosed with imaging. These oil cysts can evolve to spontaneous drainage with symptoms such as erythema, pain, and localized edema. In these cases, ultrasound-guided drainage must be performed with the use of thick needles or cannulas. If these

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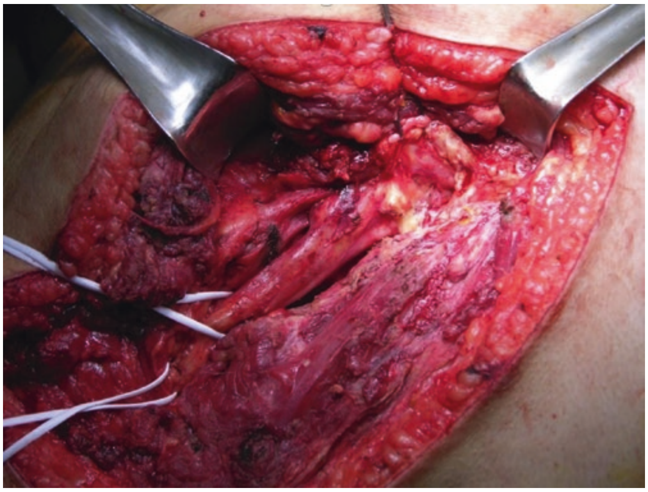

Fig. 22.1 Fat deposits within the perineurium of the sciatic nerve. (Courtesy of Alexander Cardenas-Mejia)

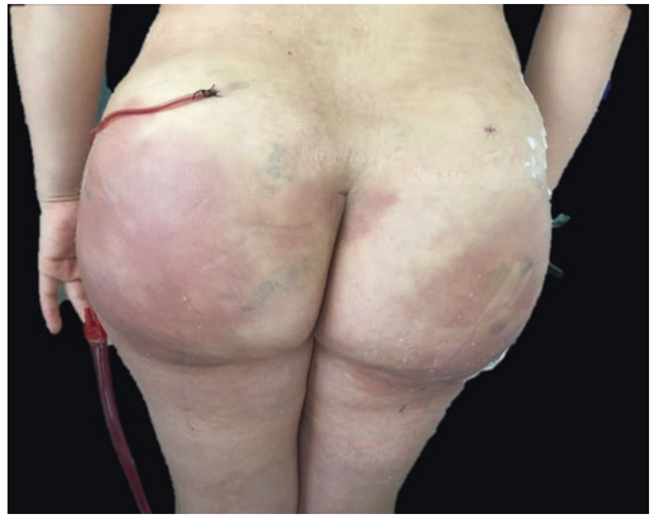

Fig. 22.2 Patient presenting to the clinic at postoperative day 2 of gluteal fat augmentation with significant erythema and edema of the gluteal region. Note that a routine drain placed intraoperatively is seen in the left gluteal region with serosanguineous drainage

cysts are large and are not diagnosed and treated adequately, the fat necrosis could serve as a culture medium, increasing the chance of major infectious complications. When fat necrosis is aspirated, culture of the secretion should be done to differentiate it from a potential infection. Oil cysts have also been reported as aseptic abscesses.

22.5 Nerve Injury

Injury to the sciatic nerve is a rare complication [8] that can occur when fat is injected intramuscularly or submuscularly when the cannula is introduced close to major vessels and nerves. With the latest recommendations to perform fat grafting in the subcutaneous plane only, this complication has significantly decreased. Damage to the sciatic nerve should be suspected in the immediate postoperative period when numbness, weakness, and pain in a limb are reported (Fig. 22.1). Large edema of the gluteal region and the limb may cause nerve compression that usually improves within a few days.

22.6 Infection

Infection rates vary from 0.3% to 1.96% [9]. One must always be aware of this complication as sepsis can occur after fat grafting to the gluteal region. It has been reported to be the second cause of death in gluteal fat augmentation [1]. Transplanted fat is an ideal culture medium, at least between the 4th and 7th day postop, when vascular ingrowth occurs. Also, the gluteal region is a potential source of contamination, due to its proximity to the anus, and any step of the procedure including harvesting, processing, and injection has a potential for contamination. The most common bacteria related to infection in gluteal fat grafting are gram-negative bacteria such as *Escherichia coli*, *Bacteroides fragilis*, Microaerophilic streptococci, *Pseudomonas aeruginosa*, Enterococcus, non-gas-forming Clostridia, and bacteria from the skin flora such as *Peptostreptococcus* and *Staphylococcus aureus* [8]. The clinical manifestations can be pain, edema, local hyperemia, and fever. These symptoms can be considered as part of the normal postoperative course (Fig. 22.2). However, one must remain alert as delaying the diagnosis and treatment of such infections can lead to the formation of abscess and sepsis. When fluctuence is present in an area, the treatment consists of immediate drainage of the purulent discharge, debridement of devitalized tissues, and copious irrigation with normal saline. Culture of the drained secretion and the debrided tissues should be done, including culture for mycobacteria. Treatment with a course of empiric intravenous antibiotics should be initiated (metronidazole or clindamycin with a second- or third-generation cephalosporin) (Fig. 22.3). Once the results of the cultures are obtained, the appropriate antibiotic should be instituted.

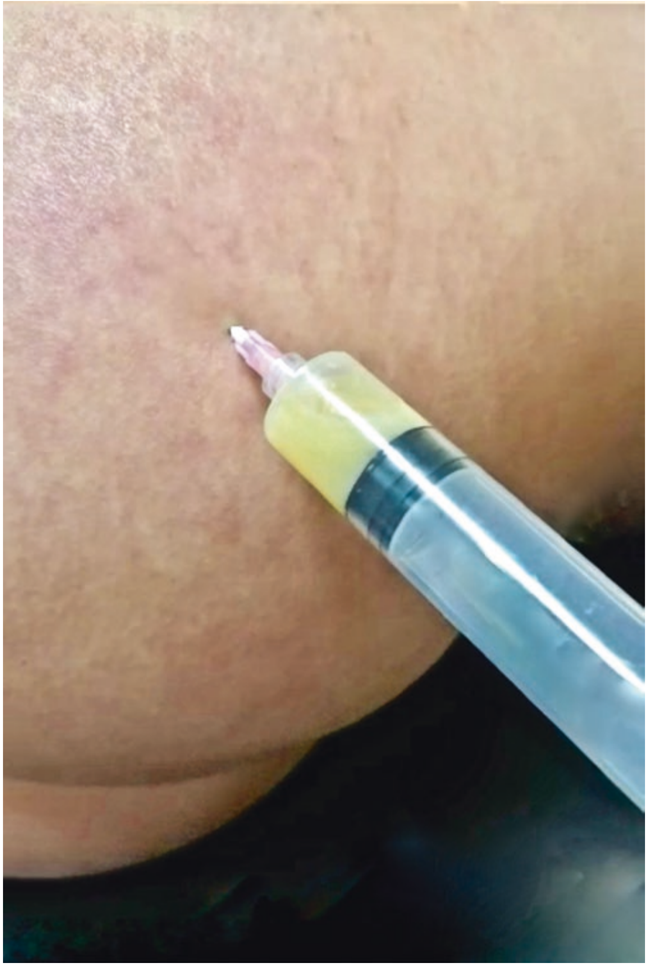

Fig. 22.3 Aspiration of purulent secretion with an 18G needle attached to a 20 cc syringe

The mycobacterial infection occurring with liposuction or fat grafting is complex as the infection is indolent. The symptoms may start a few weeks after the procedure with the patient presenting localized erythema and edema that evolve into purulent discharge and necrotic tissue in multiple sites (Fig. 22.4). Lowenstein–Jensen or other mycobacterial culture media should be used when mycobacterium species are suspected, especially in cases of medical tourism [10, 11]. Polymerase chain reaction (PCR) may also be used to confirm the diagnosis [12]. Other possible causes of mycobacterial infection are injection of unidentified and nonspecified substances in nonaccredited facilities such as spas and gyms. Patients may have received an injection months prior to the procedure with the mycobacteria remaining incipient and once the fat is injected in the gluteal region, the mycobacterial infection progresses to active disease [13]. Any previous injection of fillers or other materials such as mineral oil, medications, deoxycholic acid in the region must be inquired and the possible risk of infection must be discussed with the patient [14]. Rigorous antibiotic protocol must be adopted to prevent infection post gluteal fat grafting. A first-generation cephalosporin or ciprofloxacin [3] is recommended prophylactically and up to the 7th day postop. Preoperative aseptia of the surgical field with povidone iodine solution should be done. A soaked lap or a transparent film dressing should be placed in the gluteal cleft prior to skin incision and during the procedure to minimize contamination from the anal region. Avoiding fat manipulation with the use of a closed system to harvest, process, and inject the fat will also help decrease contamination and subsequent infection [15] (Fig. 22.5).

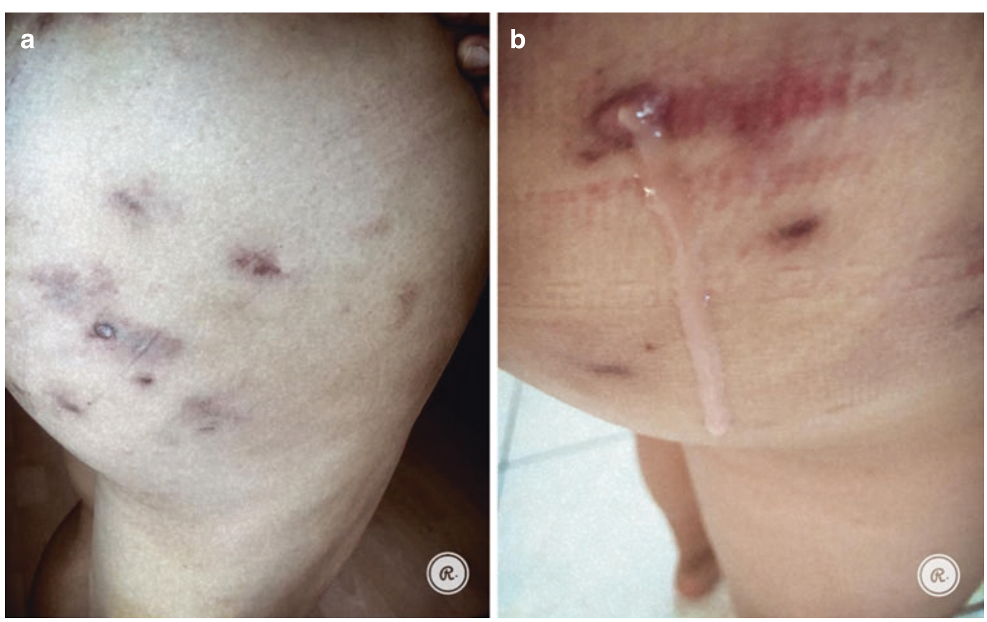

Fig. 22.4 (**a**) A 32-year-old female patient, who had 500 ml of fat injected in each buttock presenting at 35 days postop with localized erythema and purulent discharge with evidence of mycobacterial infection in culture. (**b**) Patient at 3 months postop. (Courtesy of Miguel Angel Leon, MD)

Fig. 22.5 Closed system for fat grafting to harvest, process and injection fat, further decreasing the risks of contamination

22.7 Thromboembolism

Thromboembolism is a concern when performing liposuction and fat grafting to the gluteal region. Preoperative screening for deep venous thrombosis and pulmonary embolism, and assessment of the Caprini score is mandatory in patients being submitted to these procedures. Before the induction of anesthesia, compression garment in the lower extremities should be placed and intermittent compression should be performed during the whole procedure and in the postoperative period to reduce the risk of thrombosis.

22.8 Fat Embolism

Cardenas-Camarena et al. [16] were the first to draw attention to the high risk of fat embolism in gluteal fat grafting, due to the injection of fat into a highly vascularized tissue (the muscles) and close to the great vessels of the gluteal region. They were also the first to describe the mechanisms by which fat particles penetrated the bloodstream causing fat embolism. These mechanisms called MIFE (MIcro Fat Embolism) and MAFE (MAcro Fat Embolism) [17, 18] are described in more detail in Chap. 21.

22.9 Death

With the increase in popularity of this procedure, an increase in the number of deaths has also been reported [16]. A survey done by the Aesthetic Surgery Education and Research Foundation (ASERF) task force reported a mortality ratio ranging from 1:2.351 to 1:6.214 cases, depending on the methodology used [5]. A more recent survey performed among board certified Brazilian plastic surgeons showed a mortality risk of 1:20.117 cases with fat embolism being the most common cause (54.55%), followed by thromboembolism (18.18%) and infection (18.18%) [1].

22.10 Conclusions

Fat grafting is the preferred method to perform gluteal augmentation as it can achieve aesthetically pleasing long-term outcomes, with fast recovery and low complication rates. Plastic surgeons need to be prepared to diagnose and treat any possible complications intraoperatively and postoperatively in order to improve safety of this procedure.

Disclosure The authors report no conflict of interest.

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23 Safety in Gluteal Fat Augmentation

Alvaro Cansanção, Alexandra Condé-Green, and Amin Kalaaji

23.1 Introduction

Gluteal fat grafting was presented for the first time by the Brazilian Plastic Surgeon Raul Gonzales, and then published by Luiz Toledo in the 1980s [1, 2], gaining popularity in Latin America. This popularity was not seen initially in North America and Europe due to cultural preferences, as in these countries the beauty standard was smaller and athletic-looking buttocks. In the late 2000s, with the advent of social media, the pattern of beauty and sexuality changed around the world, especially in the United States [3] where celebrities with large buttocks became popular, leading many women to desire fuller contours. The demand for gluteal augmentation surgery using autologous fat grafting skyrocketed in the recent years [4], due to the perception that it was a safe surgery with fast recovery and low complication rates [5].

Cardenas-Camarena was the first to report that along with the increase demand for gluteal fat augmentation, serious complications and fatalities were also increasing [6]. The cause of death was mainly fat embolism due to fat being injected in the intramuscular plane. He described the different mechanisms [7, 8] by which fat lobules penetrate the bloodstream and travel to the lungs, macro fat embolism (MAFE) and micro fat embolism (MIFE). Subsequently, Rosique and Rosique conducted a study where they described the danger zone, a triangular area that contains the deep gluteal vessels where intramuscular fat grafting should be avoided [9]. In 2017, the Aesthetic Surgery Education and Research Foundation (ASERF) launched a survey among board-certified plastic surgeons and reported a mortality rate related to gluteal fat grafting of 1:3000 cases [10]. Some surgeons who had reported death of their patient from fat embolism stated that they had injected fat in the subcutaneous plane, however the autopsy had shown the presence of fat intramuscularly. This finding confirmed the correlation of intramuscular gluteal fat grafting and fat embolism, but raised doubts on the ability of surgeons to make sure that they were injecting fat in the correct and safest plane. Injecting fat in the gluteal region was considered a blind procedure.

A multi-society gluteal fat grafting task force was formed by multiple societies, including the American Society of Plastic Surgeons (ASPS), the American Society of Aesthetic Plastic Surgery (ASAPS), the International Society of Aesthetic Plastic Surgery (ISAPS), the International Society of Plastic Regenerative Surgery (ISPRES), and the International Federation of Adipose Therapeutics and Science (IFATS) in order to establish guidelines of safety for the procedure. The most important recommendation was to avoid intramuscular gluteal fat augmentation [11].

In 2018, deaths were still happening and some plastic surgery societies were contemplating the possibility of creating a moratorium or a ban of the gluteal fat augmentation procedure until they better understood the mechanism by which embolism was occurring. Cansanção et al. introduced a technique called "real-time ultrasound-assisted gluteal fat grafting" that was published that same year in *Plastic and Reconstructive Surgery* [12], which consists in performing ultrasound-guided fat grafting, allowing the surgeon to know exactly in which plane the fat is being injected (superficial subcutaneous or deep subcutaneous), avoiding at all times the intramuscular plane. This technique allows fat to be injected under direct vision of the tip of the cannula making it less of a blind procedure.

Then, Del Vecchio et al. described the fat migration theory [13], showing that fat injected intramuscularly can migrate to any region of the gluteus maximus muscle, including the deep intramuscular plane and the submuscular plane, where

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the great vessels are located, thus increasing the chance of fat embolism and consequently death. This theory overturned the argument that it was safe to inject fat into the superficial intramuscular plane, showing that the risk of complications exists regardless the region of the gluteus maximus muscle in which fat is injected; therefore, one should stay away from the muscular plane. The Multi-Society Task Force published another statement later that year, showing that intramuscular gluteal fat grafting had been banned in the state of Florida and recommending that all its members follow this recommendation [11].

Since Guerrero-Santos published his study on fat retention in the 1990s [14], intramuscular gluteal fat grafting had been considered the gold standard to increase fat graft take. However, with the recommendations from the task force, many surgeons were wary of the possibility of poor results. Cansanção et al. in 2019 showed their results of gluteal fat retention in a study evaluating long-term fat retention when injected in the subcutaneous plane only [15]. They found that there was approximately 80% graft take in that plane, making surgeons more confident in adopting the subcutaneous plane for gluteal fat augmentation. Despite all these advances in knowledge and efforts for patient safety, some surgeons are still advocating for a ban on gluteal fat grafting, based on the argument that it is the aesthetic procedure with the highest mortality rate (1:3000) according to Moffid in 2017 [10]. However, a recent survey from board-certified Brazilian plastic surgeons reported a mortality rate of 1:20,000 [16]. This recent publication has been helping those who advocate in avail of gluteal fat grafting to show that this surgery can be done safely and that education and training of plastic surgeons to perform this procedure safely was most important than banning the procedure.

The Brazilian survey published by Cansanção et al. showed other important data, such as other causes of death of gluteal fat grafting. Fat embolism was the main cause of death (50% of cases), but pulmonary thromboembolism and infection were also reported. This study also confirmed the direct relationship between intramuscular fat injection and fat embolism as the risk of death (from any cause) was 16 times greater when fat was injected intramuscularly and fat embolism was infinitely higher as well [16] (incalculable risk – OR = 0).

23.2 Understanding and Avoiding the Main Causes of Death in Gluteal Fat Grafting

Like any surgical procedure, gluteal fat augmentation has risks and it is up to us plastic surgeons to know how to identify them and minimize their occurrence. In our recent survey, three complications led to death:

- Infection: Infection has been reported as one of the complications of gluteal fat grafting that may evolve to a fatal outcome [16]. Two factors contribute to making the gluteal region a higher risk location:
  - Proximity of the incision sites with the perianal region, which has gram-negative bacteria (enterococcus).
  - Unlike fat grafting to the face, the breasts, or for muscular definition in high-definition liposuction, in the gluteal region, large volumes of fat grafting increase the incidence of fat necrosis and oil cysts that may serve as a culture medium for bacteria. The incidence of infection was higher in the past due to more manipulation of fat during the processing method before injection. With the advent of closed fat processing systems with minimal manipulation and exposure to air during the whole process, the risk is much lower.
- Pulmonary thromboembolism: The occurrence of thromboembolic phenomena should be considered when performing major surgical procedure, just like in gluteal fat augmentation. However, the risk is not higher in this procedure when compared to other surgical procedures and its occurrence cannot be confused with fat embolism, which present with different mechanisms. Patients should be risk stratified for deep venous thromboembolism and pulmonary embolism (DVT/PE) through protocols, such as the Caprini risk assessment model [17] in order to implement prophylactic measures, such as anticoagulants (low-molecular-weight heparin, LMWH). The use of mechanical prophylactic measures, such as hyperhydration, the use of intermittent pneumatic compression devices, compression stockings, early ambulation, among others, should always be instituted and the team should always be alert to any DVT/PE signs.
- Fat embolism: Fat embolism was identified as a major risk factor in all studies related to gluteal fat augmentation. It occurs due to the entry of fat particles into the bloodstream which migrate to the pulmonary vessels and bronchi, causing obstruction preventing gas exchange in the lung, which can lead to disastrous consequences within minutes.
- The entry of fat into the bloodstream takes place in three different ways:
  - Intravascular injection: by canalization of a large-caliber vessel by the cannula with consequent fat injection into it.
  - Siphon effect: In a partially injured vessel, the blood flow creates a negative pressure gradient that can suck small fat particles into the bloodstream.
  - Capillary permeability: The blood vessel walls have lipophilic characteristics, allowing the entry of small particles of oily substances. The oil found in the processed lipoaspirate, when not completely removed, can enter the bloodstream where it is degraded to fatty

acid molecules [18]. These fatty acids are irritating to the vascular walls, ultimately leading to fat embolism syndrome, which has a distinct pathophysiology, symptoms, and treatments from fat embolism.

23.3 Safety Recommendations

Based on our experience and the knowledge currently available on the anatomy of the gluteal region and the surgical procedures in that region, we recommend the following to safely perform gluteal fat augmentation (Table 23.1):

- *Fat should be injected in the subcutaneous plane only*: the relationship between intramuscular fat injection and fat embolism has already been exhaustively demonstrated, so there is no justification for continuing to inject fat in the muscle knowing the significantly higher rate of severe complications.
- *Avoid large-volume fat grafting*: There is no statistical evidence of a relationship between the volume of fat injected in the gluteal region and fat embolism when fat is injected in the subcutaneous plane. Large-volume fat grafting could lead to more fat necrosis and oil cyst formation, culture media for bacteria that can lead to infection. In addition, large volume of fat injected can lead to high pressure over the fat and facilitate migration into the intravascular space. If a large-volume fat grafting is desired by the patient, staging of the procedure must be considered.
- *Use a larger diameter cannula for fat injection*: Smaller diameter cannulas can easily bend and penetrate the intramuscular plane.
- *Inject fat with the cannula always in motion*: It is strongly recommended to inject with the cannula always in motion to avoid bolus injection near a vessel that could increase the probability of migration of fat lobules into the bloodstream by the siphon effect.

Table 23.1 Safety recommendations to perform gluteal fat augmentation

1	Fat should be injected in the subcutaneous plane only
2	Avoid large-volume fat grafting
3	Acquire experience with the procedure and become familiar with gluteal anatomy
4	Adequate patient selection
5	Optimal clinical management
6	Avoid the use of lidocaine in the infiltration solution
7	Use a closed system to harvest and inject fat
8	Use of prophylactic antibiotic
9	Use a larger diameter cannula for fat injection
10	Inject fat with the cannula always in motion

Reused with authorization by *Plastic and Reconstructive Surgery* from Cansancao et al. [16]

- *Use a closed system to harvest and inject fat*: Manipulation can increase the risk of fat contamination and infection, especially because prior to transfer into the body, fat can serve as a culture medium to microorganisms.
- *Use prophylactic antibiotic therapy*: Since infection was reported as one of the most common causes of death in gluteal fat augmentation, prophylactic antibiotic should always be considered. A large-spectrum antibiotic should be used to cover gram-negative and gram-positive organisms of the skin flora.
- *Become familiar with the anatomy of the gluteal region*: The gluteal region has odd anatomical characteristics that make it more favorable to the occurrence of fat embolism when fat is injected intramuscularly. The gluteus maximus muscle is vascularized by the superior and inferior gluteal vessels, which are large vessels that run directly into the internal iliac vessels. The inferior gluteal vein is in continuation with the internal iliac vein, so any fat particle that penetrates the blood stream has a direct path to the heart, facilitating the occurrence of fat embolism. Therefore again, fat injection into the gluteal muscle must always be avoided.
- *Acquire experience with the procedure*: With the recent increase in demand for gluteal fat augmentation, many plastic surgeons who did not have experience with this procedure started to perform it without previous training. Gluteal fat augmentation should only be performed by board-certified plastic surgeons, properly trained in this specific procedure. Hands on course and fellowships with highly experienced plastic surgeons should be encouraged by plastic surgery societies in order to improve patient safety and undo the label that this surgery is dangerous and should be avoided.

When applying the principles outlined above, gluteal fat augmentation can be performed safely with great long-term outcomes.

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24 Liposuction for High-Definition Gluteal Contour

Alfredo Hoyos, David E. Guarin, and Mauricio Pérez

24.1 Introduction

The full buttocks and narrow waist of the desired gluteal contour have been a constant between cultures, generations, and ethnicities. This is closely associated in women with reproductive potential and physical health. Also, a rounded and well-projected buttock is related to youth and provides an indirect index of the pelvis size and fertility [1, 2].

Although volume enhancement by means of implants or fat grafting has become crucial to obtain an adequate buttocks contour, liposculpture of the buttocks and the surrounding structures are the keystones to create a beautiful frame to shape the ideal buttocks [3].

In this chapter, we discuss the anatomy and liposuction technique of the gluteal region to obtain the best results. It is crucial to understand the gluteal structure, starting with the bony scaffold (pelvis), the muscles, fat deposits, and skin [4, 5]. These structures have a distinguished gender difference which defines the desired and undesired features of the female-like and the male-like buttock. Smooth curves from the waist to the thigh, lack of trochanteric depression, roundness, and a visible difference between the waist and hips are the most noticeable characteristics of a female buttock. The underling muscular anatomy is a basic feature that guides the contouring process.

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24.2 Anatomy

24.2.1 Gluteus Maximus Muscle

Most of the buttock volume and posterior convexity in slim and fit individuals are produced by the gluteus maximus muscle. The fibers runs inferolaterally, originating from the gluteal line of the gluteal surface of the ala of the ilium, the sacrum, coccyx, and sacroiliac ligaments, curving around the hip and finally insert into the iliotibial tract. The deep fibers insert into the posterior aspect of the proximal femur shaft, and the medial fibers originate from the posterior superior iliac spine and generate a natural depression. A triangle is formed between the two depressions or dimples on either side of the midline and the gluteal cleft. The medial part of the infragluteal fold is formed by a fat pad that covers the inferior medial border of the gluteus maximus muscle. The lateral part of the gluteus maximus muscle tapers between the long head of the biceps femoris and the vastus lateralis muscles. The inferiorly oriented form of the muscle may be visible in males, but in females the overlying fat often obscures it. A band of fascia across the inferior aspect of the gluteus maximus muscle creates a deep infragluteal fold with the extension to the hip. This fold extends from the gluteal cleft in the midline for a variable distance laterally depending on the volume of the buttock and the tone of the skin [6].

24.2.2 Gluteus Medius Muscle

The gluteus medius muscle is a fan-shaped muscle that lies deep to the gluteus maximus muscle. It runs from the anterior part of the lateral aspect of the ilium to the lateral surface of the greater trochanter. The posterior part hides deep to the fibers of the gluteus maximus muscle. It is bounded anteriorly by the tensor fascia lata.

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24.3 Preoperative Period

Markings The buttock shape closely resembles a half sphere where the only defined edge is the inferior medial aspect, as the rest blends seamlessly with the surrounding thigh and torso. For contouring purposes, the gluteal region extends superiorly to include the lower back, caudally to include the upper thigh, and laterally toward the hips. The lower back plays a pivotal role on the general gluteal shape and should be addressed properly [7].

The deep fat deposits located in the flanks, sacral region, hips, and lateral and medial thighs must be identified as they will be treated with liposuction [8, 9]. In women, the sacral dimples must be framed. The triangular area located between a line that goes from the point of maximum indentation (PMI) at the waist to the upper limit of the intergluteal crease and then to the superior iliac crest represents a "green zone" where fat can be aggressively removed. Another triangular area located between a line that goes from the top of the trochanteric depression to the upper limit of the intergluteal crease and then to the upper border of the gluteus maximus muscle represents the "red zone," where careful liposuction must be performed. The transition between these two triangular areas must blend seamlessly to create a smooth contour (Fig. 24.1).

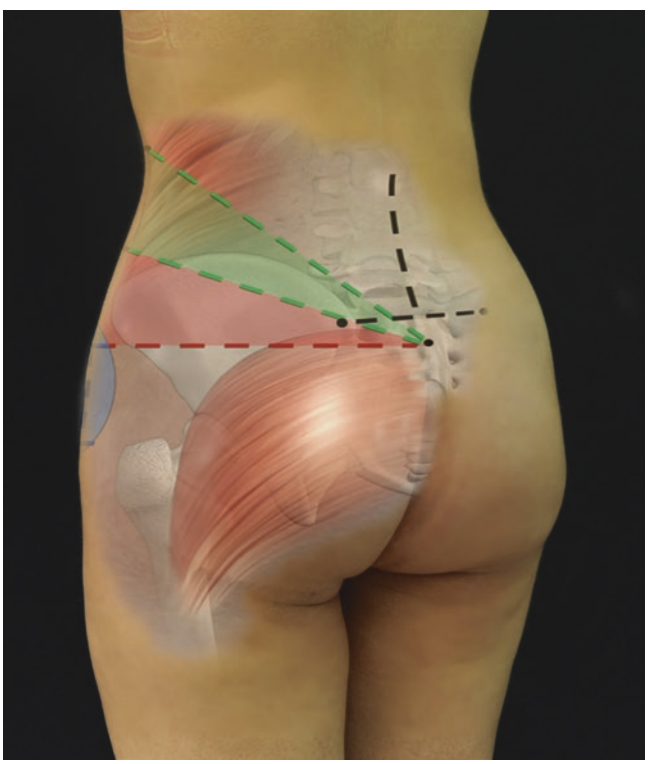

Fig. 24.1 Areas where liposuction should be done to enhance gluteal contour. In the "green zone," fat can be aggressively removed, while in the "red zone," careful liposuction must be performed

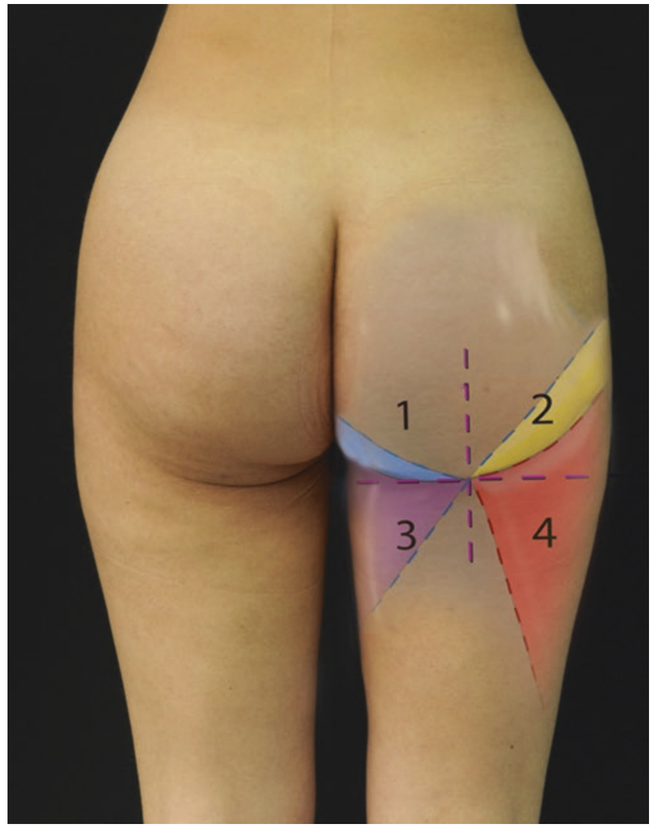

Fig. 24.2 The inferior gluteal region is divided into four quadrants: The lower medial gluteal area, the lower lateral gluteal area, the inner thigh, and the outer thigh

The inferior gluteal region is divided into four quadrants defined by a vertical line that goes from the center of the buttock to the infragluteal fold. The first zone, the lower medial gluteal area, must form an acute angle. The second zone, the lower lateral gluteal area, must form a smooth round contour in the transition between the buttock and the lateral thigh. The third zone, the inner thigh, contains only superficial fat, therefore over resection of fat up to the middle third of the inner thigh must be avoided. The fourth zone, the outer thigh, requires more aggressive liposuction from the inferior aspect of the trochanteric depression up to the distal third of the thigh (Fig. 24.2). Areas of deep liposuction and zones for smooth definition must be carefully marked to avoid contour irregularities (Figs. 24.3 and 24.4).

In most cases, the infragluteal fold ends at the midpoint of the inferior buttock. The lateral border of the gluteus maximus muscle is easier to identify when the patient internally rotates the thigh. This maneuver is important to delineate the lateral margin on the gluteal area to adequately define the lower lateral transition area. The inferior medial quadrant represents the inferior medial border of the buttock where an acute angle must be created to obtain a round shape and a youthful "rhomboid" shade of light between the inferior border of the buttocks and the upper inner thighs.

Fig. 24.3 Markings in a female patient, showing the areas of deep liposuction

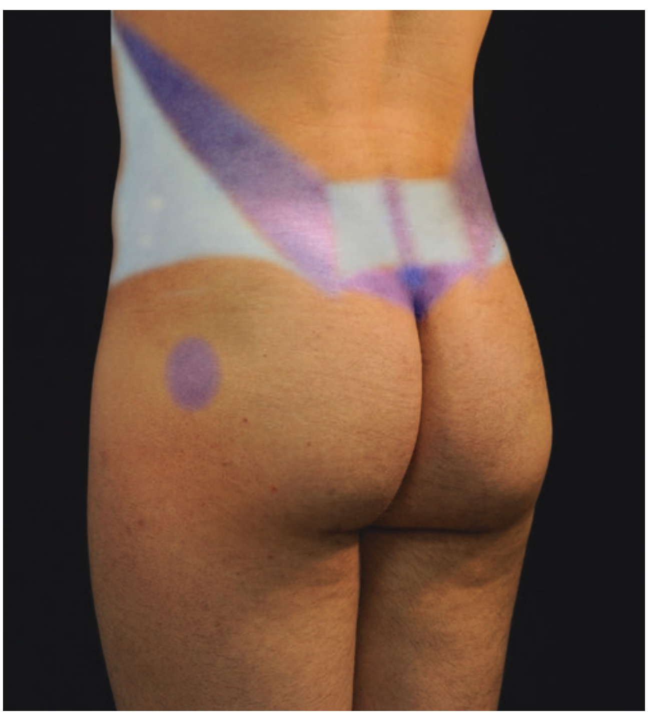

Fig. 24.4 Marking in a male patient, showing the negative spaces (purple) and the transition zones (light blue)

The buttock overall is divided into horizontal thirds with the middle third being the point of maximal projection. Liposuction is usually performed in the upper and lower thirds and fat grafting in the middle third to further increase gluteal projection.

24.4 Surgical Technique

The procedure is performed under general anesthesia with the patient in prone position. Gluteal sculpting is performed to obtain a round appealing shape by means of selective liposuction, fat grafting, and blending the gluteal and perigluteal regions [10]. The incisions are located preferably in the intergluteal crease and the mid inferior gluteal fold bilaterally. The incision sites must be protected from burns with the use of ports. Subcutaneous infiltration of a vasoconstrictive solution consisting in normal saline and epinephrine at 1:500,000 with varying amounts of lidocaine at a ratio of 2:1 is performed in the deep and superficial fat layers.

Fat emulsification with the third-generation ultrasound has been broadly tested and has shown to be safe. It reduces the surgeon effort and enhances fat extraction while keeping the viability of the graft. We use a 3.7-mm ultrasonic probe for the emulsification. The regular emulsification time is 2 min per 100 mL of infiltration solution. The clinical endpoint is the loss of tissue resistance. One must be cautious during this procedure to protect the skin at all the time in order to avoid skin burns.

Liposuction Technique Liposuction begins in the deep fat layers using a 3-mm diameter blunt cannula in the areas previously marked. Power-assisted liposuction is useful to harvest fat in these areas as it may help reduce tissue trauma. The lower back and upper gluteal region excess fat is accessed via the intergluteal port, without over resecting to ensure a smooth transition with the trochanteric depression. From the infragluteal midpoint (IGM) incision site, liposuction is performed in the lower and lateral gluteal areas and the inner thigh. In order to achieve a smooth transition, liposuction must be performed from distal (upper limit of the adhesion zone) to proximal in the overall buttock.

The superficial framing is only done over the sacral dimples using a 3-mm diameter blunt cannula. The depth of the cannula in the subcutaneous layer is controlled with the nondominant hand following the tip of the cannula, in order to remove most of the subcutaneous fat at the dimples. The paralumbar lateral and medial limits can be further deepened as far inferiorly as an imaginary line between the sacral dimples.

Fig. 24.5 VASER-assisted gluteal lipoplasty (high definition) performed in a 35-year-old female patient. Total lipoaspirate was 5200 cc. Injection of 300 mL of fat per buttock was done with 60-cc syringes attached to a 4-mm diameter blunt tip cannula in the subcutaneous layer only. Preoperative (**a**–**c**) pictures depict a prominent trochanteric depression, lower back fat deposits, and upper thigh fat excess. Postoperative photos at 7 months (**d**–**f**) reflect a round and voluptuous gluteal zone with a general slim and athletic body contour

In the waistline and sacral region, a smooth transition must be created between the aggressive zones of liposuction and the surrounding areas. Curved 4.6-mm and 3.0-mm cannulas are helpful to reach these areas using the same ports.

In the lateral lower buttock, a negative space must be created to blend with the lateral thigh. A line situated between the infragluteal midpoint and the trochanteric depression serves as a reference where moderate liposuction should be done to create a smooth transition in that area. Liposuction of the middle thigh can also be done from the infragluteal midpoint incision site while carefully blending the superior third of the thigh with the mid adhesion area to avoid irregularities.

Selective fat grafting is performed only in the subcutaneous layer using a 4-mm diameter blunt tip cannula connected to a 60-mL syringe. The lipoaspirate is processed by decantation and centrifugation to obtain the final adipose graft. Then, lipoinjection is achieved from proximal to distal through an inferior incision or from distal to proximal through an intergluteal incision (Figs. 24.5 and 24.6).

Fig. 24.6 VASER-assisted gluteal liposculpture (high definition) performed in a 43-year-old male patient. Total lipoaspirate was 3800 cc. Injection of 200 ml of fat per buttock was done with 60-cc syringes attached to a 4-mm diameter blunt cannula in the subcutaneous layer only. Note the loose appearance and lack of projection in the preoperative pictures (**a**–**b**), compared to the tonic, muscular, and full-figured buttock volume in the 1-year postoperative photos (**c**–**d**)

24.5 Postoperative Period

Nonsteroid anti-inflammatory drugs and acetaminophen are given for 7 days as needed. Prophylactic antibiotics are recommended. Presurgical medication with pregabalin 75 mg per day for 5 days prior to surgery may help in the modulation and superficial dysesthesia related to the ultrasound. Deep vein thrombosis prevention is given following the Caprini risk assessment score recommendations. Garments should be worn for at least 2 months with mild compression over the buttock area to avoid graft reabsorption and regular compression over the donor sites such as the thighs and lower back to limit edema. Manual lymphatic drainage over the donor sites from the thighs to the inguinal lymph nodes helps reduce edema.

24.6 Complications

The presurgical and surgical protocols for the high-definition gluteal contour aim for the prevention of serious medical and aesthetic complications. The most common medical complication of general liposuction is lower back seroma which usually requires multiple drainages and the prolong use of compression garments.

Bleeding and necrosis of the skin are rarely seen and even reduced when using the ultrasound device. However, burns may appear when there is not enough skin protection from the ultrasound probe. These are more frequent at the beginning of the training curve when the amount of energy/time is not well controlled. It is of paramount importance to use protective ports, soak wet towels at the pre-port skin incisions, and adequate tumescent infiltration in the harvested sites.

The aesthetic complications including asymmetry, contour irregularities, unnatural appearance, skin retraction/laxity, and inflammatory changes are common findings and may require revision procedures.

24.7 Discussion

The sequential analysis and approach to the buttock contour enhance the quality and reproducibility of the procedure [11]. The technique requires a good knowledge of the gluteal anatomy, the ideal aesthetics, the ethnic and cultural preferences, as well as the technology used. The use of the ultrasound helps in the extraction of fat and reduces edema, bleeding, and surgeon fatigue. The gluteal region is one of the most rewarding areas to treat with high-definition body sculpting with great long-term outcomes and satisfaction rate. We have successfully treated more than 2000 patients with follow-ups of more than 10 years. Additional fat grafting may further enhance gluteal contour and projection complementing the results of the gluteal sculpting [12].

24.8 Conclusion

The high-definition gluteal contour approach is a safe and reproducible procedure based on the underlying anatomy with an artistic concept. The cautious identification of the misplaced adipose tissue is the key point to achieve the desired and enhanced gluteal contour. The adipose tissue must be sculpted to obtain projection and volume in an aesthetic proportion according to the individuals' anatomy and preferences. The adequate use of technology and liposuction tools is essential to reach all areas to be treated, reduce complication rates, and enhance results and patient recovery. Care must be taken to avoid fat grafting in the muscular plane to reduce the well-known risks of fat embolism.

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Statement of Financial Interest Dr. Hoyos was an unpaid speaker and advisor for the product development team of Sound Surgical (now *Valeant* Pharmaceuticals International) up to May 2013. Since May 2013, he receives royalties for the liposuction kits named after him. During the time of the study, the authors did not have financial interest nor receive any financial support of the products or devices mentioned in this article.

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25 Gluteal Augmentation with Implants

Fernando Serra-Guimarães, Joao Henrique Spagolla Pontello, and José Horácio Aboudib

25.1 Introduction

The posterior contour, the overall shape, and the projection of the buttocks are among the main characteristics responsible for the beauty of the female body [1].

The enlargement of the buttocks with silicone implants started in 1969 when Bartels and collaborators [2] used breast implants to treat gluteal atrophy. The technique then evolved with placement of the implants subcutaneously [3, 4], submuscularly [5], and subfascially [6]. There were many complications such as contracture and ptosis when implants were placed subcutaneously, the risk of sciatic nerve compression when the implants were placed submuscularly, and the implants were perceptible when placed subfascially. In 1996, Vergara placed the implant intramuscularly accidently in a patient and had a great outcome. Since then, he established the parameters for intramuscular gluteal implant augmentation [7]. This technique was responsible for the increasing popularity of buttock augmentation in the last 15 years. Many studies have demonstrated the safety of this procedure, the stability of the implants [1], and, most importantly, the lower rate of complications [8]. The dissection of the gluteus maximus muscle is performed in the absence of an anatomical plane that requires extensive knowledge of the gluteal anatomy and its deep structures.

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25.2 Operative Technique

In order to perform adequate intramuscular dissection, the following parameters must be defined:

- Position of the gluteus maximus muscle based on bone reference points: posterior superior iliac spine, iliac crest, greater trochanter, and sacrum
- Upper border of the intergluteal cleft which constitutes the upper limit of the incision, so that it remains hidden and buried within the intergluteal cleft
- Greatest projection point of the buttocks
- Implant base dimensions

The technique is performed based on the anatomical bony landmarks (Fig. 25.1). The marking does not denote the position of the bones and muscles, but rather their cutaneous correspondents, and may vary according to the patient's positions. From the upright position to the supine position, the skin of the back rises in relation to the skeleton.

25.2.1 Markings

The skin markings should initially be done with the patient in a standing position delimiting the soft tissues such as the upper border of the intergluteal cleft, the point of greater projection of the buttocks, and any area of lipodystrophy (Fig. 25.2). The bony anatomical landmarks and the position of the gluteus maximus muscle should be marked with the patient in prone position.

25.2.2 Anesthesia

The procedure is done with the patient under loco-regional anesthesia with sedation or general anesthesia. Our preference is for the latter. Antibiotic prophylaxis with a first-generation cephalosporin is given 45 minutes before the procedure.

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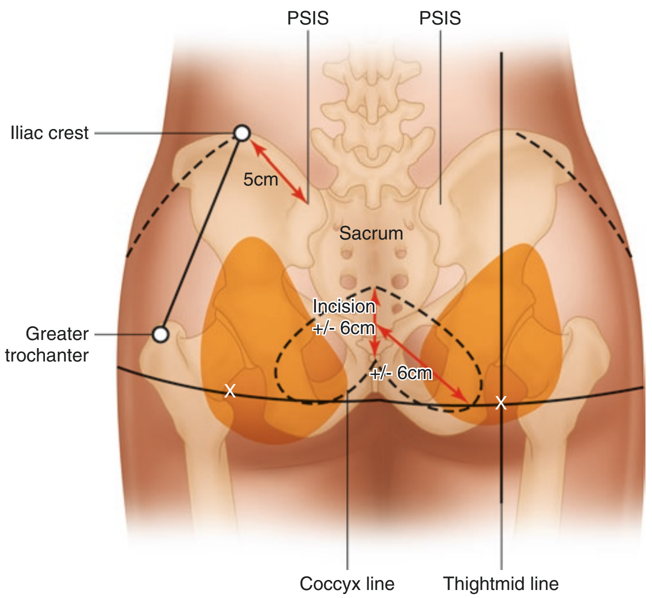

Fig. 25.1 Anatomical bony landmarks of the gluteal region

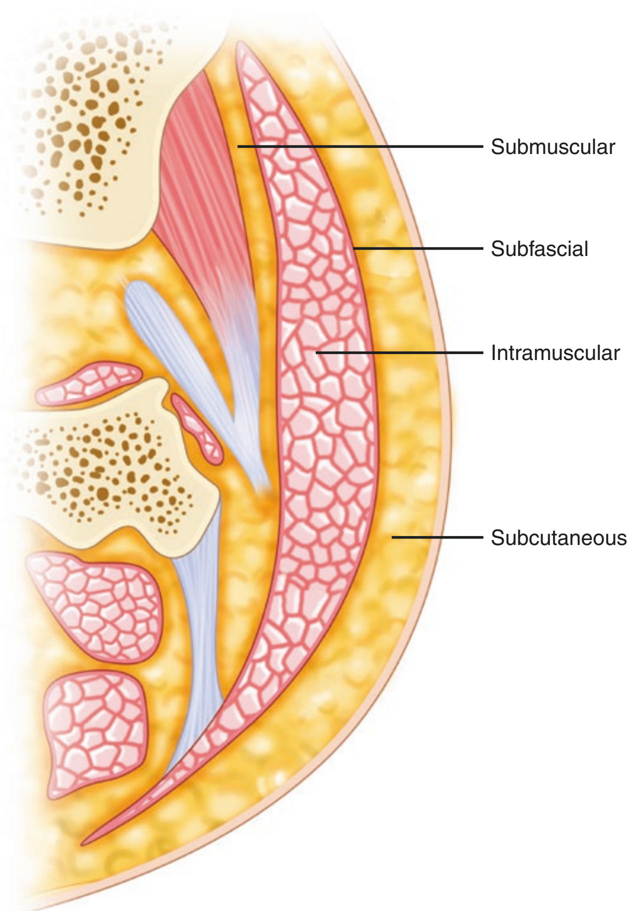

Fig. 25.2 Areas of lipodystrophy in the gluteal region

25.2.3 Muscular Anatomy

The gluteus maximus muscle originates in the posterior superior iliac spine (PSIS) and the iliac crest between 3 and 7 cm from the intergluteal cleft. The upper limit of the gluteus maximus can be identified by a line linking the medial third of the iliac crest and the greater trochanter and inserts laterally in the iliotibial tract of the fascia lata. The free edge of the muscle can be located during voluntary contraction, rendering the marking before the anesthetic procedure easier (Fig. 25.3).

