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Editor

Managing Common and Uncommon Complications of Aesthetic Breast Surgery

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Editor
John Y. S. Kim
Feinberg School of Medicine
Northwestern University
Chicago, IL
USA

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Dedicated to the love and sacrifices of parents everywhere (JJ and CY) and to the future being laid down for others (Ae^3)

Preface

Experience is simply the name we give our mistakes.
Oscar Wilde

Aesthetic breast surgery is a central pillar of modern plastic surgery. There are almost half a million cosmetic breast surgeries performed in the USA alone and 90% of board-certified plastic surgeons perform aesthetic breast surgery. [1, 2]Despite its ubiquity, aesthetic breast surgery has low complication and high satisfaction rates. This means that sundry adverse events such as ruptures, capsular contractures, implant malpositions, and asymmetries will be relatively rare. Hence, the genesis of this book: to offer the perspective of surgeons who have seen, thought about, and worked through the common and uncommon problems of aesthetic breast surgery.

It is said that the basis of surgery is anatomy, and I would suggest that the important corollary to this is that the basis of *fixing* surgical problems is also anatomy. Accordingly, this book begins with a distillation of key relevant highlights of embryology and anatomy of the breast. Then we turn to common problems in breast surgery, stratified by implant-related surgery and breast lifts and reductions. The juxtaposition of manipulated soft tissues with fallible devices necessarily creates the occasional conflict. This, in turn, manifests as diverse phenomena such as rupture, capsular contracture, implant malposition, animation, double capsules, double-bubbles, and even an uncommon form of surface texture–associated lymphoma. Our authors plumb the pathophysiology of these processes in detail and propose carefully crafted, practical, and experientially tested solutions.

Beyond implants, mastopexies and breast reductions engender their own complications through violations of blood supply and the natural healing process. Experts offer perspectives on scarring, wound healing, infections, pedicle choice, and varying concomitant cancer-related topics. The intersection of reductions/mastopexies and implants lends itself to aesthetic synergies with improved shape and volume. Our authors illuminate their decision-making process for these complex procedures and help steer away from problems (and navigate toward solutions when they arise).

Over the last decade, there has also been an intensified interest in new techniques and technologies for not only traditional breast surgery but also for more modern permutations such as transgender and male breast surgery. The influx of novel technology platforms such as radiofrequency devices, 3D imaging, and absorbable mesh has enabled surgeons to improve outcomes while limiting the impact of complications and technical malfeasance. Our authors also ensure that clear indications and technical pearls are provided for less common procedures such as transaxillary breast augmentation and neo-subpectoral pocket conversions.

Oscar Wilde's truism that experience equates with error has marked resonance in surgery. The sum of our satisfactory outcomes will not teach us as much as the sporadic experiences of

[1]American Society of Plastic Surgery. 2018 Procedure Statistics. https://www.surgery.org/sites/default/files/ASAPS-Stats2018_0.pdf. Accessed May 11, 2020.

[2]American Society for Aesthetic Plastic Surgery. Cosmetic (Aesthetic) Surgery National Databank 2018. https://www.surgery.org/sites/default/files/ASAPS-Stats2018_0.pdf Accessed May 15, 2020.

missed expectations or frank failure—as long as we strive to learn from each and every one of these complications. Therein lies the essence of this book: it provides a means to learn from the experience and error of others. This gift of experience is willingly shared by us with you—our reader and colleague—through this book.

On behalf of my fellow authors,

John Y. S. Kim, MD, MA

Contents

Contributors

Yoav Barnea, MD Plastic and Reconstructive Breast Surgery Unit, Plastic Surgery Department, Tel-Aviv Sourasky Medical Center, Sackler Faculty of Medicine, Tel-Aviv, Israel

Hilton Becker, MD, FACS Boca Raton Regional Hospital, Hilton Becker MD, Clinic of Plastic Surgery, Boca Raton, FL, USA

M. Bradley Calobrace, MD, FACS Clinical Faculty, Division of Plastic Surgery, University of Louisville, Louisville, KY, USA

Clinical Faculty, Division of Plastic Surgery, University of Kentucky, Louisville, KY, USA

Wen-Kuan Chiu, MD Department of Surgery, Taipei Municipal Wanfang Hospital, Taipei City, Taiwan

Karan Chopra, MD Department of Plastic and Reconstructive Surgery, Johns Hopkins University, Baltimore, MD, USA

Ian Chow, MD Department of Plastic Surgery, University of Pittsburgh Medical Center, Pittsburgh, PA, USA

Mark W. Clemens, MD, FACS Department of Plastic Surgery, MD Anderson Cancer Center, Houston, TX, USA

Robert Cohen, MD, FACS Scottsdale Center for Plastic Surgery, Paradise Valley, AZ, USA

Ahmed Taha Darwish, MD Department of Plastic Surgery, University of Cairo, Cairo, Egypt

Carolyn DeLaCruz, MD Department of Plastic Surgery, University of Pittsburgh Medical Center, Pittsburgh, PA, USA

Jeena M. Easow, MD, MPH University of Miami/Jackson Memorial Hospital, Division of Plastic, Aesthetic and Reconstructive Surgery, Miami, FL, USA

DeWitt Daughtry Family Department of Surgery, University of Miami, Leonard M. Miller School of Medicine, Miami, FL, USA

Alexander R. Facque, MD The Center for Gender Confirmation Surgery, Louis A. Weiss Memorial Hospital, Chicago, IL, USA

Neil A. Fine, MD, FACS Northwestern Specialists in Plastic Surgery, Chicago, IL, USA

Megan Fracol, MD Department of Surgery, Northwestern University, Feinberg School of Medicine, Chicago, IL, USA

Jordan D. Frey, MD Hansjörg Wyss Department of Plastic Surgery, NYU Langone Medical Center, New York, NY, USA

Or Friedman, MD Department of Plastic Surgery, Tel-Aviv Sourasky Medical Center, Tel-Aviv, Israel

Allen Gabriel, MD, FACS Department of Plastic Surgery, Loma Linda University Medical Center, Loma Linda, CA, USA

Robert D. Galiano, MD, FACS Department of Surgery, Plastic and Reconstructive Surgery Division, Northwestern University, Chicago, IL, USA

Caroline A. Glicksman, MD, MSJ Department of Surgery, Hackensack Meridian, School of Medicine at Seton Hall, Sea Girt, NJ, USA

David W. Grant Division of Plastic and Reconstructive Surgery, Department of Surgery, Washington University School of Medicine, St. Louis, MO, USA

Joseph M. Gryskiewicz, MD, FACS Cleft Palate and Craniofacial Clinics, University of Minnesota School of Dentistry, Burnsville, MN, USA

Austin Y. Ha, MD Division of Plastic and Reconstructive Surgery, Department of Surgery, Washington University School of Medicine, St. Louis, MO, USA

Kent K. Higdon, MD, FACS Department of Plastic Surgery, Vanderbilt University Medical Center, Nashville, TN, USA

Ji-Cheng Hsieh, BA Department of Surgery, Plastic and Reconstructive Surgery, Northwestern University, Chicago, IL, USA

Dennis J. Hurwitz, MD Department of Plastic Surgery, UPMC Magee Woman's Hospital, Pittsburgh, PA, USA

Chitang J. Joshi, MBBS, MD Division of Plastic and Reconstructive Surgery, Northwestern University, Chicago, IL, USA

Nolan S. Karp, MD Hansjörg Wyss Department of Plastic Surgery, NYU Langone Medical Center, New York, NY, USA

Daniel J. Kedar, MD Plastic and Reconstructive Surgery Department, Tel-Aviv Sourasky Medical Center, Sackler Faculty of Medicine, Tel Aviv, Israel

John Y. S. Kim, MD Feinberg School of Medicine, Northwestern University, Chicago, IL, USA

G. Patrick Maxwell, MD Department of Plastic Surgery, Loma Linda University Medical Center, Loma Linda, CA, USA

Chet Mays, MD Clinical Faculty, Division of Plastic Surgery. University of Louisville, Louisville, KY, USA

Patricia McGuire, MD Washington University, and Parkcrest Plastic Surgery, St. Louis, MO, USA

Rafael Mendoza, MD Department of Surgery, Plastic and Reconstructive Surgery Division, Northwestern University, Chicago, IL, USA

Lauren M. Mioton, MD Department of Plastic and Reconstructive Surgery, Northwestern Memorial Hospital, Chicago, IL, USA

Terence M. Myckatyn, MD, FACS, FRCSC Division of Plastic and Reconstructive Surgery, Department of Surgery, Washington University School of Medicine, St. Louis, MO, USA

Ali A. Qureshi, MD Marina Plastic Surgery, Marina del Rey, CA, USA

Charles Randquist Department of Plastic and Reconstructive Surgery, Victoriakliniken, Saltsjobaden, Sweden

Timothy M. Rankin, MD, MS Department of Plastic Surgery, Vanderbilt University Medical Center, Nashville, TN, USA

Ara A. Salibian, MD Hansjörg Wyss Department of Plastic Surgery, NYU Langone Medical Center, New York, NY, USA

Loren S. Schechter, MD, FACS The Center for Gender Confirmation Surgery, Louis A. Weiss Memorial Hospital, Chicago, IL, USA

Michael Scheflan, MD Department of Surgery, Assuta Medical Center, Tel Aviv, Israel

Clark F. Schierle, MD, PhD Northwestern Specialists in Plastic Surgery, Chicago, IL, USA

Kenneth C. Shestak, MD Department of Plastic Surgery, University of Pittsburgh Medical Center, Pittsburgh, PA, USA

W. Grant Stevens, MD University of Southern California, Marina Plastic Surgery, Marina del Rey, CA, USA

Eric Swanson, MD Private Practice, Leawood, KS, USA

Marissa M. Tenenbaum, MD Division of Plastic and Reconstructive Surgery, Department of Surgery, Washington University School of Medicine, St. Louis, MO, USA

Blair A. Wormer, MD Department of Plastic Surgery, Vanderbilt University Medical Center, Nashville, TN, USA

Part I

Implants and Breast Augmentation

Breast Embryology and Anatomy

1

John Y. S. Kim and Megan Fracol

Introduction

Anatomy forms the critical underpinning of surgery, and the dual interests of form and function in breast surgery are beholden to anatomy to ensure good outcomes. For instance, in a mastopexy or reduction, the aesthetic remodeling of nipple position and the skin envelope must respect the limits of perfusion and vascular territories. Accordingly, in this chapter, we review breast anatomy with specific attention to the vascular supply to the nipple-areolar complex (NAC), pedicles that will support a perfused NAC, innervation to the nipple, pectoralis anatomy with respect to breast surgery, and the structural characteristics of the inframammary fold (IMF).

Embryology and Development

Breast development begins prenatally, around 4–6 weeks of gestation [1, 2]. During this time, mammary progenitor cells of ectodermal origin form the mammary crest, which is a paired line that gently curves from the axilla to the inguinal region bilaterally (Fig. 1.1) [1]. Most of the mammary crest atrophies to leave paired primary breast buds at the fourth intercostal space [3]. These ectodermal cells subsequently invaginate into the underlying mesoderm and begin to form the network that will eventually become the lactiferous acini and ducts, or the gland itself [4]. The mesenchymal cells will eventually form into adipocytes, fibroblasts, and smooth muscle cells to become the future stroma surrounding the breast gland [4].

By the end of the first trimester, the mammary bud is largely formed. During the second trimester, secondary branching patterns off the initial mammary bud continue to invaginate into the underlying mesenchyme to form a more complex network of mammary ducts [5]. This continues into the third trimester until birth. By birth, the breast gland contains around 15–20 lobes, each with their own lactiferous duct drainage system that converges on the nipple [1].

After birth and during the first 2 years of life, both male and female infants will have transient breast enlargement and some will secrete milk from the rudimentary breast gland [6, 7]. All of these changes are dependent on fluctuating hormone levels in the newborn, in large part mediated by estradiol. By 2 years of age, however, the breast gland becomes quiescent until puberty [8, 9].

Breast development is the first sign of puberty in the female and is dependent not only on estrogen but also on growth hormone and insulin-like growth factor-1 [10]. On average, the mature breast forms between 8 and 13 years of age and is considered pathological if no breast development occurs by 14 years. The Tanner stages are commonly used to describe the stages of pubertal breast development and are as follows: Tanner stage 1 – elevation of the papillae; Tanner stage 2 – formation of a small mound of breast tissue with enlargement of the areola and elevation of the nipple; Tanner stage 3 – further breast and areola enlargement; Tanner stage 4 – secondary breast mound creation due to enlargement of the nipple and areola; and Tanner stage 5 – areola recession onto the breast mound and final breast contour (Fig. 1.2) [11].

Malformations of the breast can occur during embryogenesis, leading to clinical sequelae such as tuberous breast deformity or Poland syndrome (absence of the pectoralis with deficiency in the breast volume). Such malformations can be present at birth (as in some cases of Poland syndrome that are associated with other abnormalities), while others may not manifest until puberty (as can be the case with tuberous breast deformity, which becomes more apparent with puberty).

Lactation is the basic function of the breast. Based on a study by Cruz et al., there is no difference in breast feeding

J. Y. S. Kim (✉)
Feinberg School of Medicine, Northwestern University, Chicago, IL, USA
e-mail: john.kim@nm.org

M. Fracol
Department of Surgery, Northwestern University, Feinberg School of Medicine, Chicago, IL, USA

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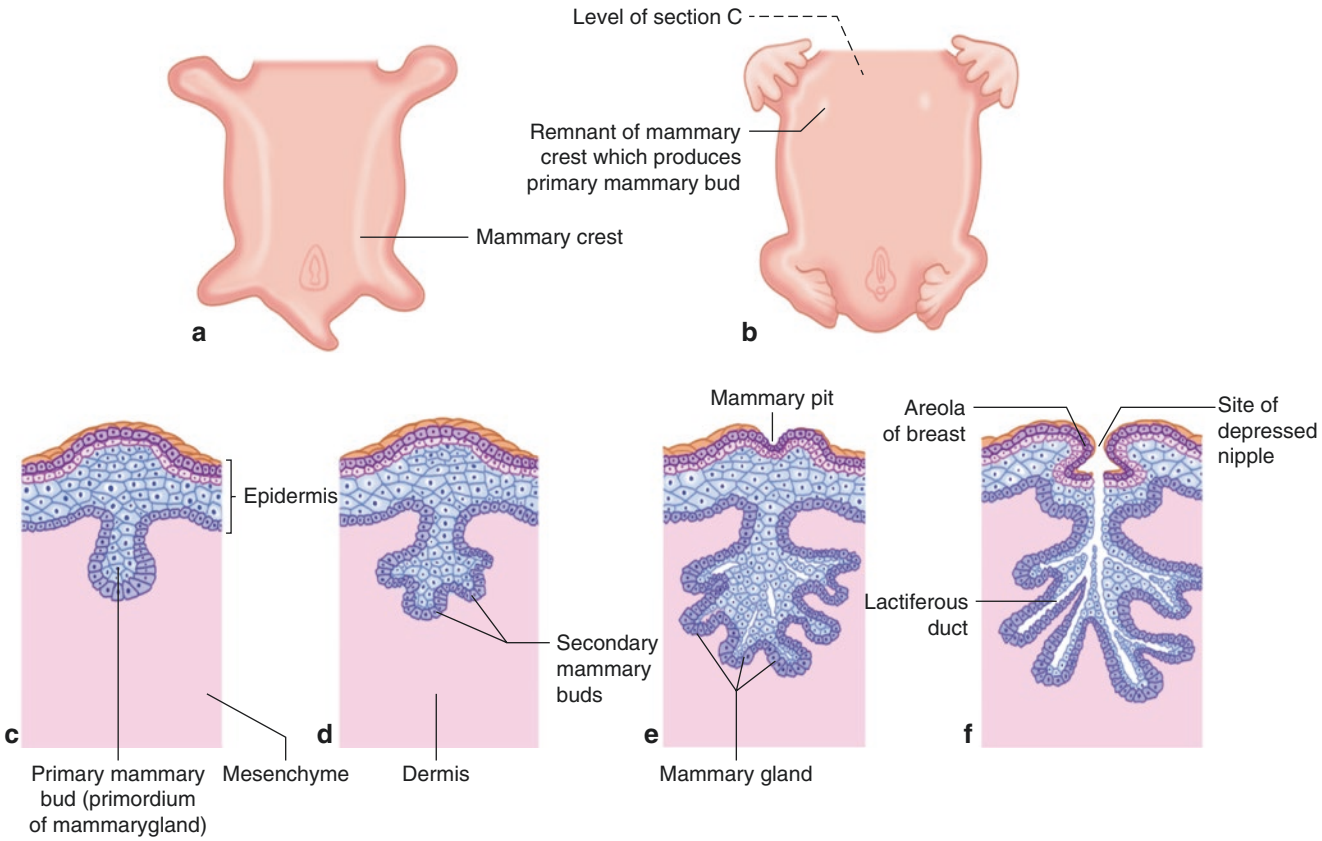

Fig. 1.1 Embryologic development of the mammary gland occurs through paired mammary crest lines that curve from the axilla to the groin. The paired mammary buds atrophy with the exception of those at the fourth intercostal space which go on to become the breast gland. (**a**) Prenatal breast development (4–6 weeks gestation) showing mammary progenitor cells of ectodermal origin along the mammary crest (white curved line). (**b**) Atrophy of mammary crest leading to paired primary breast buds. (**c**) Histologic cross section of primary mammary bud (end of first trimester). (**d**) Secondary branching patterns forming secondary mammary buds (second trimester). (**e**) Ongoing branching patterns with development of a mammary pit (third trimester). (f) Development of lactiferous ducts, the areola, and nipple structures (by birth)

success between women who have undergone breast reduction compared to women with macromastia but no surgical breast history [12]. On average, around 60% of women were able to successfully breastfeed in both cohorts. Furthermore, pedicle choice for breast reduction also had no impact on breast feeding success.

Blood Supply to the Nipple-Areolar Complex

Understanding – and managing – the blood supply to the nipple-areolar complex (NAC) is a central tenet of breast surgery. An important initial point is that perfusion to the nipple can be a distinct clinical process from perfusion to the breast gland itself; hence isolated NAC ischemic compromise can exist concomitantly to a well-perfused breast [13]. While significant variations in the blood supply to the NAC have been described, most authors agree the dominant supply comes from the internal mammary and lateral thoracic arteries, with minor contributions arising from the thoracoacromial and intercostal vessels [13–16]. In general, the internal mammary and lateral thoracic arteries course toward each other medially and laterally, in a segmental pattern, to meet and anastomose around the nipple. Occasionally, however, one of these two sources is missing [13, 17]. Other times, inferior-based branches from the fourth through sixth intercostal arteries will run perpendicular to this network, coursing cranially until they anastomose with internal mammary vessels (Fig. 1.3) [13]. Other vessels that have been mentioned in the literature but less reliably described include the superficial thoracic artery and the highest thoracic artery [17]. Thus, as described, the relative contribution and frequency of each of the major blood vessels may vary.