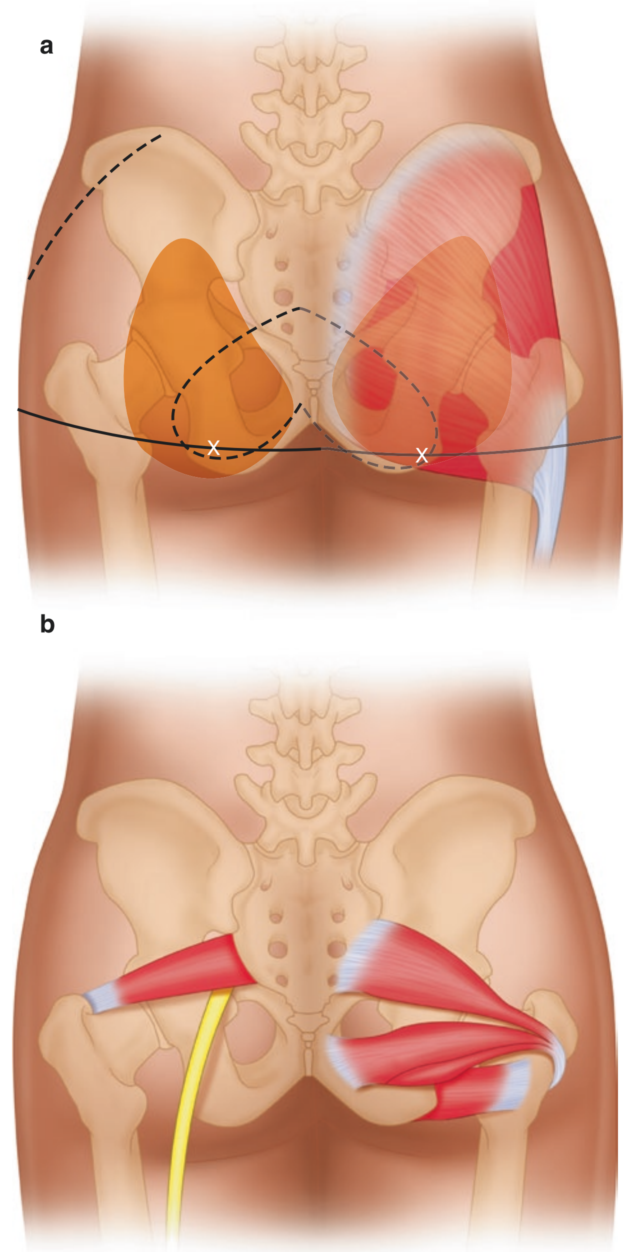

Fig. 25.3 (**a**) Superimposed anatomical figure. Overlap of the gluteus maximus muscle with the surgical markings. (**b**) Location of the piriformis muscle and sciatic nerve superimposed with the surgical markings. (From Serra et al. [10]; used with permission)

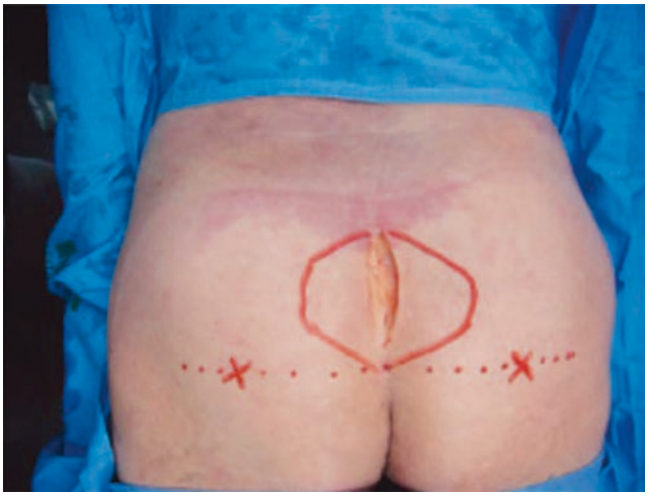

Fig. 25.4 Intergluteal cleft skin incision – area of subcutaneous dissection. (From Aboudib et al. [11]; used with permission)

A 6-cm vertical skin incision is marked from the upper border of the intergluteal cleft caudally.

25.2.4 Implant Positioning

The extent of the intramuscular dissection is marked according to the dimensions and shape of the implant, and 3 cm wider in order to compensate for the implant's depth. The direction of dissection in cases of oval implants should follow the same angle of inclination as the gluteus maximus muscle.

25.2.5 Infiltration

Before starting the procedure, the anal region is covered with a dry laparotomy pad fixed with stitches. Subcutaneous infiltration is done with a vasoconstrictive solution containing 1:250,000 epinephrine in the area that will be undermined.

25.2.6 Subcutaneous Dissection

The 6.0-cm intergluteal incision follows the previously described marking (Fig. 25.4). Subcutaneous dissection is performed at 45 degrees, preserving the sacral ligament (Fig. 25.5).

25.2.7 Suprafascial Dissection

Suprafascial dissection is performed in order to expose the segment of the fascia that will be incised giving access to the gluteus maximus muscle. It should be as small as 2.0 cm wide and 5.0 cm long, following the direction of the muscle fibers. The fascia is then incised, exposing the fibers of the gluteus maximus (Fig. 25.6).

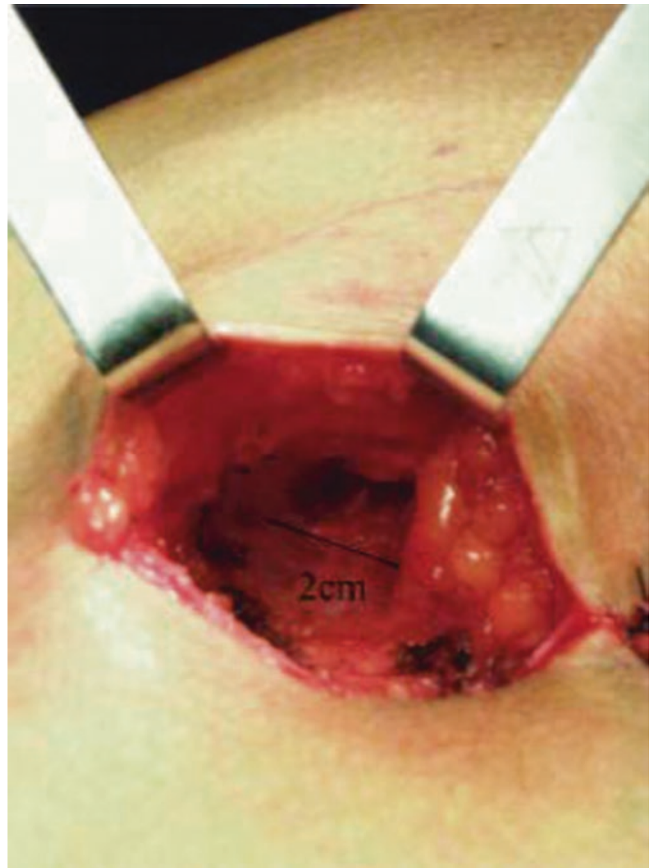

Fig. 25.5 Exposure of the gluteal maximus fascia through the intergluteal cleft. (From Serra et al. [9]; used with permission)

25.2.8 Intramuscular Dissection

The depth of the dissection is initially determined between 2.5 and 3.0 cm, given it represents half of the thickness of the muscle's central portion. The intramuscular dissection is performed up to its fixation points, ensuring that the entire pocket remains within the muscle. At first, the undermining is performed superiorly toward the PSIS and iliac crest, since in this region, dissection is safe, away from the neurovascular structures beneath the gluteal maximus muscle (Fig. 25.7). Then, undermining is continued laterally toward the iliotibial tract and inferiorly toward the femur. The entire dissection must remain within the limits of the markings (Fig. 25.8).

Undermining is performed with blunt instruments, initially with a 2.0-cm wide dissector, followed by a 3.0-cm V-shaped retractor. Hemostasis is meticulously done, and an

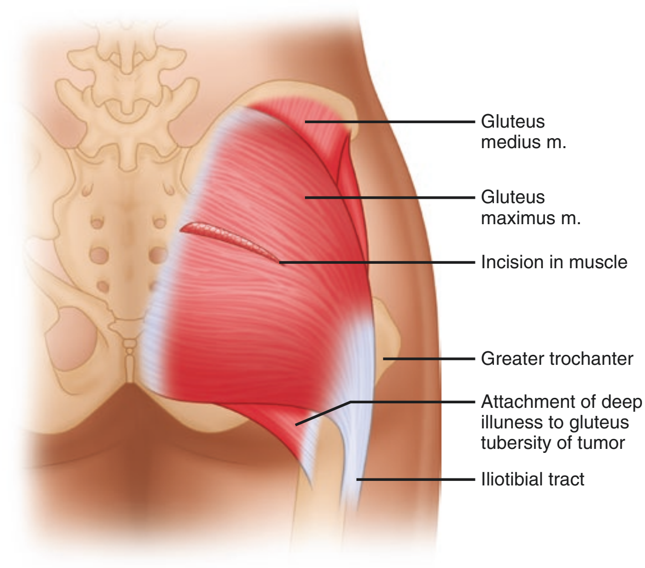

Fig. 25.6 Incision in the gluteus maximus muscle for intramuscular implant placement

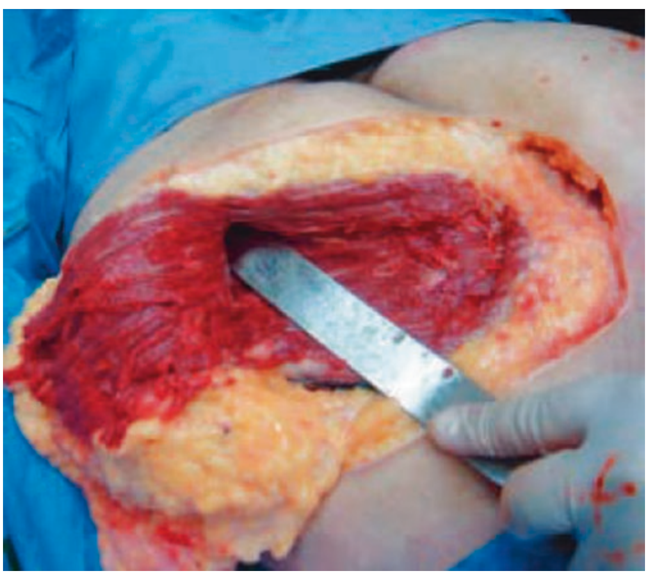

Fig. 25.7 Cadaver dissection: Intramuscular pocket with approximately 2.0–2.5 cm in depth within the gluteus maximus muscle

epinephrine solution (1:250,000) soaked laparotomy pad is kept in the pocket for 10 min.

25.2.9 Implant Insertion and Symmetry

If an oval-based gluteal implant is used, the narrow end is inserted first. The implant is then rotated and placed in an oblique position in the same direction as the muscle fibers. Some implants have a transverse strip on their anterior

Fig. 25.8 Intraoperative view of the dissection of the intramuscular implant pocket with the retractor oriented toward the iliotibial tract. (From Serra et al. [10]; used with permission)

surface that facilitates positioning (Fig. 25.9). The correct implant position can be seen with computed tomography (Fig. 25.10).

25.2.10 Closure

Once the implants are positioned and symmetry confirmed, the muscle opening is closed without tension incorporating the muscle fascia with mononylon 2-0 sutures. In the area that was undermined subcutaneously, adhesion sutures are placed between the fascia and the subcutaneous plane with Vicryl 3-0 in order to decrease the dead space. The intergluteal cleft is reconstructed with Mononylon 2-0 sutures connecting the presacral fat to the respective fascia. The skin closure is done in two layers with separate sutures of monocryl 4-0 and monocryl 5-0. No drain is used.

25.2.11 Technical Considerations

The size of the pocket must be tailored to the dimensions of the implant. It is easy to expand the intramuscular pocket to fit the implant, but it is difficult to reduce the pocket size if extensive undermining has been done. The most frequent cause of implant displacement is the creation of a super-

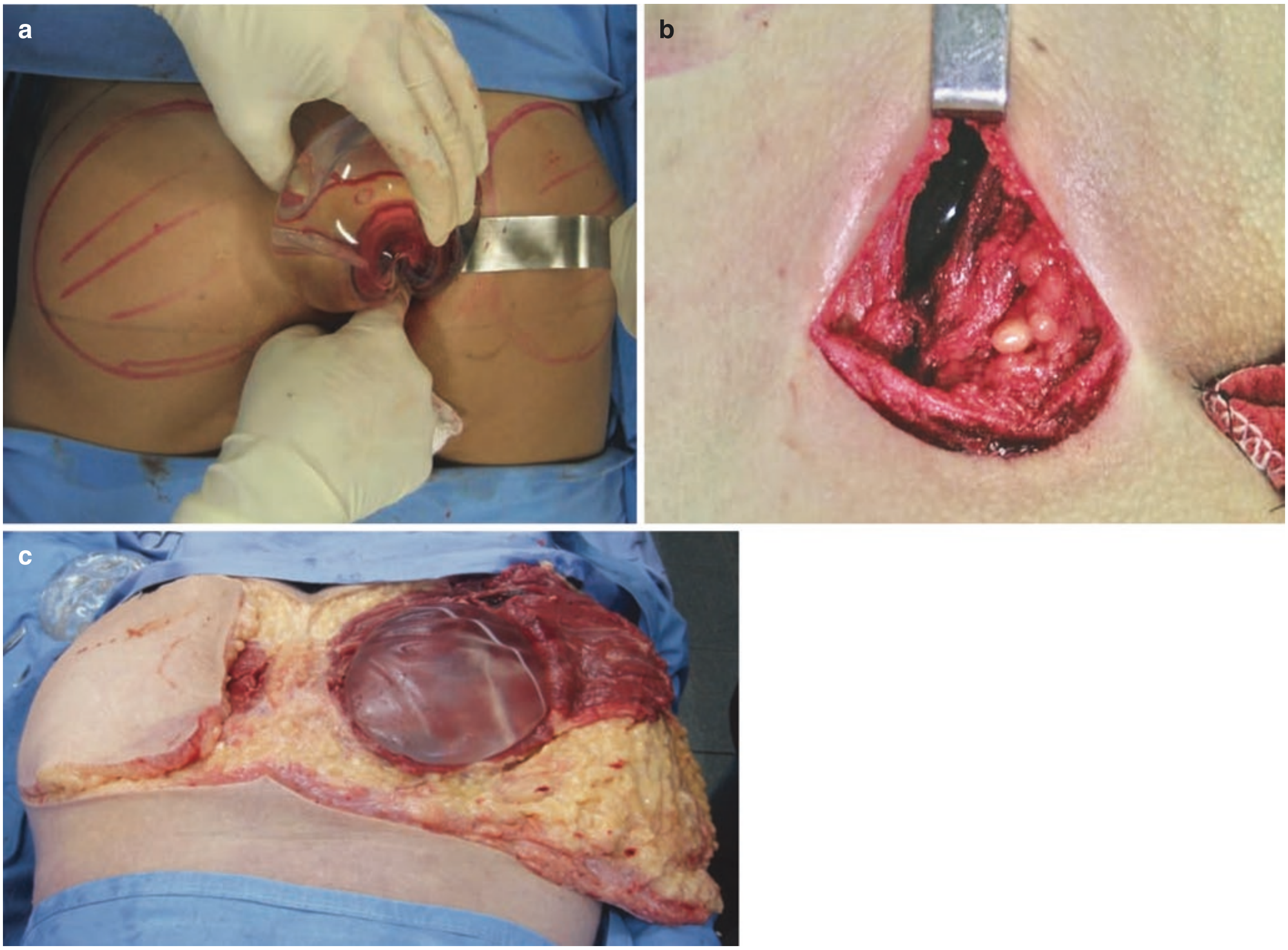

Fig. 25.9 (**a**) Insertion of the implant intramuscularly. (**b**) Implant visualized in the intramuscular pocket. (**c**) Correct position of the implant within the intramuscular pocket in a fresh cadaver. (Parts **a** and **b** from Serra et al. [10]; used with permission. Part **c** from Aboudib et al. [11]; used with permission)

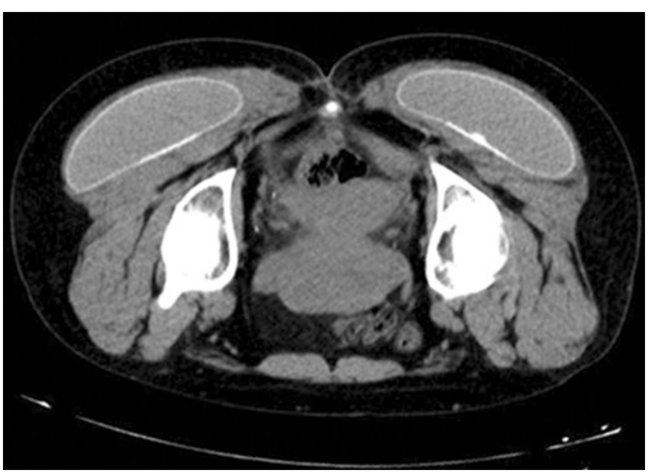

Fig. 25.10 Computed tomography scan showing the gluteal implants placed intramuscularly. (From Serra et al. [10]; used with permission)

ficial pocket. The fibers of the gluteus maximus muscle have an oblique direction toward the hip, and this direction should be followed in order to keep the pocket in an intramuscular plane. At the beginning of the dissection, the correct plane is easy to maintain as it is done under direct vision. When dissection is continued superiorly and laterally, where the muscle is thinner, one must be cautious as to not change the plane of dissection. The use of curved dissectors for undermining is not recommended. Deep undermining within the muscle is rare because of the thickness of the muscle; however, undermining in the inferior medial quadrant must be done carefully due to its proximity to the rectum.

The buttock has a point of maximum projection that, in most patients, is aligned with the pubis. The point of greatest projection of the implant should be aligned with the maximum point of projection of the buttock. Patients generally

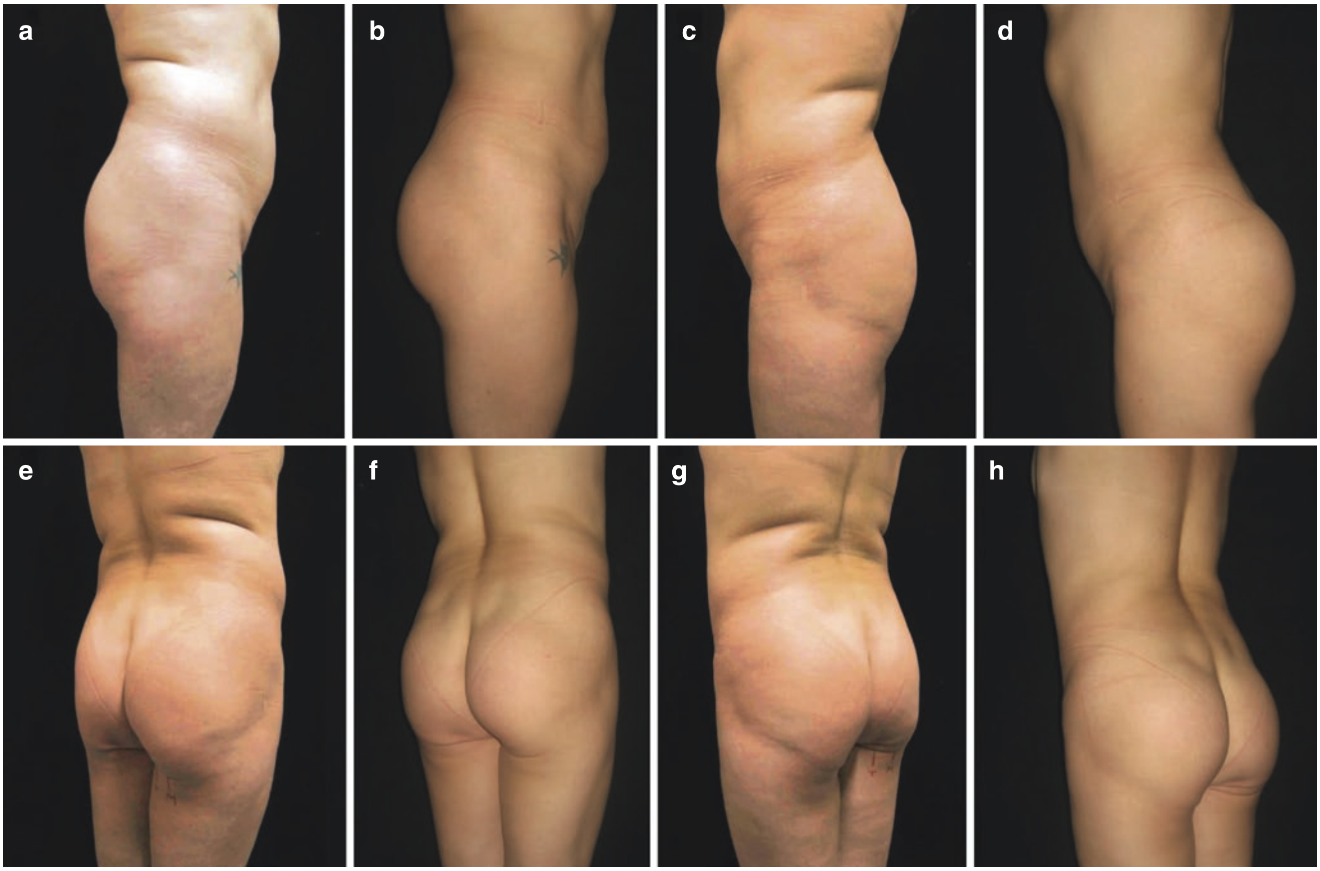

Fig. 25.11 (**a**, **c**, **e**, **g**) Preoperative photographs of a 44-year-old female patient whose main complaint was lack of gluteal projection. (**b**, **d**, **f**, **h**) One year following the insertion of a 300-mL anatomic-base implant bilaterally. (From Serra et al. [10]; used with permission)

express their desire for higher projection in the upper third of the buttock. Nonetheless, positioning the implant too high may lead to a perceptible implant and an unnatural look. The intramuscular pocket should be precise, not too tight as to avoid tension during closure and not too large as to result in implant rotation.

The results can be seen in Fig. 25.11.

25.3 Postoperative Care

In the immediate postoperative period, patients can remain semi-seated with pillows under the lumbar region and the posterior thighs to avoid pressure on the gluteal region. Patients are encouraged to walk with assistance and remain in the position that is most comfortable. Seating is allowed, although this position can be uncomfortable during the first days. The patient is kept in observation for 24 hours and discharged with analgesics and nonsteroidal anti-inflammatory agents. Narcotics are reserved for severe pain. Compression garments are recommended only for patients who had additional liposuction. The patient is seen weekly for 1 month and sutures are removed at day 14.

Patients are allowed to return to their routine activities after 15 days. Sexual activity can be resumed after 21 days, while physical exercises should be avoided for 6 weeks. High impact sports and gluteal-specific workout can be resumed after 3 months.

25.4 Complications

With the increase in popularity of gluteal augmentation with implants, the complication rate has also increased. However, the intramuscular placement of implants has shown less complication compared to the other techniques when implants were placed in other planes. With the intramuscular technique, the risk of injury to the sciatic nerve is low; however, seroma and wound dehiscence may be seen.

Seromas are often superficial mainly in the midline where subcutaneous undermining is performed. With the placement of adhesion sutures between the fascia and the subcutaneous tissue, the rate of seroma has significantly decreased in our practice [9]. Wound dehiscence has also decreased in our practice because of the multiple layer closure of the skin and the preservation of the vascularization of the sacral region when placing the implant submuscularly.

25.5 Discussion

The intramuscular technique is a product of the evolution of gluteoplasty, where each new method represented the solution to an existing problem. The submuscular technique proposed in the 1980s [5] resolved adverse aspects that were seen with the subcutaneous technique, such as contracture and ptosis, but the results were not great as the implant was placed superior to the piriformis muscle and the sciatic nerve. In the subfascial technique, the implant is located in the correct position and can produce excellent short-term results, especially when low profile gluteal implants are used. However, the fascia is a tissue with little resistance and thickness; therefore the implants can be felt superficially in the long term, with the presence of late seroma, capsular contracture, and asymmetry [9].

The intramuscular technique [7, 10, 11] can achieve natural results due to the centrally positioned implant in the region of greater projection of the buttock, without the risk of injury to sciatic nerve as it is protected by the deeper portion of the gluteal maximus muscle. Therefore, the postoperative period is less painful as there is less risk of sciatic nerve compression. Intramuscular positioning of the implant ensures that it is covered by the whole muscle and is not perceptible. The patient satisfaction rate has been high with this technique as the results are natural [12]. The contour of the buttocks depends basically on the gluteus maximus muscle, as when the implant is placed, the volume of the muscle increases.

Despite the great results obtained with this procedure, there were many reports of seroma and wound dehiscence, which limited the widespread of the procedure [13]. With the technical changes in the procedure, such as limited subcutaneous undermining and placement of adhesion sutures, complication rates have decreased. The use of drains is controversial [14]. We do not place drains as the gluteal muscle being a striated muscle has an inherent absorptive capacity and the presence of drains does not prevent seroma or hematoma formation [10]. The risk of seromas is highest when the implants are placed subcutaneously and present between the second and third postoperative weeks [15], when drains have already been removed. Thus, we prefer to perform adhesion sutures as described above to decrease the dead space [15, 16].

Since the intramuscular technique has been described in the last 20 years, the long-term evolution of the gluteus maximus muscle harboring an implant that surpasses half the muscle's initial volume is still being elucidated. We have had encouraging results so far, with the presence of muscle atrophy within physiological standards, with no functional changes or impairment [1, 17–19].

25.6 Conclusion

Augmentation gluteoplasty with cohesive silicone gel implants using the intramuscular technique is safe, is reproducible, and has shown good results to patient and surgeon satisfaction. A good knowledge of the gluteal anatomy and the surgical technique is imperative to perform this procedure safely with great outcomes.

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26 Composite Gluteal Augmentation: Implant + Fat Grafting: Getting the Best of Both Worlds

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26.1 Background

Gluteal augmentation is one of the hottest topics in plastic surgery. The demand for this procedure has increased by 103% in the last 4 years according to American Society of Plastic Surgery statistics [1]. However, with this increase in popularity, there has also been an increase in complications and death ratio. Moffid [2] et al. reported a death ratio of 1:3000 cases of gluteal fat augmentation in 2017. Cansanção et al. [3], in a survey with board-certified Brazilian plastic surgeons, found a death ratio of 1:20.117 cases.

Because of this high mortality ratio, a task force (Multi Society Gluteal Fat Grafting Task Force) was created in order to understand the causes of this high mortality ratio and propose guidelines to perform this procedure safely. Until now, the studies performed by the task force have corroborated the findings published by Cardenas-Camarena [4–7] who identified fat embolism as the cause of the increased mortality rates. Fat embolism has been largely associated with intramuscular gluteal fat injection and the task force advised surgeons around the world to avoid injecting fat in this layer [8].

Since Guerrero Santos [9] published his study showing a higher take when fat was injected in the muscle, it was considered by most surgeons the ideal plane of injection.

The standard of beauty desired by women is different according to the ethnical and cultural characteristics [10–12]. African-Americans and Latin women have preference for large buttocks and often request higher volumes of fat be grafted. Injecting large volumes of fat could increase the risk of fat embolism and lead to death. The Multi-Society Gluteal Fat Grafting Task Force recommended to stage the procedure if patients require large volumes of fat to achieve their desired results [8].

Augmentation gluteoplasty with implants is a worldwide recognized technique [13–15]. However, it did not become as popular as gluteal fat augmentation, most probably because of the high incidence of complications [16] that were reported and the unnatural look observed at the beginning, especially when the implants were placed below the muscle, in the sub-fascial or subcutaneous planes [17]. Nowadays, gluteal augmentation with implant has evolved, especially with the intramuscular approach that lead to great results, with a lower complication ratio.

There is not a technique that can be used for all cases of gluteal deformities or lack of volume and projection. Gluteal augmentation with implant or with fat grafting have advantages and disadvantages (Table 26.1) and are indicated for the majority of patients with good reported outcomes, especially when associated with other techniques like liposuction of the surrounding regions of the gluteal region.

In this chapter, the author shows his experience with composite gluteal augmentation, combining the gluteal augmentation with implants associated with fat grafting to achieve consistent good projection, good waist-to-hip ratio and a harmonious gluteal region.

Table 26.1 Advantages and disadvantages of the two most commonly used techniques for gluteal augmentation: Gluteoplasty with implant X Gluteal Fat Grafting

	Advantages	Disadvantages
Gluteal implant	Volume does not change Liposuction is not required Less surgical time	Wound dehiscence Longer scar, although it is located in a place that can be hidden Sciatic nerve injury risk Capsular contracture risk ALCL risk Implant exchange may be needed Malposition, risk of asymmetry
Fat grafting	Autologous tissue Smaller incision Liposuction of the contour of the buttocks	Loss of injected volume Fat embolism risk (MIFE and MAFE) Longer surgical time

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26.2 Patients and Methods

26.2.1 Patient Selection

From October 2014 to June 2017, patients who underwent composite gluteal augmentation were evaluated in a prospective study. Inclusion criteria were patients presenting lack of gluteal projection with mild-to-moderate excess fat in the sacral region, posterior and lateral flanks that desire larger volume, and improved contour to the gluteal region. Exclusion criteria were the following: age >18 years and <60 years, active smokers, BMI > 24.9, and post-bariatric patients even with normal BMI. Patients with chronic pathologies such as diabetes, on corticosteroids, or those who have already been submitted to a gluteal augmentation or gluteal lift surgery were also excluded.

26.2.2 Preoperative Marking

Marking is performed at two time points: preoperatively and intraoperatively.

Preoperative marking is performed with the patient in standing position. The donor sites and the recipient areas for fat are marked (Fig. 26.1). For the implant position, a single point is marked at the superior edge of the intergluteal fold. This point of reference is paramount to the surgical planning as when the patient lies down, it is dislocated.

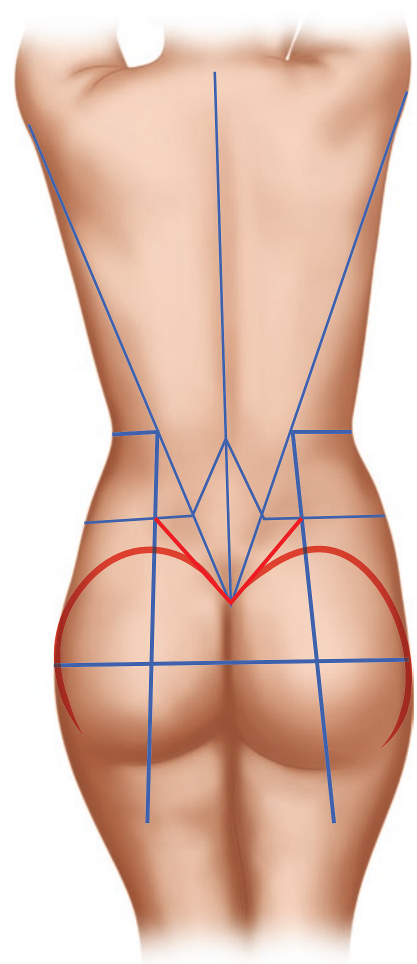

Fig. 26.1 Preoperative marking of the areas of liposuction

26.2.3 Anesthesia

The procedure can be performed under general or regional (spinal or epidural) anesthesia. In our series, all patients were submitted to general anesthesia.

26.2.4 Positioning

The patient is placed in the prone position, with a projection cushion placed under the hips in order to project the buttocks and facilitate undermining of the pocket for the implant.

26.2.5 Patient Preparation

After preparation of the skin with a bactericidal solution, a transparent film dressing (Tegaderm, Minnesota, USA) is placed over the anal region and a surgical compress is sutured 1 cm above the superior border of the anus and on the surrounding skin in order to avoid any contamination.

26.2.6 Intraoperative Marking

The intraoperative marking is based on one reference point: the ischial tuberosity. With the patient in the prone position, the ischial tuberosity is easily identified posteriorly on the superior ramus of the ischium. It is the most projected bony part that can be found on palpation of the gluteal region. One medial line is drawn on the intergluteal cleft (line A); two parallel lines one on each side are drawn at a distance of 4 cm to the medial line (lines B). A horizontal line is drawn from one ischial tuberosity to the other on the contralateral side (line C). The identification of the correct localization of the ischial tuberosity is primordial since it represents the inferior limit of the plane of dissection of the pocket.

The superior and lateral limits of the pocket are determined by the imprinting of the implant on the gluteal skin. The implant (or preferably a sterile mold) is placed over the gluteal region, with its widest part toward the horizontal line (line C) and the medial part toward line B.

The superior limit of the pocket is determined by the superior edge of the implant, and the lateral limit is determined by the lateral portion of the implant. Using the implant's dimensions to determine the limits of the pocket allows a safe and precise plane of dissection. This maneuver aims to obtain a tight pocket that keeps the implant in a specific and definite position and prevents its rotation or malposition.

26.2.7 Fat Harvesting

The donor sites previously marked are infiltrated subcutaneously with a solution of normal saline and epinephrine at 1:500,000 according to the super-wet (1:1 mL) technique with a Klein cannula connected to a 60-cc syringe. Liposuction of the gluteal surroundings (lumbosacral region, hips, saddle bags and posterior aspect of the tights) is key to emphasize gluteal projection. A 4-mm-diameter blunt cannula with three holes is used. The lipoaspirate is collected in a closed system with Puregraft (Puregraft LLC, San Diego, CA, USA).

26.2.8 Implant Placement

A 6-cm skin incision is made on the intergluteal cleft. The skin island on the intergluteal cleft is not preserved. We believe that once the implants are in place, the tension on the incision may increase; therefore, if the skin island was resected, the tension on the scar would be higher and lead to dehiscence. The undermining in that region is started at 45 degrees in order to preserve the sacrocutaneous ligament until the identification of the major gluteal fascia. The undermining above the fascia progresses until the limits of line B. The dissection from the intergluteal cleft to line B should not be limited to a 2-cm tunnel. The dissection of the pocket in the intramuscular plane is performed with a blunt dissector and aims to separate the gluteus maximus in two 3-cm flaps. The limits of the dissection are determined by the implant size. In order to prevent excessive bleeding in the pocket, we place a sterile surgical compress immersed with adrenaline solution, while the contralateral dissection is performed.

The implant is inserted with the help of sterile plastic funnel device. The gluteal fascia is closed with discontinuous 3-0 nylon sutures and the subcutaneous layer is sutured to the fascia with 4-0 nylon sutures in order to avoid any accumulation of fluid. The subcutaneous layer on the incision is approximated with inverted discontinuous 3-0 nylon sutures. Skin glue is used over the scar in order to create a seal.

26.2.9 Fat Grafting

After the implant is placed, fat grafting to the previously marked areas is performed using a 3-mm blunt cannula attached to a 60-cc syringe. The cannula is positioned in the subcutaneous layers through superior incisions. The intramuscular plane is avoided in order to prevent implant rupture and injury to the gluteal vessels. The volume of fat injected varies according to each patient. Fat is injected primarily in the upper and lower poles of the buttocks to provide a smoother contour, softening the implant borders (especially in patients presenting hypoplastic buttocks). Fat is also injected in the trochanteric region or the hips when needed (Fig. 26.2).

26.2.10 Postoperative Care

Elastic bandages are used in order to provide a flexible strong support and compression in the operating room on the superior portion of the gluteal region. A girdle is worn

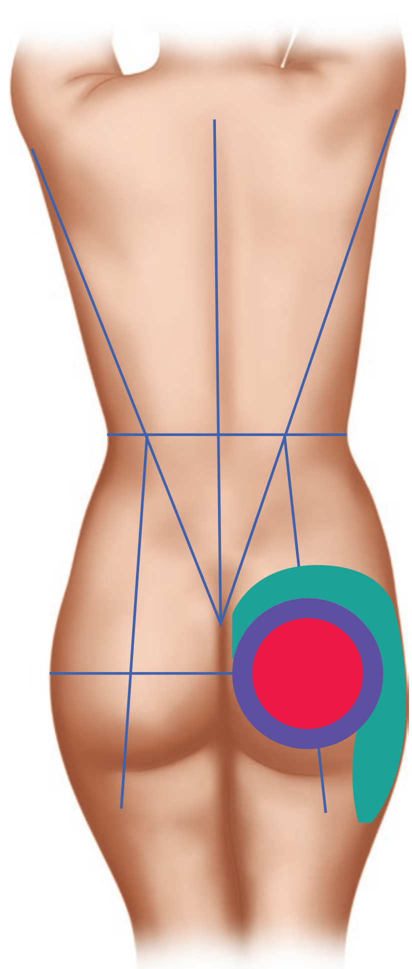

Fig. 26.2 Areas for fat grafting. Area 1 (Green): The frame area. Fat grafting to this area is important to improve buttock shape. Area 2 (Blue): The Edge area. Fat grafting to this area is done to smooth the transition between the implant borders and the surroundings areas. Area 3 (Red): The implant Area. Fat grafting to this area can be done to improve buttock projection

for 2 months. To reduce the risk of venous thrombosis, all patients use sequential compression device (SCD) during their hospital stay, early ambulation is encouraged, and compression stockings are used up to the knees for 7 days after discharge. Patients who present Caprini risk factor scores of 3 and 4 receive anticoagulation with one dose of low molecular weight heparin subcutaneously at 12 h postoperatively. Patients with scores 5 and 6 receive anticoagulation for 7 days.

Patients are discharged on postoperative day 1. Muscle relaxants and oral antibiotics (Levofloxacin) are routinely used for 7 days. Compression garments are worn on the donor site regions for 4 weeks. Massage and lymphatic drainage are performed in the donor sites starting at day 7 postoperatively. All patients are encouraged to sit on a flocked cushion positioned under the thighs leaving the buttocks with no pressure. Regular exercises can be resumed at 8 weeks. Patients are seen at 7 days, 15 days, 1 month, 3 months, 6 months, and 1 year postoperatively.

26.3 Results

Thirty-one consecutive patients were included in this series from October 2014 to June 2017. All patients were female aged 33–56 years. All patients had fat harvested from the flanks, lower back and saddle bag areas. The lipoaspirate volume ranged from 400 mL to 2400 mL with an average of 1500 mL. Patients received gluteal anatomic implants ranging from 300 to 375 cc and from 40 mL to 120 mL of fat was injected in each buttock. The average surgical time was 120 min (range 90–150 min) (Fig. 26.3).

Complications included two cases of wound dehiscence (6,44%). There were no seroma, no hematoma, and no major complications.

Satisfaction rate was measured by surveys sent to patients after 1 year postop and two plastic surgeons that did not participate in the surgeries through photographic analysis.

Photographs were taken in seven positions: back, lateral (right and left), oblique (right and left), and two dynamic positions (with the patient standing with a flexed thigh, right side and left side) with the purpose of showing the interaction of the gluteal muscles with the skin and verify the presence of any gluteal retractions.

26.4 Discussion

To obtain the desired outcomes for gluteal reshaping, we need to improve not only the volume of the buttocks but the proportions of the adjacent areas as well.

Cansanção et al. presented a concept of modeling the buttocks, by performing liposuction of its surroundings, making the buttocks stand out, giving the impression of augmentation and suspension of that area [18]. This technique however does not address any hypoplasia of the gluteal muscles;

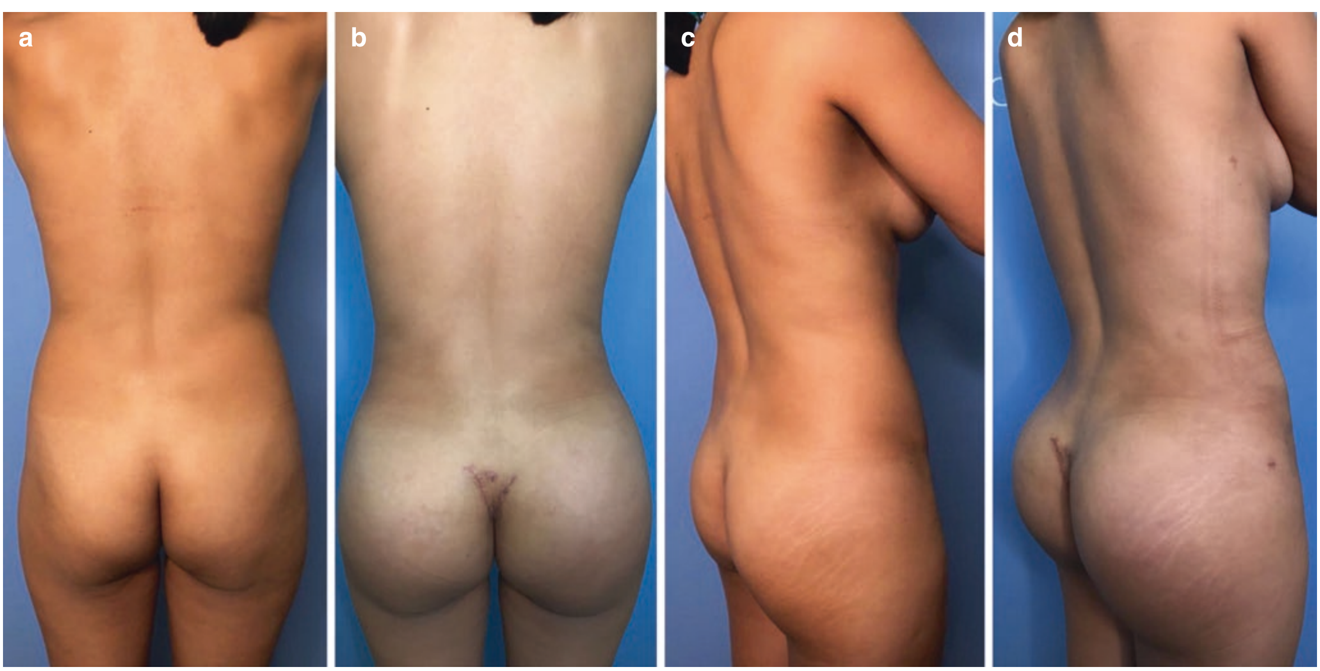

Fig. 26.3 A 24-year-old woman, BMI = 26 kg/m^2, submitted to composite gluteal augmentation with placement of 300-cc anatomic gluteal implants and fat grafting to the areas 1, 2, and 3 (110 mL in each buttock). (**a**) Preoperative posterior view; (**b**) 3 months postoperative posterior view; (**c**) Preoperative posterior oblique view; (**d**) 3 months postoperative posterior oblique view

Table 26.2 Indications for composite gluteal augmentation surgery

Indications for composite gluteal augmentation
Severe hypoplasia of the buttocks
Thin patient (BMI < 23)
Poor soft tissue covering (pinch test <2 cm)
Patients with insufficient body fat for buttock augmentation
Patients with previous gluteal fat grafting who desire more volume

therefore, in these cases, the association of gluteal fat grafting can address the lack of projection. Large-volume fat grafting is not recommended in an area as the fat situated on the central portion of the graft does not receive an adequate blood supply and can suffer several degrees of necrosis resulting in complications such as oil cysts and fat necrosis [19].

Liposuction of the gluteal contour and gluteal augmentation with silicone implants has been previously described by Cárdenas-Camarena and Paillet as an effective and safe procedure for improvement of gluteal projection [20]. Even though they can achieve great contour and projection combining liposuction and implants, in some patients the implant edges are noticeable.

In our experience, the concept of Hybrid surgery, using small gluteal silicone implants associated with fat grafting in selected areas of the buttocks give us the best of both worlds. A pre-established form determined by the silicone implants allows a predictable improvement of the gluteal projection. Fat grafting can help improve the contour and shape of the gluteal region promoting a smooth transition between the implant and the surrounding areas.

Thin patients with expressive gluteal hypoplasia combined with moderate fat in the flanks can benefit from the composite gluteal augmentation technique (Table 26.2). For these patients, the correct choice of the prosthetic materials will give the desired results and outcomes.

26.5 Conclusion

Composite gluteal augmentation is defined by buttock augmentation with simultaneous placement of gluteal implant and fat grafting. It represents a powerful and versatile approach to the gluteal region, combining the core volume projection of gluteal implants with the natural look and feel of overlying fat. This technique presents a good and promising alternative to intramuscular fat injection (no longer recommended), promoting excellent gluteal projection and stable and consistent results.

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27 Gluteal Lift

Michele A. Shermak

27.1 Introduction

Gluteal lift describes excision of lax and/or redundant lower back skin and fat to improve the shape of the buttocks, as well as the posterior waist and upper outer thigh contour. It is the basis for the posterior element to lower body lifting for individuals who have sustained massive weight loss. The procedure may be performed in combination with augmentation of the buttocks using fat, autologous flaps, or implants, or with lifts of adjacent body regions such as the abdomen and/or inner thighs to globally improve the lower body. Autologous gluteal augmentation is planned for individuals with total deflation and lack of gluteal soft tissue padding, such that a lift without augmentation will result in lack of any gluteal fullness, a functional issue with holding pants and skirts up. In most cases, gluteal lift without augmentation provides adequate treatment to improving gluteal aesthetics.

Individuals who have sustained massive weight loss often have redundant, ptotic skin circumferentially around the trunk. Often the skin is thinned with stretch marks and focal adiposity. Attempts may be made to camouflage the deflated appearance with fat transfer to the buttock in combination with liposuction of the posterior waist and back. If a gluteal lift is not performed and only fat is transferred to the deflated gluteal region, individuals will likely find that they are left with wide hips and buttocks, exaggerated if abdominoplasty is performed as well (Fig. 27.1a–d). The buttock can only host so much transferred fat, and with massive weight loss, there is typically not enough gluteal recipient bed to provide adequate circulation to the volume of fat needed to fill all the loose skin present. Skin removal in these individuals provides needed gluteal lift, and vertical back and circumferential torso reduction.

Gluteal aesthetics may improve with gluteal lift without any direct gluteal work. Mendieta in his anatomical studies of this region designated ten gluteal aesthetic units [1] (Fig. 27.2). Lower back lift addressing the upper buttock, lower back, flank, and diamond zone indirectly improves gluteal aesthetics.

27.2 Preoperative Period

27.2.1 Patient Selection

Patients present for consultation aiming for removal of excess skin of the lower back with lifting of the outer thighs and gluteal region or for hip reduction. Patients often report significant weight loss causing this condition, and they should ideally be at a stable weight for 6 months prior to proceeding with body contouring surgery. BMI ideally should be no greater than 35 [2, 3]. In some cases, patients present for abdominal contouring and ultimately decide to undergo a combination abdominoplasty/lower back lift, also known as a belt lipectomy, in their desire to eliminate dog ears from an abdominoplasty alone when their skin redundancy is circumferential. Discussion of patient goals helps better direct history and examination, as well as provide a window into potential psychosocial problems.

Potential patients are questioned about their medical and surgical history. Comorbidities such as morbid obesity, diabetes, hypothyroidism, autoimmune disorders, and history of venous thromboembolism (VTE) raise concerns about healing capability and the surgeon may decide on a course of action which is less ambitious in order to protect patient safety depending on the significance and number of concerns, as seen in the Caprini Risk Score for VTE [4]. Tobacco use should be stopped or at least significantly reduced as tobacco use impairs healing and incites wound infection [5]. Surgical history and any difficulties with prior anesthesia, healing or scarring problems should be queried.

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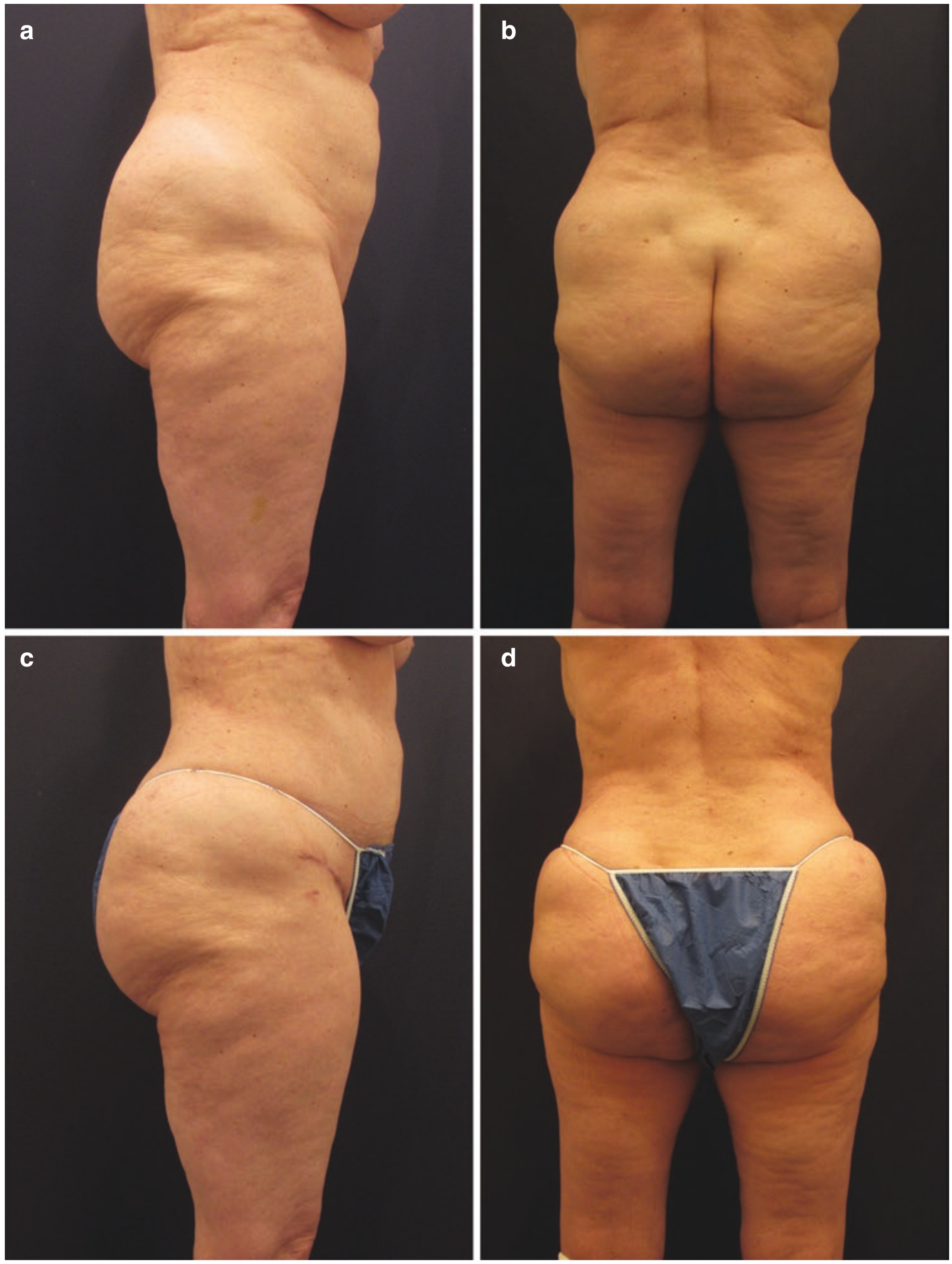

Fig. 27.1 (**a**, **b**) This woman presented for treatment of buttock deflation, and desire to reduce back fat. (**c**, **d**) She underwent liposuction of the back with fat transfer to the gluteal region leaving fullness of the outer hip region. Gluteal lift would reduce torso circumference and the fullness seen

Nutritional assessment should take place, not only through examination but also through history, particularly if the individual sustained significant weight loss through diet or surgery [5]. Michaels et al. report that patient self-reporting of protein intake does not correlate with laboratory measures of nutritional status. Laboratory assessment should include albumin and prealbumin levels. Patients who reveal inadequate protein intake or malabsorption are referred to a nutritionist and possibly back to their bariatric surgeon.

Physical examination guides determination of the best procedure to improve back and gluteal aesthetics. Patients with redundant lower back skin, gluteal deflation, and ptotic tissues are good candidates for gluteal lift. If the buttock is particularly volume deficient, augmentation should be considered, as the best source of tissue for augmentation is the tissue that will be discarded and lost as a future source of augmentation in gluteal lift.

Laboratory assessment prior to surgery reveals any deficiency and *predicts* healing risks that might be elevated. Transferrin, protein, and albumin levels help provide a window into nutritional adequacy. Hemoglobin and hematocrit provide anemia assessment which is so important after malabsorptive bariatric surgery [2, 5].

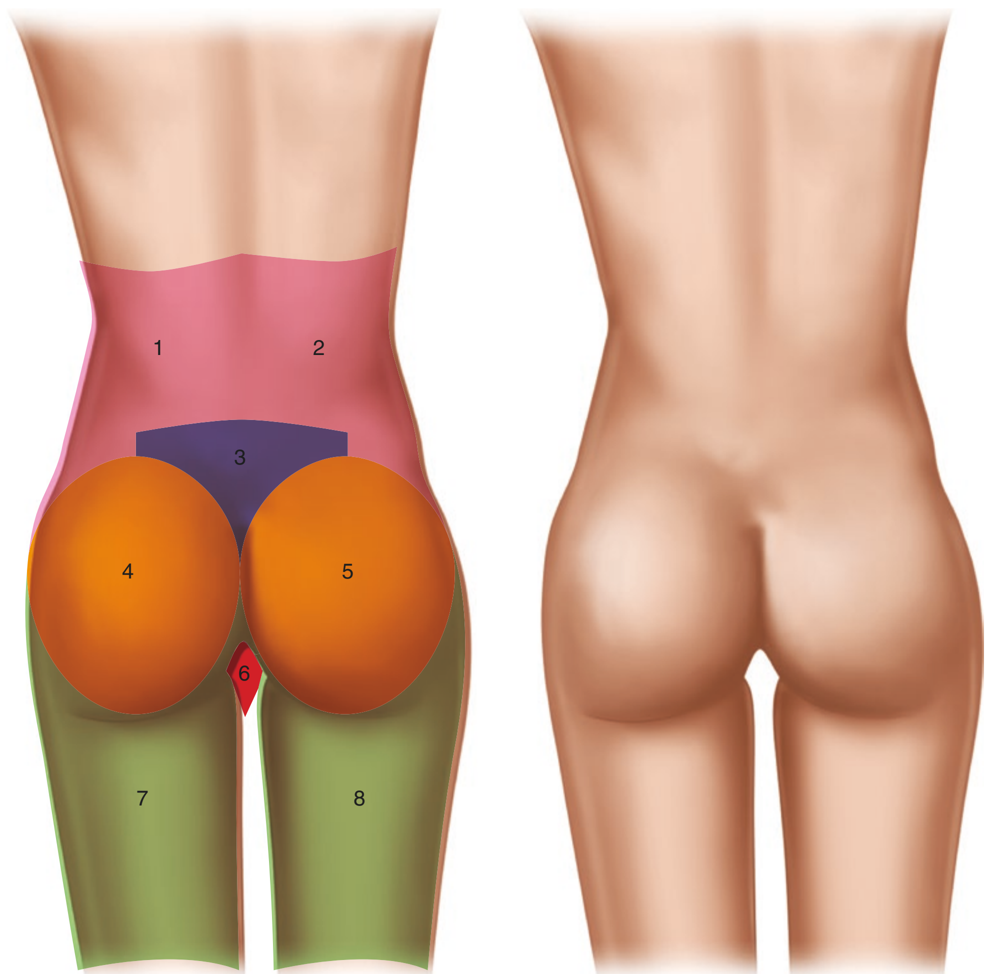

Fig. 27.2 The eight gluteal aesthetic units, most paired, include sacrum, flank, glutei, inner thighs, and inferior gluteal/posterior leg junction

For surgical planning, staging body region improvement may need to be discussed, either due to concerns about longer surgical procedures with greater healing requirement or surgery which results in contradictory forces that will limit aesthetic outcome and increase tension. Upper back lift will limit excision and provide cording across the back when performed in conjunction with a lower back lift. Tension of the anterior closure of abdominoplasty with associated intraoperative flexion *may* have negative ramifications on the posterior closure. If circumferential belt lipectomy or lower body lift is broken into an anterior stage and posterior stage, less opposing forces play a role in wound closure and healing. Additionally, separating the front and back of the trunk into stages provides an additional advantage of lifting the lateral thigh twice as it is an area of high relapse with residual laxity over the healing period. For instance, the lateral thigh can be addressed (in part) from the anterior approach, but when the second, posterior stage is completed, the "dog ear" redundancy can be addressed by anteriorly extending the excision into the lateral and anterolateral sites, which results in a secondary excision and lift. A minimum period of 3 months between stages allows the patients to fully recover, regain their mobility, and allow time for swelling to resolve [6].

Surgical location also must be included in preoperative planning, with consideration as to whether surgery will be performed in a hospital or ambulatory surgery center setting. Increasingly more surgery is being performed as an outpatient, due to convenience, increased safety measures, and cost. While some speculate surgery in an outpatient setting reduces risk of hospital-acquired infections, patients with greater medical risk and longer procedures who require more observation to assure safe discharge are best served by staying in the hospital to recover [7, 8].

27.2.2 Markings

Markings are done with the patient standing. On the back, lateral excursion is much greater than in the midline which is typically fixed and not markedly redundant. The pattern of excision is therefore minimal in the back midline, flaring laterally toward the hip. Pinch technique guides markings and are centered just above the gluteal cleft. Cross hatches facilitate symmetrical closure, as the upper back incision is typically shorter than the lower back incision (Fig. 27.3). Laterally, the markings either converge into abdominoplasty

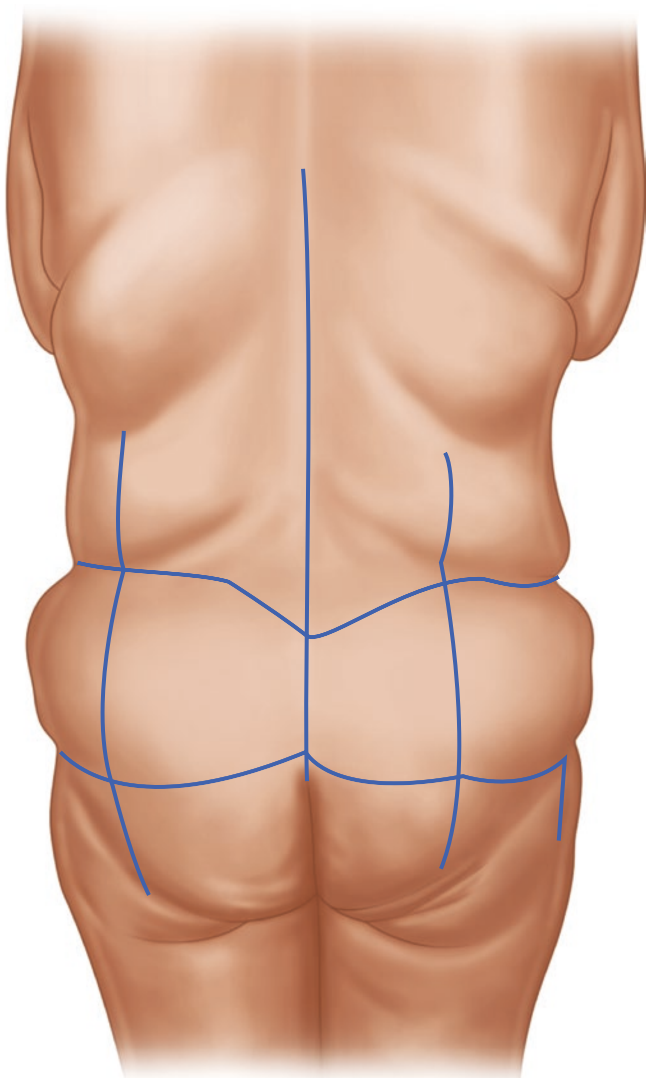

Fig. 27.3 Markings for patient undergoing gluteal lift without autologous gluteal augmentation

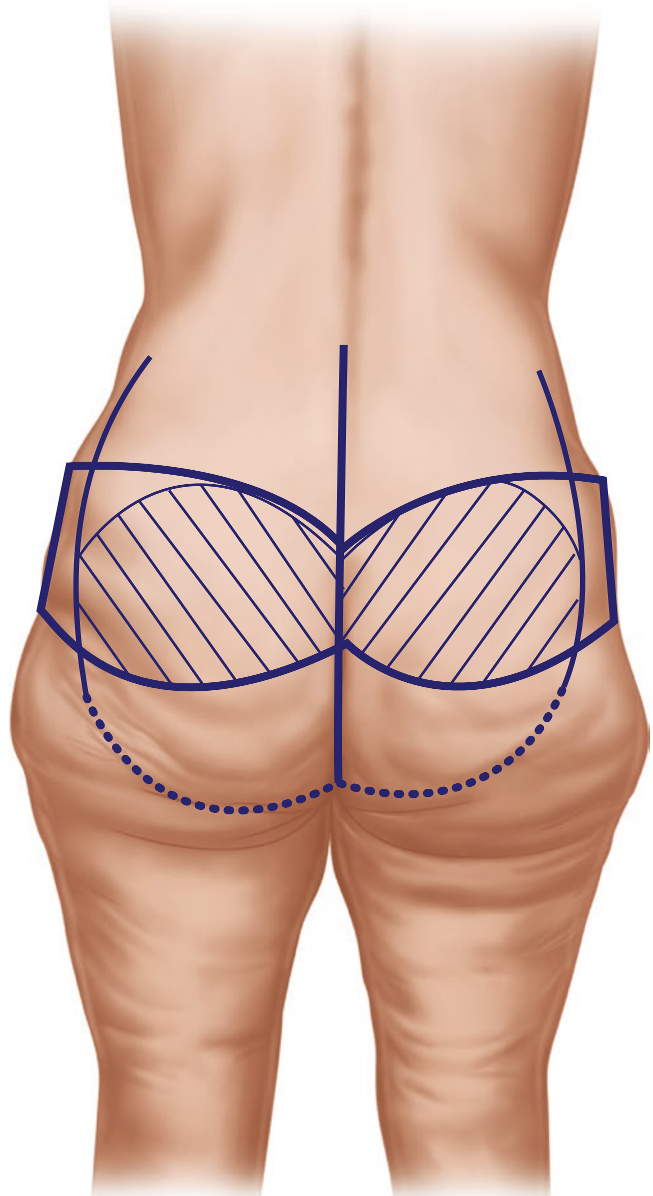

Fig. 27.4 Markings for patient undergoing gluteal lift with gluteal augmentation

markings or taper anteriorly. Markings may seem to ride up with the patient on the OR table, and adjustment for symmetry and the lower aspect of the incision may be revised. The markings serve as a guide, not a mandate, so tailoring the closure is best performed at the time of surgery to assure a nice taut result without undue tension [9, 10]. Ideally, closure should also look like a "gull wing" to highlight gluteal shape and proper regional aesthetic units. This shaping in the midline is best performed intraoperatively to create the best "V" with limited midline tension to reduce healing risk.

If there are plans to perform autologous gluteal augmentation, then marking for skin excision should be less aggressive (Fig. 27.4). The flaps for augmentation are marked within the area of planned skin resection as a mirror image of the lower gluteal region which will receive the flaps. Closure of gluteal lift over gluteal augmentation will be more tense with more volume under the skin closure from the flap, with increased circulatory challenges related to undermining the gluteal skin to allow the flaps to be buried and placed as low as possible. Typically, incision closure will be more horizontal and linear over an augmented gluteal region relative to closure over back lift alone.

27.2.3 Anesthetic Technique

Prone positioning is necessary for this procedure. In preparation for this, the patient is intubated with an endotracheal tube while lying on a stretcher next to the OR table. The tube must be carefully secured. The face is then placed in a prone pillow allowing for offloading of the eyes and a secure location for the breathing tube. The eyes may be further protected with goggles. Sequential compression devices are active prior to administering general anesthesia to protect against VTE. A foley catheter may be placed to assist in hemodynamic monitoring. Intravenous antibiotics are given. The patient is then carefully turned prone onto the OR table in a controlled manner, logrolling the patient to protect the cervical and lumbar spine. The patient is rolled onto two gel rolls oriented horizontally, one gel roll placed under the chest and the axillae and the other across the hip area, being careful to avoid any compression on male genitalia. The arms are positioned at 90° from the body and the elbows are at 90° from the arms. This positioning is designed to avoid traction on neurovascular structures. The legs are each placed on a pillow. Intraoperatively, the surgeon can help limit anesthesia by using local anesthetics, such as liposomal bupivacaine to ease the pain associated with surgery [11] (Fig. 27.5a–d).

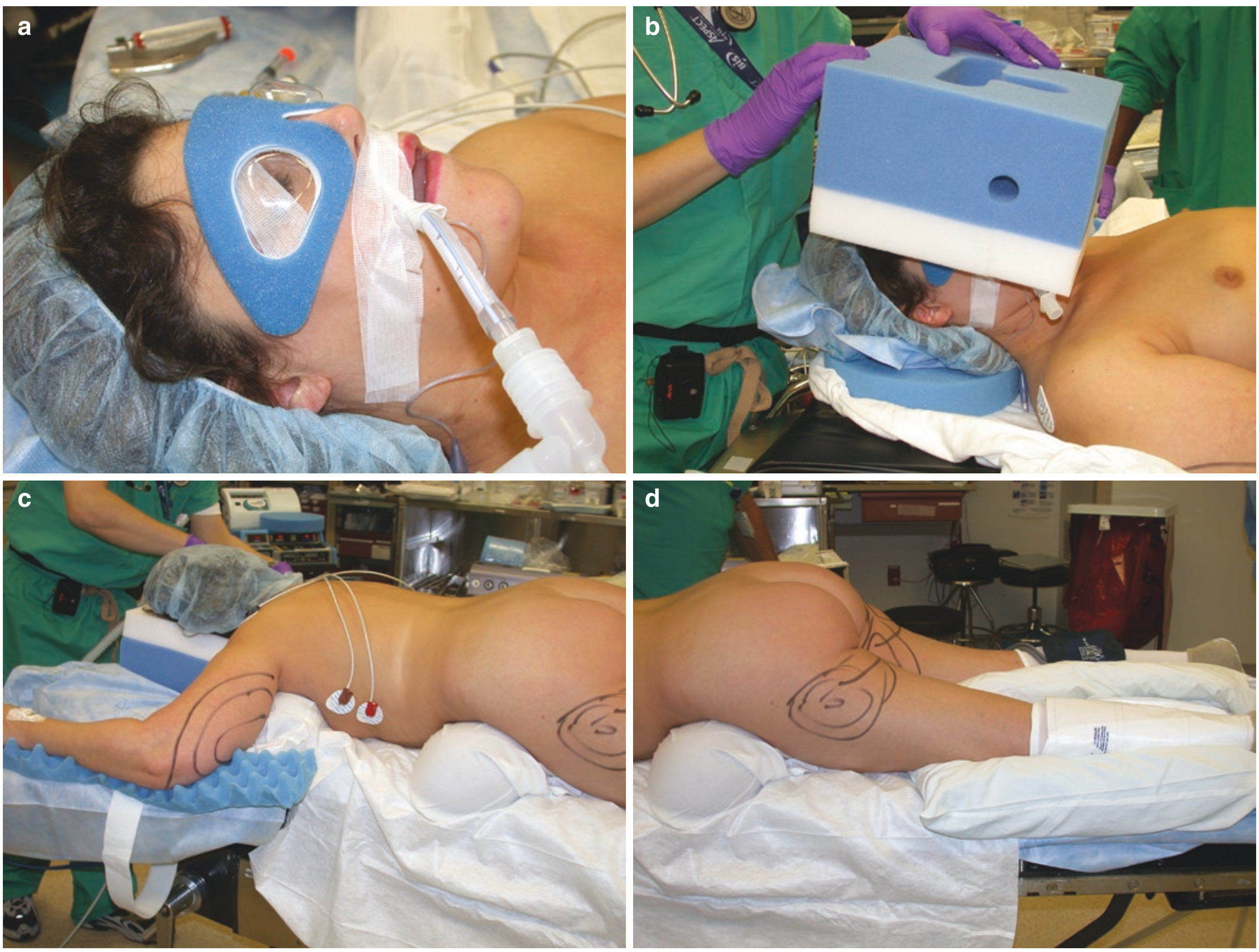

Fig. 27.5 (**a**) Goggles over the eyes provide moisture and offloading to protect the eyes. (**b**) A prone pillow supports the face and endotracheal tube when the patient is prone. This pillow is placed prior to prone positioning. (**c**) The upper body has a gel roll across the chest extending just underneath the axillae. The neck is in neutral to avoid kinking and potential dissection of the carotid and vertebral arteries. (**d**) Sequential compressive devices are placed to bilateral lower extremities

27.3 Surgical Technique

27.3.1 Gluteal Lift Without Autologous Gluteal Augmentation (Fig. 27.6a–d)

The patient is positioned prone. The upper incision of the pattern is made first. Dissection is taken down to the deep fascia. Lower back tissue is then elevated off the back in an inferior direction to the lower line marked. Careful hemostasis is achieved, and the deep tissues may be infiltrated with local anesthesia. Tailor tacking is performed determining the degree of tissue removal that optimizes tautness with risking tension, incising at the hatchmarks marked preoperatively. Between these cuts, the tissue to be removed is marked and excised. Temporary closure of the wound is performed with staples. Two 10-mm flat Jackson Pratt drains are placed in the wound, exiting laterally. Tailoring of the midline of the back with a "V" flap advanced inferiorly is performed to shape the closure and improve gluteal aesthetics. The wound is then closed in a layered fashion after local

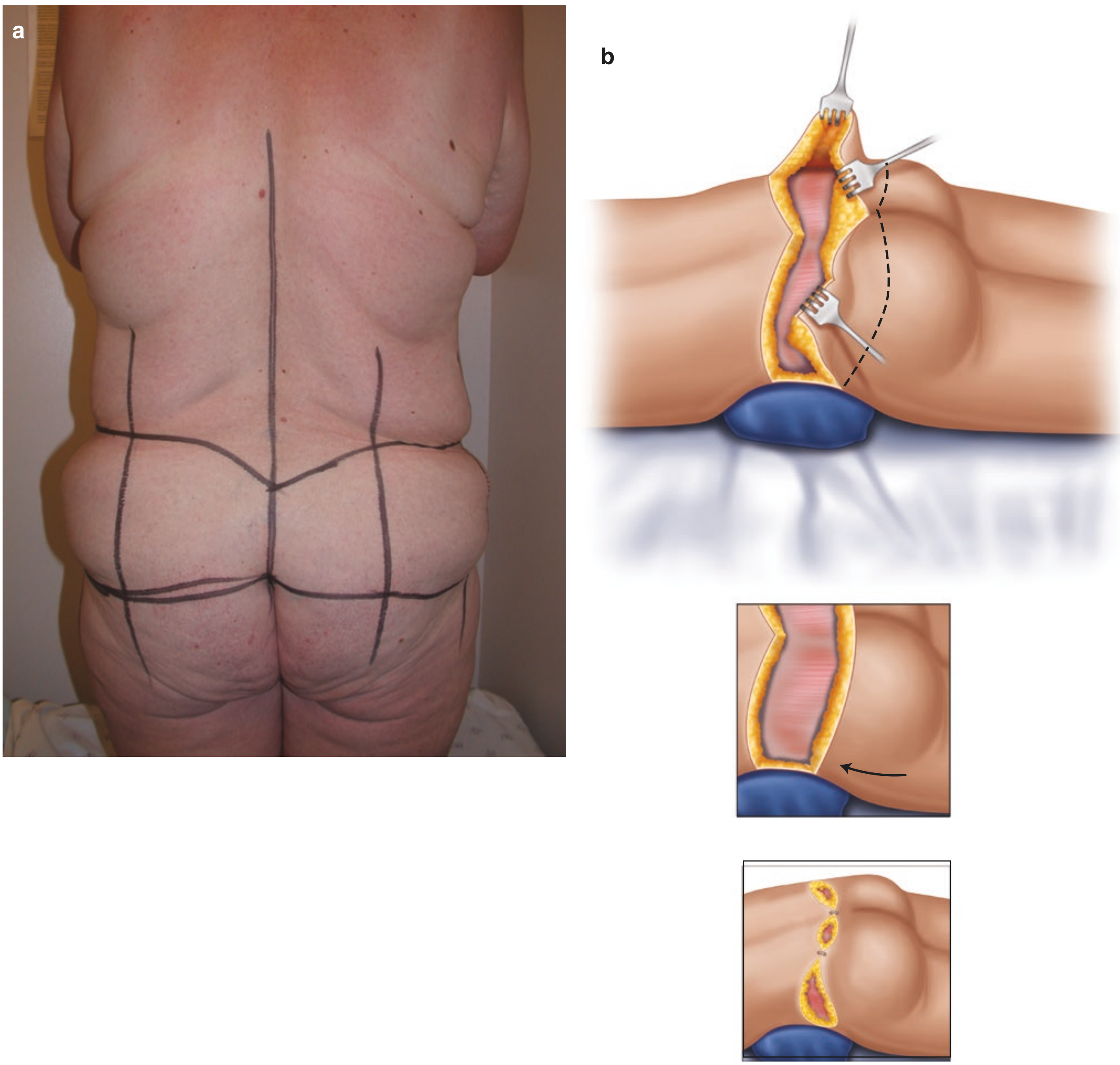

Fig. 27.6 (**a**) Markings are made as described in the text, with cross-hatches to help guide closure. (**b**) Patient in prone position, with upper incision made down to deep fascia, and undermining inferiorly, with tailor tacking prior to definitive excision. (**c**) Closure is performed in layered fashion over drains, closing down dead space with suturing down to deep fascia. (**d**) Closure should resemble a gull wing to enhance buttock shape

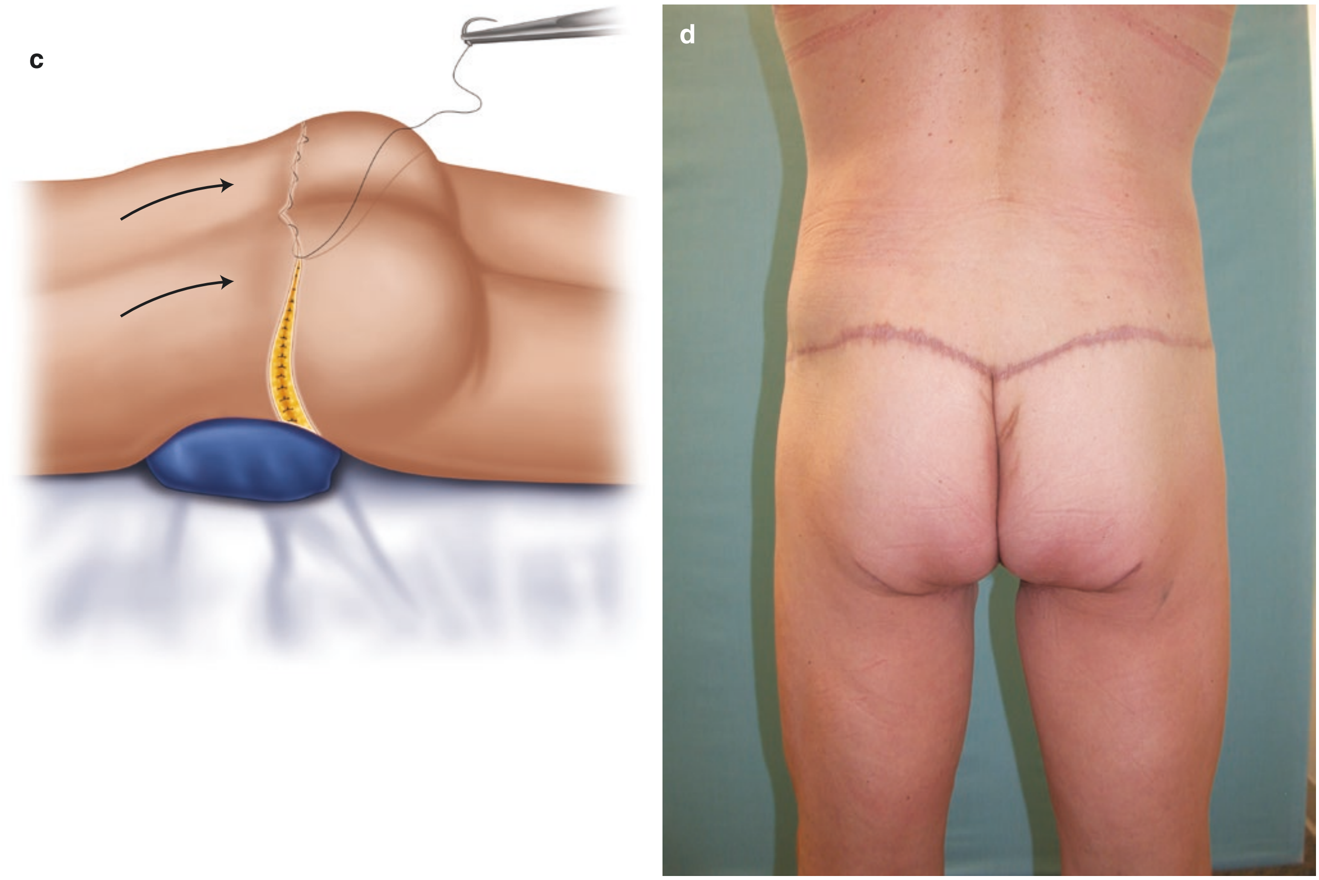

Fig. 27.6 (continued)

anesthetic is injected into deep fascia. The superficial fascia in the subcutaneous fat is approximated with #1 braided permanent suture in a three-way fashion with a bite of deep fascia to close the dead space. The skin is approximated in deep dermis and superficial dermis with monofilament absorbable suture, and more local anesthetic is injected into the skin closure. The closure is dressed with skin glue. The patient may then need to be turned supine to completely excise the lateral dog ears associated with back lift or to proceed with abdominoplasty. If thigh lift is also planned, lower back lift precedes thigh lift, as the lower back lift may elevate incision lines marked below the gluteal fold for the thigh lift.

Issues during surgery that are important to address include keeping the patient warm with warmed fluids and forced warming blankets; minimizing blood loss; and expediting surgical times with a team approach to help improve healing outcome and reduce infection and VTE risk.

27.3.2 Gluteal Lift with Autologous Gluteal Augmentation (Fig. 27.7a–d)

First the skin of the proposed gluteal flaps is sharply de-epithelialized. Blood loss here may be remarkable and is controlled with cautery and/or dilute epinephrine-moistened laparotomy pads. The upper incision of the marking is made as well as incision between and lateral to the gluteal flaps. Tissue between and lateral to the flaps is excised full thickness to deep fascia, tapering away from the flaps to optimize circulation. The lower skin flap incision is made into subcutaneous fat, and skin flaps are elevated off the deep gluteal fascia where the gluteal region will be augmented, creating limited pockets for the tissue, as low as possible so the flaps are not too high-riding. Deep fascia is incised around the flaps, allowing the flaps mobility, and the tissue will easily translate under the gluteal skin flaps. The augmentation is held in position with #2-0 braided absorbable sutures. The

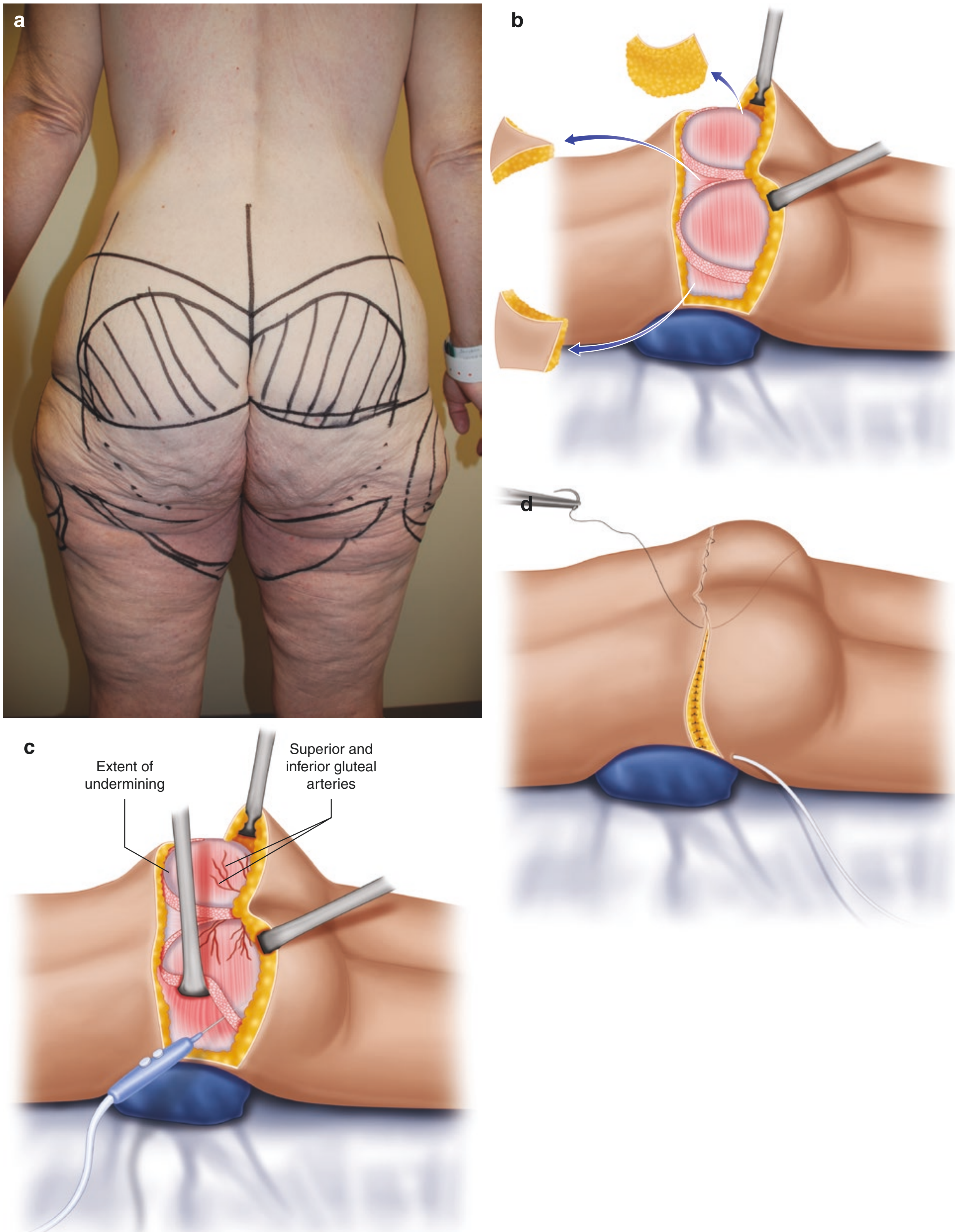

Fig. 27.7 (**a**) Markings are made for excision with flaps marked mirroring the deficient deflated area of the buttocks, with crosshatches to help guide closure. (**b**) Tissue is removed around the de-epithelialized flaps and pockets are developed for these flaps. (**c**) The deep fascia around the flaps is incised to mobilize the tissue to move under the gluteal skin flaps. (**d**) Closure is layered over top of the flaps, with drains placed

deep tissues are injected with local anesthetic. The skin is then pulled up and over the tissue augmentation, stapled together temporarily. Two 10-mm flat Jackson Pratt drains are placed in the wound, exiting laterally. The closure will be a straight, symmetric line unlike the gull wing configuration of the gluteal lift without augmentation. The wound is closed in a layered fashion without approximation of dead space as the flaps fill this space. Local anesthetic is injected into deep fascia prior to closure. The superficial fascia in the subcutaneous fat is approximated with #1 braided permanent suture. The skin is approximated in deep dermis and superficial dermis with monofilament absorbable sutures, and more local anesthetic is injected into the skin closure. The closure is dressed with skin glue. The patient may then need to be turned supine to completely excise the lateral dog ears associated with gluteal lift or to proceed with abdominoplasty.

27.4 Postoperative Period

Antibiotics are provided for at least the first 24 h after surgery and are not necessary beyond this time period, unless the surgeon is concerned about infection related to drains, circulatory challenge, or patient medical liabilities. Patients are provided pain management, and Enhanced recovery pathway includes acetaminophen, non-steroidal anti-inflammatory medications, possibly muscle relaxants, with narcotics, as needed. Liposomal bupivacaine injected intraoperatively will assist in easing pain the first 4 days after surgery. Pain management aids in early ambulation, protecting against VTE [6]. Compression hose is another excellent prophylactic measure against VTE. Patients at high risk for VTE and/or limited mobility requiring overnight hospitalization are provided heparin or low molecular weight (LMW) heparin while in hospital, with injectable LMW heparin prescribed for 2 weeks in patients at relatively high risk for VTE, with Caprini score greater than 7. Garments include a binder which accommodates the drain tubes better than a girdle does. Drains are removed once the output drops to about 30 cc/day [6, 10]. Patients undergoing gluteal lift must walk by the day after surgery: physical activity should be non-exertional for 3 weeks. Incision management may advance from moisture with vaseline or Aquaphor for the first 2 weeks, to taping for 2 more weeks, to moisturizers and massage, and onto silicone topical gels to optimize scar outcome. Patients are educated throughout the postoperative period to assure they understand drain management, activity requirements to avoid VTE, nutrition to optimize healing, and dressing care [12]. Patients are initially seen after surgery on a weekly basis until drains are out, then on a monthly basis and extending visits depending on the patient's recovery.

27.5 Complications

Complications are not uncommon with gluteal lift procedures and the best strategy in averting problems is actively taking steps to protect against problems [12, 13]. Superficial wound separation is not uncommon with gluteal lift, particularly in the mid-sacral area, theoretically due to tension, moisture, shear, or seroma formation [7]. Wound healing difficulties are more common with auto-augmentation due to greater tension on skin closure and undermining [14, 15]. With or without wound healing issues, scar optimization discussions are held after surgery, and silicone-based topicals are great in reducing scarring. Careful attention to symmetric scar creation is important to aesthetic scarring.

Seroma is a risk and is more risky with larger tissue removals and medical comorbidities [3]. Seromas are best avoided by leaving tissue on deep fascia that includes lymphatic and vascular channels to allow fluid egress, by closing dead space, and by limiting shear and tension [3, 15]. Seromas are avoided by maintaining drain tubes until daily output is low, less than 30 cc a day. If the drain is out, then needle aspiration may be performed. If needle aspiration is not completely effective, then a drain should be replaced. Continued seromas may be treated through the drain tube with sclerosing agents, and if that is unsuccessful, then the seroma cavity will need surgical treatment. Surgery ranges from quilting sutures to enucleation and VAC placement [15].

Infection is a risk with circulatory challenge, medical issues like diabetes, seromas, and hypothermia. Any cellulitis or sign of systemic infection, such as focal pain, swelling, or fevers, demands antibiotic therapy. Drainage with clinical abscess, or if etiology of infection is unknown CT scan, is necessary to treat infected seromas.

VTE prophylaxis takes place preoperatively in creating a safe surgical plan; intraoperatively with warming, sequential compression, and expediting surgical time; and continues on after surgery, with encouragement of ambulation, hydration, lower extremity compression, and unfractionated heparin as determined to be necessary.

27.6 Conclusion

Gluteal lift is an effective way to optimize gluteal aesthetics when gluteal deflation and lower back skin redundancy, particularly as seen in individuals who have sustained massive weight loss, are significant. It is the most effective way to extend the results of an abdominoplasty in an individual with laxity of the back, lifting the buttocks and outer thigh, improving cellulite and skin quality appearance. Autologous flaps created from the lower back tissue that would otherwise be discarded in gluteal lift provide reliable volume in particularly deflated buttocks. Operative technique, while focused on symmetric lift and tightening, need to address warming, limiting blood loss, VTE prophylaxis, expedited surgery times to optimize safety and outcomes. Preoperative planning, intraoperative treatment, and postoperative counseling and surveillance optimize outcome with gluteal lift. Recovery from a gluteal lift, particularly when part of a belt lipectomy or lower body lift, may have relatively high discomfort, healing complications, and less than optimal scar aesthetics. Although most body contouring procedures are cosmetic and elective, individuals undergoing gluteal lift may be at a higher risk for complications compared with other cosmetic candidates. The best strategy for minimizing complications is actively preventing them.

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28 Gluteal Augmentation with Injectable Fillers

Denis Souto Valente

28.1 Background

The search for prominent buttocks has increased in the last years. Gluteal augmentation procedures are becoming more prevalent in the field of plastic surgery. Aesthetic surgery of the buttocks usually involves either augmentation or reshaping. This may be achieved with liposuction alone, liposuction in combination with lipotransfer, gluteal lift, silicone implants, injectable alloplastic implants, or a combination of these methods. The elected technique for each patient searching for gluteal augmentation varies among plastic surgeons [1].

Minimally invasive procedures have become increasingly popular because of the ease of the technique, rapid recovery, and satisfactory results. The role of minimally invasive procedures as part of a thriving practice will loom large over the next years as plastic surgeons grapple with profitability issues and public perceptions of risks. In some patients' perception, injectable fillers are perceived less risky than surgery [2, 3]. In facial rejuvenation, injection of fillers is less expensive than a surgical facelift. However, in gluteal augmentation, the use of a large amount of fillers may be more expensive than conventional plastic surgery and their long-term effects are relatively unknown. It is important to assert that gluteal augmentation with fillers is not aimed to substitute the classical techniques of plastic surgery. However, it may be useful in certain circumstances with proper patient selection.