In the 1930s and 1940s, Marcus and Maliniac described findings from cadaver dissections, with three major patterns of blood supply to the breast gland: that from the internal mammary plus lateral thoracic arteries (50% of the time), that from the internal mammary and intercostal arteries (30% of the time), and that from the internal mammary, lateral thoracic, and intercostal arteries (18% of the time). The blood supply to the NAC mimicked this pattern in their dissections, with 74% having ring anastomoses coming from the internal

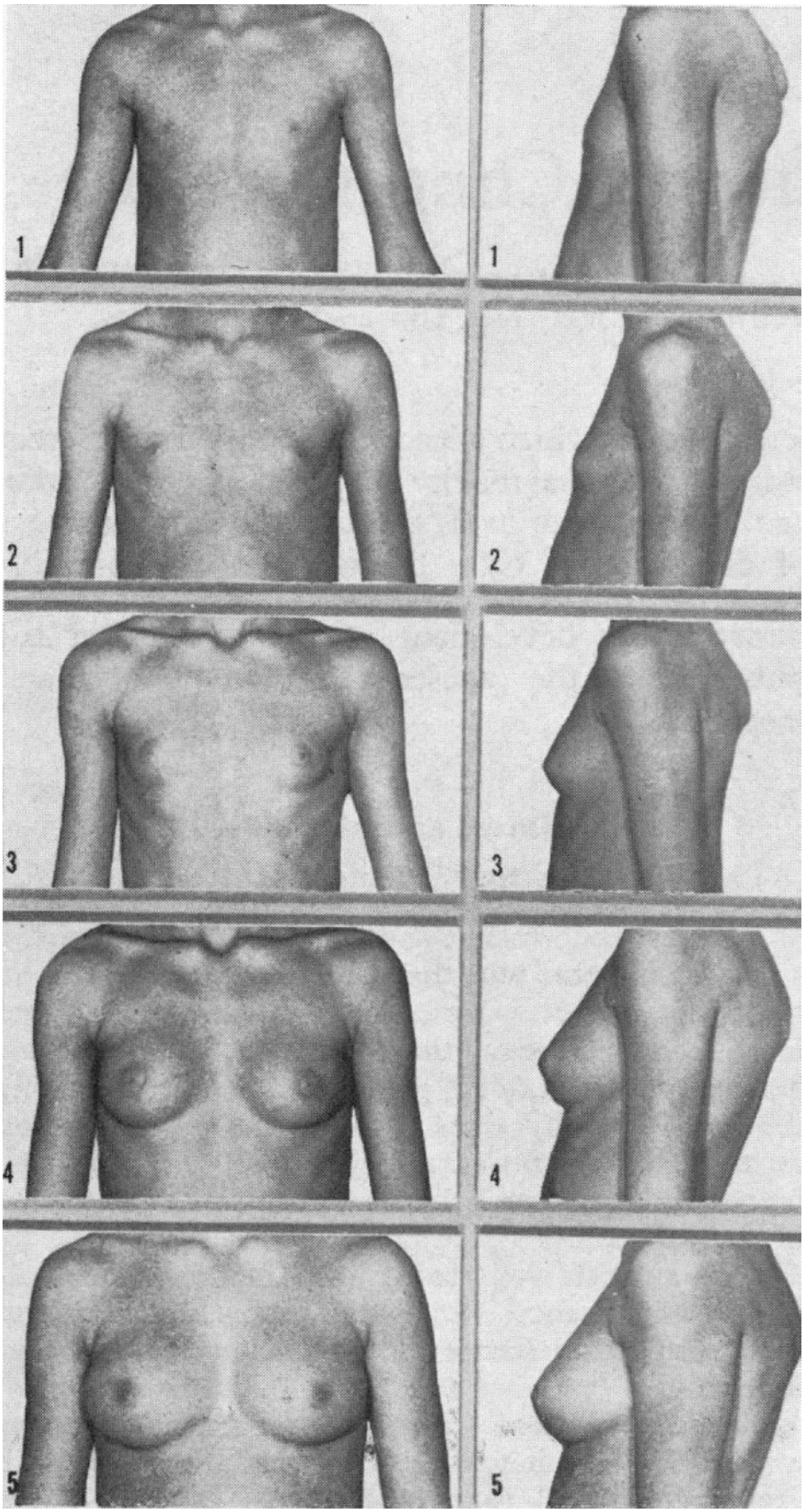

Fig. 1.2 Stages of Tanner development. (Reprinted from Marshall and Tanner [11], with permission from BMJ Publishing Group Ltd.)

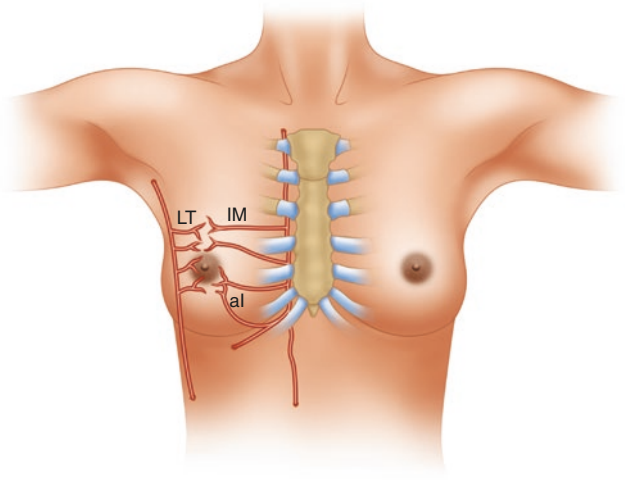

Fig. 1.3 Blood supply to the NAC can come from three major arterial networks. The internal mammary (IM) and lateral thoracic (LT) arteries send perforators that run in a horizontal direction, while the anterior intercostal (aI) arteries also send perforators that run in a vertical direction

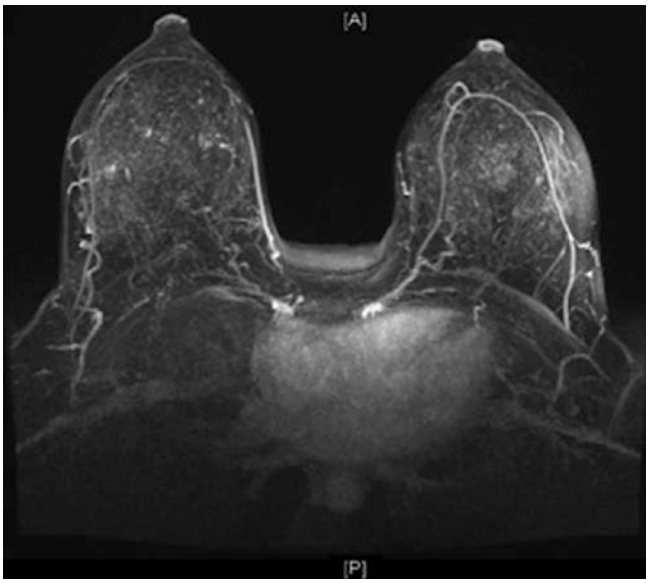

Fig. 1.4 Functional MRI demonstrates perfusion to the breast gland comes primarily from medial and lateral perforators. (Reprinted from Seitz et al. [22], Copyright 2015, with permission from Elsevier)

mammary artery, 20% having loop anastomoses coming from the lateral thoracic artery, and 6% being perfused radially from all directions with no dominant blood supply [18, 19]. More recent cadaver studies similarly found the lateral thoracic and internal mammary arteries to be dominant suppliers to the NAC, although they differ on which of these is the more frequent sole supply [13, 16, 17].

Other important findings include a network of vessels supplying the NAC that arises around the level of the inframammary fold (IMF) as well as descriptions of separate cranial and caudal networks of NAC supply separated by a fibrous horizontal septum through the breast, originating from the lateral thoracic/thoracoacromial and internal mammary/intercostal vessels, respectively [20, 21]. Notably, the arterial supply courses in the subcutaneous tissue, around 1–2 cm below the skin [16].

More recently, functional studies have been performed to evaluate in vivo perfusion of the NAC in real time. An MRI study by Seitz et al. largely confirmed the cadaver findings of Marcus and Maliniac 80 years previously [22]. They identified dominant blood supply to the NAC based on the dominant blood vessel filling 70 s after contrast infusion. Ninety-six percent of NACs were supplied by a medial vessel, with this representing the sole dominant blood supply in over half. Forty-two percent of NACs had multizone blood supply with the most common being a combination of medial and lateral and the second most common being a combination of medial and central blood vessels (Fig. 1.4). It was rare for a NAC to have a sole lateral or central only blood supply (less than 2% of the time for each). Intraoperative use of indocyanine green (ICG) and infrared camera is a newer tool in the breast surgeon's armamentarium that has been used to study intraoperative perfusion to the NAC during mastectomy [23]. This study found three patterns of perfusion to the NAC: that from the underlying breast (type V1), that from the surrounding skin (type V2), and that from both (V3). While perfusion from the underlying breast was the least common supply (18% of NACs), these were significantly more likely to end up with ischemia (71% of NACs with this pattern).

Lastly, while arterial inflow to the NAC has tended to be the focus of cadaver studies, it is also important to understand venous drainage patterns, particularly given this is the predominant cause of NAC compromise in breast reduction surgery. Both a superficial and deep venous drainage system exist, with the deep system accompanying the major arteries to the breast. It is the superficial system that is largely responsible for drainage of the NAC [20, 24]. The venous drainage of the NAC begins immediately below it in the subdermal plexus. It then radiates out in all directions; however, dominant drainage tends to course superomedially and inferiorly to the IMF (Fig. 1.5) [25, 26]. Dominant drainage from both these patterns tends to converge upon the second through fifth intercostal spaces. While lateral drainage patterns do exist, they tend to enter the breast parenchyma shortly after draining the NAC and run a deeper course [26].

Pedicles to the Nipple-Areolar Complex

Essentially, the NAC can be maintained on a pedicle from any direction in the breast. However, certain pedicles are more reliable than others given what we now know about perfusion

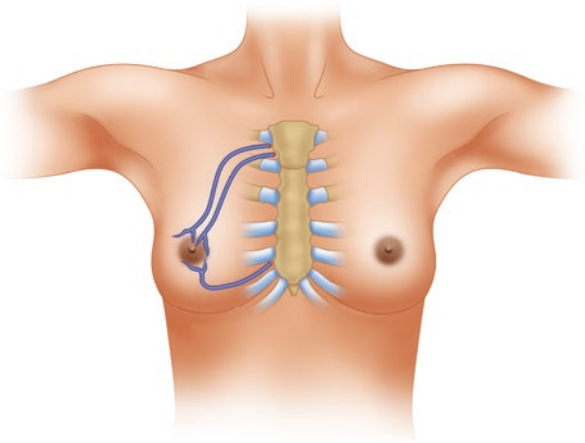

Fig. 1.5 Venous drainage of the NAC occurs primarily in a dermal network that courses superomedially as well as inferiorly

patterns. Two key points should be emphasized: first, the most robust pedicles are those originating from the medial and lateral positions as this is where the dominant pedicles (internal mammary and lateral thoracic) originate from. Second, any pedicle can be made more robust by incorporating more than one quadrant of the breast (i.e., a superomedial pedicle is more robust than a medial-only pedicle).

To review, pedicles are supplied as follows: inferior by anterior intercostal perforators (fourth through sixth); medial by internal mammary and anterior intercostal perforators (third through fifth); lateral by lateral thoracic perforators; and superior by internal mammary, anterior intercostal (second), and thoracoacromial perforators (Fig. 1.6) [17]. Again, combinations of these pedicles will be more robust: a superomedial pedicle will be supplied by both the second and the third through fifth anterior intercostal perforators.

Innervation to the Breast and Nipple-Areolar Complex

Preserving nipple innervation during breast surgery can help preserve sensual function and breastfeeding potential [27, 28]. Nerve injury even in straightforward breast augmentations is probably more common than realized, with an estimated risk around 10–15% based on meta-analysis [29]. The most commonly injured nerves are the cutaneous intercostal nerves supplying the breast skin, followed by those supplying the NAC. More rarely, the intercostobrachial nerve and long thoracic nerve will be injured. Sensory deficits after breast augmentation have been reported in a meta-analysis, with pain occurring in 7.51% of cases, hyperesthesia in 4.71% of cases, hypoesthesia in 8.72% of cases, and numbness in 2.28% of cases [29]. Three prospective studies have been performed that have objectively examined changes in breast sensation after augmentation. While one study found no changes in pre- to postoperative sensory levels, two other studies found significantly decreased postoperative sensation [30–32]. Both these studies found sensory changes were most likely to be found around the NAC and the inferior pole of the breast [31, 32]. One study found sensory recovery to be slower in older patients [31]. The other study found larger implants and smaller breasts were more likely to be affected by decreased sensation [32]. A better understanding of nerve supply to the breast and NAC may help the plastic surgeon avoid sensory deficits after breast surgery.

The skin overlying the breast is innervated by the second through sixth intercostal nerves both laterally and medially [33, 34]. Laterally, the intercostal nerves branch into a posterior and anterior division, the latter of which innervates the breast from the lateral aspect. Medially, the anterior cutaneous branches of the intercostal nerves innervate the breast (Fig. 1.7). These nerve branches all travel in a superficial subcutaneous position as they arborize into the overlying dermis, with the exception of the fourth intercostal nerve which has a deep branch in addition to the superficial anterior division. This deep branch of the fourth intercostal nerve travels in a retromammary position before becoming superficial and traveling toward the NAC from an inferolateral direction (Fig. 1.8). The superior breast skin also receives some innervation from the supraclavicular nerve.

The NAC receives innervation from the second through fifth intercostal nerves. However, it is the lateral fourth intercostal nerve that predominates in supplying the NAC, with the deep branch of the lateral fourth intercostal nerve representing the largest branch [33]. This is of particular significance when performing a subglandular breast augmentation as the deep branch of the nerve is sometimes encountered as it passes in the retromammary space before coursing superficially and thus should be preserved to retain full nipple sensation. Even if severed, the nipple can retain its sensation via a rich network of nerve plexus supplied from both the medial and lateral aspects of the breast. This overlapping innervation is evident in retained nipple sensation from a variety of pedicle locations with varying orientation of glandular resection [35, 36].

Pectoralis Muscle Anatomy

The pectoralis major and minor muscles are frequently encountered in breast surgery and often dissected as part of the breast pocket in both breast augmentation and breast reconstruction cases. Thus, an understanding of pectoralis blood supply, innervation patterns, and functional anatomy is important.

The blood supply to the pectoralis major comes from the pectoral branch off the thoracoacromial artery. This vessel

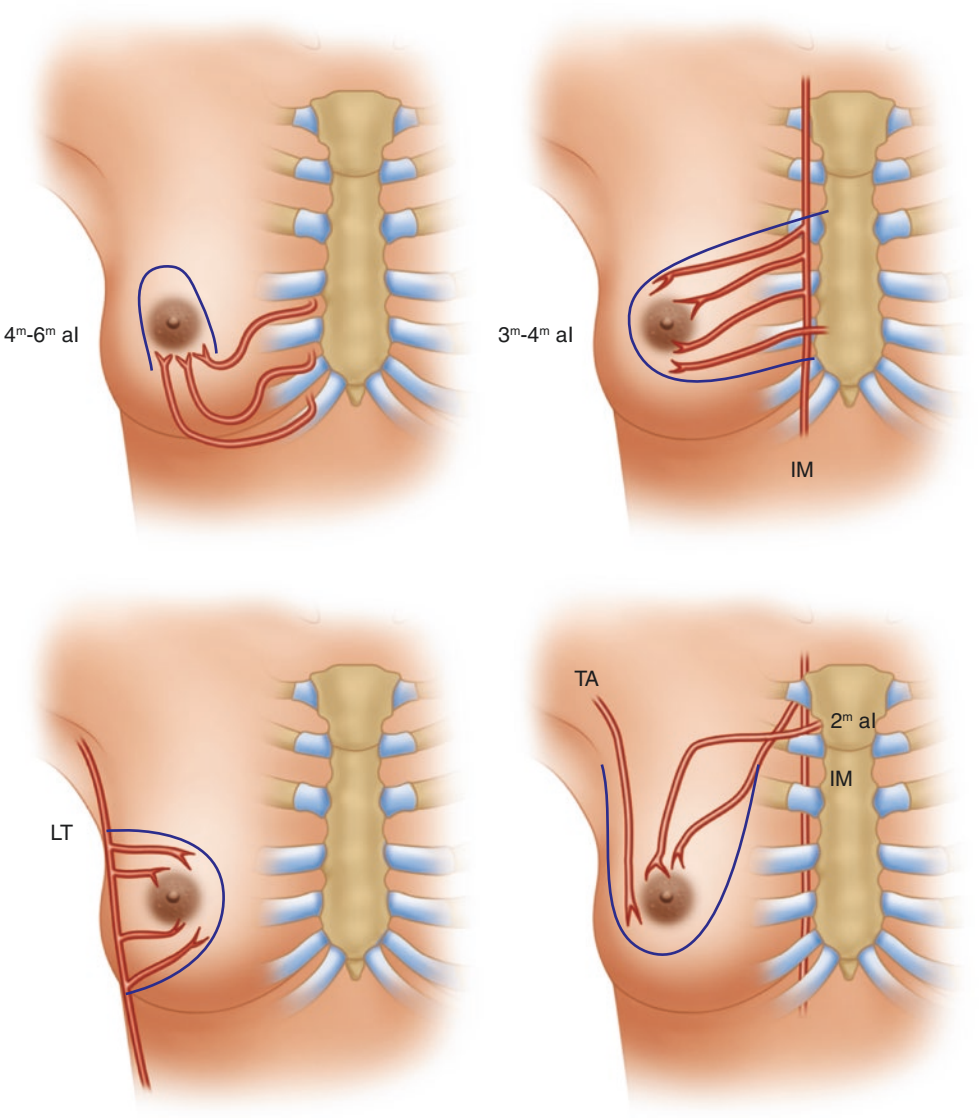

Fig. 1.6 Major pedicles to the breast include the internal mammary perforators medially, intercostal perforators both medially and inferiorly, lateral thoracic perforators laterally, and thoracoacromial perforators superolaterally. An inferior pedicle (upper left) is based on perforators from the fourth to sixth anterior intercostal (aI) arteries. A medial pedicle (upper right) is based on perforators from the third to fourth anterior intercostal (aI) arteries. A lateral pedicle (lower left) is based on perforators from the lateral thoracic (LT) artery. A superior pedicle (lower right) is based on perforators from the thoracoacromial (TA) artery, the second anterior intercostal artery (aI), and direct perforators from the internal mammary (IM) artery

courses on the undersurface of the pectoralis major muscle and above the pectoralis minor muscle. Additional blood supply comes from internal mammary perforators. Thus, the pectoralis major has a dual blood supply and is classified as a Mathes-Nahai Type V flap (one dominant pedicle and secondary segmental pedicles) [37]. The dominant pedicle to the pectoralis major muscle (off the thoracoacromial trunk) enters the muscle just lateral to the midpoint of the clavicle and approximately 8.8 cm inferior to the clavicle, usually at the third rib or third intercostal space [38].

Nerve innervation to the pectoralis muscle is slightly more complex and our understanding of the innervation pattern has changed with time. Confusion partly comes from the fact that the medial and lateral pectoral nerves are named with respect to their origin off the brachial plexus, but their courses cross such that the lateral pectoral nerve actually lies medial to the medial pectoral nerve distally [39, 40]. Originally, the pectoralis major was believed to be innervated by two major nerve branches: that from the medial and that from the lateral pectoral nerves [41]. More recent studies, however, identify three major nerve branches to the pectoralis [42–44]. In a cadaver study by David et al., three consistent nerve branches to the pectoralis major were identified: a superior branch innervating the clavicular head, a middle branch innervating the upper portions of the sternocostal head, and an inferior branch innervating the lower portions of the sternocostal head (Fig. 1.9) [45].

This triplet innervation resonates with a former study by Tobin in 1985 that described three functional subunits to the pectoralis muscle [46]. These three functional subunits had separate blood supply, separate innervation, and separate tendinous insertions. He described a clavicular portion that

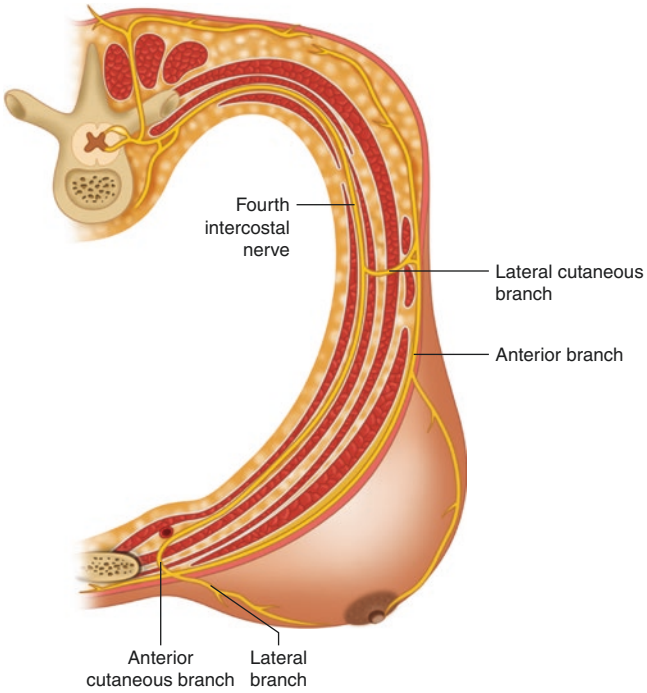

Fig. 1.7 Sensation to the overlying breast skin comes from the anterior and lateral intercostal nerves. The anterior intercostal nerves have a lateral branch that goes on to supply overlying breast skin, while the lateral intercostal nerves have an anterior branch that goes on to supply overlying breast skin

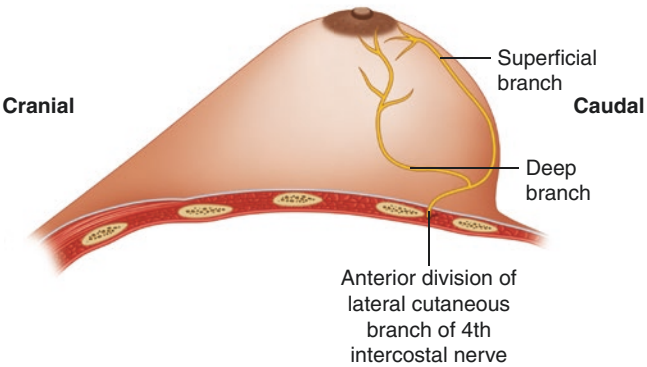

Fig. 1.8 The deep branch of the fourth lateral intercostal nerve supplies the NAC from a deep plane, where it courses subglandularly before coursing superficially from the inferolateral direction of the breast

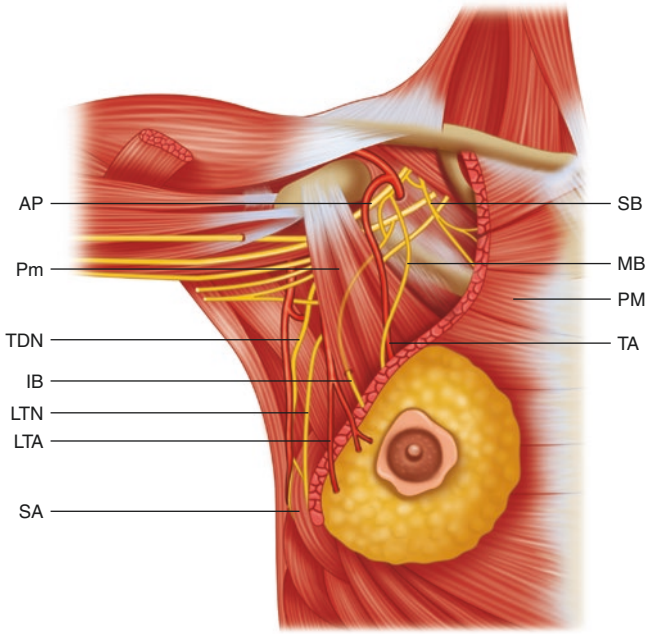

Fig. 1.9 Nerve innervation to the pectoralis major can be divided into three major branches: a superior branch supplying the clavicular portion, a middle branch supplying the upper sternal portion, and an inferior branch supplying the lower-most sternal portion

was supplied by a superior branch of the thoracoacromial artery, innervated by the lateral pectoral nerve, and inserted as the ventral portion of the U-shaped tendon. The sternocostal segment was the second described functional subunit and made up the majority of the muscle bulk. This subunit was supplied by an inferior branch of the thoracoacromial vessels, innervated by both medial and lateral pectoral nerves, and inserted as the inferior cup of the U-shaped tendon. The external segment was the name given to the lateral-most portion of the muscle that sometimes consisted of sternocostal fibers and sometimes consisted of fibers that exclusively originated on the upper abdominal wall. This subunit was supplied sometimes by a lateral branch of the thoracoacromial vessels, sometimes by lateral thoracic perforators, and sometimes by both. It was solely innervated by medial pectoral nerve branches and inserted as the dorsal portion of the U-shaped tendon.

These functional subunits of the pectoralis are important to understand as this functional anatomy may give rise to animation deformity in breast augmentation and breast reconstruction. It has been noted the average vector of implant displacement in animation deformity is 62° in the superolateral direction, which is approximately parallel to the action of the inferior-most pectoralis fibers and likely part of what Tobin described as the "external segment" of the pectoralis (Fig. 1.10) [47]. While many authors have advocated for enhanced understanding of neurovascular anatomy to avoid damage to the pectoralis in breast surgery, other authors have noted that selective damage to the medial pectoral nerve (otherwise noted as the inferior pectoral nerve by David et al.) can actually be beneficial in weakening this most inferior aspect of the muscle to improve breast projection and decrease animation [41, 48].

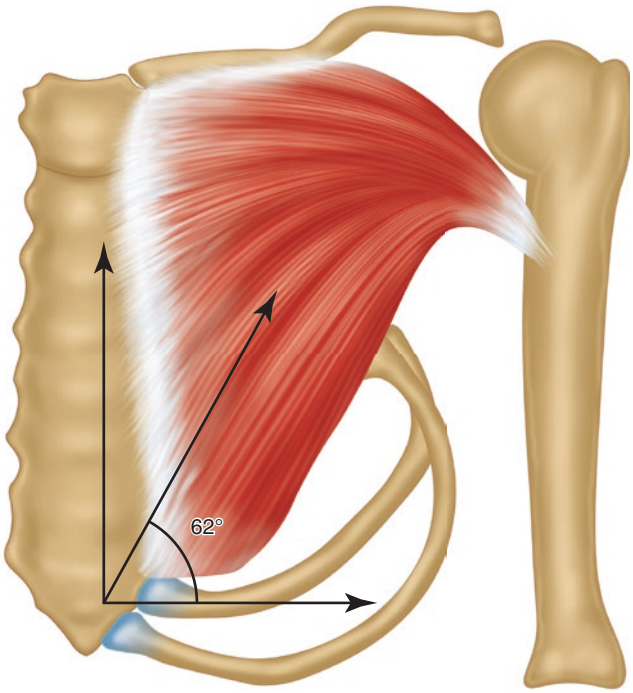

Fig. 1.10 Animation deformity pushes the implant in a superolateral direction with pectoralis contraction. The average vector of nipple displacement is 62° in the superolateral direction, approximately parallel to the action of the lower pectoralis fibers

Fig. 1.11 Histology demonstrating the dermal thickening and connections between the superficial and deep fascia at the IMF. (Reprinted with permission from Muntan et al. [49])

What Is the IMF?

Historically, debate existed over whether the IMF arises from a ligamentous structure or not [48, 49]. While a ligament by definition does connect two pieces of tissue, histologic exam of the IMF shows a thickening of the deep dermis with connections between the superficial fascia and deep fascia of the chest muscles rather than a true ligament (Fig. 1.11) [50]. Collagen fibers below the IMF are organized and oriented parallel to its axis, unlike subdermal collagen fibers found elsewhere in the body [51]. Notably, the IMF appears to be a two-part structure, consisting of both the connection between the superficial and deep fascia and the dermal condensation above the superficial fascia (Fig. 1.12). This is evident in that the IMF position can change if dissection proceeds inferiorly enough between fascial layers, but the crease is retained due to the dermal thickening [51].

Technical errors can lead to asymmetry in the position of the IMF or violation of the IMF itself. In such instances, recreating the fold can be accomplished by promoting scarring of opposing tissue layers at the desired level. This can be done surgically, as in the case of capsulorrhaphy, or can also be done in the immediate postoperative period nonsurgically when early malposition is identified with the use of breast "braces." Mills et al. described the use of the shoelace breast cast – a nonoperative technique that utilizes shoe laces wrapped around the neck and inferior pole of the breast to act as a brace that promotes scarring at the desired level of the IMF [52].

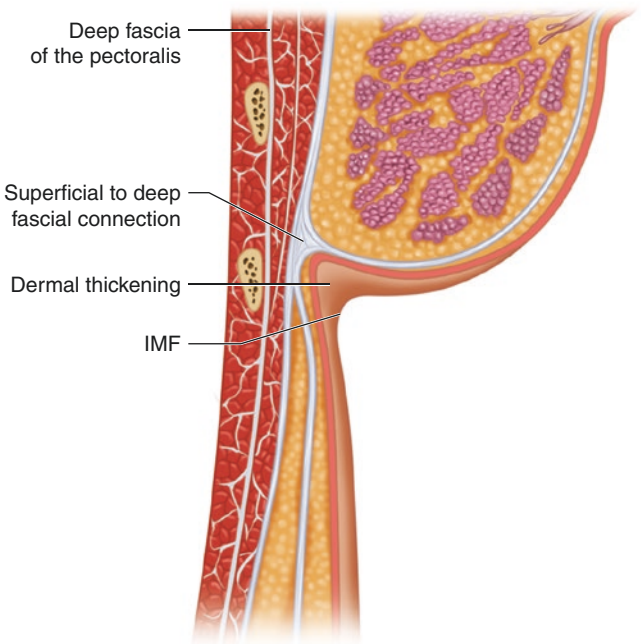

Fig. 1.12 The IMF is a two-part structure composed both of a dermal thickening and connections between superficial and deep fascia

Conclusion

While other parts of the body have been claimed by various surgical specialties, the breast is one area that will likely remain within the plastic surgeon's sole realm. As such, a thorough understanding of breast anatomy is essential to any plastic surgeon's practice. This chapter focused on perfusion and drainage patterns of the breast with key attention to the NAC to prevent disastrous outcomes. Further understanding of the innervation pattern to the nipple and the elusive structure of the IMF will help augment the plastic surgeon's ability to enhance the natural beauty of the breast.

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Double Bubble: An Anatomic Analysis and Management Algorithm

2

Megan Fracol and John Y. S. Kim

Introduction

"Double-bubble" deformity is an uncommon complication of breast augmentation surgery that denotes the appearance of two asymmetric and separate breast mounds ("bubbles"). The superior mound, bounded inferiorly by a transverse crease across the lower pole of the breast, represents the native breast tissue. The inferior breast mound represents downward descent of the prosthesis below the level of the native IMF (Fig. 2.1).

Much of this phenomenon is due to violation of the inframammary fold (IMF), and a better understanding of IMF anatomy is critical to not only avoiding this complication but correcting this if it occurs. This chapter reviews IMF anatomy: etiologies, incidence, risk factors, prevention of double bubble, and techniques for repairing a double bubble when it does occur.

What Is the IMF?

Historically, debate has existed over whether the IMF arises from a ligamentous structure or not. The ligamentous and fascial networks of the breast were first described by Sir Astley Cooper in 1845. Additional anatomic reports initially described a ligamentous structure arising from the fifth rib periosteum medially and the space between the fifth and sixth ribs laterally, creating the IMF [1–3].

More recent cadaveric and histologic studies, however, have failed to identify a true ligamentous structure and rather depict the IMF as a complex fascial network. Lockwood was one of the first to detail the superficial fascial systems throughout the body, including the breast [4]. He described a fascial zone of adherence at the level of the IMF. Later histologic exams of the IMF by other authors have confirmed connections between the deep fascia of the breast and superficial fascia of the chest muscles [5]. In addition to these deep fascial connections, the IMF is also created more superficially by changes in the intradermal collagen network. Collagen fibers at the IMF demonstrate an intradermal condensation. These fibers are organized and oriented parallel to the IMF axis, unlike subdermal collagen fibers found elsewhere in the body (Fig. 2.2) [6].

Multiple authors have described the IMF as a two-part structure (Fig. 2.3). Muntan performed 12 cadaver dissections and described 2 horizontal membranous sheets at the IMF with varying degrees of fusion between cadavers [7]. The more superficial horizontal sheet continued as a fascial layer anterior to the breast gland, while the posterior horizontal sheet continued posterior to the breast gland. Salgarello and Visconti described their findings from 4 cadaver dissections and over 200 intraoperative breast augmentation dissections. They identified a two-part fascial structure whereby the superficial pectoral fascia fanned into two wings at the level of the IMF: a superior wing that inserts into the subcutaneous tissue of the IMF and an inferior wing that continues caudal to blend into the rectus abdominis fascia [8]. Matousek further identified a triangular fascial condensation at the level of the IMF with two directions of fibers: superior fibers inserting into the lower pole glandular tissue and inferior fibers inserting into the dermis at the level of the IMF [9].

There is direct clinical relevance to this two-part structure of the IMF: when performing cranio-caudal dissection, the IMF position can change if dissection proceeds inferiorly and deep enough between fascial layers, but the crease is retained due to the more superficial structural components [6].

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M. Fracol
Department of Surgery, Northwestern University, Feinberg School of Medicine, Chicago, IL, USA

J. Y. S. Kim (✉)
Feinberg School of Medicine, Northwestern University, Chicago, IL, USA
e-mail: john.kim@nm.org

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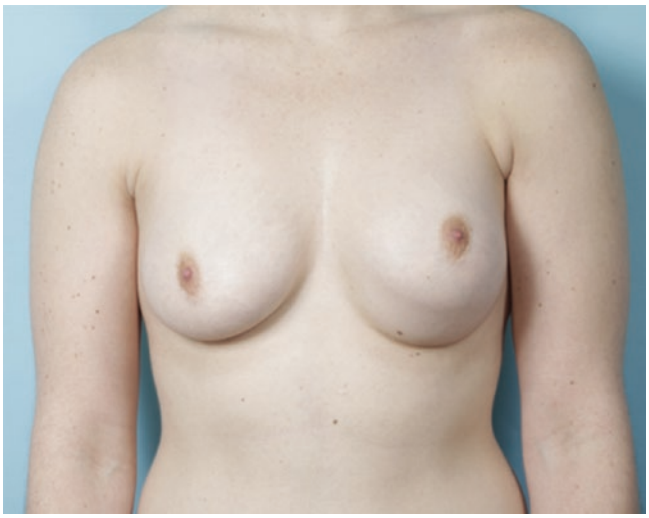


Fig. 2.1 Example of double deformity in the left breast. The transverse crease across the lower breast represents the native inframammary fold. The mound below this crease is created by downward descent of the implant. The mound above this crease is the native breast tissue

Translating IMF Anatomy to Iatrogenic Deformities: Pathophysiology of Double-Bubble Deformities

As described in the previous anatomy section, the IMF can be thought of as a two-part structure: a superficial structure that inserts into the dermis and a deeper structure that anchors the fascial condensation to the chest wall. With this framework, we can now understand how double-bubble deformity occurs and why it is more prone to occur in a submuscular augmentation plane. When dissecting under the pectoralis, violation of the deeper fascial structures anchoring the breast gland to the chest wall can occur without violation of the more superficial inframammary crease attachments. This results in double bubble when the implant slides inferiorly. Figure 2.4a, b demonstrates this anatomic relationship between the plane of dissection, implant descent, and the location of the IMF crease.

While the focus of this chapter is on double-bubble deformity, there are also proximate IMF-related deformities, most notably the clinical complication known as "bottoming out."

Bottoming out is the consequence of inferior pocket overdissection in addition to violation of the IMF. While both bottoming out and double-bubble deformity are a consequence of IMF violation, the specific deformity that manifests is dependent on the depth of fascial dissection [8]. Violation of the superficial fascial structures releases the inframammary crease, effectively destroying it and allowing the implant to slide inferiorly (bottom out). Figure 2.4b, c demonstrates how the two deformities develop with violation at these different fascial levels. Sub-glandular implant placement may lead to bottoming out but rarely leads to double-bubble deformity since inferior overdissection would release this superficial fascial network. Moreover, subglandular pocket conversion is one technique for correction of double bubble after subpectoral augmentation.

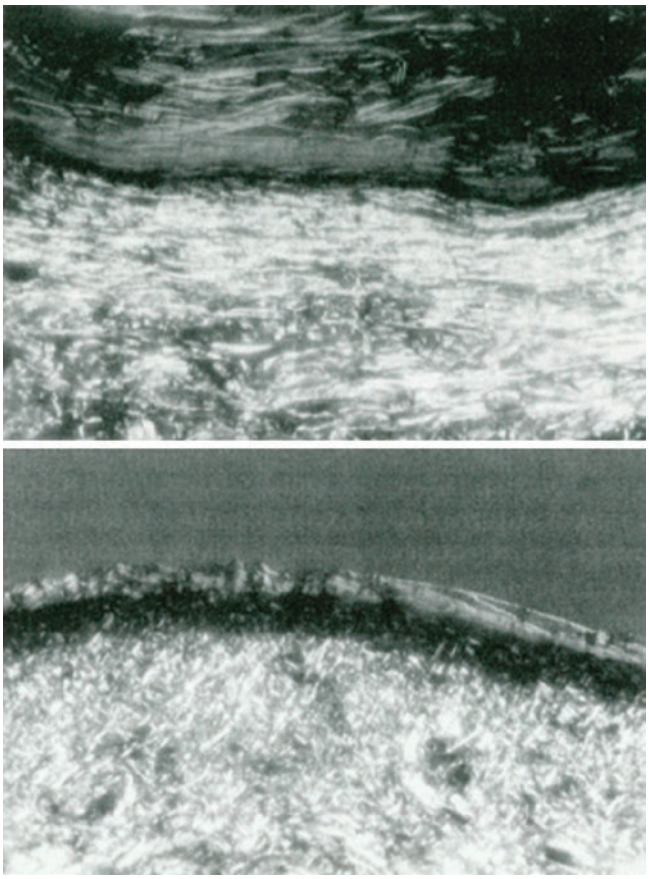


Fig. 2.2 Photomicrograph of collagen staining below the dermis. The inframammary fold (above) demonstrates dense, organized collagen fibers that run parallel to the IMF. Control sections (below) demonstrate disorganized collagen fibers that insert perpendicularly into the dermis. (Reprinted with permission from Boutros et al. [6])

Etiology, Incidence, and Risk Factors

With a deeper understanding of IMF anatomy and how this relates to the double-bubble deformity, one can begin to consider the etiology, incidence, and risk factors for double bubble. A study by Salgarello and Visconti reviewed 207 breast augmentations and identified 6 cases (3%) of double-bubble deformity over an average 28-month follow-up [8]. Four of the six cases occurred in breasts with constricted lower poles/tuberous breasts, and the other two cases occurred in breasts with high IMFs. In a review of 200 primary breast augmentations, Chardon and colleagues identified "double breast contour" in 7% of cases [12]. However, these were all Type I, also known as waterfall deformity, which many plastic

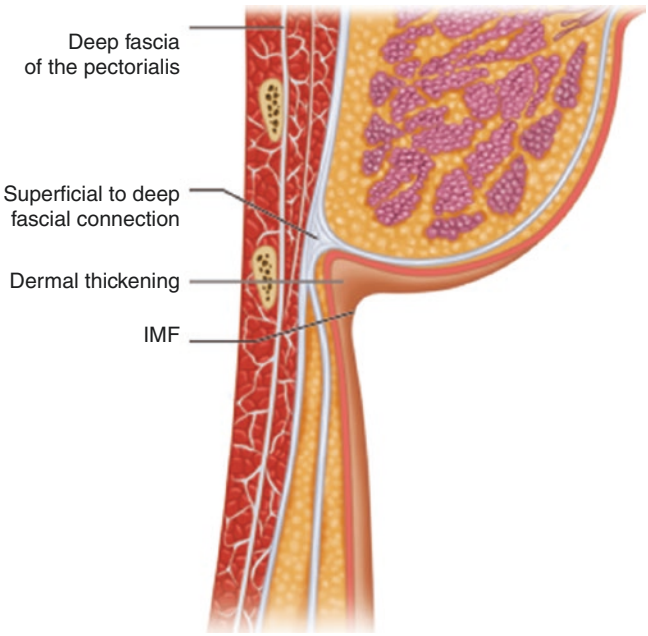


Fig. 2.3 The IMF can be thought of as a two-part structure, consisting of a superficial condensation of dermis and superficial fascial fibers, as well as a deeper structure that fuses superficial and deep fascial fibers together

surgeons – including the authors – attribute to a very distinct pathophysiology than double bubble. They had no instances of Type II double inframammary crease deformities at an average 36-month follow-up. Notably, tuberous breasts were excluded from this analysis which would be more prone to develop double-bubble deformity. It is important to note that waterfall deformity, although sometimes blended into the spectrum of IMF abnormalities, is a distinct entity from double bubble with different anatomic issues (high-riding implant with intact IMF in the setting of ptotic breast tissue) [10, 11]. This distinction is highlighted in Fig. 2.4d. Waterfall deformity is discussed further in Chaps. 23 and 24.