Despite the historical complications caused by gluteal silicone injections, there are safe options to perform gluteal augmentation as a minimally invasive procedure. Some alloplastic injectables such as polymethylmethacrylate (PMMA), calcium hydroxyapatite (CaHA), hyaluronic acid (HA), and poly-L-lactic acid (PLLA) can be used for this purpose. The aim of this chapter was to present techniques of gluteal augmentation with these four dermal fillers as well as the results and complications.

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28.2 Filler Selection

The choice of alloplastic injectable products has changed over time. There is a controversy regarding the recipient tissue viability when large volumes are injected. Biodegradable fillers are preferred over permanent fillers because of safety issues [4, 5]. The average cost of the procedure is dependent on the type and the amount of filler injected.

Polymethylmethacrylate is a biocompatible, nonbiodegradable, and stable synthetic resin produced from the polymerization of methyl methacrylate. PMMA microspheres are tiny, round, smooth particles that are not absorbed by the human body. PMMA beads are commercially available, suspended in a collagen or hydroxypropyl methylcellulose solution. This material is used in other medical devices, such as microsensors, drug delivery applications, bone cement, intraocular lenses. Once injected, PMMA is capable of incrementing the vascularity of the recipient site, allowing a better tissue environment avoiding subsequent infection.

All permanent fillers, like PMMA, injected anywhere in the body, run the risk of creating foreign body granuloma in an attempt to encapsulate the material and isolate it from the rest of the body. These masses can cause deformities, chronic pain, inflammatory reactions that respond temporarily to corticosteroids. It is difficult to remove PMMA from the gluteal region without important sequelae. There are many types of PMMA formulations marketed worldwide. For gluteal augmentation, it is vital that the PMMA does not contain silicone or local anesthetics in the formula, in order to avoid undesirable complications related to liquid silicone and anesthetic toxicity [6].

Calcium hydroxyapatite is a biodegradable filler and is commercially available in a sterile, non-pyrogenic, latex-free, cohesive, semisolid injectable implant containing

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microspheres of 25–45-micron diameter in a gel carrier that consists of glycerin and carboxymethylcellulose. It has the ability to provide both volume and collagen biostimulation. It acts as a scaffold promoting the development of collagen, elastin, and fibroblasts. This is consistent with the remodeling process and collagen production occurring under physiologic conditions [7].

CaHA is long lasting with an average duration of 20 months, and in some cases up to 30 months. The longevity of CaHA is a result of its twofold mechanism of action. Radiologic studies of CaHA have shown that in many patients, the volume remains despite no CaHA being visible. It is hypothesized that the duration of its effects is a result of long-term deposition of new collagen and not due to the continued presence of the CaHA microspheres. CaHA has high viscosity and elasticity, which prevent it from moving to other areas, resisting to the applied forces. For gluteal augmentation, the author dilutes a 1,5-cc syringe of CaHa with 8,5 cc of normal saline.

Hyaluronic acid is a natural, repetitive disaccharide macromolecule, composed of D-glucuronic acid and N-acetyl-D-glycosamine monosaccharide. HA fillers are derived from biotechnological processes utilizing streptococcus biofermentation and are generally cross-linked with a binding agent. Cross-linked fillers can be classified into two types: monophasic (cohesive) and biphasic (non-cohesive). Monophasic fillers are composed of a single phase of HA, which is cross-linked once (monodensified) or continuously (polydensified). Biphasic fillers are characterized by cross-linked particles suspended in a non-cross-linked HA matrix manufactured with non-animal-stabilized technology. These characteristics and the resulting degree and type of cross-linking determine the viscoelastic properties of HA fillers. The effect of soft tissue volume augmentation is limited to 6–18 months depending on the type of filler used, the anatomical site, and the patient's metabolism [8].

Enzymes such as hyaluronidase and free radicals can rapidly degrade HA polymers. Obvious limitations with HA gluteal augmentation relate to material degradation and the need for repeated treatments to maintain the initial and desired effect. HA can be removed by aspiration or dissolved with hyaluronidase infiltration. This is advantageous compared to permanent fillers, for which correction generally requires more invasive surgical procedures.

Poly-L-lactic acid is a biocompatible, immunologically inert, synthetic polymer from the alpha-hydroxy-acid family. Injectable PLLA is composed of crystalline, irregularly sized microparticles. PLLA is biodegradable over 2–3 years and is likely to remain active over that period in the dermis. When injected, a foreign body giant cell reaction occurs, eliciting fibroblast proliferation causing an increase in collagen production. It also improves corporal volume deficiency by serving as a scaffold, promoting neo-collagenesis, expanding dermal thickness [9].

PLLA progressively increases the volume of the injected areas over the course of weeks to months. A clinical implication of this gradual mechanism of action is the importance of promoting hypo-correction during injections, which would otherwise provide unpleasant results if hyper-correction was performed. PLLA reconstitution must be performed 12–70 h before the procedure [10].

28.3 Patient Selection

This procedure is ideal for individuals lacking fat for autologous fat grafting, patients who have lost weight and wish to improve the appearance of their buttocks, and patients who had previous gluteal fat augmentation who desire more volume and projection. The majority of patients who choose injectable fillers do not want to undergo a procedure under locoregional or general anesthesia or do not wish to have silicone implants. Previous history of gluteal fat augmentation and removal of gluteal silicone implants are not contraindications for gluteal augmentation with fillers. History of sciatica should be noted preoperatively as the sciatic nerve may be injured during injection [11].

The author's contraindications include previous unknown filler injections in the gluteal, trochanteric or sacral regions performed by other individuals, presence of silicone implants, ptosis of the buttocks, hypersensitivity to one of the components in the filler formulation, bleeding disorders, recent use of anticoagulants or herbal supplements that may increase bleeding, rheumatologic diseases, personal history of deep venous thrombosis or pulmonary embolism, body dysmorphic disorder, and severe allergy or anaphylaxis history.

28.4 Volume of Fillers Injected

The ideal volume for a given patient is difficult to determine before the procedure. The author prefers to inject 30–60 cc of fillers per buttock per session until the desired volume is obtained. Overinjection in a single session must be avoided. If a permanent filler is chosen, the patient must be warned that the material will remain in the body, and cannot be resected without sequelae. If a biodegradable filler is injected, the patient must be aware that after absorption, the gluteal region could show some areas of deflation with possible excess skin laxity that may require additional treatment or a secondary gluteal augmentation therapy. In 2006, Roberts et al. described features that are common to youthful and attractive buttocks across all ethnic groups: a smooth inward sweep of the lumbosacral area and waist, a feminine cleavage as the buttocks separate, maximum prominence in the mid-to-upper buttocks, and a minimal infragluteal fold. The injected volume must be chosen, and adequately placed into the buttocks bearing in mind these features [12].

28.5 Marking

This procedure presents both artistic and technical challenges, especially because every patient has their own expectations and anatomical features. Cuenca-Guerra and Quezada described in 2004 the four main characteristics that determine attractive buttocks in addition to the balanced anatomical dimensions of the maximal point of gluteal projection:

- Supragluteal fossette
- Mild lateral depression at the greater trochanter
- Short gluteal fold
- V-shaped sacral triangle [13]

Independent of the filler chosen, the marking of the area to be filled follows some of the landmarks described above in order to achieve the desired gluteal contour. As can be seen in Fig. 28.1, four points along the gluteal surface anatomy are marked in each buttock with the patient in the standing position:

- Point "A" is marked in the center of the buttock, 1 cm below a virtual line joining the 2 posterior superior iliac spines.
- Point "B" is marked 1 cm medial to the greater trochanter projection.
- Point "C" is marked in the center of the buttock, 3 cm above the infragluteal fold.
- Point "D" is marked 4 cm lateral to the intergluteal cleft at the same level of point "B."

By connecting all four points A, B, C, and D, we obtain a diamond-shaped figure, which can be divided into superior and inferior triangles. When more projection is desired, most of the filler must be injected in the inferior triangle. When the patient desires a rounder appearance of the buttocks, most of the filler must be injected in the superior triangle. Equal distribution of the filler in both triangles will augment the gluteal region without any change in the gluteal shape.

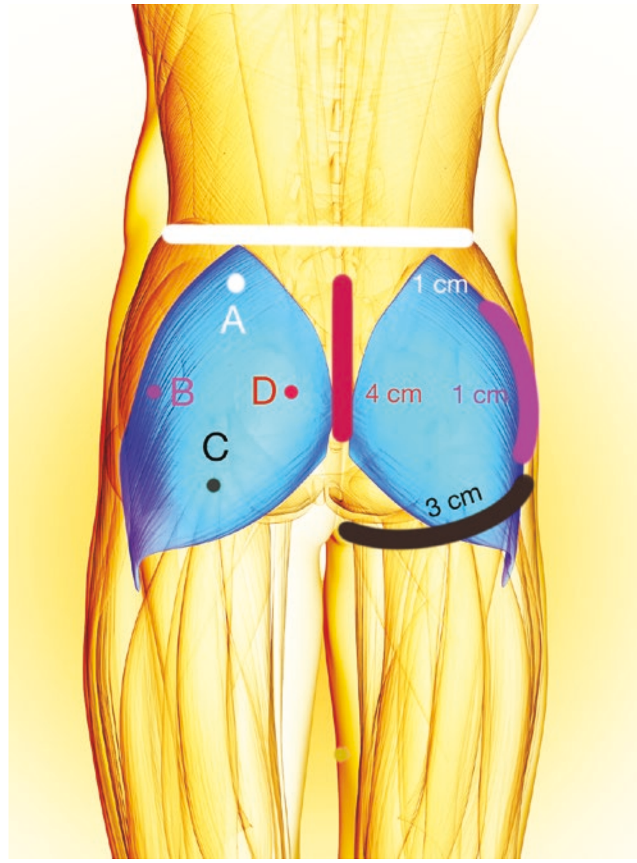

Fig. 28.1 Landmarks for gluteal injection of fillers

28.6 Filler Injection Technique

With the patient in prone position, asepsis of the gluteal region is performed. Using an 18-gauge (G) × 1/2″ needle, the skin is punctured in the central point of the marked diamond. A solution of local anesthesia (20 mL of lidocaine 2%, 20 mL of ropivacaine 10%, 40 mL of normal saline) is infiltrated in each buttock along the superficial gluteus musculature, using a 16-G × 4″ disposable micro-cannula, over the entire diamond-shaped area previously marked.

PMMA, CaHA, and HA are injected in a superficial muscular plane using the same micro-cannula and entry site as for the infiltration at a 40–90° angle to the skin. The injection is done in multiple tunnels, using the fanning technique from the site of injection, in a retrograde manner. Continuous motion of the cannula while injecting the filler helps prevent direct injection into a vessel and disperses the filler throughout the muscle, allowing adequate diffusion of the filler (Fig. 28.2).

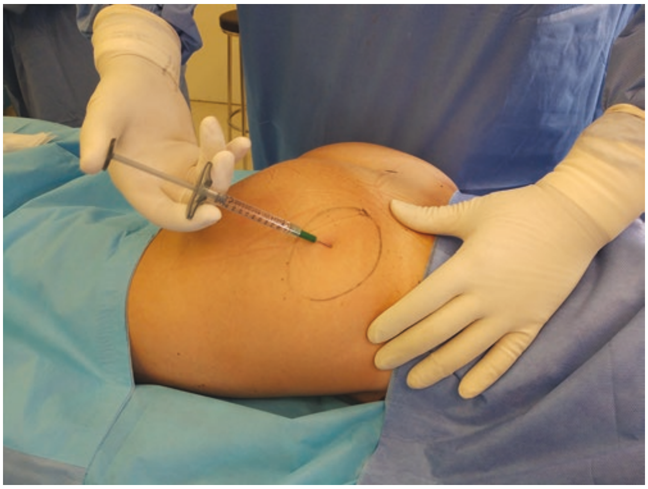

Fig. 28.2 Filler injection technique showing the cannula at the desired angle

PLLA (1 vial) is reconstituted with 3,5 cc of sterile water and 1,5 cc of lidocaine 2%. PLLA injection does not require prior infiltration with local anesthesia. Multiple punctures in the skin are done using an 18-G × ½″ needle. PLLA solution is injected in the deep dermis using a threading technique in a grid pattern with an 18-G × 2¾″ disposable micro-cannula at 30–40° angle to the skin. Massage is performed in the areas injected in order to spread the PLLA into adjacent tissues.

28.7 Post-procedural Care

Analgesics are prescribed for 5 days and antibiotics (amoxicillin–clavulanate 875–125 mg PO q12h) for 7 days. Immediately after the procedure, ambulation is recommended. Depending on the patient's Caprini score, deep venous thrombosis prophylaxis should be administered. Patients are allowed to sit and lie supine as usual. They can return to work on the following day after the injection and return to normal physical activities after 1 week. Use of compressive garments, lymphatic drainage, and massage of the treated areas are not recommended.

28.8 Casuistics

A total of 431 patients received PMMA injections in the gluteal region with an average of 219 cc injected per side for the whole treatment (Fig. 28.3a, b). Thirty-two patients received CaHA injections with an average of 104 cc injected per side (Fig. 28.4a, b). Fourteen patients received an average of 66 cc of HA per buttock (Fig. 28.5a, b). Twelve patients received an average of 18 cc of PLLA per buttock. Eighty-three percent of patients were female.

The total complication rate was 14.3% and consisted of palpable noninflammatory nodules (8.4%), seroma (1.6%), striae distensae (1.4%), transient sciatic neuropraxia (1.2%), pyramidal syndrome (0.6%), skin necrosis (0.2%), and deep venous thrombosis (0.2%). The longest follow-up period was 13 years. Patients who received PMMA injections presented a mean of 15.5% complication rate and those who received biodegradable fillers presented a mean of 2.2% complication rate. Therefore, patients who received permanent fillers were seven times more likely to develop complications in comparison to those who received biodegradable fillers.

28.9 Discussion

Gluteal augmentation with fillers can be performed either in the clinic or in the hospital as an outpatient procedure. It is safer to inject PMMA in the superficial muscular plane than in the subcutaneous plane. The use of blunt cannulas is mandatory in order to avoid intravascular injections [14]. Possible complications of intramuscular injections of fillers include leakage of the filler from the injection site, bleeding, inadvertent intravascular injection, nerve injury, persistent pain, abscess formation, necrosis of the surrounding tissue, scar formation, possible muscular fibrosis. Noninflammatory nodules were the most common complication and may be due to erroneous injection in the subcutaneous plane or leakage of the fillers in that plane (Fig. 28.6).

28.10 Conclusion

Fat grafting is the author's first choice for gluteal augmentation. However, gluteal augmentation with injectable fillers, preferably with biodegradable fillers may be performed in some patients who desire quicker recovery and do not have sufficient fat for grafting. It presents an acceptable complication rate with satisfactory results. The injection of permanent fillers in the gluteal region is not illegal in Brazil as of this date; however, the injection of large amounts of fillers is not endorsed by the Brazilian Society of Plastic Surgeons.

Fig. 28.3 Pre-procedure and 6 years post-procedure of a 26-year-old woman who received 240 cc of PMMA injection per buttock (Posterior (**a**) and lateral (**b**) views)

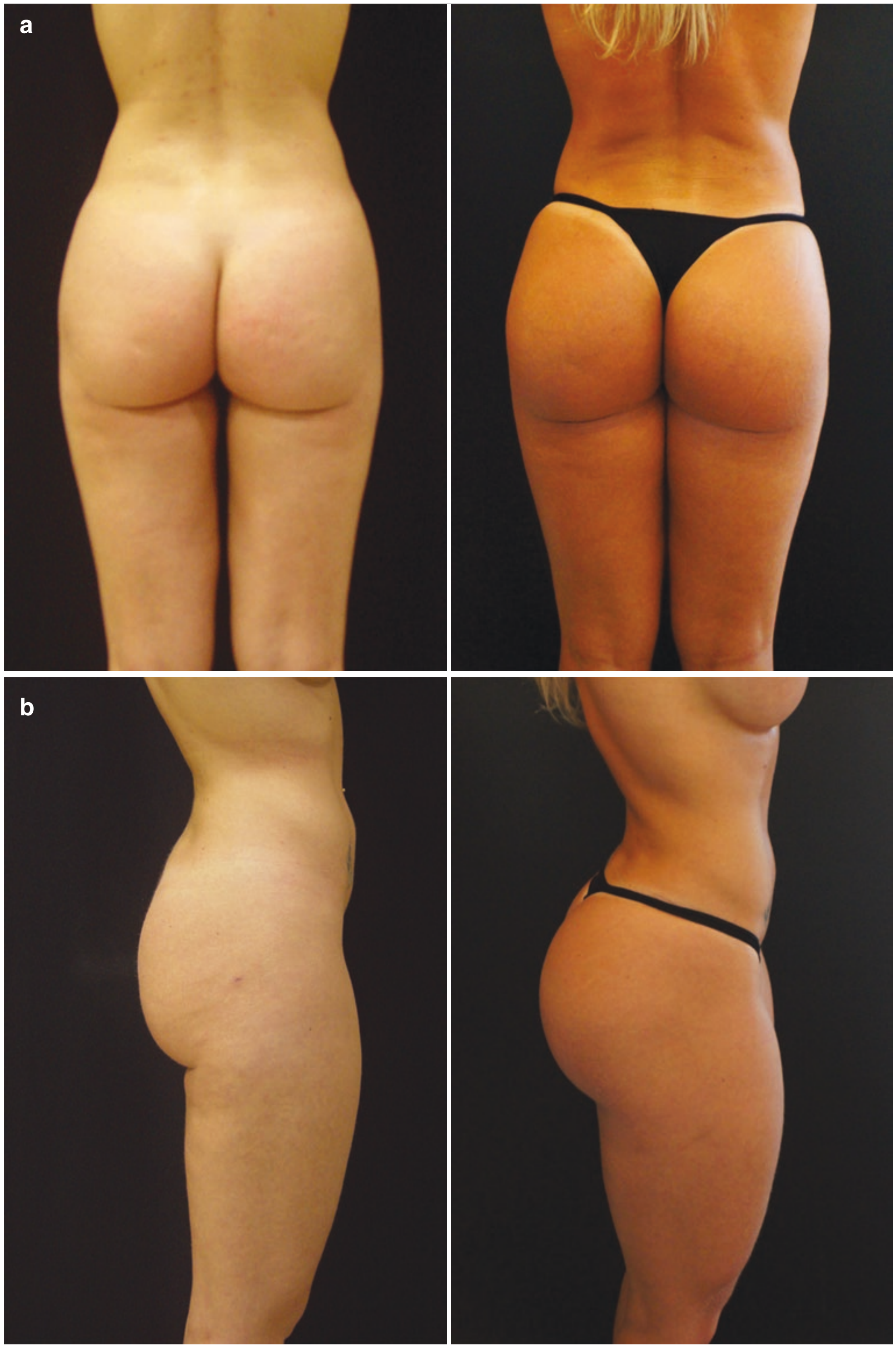

Fig. 28.4 Pre-procedure and 15 months post-procedure of a 31-year-old woman who received 100 cc of diluted CaHA injection per buttock (Posterior (**a**) and lateral (**b**) views)

Fig. 28.5 Pre-procedure and 9 months post-procedure of a 46-year-old man who received 90 cc of HA injection per buttock (Posterior (**a**) and lateral (**b**) views)

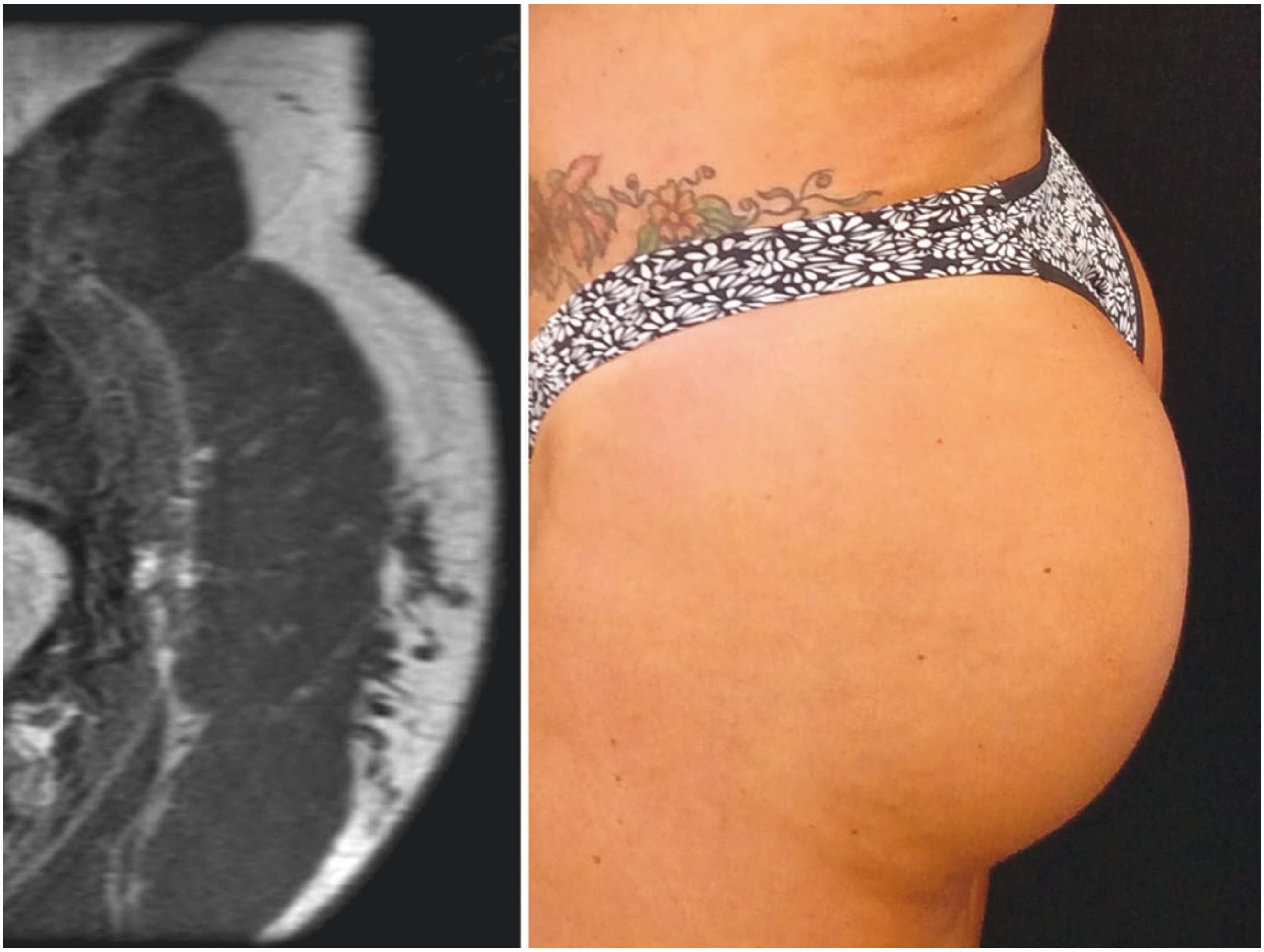

Fig. 28.6 Patient presenting noninflammatory nodule in the left buttock caused by leakage of filler. The nodule is not seen but is palpable and evident on the magnetic resonance image; 2 years after injection of 360 cc of PMMA per buttock

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Male Gluteal Augmentation with BodyBanking Lipocell Transfer and Silicone Implant

29

Douglas S. Steinbrech and Eduardo Gonzalez

29.1 Introduction

Representing a visual transition point between the torso and the lower extremities [1], the buttocks is the principal focal point leading to attractiveness from a posterior view of the human body. In women, the buttocks along with its relationship to a narrower waist gives the characteristic "hour glass" aesthetic silhouette [2]. However, this well-accepted female standard of beauty cannot be applied to males [3]. These contrasting features between females and males can be appreciated in Fig. 29.1. For men, the principal dimorphic characteristic, and perhaps the main one if we exclude facial features, is a muscular body build [4]. This is representative of health, physical capacity to perform tasks, ability to interact with a hostile environment, endurance, and capability of physically caring for others [4]. Furthermore, it also gives the perception of youth and fertility, as it is a result of healthy development of testosterone-dependent secondary sexual characteristics.

The surgeon must be cognizant that unlike female gluteal augmentation, fullness is not sufficient for the aesthetic male body. Gluteal augmentation in males must deliver a muscular appearance, which consequently will also provide some projection and contour; nevertheless, the targeted visual impression must be one of virility and health. An example of this is the importance of preserving the trochanteric depression during male gluteal sculpting, which highlights the periphery of the gluteus maximus muscle [5]. All surgical techniques in male gluteal sculpting, particularly those adapted from female buttocks augmentation, must abide to this principle of enhancing a muscular appearance.

While men still represent a smaller fraction of the aesthetic surgery industry, there has been a significant growth in the demand for male aesthetic procedures. From 1997 to 2014, the total number of aesthetic cases on male patients increased by 273% [6]. Furthermore, in 2017, gluteal augmentation was one of the three fastest growing procedures in aesthetic surgery [6]. Thus, the contemporary plastic surgeon must be well versed in managing a male patient consultation, selecting a male-specific surgical technique, and consider gluteal augmentation, if indicated, as a tool to getting patients closer to the male aesthetic ideal.

Gluteal augmentation remains a technically demanding procedure as it requires thorough knowledge of the various available techniques, anatomy of vital structures surrounding the gluteal muscles, management of patient expectations (some of which are specific to males), and anticipation of potential complications. The two most commonly used surgical techniques for buttocks augmentation remain gluteal implants and fat grafting. These two techniques are the focus of this chapter based on our senior author's own practice. Although techniques of auto-augmentation with fasciocutaneous and musculocutaneous flaps have been described, these are not included in this chapter as they apply to situations of skin and soft tissue redundancy, as is the case with post-bariatric body contouring.

The two most utilized approaches for placement of gluteal implants are the subfascial and intramuscular techniques [7]. The intramuscular approach is our preferred technique, as it maximizes implant coverage, limits implant migration, circumvent restrictions caused by deeper neurovascular structures, and prevent contour deformities.

Use of implants prevailed as the main surgical approach for achieving gluteal augmentation for almost three decades [8]. Recently, gluteal "fat grafting" has become the preferred procedure for gluteal augmentation and contouring for many plastic surgeons. Statistics published by the American Society of Plastic Surgeons for the year of 2016 [9] reported a 26% growth in buttocks augmentation with fat grafting, while implant-based augmentation grew by 18%. Of note, we have found that the term "fat grafting" is difficult for

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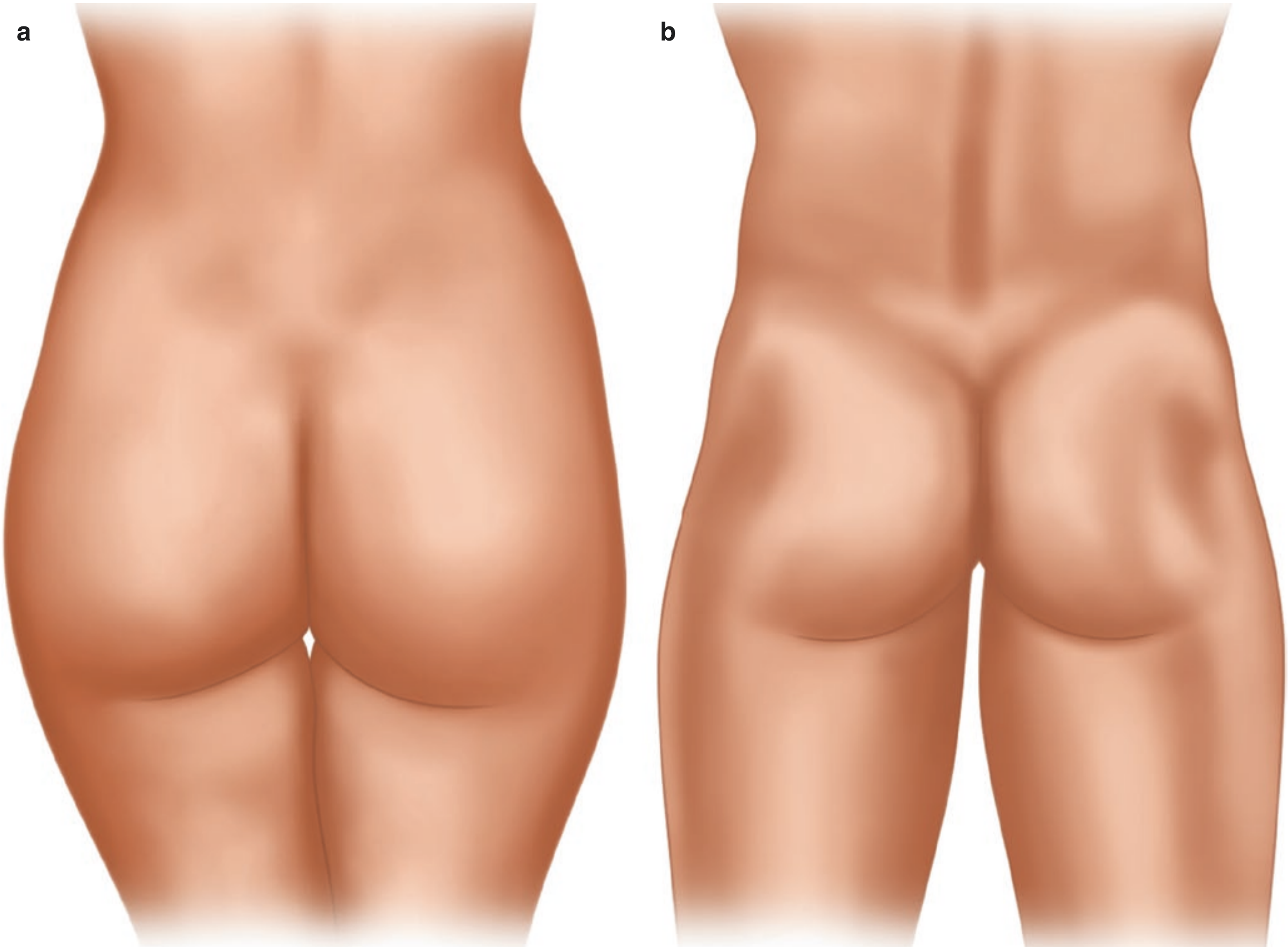


Fig. 29.1 Contrasting features of the buttocks relationships between females and males that lead to their dimorphic aesthetics. (**a**) In females, the waist-to-hip ratio leads to the hour-glass silhouette, while in males (**b**) the muscular projection and definition of the gluteus muscle results in an aesthetic appeal. In males, note the visible trochanteric depressions, the tall buttocks in which the projection of the upper pole of the gluteus musculature continues cephalad toward the lumbar region well beyond the beginning of the gluteal cleft. The gluteal cleft in males is shorter than in females, and the inferior gluteal crease in males is limited to the inner third of the breadth of the buttocks while in females it occupies the inner half, approximating the meridian of the buttocks

patients to understand; thus, we use the term "lipocell transfer" as it is more descriptive of what the procedure entails.

The advantage of gluteal lipocell transfer is the avoidance of implant-specific complications, such as implant migration and capsular contracture, while providing greater accuracy of gluteal sculpting by enhancing more precise areas, as well as the "dual benefit" of liposuction and augmentation [10]. Furthermore, lipocell transfer techniques have evolved and proven to be safe and effective [11]. Over the last decade, advances in fat-harvesting techniques and a more comprehensive understanding of those risk factors leading to complications, have reintroduced lipocell transfer as a well-accepted procedure for buttocks augmentation and sculpting. We have incorporated the BodyBanking™ [12] lipocell transfer approach to gluteal augmentation for a more athletic and masculine final result.

29.2 Surgical Anatomy

The plastic surgeon must have a thorough understanding of the skeletal, neurovascular, muscular, and fascial anatomy of the gluteal region in order to achieve an optimal aesthetic result while avoiding complications. In this section, we point out distinct anatomical features of the male buttocks, as well as the surgical landmarks utilized for staying safe.

The gluteal region should be conceptualized as a frame of bony structures (Fig. 29.2) that support the gluteal musculature through ligaments and fascial planes that ultimately attach to the skin, resulting in the characteristic aesthetic contours. The external landmarks of this frame in a clockwise orientation are as follows: the sacral triangle at the midline is defined by the paired posterior superior iliac spines (PSIS), cephalad (as the base of the inverted triangle), and

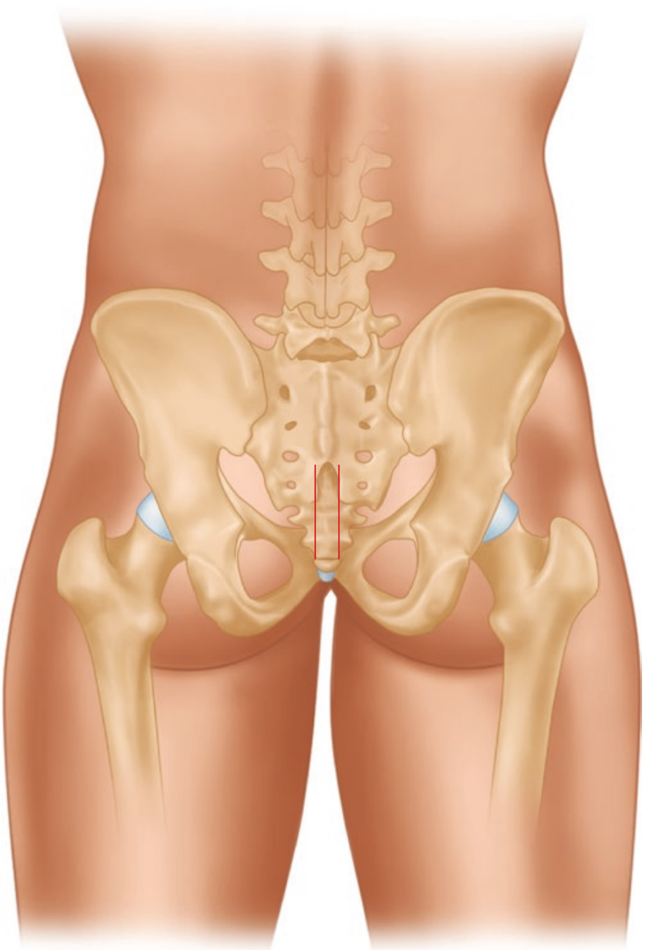


Fig. 29.2 Bony frame of buttocks

the coccyx caudally (as the tip of the triangle); parting from the PSIS, the iliac crests then continue as an arch in a cephalad, anterior (ventral), and lateral direction; the highest point of the iliac crest defines the cephalad limit of the bony frame of the buttocks which intersects the axis of the apex of the scapula; the most lateral aspect of the frame is marked by the greater trochanter of the femur to which tendinous muscular insertions define the distinctive lateral trochanteric depression desired in males; caudally, the ischial tuberosity defines the most inferior extent of the osseous frame of the buttocks. This bony frame not only provides sites of insertion for the important gluteal musculature but also connects with the skin of the buttocks through osteocutaneous ligaments [13]. Two of these ligaments are noted, both of which originate at midline: the sacrocutaneous ligament and the ischiocutaneous ligament. The sacrocutaneous ligament originates at the lateral border of the sacrum and is densely attached to the skin overlying it; it then extends as an arch superolaterally to interdigitate with the adhesions of the iliac crest periosteum to the dermis [13]. Through descriptions of cadaveric studies, Lockwood reported that this sacrocutaneous ligament is more adherent in males compared to females [14]; this results in a pronounced transition between the sacral triangle and the gluteal upper pole that is characteristic of an aesthetic male physique. The ischiocutaneous ligament is fan-shaped and originates from the ischial tuberosity to extend toward the dermis of the mid-buttocks. As it fans superomedially, it merges with the fasciocutaneous ligament of the natal cleft, and as it fans inferolaterally, it merges with the fasciocutaneous ligament of the infragluteal crease.

There are three aesthetic focal points of the buttocks that result from fasciocutaneous adherences: the natal cleft medially, the trochanteric depression laterally, and the infragluteal crease caudally. In 1989, Illouz characterized these zones as “fixed points” that should not be surgically disrupted, as they cannot be recreated [15]. Lockwood subsequently characterized them as “zones of adherence” of the superficial fascial system to the dermis [14]. These fasciocutaneous tissues take the form of septa that encase, support, and shape the adipose tissue, and can be used to the surgeon’s advantage during liposculpting. Parenthetically, they are thicker in males compared to females. At the midline, the natal cleft fasciocutaneous adherence extends from the gluteal fascia (i.e., the deep fascial plane, which in this location corresponds to the aponeurosis of the gluteus maximus) to the dermis, merging cephalad with the sacrocutaneous ligament and caudally with the ischiocutaneous ligament. Laterally, the trochanteric depression is formed by the ligamentous and tendinous attachments of the gluteus medius, vastus lateralis, quadratus femoris, and gluteus maximus muscles to the greater trochanter of the femur as they approximate the superficial fascial system, with minimal adipose tissue between these planes. The important infragluteal crease is a unique structure that, unlike prior assumptions, is distinct from the superficial fascial system [16]. It originates from the dermis of the medial one-third of the lower buttocks, forming a heavy and thick septum that not only interdigitates with the gluteal fascia but also extends more deeply to attach to the ischial ramus and the sacral bone, taking a horizontal J-shaped form [16]. Thus, the infragluteal crease can be characterized both as an osteocutaneous ligament and as a fasciocutaneous adherence, which explains the fixed and well-defined nature of this structure. Furthermore, the infragluteal crease is a key aesthetic component of the male buttocks. The definition of its length should not exceed the medial third of the width of the buttocks, as a longer crease results from skin redundancy, lax fascial planes, and loss of muscle mass, suggesting ptotic and aged buttocks.

Once the reader can delineate the patient’s bony frame, as well as the osteocutaneous and fasciocutaneous planes, the musculature can be conceptualized as occurring within this scaffold. The most superficial muscle of this group is the gluteus maximus which is the body’s thickest muscle (approximately 4–7 cm); it originates from the lateral coccyx, lateral sacrum, sacrotuberous ligament, fascia of the erector spinae, posterior ilium, and the medial third of the posterior iliac crest; it runs a caudolateral course with its superficial fibers inserting to the iliotibial tract and the deeper fibers inserting to the gluteal tuberosity of the femur. The gluteus medius muscle originates from the lateral two-thirds of the iliac crest, inserting on the greater trochanter of the femur. It is immediately deep to the gluteus maximus, except for its origin at the iliac crest where it resides uncovered by the gluteus maximus. Beyond this point, the two muscles interdigitate and can only be differentiated by the course of their fibers. The fibers of gluteus maximus are identified running obliquely while the deeper fibers of the gluteus medius are identified running vertically. The gluteus minimus lies deep to the gluteus medius, and has a similar course originating from the gluteal surface of the ilium with vertically oriented fibers inserting to the hip joint capsule and greater trochanter of the femur. A group of smaller muscles deep to the gluteus minimus consists of the piriformis (most cephalad), followed by the gemellus superior, obturator internus, gemellus inferior, and quadratus femoris (most caudally). These muscles are not routinely encountered during dissection for intramuscular gluteal implant placement; however, they serve as important landmarks for neurovascular structures exiting the pelvis. The piriform muscle originates from the sacrum and sacrotuberal ligament and inserts to the greater trochanter of the femur. It is of anatomic importance because it splits the sciatic foramen. The sciatic nerve exits the pelvis through the sciatic foramen caudal to the piriformis muscle, at a midpoint between the ischial tuberosity and the greater trochanter. The sciatic nerve then courses laterally and caudally to the pelvic acetabulum, which can be palpated intraoperatively for orientation. The superior gluteal artery exits in a cephalad direction to the piriformis muscle dividing into a superficial and deep branch; the superficial branch courses along the deep surface of the gluteus maximus muscle while the deep branch courses between the gluteus medius and minimus muscles. This trajectory of the superior gluteal artery can be traced along an axis from the PSIS to the greater trochanter of the femur. The inferior gluteal artery emerges caudally to the piriformis muscle coursing along the deep aspect of the gluteus maximus toward the posterior thigh. The superior and inferior gluteal veins follow the respective gluteal arteries into the pelvis, where they join the pelvic venous plexus.

In addition to preoperative markings of the aesthetic focal points and the areas to be addressed with lipectomy, the surgeon must identify external landmarks that delineate a safety triangle on each buttock [17]. The apex of each triangle is the PSIS, with the lateral point located at the greater trochanter, and the medial point at the ischial tuberosity. It is within this triangle that the gluteal vessels and the sciatic nerve course, where one must be more cautious when injecting fat. In males, augmenting beyond these aesthetic focal points, or blunting them, will result in an augmented, but less muscular, endomorphic appearance.

29.3 Preoperative Considerations and Patient Positioning

Preoperative photography is critical for surgical planning, educating the patient on expected results, and for postoperative comparison. Photographs should encompass 360-degree views, with arms up and arms down, and should be taken with the patient in flexed and repose positions in order to highlight the gluteal musculature and aesthetic focal points. The same approach is taken when placing preoperative markings, with the surgeon sitting in order to have an eye-level appreciation of the markings. The following anatomical landmarks are marked: midline along the lumbar spinous processes, the sacral triangle, PSIS, iliac crests, infragluteal creases, and lateral trochanters (Fig. 29.3). The planned incision is marked at the natural gluteal crease and ranges 5–7 cm depending on the implant size, which is typically inserted in a folded fashion. The same incision is used to create the left and right implant pockets. Alternating between a flexed and in repose posture, the gluteal muscle groups and the proposed implant pocket dimensions are marked. Correcting for any asymmetry can be done by adjusting the markings of the implant pocket size and location. Markings are then completed by delineating the areas for donor liposuction, BodyBanking™, lipocell transfer, and MuscleShadowing™.

General endotracheal anesthesia is preferred as paralysis allows for adequate retraction of the gluteus musculature, optimizing dissection of the intramuscular implant pocket. Cefazolin or clindamycin is administered intravenously prior to induction as prophylaxis. In the operating room, the patient undergoes a standing chlorhexidine prep of lower back, flanks, hips, buttocks, and circumferential thighs. Sterile stockinettes over venodynes are placed for venous thromboembolism prophylaxis. The patient then lies down on sterile drapes with a crossing sterile Mayo stand cover as a "draw sheet." Induction and intubation by the anesthesiologist are then undertaken, and once effective ventilation is confirmed and the airway is secured, the patient is rotated onto a prone position using the sterile draw sheet. Safety while mobilizing the patient into the prone position is approached as a "team effort" by verbalizing the specific role of each team member, which is again repeated at the completion of the procedure when rotating to the supine position. Areas of potential pressure are padded and checked every time the patient is repositioned.