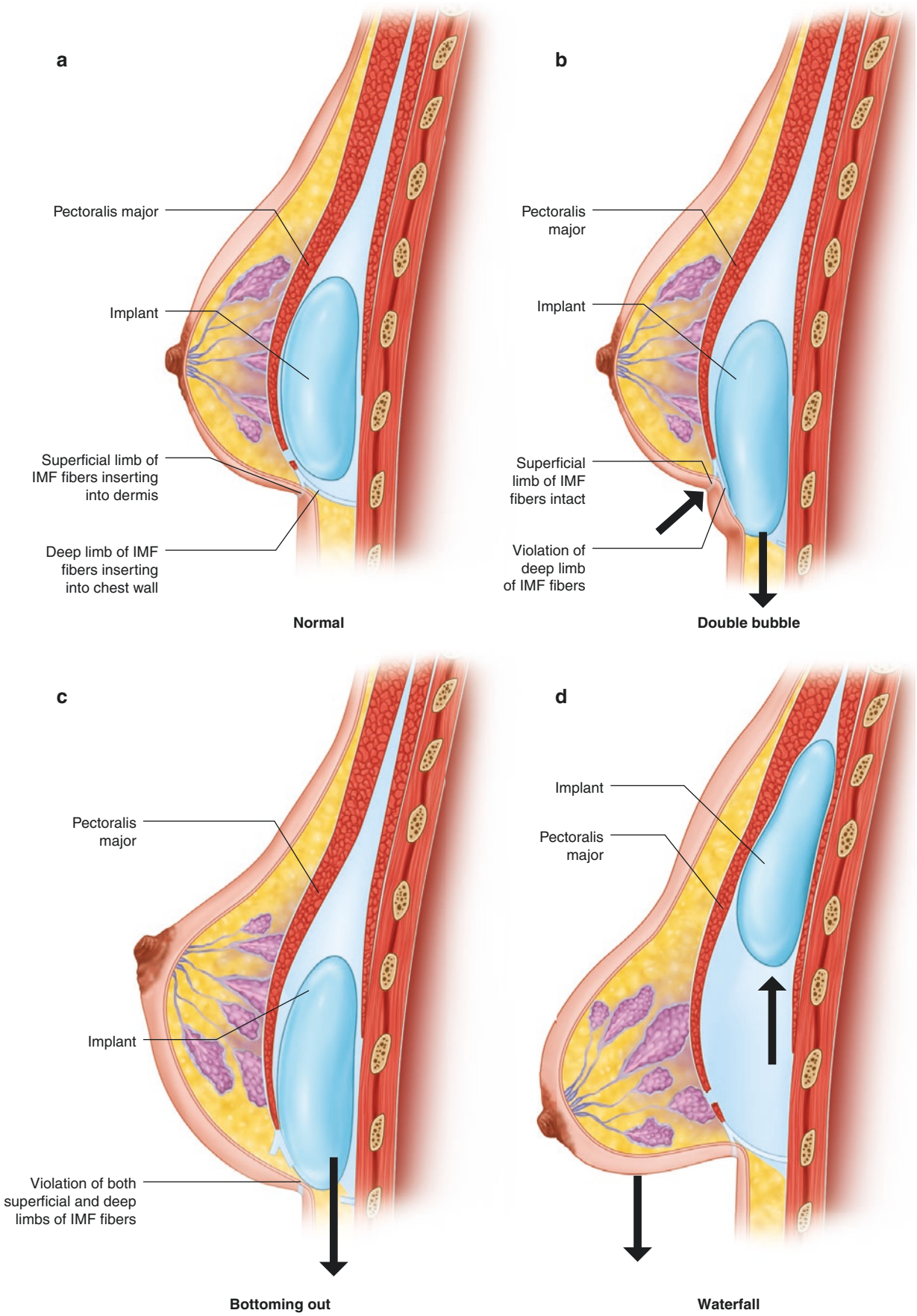
Risk factors for double-bubble deformity include anatomical variants that would make it difficult for the lower pole breast gland to conform to the underlying implant and tight IMFs with excessive memory. Thus, tuberous breasts, breasts with a constricted lower pole, high-riding IMF, narrow base width, dense/highly formed breasts, and generally tight IMFs are all prone to developing double bubble after augmentation.

Surgical causes of double bubble include excessive dissection along the deep portion of the IMF fascia resulting in a path of least resistance inferiorly for displacement of the implant. This is typically coupled with persistent superficial fascial attachments which create the groove appearance of the double bubble. Beyond this primary etiology, double bubble can be exacerbated with the use of an implant with an excessive base width or by the smooth surface of the implant creating micromotion and continuous erosion of the soft tissue constraints along a weakened IMF. Notably, Baxter described cases of double bubble occurring in conjunction with animation deformity in breasts with otherwise normal anatomy [13]. Pectoralis animation accentuated the double-bubble deformity, and the external transverse crease across the breast corresponded to the termination of pectoralis fibers in the anterior implant capsule. Thus, submuscular augmentation increases risk of double-bubble deformity both by preventing release of more superficial fascial fibers and by surgically creating a fusion line between muscle and capsule that will naturally lie cranial to the IMF after pectoralis fiber release. The pectoralis muscle can also contribute to double-bubble deformity by the deforming forces that push the implant down, deep and inferior the native IMF. Ultimately these forces contribute to the creation of two separate breast mounds: that of the implant displaced inferiorly and that of the native breast superiorly. Figure 2.5 depicts a patient with simultaneous animation deformity and accentuated double-bubble deformity.

Prevention

Two of the most obvious ways to prevent double-bubble deformity include (1) respecting the boundaries of the IMF and (2), in the situation where the IMF must be lowered to obtain desired aesthetics and volume enhancement, ensuring sufficient release of superficial fascial IMF attachments and creating a durable support for the new lowered fold by capsulorrhaphy and/or mesh.

Because tuberous breasts manifest anatomic variants that also predispose to double-bubble deformity, many of the same techniques specific to augmentation of the tuberous breast can be helpful to prevent double-bubble deformity. Radial scoring allows expansion of the lower pole breast tissue and can widen the base diameter in an otherwise narrow breast [14]. Beyond widening the breast, radial scoring also allows otherwise dense glandular tissue to conform more naturally to the underlying implant. Radial scoring at and perpendicular to the axis of the IMF itself can help obliterate the old IMF when creating a lower fold. Similar to radial scoring, Puckett described the unfurling technique for primary prevention of double-bubble deformity in the narrow-based breast [15]. This description utilizes a peri-areolar incision to dissect in the subcutaneous plane to pectoralis fascia. Dissection then proceeds cranially in the subglandular plane until the midpoint of the breast (about the level of the nipple). The gland is then incised from posterior to anterior, and the lower pole flap of glandular tissue is unfurled inferiorly to advance the constricted lower pole (Fig. 2.6). The unfurled flap is then sutured in place to the inferior extent of the breast pocket.


a
Pectoralis major
Implant
Superficial limb of IMF fibers inserting into dermis
Deep limb of IMF fibers inserting into chest wall
Normal
b
Pectoralis major
Implant
Superficial limb of IMF fibers intact
Violation of deep limb of IMF fibers
Double bubble
c
Pectoralis major
Implant
Violation of both superficial and deep limbs of IMF fibers
Bottoming out
d
Implant
Pectoralis major
Waterfall

Traditionally, IMF incisions have been placed slightly below the IMF to anticipate recruitment of lower pole skin once the implant is in place, thereby hiding the scar more discreetly in the newer cusp of the breast and torso. The incision must be beveled cephalad to ensure a dissection plane that does not inadvertently violate the IMF. Alternatively, Swanson described the use of a supra-inframammary fold incision to avoid the IMF altogether and correspondingly avoid double-bubble deformity [16].

In the early postoperative period, if a patient is deemed at risk for double bubble or if an incipient deformity is seen, then the concept of "breast casting" can be utilized. Mills describes a technique by which shoelaces are strung around the neck, circumferentially around the chest and at the level of the desired IMF to promote adhesion in the correct position [17] (Fig. 2.7). Another permutation of this technique is advocated by Handel who uses elastic compression in the superior pole of the breast to push the implant down and help expand the lower pole breast tissue while maintaining the IMF with tape or an underwire bra.

Techniques for Correction

Once double-bubble deformity occurs, correction depends on etiology, anatomy, degree of deformity, and patient factors including expectation. Because double-bubble deformity manifests as an implant residing in a problematic pocket, the concept of changing to a new pocket and resetting to a new, more secure IMF is a mainstay of revision surgery. As mentioned previously, double bubble rarely occurs after sub-glandular augmentation. This is because inferior sub-glandular dissection will naturally release more superficial fascial attachments, thereby obliterating the native IMF if dissection proceeds too far inferior. This generally results in bottoming out rather than double-bubble deformity.

Pocket Conversion Techniques

For double-bubble deformity after submuscular augmentation, pocket conversion to a sub-glandular plane can alleviate the deformity [14]. However, not all patients are good candidates for sub-glandular augmentation, particularly after an implant has already stretched and thinned the overlying glandular tissue. For these patients, two alternatives include conversion to a dual-plane/split muscle pocket or conversion to a neo-subpectoral pocket [18].

Split muscle augmentation, described by Khan and Baxter, likewise places the implant in a subpectoral plane superiorly and a sub-glandular plane inferiorly, but does so by splitting the muscle fibers at a desired level to eliminate inferior pectoralis fibers' action on the anterior implant capsule [13, 19]. Whereas in a dual-plane technique these inferior pectoralis fibers would be released and sit anterior to the implant, a split muscle technique places these most inferior pectoralis fibers posterior to the implant. A split-muscle technique can therefore be helpful in cases where animation deformity is contributing to a transverse crease across the breast mound because it places these released muscle fibers posterior to the implant and only superior muscle fibers with retained sternal attachments (and inability to exert their action on the breast mound) now lie anterior to the implant. Figure 2.8 demonstrates the split muscle bi-plane technique.

For patients in whom submuscular coverage is still desired, Maxwell and colleagues described the neo-subpectoral pocket [20, 21]. This dissection is performed by separating the anterior implant capsule from the overlying pectoralis, which becomes the new implant pocket (Fig. 2.9). The prior pocket space is then obliterated by suturing the prior anterior and posterior capsule together.

Inferior Support with Suture or Mesh-Assisted Capsulorrhaphy

After pocket conversion, most implants will need some inferior support to prevent secondary bottoming out deformity or attenuation on the newly created inframammary crease. Support for the inferior pole can be provided in two main ways: suture capsulorrhaphy or mesh-supported capsulorrhaphy. Commonly used meshes include biologics (such as human cadaveric acellularized dermal matrix) or absorbable meshes (such as poly-4-hydroxybutyrate or polydioxanone).

Suture capsulorrhaphy was initially described by Spear and colleagues in 1988 [22]. The inferior capsule can be reinforced with stitches placed from the dermis to the chest wall at the desired position of the new IMF. We prefer to do capsulorrhaphy in two layers with a buried interrupted PDS sutures oversewn with running PDS sutures.

Fig. 2.4 Differences in fascial dissection lead to various implant malposition deformities. (**a**) demonstrates the normal, correct location of a submuscular implant. Double-bubble deformity and bottoming out can both occur from inferior pocket overdissection. Double-bubble deformity occurs if pocket dissection is deep and only violates the deep fascial fibers, leaving the superficial IMF fascial fibers intact (**b**). Bottoming out occurs if pocket dissection is more superficial and those superficial fascial fibers are released (**c**). Waterfall deformity (**d**) is a distinct phenomenon that, although sometimes confused with double-bubble deformity, results from a high-riding rather than low-riding implant

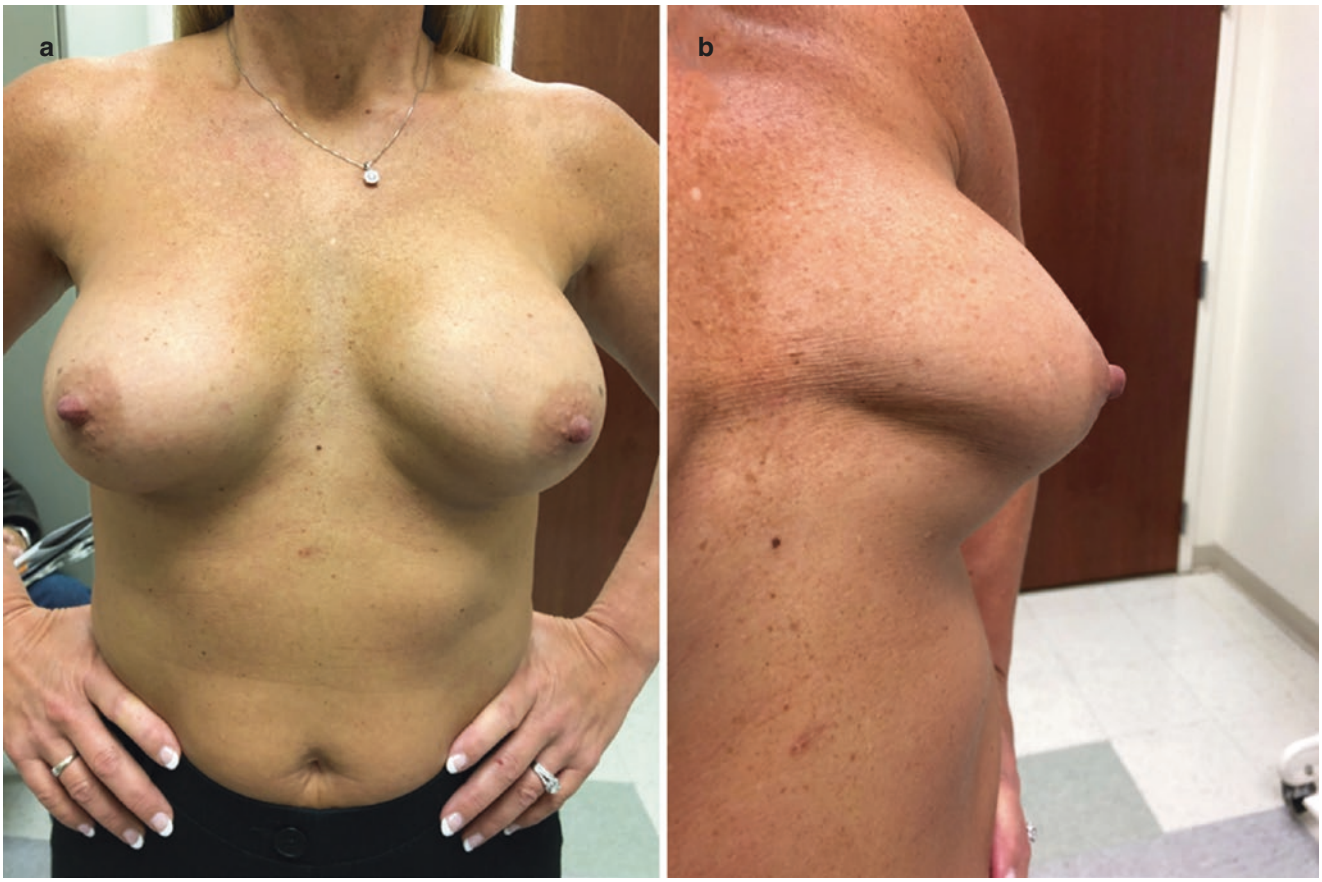


Fig. 2.5 Patient with simultaneous animation deformity and double-bubble deformity at rest (**a**). Patient shows accentuation of the double bubble with pectoralis animation (**b**)

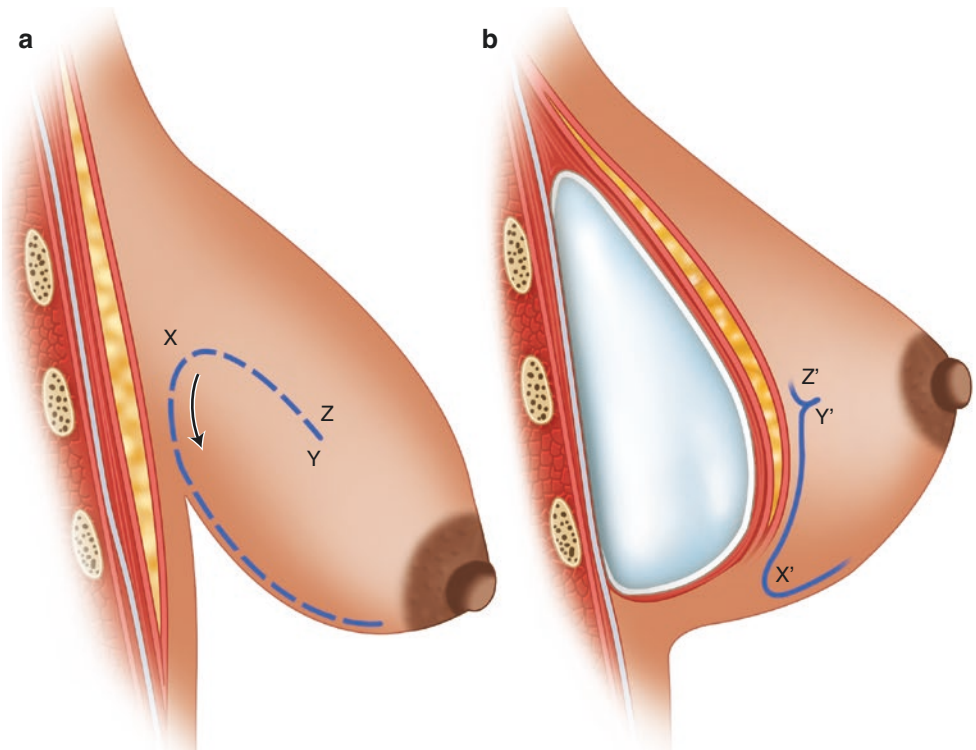


Fig. 2.6 Example of Puckett's unfurling technique to prevent double-bubble deformity in the breast with a constricted lower pole. In this technique, a sub-glandular dissection proceeds from caudal to cranial until the midpoint of the gland is reached (about the level of the nipple) (**a**). The breast tissue is then split in a posterior to anterior direction and unfurled inferiorly, thereby expanding the lower pole of the breast (**b**)

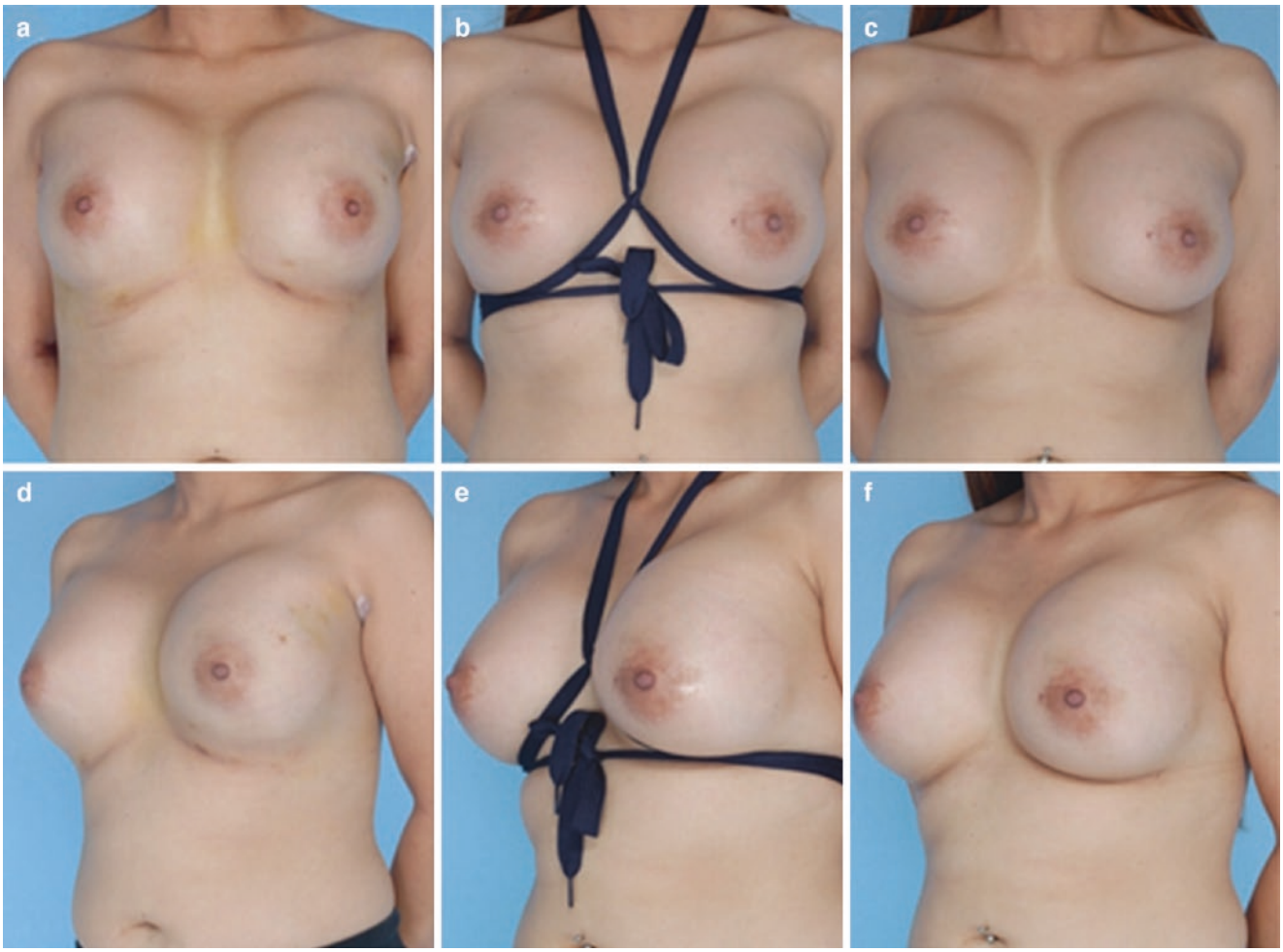


Fig. 2.7 Example of the shoelace breast cast. (**a**, **d**) Patient presented 4 days after trans-axillary breast augmentation with slight double-bubble deformity and implant malposition. (**b**, **e**) Shoelace breast cast in place. (**c**, **f**) The patient's double-bubble deformity was corrected, and the inframammary crease was better defined after 19 days in the shoelace breast cast. (Reprinted with permission from Mills [17])

Inferior pole support with biologic or absorbable synthetic mesh has been described in a multitude of techniques, utilizing a variety of pockets (sub-glandular, neopectoral, muscle splitting bi-plane) [23–26]. We prefer to use absorbable synthetic mesh as we have found that this results in superior long-term outcomes with less need for revisions (unpublished results). We use a butterfly-shaped mesh, with one wing of the butterfly secured to the chest wall and the other wing of the butterfly resting against the underside of the anterior breast tissue. 2.0 PDS sutures are used to secure this butterfly mesh along the chest wall and the gutter of the inset "sleeve" of mesh represented by the analogous body or thorax of the butterfly shape. The anterior wing of the mesh is then tensioned appropriately to the anterior breast to secure the implant without creating a tethering or flattening of the lower pole. If mesh is to be used, then the aforementioned suture capsulorrhaphy is still used slightly inferior to the mesh neo-IMF so that the weight of the implant rests on the mesh and not directly on the more vulnerable suture line. The case example to follow highlights our use of mesh, demonstrated in Fig. 2.10.