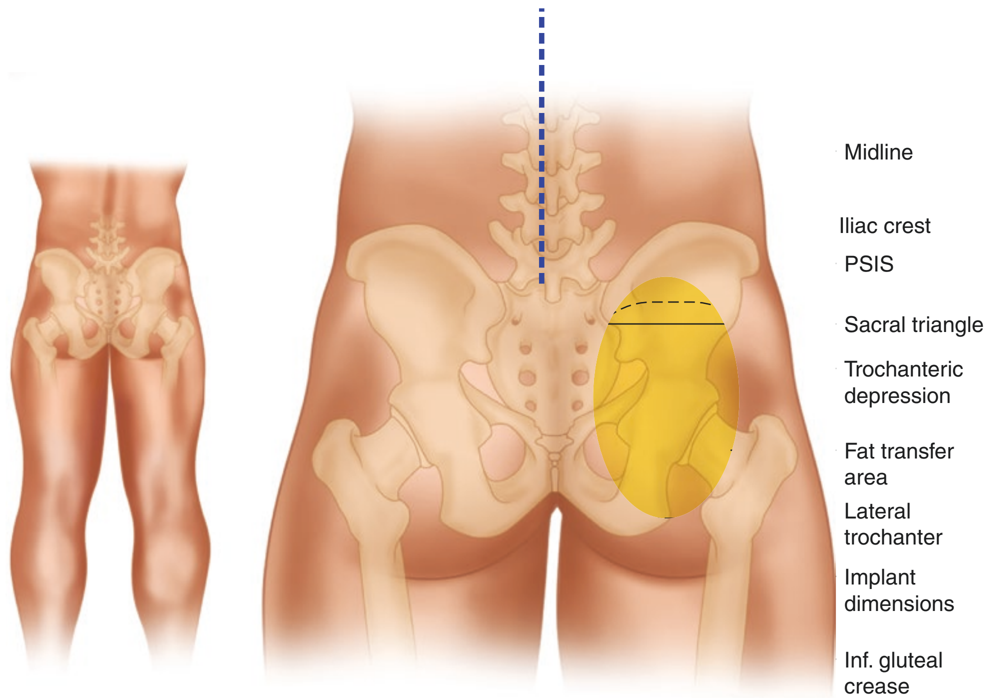


Fig. 29.3 Preoperative markings with the patient standing. The following landmarks are delineated: midline along the lumbar spinous processes, the sacral triangle, posterior superior iliac spine (PSIS), iliac crests, infragluteal creases, and lateral trochanters. The planned incision for placement of the gluteal implant is marked at the natural gluteal crease (appx. 5 cm), shown in red. Alternating between a flexed and in repose posture, the gluteal muscle groups and the proposed implant pocket dimensions are marked. The area to which fat will be transferred (Lipo-cell transfer) is shaded in yellow

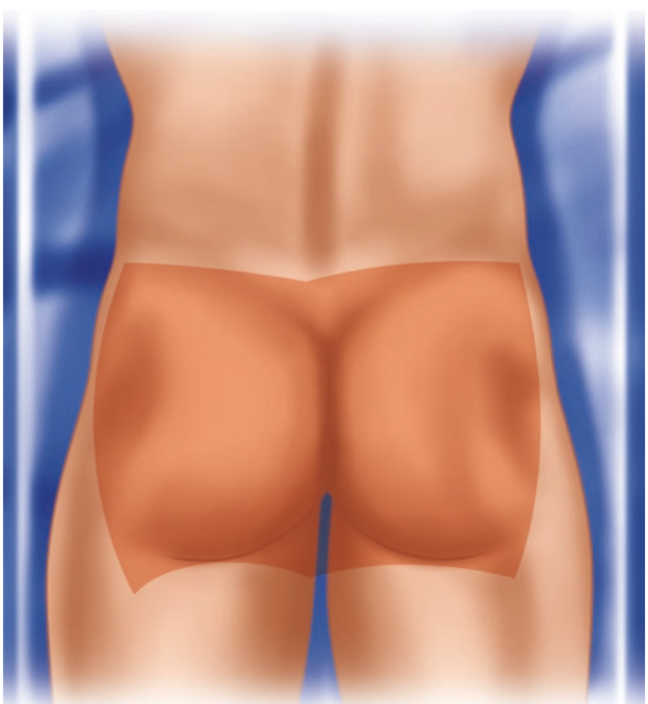


Fig. 29.4 Intraoperative draping and positioning

29.4 Surgical Technique

Once the patient is safely positioned on the operating table, integrity of the sterile prep is assessed and reapplied if needed prior to applying the surgical drapes. It is important that included within the surgical field, are the lower back, lateral hip areas, and posterior thighs, as these serve as aesthetic reference points against which augmentation, liposcultping, and symmetry are gauged against. A betadine-soaked perianal gauze is placed and secured with 4-0 nylon suture and then covered by an Ioban™ (3 M™) drape to isolate this area from the rest of the surgical field (Fig. 29.4). The planned incisions are injected with lidocaine 2% with epinephrine 1:100,000. We proceed with infiltration of tumescent solution (e.g., 0.9% saline, lidocaine 0.1%, and epinephrine 1:1,000,000) using a blunt tip cannula to areas of donor liposuction, as well as approximately 100 mL into the superficial aspect of the gluteus maximus muscle. A dwelling time of 10 min is allowed. The upper gluteal central incision is used as a cannula access site for power-assisted liposuction (PAL) (MicroAire™, Charlottesville, VA). Pretunneling of all areas of donor liposuction is done using a powered 4 mL basket cannula OFF suction. Suction may be ON if the patient had no previous liposuction preformed. Suction should be OFF if scarring is present from previous liposuction procedures. Suction lipectomy is carried out through the lateral hips and thighs in order to achieve the aesthetic subtle concavities of MuscleShadowing™. For greater areas of adiposity, a larger powered 8 mL suction basket cannula can be used (Alpha Aesthetics AART, Inc., Carson City, NV). The lipoaspirate is then collected and ran through a metal strainer to be then aliquoted into 20 mL syringes for BodyBanking Lipocell Transfer™ after implant placement.

The gluteal crease incision is accessed sharply, and with meticulous hemostasis dissection, is tunneled in a subcutaneous plane toward the medial (flexor) or lateral (extensor) muscle groups, remaining superficial to the fascia of the gluteus maximus muscle (Fig. 29.5). This fascia of the gluteus maximus muscle is then incised at 2 cm from the central gluteal crease. This allows for a 2 cm cuff of muscle and fascia during closure of the implant pocket. Dry intramuscular dissection using the cautery is then continued to an intermediate depth within the gluteus maximus that leaves 1.5 cm of muscle coverage superficial to the pocket (Fig. 29.6). This thickness should be continuously checked by the surgeon using their thumb. Dissection is continued in a lateral, superior, and inferior direction to create the implant pocket. This is facilitated by use of counter tension with a malleable and placement of incrementally larger retractors by the assistant. Use of a headlight optimizes visualization of the intramuscular plane. Direct visualization of dissection in this intramuscular plane is critical in order to avoid approximation to the sciatic nerve which should always remain covered by muscle deep to the dissection plane. Meticulous hemostasis must be maintained as dissection is ongoing, being mindful of the expected location of the inferior gluteal artery perforators.

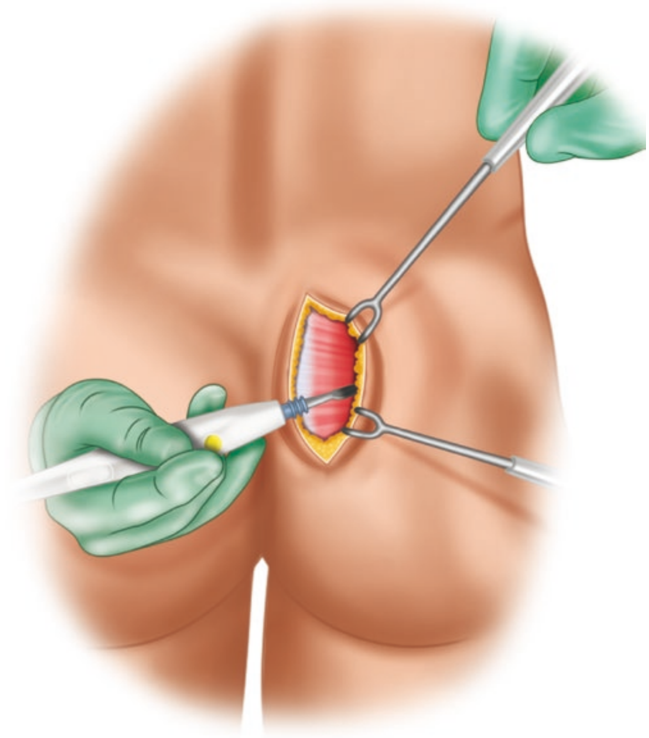


Fig. 29.5 Initial access through a subcutaneous plane staying superficial to the fascia of the gluteus maximus muscle

A more athletic contour after silicone implant (AART, Inc., Carson City, NV) placement is achieved by medial and lateral carving of the implant, allowing it to take the more vertical convexity characteristic of the male buttocks aesthetics. An antibiotic solution (e.g., cefazolin, bacitracin, gentamicin, and betadine) is used to rinse the implant and instill the pocket. For a "no-touch" introduction of the implant, an Ioban™ drape is placed over the incision, with an opening to fit a Keller Funnel™ (Dublin, Ireland) through which the implant is inserted into the intramuscular pocket (Fig. 29.7). Surgeon and assistants then change their gloves for any implant and/or pocket adjustment and closure. After bilateral implants are inserted, the buttocks are examined for shape, size, and symmetry (Fig. 29.8); if any modifications of the dissection pocket or implants are warranted, the surgeon's fingers are dipped into the antibiotic solution. A Jackson

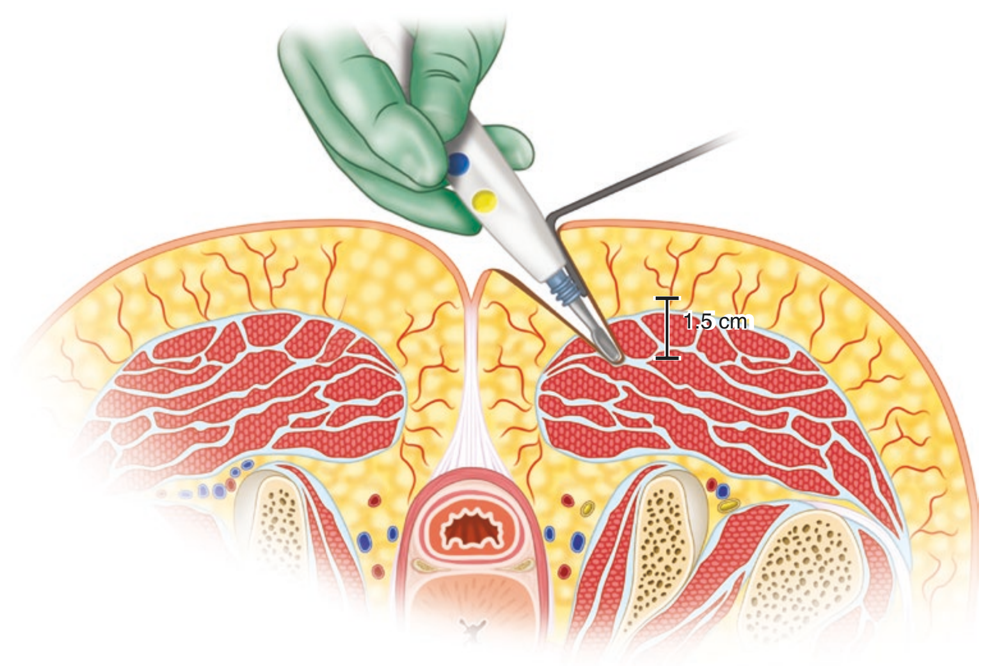


Fig. 29.6 Intramuscular dissection at an intermediate depth, leaving 1.5 cm of muscle coverage superficial to the implant pocket created

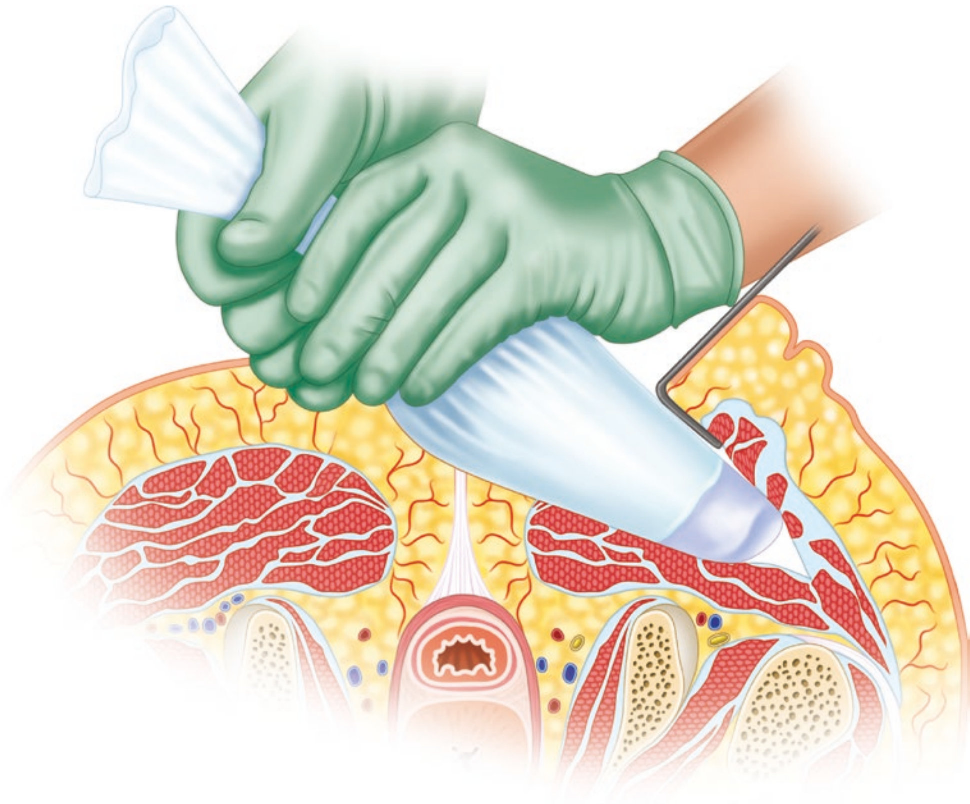


Fig. 29.7 No-touch technique for insertion of the gluteal implant into the intramuscular pocket

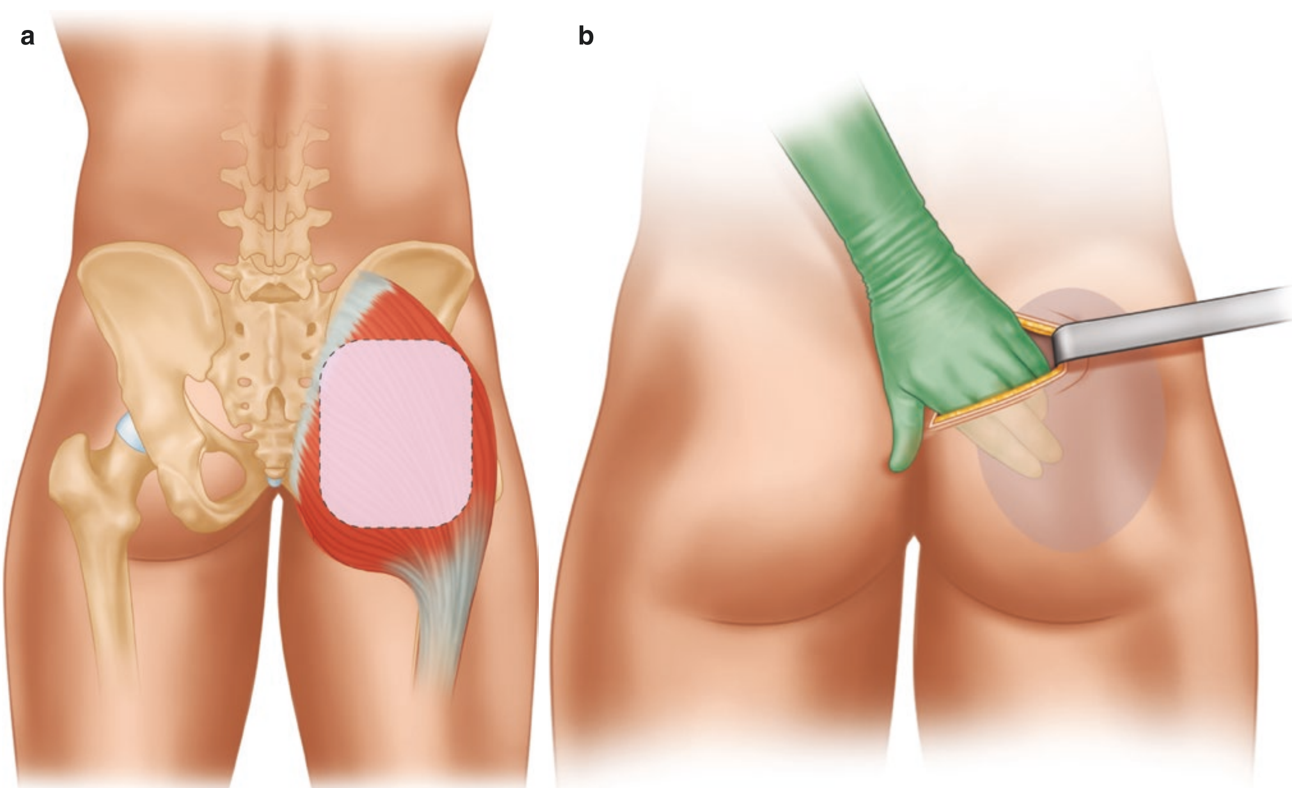
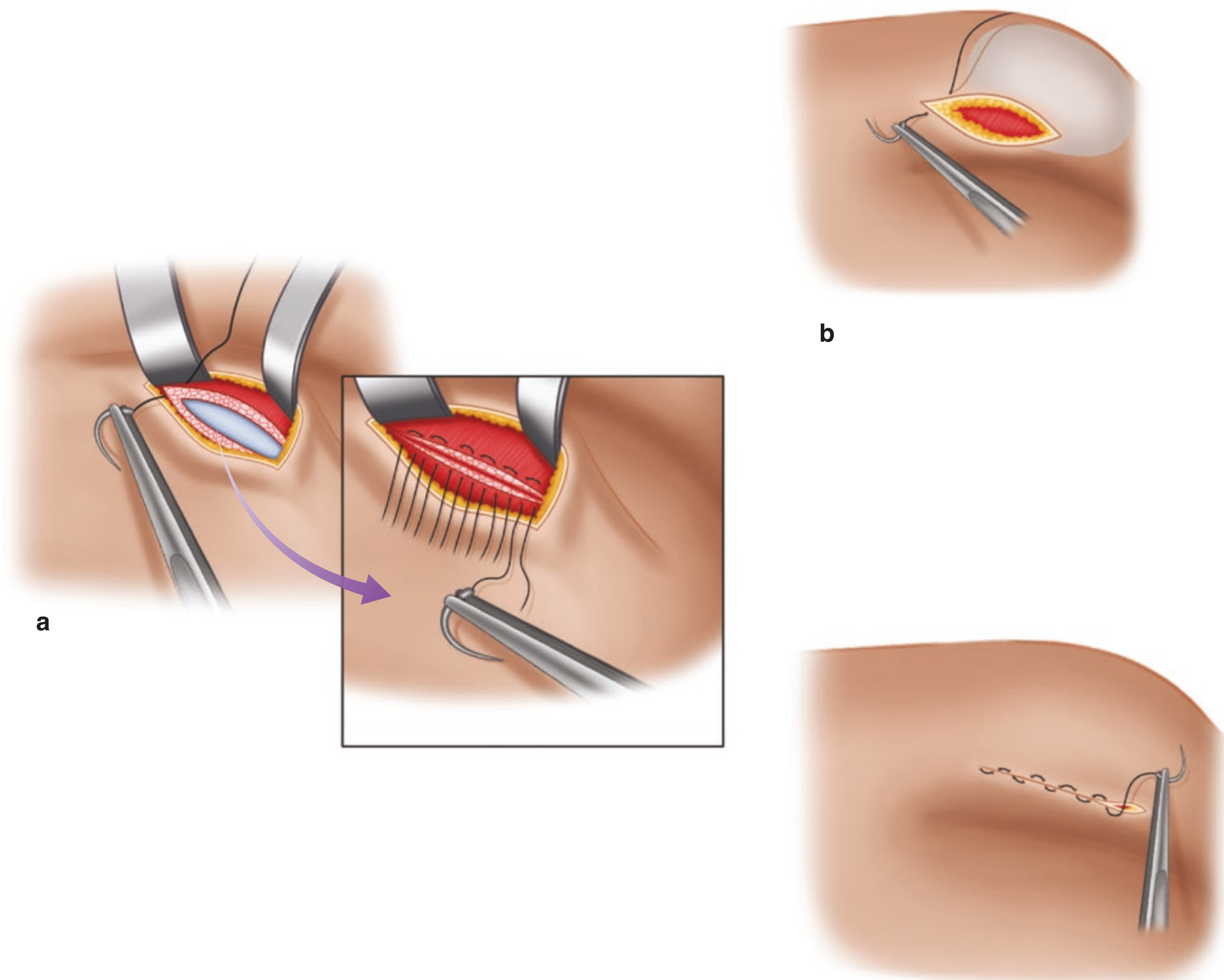


Fig. 29.8 Ideal location of the silicone implant within the intramuscular pocket (**a**) allowing the implant to be centered in the buttcoks (**b**)

Pratt drain may be placed in each implant pocket and brought out laterally in the infragluteal fold through a separate stab incision, if necessary. In our practice, we have not been using drains for gluteal augmentation. It must be underscored that the closure of the implant pocket should be tension-free. The muscle fascial edges should approximate with ease, and a "watertight" closure is performed with eight to ten simple interrupted 0 Vicryl™ (polyglactin 910) sutures [7]. The superficial fascia is then closed by placement of a running 2-0 Vicryl™ suture. The mid-dermis is approximated with a running 3-0 Vicryl™ suture, while a running 3-0 Monocryl™ (poliglycaprone 25) stitch with bipolar buried knots closes the incision at the subcuticular level (Fig. 29.9).

Lipocell transfer then follows using BodyBanking™ through nick incisions 2 cm cranial to the implant incision and 1 cm below the flank liposuction incision. The processed fat is grafted into the subcutaneous plane with 2 mm curved lipocell transfer cannulas implant (Alpha Aesthetics AART, Inc., Carson City, NV) by strategically placing it over the superior and inferior poles of each buttock, as well as medial placement for greater projection (Figs. 29.10 and 29.11). This narrows the buttock and allows for increased mid-gluteal projection while enhancing the lateral trochanteric depression. Achieving such contour gives the appearance of a tall, powerful, gluteal musculature with an upper pole transition zone at the lower back, maximal height at the mid-gluteal projection, and a lower pole transition zone with the biceps femoris at the posterior thigh. Unlike female buttocks liposculpting, fat grafting of the lateral buttocks is avoided in males, as this leads to a less muscular and more endomorphic appearance. When injecting lipocells, the surgeon is mindful of the safe zone triangle previously described, in order to avoid an intramuscular course of the cannula.



a b c

Fig. 29.9 "Watertight" closure of the muscle fascia (**a**), the superficial fascia (**b**), and dermis (**c**)

Fig. 29.10 Preoperative (**a**–**c**) and postoperative 21 months follow-up photography (**d**–**f**) of 29-year-old male, 5 foot 11 inch, 165 pounds, and ectomorphic model/runner who underwent intramuscular gluteal augmentation with a 276-cc custom-contoured silicone MuscleGel implant. BodyBanking fat was added cranially to define the upper gluteal pole resulting in a more elongated muscular appearance while avoiding a step-off appearance

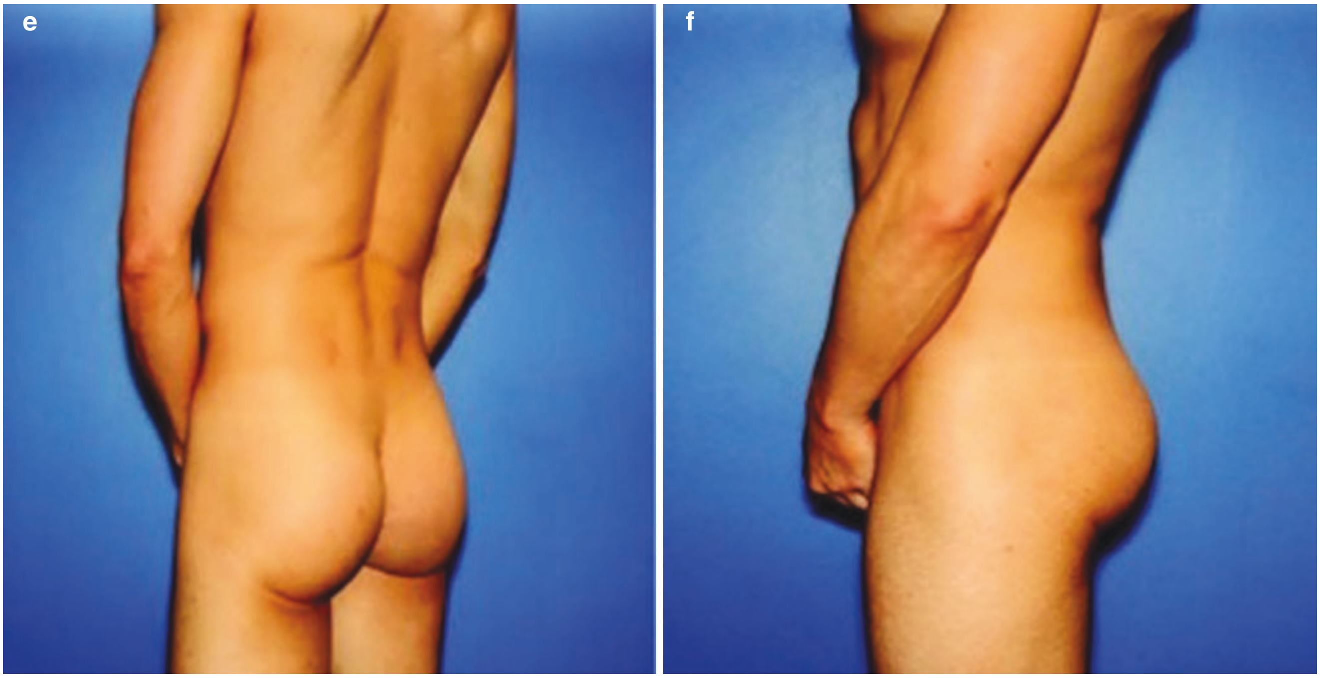


Fig. 29.10 (continued)

For dressings, one-inch Steri-strips ™ (3 M) with Mastisol adhesive are applied to the incision followed by gauze and paper tape. If lateral MuscleShadowing™ was performed, lateral gluteal concavity BodyBanking buttresses are placed. A snug but not tight postoperative garment is placed over the dressings and worn for 3 weeks.

29.5 Postoperative Care

Patients are discharged home the same day of surgery once postoperative anesthesia care unit discharge criteria are met. Prior to their departure, an educational session is held with the patient and their designated care person in which drain care, dressing care, positioning, and activity restrictions are reviewed in detail. It is imperative to avoid manipulation and activities that can displace the implants or hinder healing of the implant pockets (e.g., massages, sitting, and exercise using gluteus musculature). Activity instructions include no sitting for 2 weeks, squat facing the commode in the restroom for 2 weeks, gym exercise is allowed at 2 weeks without using the gluteus muscles, and mild exercises that use gluteus muscles can begin at 4 months postoperatively. Antibiotic prophylaxis is continued postoperatively while drains are in place. Patients are allowed to shower with drains, avoiding any immersion of drains or incisions in water. Penrose drains if placed in the flanks may be removed at 10 days. If bulb drains are used in the implant pockets, they are removed when output reaches less than 30 mL/drain/day (varies with patient body habitus). Compression garments are worn for 3 weeks.

A Skype™ or Facetime® follow-up is done on postoperative day 1 to confirm correct dressing and drain care as well as reinforcing positioning and activity instructions. The first in-person follow-up visit is between postoperative days 5–7. Subsequent visits occur every 1–2 weeks during the first 6 weeks and every several months thereafter.

29.6 Management of Complications

With refinement of technique, understanding of anatomy and adhering to surgical principles, complications of gluteal augmentation have decreased from a previously reported rate of 30% to 5% in more contemporary series [18]. Nevertheless, when complications arise, patients must be seen as frequently as needed in the office until resolution of the issue. Wound dehiscence is prevented by appropriate implant size selection, tension-free closure, and adhering to postoperative activity restrictions. If small areas of dehiscence that do not go beyond the superficial fascia occur, they can be managed with local wound care. If the extent of the dehiscence is significant or if it involves the superficial fascial closure, washout, and reapproximation of tissues are indicated, as long as the implant has not been exposed. When implant exposure occurs, salvage can be attempted with washout and implant exchange if exposure is minimal, coverage is feasible, and there is no evidence of implant pocket infection. Infection is

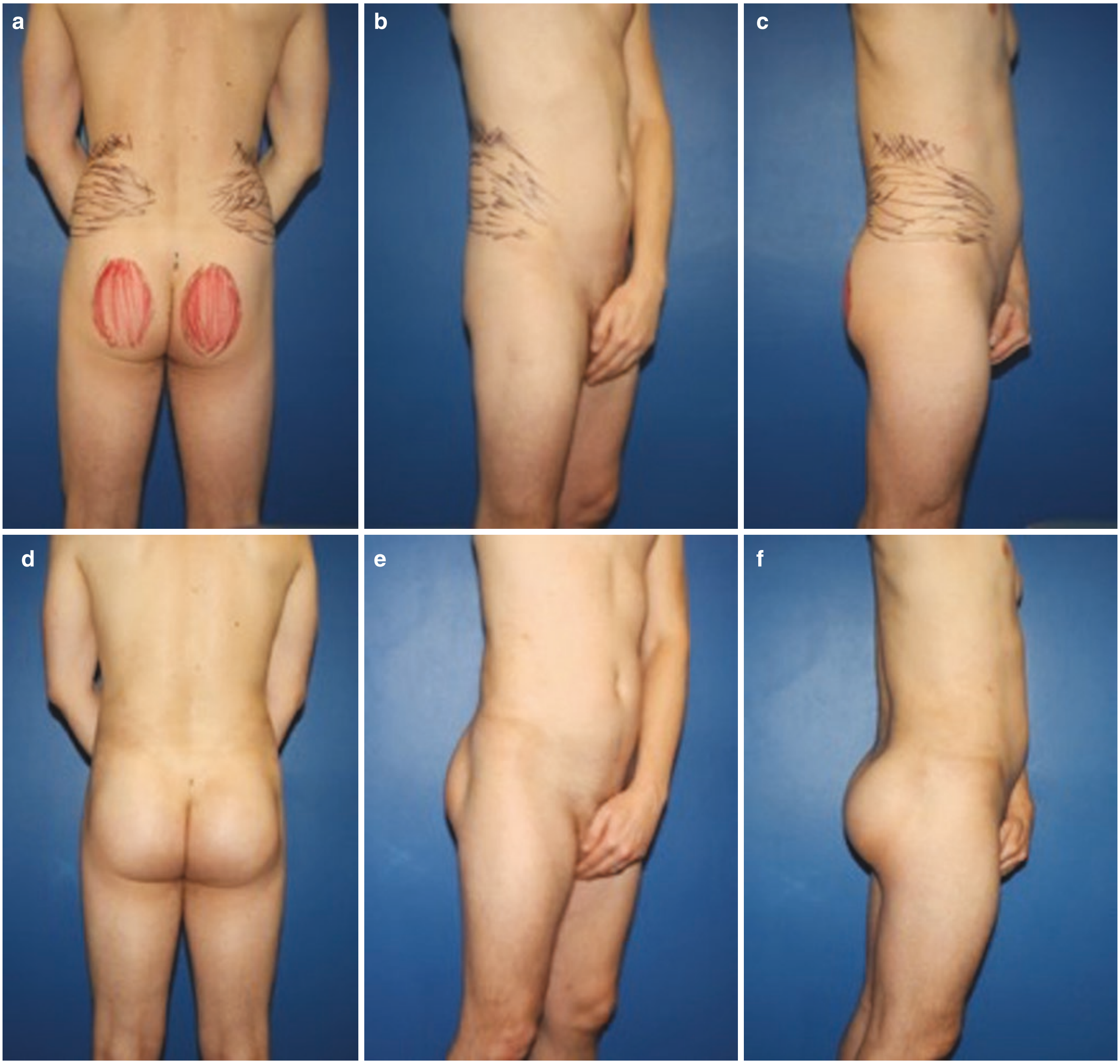


Fig. 29.11 Preoperative (**a**–**c**) and postoperative 2-year follow-up photography (**d**–**f**) of 32-year-old male, who underwent intramuscular gluteal implantation with a 200-cc custom-contoured silicone MuscleGel implant. The round implant was trimmed medially and laterally to allow a more athletic, lean appearance by elongating the buttocks, while enhancing the concavity of the lateral trochanteric depression

a rare but troublesome complication. Localized, superficial cellulitis may be treated with a trial of antibiotics; however, any concern for deeper infection or implant pocket involvement warrants return to the operating room and at minimum washout and possible implant removal. In cases of explantation, reinsertion is delayed until there is no evidence of infection and a full antibiotic course has been completed. With adequate drain management seromas are uncommon. However, if they are symptomatic and persistent, aspiration is warranted, and if it is believed that the seroma has significantly encapsulated, it must be surgically evacuated. Implant malposition can be significantly decreased with appropriate pocket dissection and choice of implant. Although not a complication, temporary loss of gluteal sensation is expected, and patients must be counseled preoperatively. Temporary sciatic neurapraxia has also been reported, but generally passes when short-term treatment is given with Gabapentin or Ibuprofen.

29.7 Bullet Steps

- Mark the patient standing in flexed and repose postures to better identify the gluteal musculature and aesthetic focal points.
- Mark the dimensions of the implant pocket on the patient and document its measurements.
- General endotracheal anesthesia is preferred as paralysis allows for adequate retraction of the gluteus musculature.
- The patient undergoes a standing chlorhexidine prep of lower back, buttocks, and circumferential thighs.
- The patient must be rotated onto a prone position safely with a team approach.
- The areas of donor liposuction are tumesced using a blunt tip cannula, as well as approximately 100 mL into the superficial aspect of the gluteus maximus muscle.
- Power-assisted liposuction (PAL) (MicroAire™, Charlottesville, VA) is performed with pretunneling of all areas using a powered 4 mL basket cannula OFF suction.
- Suction lipectomy is then performed over these pretunneled areas with the same powered cannula now with suction ON.
- Suction lipectomy is carried out through the lateral hips and thighs in order to achieve the aesthetic subtle concavities of MuscleShadowing™.
- The lipoaspirate is then collected and ran through a metal strainer to then be aliquoted into 20 mL syringes for BodyBanking™ after implant placement.
- The gluteal crease incision is accessed sharply and tunneled, staying superficial to the fascia of the gluteus maximus muscle.
- The fascia of the gluteus maximus muscle is then incised at 2 cm from the central gluteal crease.
- Intramuscular dissection using the cautery is then continued to an intermediate depth within the gluteus maximus that leaves 1.5 cm of muscle coverage superficial to the pocket.
- The thickness should be continuously checked by the surgeon using their thumb.
- Dissection is continued in a lateral, superior, and inferior direction to create the implant pocket.
- Direct visualization of dissection in this intramuscular plane is critical in order to avoid approximation to the sciatic nerve which should always remain covered by muscle deep to the dissection plane.
- A more athletic contour of MuscleGel™ (Alpha Aesthetics AART, Inc., Carson City, NV) implants is achieved by medial and lateral carving of the implant, allowing the implant to take the more vertical convexity characteristic of male buttocks aesthetics.
- Triple antibiotic solution (e.g., bacitracin, cefazolin, and gentamicin) is used to rinse the implant and instill the incision.
- A "no-touch" introduction of the implant into the intramuscular pocket is done using an Ioban™ drape and a Keller Funnel™ (Dublin, Ireland).
- A Jackson Pratt drain is then placed in each implant pocket and brought out laterally in the infragluteal fold through a separate stab incision.
- Closure of the implant pocket should be tension-free. The muscle fascial edges should approximate with ease and a "watertight" closure is performed using eight to ten simple interrupted 0 or 2-0 Vicryl™ (polyglactin 910) sutures.
- Separate closure of the superficial fascial (Vicryl), deep dermal (Vicryl), dermal (Vicryl), and subcuticular closures (Monocryl) are performed.
- Utilize 2 mm BodyBanking® lipocell transfer (Alpha Aesthetics) to the superior and inferior poles of the buttocks while utilizing MuscleShadowingTM to define the lateral trochanteric depression to achieve masculine aesthetics.
- When injecting lipocells, the surgeon is mindful of the safe zone triangle [19] in order to avoid an intramuscular course of the cannula.
- Activity instructions include no sitting for 2 weeks, squat facing the commode in the restroom for 2 weeks, gym exercise is allowed at 2 weeks without using gluteus muscles, and mild exercises that use gluteus muscles can begin at 4 months postoperatively.

29.8 Conclusion

Success in male gluteal augmentation is achieved by adhering to thorough preoperative planning, comprehension of anatomy, systematic operative technique, and understanding of the unique aesthetics of males reviewed in this chapter, in order to achieve effective, safe, and reproducible outcomes that keep patients happy and the surgeon busy.

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30 Gluteal Augmentation in Patients with Lipodystrophy Due to the Use of Antiretroviral Therapy

Eliane Hwang and Mario J. Warde Filho

30.1 Background

With the introduction of effective antiretroviral therapy (ARVT) for the treatment of human immunodeficiency virus (HIV) infection in 1996, there has been a surge of patients presenting redistribution of their body fat resulting in contour deformities such as central fat accumulation and peripheral fat loss [1–3]. The term "HIV-associated lipodystrophy syndrome" refers to multiple changes in fat distribution that are often associated with metabolic abnormalities, including dyslipidemia and insulin resistance. Lipoatrophy is mainly seen in the face, the extremities and the gluteal region. Fat accumulation is mainly seen in the abdomen, the breasts and the posterior aspect of the neck, also known as buffalo hump [4].

The major cause of lipoatrophy is the exposure to thymidine analogue nucleoside reverse transcriptase inhibitors (NRTIs). Trials comparing different antiretroviral therapies suggest that Stavudine and Zidovudine play an important role in the pathogenesis of lipoatrophy [5]. Lipoatrophy with thymidine analogue use may be due to NRTIs-induced inhibition of mitochondrial DNA polymerase gamma and mitochondrial toxicity. The biopsy of the areas presenting lipoatrophy is characterized by mitochondrial DNA depletion, inflammation and apoptosis [6, 7]. Both lipoatrophy and fat accumulation have been associated with abnormalities in glucose and lipid metabolism, even in the absence of obesity. Adipocytes secrete hormones, such as adiponectin, leptin and resistin, which are involved in metabolic pathways. Decreased adiponectin levels are associated with insulin resistance and type 2 diabetes, and in HIV-infected patients with peripheral lipoatrophy and central lipohypertrophy. The normal relationship between adiponectin levels and adiposity is lost in HIV-infected patients, possibly due to changes in adipocyte function associated with HIV lipodystrophy, whereas the inverse association of adiponectin and visceral adipose tissue is maintained [8].

Several clinical trials demonstrated an improvement in the areas of lipoatrophy when patients stopped taking Stavudine and Zidovudine and switched to other NRTI such as Tenofovir and Abacavir. In fact, Tenofovir and Abacavir are first-line NRTIs because of their efficacy and convenience, whereas Stavudine and Zidovudine have shown an inferior virologic potency and are associated with many other side effects aside from lipodystrophy. Thus, switching medications should be considered if possible in these patients [9, 10]. Even though some improvement can be seen, the changes are moderate and temporary. Patients should be advised not to expect dramatic changes in appearance [2].

Fortunately, there are many surgical approaches to help patients with these body contour deformities. Autologous fat transplantation and injections of biodegradable or nonbiodegradable fillers can be used. Silicone implants are widely used for gluteal atrophy alone or in combination with autologous fat grafting and/or polymethyl methacrylate (PMMA) injections.

30.2 Preoperative Evaluation

Surgical procedures to address lipodystrophy encountered in these conditions should be performed in patients who are in good health. A follow-up with an infectious disease specialist is necessary as the patient's viral load must be undetectable and the CD4 count must be over 250 cells/mm^3. These procedures are not recommended for patients who are co-infected with the hepatitis C virus, as the local side effects are significantly increased [11]. The lipoatrophy encountered in these patients is distributed over the entire gluteal region, including the perineal region and the infragluteal fold. The bones are prominent in this region with severe wasting, skin laxity and widening of the intergluteal cleft. The signs are

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worse in women compared to men, because fat loss is mostly encountered in the hips, buttocks and lower extremities, areas that characterize the female body type (gynoid). With this distribution of lipoatrophy, the woman's body resembles that of a man.

We classified the gluteal lipoatrophy seen in these patients in different grades in order to propose the adequate treatment (Table 30.1, Figs. 30.1, 30.2 and 30.3).

Table 30.1 Warde gluteal lipoatrophy classification—proposed surgical management

Grade I	A	Loss of gluteal volume/projection; available fat in other parts of the body	Liposuction + Fat graft
	B	Loss of gluteal volume/projection; no available fat in other parts of the body	Silicone implant
Grade II	A	Grade I + hip narrowing; available fat in other parts of the body	Liposuction + Fat graft
	B	Grade I + hip narrowing; no available fat in other parts of the body	Silicone implant/ PMMA 30%
Grade III	A	Grade II + widening of intergluteal fold + ischiatic dermatitis/ulcers; available fat in other parts of the body	Liposuction + Fat graft
	B	Grade II + widening of intergluteal fold + ischiatic dermatitis/ulcers; no available fat in other parts of the body	PMMA 30%

30.3 Surgical Procedures

30.3.1 Liposuction and Fat Grafting

Autologous fat grafting is the most common procedure proposed for HIV lipodystrophy. The areas of fat accumulation can be addressed with liposuction and the areas of lipoatrophy with autologous fat grafting during the same procedure. Fat is an appealing filler material because of its biocompatibility and its abundance. It can be harvested easily, processed and injected in desirable amounts. As much as 40–60% of the volume of fat injected can be lost due to reabsorption or fat necrosis [12]. Unfortunately, many patients who present with areas of lipoatrophy don't have enough fat available in other parts of their body to fill those areas. Liposuction and fat grafting performed in HIV lipodystrophy are not different from that performed in aesthetic or other reconstructive cases. Fat can be harvested from the abdomen, thighs, flanks, lower back, knees, or any area where there is undesirable accumulation of fat. In our practice, we infiltrate the donor sites with a tumescent solution composed of normal saline and epinephrine at 1:300.000. Suction-assisted liposuction, power-assisted liposuction or syringes attached to blunt tip cannulas of 4.0, 3.5 and 3.0 mm diameter are used for fat harvesting. The lipoaspirate is then washed one to three times with normal saline and left to decant under gravity. The processed fat is injected

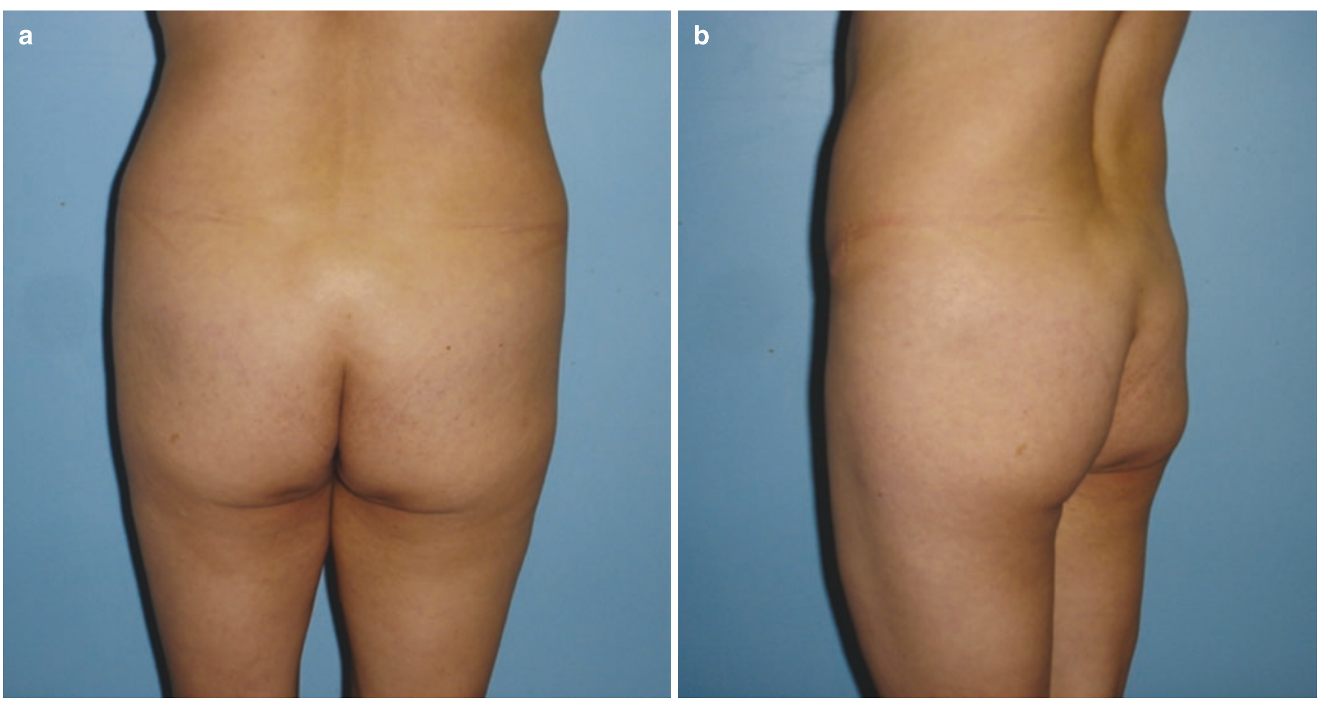

Fig. 30.1 Gluteal lipoatrophy grade I. (**a**) Patient presenting loss of gluteal volume and projection. There is available fat at the flanks. The indicated treatment for this grade IA lipoatrophy is liposuction of the flanks and gluteal fat grafting. (**b**) The loss of projection and available fat at the flanks is best seen in an oblique position

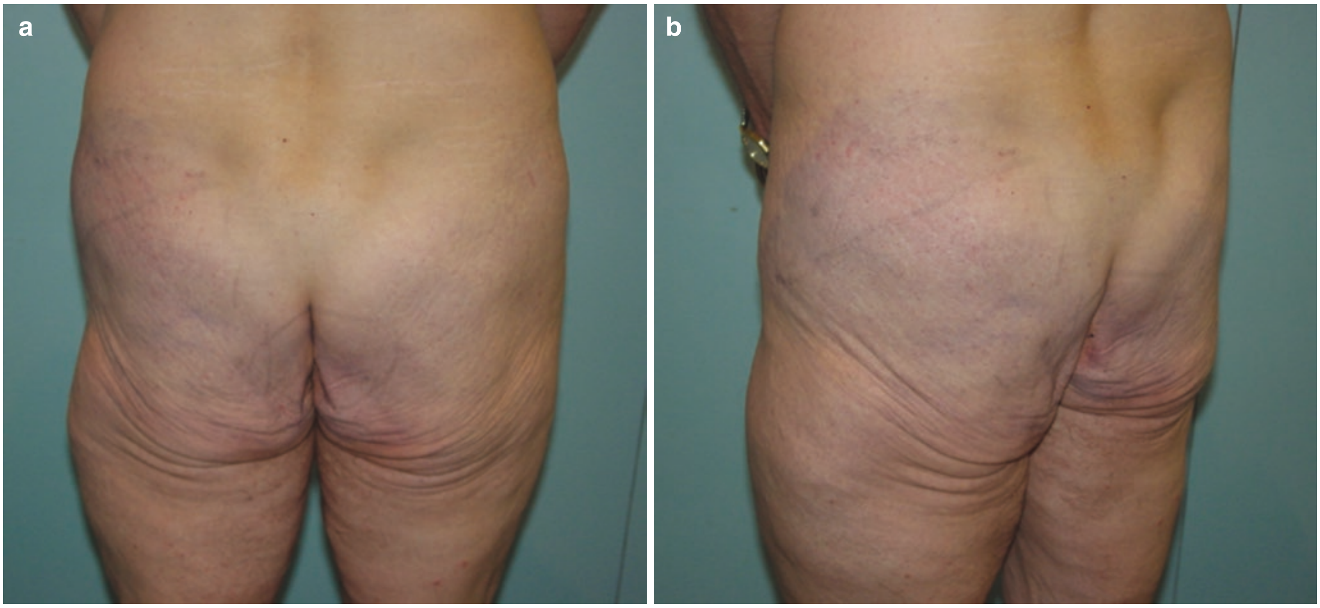

Fig. 30.2 Gluteal lipoatrophy grade II. (**a**) Patient presenting loss of gluteal volume and projection, hip narrowing and no available fat in other parts of the body. The indicated treatment for this grade IIB lipoatrophy is silicone implant or injections of PMMA 30%. (**b**) The oblique position shows the complete loss or gluteal volume and projection. There is a depression of the hips and slight laxity of the gluteal skin

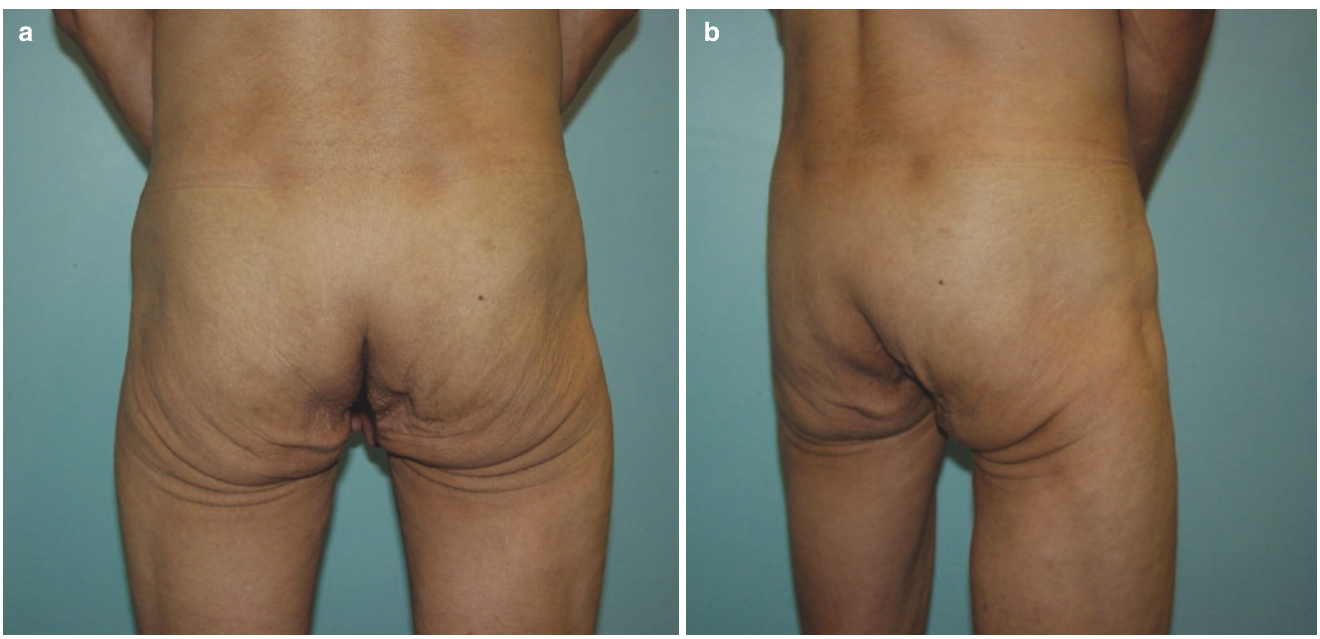

Fig. 30.3 Gluteal lipoatrophy grade III. (**a**) Patient presenting loss of gluteal volume and projection, hip narrowing, widening of intergluteal fold and ischiatic dermatitis. Also there is no available fat in other parts of the body. The indicated treatment for this grade IIIB lipoatrophy is injections of PMMA 30%. (**b**) The widening of the intergluteal fold and the evident laxity of the gluteal skin makes the injections of PMMA 30% a better option than the silicone implant because of a more anatomic appearance. Even the silicon goes underneath the muscle, it is not enough for covering

in the gluteal region in a subcutaneous plane with 3.0 mm diameter blunt tip cannulas attached to 20 ml syringes. The average volume of fat injected depends on the total volume of fat harvested and the clinical presentation of the patient. We inject 180–400 cc of fat per buttock in general via an intergluteal cleft incision. The incision sites are closed with 5-0 nylon sutures. A garment is worn for at least 30 days postop (Fig. 30.4).

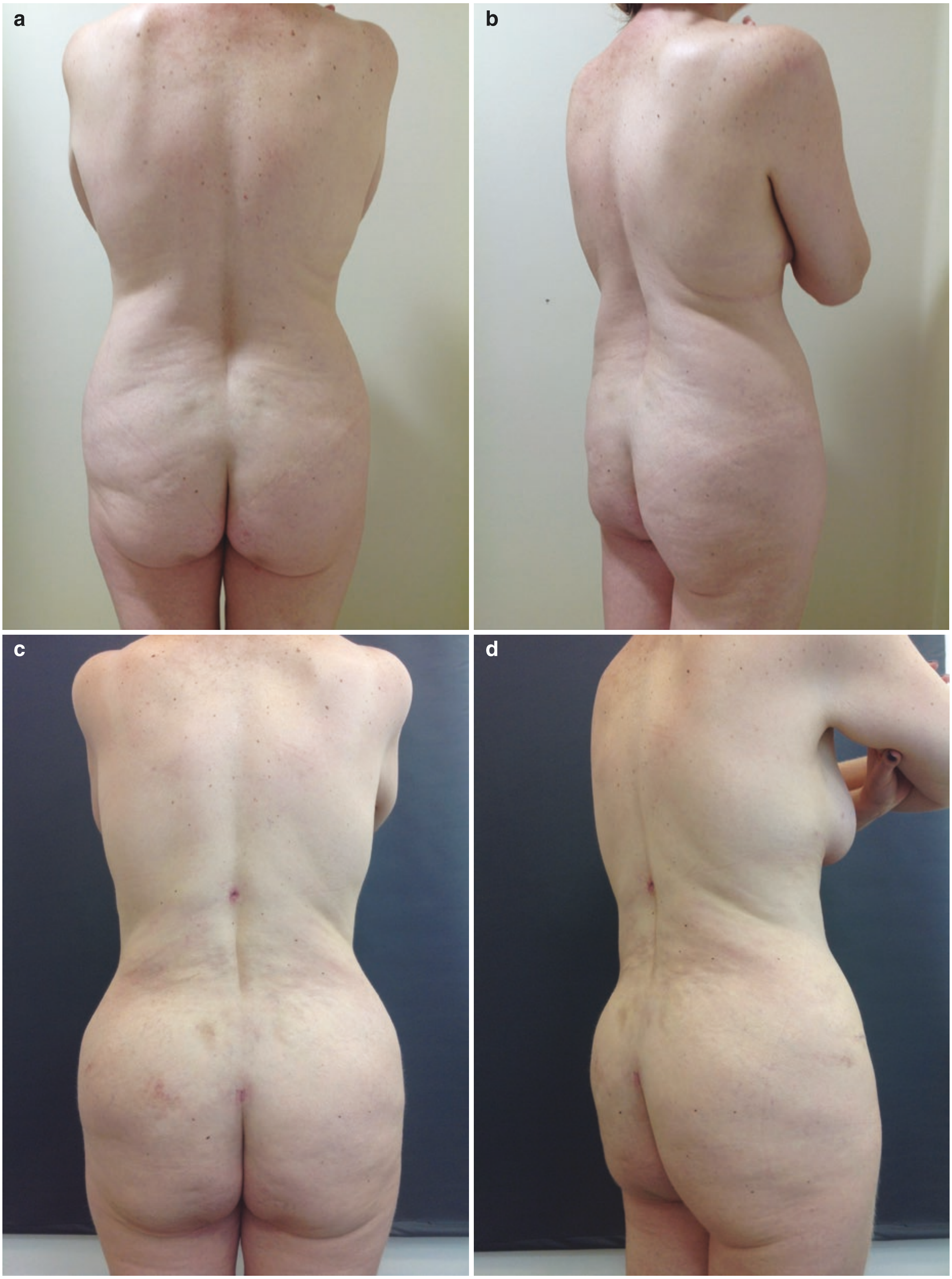

Fig. 30.4 Preoperative and 3-month postoperative pictures of a 40-year-old woman, BMI: 23.1, presenting Warde's grade IA gluteal lipoatrophy who had liposuction and fat grafting. Lipoaspirate 1900 mL, Volume of fat injected per buttock 350 mL. (**a**) Preoperative (front) picture showing loss of gluteal volume and projection and available fat at the flanks. Grade IA. (**b**) Preoperative (oblique) picture showing loss of volume and available fat at the flanks. Grade IA. (**c**) Postoperative (front) picture showing narrowing of the waist after liposuction of the flanks. (**d**) Postoperative (oblique) picture showing gain of gluteal projection after fat grafting

30.3.2 Injection of Polymethyl methacrylate

Polymethyl methacrylate (PMMA) injections are widely performed in Brazil since the beginning of 2000. In December 2004, a ministerial law authorized injections of PMMA (permanent filler) for the treatment of facial lipoathrophy associated with the use of antiretroviral therapy in HIV patients in the Public Health System. Improvement in quality of life, self-esteem and depression symptoms are reported after facial reconstruction with PMMA in HIV-infected patients presenting with facial lipoathrophy [11]. Such evidence is lacking with the use of PMMA for reconstruction of the gluteal region. When used in this region, it should be placed in the subcutaneous plane and never intramuscularly, as there is no evidence of its effects on increasing muscle mass and because of the risks of injury to neurovascular structures.

According to the classification described above (Table 30.1), PMMA injections are indicated in patients presenting with grade II B and grade III B gluteal atrophy, in order to augment the gluteal region and minimize resorption and volume loss that is often seen with fat grafting.

Below are some of our considerations for the use of PMMA:

- PMMA injections should be performed in adequate outpatient care facilities.
- Asepsis and sterile equipment must be used during injection.
- PMMA 30% must be exclusively injected subcutaneously, in order to avoid cutaneous complications and injury to neurovascular structures.
- Injection of PMMA is limited to 30 mL during the first session.
- Sessions can be repeated at the physician's discretion and according the patients' needs at 3–4 weeks intervals, in order to avoid severe pain and local edema.

Areas to be treated with PMMA are marked with the patient standing. Infiltration of the areas is done with a solution of 20 mL of lidocaine 2%, 100 mL normal saline and 1 mL epinephrine. Depending on the combination of ARVT that the patient is taking, non-steroidal anti-inflammatory medications are prescribed for 3 days in the postoperative period. Antibiotic prophylaxis is not necessary once the principles of asepsis are respected. Patients may shower the day after the injections. They are required to avoid sitting immediately postop and avoid resistance exercises for 3–4 days. Infection and granuloma can occur in the short- or long-term postoperative period [13] (Fig. 30.5).

30.3.3 Silicone Implants

The preferred treatment for gluteal lipoatrophy grades I B and II B is placement of gluteal silicone implants (Table 30.1). We use the XYZ technique described by Gonzalez et al. [14, 15]. The implants are placed in an intramuscular plane, guided by anatomical bony landmarks in order to provide safe dissection and prevent visible or palpable implants. The most cephalic point (A) of the intergluteal cleft is marked with the patient in an upright position. The point X on each side represent the medial limit of the gluteus maximus muscle in proximity to the incision. The G line represents the lateral limit of the gluteal maximus muscle from the posterior superior iliac spine (point Y) to the greater trochanter (point Z). The dissection should not extend beyond the limits of the G line in order to prevent the implants from being palpable and perceptible (Fig. 30.6).

After receiving general anesthesia, the patient is positioned prone and injection of a solution of local anesthesia containing lidocaine (20 mL) and bupivacaine (20 mL) with epinephrine at 1:150.000 is done in the marked (inverted red heart) region. From point A, a 6.0 cm fusiform incision is performed on each side medially, preserving the sacrocutaneous ligament in the middle (Fig. 30.7). Dissection proceeds subcutaneously from point X until the fascia is exposed following the marked (inverted red heart) area. A 6.0 cm incision in the gluteus maximus muscle is performed following the direction of its fibers at a depth of 3 cm. Undermining continues intramuscularly, up to the lateral aspect of the gluteus maximus muscle identified by points Y and Z, which corresponds to the lateral limits where the implant should be placed (Fig. 30.8). The muscle and fascia are approximated with 2-0 vicryl sutures and adhesion stiches with 3-0 vicryl are placed in the area undermined subcutaneously. The incision is closed in two layers, with Monocryl 3-0 sutures anchoring the de-epithelialized fusiform skin and simple 4-0 nylon sutures on the skin. Micropore® tape is used along the incisions. No drains are placed [16, 17].

The implants used for patients presenting with HIV gluteal lipoatrophy are smaller than the ones used for aesthetic

Fig. 30.5 Preoperative and 6-month postoperative pictures of a 48-year-old male transgender, BMI: 22, presenting Warde's grade III B gluteal lipoatrophy who had injections of PMMA. A total of 650 mL of PMMA was injected over 11 sessions with an average of 60 mL per session

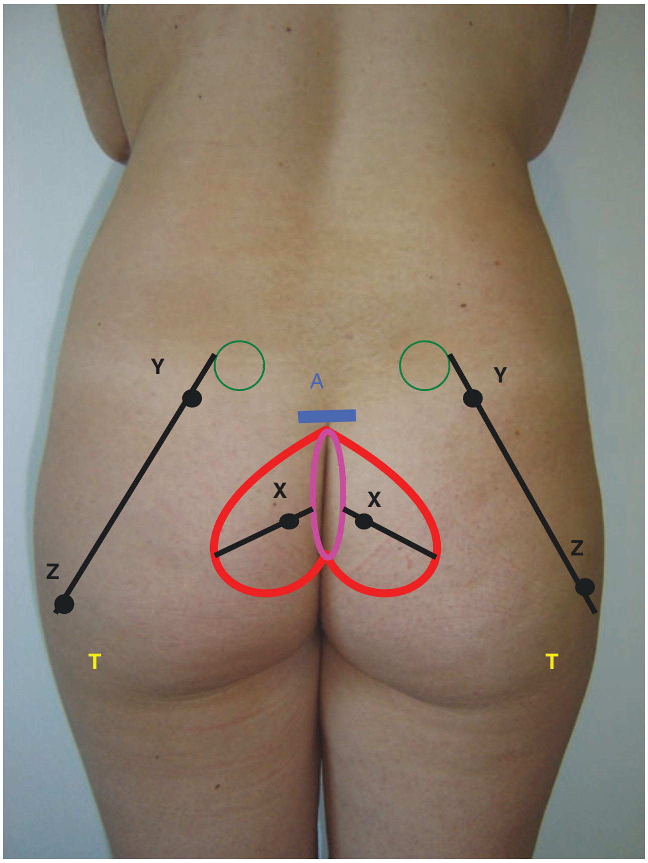

Fig. 30.6 Preoperative markings for placement of gluteal silicone implants with the patient in upright position. G line (in black, linking points Y and Z) corresponds to the lateral limit of the gluteus maximus muscle. T represents the greater trochanter. A represents the most cephalic point of the intergluteal cleft. Point X represents the medial limit of the gluteus maximus muscle. Point A (blue)– The most cephalic point of the intergluteal cleft marked in an upright position; Shape in pink – Fusiform incision to preserve the sacrocutaneous ligament that will remain fixed on the sacro bone; Shape in red – Inverted red heart – Area to be dissected subcutaneously to expose the gluteal maximus fascia; Point X – Point where the intramuscular dissection begins and goes to point Y and Z. Represent the medial limit of the gluteus maximus; Point Y – Superior limit of the gluteus maximus; Point Z – Inferior limit of the gluteus maximus; Point T (yellow) – Trocanter; Postsuperior iliac spine (green)

Fig. 30.7 Fusiform medial skin incision on each side of the gluteal region preserving the sacrocutaneous ligament

Fig. 30.8 Intramuscular undermining up to the lateral limits of the gluteus maximus muscle represented by the G line linking points Y and Z

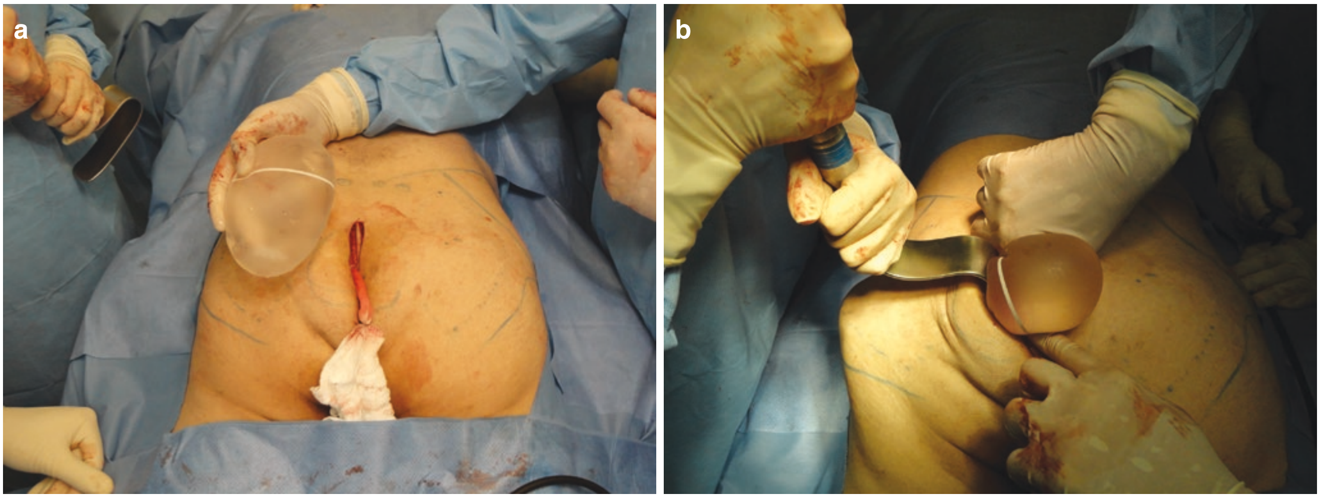

Fig. 30.9 Placement of gluteal silicone gel implant intramuscularly (larger side facing upwards). (**a**) The picture shows the position that the silicon implant should be inside of the gluteus maximus muscle. The larger side of an oval implant is positioned in the superior part, next to the post superior iliac spine. (**b**) The introduction of the implant begins with the smaller part and once it is inside of the muscle, it is positioned with the larger side facing upwards

purposes due to the significant loss of the fat pad that should cover the implant. Large implants can appear unnatural and unaesthetic if they are placed beyond the lateral limits of the gluteus maximus muscle. We use oval-shaped gluteal silicone gel implants (Fig. 30.9). Smaller size implants up to 300 cm^3 are preferred as larger implants tend to extrude and may create a double bubble effect especially because of the lack of thickness of subcutaneous fat. Prophylactic antibiotics are given for 5 days in the postoperative period. Patients are required to wear compressive garments and avoid lying on their back for 15 days (Figs. 30.10 and 30.11). Wound dehiscence with healing by secondary intention represents the most common complication (Fig. 30.12).

Fig. 30.10 Pre- and 6-month postoperative pictures of a 39-year-old woman, BMI: 20.6, presenting with Warde's grade I B gluteal lipoatrophy who had placement of oval-shaped silicone gel implants, 230 cm^3 on each side

30.4 Conclusion

There are several potential benefits for treating patients who present with HIV-associated lipodystrophy of the gluteal region which are beyond aesthetic. Severe changes in body contour can be associated with psychological distress that affects self-esteem and even adherence to ARVT regimen. The improvement in quality of life, self-esteem and a significant reduction in depression symptoms after surgical procedures are well known [11, 16]. Additionally, certain therapeutic interventions for HIV-associated lipodystrophy have the potential to favorably affect associated metabolic disorders, such as dyslipidemia and abnormal glucose metabolism [17, 18]. Therefore, these plastic surgery procedures are highly indicated in these patients.

Fig. 30.11 Pre- and 6-month postoperative pictures of a 46-year-old woman, BMI: 23.6, presenting with Warde's grade I B gluteal lipoatrophy who had placement of oval-shaped silicone gel implants, 260 cm^3 on each side

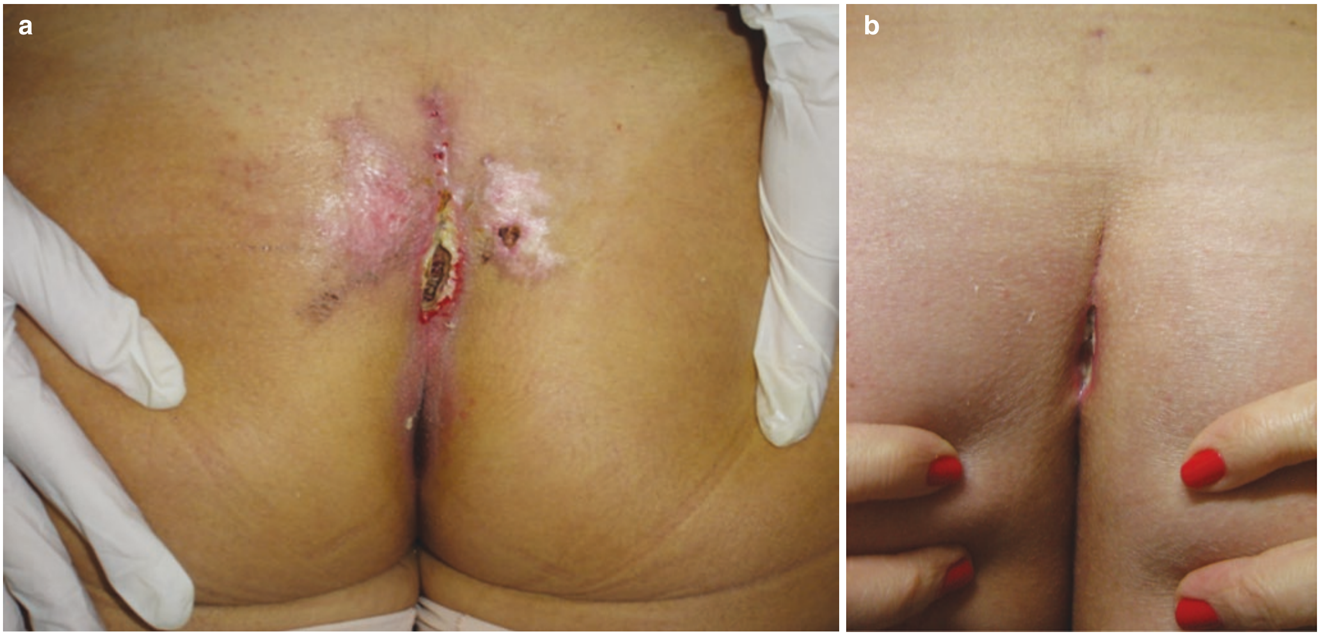

Fig. 30.12 Wound dehiscence with no exposure of the gluteal implants at 15 days postop. The wounds healed by secondary intention. (**a**) Wound dehiscence and skin scarification caused by the use of adhesive dressings with 15 days postop. (**b**) Wound dehiscence in healing process after 3 weeks. No adhesive dressings were used because of the earlier scarification process. Patient used only topic povidine. The wound healed after 30 days postop

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Gluteal Augmentation in Post-Massive Weight Loss Patients

31

Flavio Henrique Mendes and Fausto Viterbo

31.1 Background

Massive weight loss (MWL) procedures have become a fast-growing field of plastic surgery, demanding important modifications and refinements in order to handle the dramatic body contour deformities encountered especially in postbariatric patients. These patients present a diverse and generalized pattern of body morphologic changes due to severe disarrangement of the skin/superficial fascial system (SFS) complex, during obesity and following MWL. In this chapter, we specifically discuss general aspects of buttocks evaluation and surgical approach during MWL body contouring.

31.2 Anatomical Topography and Gluteal Aesthetics

In MWL patients, we should always try to achieve the same aesthetic standards as for regular patients. However, achieving great results is challenging because of the tissue damage caused by obesity and the weight loss process. These patients show elongated superficial fascial system's collagenous sheets and septa due to the mechanical stress resulting in generalized excess skin laxity in a circumferential pattern, including the gluteal region [1].

Mendieta's classification for gluteal evaluation may also be used in massive weight loss patients. The gluteal region contains two separate removable structures: the frame (the bony framework, the subcutaneous fat, and the skin) and the gluteal musculature. Evaluating the relationship between the musculature and the frame is essential for diagnosis and treatment of buttock disorders [2].

Frame Types With the patient standing, the most protruding points of the gluteal region are identified as follows: point A: upper lateral; point B: inferior lateral thigh; point C: lateral mid-buttock. The connection of these three points on each side of the body helps identify the four basic frame types of the buttocks: A-shaped, V-shaped, round, and square, which are similar in MWL patients (Fig. 31.1). Nevertheless, the excess skin laxity present in these patients influences the overall silhouette. Therefore, the frame reshaping should be addressed (buttocks lifting) before considering gluteal augmentation options.

Gluteal Aesthetic Units The gluteal aesthetic units and their relation to the frame are used to orient and determine which areas may benefit from liposuction, fat transfer, or lift [3]. They were designed to distinguish frame zones of regular patients and are difficult to apply to massive weight loss patients. Figure 31.2 shows the demarcation of the gluteal aesthetic units with and without the sagging effect of gravity over the frame structures, demonstrating a conflictive variation. It is important to evaluate the need for circumferential lipectomy to improve the gluteal shape, before indicating any augmentation technique. Careful analysis of the gluteal anatomy and surgical planning should be done with the patient to determine its aesthetic preferences.

Skin/SFS Laxity The degree of skin laxity should also be assessed by dynamic physical examination. Elongated collagen fibers of the superficial fascial system (SFS) are inefficient to maintain the skin and subcutaneous fat in close contact to the deep muscular fascia. If there is significant skin laxity, circumferential dermolipectomy might be indicated for gluteal lift; however, fat grafting, autologous flaps, or alloplastic gluteal implants may be required to correct the overall deformity. The zones of adherence in contrast to the gravitational effect upon the deflated tissues usually affect the frame shape creating depressions at the lateral mid-buttock region, which may be corrected with buttock lift [1].

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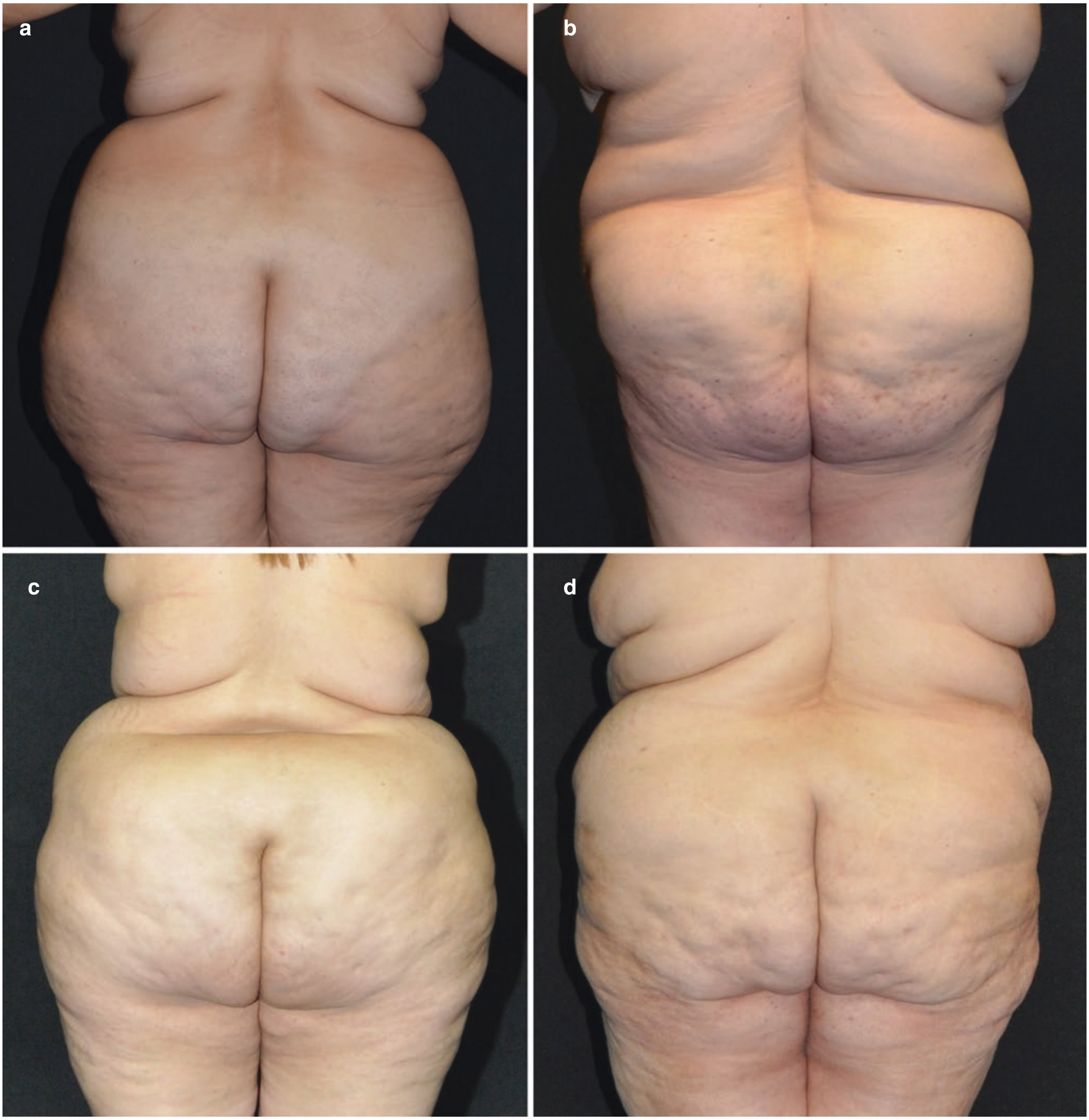

Fig. 31.1 Frame types in obese patients: (**a**) A shape, (**b**) V shape, (**c**) round, and (**d**) square

Gluteal Musculature The transition points between the gluteus muscles and the bony framework should be smooth. There are four cardinal attachment points: the upper inner gluteal or sacral junction, the infragluteal fold–thigh junction, the lower lateral gluteal–thigh junction, and the mid-lateral gluteal–hip junction.

31.2.1 Upper Gluteal Cleavage

The junction between the intergluteal and sacral space needs to be well defined to create a V-shaped depression. If there is excess fat in the V-zone, liposuction is indicated. If there is a lack of volume in the upper–inner muscle, augmentation

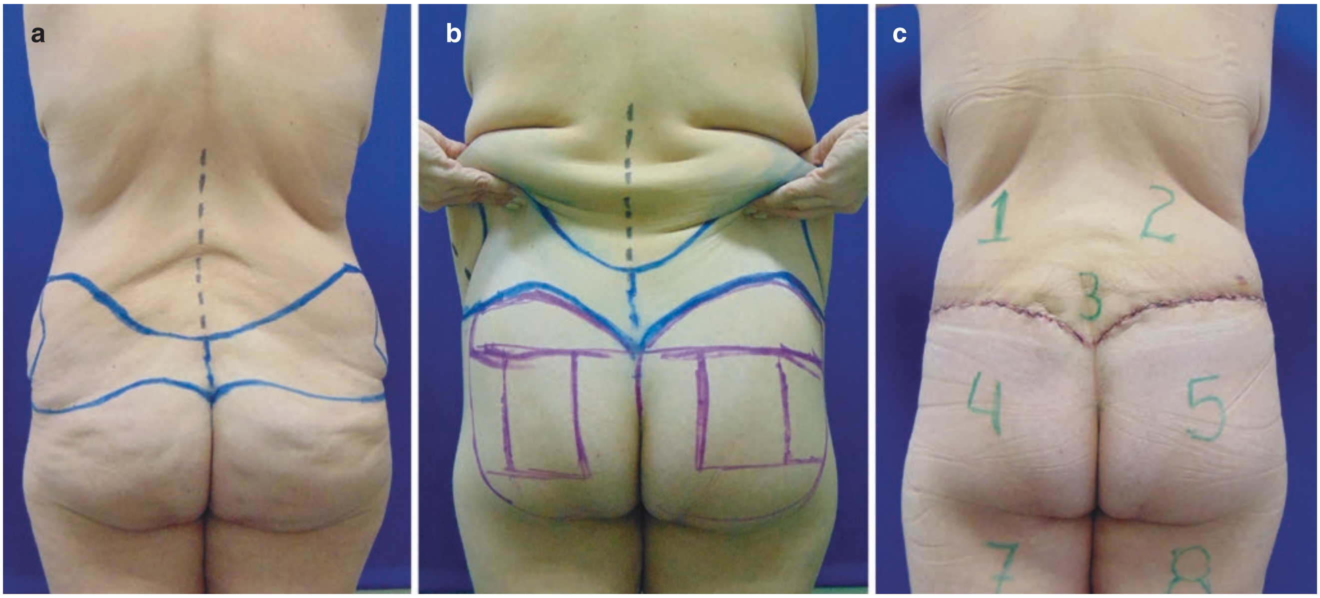

Fig. 31.2 Gluteal aesthetic units applied to massive weight loss patients undergoing circumferential lipectomies. (**a**) Marking of the circumferential body lift. (**b**) Marking after simulating the desired effects of the lower body lift. (**c**) Postoperative day 5 of a patient who underwent reshaping of the gluteal frame and reestablishment of the aesthetic units

with either implants or fat grafting is required. In MWL patients, the excess skin laxity may also add to the bluntness of this region requiring belt lipectomy to lift the buttock and enhance the V-zone.

31.2.2 Lower Gluteal Cleavage

There should be a diamond-shaped space between the infragluteal fold and the inner thigh. In a large buttock, the infragluteal fold is more horizontal and assumes an upward inverse slope (negative angle). The diamond-shaped space turns into a straight line, which is less aesthetically appealing. MWL patients usually present with this negative angle and might need lifting procedures with or without skin resection at the infragluteal fold.

31.2.3 Lateral Thigh/Hip Junctions

The lower lateral gluteal–thigh and mid-lateral gluteal–hip junctions are characterized by a smooth transition and the buttock should appear as a single unit. In some MWL patients, the muscle edge is well-delineated creating a sharp demarcation line. Lifting procedures as well as localized fat grafting may help soften this transition.

31.3 Physiopathology of Massive Weight Loss Deformities

Morbid obesity causes generalized anatomical changes to the subcutaneous layers. There is an overall increase in buttock dimensions (height and width), lengthening the intergluteal cleft and shortening the infragluteal fold. Bony framework and musculature may also be affected by weight disorders and influence gluteal aesthetics, but they cannot be targeted by surgical reshaping techniques and will not be discussed in this chapter.

Skin Unlike most clinical comorbidities that regress with the weight loss process, fine anatomic, histologic, and immunologic studies showed that cutaneous disarrangement does not improve. The skin is loose, thin, nonpliable, and inelastic [4]. Collagen structure is disorganized and damaged with reduced fibroblasts at the papillary dermis and higher incidence of localized inflammation of the sebaceous glands. Elastin fibers are fragmented, with sparse scar evidence throughout the tissue. The low skin quality in these patients may explain the higher wound-healing complication rates encountered. Cutaneous disorders including collagen cross-link and structural disarrangement by defective biochemical signalization are probably some of the involved inhibiting mechanisms [4].

Subcutaneous Fat The amount of subcutaneous fat besides the muscles contributes to buttock projection and accounts for the different buttock shapes. Fat distribution depends on both age and gender, as body shape seems to be similar in infancy, early childhood, and old age, showing most differences from the early teens until late middle age. The nature of fat distribution that determines each body shape is influenced by sex hormones, as estrogen inhibits fat deposition in the abdominal region and stimulates fat deposition in the gluteofemoral region more than in other areas. Testosterone, in contrast, stimulates fat deposition in the abdominal region and inhibits deposition in the gluteofemoral region. The volume of the buttocks may change, but usually the particular individual gluteal shape is maintained over subcutaneous expansion (obesity) and tissue deflation, following MWL. A great difference when examining the post-MWL buttock lies in the excess fascial laxity of the subcutaneous layers, which makes the active physical examination crucial for surgical planning.

Superficial Fascia System The superficial fascia system (SFS) is a constant structure, dividing superficial and deep fat compartments throughout nearly all the trunk and limbs. It is a network of connective tissue that begins with the subdermal plane and continues down to the underlying muscle fascia, mainly composed of a single or many slender, horizontal membranous sheets divided by fluctuating amounts of fat with adjoining vertical or oblique fibrous septae (Fig. 31.3a). The architecture of the superficial fascia system may change with sex, adiposity, and region of the body, and its function is to support and shape the fat of the trunk and extremities while adhering the skin to the underlying tissues. The irregular deep adherence characteristics of the overall system submitted to the action of gravity are responsible for the folds, creases, bulges, valleys, and other skin irregularities that ultimately define the body contour [1]. Large accumulations of fat in obese patients create a generalized mechanical stretching effect in the SFS (Fig. 31.3b). Meanwhile, weight loss causes massive fat reduction reflecting volumetric deflation of the subcutaneous tissue without retraction of collagen fibers, which remain elongated and weak (Fig. 31.3c). Ultimately, SFS disability leads to significant looseness of the skin.

Buttocks Dynamics Following MWL, patients experience generalized laxity with great mobility of the skin that directly impacts the body contour. The zones of adherence promote a "selective limitation" in the mobility of skin coverage around the body [5]. This is the fundamental anatomic rule that defines body contour deformities in the MWL population, demanding a different approach, targeting the new biody-

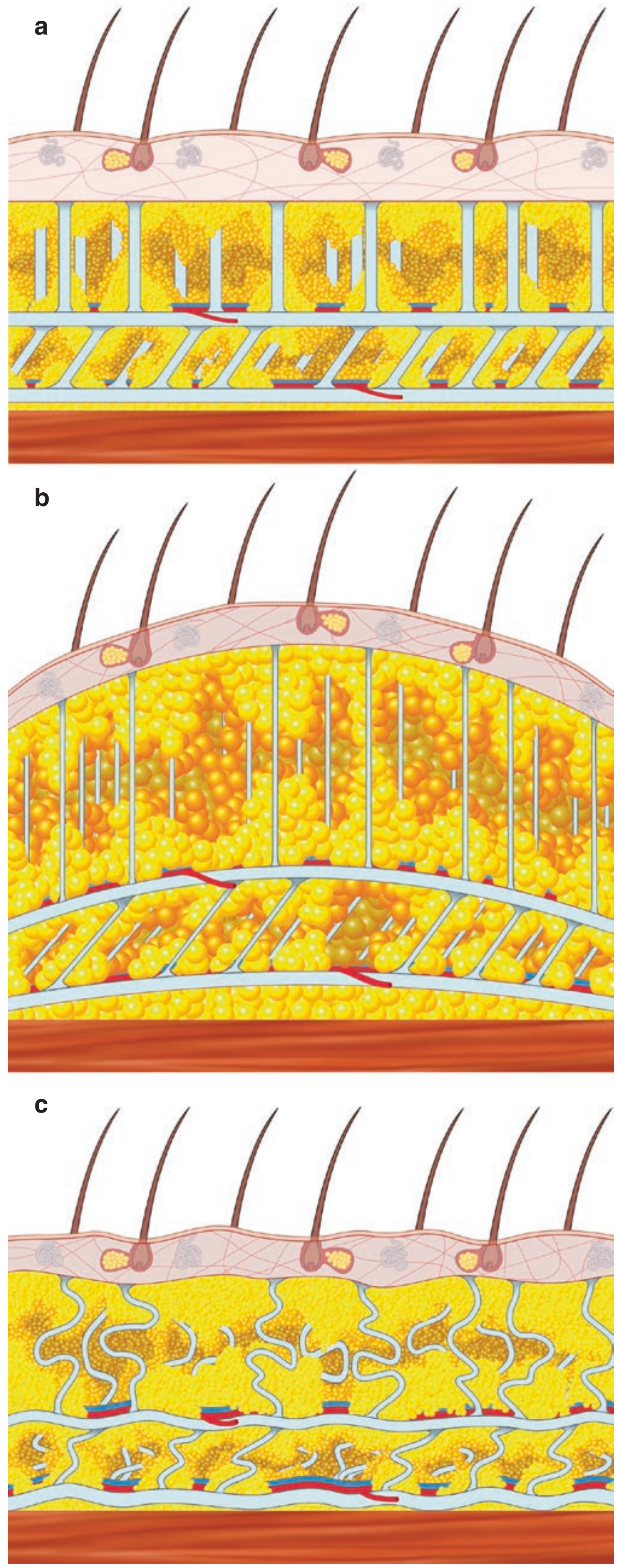

Fig. 31.3 Superficial fascial system: (**a**) normal, (**b**) obese, and (**c**) deflated. Note the stretching effect over the SFS collagen fibers network and the resulting tissue looseness

namics of the involved tissues [6]. Figure 31.4 shows the distraction of the gluteal SFS in the obese state and following MWL. Ptosis is the main concern in the gluteal region. Orthostatic observation will show a decrease in buttock height and width, shortening of the intergluteal cleft, and lengthening of the infragluteal fold (Fig. 31.5).

31.4 Diagnosis and Surgical Options

A good understanding of the distinct physiopathology and tissue biodynamics is fundamental for diagnosis and surgical planning in these patients. Lower body contouring including gluteal reshaping usually demands surgical treatment of con-

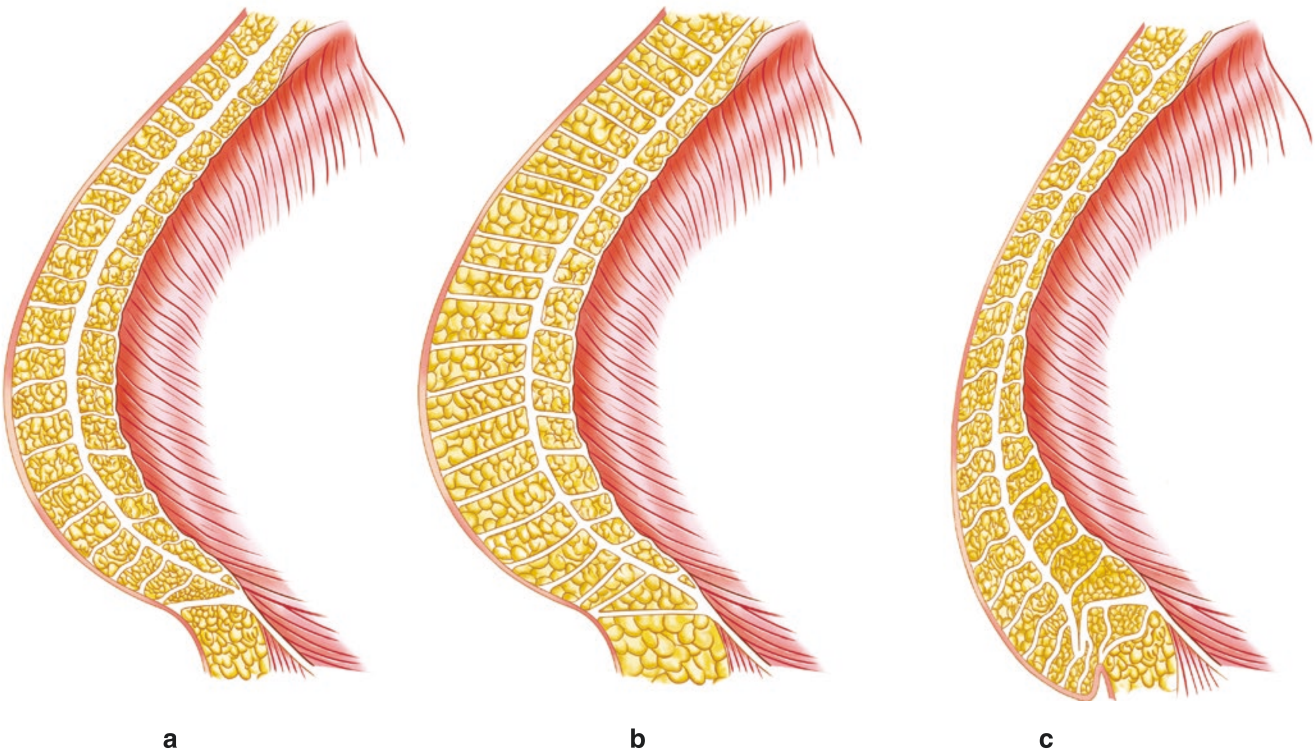

Fig. 31.4 Massive weight loss deformities and buttocks dynamics: (**a**) normal, (**b**) obese, and (**c**) deflated. Note the stretching effect over the SFS network and resulting gluteal ptosis

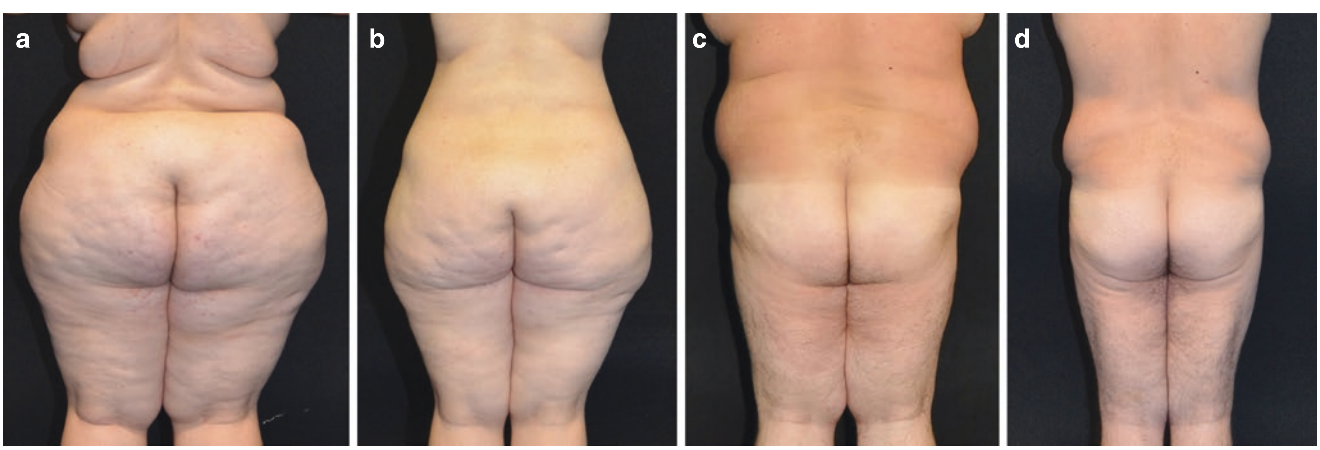

Fig. 31.5 Massive weight loss contour behavior (obese and deflated). (**a**, **b**) Female gynoid somatotype patient, where the buttocks are mostly affected by tissue deflation. (**c**, **d**) Male android somatotype patient, where the gluteal structures are relatively preserved

tiguous segments, as the thighs, flanks, hips, back, and abdomen. Some patients like those with the classic apple somatotype may not require the addition of these circumferential procedures to improve the gluteal contour and may benefit only from surgery to the gluteal region. Other patients may obtain great improvement of the gluteal contour with circumferential body lift (CBL) only (Fig. 31.6). However, it is important to note that CBL improves the gluteal frame, but does not enhance the gluteal projection. It is important not to indicate a gluteal augmentation procedure without correcting any excess skin laxity around the gluteal region. After the lifting procedure, if there is an important lack of gluteal projection, fat transfer, autologous flaps, and/or silicone implants may be indicated during the same procedure or at a later stage. Patients who do not need a lower body lift procedure but complain of lack of gluteal projection may consider an augmentation procedure (Fig. 31.7).