Adjunct procedures to ameliorate the IMF correction include fat grafting. This can be performed in conjunction with open or percutaneous release of persistent superficial retained condensations of the IMF to the skin. Bresnick used fat grafting as the primary modality for correction of double bubble in a small series of patients, reporting an average of 2.1 sessions of fat grafting in 28 patients for correction of double-bubble deformity with no additional revisional surgery required [27].

Algorithm for Double-Bubble Treatment

When a patient presents with a double-bubble deformity, the surgeon should first consider if this is something that can be treated with conservative means. In patients who are relatively early postoperatively (even up to 4–6 months after

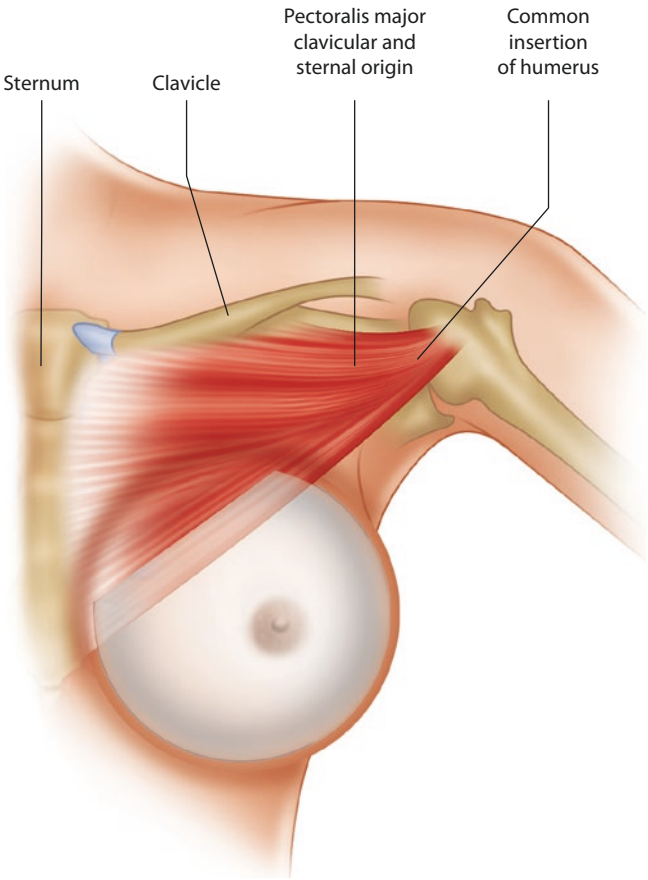


Fig. 2.8 Example of the split muscle bi-plane technique. This technique allows superior pole coverage of the implant with pectoralis muscle while placing the inferior pole of the implant in a sub-glandular pocket. Unlike dual-plane augmentation in which all pectoralis fibers sit anterior to the breast implant, this technique splits the pectoralis fibers parallel to their orientation and places the implant superficial to the most inferior pectoralis fibers

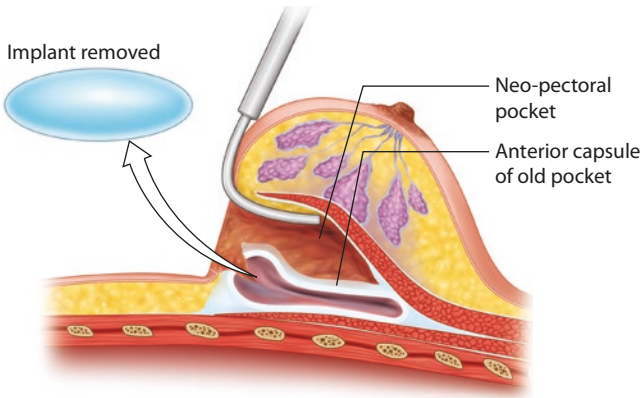


Fig. 2.9 Example of the neopectoral pocket, created by developing the space between the prior anterior capsule and pectoralis

breast augmentation), breast casting alone can fix the deformity by repositioning the implant and promoting scarring with the implant "externally held" in its desired pocket

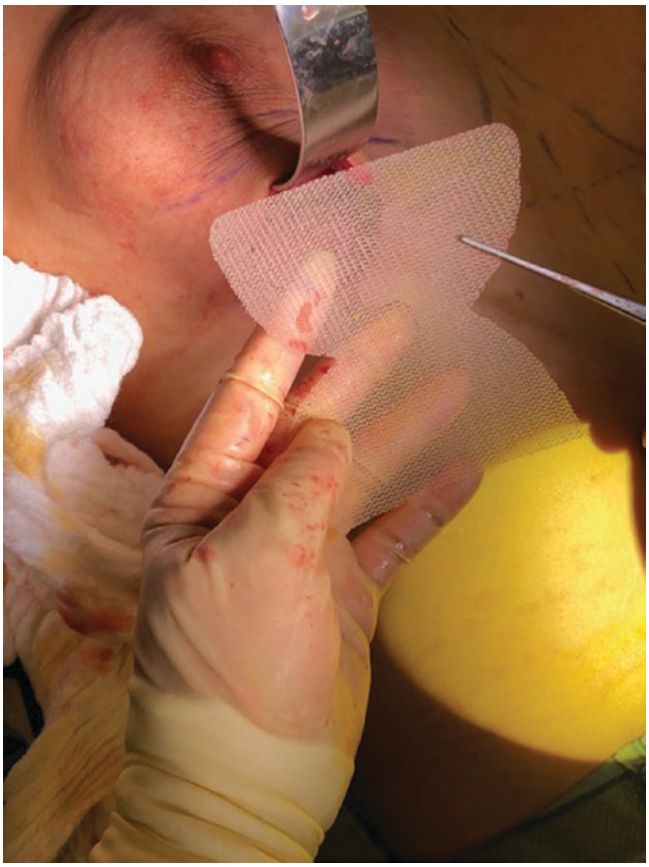


Fig. 2.10 Mesh is cut into the shape of a butterfly. One wing will be secured to the chest wall. The thorax of the butterfly will be placed at the level of the desired IMF and secured in place. The other wing of the butterfly will sit anterior to the implant and will abut the anterior glandular flap, thereby creating a hammock of support for the implant in its new sub-glandular position to prevent bottoming out

(Fig. 2.11, *green pathway*). When this does not fix the problem, or in patients who are further out from surgery or with more severe deformity, then surgical correction is considered.

The most important consideration is whether the implant is inferiorly displaced from its desired position on the chest mound (Fig. 2.11, *purple pathway*). When this is the case, a capsulectomy is performed, resetting the IMF to the desired position. Often, a pocket change can provide greater stability than capsulorrhaphy of the existing pocket alone. If adequate soft tissue is present, a sub-glandular pocket is advocated to promote release of superficial fibrous attachments contributing to the double-bubble deformity. If inadequate soft tissue is present, then a neo-subpectoral pocket will suffice.

In other patients, the implant is actually sitting at the desired level on the chest wall, but double bubble deformity is present due to predisposing factors such as an abnormally high native IMF that was not appropriately obliterated in the original augmentation (Fig. 2.11, *blue*

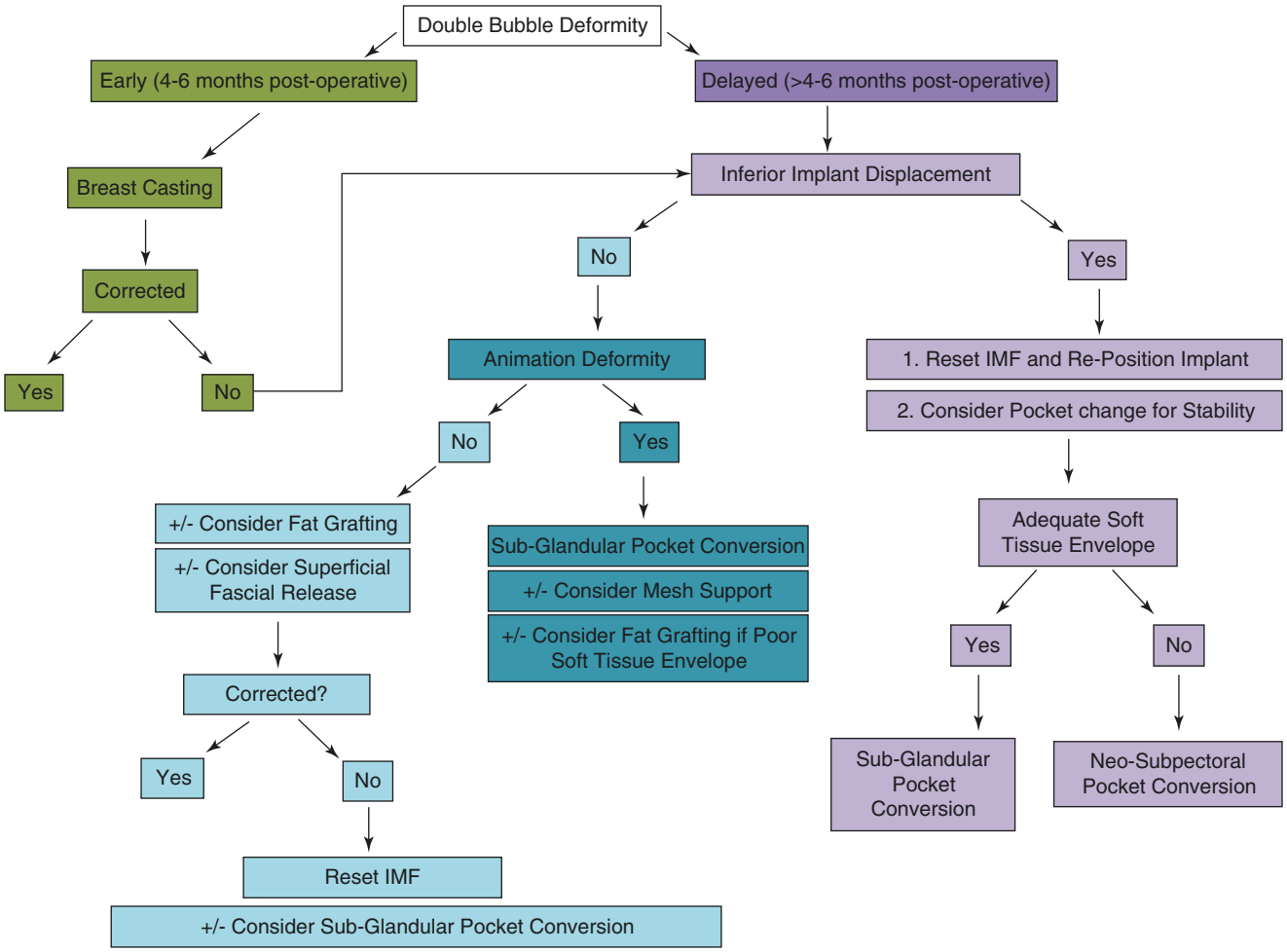


Fig. 2.11 Algorithm for management of double-bubble deformity

pathway). In these instances, it is important to ascertain whether animation deformity is present. If animation deformity is present (and perhaps contributing to the transverse crease on the breast mound), then a pocket change will be necessary regardless of the fact that the implant is sitting in the correct position. We advocate for a sub-glandular pocket for all animation deformity cases and fat grafting and lower pole mesh to support the soft tissue envelope, if needed.

When the implant is sitting at the desired level on the chest wall *and* there is no evidence of animation deformity, then slightly more conservative surgical approaches can be taken that simply rely on obliterating the transverse crease across the breast mound without opening the implant pocket. This can be as simple as fat grafting to disguise the crease or surgical release of these superficial fascial bands. Sometimes, this is not enough to correct the deformity, and in these instances the pocket must subsequently be reopened with resetting of the IMF (often with pocket conversion).

Case Example

The patient is a 27-year-old female who presented with bilateral double-bubble deformity after cosmetic breast augmentation (Fig. 2.12). She had undergone a submuscular augmentation 4 years previously via an IMF incision. On exam, she had a transverse crease across the inferior pole of both breasts, right worse than left, representing the double-bubble deformity. Compounding this static issue was the dynamic problem of animation that she had coincident with the double bubble. Finally, she also had keloiding of her prior IMF incision scar and modest ptosis.

The surgical plan included revision with exchange to a sub-glandular pocket via the prior IMF incisions with excision of keloid scars, lower pole support with absorbable mesh placement and circumareolar mastopexy.

In the operating room under general anesthesia, access to the breast was obtained through the pre-existing IMF incisions. Dissection proceeded into the capsule, and it was noted that the right breast implant was ruptured. Both

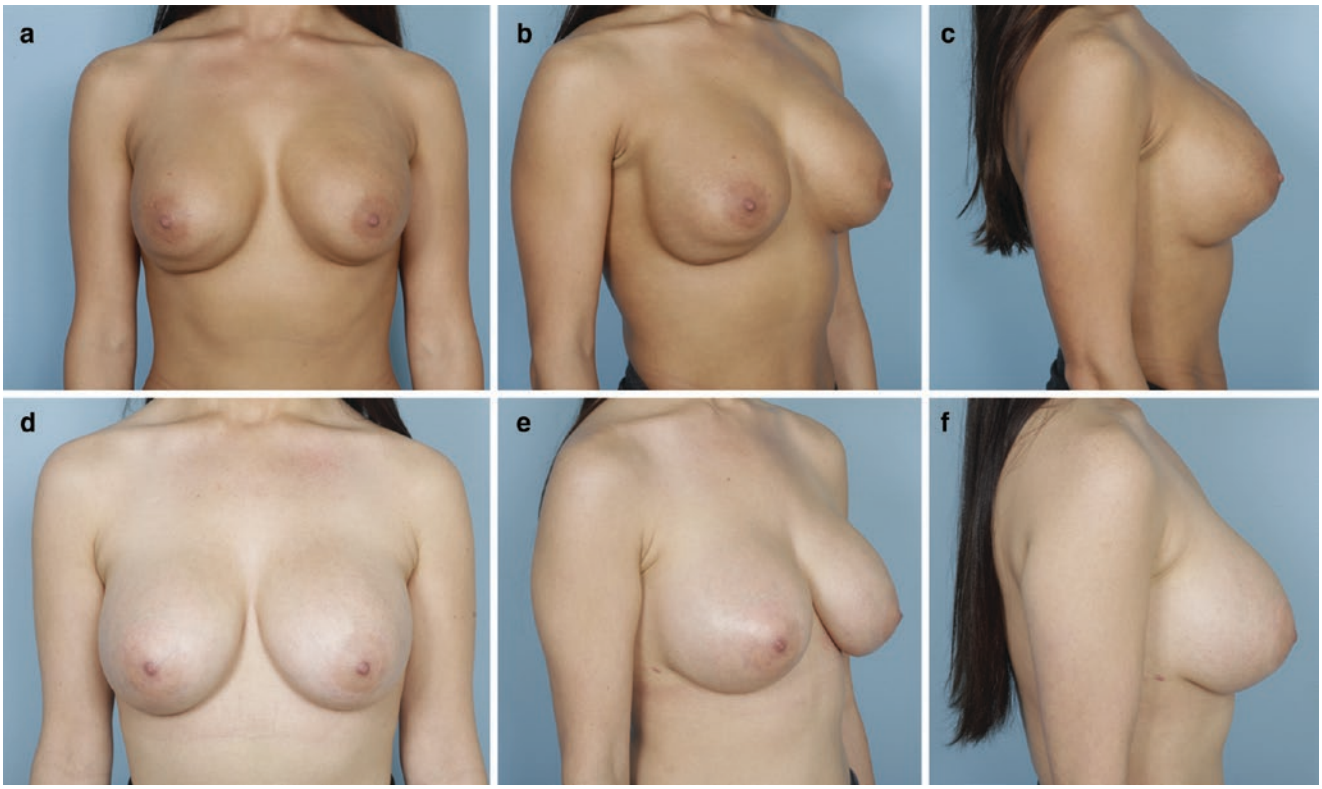


Fig. 2.12 Preoperative (**a**–**c**) and postoperative (**d**–**f**) photographs of a patient with double-bubble deformity, repaired with release of superficial fascial fibers, conversion to a sub-glandular pocket, and mesh capsulorrhaphy

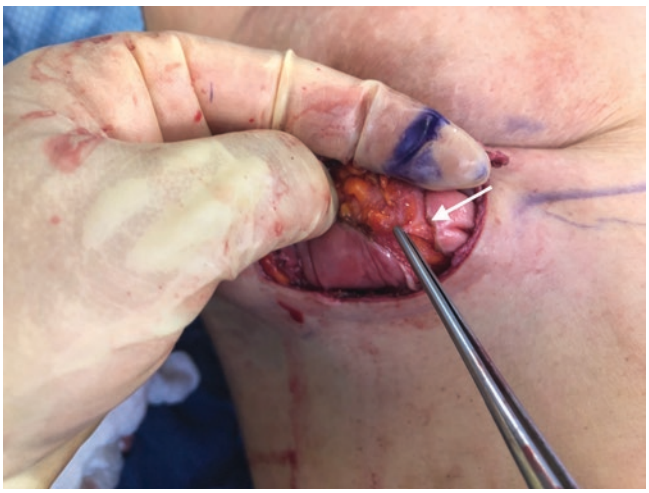


Fig. 2.13 This demonstrates the superficial fascial fibers of the native IMF of the patient in Fig. 2.12 during operative revision. This view is through an IMF approach, with the inferior breast parenchyma everted. The old implant capsule has been divided with radial scoring. Superficial to the capsule, the pick-ups are holding superficial fibers running transversely across the glandular tissue, which the white arrow also points to. These transverse fibers represent the native IMF and are found at the same level as the transverse skin crease across the breast mound

implants were removed, and multiple rounds of irrigation were performed. At the level of the double-bubble deformity, pectoralis fibers were noted to be inserting into the more superficial glandular tissue and region of the original IMF. The pectoralis muscle was dissected off the overlying breast tissue and sutured back into position on the chest wall. The new sub-glandular pocket for the breast implant was thus created. Additional superficial fascial fibers were noted, representing the original IMF, at the same level of the external transverse crease across the breast (Fig. 2.13 and Video 2.1). These fibers were released with radial scoring extending from this region through the breast parenchyma. Significant radial scoring of the breast parenchyma was required in order to get adequate release of the transverse skin crease across the lower pole of the breast mound. The IMF was then re-created at the appropriate position via 2.0 PDS sutures in two-layer fashion. Cephalad to this suture, absorbable mesh was inset in the same butterfly technique noted previously (see Fig. 2.10). The new silicone implants were then placed, and the other half of the mesh was judiciously secured to the anterior flap of breast mound. Pre- and postoperative photographs are shown in Fig. 2.12.

Conclusion

Double-bubble deformity occurs from a combination of (1) overdissection of the deep IMF fibers, resulting in implant displacement inferiorly, and (2) persistence of superficial fascial elements of the IMF, giving the appearance of a transverse band across the lower pole of the implant. Avoidance of this uncommon complication is predicated on understanding IMF anatomy and preserving it (and in cases where it must perforce be modified, ensuring that appropriate support is established at the reset IMF). Treatment is stratified by severity with initial nonsurgical approaches for modest deformities. More significant double-bubble deformities will generally require release of the superficial band with appropriate sizing of implants, augmented suture and mesh capsulorrhaphy, and possible pocket change.

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3 Guiding Principles for Congenital Chest Wall and Breast Anomalies: Avoiding Complications

Caroline A. Glicksman and Patricia McGuire

Introduction

Originally described by Poland and Froriep in the nineteenth century, congenital chest and breast anomalies have long challenged both pediatric and plastic surgeons. The management of congenital chest wall and breast anomalies has evolved dramatically over the last 50 years, and modern techniques may allow women born with deformities to achieve outstanding aesthetic results. Although uncommon, chest wall deformities observed at birth may require early intervention due to the compression of the heart and lungs. When surgical intervention is necessary, minimally invasive procedures (MIRPE) such as the Nuss [1] or pectus bar procedure, first introduced into the American Pediatric Association in 1997, have replaced the more invasive procedures described by Ravitch [2]. Previously classified into five distinct categories [3], chest wall deformities include pectus excavatum, pectus carinatum, Poland syndrome, defects of sternal fusion, and defects of the skeletal wall. More commonly seen in plastic surgery are the isolated chest wall and breast anomalies, such as tuberous and constricted base breast deformities and the rare congenital absence of the breast (Fig. 3.1).