Autologous Flaps The use of de-epithelized flaps from the posterior trunk to improve gluteal contour has been described more than 40 years ago [7]. The main concept is to use available and well-vascularized autologous tissue to enhance gluteal projection, especially addressing the flattening effects of CBL. Instead of removing and discarding the tissue from the lower posterior trunk during dermolipectomy, it can be molded into the shape of an implant and inset beneath the CBL skin flaps. Many autologous flap designs emerged over the years [8–13], especially following the descriptions of the superior and inferior gluteal artery perforators, as well as the transverse lumbosacral perforators that have substantiated their clinical viability (Fig. 31.8). There has not been any report of the superiority of augmentation techniques over these autologous flaps, nor the superiority of one specific type of flap over the other. We often use the island flap proposed by Pascal [8], which has good outcomes and few complications (Fig. 31.9). In some patients, gluteal augmentation flaps can be performed with an isolated posterior lipectomy, whereas others will benefit from the circumferential approach. The procedure may be performed in the following positions: supine and bilateral lateral decubitus [14] or prone and supine [8–12]. Planning of the position of the final scars is important. Special attention should be taken on the poste-

Fig. 31.6 Preoperative and 12-month postoperative pictures of a massive weight loss male patient submitted to a belt lipectomy only. Note the improvement to gluteal frame with satisfactory buttocks projection

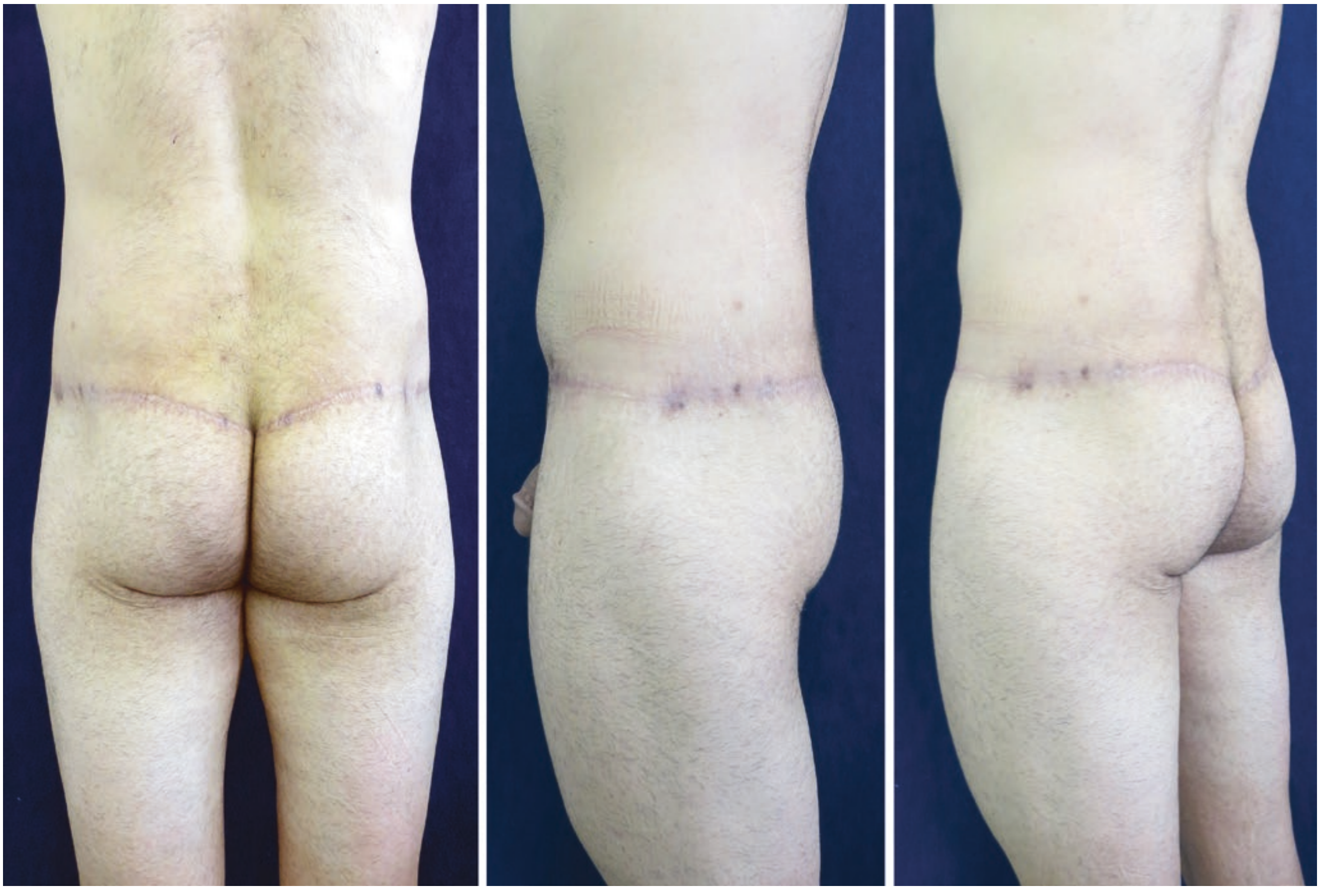

Fig. 31.6 (continued)

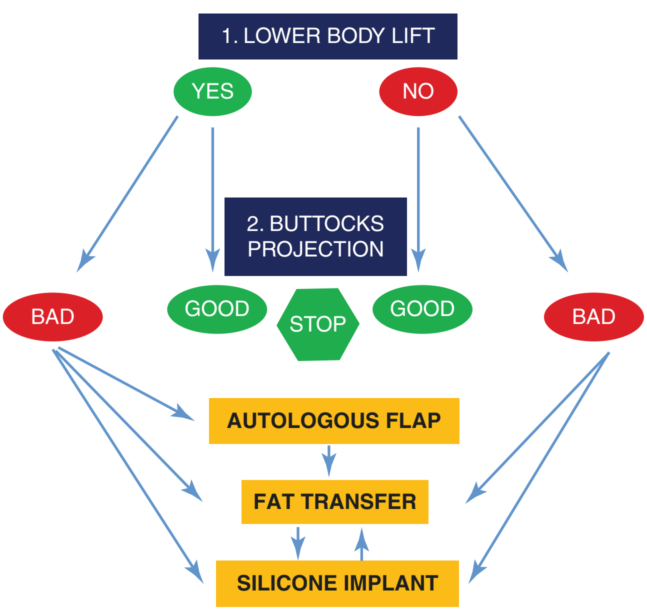

Fig. 31.7 Decision-making algorithm for massive weight loss gluteal contouring

rior central resection to avoid lengthening of the inter gluteal cleft. It is best to avoid low horizontal scar lines as they cross the gluteal aesthetic unit leading to an unnatural flattened appearance. Central body lifts with high scars may also be unaesthetic as they elongate the buttocks. We place the scars "in the middle" with the "V zone" superiorly arched at the margin of the separation of the gluteal aesthetic units, which is higher in women than in men. The symmetric and correct positioning of these scars is a keystone for gluteal frame reshaping and best aesthetic outcomes (Fig. 31.10).

Silicone Implants Massive subcutaneous deflation causes a great disarrangement of gluteal covering tissue, therefore placement of silicone implants only may not be suitable to MWL patients. They may be associated with CBL to enhance gluteal projection. This was described by Tavares Filho et al. who used the posterior incisions of the belt lipectomy to access the intramuscular space to place the implants. The surgical maneuvers are facilitated by the great visibility of this technique allowing placements of the implants submus-

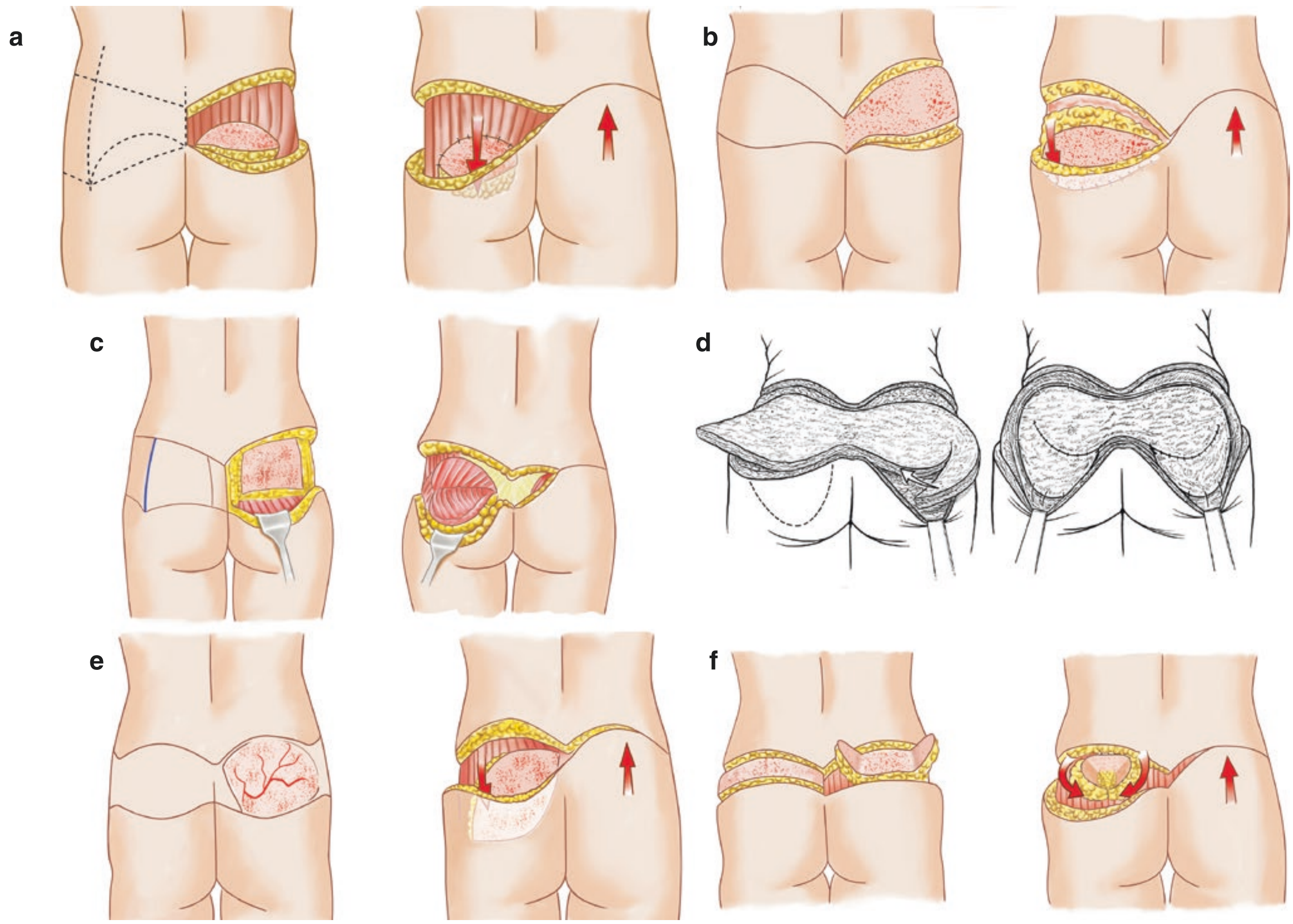

Fig. 31.8 Schematic demonstration of the most common gluteal dermal flaps for auto augmentation. (**a**) Pascal, (**b**) Mendieta, (**c**) Sozer, (**d**) Centeno, (**e**) Cowel, (**f**) Raposo Amaral

cularly or intramuscularly [15] (Figs. 31.11 and 31.12). When indicated, autologous flaps or fat grafting can be associated to this technique. In these cases, the preoperative posterior belt skin markings are readjusted because of the added implants, flaps, or fat grafting providing extra gluteal projection.

Fat Grafting In MWL patients, fat grafting allows the treatment of the different buttocks aesthetic units. Autologous flaps and silicone implants alone may help with gluteal projection; however, they are unable to reshape the whole gluteal region. Better overall outcomes are obtained when fat grafting is associated to these procedures. In many cases, it is possible to obtain good contouring results with the association of CBL and gluteal fat grafting (Fig. 31.13). Liposuction of the surroundings also gives an impression of gluteal lift and augmentation [16]. We perform syringe-assisted liposuction, process the fat with a manual centrifuge, and inject subcutaneously. For many patients, gluteal augmentation with autologous fat grafting is not an option because of the lack of donor sites. On the other hand, surgical specimens resected in belt lipectomies contain loose adipose tissue that, if properly harvested, could be grafted in the buttocks. These usually discarded materials hold precious adipose tissue, and efforts should be taken toward developing new harvesting techniques to make it possible to convert them into viable and injectable fat grafts. Fat should be injected in the subcutaneous plane, maintaining the cannula parallel to the gluteal surface so that entry into the channels is prevented. Lateral and prone positions may be suitable for injection, depending on preoperative makings, the sequence for the circumferential approach, and surgeons' preference.

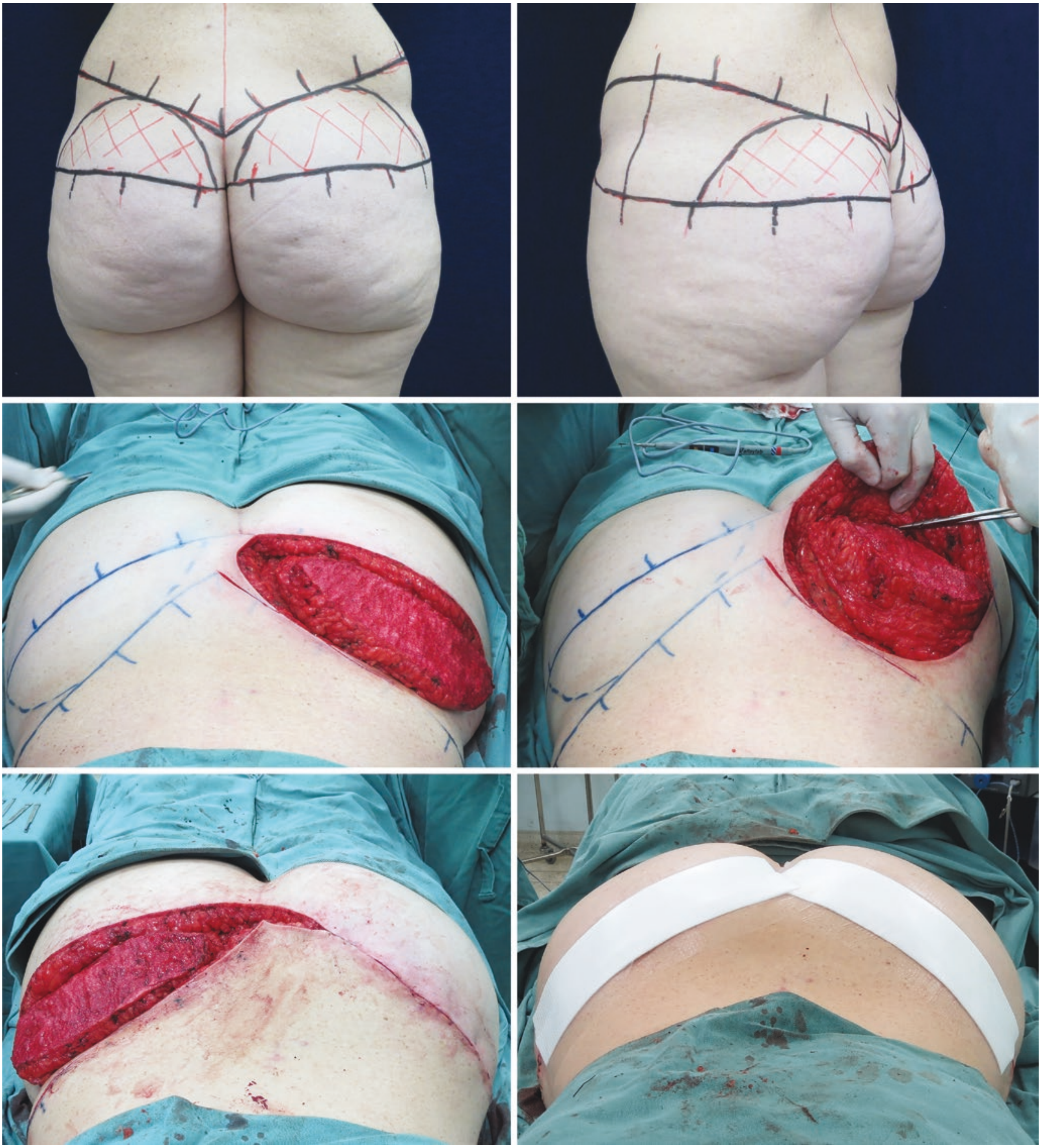

Fig. 31.9 Preoperative markings and intra-operative steps of the island flap technique associated to the circumferential body lift to reshape the gluteal frame and increase gluteal projection

Fig. 31.10 Preoperative and 6-month postoperative results of the circumferential body lift with island flap of the patient shown in Fig. 31.9 intraoperatively

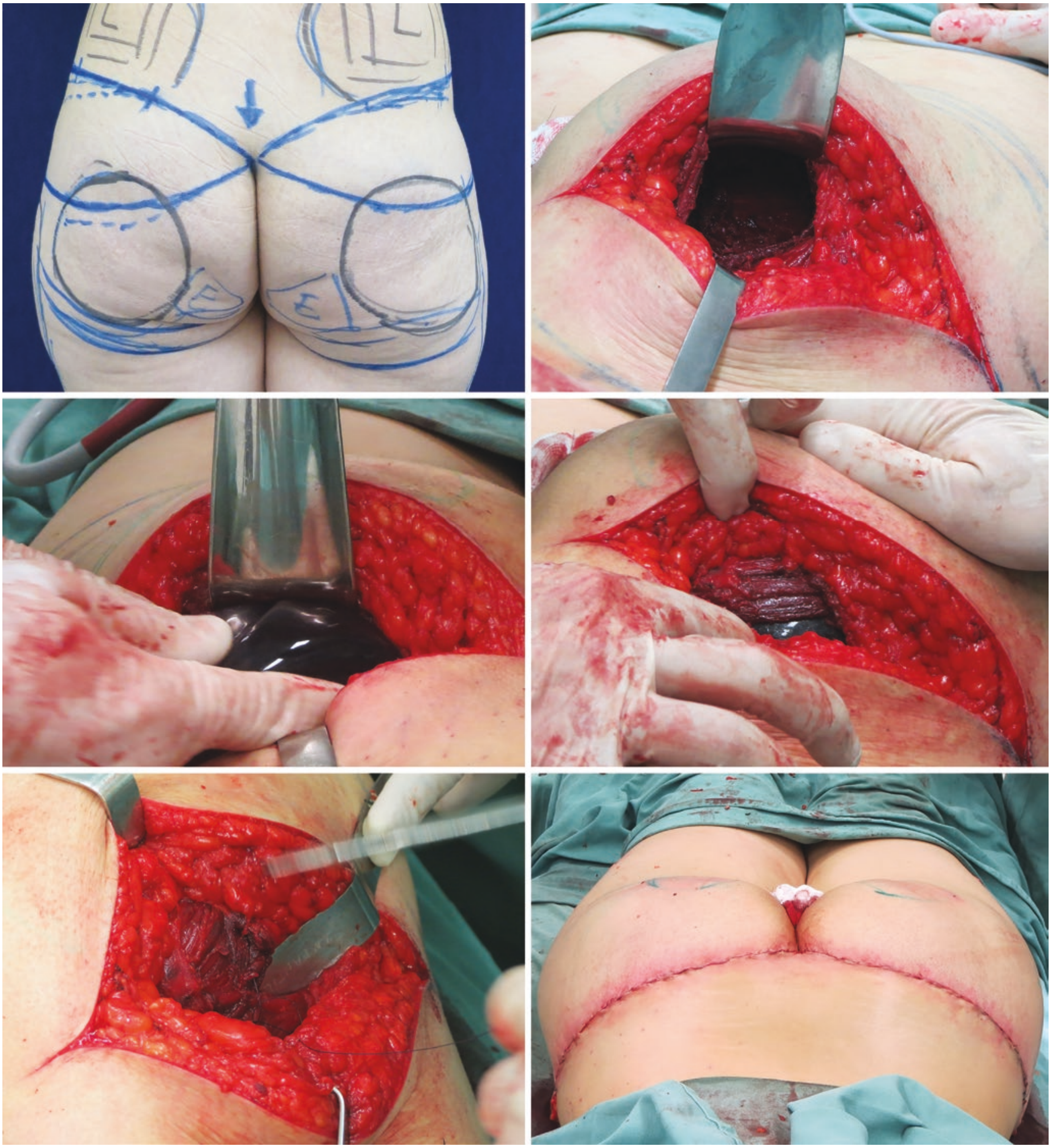

Fig. 31.11 Preoperative markings and intra-operative steps of a CBL associated with placement of 300 cc gluteal silicone implants intramuscularly to increase gluteal projection

Fig. 31.12 Preoperative and 6-months postoperative results of the circumferential body lift with intramuscular bilateral 300 cc gluteal silicone implants of the patient shown in Fig. 31.11 intraoperatively

Fig. 31.13 Preoperative and 2-year postoperative results of a massive weight loss patient who has undergone circumferential body lift associated to fat grafting

31.5 Complications

31.5.1 Minor Complications

Seroma Seroma occurs in 15–50% of cases and is considered the most common complication. Because of the significant undermining during CBL, there is subcutaneous accumulation of transudate that may lead to fibrosis in adjacent areas compromising the results. Patients with higher body mass index (BMI) are more susceptible to develop seroma. Limiting the undermining areas and placing sutures in three to four planes in an attempt to avoid formation of dead space may decrease the incidence of seroma. Drains are usually placed and kept until daily secretions are less than 30 cc. Aspiration of these seromas is usually effective in most cases; however, if they persist for more than 4 weeks, an ultrasound-guided drainage catheter and continuing local compression can be used. If they are refractory to the above, open drainage is indicated with resection of the capsule and placement of adherence sutures [17].

Wound Dehiscence Wound dehiscence occurs in the areas of greater tension above the incisions, due to the mechanical distress caused by the macro and micronutrients' deficit, as well as the defective protein metabolism of the extracellular dermal matrix. Other related factors are elevated BMI at the time of body contouring, prolonged surgical time, excision of large amount of tissue, diabetes, hypertension, and tobacco [18]. Management of wound dehiscence will depend on the size of the affected areas and when it occurs early or late. Early dehiscence can be treated with primary closure or secondary intention.

Compression Nerve Injuries from Intraoperative Patient Positioning Safe positioning of the patient, especially in procedures with multiple changes of position, is important to reduce intraoperative neurological, vascular, and ocular damage. Arms and elbows must be placed at angles that avoid excessive traction and possible injuries to the brachial plexus. The head, arms, elbows, knees, legs, and heels must be supported with pads to avoid any nerve compression. Ophthalmic lubricant must be used and the eyes kept closed and protected. In the prone position, special care should be taken to avoid any increase in intraocular pressure, which has been responsible for vision loss in rare reported cases.

31.5.2 Major Complications

Hematomas Hematomas can be caused by impaired hemostasis, hypertensive peaks, coagulation disorders, or use of anticoagulants. The presence of an expanding hematoma indicates a medical emergency as it can cause acute anemia and hypovolemic shock. Smaller and unidentified hematomas can lead to colonization and infection, or even compromise the vascularization of skin flaps, leading to ischemia and necrosis. Good history and adequate laboratory testing can greatly reduce the incidence of bleeding and subsequent formation of hematomas by identifying coagulation disorders. It is important to obtain efficient hemostasis intraoperatively, to prevent nausea and vomiting, and to control blood pressure in the postoperative period. Large or expanding hematomas warrant opening of the incision in order to cauterize the bleeding vessel, whereas smaller ones can be treated by closed drainage followed by compression.

Skin and Fat Necrosis Skin necrosis can be caused by tobacco use and diabetes that can reduce blood circulation. In CML, localized skin necrosis at the waistline and intergluteal cleft may occur as well as fat necrosis, especially when gluteal flaps are associated. Debridement of the necrotic tissues and primary closure can sometimes be done when the area is small, left to heal by secondary intention or benefit from late coverage of the wound.

Infection There is an increase rate of surgical site infections in postbariatric body contouring procedures, suggesting a direct cause/effect relationship with nutritional deficiencies in this patient-population. Careful asepsis, preoperative showers with an antiseptic soap, avoidance of shaving in the area of the incisions, adequate surgical technique, reduced hospital stay, and antibiotic prophylaxis should be done. Treatment consists in incision and drainage of collected fluids and appropriate antibiotic therapy.

Thromboembolism CBL presents a high rate of deep venous thrombosis (DVT) and pulmonary thromboembolism (PE), especially when associated with other risk factors such as high BMI > 30, use of hormonal therapy, prolonged surgery time, and age. Preventative measures such as intermittent pneumatic massage to the lower extremities, the use of antithrombotic stockings, early ambulation, loco-regional anesthesia as opposed to general anesthesia, and chemoprophylaxis with low-molecular-weight heparin may decrease the incidence of DVT and PE. More evidence-based studies are necessary to establish the ideal dosage, onset, and length of chemoprophylaxis because of the risk of bleeding and hematomas associated with these procedures [19, 20].

31.6 Conclusion

Massive weight loss patients usually present with body contour deformities that often affect gluteal aesthetics. The lack of volume and projection is related to a severe disarrangement of the buttocks' frame, which requires specific measures to restore anatomical landmarks and to enhance shape and contour of the gluteal region. In most cases, CBL will be the first step to readjust the gluteal frame. Augmentation techniques such as fat grafting, autologous flaps, and alloplastic implants can be associated to enhance buttocks projection. Fat grafting helps restore volume and projection to the MWL buttocks, targeting different aesthetic units and globally promoting a true "refill" of the deflated subcutaneous spaces. Besides volume restoration, other regenerative and angiogenic properties of adipose tissue may be responsible for metabolic turnover and improvement in skin quality. Dermal flaps and silicone implants also contribute to increase buttock projection in specific gluteal units. As we continue to advance in our understanding of the MWL deformities, surgical techniques for gluteal contour will certainly be refined toward improving aesthetic outcomes and fewer complications.

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32 Nonaesthetic Gluteal Deformities

Lydia Masako Ferreira and Felipe Contoli Isoldi

32.1 Background

The gluteal region is the target of trauma, drug application, therapeutic interventions, as well as congenital malformations [1]. Given its strategic location and large amount of soft tissue, these situations can lead to deformities of the component structures from the skin to the deep muscular plane. Therefore, imperfections in the gluteal region can cause stigma and low self-esteem [2].

32.2 Evaluation of Gluteal Deformities

Deformities may occur in one or more layers of the gluteal region: skin, subcutaneous tissue, fascia, and/or muscles. The manifestation in each of these layers reveals information in the clinical exam, which is complemented by subsidiary imaging. These deformities are initially assessed through the history identifying the cause and the physical exam with the patient in standing position. The patient is then asked to perform hip extension and flexion in order to evaluate the depth and planes of tissue involvement of these deformities [1]. Ultrasound is the first line of imaging modality to examine soft-tissue injuries of the gluteal region [3]. High frequencies (>10 MHz) are used to evaluate surface structures, while lower frequencies (5–10 MHz) evaluate deeper structures [4]. Ultrasound examinations can be complemented with Doppler in order to identify any vascular anomaly. Computerized tomography allows detailed evaluation of the soft tissues and their correlation with other pelvic and intra-abdominal structures. However, it uses ionizing radiation and requires injection of intravenous contrast. Magnetic resonance imaging is one of the best methods for evaluation of soft tissues, providing better anatomical study of lesions of the buttocks [5]. However, patients who are claustrophobic and have metallic implants cannot undergo this exam. All three modalities have indications and limitations regarding diagnostic and therapeutic planning.

Table 32.1 Classification of gluteal deformities proposed by Gonzalez

Types	Extent of deformity
I	*Subcutaneous tissue* Lipodystrophy Fibrotic Mixed
II	*Fascia*
III	*Muscle*
IV	*Mixed*

32.3 Clinical Classification of Gluteal Deformities

The classification of deformities in the gluteal region is determined by the extent and depth of tissue involvement. Gonzalez classified these deformities based on the soft-tissue involvement and the characteristics of the lesions in four types: lesions that affect the skin and subcutaneous tissue, the fascia, the muscles, and mixed lesions [1]. For each type of lesion, a therapeutic conduct is proposed. Fat grafting is the first choice for type IA and type IC lesions, and can also be used in the other types (Table 32.1).

32.4 Etiology of Gluteal Deformities

32.4.1 Siliconoma

Siliconoma is a serious and important public health problem [6]. For many years, liquid silicone has been injected as a fast

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and inexpensive method for body contouring. The gluteal region is one of the most selected regions of the body for this practice. The injection of large volumes of industrial silicone has devastating consequences on the body. After its injection, there is an indeterminate period of latency in which the patient presents few symptoms, usually restricted to the site of infiltration. However, over time, the chronic inflammatory process due to the presence of the silicone worsens and can disperse throughout the body, resulting in the presence of granulomas, dyschromia, abscesses, and cellulitis, causing disfigurement and imperfections. Pain and discomfort are common at this stage. Lymphadenopathy and compression of the sciatic nerve can occur. Systemic complications are also described, most commonly vascular and pulmonary [7].

In general, the complete removal of the siliconoma is difficult, often not possible, as it is strongly adherent to the soft tissues and results in severe deformities of the region. An incision is made over the area of greatest silicone accumulation and a maximum amount is removed while minimizing tissue damage. Salgado et al. described the use of conventional liposuction associated with ultrasound for the removal of siliconoma, and subsequent autologous fat grafting (with fat harvested from an area without the presence of silicone). They reported significant improvement in the symptoms and local complications and an improvement in the patients' quality of life [6].

32.4.2 Gluteal Injections

The gluteal region is a common site for intramuscular injection of medications. Greenblat et al. reported 12,834 patients who had at least one intramuscular injection, of which 0.4% developed adverse reactions attributed to the injection [8]. The reactions reported were hematomas, abscess, granulomas, and muscle necrosis. Subsequently, retractions and deformities can appear at the site of injection. Wang et al. reported these deformities in children who had received injections in the gluteal region [9]. These lesions were characterized as concave deformities with adhesion to the dermis and fascia, which were more pronounced when the patient would gain weight. They can be treated with resection of the fibrotic tissue and the adherence to the deep plane, followed by liposuction of the adjacent area and local fat grafting. In some cases, the adhesion can be released with multiple passages of the cannula or subcision.

32.4.3 Gluteal Retractions

Retractions may be related to local inflammatory processes, usually trauma (injections), with subsequent formation of fibrosis and necrosis of adjacent soft tissues (Fig. 32.1). Static and dynamic clinical exam is important to identify the size of the gluteal defect and the type of tissue affected. For types IA and IC lesions, autologous fat grafting can be performed to treat these retractions. In type C lesions, autologous fat grafting associated with subcision to release the fibrotic tissue from the deeper planes is performed. Type IV (mixed) lesions can be managed with the same procedures or may require open surgical approaches. Type II and III lesions should be managed with open surgical approaches by direct removal of the retractions. Patient should be informed of the possible need for revision procedures (Table 32.1).

32.4.4 Lipodystrophy

Subcutaneous tissue atrophy or lipodystrophy can occur in any region of the body. The buttocks and the thighs are the most common regions. Lipodystrophy can be associated with some form of trauma to the tissues, such as injections, use of medications such as antiretroviral therapy

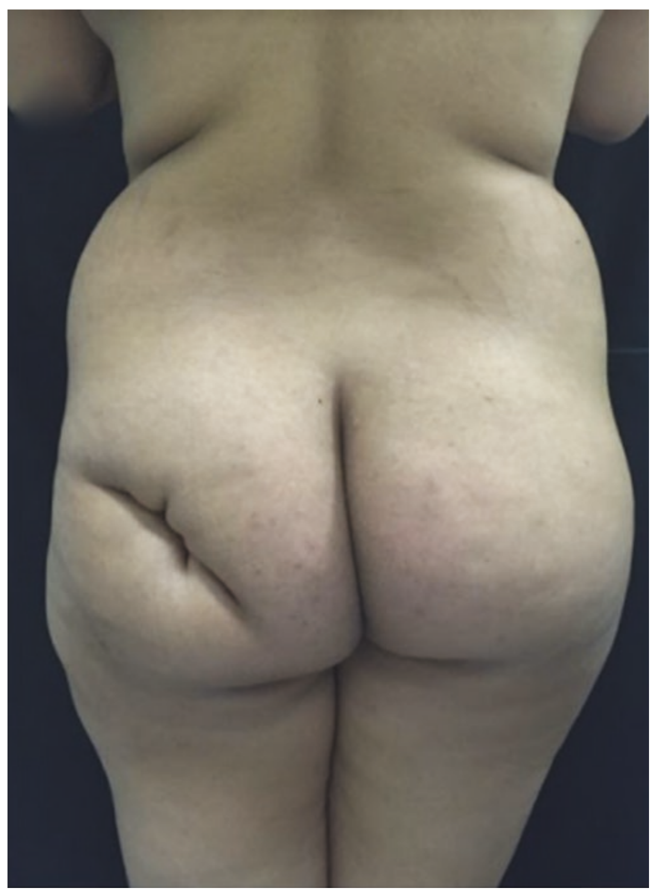

Fig. 32.1 Patient presenting with retraction of the left gluteal region after local trauma

[10], and congenital diseases. These deformities may be treated with autologous fat grafting, and in more severe cases, placement of silicone implants or autologous flaps [11] (Fig. 32.2).

32.4.5 Postoperative Sequelae

Liposuction, body contouring, and other reconstructive procedures may generate contour irregularities, deformities, and retractions where large volumes of fat are removed. Excessive liposuction in an area can cause the superficial layer of the subcutaneous tissue to adhere to the muscular aponeurosis, causing retractions and deformities in the gluteal sulcus. Autologous fat grafting has been used to correct these deformities with good results [12]. Avendaño-Valenzuela and Guerrerosantos published a series of 300 patients presenting with lipodystrophy in the gluteal region caused by trauma, congenital lesions, and postliposuction. They reported the use of autologous fat grafting for the treatment of 75% of their patients, with good long-term results [13]. Any type of procedure in the buttocks such as flaps or treatment of pressure ulcers can lead to these deformities (Figs. 32.3, 32.4, and 32.5).

Fig. 32.2 Patient with lipodystrophy of the gluteal due to the use of antiretroviral therapy

Fig. 32.3 Gluteal deformity caused by soft-tissue necrosis following a lower body lift

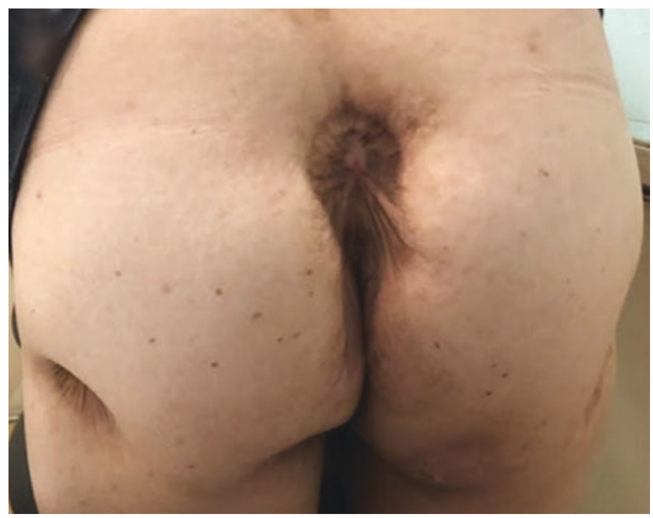

Fig. 32.4 Patient presenting with retractions following wound healing by secondary intention of sacral and trochanteric pressure ulcers

Fig. 32.5 Patient presenting gluteal deformity after local flap for wound closure

32.5 Management of Nonaesthetic Gluteal Deformities

Fat grafting is widely used to treat nonaesthetic gluteal deformities. It is essential to identify the area most suitable for fat harvesting. The abdomen is the most common donor site, followed by the thighs and knees. Fat can be harvested by different methods such as vacuum suction or syringe. It is processed before injection in order to eliminate contaminants such as cell debris, free oil, and blood that may exacerbate inflammation in the recipient tissue hindering graft take. Fat is injected with blunt, sharp, or V dissector cannulas in various tunnels in a retrograde fashion, covering the whole area to be treated. Fat has shown to play a role in skin regeneration, forming a subcutaneous mesh, correcting the lipodystrophies, retractions, and atrophic scars. Final clinical results are still unpredictable, and sequential grafting sessions are generally required for better results. In studies using fat grafting to treat nonaesthetic gluteal deformities, all authors reported good results. Fat grafting can be used alone or in combination with surgical resection and/or use of silicone implants. There is no consensus or defined protocols for the treatment of these gluteal deformities. Even so, the use of fat grafting has gained recognition for this purpose.

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Managing Complications of Non-approved Fillers

33

Denis Souto Valente and José Ricardo Simões

33.1 Background

Some surgical procedures are performed for aesthetic reasons in healthy patients seeking to improve their body image, and some are performed for reconstruction after cancer, trauma, or other chronic illnesses. The practice of soft-tissue augmentation with injectable fillers is more than 100 years old. Whereas the majority of these procedures are performed for facial rejuvenation using small volume approved temporary fillers, some procedures involve injections of large volumes in other areas of the body. Unfortunately, permanent alloplastic materials not designed for injections into humans are also used. Regardless of the location and the type of injectable fillers used, local complications can generally be classified as: fluid collection, migration, infection, nerve injury, vascular compromise, foreign body reaction, and fibrosis [1].

Injection of industrial-grade materials is a complex and challenging health problem. There is a dearth of empirical studies that quantify its prevalence. Gluteal augmentation using injectable filers should be performed only by trained medical professionals, and autologous fat should be the material of choice because of its low complication rates. There are, however, a frightening number of large-volume gluteal injections performed by non-medical personnel. Unfortunately, these injections frequently involve non-medical-grade products in non-sterile environment. Compared with conventional plastic surgery procedures, these illegal injections require limited recovery time and are less expensive. Wallace described some factors related to the use of illegal fillers, such as misperceptions about the risks, poor self-image, low access to health insurance, and discomfort in public [2]. There is a disquieting rate of industrial-grade silicone injections with unpredictable and often uncorrectable consequences. Such injections can lead to permanent disfiguration, serious health issues, severe complications, and sometimes death [2, 3].

The treatment of patients undergoing illegal gluteal augmentation presents several additional concerns including those of obligation to treat and liability. Many surgeons are cautious to treat these patients due to the litigation risk. Successful management strategies depend on the illicit material injected, the individual clinical presentation, as well as the previous therapies conducted elsewhere which may involve scarring and the presence of biofilms. Before beginning any reconstructive therapy, it is essential to document the limitations of the procedure, the duration of treatment, the limited outcomes, and any other problems that may appear when managing these complications. A signed informed consent and photography is imperative prior to any treatment [4].

Non-medical-grade silicone is the most common substance used for illegal gluteal augmentation. While many non-surgical procedures involving injectable fillers are generally safe, some carry potential risks, especially when there is uncertainty regarding the quality and purity of the injected material [5, 6].

33.2 History of Injectable Silicone

Silicone has a broad range of medical applications and plays an important role in plastic surgery. Solid silicone implants have revolutionized body contouring surgery. However, injection of silicone has historically been fraught with legal issues, although it continues to be used for augmentation in many areas of the body. Previously, only industrial-grade silicone was available, and it was never meant to be used in humans, because of its impurities. Corning Glass and Dow Corning Corporation (Michigan, USA) formed a joint venture in the United States to develop silicone products for

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military purposes. During the Second World War, the US army in Yokohama noticed the disappearance of drums of liquid silicone from the docks that were probably used for injection into the body of some local women entertainers. Near the end of this conflict, a large number of women in the region used industrial-grade injectable liquid silicone in their body [5, 7]. In 1961, the joint venture developed its first medical-grade silicone (Dow Corning 200). This material was subsequently refined and marketed as Dow Corning 360 with a viscosity of 350 cS (100 cS being the viscosity of water). Its initial purpose was for waterproofing the skin, primarily in burn victims.

Because of the complications caused by uncontrolled injectable silicone use by unqualified practitioners, in 1966, the Food and Drug Administration (FDA) labeled silicone injections as a new drug. This ruling stipulated that silicone must undergo certain laboratory investigations before it could be approved for use in humans. To date, these studies have never been done. In 1977, Wilkie reported the appearance of granulomas following injection of medical-grade silicone [8]. By 1991, over 100,000 patients had received silicone gel injections of known or unknown origin. The FDA issued guidelines clearly forbidding the marketing or sale of injectable liquid silicone for aesthetic injection purposes, until appropriate studies had been completed (to date, these long-term clinical investigations have never been done). Silicone injections were labeled as adulterated by the FDA to indicate that they had not received approval for marketing. In 1992, the FDA officially banned the use of all silicone injection products. In 1994, the FDA-approved silicone oil for the treatment of complicated retinal detachment: Silikon 1000 (Alcon Laboratories, Texas, USA), and Adatosil 5000 (Bausch & Lomb, New York, USA). For many years, a number of practitioners had purchased these products to treat wrinkles and other aesthetic issues without FDA approval for these purposes [9]. However, the FDA Modernization Act of 1997 permits FDA-cleared devices to be used off-label, for any condition within the physician–patient relationship. Recently, the American Society of Plastic Surgeons has launched a public consciousness campaign through various statements and patient stories in response to the rise in complications related to the illicit practice of gluteal augmentation with silicone injections. In spite of all the warnings and cautions, liquid silicone injections were easily obtainable by those who wanted them. Liquid silicone is inexpensive, likely non-carcinogenic, minimally antigenic, and inhospitable to bacterial growth. It was frequently injected in lay facilities in many regions of the US, especially in California. A recent study showed a 16.7% weighted prevalence of silicone injection among transwomen in San Francisco [10].

For most of its legitimate medical uses, liquid silicone should be isolated from the soft tissues. If the silicone-containing material is exposed to soft tissue, it will generate a fibroblastic response and gradually increase the volume of the region. After injection, silicone is dispersed into the injected tissues as millions of microdroplets. Transient inflammation occurs locally and subsides after 3 weeks. At 4 weeks, the droplets are encapsulated by fibroblasts generating collagen, and at 10 months, granulomatous depots surrounded by fibrous tissue are found (Fig. 33.1). At 1 year, the result of soft-tissue augmentation is achieved because of the injected filler volume and the intense fibrosis generated [11].