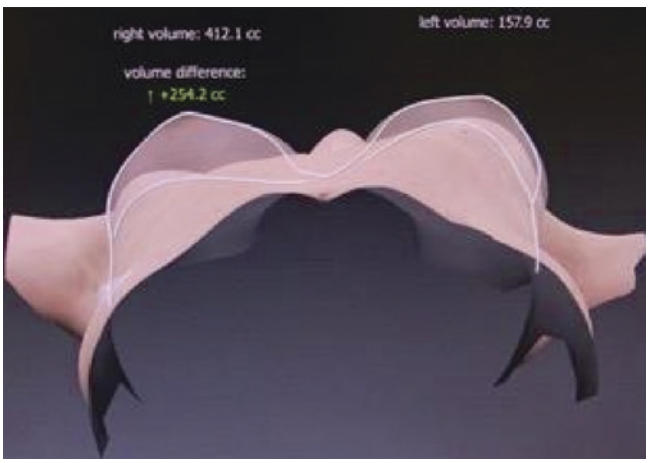

Fig. 3.1 3D Simulation of chest wall anomaly

Basic Science: Chest Wall Embryology and Breast Development

The embryologic basis for congenital defects of the thoracic region, although well described, is not always clear. Defects may be severe, though these are mostly treated in earlier childhood long before the adolescent female may present to the plastic surgeon [4]. Beginning in the 4th week of the development of the musculoskeletal system of the chest is a multistep process usually completed by the 8th week of gestation. The first step involves the division of the paraxial mesoderm into two distinct cell populations, the dorsolateral subpopulation and the ventromedial subpopulation (also called the dermomyotome and the sclerotome). Each zone proliferates individually over several weeks as the myoblasts differentiate into the skeletal musculature and the sclerotome becomes the vertebrae and ribs. By the 6th to 7th week of embryonic development, the ribs and sternum start to fuse in the midline, and failure to do so leads to a variety of sternal clefts. Fusion occurs in a cranial-caudal direction completed by the 10th week. Sternal deformities have been previously well described [5], and the most common clefts occur at the cranial end of the sternum, creating a partial sternal cleft that does not affect breast shape and development. Rarely there is an isolated fissure at the caudal portion of the sternum without other congenital deformities. The manubrium develops separately from the embryonic tissues

C. A. Glicksman (✉)
Department of Surgery, Hackensack Meridian, School of Medicine at Seton Hall, Sea Girt, NJ, USA

P. McGuire
Washington University, and Parkcrest Plastic Surgery, St. Louis, MO, USA

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between the two clavicles [6]. Surgical intervention for sternal clefts in early childhood is based on signs of respiratory distress including intermittent cyanosis, dyspnea, and tachypnea [7]. Acquired injuries of the breast bud during these surgical procedures, while rare, can certainly occur and have been observed. The breast develops from an ectodermal origin along the milk line during the 6th week of gestation. This line spans from the axilla to the groin and slowly atrophies, leaving only the middle or pectoral ridges to develop into breast tissue. Size differences in breasts may occur as a result of an uneven distribution of primordial breast cells or a differential response to hormones during puberty. Congenital breast deformities are quite often associated with underlying congenital chest deformities; therefore, a detailed history of both genetic and acquired factors must be considered. The precise causes and classifications of deformities of the chest wall and sternum remain controversial and include overgrowth of costal cartilages, sternal twisting, and a relative weakening of the costal cartilages [8]. Chest wall and breast deformities can be defined as either monogenic, disruption sequences, isolated chest wall deformities, or the acquired chest and breast deformities associated with pediatric surgery and trauma. Table 3.1 reviews the etiology of the most commonly encountered congenital and acquired chest wall anomalies and resultant end-organ failure.

Table 3.1 Congenital and acquired chest wall and breast anomalies

Origin of anomaly	Anatomic structures affected	Disorder
Monogenic syndromes	Ventral body wall, rib sternum, breast, spine	Marfan syndrome Noonan syndrome
Disruption sequences	Thoracic musculature ventral body wall, rib, breast, spine	Poland syndrome Moebius syndrome
Genetic associations (chromosomal aberrations)	Ventral body wall, rib, sternum	PHACE (posterior fossa brain malformations) Cantrell's pentalogy, asphyxiating thoracic dystrophy (Jeune's syndrome), cleft or bifid sternum
Isolated chest wall deformities	Breast, ventral body wall, rib, sternum, spine	Pectus excavatum, pectus carinatum, thoracic hypoplasia, supernumerary breasts, congenital absence breast, tuberous and constricted base breast, gynecomastia
Acquired chest wall deformities	Ventral body, thoracic musculature, breast	Tetralogy of Fallot, phyllodes tumor, surgical trauma, burn

Surgical Correction of Chest Wall Anomalies

Anomalies of the chest have been described in the literature since the sixteenth century [9]. While the first modern repairs of the chest wall were performed by Meyer in 1911 [10], it is Ravitch who is known for his surgical correction that included posterior osteotomies and internal fixation of the sternum [11]. The primary purpose of early attempts at reconstructive surgery was for improvements in cardiovascular and pulmonary function. Timing of the surgical correction moved from early childhood to adolescents when it was determined that resecting the rib cartilages of very young patients led to worsening of some deformities. The modified Nuss procedure was developed in 1986 based on the fact that children have malleable chests and the minimally invasive procedure led to less scarring and disfigurement [12].

Further innovation included the use of local muscle flaps to correct absent or inadequate chest wall musculature, including latissimus flaps. One of the mainstays of early aesthetic correction of chest wall deformities involved the use of semi-solid of soft silicone implants that were fabrication from custom moulages. Most of the leading breast implant manufacturers importing breast implants into the United States from the early 1970s through 2010 had "custom" departments that would fabricate a silicone chest wall or breast implant based on a plaster-type mold of the patient's chest. At this time, custom implants continue to be fabricated by several international implant manufacturers, but not available in the United States [13]. For many years surgeons embraced the use of inflatable saline implants to correct underlying chest wall and breast asymmetries, but results were sub-optimal due to visibility and palpability of the devices through the thin soft tissue coverage over asymmetric areas of the chest. Decisions concerning size, shape, and fill volume were often made in the operating room, resulting in oversized or malpositioned implants that simply lead to a different kind of deformity (Fig. 3.2).

Rare Acquired Deformities

Acquired deformities of the chest and breast are infrequent but may be encountered in a busy plastic surgical practice. These patients may have had an underlying chest wall deformity at birth which may have been exacerbated by multiple thoracic procedures in early childhood. Acquired deformities of the chest may be divided into four possible etiologies: (1) a result of a pathological process within the thorax (heart enlargement, previous mediastinal tumors); (2) a result of chest wall disease such as rib osteomyelitis; (3) iatrogenic deformities that result from early cardiothoracic surgery such as harvested rib, or damage to muscle, or breast bud tissue; and (4) post-traumatic deformities such as after tumor

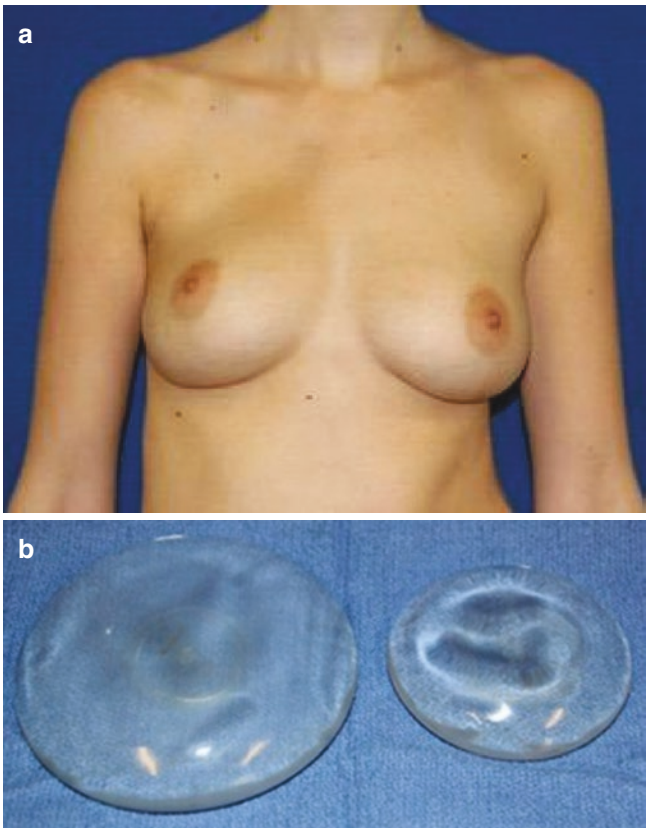

Fig. 3.2 (**a**) Marfan syndrome asymmetric round saline correction. (**b**) Explanted saline implants

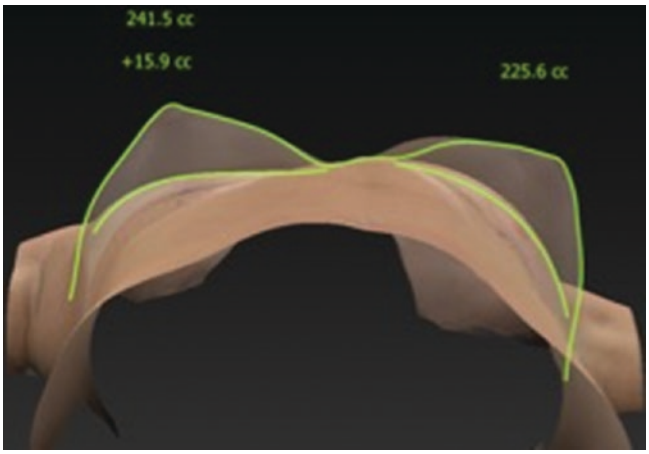

Fig. 3.3 A 22-year-old with chest wall deformity secondary to pediatric surgery for tetralogy of Fallot

resection or burns [14]. There is a greater recognition today that iatrogenic damage to the costosternal and costochondral junctions during thoracic surgery affects thoracic growth and mobility. Tumors are rare in the adolescent population but may account for significant breast asymmetry (Fig. 3.3).

The Psychosocial Implications

There is a well-documented psychological stress associated with chest wall and breast deformities. It is well acknowledged that adolescent females demonstrate improvement in their psychosocial functioning, including less social self-consciousness and more favorable body image after chest wall reconstruction [15]. Girls with chest wall anomalies as young as 4–6 years old begin to perceive themselves as different from other children and grow up with poor body self-image. Many patients with significant genetic or acquired thoracic deformities have other medical conditions that are the primary concern of their parents and family physicians. These patients often hide their body image issues from their parents. In later adolescence and young adulthood, their independence often drives them to seek the aid of a plastic surgeon to correct their breast and chest deformities. Studies have demonstrated that when compared to macromastia in adolescents, asymmetry patients have a similar fall off in emotional functioning, mental health, self-esteem, and eating behaviors and attitudes [16]. Some literature speaks to the option of prosthetic devices to be worn externally and reports improvement in self-esteem in adolescent girls [5, 17]. While camouflage may support a teenager in the locker room, padded bras or external prosthetics fail to provide any improvement in self-confidence once a young woman begins to establish her own identity and begin personal sexual relationships (Figs. 3.4 and 3.5).

Patient Assessment and Planning for Patients with Chest Wall and Breast Asymmetry

There is a wide continuum between the rarer difficult-to-treat congenital chest wall anomalies and patients with mild breast asymmetry. To identify the anatomy and pathology of complex congenital malformations, thoracic surgeons may rely on cross-sectional imaging to appreciate sternal depressions or protrusions or other anomalies related to abnormal spine or rib development. Using low-dose chest CT, patients may be scanned to assist in chest wall reconstructive procedures [18]. As plastic surgeons, we may be faced with similar complex chest wall and breast asymmetry, but historically have used very few tools in surgical planning. For complex congenital anomalies, a CT scan may be invaluable; however, most patients will not have insurance coverage for aesthetic procedures including breast augmentation, and tools such as an in-office 3D capturing technology can aid in patient education, assessment, and the selection of breast implants. There are various three-dimensional simulation systems currently on the market, and they have proven to be an invaluable tool in patient education. If patients are to become

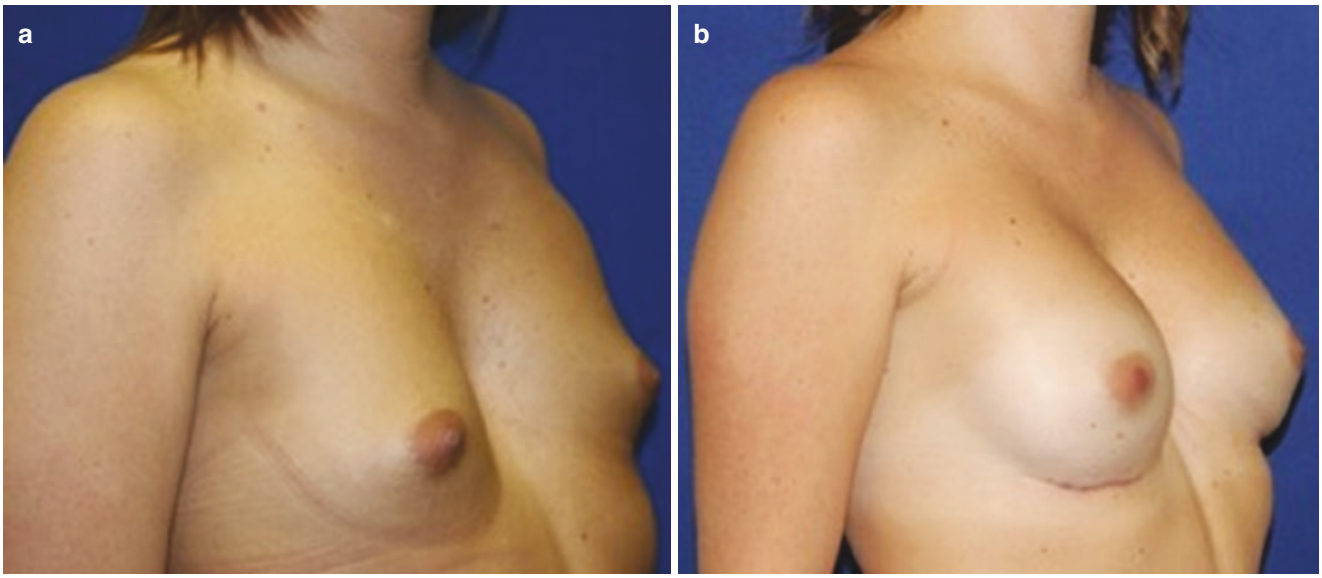

Fig. 3.4 (**a**) Unilateral hypoplasia of the chest with rib deformities and breast asymmetry preoperatively. (**b**) Postoperative photo 1 year after anatomic cohesive implants

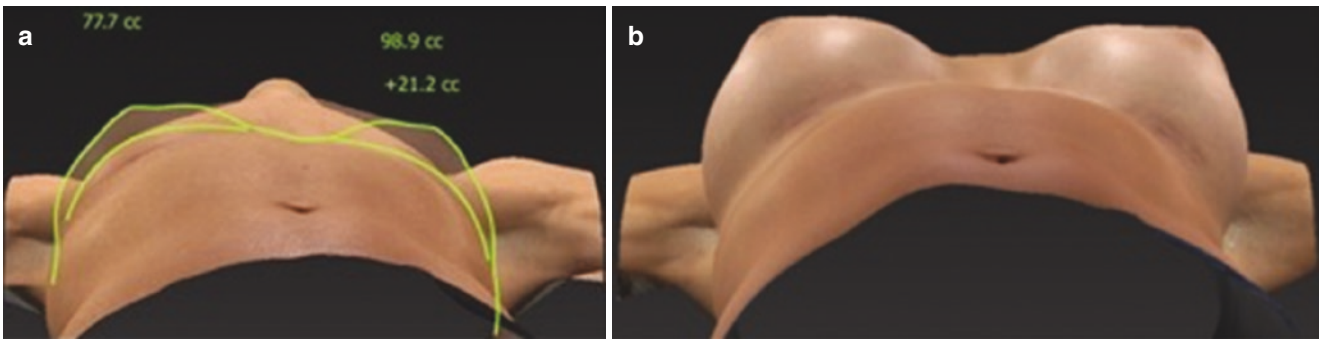

Fig. 3.5 (**a**) Analysis of chest wall asymmetry. (**b**) Postoperative simulation demonstrates actual change in projection left breast

well-informed participants in their surgical care, they need to understand what may be correctable and what may not. Three-dimensional planning and simulations aid in analysis of chest wall contours, differences in breast volume and projection, and asymmetries of the inframammary fold and underlying rib cage. Simulations can also help simplify the implant selection process, often eliminating the need to order multiple implants or sizers for surgery (Fig. 3.6).

Consultations often begin with a parent or significant other present. It is important to assess the patient's emotional and psychological state and if they are mature enough and capable of participating in the decisions involved in planning surgery. A history should include whether the patient has reached skeletal maturity and if there has been a change in bra size in the last year, any history of trauma or surgical interventions to the chest or breast in early childhood, and information on the patient's activities or involvement in competitive sports. Patients and their family should understand what the goals are and that no implant lasts a lifetime and the results will be affected by weight gains and losses, childbearing and breastfeeding, and eventually menopause and aging.

The physical examination of patients with congenital or acquired complex chest wall deformities is often challenging. The midline may be depressed, musculature may be absent, and standard landmarks may be distorted. An examination of the patient's anterior and posterior thorax, breasts, sternum, spine, pelvis, and extremities should be included to look for additional confounding factors that help in both the diagnosis and planning of breast augmentation (Fig. 3.7) [19]. Accurate tissue-based planning is essential to create natural-appearing breasts and improved symmetry. Careful assessment of the existing location of the inframammary folds and soft tissue assessment all contribute to decisions in implant selection. Considerations about the need to possibly raise or lower folds, possible associated skin procedures, or thoughts about the addition of fat should be calculated when selecting the implants.