Fig. 33.1 Granulomas (siliconomas) removed from the gluteal region of a patient who had received injections of liquid silicone 6 years earlier

The use of injectable silicone may result in unpredictable consequences ranging from edema, erythema at the site of injection, regional lymphadenopathy to the development of disseminated granulomas distant from the injection site. Both medical-grade and non-medical-grade liquid silicone can produce those complications [12].

33.3 Classification of Complications

All types of injectable fillers can cause short-term and long-term complications, as well as systemic diseases. The risks are higher with non-medical-grade substances. It is important to distinguish poor aesthetic outcomes due to technical errors from adverse events. Adverse events are generally categorized based on the time of onset following injection [13]. Early complications (during the 30 days) are usually related to the procedure itself and early host response to the injected material. Short-term complications manifest clinically by injection-associated discomfort, pruritus, bruises, edema, erythema, hematoma, mass at the injection site, infection, fluid collections, nerve damage, and vascular compromise. Patients complain of more discomfort when a thicker needle is used or the filler is highly viscous. Pruritus is due to the histaminic reaction generated by the anesthesia or the filler itself. Bruising usually develops at the time of injection and resolves in a few days. Post-traumatic edema frequently occurs after any injection; it can also result from an antibody-mediated immune response to the foreign material. Erythema may occur from a reflex cutaneous vasodilatation following vasoconstriction drugs used in the local anesthesia. The presence of a mass at the injection site may be due to maldistribution of the filler or over-injection. Seroma may sometimes occur because of the extensive tissue undermining. Infection can be due to inadequate aseptic technique prior to injection or the use of contaminated non-medical-grade fillers. Infections with *Propionibacterium acnes* and *Staphylococcus epidermidis* commonly manifest early or within 3–6 weeks after inoculation. However, delayed manifestations (months to years later) may occur and are usually caused by non-tuberculous mycobacteria or methicillin-resistant *Staphylococcus aureus*. Nerve damage from direct trauma or compression can lead to paresthesia or dysesthesia with most injuries being reversible. Piriformis muscle syndrome causing buttock pain can occur when the filler is placed deep in the gluteal muscles. Sciatic nerve damage arises most commonly from misplaced gluteal injections, but also can be caused by fluid collections. The clinical features reflect its motor and sensory distribution and may include: loss of strength and sensation below the knee, loss of knee flexion, foot drop, and loss of ankle jerk and plantar response.

The most feared and potentially serious complications are extravascular compression causing partial or complete interruption of the vascular supply, or an intravascular injection generating pulmonary embolism or complete vessel occlusion. Subsequent necrosis and scarring can occur in the areas injected and lead to permanent sequelae.

Usually, the late period (after 30 days) is the most frustrating. The surgeon must manage most of the time incurable situations, aiming for improvement of symptoms rather than cure, and deal with patients' unrealistic expectations. Long-term complications are related to the injected filler itself and delayed host response. They can manifest as infection, delayed hypersensitivity, foreign body granuloma (FBG), non-inflammatory nodule (NIN), abscess, cellulitis, secondary lymphedema and filler dislocation. Systemic diseases associated with injectable fillers include: acute hepatitis, cutaneous lymphoma, sarcoidosis, renal amyloidosis, and pulmonary embolism.

33.4 Diagnosis and Treatment

Correlation with symptoms, signs, and morphologic images is essential to establish a precise diagnostic. Ultrasound (US), Computed Tomography (CT) or Magnetic Resonance Imaging (MRI) are used to evaluate filler-related complications and assess the volume and location of the injected fillers. CT and MRI are preferred over US for the localization of dislodged fillers because they provide anatomical reference. MRI is preferred over CT due to its large visual field, superior soft-tissue discrimination capability (detection of foreign material, abscess, inflammation) [14] (Fig. 33.2). On US, injected silicone has a hyperechoic snowstorm appearance obscuring the soft-tissue details. On CT, it appears slightly more dense than the surrounding tissues. On MRI, it usually shows a chemical shift artifact, which is hyperintense on T1 images and hypointense on T2 images. After contrast administration, fat-saturated T1W images usually show variable enhancement depending on the reactive changes or inflammatory features in the adjacent tissues [15].

Non-erythematous nodules formed during the first week after injection are caused by the uneven distribution of the filler and usually resolve spontaneously. Most complications like hypersensitivity, bruising, erythema, and small nodules are treated conservatively. Delayed hypersensitivity reactions usually occur 2–20 years after filler injections and manifest as induration, erythema at the injection site. These reactions usually resolve spontaneously within 24 months without any sequelae. Oral corticoids and antibiotics for 15–30 days may be helpful.

Both NIN and FBG are terms that have been used for palpable lesions noted after filler injections. An erroneous superficial gluteal filler injection is the main cause of NIN. FBGs are often triggered by a systemic bacterial infection causing granulomatous inflammation after aggregation

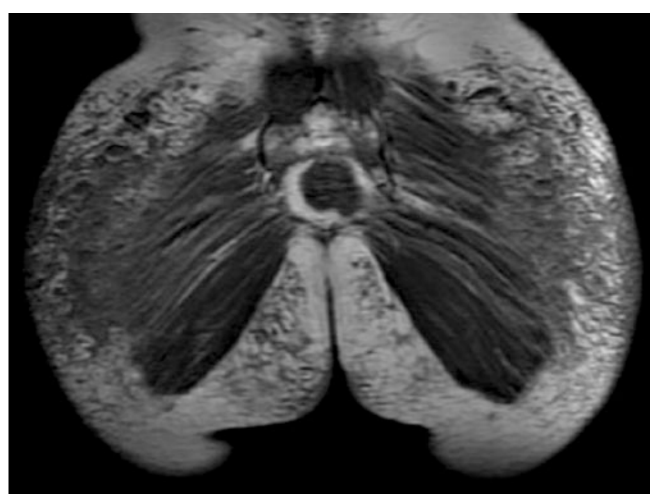

Fig. 33.2 MRI of the gluteal region of a patient who had received injections of illegal silicone 5 years earlier, showing spreading of the liquid silicone to the subcutaneous and muscular layers

Fig. 33.3 Foreign body granulomas 15 years following injection of liquid silicone

of macrophages in response to large foreign bodies that cannot be phagocytosed. They grow slowly and can manifest as multiple confluent fixed, rigid lumps, appearing months to years after injection of fillers (Fig. 33.3). They have three histological types: cystic, lipomatous, and sclerotic. Hyaluronic acid and collagen produce cystic granulomas, silicone and polyacrylamide produce lipogranulomas, polymethyl methacrylate, and polylactic acid produce sclerosing granulomas. The main characteristic of FBG on MRI is a post-contrast enhancement around the filler.

NINs, following silicone gluteal injections, manifest as multiple lumps well confined in fibrous capsules. They appear early after filler injection. On MRI, they remain stable post-contrast.

It is important to distinguish between NIN and FBG as the management is different. Incisional biopsy may be helpful. FBG is usually treated with intralesional injection of triamcinolone 40 mg/mL associated with 5-fluorouracil 10 mg/mL and xylitol 1 g/mL. Generally, 0.2 mL of this solution is injected per square centimeter of involved subcutaneous tissue. The total dose should not exceed 10 mL and can be repeated every 4 weeks. Systemic therapy with oral corticoids and antibiotics are used in refractory cases. Excision of FBG is not the first-choice therapy because they are invasive with no confined borders and their complete removal is impossible in the majority of cases. NIN does not respond to intralesional or systemic therapies (Fig. 33.4). Surgical excision is the first-choice therapy when there are well-circumscribed lesions with clear margins; however, subsequent deformities can be seen and corrected with fat grafting or tissue flaps.

Cellulitis and abscesses can occur with all types of filler injections (Fig. 33.5). They are characterized by pain, erythema, edema, fever, ulceration, fluctuance, induration, and

Fig. 33.4 Unsuccessful treatment of non-inflammatory nodule sequelae of liquid silicone injections, with prednisone injections

Fig. 33.5 Cellulitis and abscesses of the gluteal region following injection of non-medical-grade silicone

lymphadenopathy. They can evolve to fistula formation and significant tissue scarring. They appear on MRI as lobulated fluid collections with rim enhancement and adjacent fat stranding. On diffusion weighted imaging, the abscess may

Fig. 33.6 Patient presenting with sterile abscesses to the gluteal region, 8 years after receiving liquid silicone injections

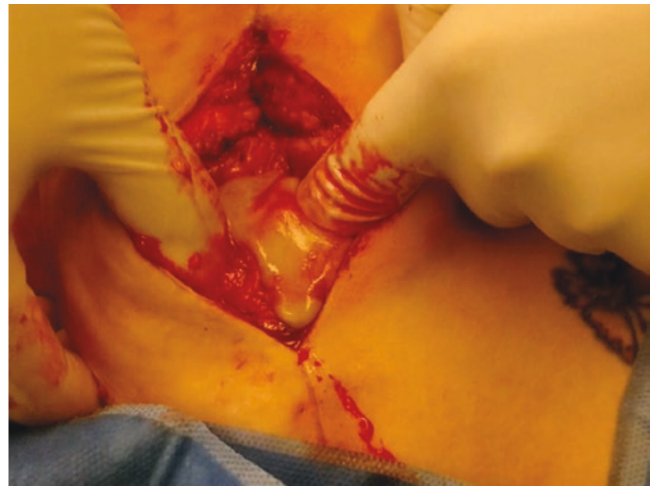

Fig. 33.7 Surgical drainage of the sterile abscess of the gluteal region

show restricted diffusion. Streaky enhancement in the subcutaneous fat corresponds to cellulitis. The first line of therapy is surgical incision and drainage of the abscess and systemic antibiotic therapy. Tissue culture, including aerobic and anaerobic, fungal, and acid-fast bacteria should be sent.

Sterile abscesses are related to a delayed-type hypersensitivity reaction to the injected filler and may present with pain, palpable mass (local tissue necrosis and liquefaction) and low-grade fever. MRI shows fluid collections with ill-defined faint enhancing margins. Surgical drainage and systemic antibiotics are the first line of treatment (Figs. 33.6 and 33.7).

Secondary lymphedema of the lower extremities consists of extracellular fluid retention caused by lymphatic obstruction that can lead to fibrosis in chronic states. On MRI, it is characterized by an increased volume of subcutaneous tissue, circumferential edema, and a honeycomb pattern above the muscle with marked thickening of the dermis. Anticoagulants, compression garments, lymphatic drainage, and physical therapy may be useful. In severe and refractory cases, dermolipectomy procedures can be done.

Filler dislocation can be clinical or subclinical. It is a mechanical phenomenon, in which the filler moves from its primary site of injection by muscular action or weight to

Fig. 33.8 Silicone dislocation from the gluteal region to the medial thigh, 18 years after liquid silicone injection

other areas of the body. Filler migration is a physiologic phenomenon in which the material injected can be carried into the lymphatic or blood vessel by macrophages or other cellular components (Fig. 33.8). Liquid silicone induces the formation of a fragile-belted fibrous capsule allowing a caudal dislocation of the material by gravity (Fig. 33.9). MRI usu-

Fig. 33.9 Silicone dislocation to the inferior aspect of the gluteal region resulting in an unaesthetic large pedunculated mass

ally shows a thick band-like silicone deposition associated with diffuse soft-tissue edema and post-contrast enhancement. Removal of the material using cannulas connected to a vacuum source, as used in liposuction can be useful for local decompression. Surgical excisions should be sidestepped, as removal will seldom result in complete removal of the material and may cause marked deformities of the gluteal region. Complete excision and reconstruction with tissue flaps or graft coverage should be reserved as a last option.

33.5 Conclusion

Gluteal augmentation with non-approved filler injections is a serious health concern. It is endemic in transgender women, but may affect all groups of the population. Patient education seems to be the only prophylaxis to prevent its complications. When treating a patient presenting complications following injection of non-approved fillers to the gluteal region, one must bear in mind that the material is probably non-medical-grade silicone. Better knowledge of the pathophysiology of these injections will lead us to improve and effectively manage patients presenting these conditions.

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Part IV

Ancillary Procedures for the Gluteal Region

34 Subcision® for the Treatment of Cellulite

Doris Hexsel, Taciana Dal'Forno Dini, and Camile L. Hexsel

34.1 Introduction

Cellulite is characterized by cutaneous relief alterations, commonly described as a quilted, cottage-cheese or "orange-peel" appearance, that result from a combination of depressed and elevated lesions on the surface of the skin [1, 2]. It is a cosmetic condition that affects nearly all women after adolescence [3]. The most commonly affected areas are the buttocks and thighs, which contain significant deposits of adipose tissue. It can also affect the abdomen, arms, and legs [2, 4].

Studies performed in cadavers, published over 30 years ago, described the anatomic basis of cellulite demonstrating that it is an expression of normal structures of the skin and the subcutaneous tissue in the affected areas [5]. Women store fat in lobes larger than those found in the adipose tissue in men, and also present a thinner dermis than men. Fat lobes are surrounded by rigid walls of connective tissue, also known as fibrous septa. These septa originate from the muscle fascia, going through the fat and connecting the skin to the subcutaneous structures [2, 4]. In women, the septa are perpendicularly oriented, whereas in men, they are mostly oblique. The traction of the septa pulling the skin down together with the accumulated fat results in the characteristic skin relief alterations found in cellulite. Indeed, subcutaneous septa are significantly associated with cellulites depressed lesions, as observed by magnetic resonance images (MRI) [6]. Cellulite severity is also associated with age and body mass index.

Cellulite Severity Scale (CSS) is a comprehensive and validated photonumeric scale developed in 2009 by the authors of this chapter, for clinical evaluation of cellulite. It assesses cellulite by addressing different morphological aspects, including the number and depth of the depressed lesions, the presence and morphological appearance of elevated lesions and the presence and degree of associated skin laxity [1]. Currently, it is widely used to evaluate the results of treatment modalities for cellulite. The appearance of cellulite changes with the position of the body. While standing, the depressed lesions are more apparent, and in decubitus position, their aspect improves. Muscular contraction and manual pinching make depressed lesions more evident as these maneuvers increase the tension over the septa. Every clinical assessment of cellulite should be made with the patient standing.

34.2 Manual Subcision®

Subcision® is a surgical technique originally described by Orentreich and Orentreich for the treatment of cutaneous depressed lesions including scars and wrinkles [7]. In 1997, Hexsel and Mazzuco described its use for the treatment of cellulite-depressed lesions, as well as for the correction of other cutaneous relief alterations due to surgery or other types of trauma outside of the face, more commonly occurring after liposuction [8]. Subcision® can be performed manually with a Subcision® needle, or with a device that uses a tissue stabilized-guided subcision system that cuts the septae (Cellfina system®), or with percutaneous subdermal delivery of laser energy [9–11].

Patients report high rate of satisfaction with the procedure after a single session and remarkable clinical improvement

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assessed by the CSS up to 7 months. Furthermore, preoperative MRI assessments showed a thick fibrous septum in the subcutaneous tissue under the cellulite-depressed lesion. Postoperative MRIs showed that the subdermal portion of the septum associated with the cellulite-depressed lesion disappeared [12]. This is probably due to the lack of vascular supply and subsequent resorption of the distal aspect cut by the Subcision® needle [12]. Subcision® is indicated only for the treatment of cellulite-depressed lesions. It has no effect on laxity and raised lesions, aspects that are also evaluated by the CSS [1].

34.3 Preoperative Evaluation

Contraindications to the procedure should be ruled out on the preoperative consultation and include local or systemic infection, pregnancy, bleeding diathesis, severe or uncompensated cardiovascular disease, and the use of medications that affect the coagulation process or interact with local anesthetics. Coagulation tests are routinely requested to exclude coagulation disorders or alterations. Additional laboratory tests are not needed unless clinically indicated. Blood thinners must be discontinued 7 days prior to the procedure to prevent excessive bleeding. Iron-containing medications and the ingestion of iron-rich food should be avoided 1 month prior to the procedure to prevent iron deposition on the skin after the procedure. Antibiotic therapy is recommended given that the procedure is performed in the buttocks and thighs, near the gastrointestinal and genitourinary tracts. Typically, a fluoroquinolone such as ciprofloxacin 500 mg starting 6 hours before the procedure and subsequently, twice a day for 3 days, allows coverage of Gram-positive and Gram-negative organisms.

Photographs to document the depressed lesions prior to treatment should be obtained without flash, with illumination coming from above and the patient standing with the gluteus muscles relaxed. With the patient in the same position, each depressed lesion that is amenable to Subcision® is marked. It is recommended to select lesions up to 3 cm in diameter or smaller, or up to 3 cm portions of larger lesions [8], to avoid hematomas and dissection planes that are too large potentially leading to complications. It is recommended to obtain photographs of the marked areas for subsequent evaluation of the response to treatment and identification of the lesions that have not been treated [2, 9, 13].

34.4 Surgical Technique

The areas to be treated must be completely cleansed with an antiseptic solution. Sterile surgical fields and sterile gown must be used. The patient is placed in ventral decubitus position. Local anesthesia with a solution of lidocaine at 0.05%

Fig. 34.1 After marking the lesions with the patient in standing position, local anesthesia is injected 1.5 cm away from the edges of the lesion, at the point of entry of the Subcision® needle. The anesthesia should comprise the entire area below the marked lesion and extend beyond the borders of the lesion

Fig. 34.2 A BD Nokor 18G needle is used to sever the septa

and epinephrine is injected retrograde in the subcutaneous plane, 2–3 cm below the surface of the skin, and up to 1 cm around the marked lesion (Fig. 34.1). A lower concentration of lidocaine solution is used to allow safe treatment of multiple lesions while still adhering to the maximum safety dose of 7 mg/kg of lidocaine with vasoconstrictor and 4 mg/kg of lidocaine without epinephrine [2, 8, 9, 13].

Subcision® is performed using a BD Nokor 18G needle (Franklin Lakes, NJ) (Fig. 34.2) preferably, or alternatively, an 18 G needle. The needle is inserted up to approximately 2 cm below the skin surface and then redirected parallel, with the cutting edge of the needle directed toward the septum that will be severed. The cutting blade is horizontally pressed against the septum to be severed while withdrawing the needle. This movement is repeated until the targeted septa are severed, releasing the traction on the skin (Fig. 34.3). Only those septa that exert traction on the skin should be sectioned as some septa must remain

Fig. 34.3 The needle is inserted approximately 1.5 cm away from the edges of each lesion to sever the underlying fibrous septa

Fig. 34.4 Pressure bandages are placed in the immediate postoperative period

intact especially in the lower buttocks and upper thighs, to avoid protrusion of subcutaneous fat. Each treated area is slightly pinched to identify whether there are residual septa pulling the skin down and whether they should be cut or not [9].

Since blood vessels accompanying the connective septa are also severed, bleeding, bruising and ecchymosis may appear, and hemostasis should be obtained with moderate and uniform pressure over the treated areas for approximately 5–10 min. A 5-kg sand bag covered in a sterile pouch may be used to allow uniform pressure on the treated regions. Pressure bandages are applied and compression garments should be worn immediately after the procedure (Figs. 34.4 and 34.5) [9, 13–15].

Fig. 34.5 Patients are instructed to use compressive garments for 15 to 30 days after the procedure.

34.5 Postoperative Period

Mild pain may occur, yet uncommon in the first 24–48 hours. Acetaminophen 500 mg every 6 hours can be used. Analgesics that have anticoagulant properties such as NSAIDS and aspirin are contraindicated. The first postoperative visit is 2–4 days after the procedure. If large hematomas are formed or if there is concern for infection, the course of the antibiotic therapy is extended. Bruising is evident from the second postoperative day (Fig. 34.6) and may worsen until the 10th day. In general, it resolves completely over 30–60 days, and the results of the procedure can be appreciated. Sun exposure should be avoided during the presence of bruising and ecchymosis. Physical activity and local massage are avoided during the first 2 weeks postop. Compression garments are maintained for 30 days after the procedure. These post-operative measures prevent worsening of the ecchymosis and excessive response (development of raised areas) in the treated areas. It also helps the healing of the treated areas [16]. Subcision® does not leave scars, as the fibrous septum are accessed via needle puncture of the skin and the septum is cut subcutaneously. The results are persistent, because it severs the subcutaneous septum resulting in an anatomical alteration of the treated areas (Figs. 34.7 and 34.8) [12].

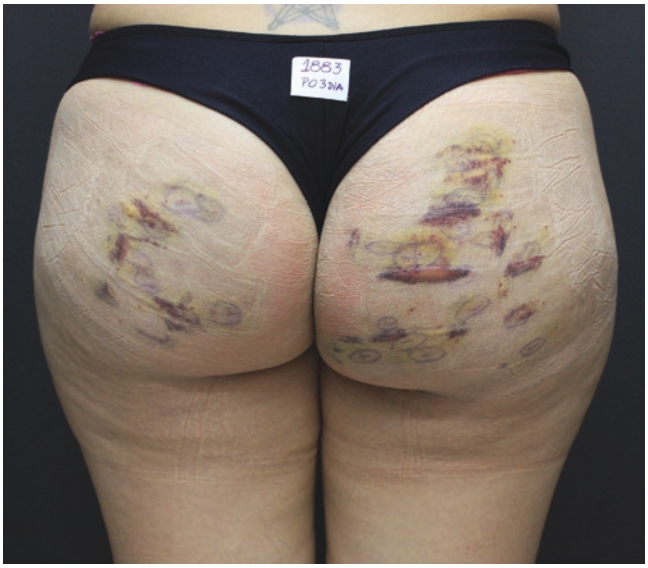

Fig. 34.6 Expected ecchymosis in the surgical area 3 days after Subcision®

34.6 Complications

Complications are generally rare and easy to manage when the proper technique is used by an experienced professional, and the recommendations followed by the patients. Bruising, ecchymosis, seroma, and local sensitivity are expected after the procedure and usually regress spontaneously. Some seromas present as palpable indurated nodules over areas of ecchymosis, and resolve spontaneously without treatment within 3 months after the procedure. Bruising can lead to iron deposition on the skin caused by hemosiderin, which presents as brown patches, and may take months to resolve. Partial and suboptimal response can occur if all the septa are not severed or if the lesions are very deep. The procedure can be repeated after at least 2 months, in the same region, provided that there are no residual complications from the previous procedure, such as iron deposition.

Excessive response can translate as raised lesions over the treated areas. This can be due to excessive fibrosis, fat herniation or if compression garments are not used for 30 days. Fibroplasia can occur when large areas are treated and when hematomas are not adequately controlled. It can be treated with local infiltration of triamcinolone. Fat herniation can arise from excessive sectioning of all the septa in certain areas or very superficial Subcision®. It can be

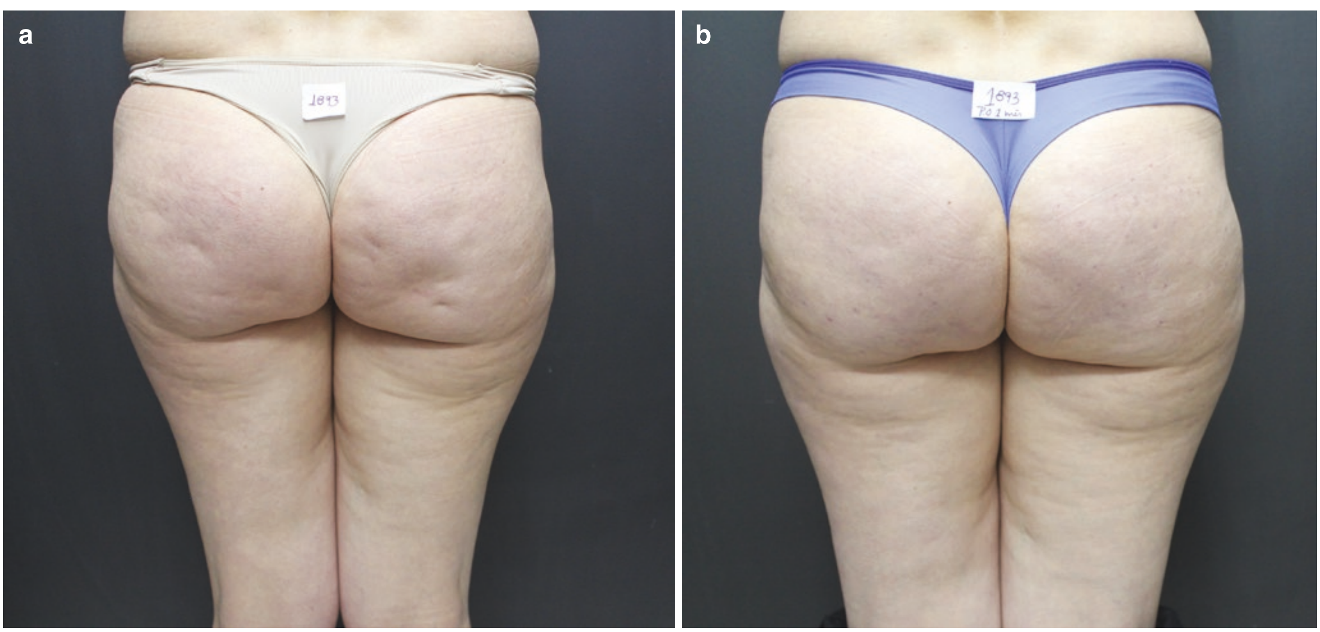

Fig. 34.7 A 47-year-old female presenting with depressed cellulite lesions in the gluteal region. (**a**) Preoperative and (**b**) 1 month post a single session of Subcision®

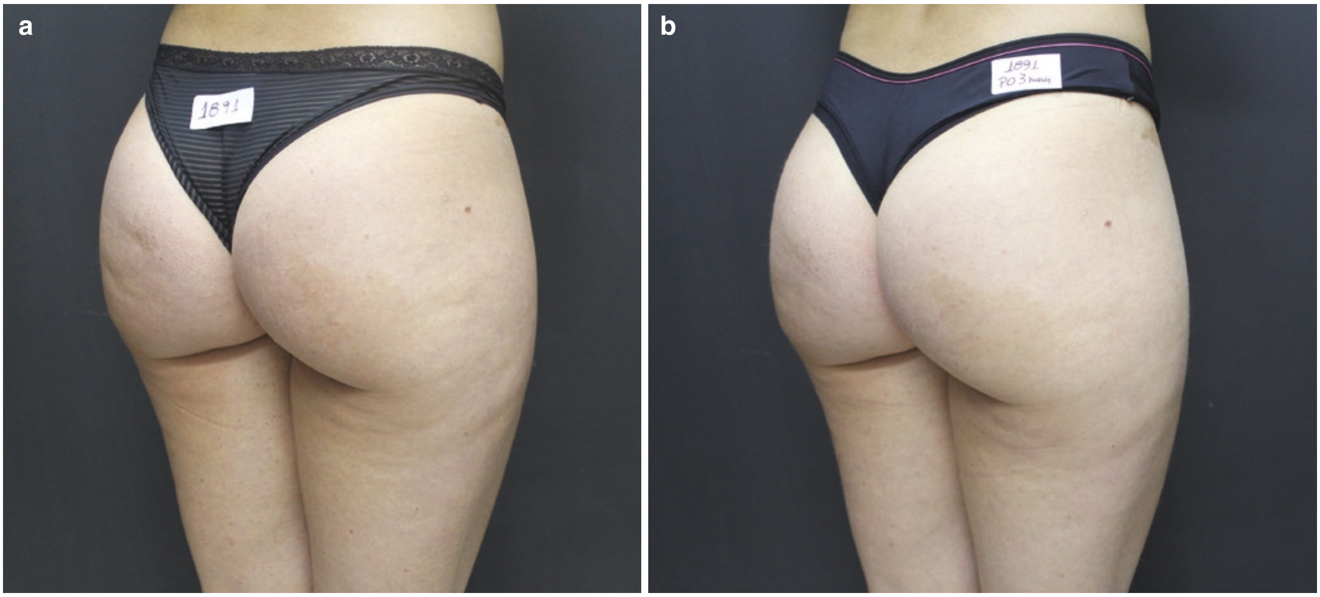

Fig. 34.8 A 38-year-old female presenting with deep depressed cellulite lesions in the left gluteus. (**a**) Preoperative and (**b**) 3 months post a single session of Subcision®

treated with localized liposuction and prolonged compression. High risk areas for over sectioning of the septum and fat herniation include the lower buttocks and the upper thighs. Excessive response can also occur if compression garments are not used for 30 days in the post-operative period.

Infection, bleeding, erythema, edema, contact dermatitis can also occur. Hypertrophic and keloid scar formation or necrosis of the treated areas have not been reported. Most complications can be minimized if the pre, intra, and postoperative recommendations are followed [2, 9, 13, 15]. These are all complications the authors have seen in more than 2000 patients treated over the last 20 years.

34.7 Subcision® by Tissue Stabilized-Guided Subcision® System

Cellfina® system (Merz, Germany) was developed for the treatment of cellulite-depressed lesions and is based on the principles of manual Subcision®. It delivers precise control of anesthesia infiltration (integrated 22-G needle) and user-selected treatment depth (0.6 or 1 cm) and area (5 cm or 3 × 6 cm) with a 0.45 mm microblade. Tissue release is achieved by a combination of reciprocating (forward and backward) and lateral (side-to-side) microblade motions [17] (Figs. 34.9 and 34.10).

A multicenter pivotal study evaluated a single treatment session of Subcision® with vacuum-assisted precise tissue release in 55 subjects. The primary release depth was 6 mm, with the 10 mm depth used for sites immediately adjacent to the ones treated at 6 mm, in order to prevent seroma formation. Statistically significant CSS score reductions from baseline were seen at 3 months and 1 year. Physician-graded global aesthetic improvement scale (GAIS) assessments showed marked improvement in 74.5% and 72% of subjects at 3 months and 1 year, respectively. Patient satisfaction was 85% at 3 months and 94% at 1 year. Highest pain scores (0–10) were observed during infiltration (mean 4.5), with some subjects experiencing mild "aching" pain for up to 6 months posttreatment. Other adverse events, including ecchymosis, edema, palpable firmness, and tingling were mild, transient, and resolved spontaneously. The 3-year follow-up assessments were performed in 45 patients, and long-lasting results were noted [10]. This study allowed Food and Drug Administration (FDA) approval of the claim of long-lasting results for Cellfina® system.

Fig. 34.9 Cellulite treatment with tissue stabilized-guided subcision system (Cellfina®)

34.8 Subcision® by Laser

Disruption of subcutaneous fibrous septae can also be performed with percutaneous subdermal delivery of laser energy [11, 18]. Although 1064-nm and 1320-nm laser wavelengths can be used effectively for this purpose, a 1440-nm laser device (Cellulaze® system, Cynosure, Inc., USA) has been the most studied for the treatment of cellulite. A prospective study of 25 female subjects with a mean age of 40 years old evaluated the efficacy of this device for cellulite grades II and III in the posterior and lateral thighs [16]. Independent physicians and subjects GAIS scores showed mild improvement in cellulite severity at 6 months (N = 20) and 2 years (N = 16) [16].

Another study [11] evaluated the use of this same laser in 57 patients with a mean age of 43 years old. Blinded physician evaluation showed improvement in the dimple count and contour irregularity in 96% of the treated areas at 6 months posttreatment. Follow-up evaluation at 1 year revealed that 90% of the treated areas maintained the improvement in both categories. At least 90% of physicians and subjects reported satisfaction with the results at 6 months [11]. A similar study [18] confirmed these findings, with 94% of subjects showing improvement in dimple count and contour irregularity at 6 months with 3D imaging. Adverse events (e.g., edema and ecchymosis) were mild and transient in both studies [11, 18].

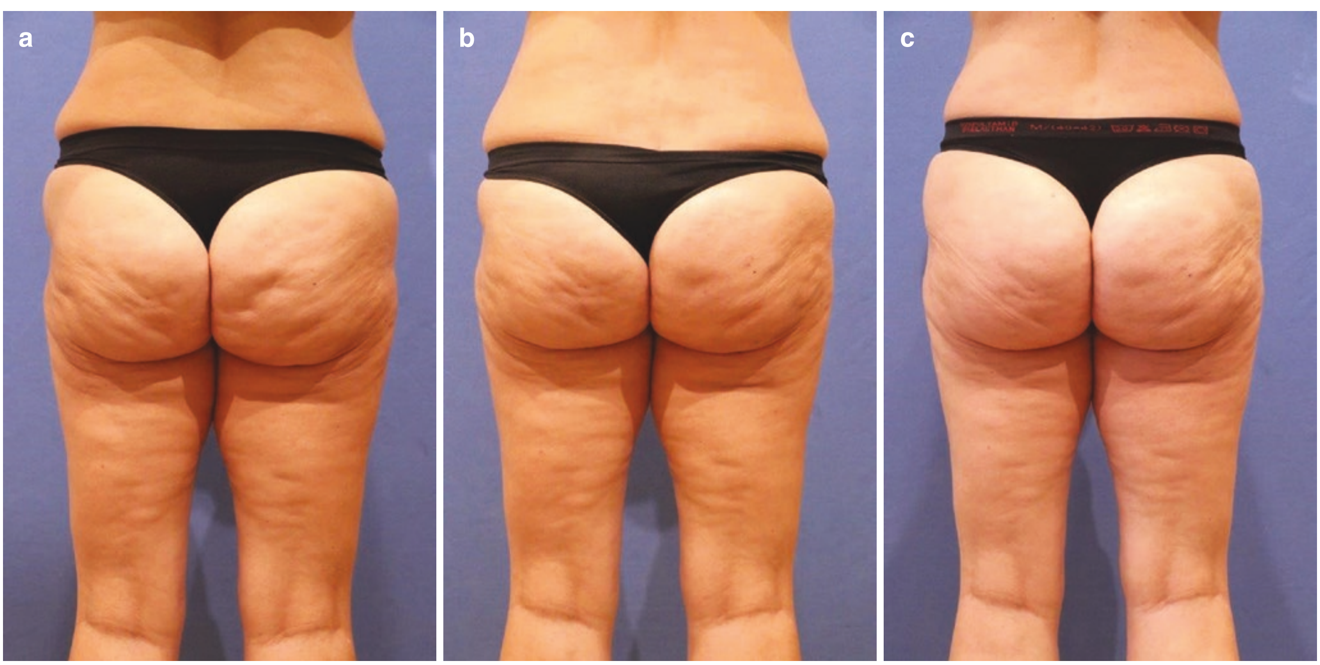

Fig. 34.10 Subcision® treatment of depressed lesions of cellulite. Left side was done with manual Subcision®, the right side with Cellfina. (**a**) Preoperative, (**b**) 6 weeks postoperative, and (**c**) 6 months postoperative. (Pictures are courtesy of Dr. Sonja Sattler)

34.9 Conclusion

Cellulite is a very common cosmetic complaint of women after adolescence. Many treatments have been proposed in the literature, but clinical efficacy is not always as high as expected. Subcision® is a safe and efficient treatment for the depressed lesions of cellulite. It is not effective for skin laxity or raised lesions, which may also accentuate cellulite appearance. The results of Subcision® are persistent. The recommendations widely discussed in this chapter are very important for the success of the treatment and to minimize complications.

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35 Management of Stretch Marks with Pigment Structuration

Ana Paula Camargo Ferreira

35.1 Introduction

Stretch marks are common and affect both men and women, but occur more frequently in women. While stretch marks rarely cause medical problems, they are considered to be of major aesthetic concern and often have a negative impact on the self-esteem and quality of life of an individual [1, 2]. Medically known as *striae distensae* (SD), they can be found on any part of the body including the breasts, abdomen, hips, thighs, and gluteal region [3]. There is a relationship between pregnancy, obesity, and the occurrence of stretch marks [4]. They have also been observed in bodybuilders who experience a rapid increase in muscle mass [5]. Once formed, stretch marks become permanent scars with dyschromia compared to the adjacent skin [6, 7].

35.1.1 Histology

Two types of collagen are primarily active in skin matrix formation: type III and type I collagen. Type III collagen, also known as embryonic collagen, consists of three alfa 1 chains and is of moderate stability, flexibility, and elasticity. Younger skin contains a large amount of type III collagen [8]. Type I collagen consists of two alfa 1 chains and one alfa 2 chain. It is highly stable, with limited flexibility and elasticity. Elderly skin consists of 80% type I collagen and only 20% type III collagen [8] at a ratio of type I/III collagen of 4:1. This ratio in the skin determines its elasticity. If type III is more prevalent, stretch marks are less frequent; while if the prevailing collagen is type I, then stretch marks are more common. In addition, there is a genetic predisposition for the formation of stretch marks [9].

35.1.2 Types of Stretch Marks

There are two types of stretch marks; *striae rubrae* (acute) and *striae albae* (chronic) [10]. The *striae rubrae* are characterized by erythematous, flat or raised, linear lesions, aligned perpendicular to the direction of skin tension lines and they can be symptomatic. The *striae albae* are characterized by atrophic, wrinkled, and hypopigmented lesions [10–12].

35.1.3 Current Treatment for Stretch Marks

Several treatments have been proposed in an attempt to obtain aesthetic improvement of stretch marks [13]. Preventative measures against stretch mark formation have been popularized with the use of creams, massage, gymnastics, and aromatherapy, etc. However, these measures are superficial and short-lived [9]. While light and laser therapies have shown some improvements in the appearance of striae, it is uncertain which technology works best and at what stage (*rubrae* or *albae*) they should be used. There are a few randomized controlled trials evaluating the long-term efficacy and safety of various topical treatments and energy-based devices. Based on clinical and anecdotal experience, non-ablative and ablative fractionated lasers have shown modest striae distensae improvement compared to other treatment modalities (including Excimer laser, CuBr laser, pulsed dye laser, and 1064-nm Nd:YAG laser) [14]. Laser is mainly used on early stage striae distensae. The complete removal of the lesions is rare; thus, earlier treatment is recommended. Percutaneous collagen induction with microneedles (PCIM) is a treatment option that stimulates collagen production without causing total de-epithelialization seen in ablative techniques [15].

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35.1.4 Camouflaging Skin Defects

Camouflage makeup is an alternative form of treatment used to complement medical or surgical therapy. It can cover topical blemishes and imperfections such as those seen in patients with vitiligo or melasma [16]. Permanent camouflage uses tattoo techniques to improve the appearance of skin imperfections.

35.2 Patient Selection

Patients presenting with *striae rubrae* are adequate candidates for traditional stretch mark treatments, while patients with *striae albae* do not respond well as they present at a later stage. Patients with thick striae and a significant difference in skin texture have a 50–70% improvement in the stretch mark appearance, but they do not completely disappear. Patients with thin *striae* without texture irregularities have the best results with an 80–100% improvement. Fortunately, the majority of *striae* in the buttocks and the thighs are thin (Fig. 35.1); therefore, the results are more noticeable. Patients with a tendency toward hyperpigmented scars must be advised as to the possibility of transitory hyperpigmentation in the treated areas. These can take between 6 and 12 months to resolve. Tattooing should be avoided when the skin is tanned, as the tattoo will appear darker than the surrounding skin [10]. After the treatment, if the patient decides to tan naturally, the striae that have been treated will not well respond to sunlight, due to the absence of melanocytes, and can become visible again.

Fig. 35.1 *Striae albae,* ideal condition for pigment structuration with predictable positive results

35.3 Materials and Machines

35.3.1 Coin Machine

This is the most common machine used by tattoo artists (Fig. 35.2a). It consists of one or two coins that generate a magnetic force that attracts an iron bar (Armature), connected to a needle that is then introduced into the dermis. For each downward movement, the connection between the bar and the contact screw is broken. This stops the electric current from passing and the magnetic force ceases. When the armature bar returns to its original position, the electric current is reestablished generating the magnetic force once more. This process occurs continuously enabling repetitive perforations of the skin, creating access to the papillary dermis layer. This mechanism allows the physician to manage and control the pressure applied to the tissue, and adjust the depth at which the tattoo ink is introduced into the dermis.

35.3.2 Needle

A 5-point or a 7-point magnum safety needle is most commonly used. When the *striae* are very thin, a 3-point needle is preferred. A compatible grip is used to support the corresponding needle. During adjustment or when the machine is turned off, the needle tip must retract into the grip in order to avoid potential damage to the tissue during the procedure. Both the grip and needle are sterile and discarded after use (Fig. 35.2b).

35.3.3 Inks

Every country has specific regulations with regards to the type and use of tattoo inks. All physicians interested in working with pigment structuration should only use inks that are approved for use (Fig. 35.2c). Nontoxic carriers and pigments are recommended when possible. In special cases, vegan inks free from animal byproducts are available.

35.3.4 Materials

The support tray (Fig. 35.2d) is used to hold different ink colors and one spot is reserved for petroleum jelly

Fig. 35.2 Materials and machines used to perform pigment structuration. (**a**) Coin machine. (**b**) Needle and grip. (**c**) Inks. (**d**) Ink support tray. (**e**) Petroleum jelly. (**f**) Chlorhexidine solution. (**g**) Gauze. (**h**) Power supply

(Fig. 35.2e). Chlorhexidine solution is used for asepsis (Fig. 35.2f). Sterile gauze (Fig. 35.2g), gloves, a mask, and a cap are used.

35.4 Selection of Colors

Selecting colors is perhaps the most challenging part of the procedure. The physician must make the distinction between the subtleties of hue and tone between the inks. A slight difference in tonality can have a significant impact on the results. The colors used to camouflage striae are: beige skin, light skin, dark skin, white, yellow, and light brown. They can be applied individually or mixed. The molecular weight of the inks may be different. Therefore, care should be taken to create an evenly balanced mix of colors and textures. It is better to use all pigments individually in layers, ensuring the appropriate quantity is applied at each stage. All tattoo inks must be discarded 3 months after opening to reduce the risk of contamination.

35.5 Anesthetic

A local anesthetic cream is applied on the area to be treated 1 hour before the procedure. However, some patients may still feel discomfort and pain. Therefore, injectable lidocaine must be available on the tray so that it could be added to the mixture of inks and applied during the procedure with the coin machine. Lidocaine infiltration is not recommended as it can modify the thickness of the skin and the ink could be distributed into the wrong skin layer. This would result in a superficial application of the ink causing the camouflage to be nonpermanent.

35.6 Technique

The coin machine is used to perform the pigment structuration. It enables greater precision, and with proper care, the complication rate is low and the results predictable. It should be adjusted in order to allow the needle to penetrate the skin at a maximum depth of 1 mm. The tattoo ink should be deposited in the papillary dermis. The machine should be set at 5 –7 volts to prevent damage to the epidermis. After asepsis with alcoholic chlorhexidine, sterile petroleum jelly is applied on the skin to minimize trauma. The needles must be placed at a 60 degree angle of the striae, in order for the pigment to be applied into the dermis.

The scars and striae are linear, hence their visibility. The pigment should be applied in such a way to interrupt these lines. The needle is dragged smoothly over the area to be treated in lateral strokes, creating pits and punctures in a scattered way as to interrupt the lines. It is the same concept as W-plasty and Z-plasty. If the inks were applied linearly, the striae would become more apparent.

35.7 Post Procedure

Immediately after the procedure, the striae disappear (Fig. 35.3a). A few minutes after, swelling develops over the whole area treated and lasts 1–2 days (Fig. 35.3b). The patient is allowed to wash the treated areas with liquid soap. No ointment should be applied and clothes should not be tight. No swimming for 15 days and no sun exposure for 2 months.

Fig. 35.3 An illustration of two stages during pigment structuration. (**a**) Disappearance of the *striae alba* during the procedure. (**b**) Evidence of swelling as a result of the procedure observed immediately after the procedure

35.8 Results

The final results are visible approximately 40 days after the procedure (Fig. 35.4). If required, the patient may at this time undergo an additional session to enhance the results. In some cases, where striae are close to each other, the swelling makes it difficult to distinguish each striae and adequately treat them. Patients must be advised that the color, the smoothness, and linear appearance of the striae will change; however, the texture and thickness of the skin will not change. The tattoo may fade over time as the pigment becomes less concentrated. The procedure may be repeated in order to camouflage the striae.

35.9 Complications

- Difficulty matching the natural skin color with synthetic material: Technical difficulties may occur when the professional does not have experience working with different colors of inks, in which case the mixture of colors applied to camouflage the striae may not blend with the surrounding skin. The ink may also be applied too deep and fade quickly. In these cases, structural pigmentation must be repeated.
- Hyperchromia: If the patient develops hyperchromia in the surrounding areas of the treated striae, conservative treatment such as avoiding sun exposure, hydration of the skin should be done (Fig. 35.5).
- Infection: If adequate measures of asepsis are not taken, infections of the treated areas may occur. Oral antibiotics are prescribed for 5–7 days. After a case of infection, the tattoo inks that were used should be discarded.
- Allergic reactions: Allergic reactions to red tattoo pigments are the most common. Mercury contained in the pigment was thought to be the cause; however, even though mercury is no longer used in the majority of these pigments, red tattoo allergic reactions continue to occur [17].

Patch tests have been used to identify allergy to mercuric chloride, but they do not identify cinnabar. Alternative red dyes have been used; however, allergic reactions are still reported [18]. Therefore, in sensitive patients, it is strongly recommended to avoid the red color ink.

Fig. 35.4 *Striae albae*, camouflage with pigment structuration technique in the right gluteal region – (**a**) Preoperative (posterior view). (**b**) Preoperative (oblique view). (**c**) Postoperative day 40 (posterior view). (**d**) Postoperative day 40 (oblique view)

Fig. 35.5 *Striae albae*, 40 days after camouflage with pigment structuration evolving with the complication of hyperpigmentation

35.10 Conclusion

Pigment structuration is effective in camouflaging the perceived flaws especially in gluteal region. Further feedback from patients and practitioners has yielded positive results from both a psychological and physiological perspective.

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