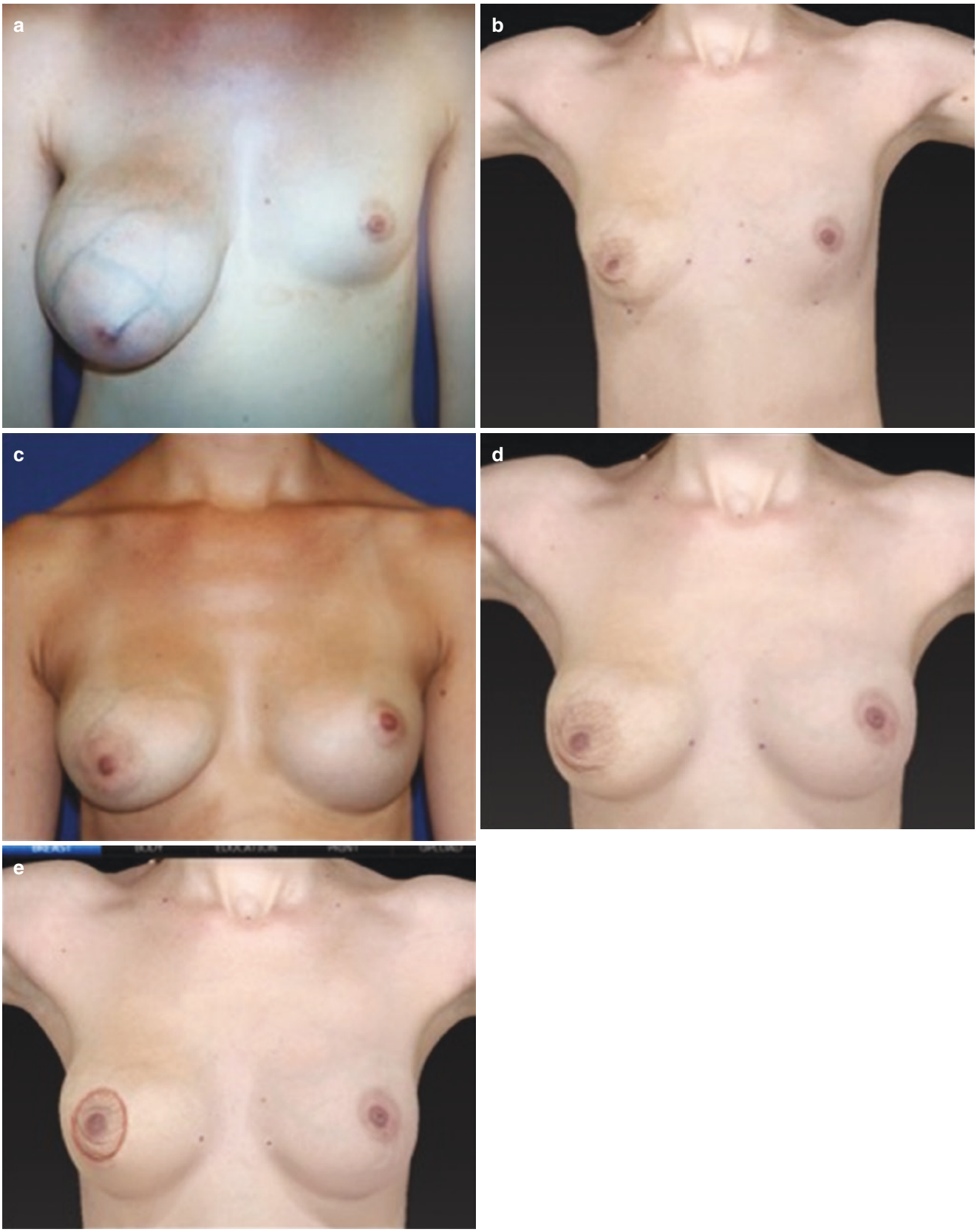

Fig. 3.6 (**a**) A 16-year-old with acquired asymmetry due to phyllodes tumor – patient presented requesting left breast augmentation. (**b**) Six months after removal of phyllodes tumor. (**c**) Simulation of possible asymmetric augmentation. (**d**) Three years postoperatively; patient considering mastopexy. (**e**) 3D simulation demonstrates possible outcome with staged mastopexy

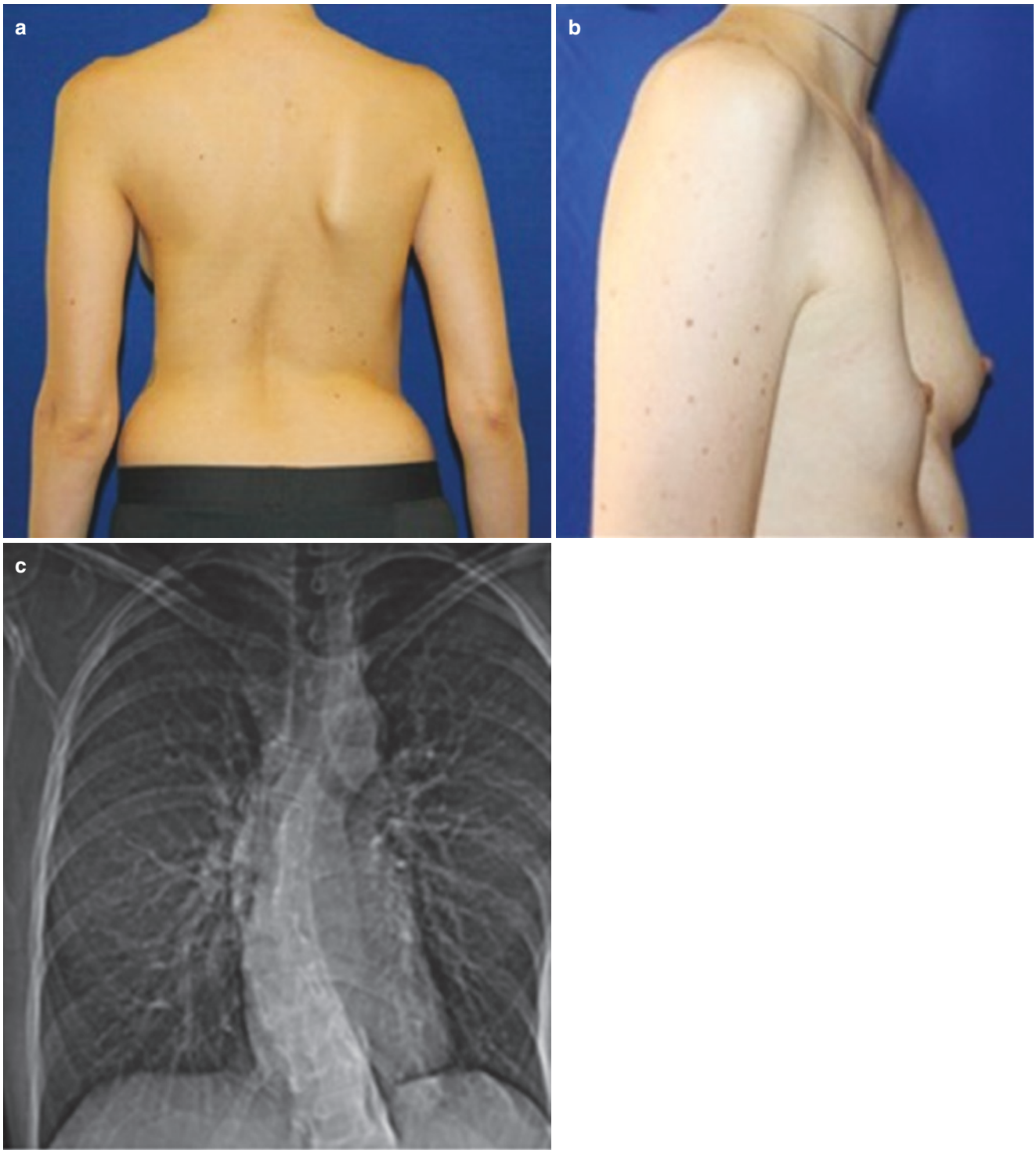

Fig. 3.7 (**a**) Scoliosis associated with Marfan syndrome in a 20-year-old woman. (**b**) Chest wall anomaly. (**c**) CXR scoliosis

Correction with Shaped Textured Versus Round Gel Implants

Both shaped and round breast implants may be indicated for the correction of chest wall and breast asymmetries. Both authors were trained to use shaped anatomic textured implants and preferred these implants in asymmetry cases for their unique characteristics in both volume and dimension to correct asymmetries of width, height, and projection. At the time of this writing, considerable controversy exists to the role played by various manufacturer's textured surfaces in BIA-ALCL. Decisions concerning the risks vs. the potential benefits of a selected device must include the risks for reoperation for malposition, continued asymmetry, and possible capsular contracture. As new surfaces and fills enter the US market, each will be evaluated for their benefits in this patient population.

Tissue-based planning is the key in the correction of breast and chest wall asymmetry. Implant selection begins with selection of the appropriate base width with a specific emphasis on soft tissue coverage, especially when using implants with lower viscoelastic properties that may ripple and be visible under thin skin. Even the most highly cohesive implants may be visible if the implant is oversized. The tissue type of the breast, also described as parenchymal fill, is another important element in implant selection (Fig. 3.8).

Breasts that have dense, firm parenchyma often associated with hypoplastic or constricted base breasts may require an implant that is more cohesive and will produce controlled shape that is usually required in the inferior pole of the breast. Determining the precise location of the inframammary fold and then maintaining this position over the years is one of the biggest challenges to "getting it right." Smooth implants tend to settle at best and "bottom out" at worst. The weight and dimensions of the implant play an important role in its effect on the tissues over time. Whenever possible, implants should be placed in a plane that produces the least visibility, most often dual-plane. If musculature is absent, the visibility of subglandular placement may be offset by autologous fat if available.

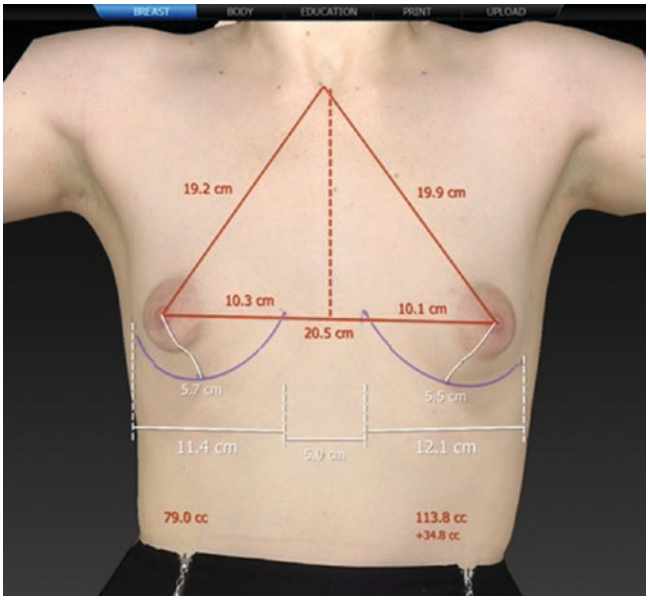

Fig. 3.8 3D assessment useful in preoperative planning and managing patient expectations

The Increasing Role of Fat

No single surgical procedure has improved the outcomes for patients with chest and breast anomalies more than the ability to safely and predictably transfer fat to the chest. When used in conjunction with asymmetric breast implants or soft tissue procedures, natural and enduring results are possible. The role of fat in soft tissue contouring in breast reconstruction has been well documented [20, 21]. Complications should be discussed with the patient, including cellulitis, superficial palpable lumps, fat reabsorption and necrosis, and cystic lesions. These complications are usually quite minor, and with advanced techniques of aspiration, fat preparation, and injection, they may occur less often. Fat grafting used in combination with smaller implants, or eventually replacing the need for breast implants altogether, is dependent upon the severity of the deformity. For certain patients, fat grafting may eventually replace the need for more complicated and riskier procedures (Fig. 3.9).

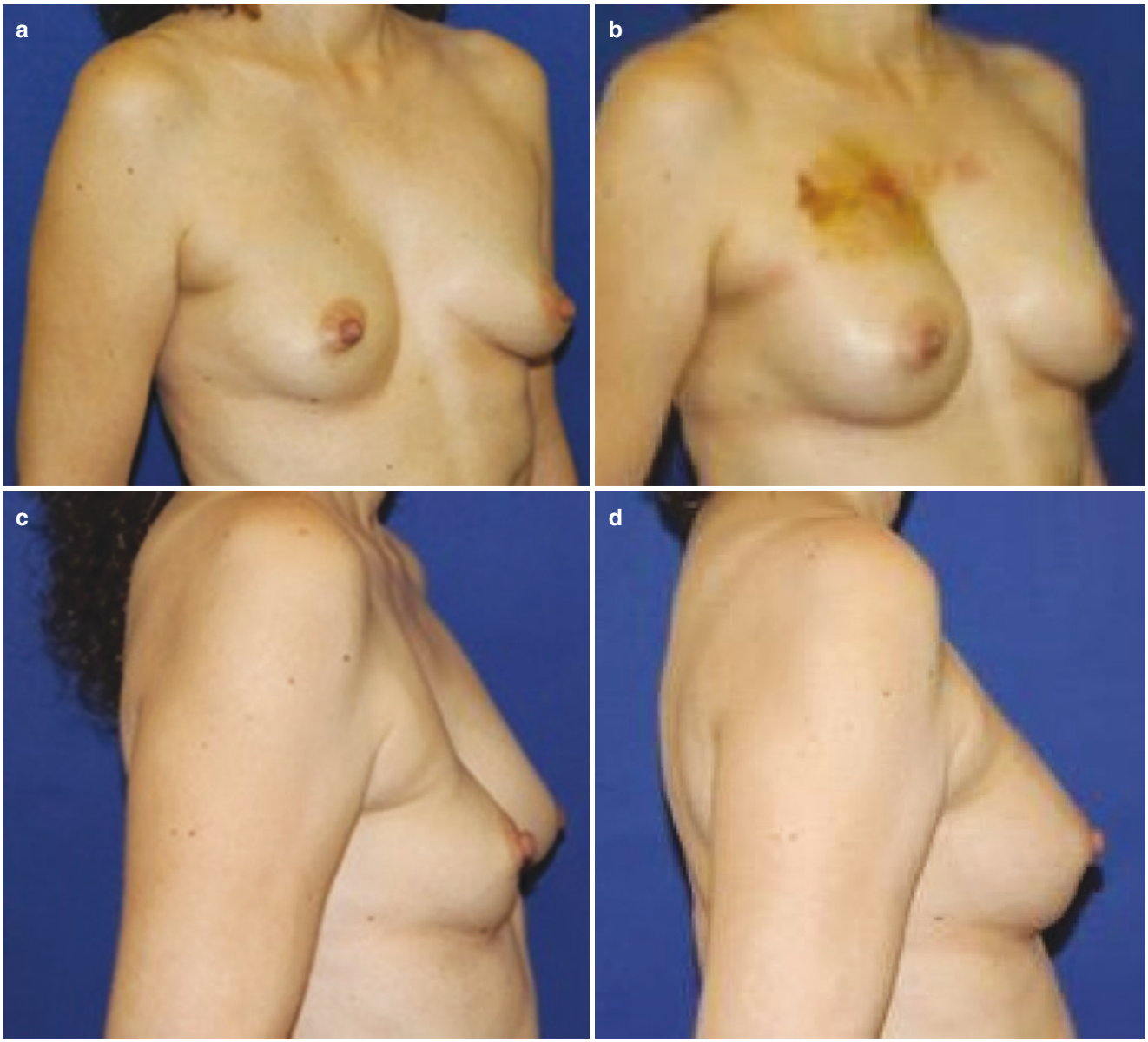

Fig. 3.9 (**a**) Preoperatively unilateral hypoplasia of the chest. (**b**) Immediately post fat transfer to right breast upper pole. (**c**) Preoperative lateral view. (**d**) Postoperatively at 2 years after breast augmentation and fat transfer

Conclusion

Congenital and acquired anomalies of the chest and breast have challenged plastic surgeons for over a century. Although rare, some anomalies require surgical correction in early childhood although most issues seen in a plastic surgery office are aesthetic asymmetries. Chest wall and breast anomalies greatly affect the self-esteem of an adolescent and are worsened by issues of intimacy in young adulthood. Initial evaluation should include a precise analysis of the chest wall, ribs, sternum, and spine, along with a detailed history of any previous surgical procedures. Biodimensional tissue-based planning and 3D simulations will help determine which implants may best correct the hypoplastic elements. Communication with the patient and her family to create a clear understanding of what may or may not be correctable is essential to reduce revisions after surgery for size change and other avoidable complications. The use of fat, when available, can soften edges and smooth abnormal bony contours as well as create more precise symmetry. Finally, patients should be aware that they will need revision procedures during the course of their lifetime as both they and their implants age.

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Treatment of Implant Malposition

4

Allen Gabriel and G. Patrick Maxwell

Introduction

Implant malposition is a common complication after breast augmentation mammoplasty. Natrelle round silicone implant core study and Natrelle 410 anatomical form-stable silicone implant core study (Allergan, Inc., Irvine, CA) indicate a 4.7% to 6.8% rate of implant malposition within 10 years after primary augmentation and a 6.0% to 9.1% rate after revision augmentation [1, 2]. In addition, implant malposition was the second most common reason for revision surgery after capsular contracture in these studies. Between 10.2% and 12.2% of revisions in primary augmentation patients and between 11.1% and 14.5% of revisions in revision augmentation patients were due to implant malposition. Improperly positioned implants are not only aesthetically unpleasing but may also adversely impact the psychological well-being and quality of life of patients.

Types of Malposition and Their Causes

Implant malposition can manifest as inferior, lateral, medial, or superior displacement of the implant from the intended location on the breast (Fig. 4.1).

Inferior Malposition

Inferior malposition is characterized by implant descent below the native inframammary fold (IMF), resulting in an increased nipple to IMF distance and stretching of the inferior pole skin. It is the most common type of implant malposition.

Inferior malposition may also present with a "bottomed-out" appearance or a "double-bubble" deformity. In bottoming out, the implant descends to lie below the central mound of the breast, resulting in fullness below the nipple. Consequently, the nipple is displaced up over the upper breast and the IMF scar is displaced up onto the lower pole of the breast.

Double bubble has a characteristic appearance of two parallel, curvilinear creases running transversely across the lower pole of the breast. The superior fold is the native IMF, while the inferior fold is the new IMF created at the time of surgery. Two types of double bubble are recognized: one where the native IMF is abnormally high and the other where the IMF is at the correct location but the lower border of the subpectoral pocket is displaced inferiorly [3].

Medial Malposition

Medial malposition refers to the displacement of one or both implants toward the midline or sternum. With bilateral implant displacement, a confluence of breast tissue from both breasts is noted. Medial malposition displaces the implant volume in between the nipples, which, in turn, cause the nipples to be displaced outward away from the central mound. Medial malposition is often confused with symmastia, but the two are not synonymous.

Symmastia is attributable to the disruption of the midsternal fascia, while in medial malposition, the midsternal fascia remains intact [4]. Two forms of symmastia are recognized – monocapsular and bicapsular. In monocapsular symmastia, the periprosthetic capsules are fused together with open communication between them. In bicapsular symmastia, the periprosthetic capsules remain as distinct entities with some muscle fibers and/or soft tissue connecting the midsternal skin to the underlying sternum on one side.

A. Gabriel (✉) · G. P. Maxwell
Department of Plastic Surgery, Loma Linda University Medical Center, Loma Linda, CA, USA

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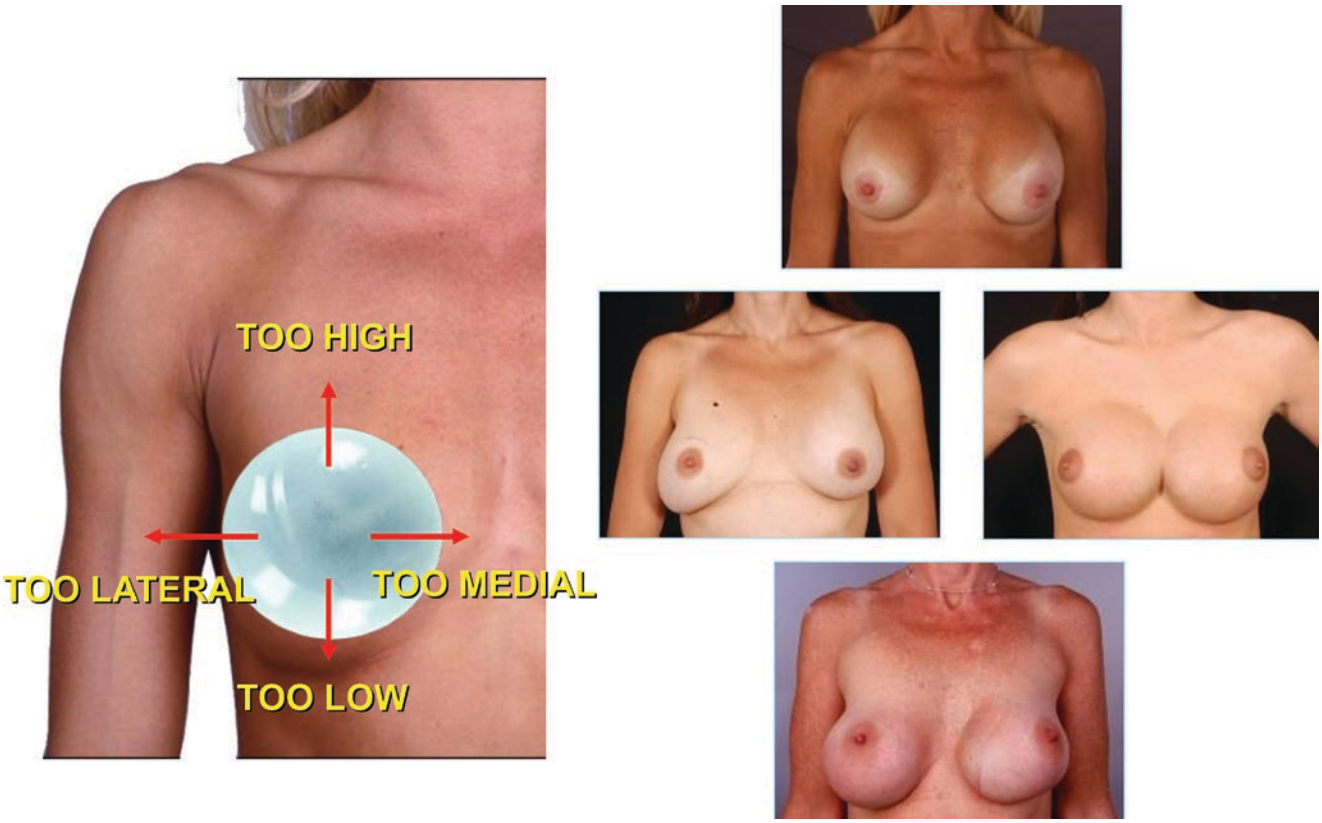

Fig. 4.1 Types of implant malposition

Lateral Malposition

Lateral malposition or telemastia is the lateral displacement of one or both implants away from the sternum. When it occurs bilaterally, an abnormally wide separation between the breasts is noted. Nipples often point inward due to the greater outer versus inner breast fill. In severe cases, laterally displaced implants can interfere with arm movements.

Superior Malposition

Superior malposition, also referred to as "high-riding implant," is the superior displacement of the implant such that most of the implant volume is above the nipple. Due to the lower fill of the implant below the nipple, the nipple points downward. The higher upper implant volume produces an unnatural upper bulge, with an overly demarcated edge that, when severe, has a shelf-like appearance.

Causes of Implant Malposition

Implant malposition may be caused by operative techniques, implants, and/or patient-related factors.

Operative Technique-Related Factors

Surgery-related factors are probably the major cause of implant malposition and are predominantly due to inadequate pocket dissection and inadequate management of the pectoralis major muscle. An overly large pocket from pocket over-dissection allows for implant mobility within the pocket and may result in inferior, medial, or lateral malposition, depending on the location of the over-dissection. A tight pocket from under-dissection on the other hand may result in superior malposition, often subsequent to capsular contracture. A pocket that is dissected too far inferiorly such that the native IMF persists cephalad to the newly created IMF may cause a double-bubble deformity.

With subpectorally placed implants, improper pectoralis major muscle dissection and release are important sources of implant malposition. A subpectoral pocket is created by releasing the lower attachments of the pectoralis major muscle from its lateral border to the sternum. Incomplete release of the lower attachments of the pectoralis major causes superior implant malposition. Over-dissection of the pectoralis major laterally leads to inferior and lateral malposition, while extensive release of the muscle medially leads to medial malposition.

Technical approaches, such as the location and length of the incision and the plane of implant placement, may also predispose to implant malposition. The risk of moderate-to-severe implant malposition is higher with periareolar or axillary incisions versus inframammary incisions, with subpectoral versus subglandular placement [5], and with longer versus shorter incisions [6]. *In an over-dissected pocket, subpectorally placed implants are more likely to have a double-bubble deformity, whereas subglandularly placed implants are more likely to bottom out* [3, 7].

Implant-Related Factors

Implant surface and implant size are two notable implant-related factors that can predispose to malposition. In general, implant malposition is less likely with textured versus smooth implants [5]. This is because the pores on the surface of textured implants allow tissue adherence and the resulting adhesive effect stabilizes the implant within the pocket. A heavy implant, in conjunction with weak inferior soft tissue support, is likely to gradually descend by gravity and cause inferior malposition or double-bubble deformity. An implant that is larger than the base width may result in medial or lateral malposition or symmastia.

Patient-Related Factors

Inherent breast and chest wall asymmetries or deformities can predispose to implant malposition that are oftentimes overlooked. An abnormally high native IMF from a short nipple to IMF distance (of less than 4 cm), a constricted IMF, or a tuberous breast may lead to double-bubble deformity [3, 7]. Breast soft tissue atrophy or laxity over time due to aging, weight changes, and pregnancy plays a contributory role in inferior implant displacement. Chest wall deformities such as pectus excavatum and pectus carinatum may affect implant positioning relative to the chest wall, the former displacing the implant medially and the latter laterally.

Postoperatively, capsular tissue attenuation and contracture are the most important patient factors contributing to implant malposition. Capsular tissue attenuation is unpredictable, although it is more frequently observed with smooth implants as they can freely move within the pocket [8]. As an attenuated capsule is not able to adequately support the implant, the effect of gravity over time or muscle activity may lead to implant malposition. Similar to capsular tissue attenuation, capsular contracture is an unpredictable event although several factors are known to increase its risk. Contracture leads to implant firmness/tightness, deformation, and dislocation.

Treatment of Implant Malposition

Evaluation

Treatment of implant malposition begins with a thorough evaluation of the patient to identify the underlying etiology and understand the anatomic limitations and the desired outcome. Often a particular malposition may have more than one etiology and more than one type of implant malposition. This is often seen with inferior malposition where the implant may also be displaced laterally or medially. There are five basic underlying etiologies that may be the cause or contribute to the cause of the problem – surgery, soft tissue, capsule, implant, and chest wall – despite the apparent complexity of a given clinical presentation. These underlying components must be carefully and systematically analyzed from the outside in (or inside out) until all layers have been evaluated. One or more of these components and layers may need to be addressed surgically for a durable repair.

Repair Approaches and Techniques

There are generally two approaches to the correction of implant malposition that involve the revision of the existing implant pocket or the creation of a new implant pocket in a different plane. In each of these approaches, a combination of techniques is often needed to reposition the implant at its intended location on the breast.

Revision of Existing Pocket

Capsulorrhaphy is the mainstay technique for the revision of an existing pocket, especially in the submuscular plane (total or dual plane). This technique is useful for reducing the size of a capsule or for releasing the tension from a tight capsule. Capsulorrhaphy is often performed in conjunction with mirror image capsulotomy to ease the tension placed on the capsulorrhaphy suture line. Implant downsizing and soft tissue reinforcement of the capsulorrhaphy suture line with acellular dermal matrix are other measures that may be utilized to help reduce suture line tension.

Thermal capsulorrhaphy is a newer form of capsulorrhaphy technique. Also referred to as popcorn capsulorrhaphy, it utilizes ball cautery to obliterate excess breast pocket space followed by barbed suture closure [9]. Capsulorrhaphy reinforces apposition of the capsular walls, while cautery contracts and thickens the capsule, thus reducing dead space and improving suture purchase. The addition of acellular dermal matrix may be needed to reinforce the revision in the context of thinned breast or capsular tissue or when correcting symmastia.

Capsulorrhaphy repair can also be reinforced with capsular flaps, but this requires thick capsules. The flaps are used to

create a sling of vascularized tissue that cushions the capsulorrhaphy suture line from the weight of the implant [10]. Capsular flaps have been successfully used to correct inferior malposition and symmastia [11–13]. The strength and longevity of capsular tissue, however, can be inconsistent and flaps can relax over time, resulting in recurrence of malposition.

The advantage of capsulorrhaphy lies in its simplicity, as it is generally an easy technique. Successful repair has been reported with this technique [9, 14], but long-term results may be poor [7, 10] if the deforming forces that caused the original malposition are not adequately addressed. Persistence of deforming forces may stretch the capsulorrhaphy, leading to recurrence.

Creation of a New Pocket

Creation of a new pocket recreates the soft tissue/implant dynamics and redefines the anatomical landmarks of a primary breast augmentation, thus providing an opportunity to start over. More precise pocket creation is achievable with a new pocket than modifying an already distorted pocket with capsulorrhaphy (thermal and/or suture) or with capsular flaps. It is also less traumatic than capsulectomy. The plane in which the new pocket is created is dependent on the presenting symptoms of malposition, availability of soft tissue, and anatomic considerations.

As mentioned above, improper pectoralis major muscle dissection and release are important sources of implant malposition with subpectorally placed implants. Moving the implant from the subpectoral to a subglandular plane releases the muscle-related deforming forces imposed on the implant. The technique involves the removal of the posterior capsule, retaining the anterior capsule, and reattaching the pectoralis muscle back to its origins. As muscle reattachment recreates the native muscle anatomy, plane change also addresses muscle contraction-induced deformities such as animation deformity. The feasibility of subglandular site change, however, is dependent on the availability of adequate soft tissue coverage for the implant. Inadequate soft tissue coverage and support may lead to undesirable consequences such as rippling, implant visibility, and implant palpability. There is also the risk of inferior malposition as well as capsular contracture.

When soft tissue coverage is inadequate, the implant may be moved from the subpectoral to a neosubpectoral location [15]. The neosubpectoral pocket is created anterior to the existing capsule after collapsing the capsule. The collapsed capsule is integrated into the new pocket, which reinforces and strengthens the neosubpectoral pocket. Creating a neosubpectoral pocket, however, may be challenging when capsular tissue is thin. Moreover, creation of a neosubpectoral pocket alone may not address muscle-related malposition. Concurrent adjustment of the subpectoral muscle may be needed.

In patients with adequate soft tissue coverage, switching from a subpectoral to a total subfascial (subaponeurotic) plane is an alternative option [16, 17]. The total subfascial plane lies below the deep thoracic fascia of the pectoralis major, the serratus, the lateral oblique, and the rectus anterior muscles. This plane yields the benefits of the subglandular and subpectoral planes while avoiding their disadvantages.

In patients with subglandular implants, switching to a subpectoral plane resolves many of the presenting symptoms of implant malposition relating to inadequate soft tissue support. However, proper muscle dissection and release from its origins are critical to avoid inferior, lateral, medial, or superior malposition and animation deformity. An alternative option would be a dual-plane implant position where the upper two-thirds of the implant are subpectoral and the lower third subglandular. As the medial origins of the pectoralis muscle are not divided in this approach, the risk of symmastia and animation deformity is attenuated compared with a total subpectoral approach. The dual-plane positioning may also be suitable when switching from a subpectoral plane for the correction of implant malposition that is due to animation deformity.

Although the creation of a new pocket can be performed as a stand-alone technique, often other techniques and additional procedures may be needed to adequately address the presenting symptoms as well as prevent or minimize unintended consequences of a pocket change. Capsulectomy and/or capsulotomy may be needed to remove or score down the existing capsule before a plane change. In patients with thin tissue, previous scarring, or problematic bony contour slopes, reinforcement of the plane change with acellular dermal matrix is highly advisable to buttress the corrected implant position [18, 19]. The matrix is sutured in the appropriate position with proper purchase to achieve support and provide better control of implant pocket and position. Autologous fat grafting may be needed to provide additional soft tissue coverage, especially with subglandular pocket change, to mitigate implant rippling, palpability, and/or visibility.

Case Examples

Correction of Inferolateral Malposition

A 23-year-old woman who had undergone bilateral breast augmentation in 2011 presented with bilateral inferolateral malposition (Fig. 4.2). She had smooth, round, saline implants (325 cc) placed via a transaxillary incision. Implant malposition was corrected using a combination of procedures, including site change from submuscular to subfascial via a new inframammary incision, implant exchange from round to anatomic implant (Natrelle® 410 Style MF 420 cc; Allergan, Irvine, CA) (Fig. 4.3), and use of bioresorbable

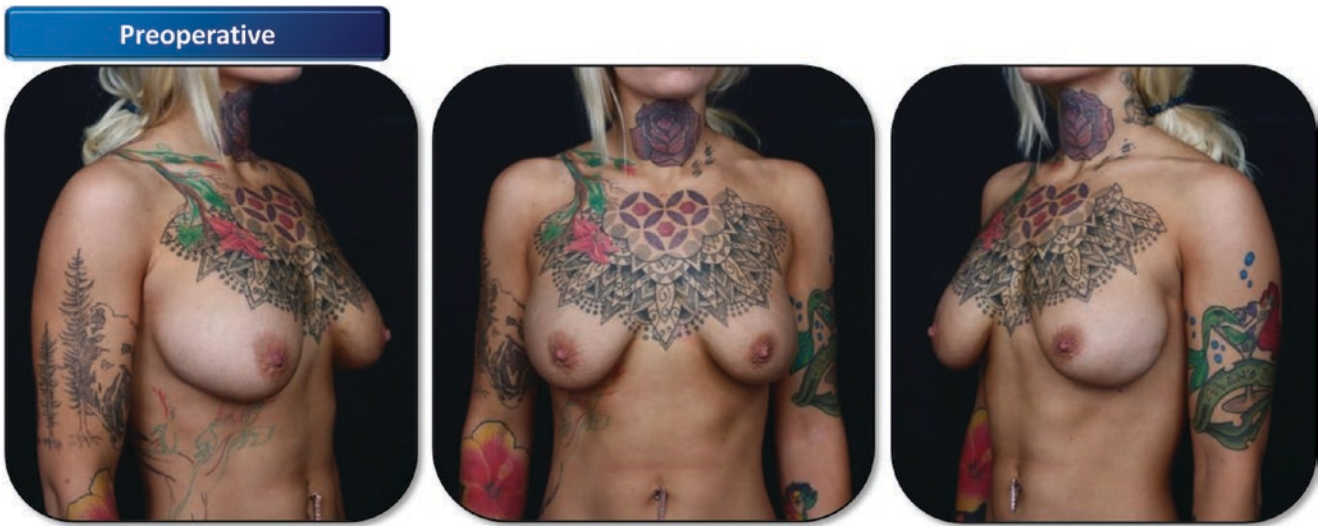

Fig. 4.2 Preoperative view of patient presenting with bilateral inferolateral malposition

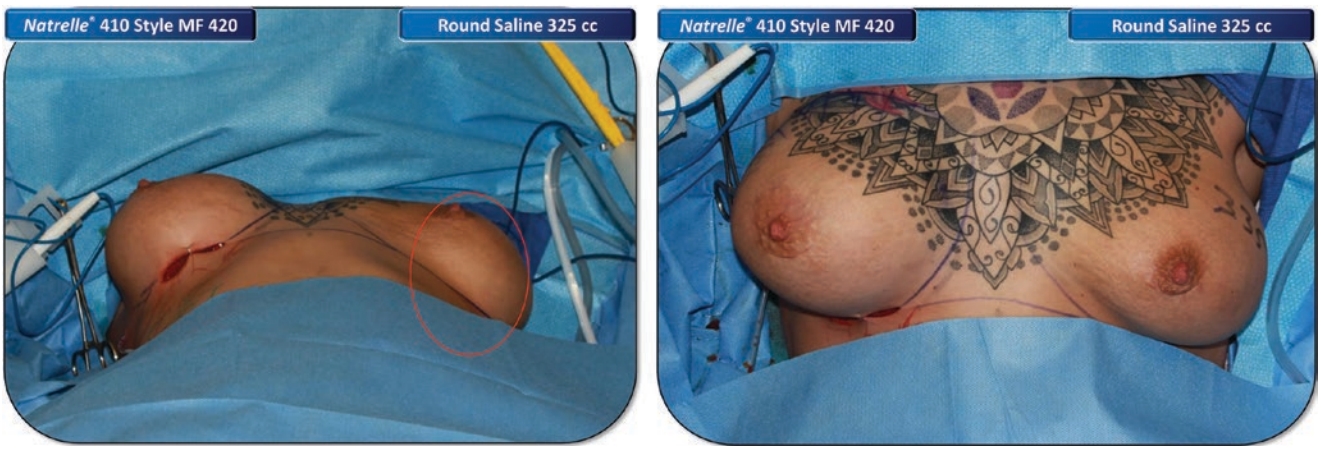

Fig. 4.3 Correction of inferolateral malposition. Corrective surgery included implant site change, followed by implant exchange, and mesh support at lower pole. Round, saline implants were replaced with anatomic implants. Patient is from Fig. 4.2

mesh (GalaFLEX®, Galatea Surgical, Lexington, MA) for soft tissue support and repair and to minimize long-term ptosis. For site change, an anterior capsulectomy was performed on each breast followed by pectoralis major muscle release from the overlying glandular tissue. Care was taken to ensure a precise dissection as an anatomical device was to be placed. The muscle was pulled caudal and tacked down to its origin with 0-PDO sutures (STRATAFIX™, Ethicon US LLC, Cincinnati, OH). Following creation of the new pocket, the implant was introduced into the pocket and the bioresorbable mesh was placed at the lower pole. The mesh was tacked down to the IMF with 0-Vicryl sutures with a 3–5 cm posterior overlap for successful gutter creation. At 12-month follow-up, there was no recurrence of inferolateral malposition (Fig. 4.4).

Correction of Medial Malposition

A 35-year-old woman presented with bilateral medial malposition 2 years following her dual-plane augmentation with silicone implants (Fig. 4.5). Planned corrective surgery for this patient included medial and inferior popcorn capsulorrhaphy followed by mesh support. At times a site change to neopectoral may be needed depending on the severity of the deformity and chest wall asymmetry. In this case, popcorn capsulorrhaphy with mesh support was completed followed by placement of round, smooth, full-profile, silicone implants (Natrelle). At 12-month follow-up, her medial malposition correction was maintained (see Fig. 4.5).

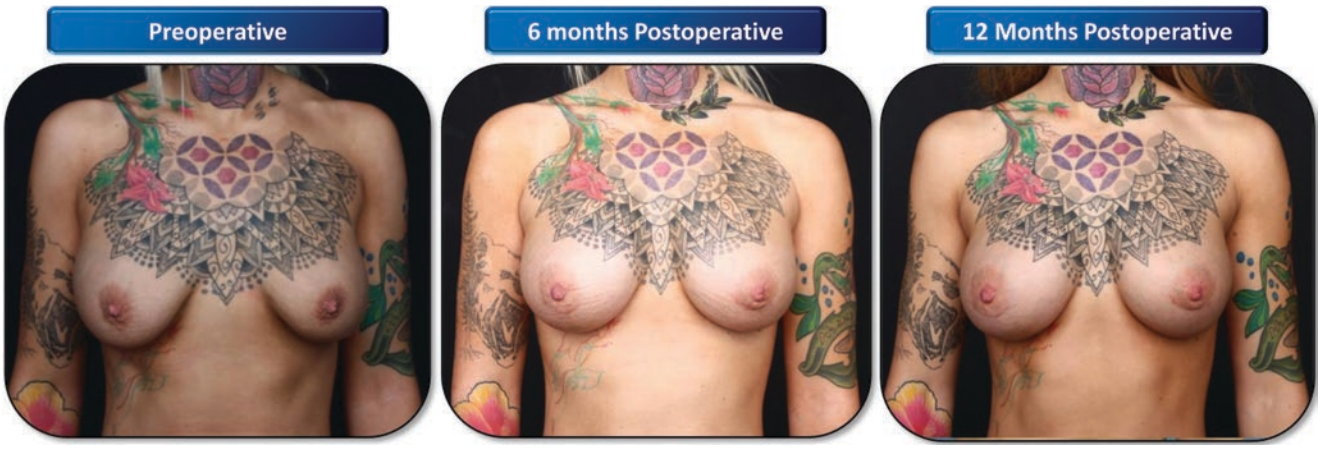

Fig. 4.4 Postoperative view of patient after correction of bilateral inferolateral malposition. Patient is from Fig. 4.2

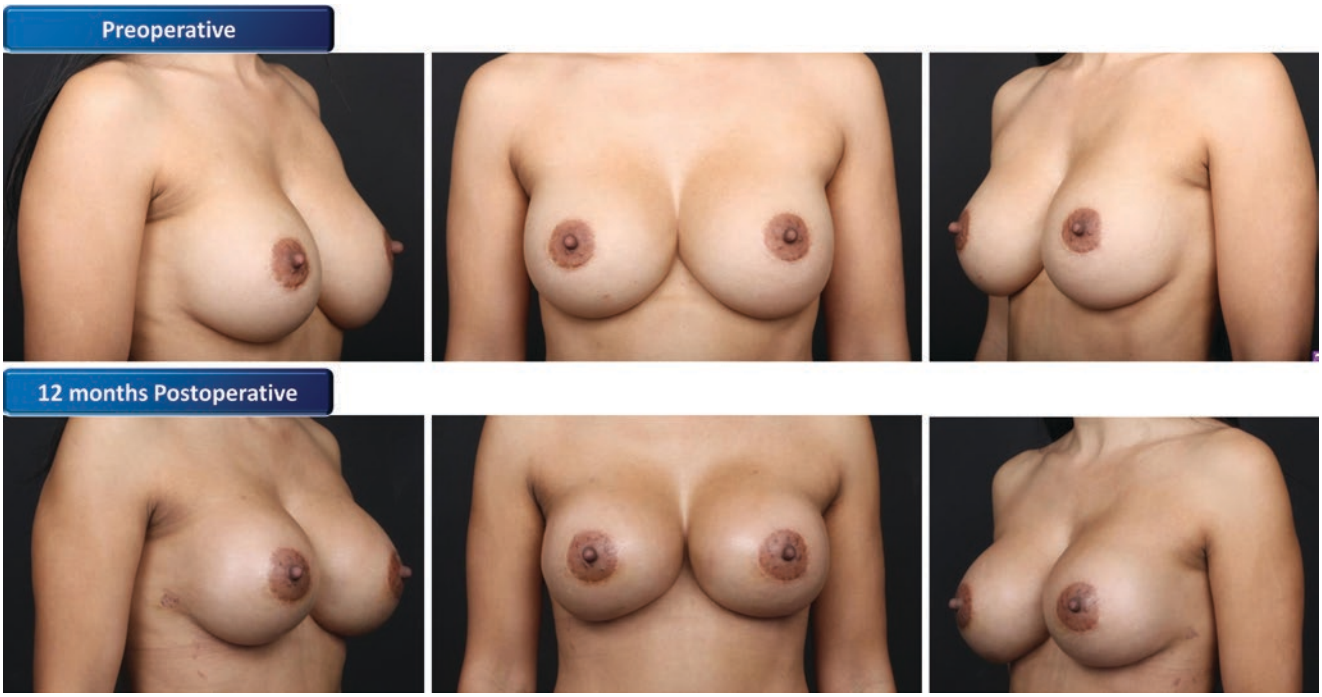

Fig. 4.5 Pre- and postoperative views of a patient who presented with bilateral medial malposition. Corrective surgery included medial and inferior popcorn capsulorrhaphy followed by mesh support at lower pole. Round, smooth, full-profile, silicone implants were placed

Correction of Inferior Malposition

A 41-year-old woman presented with severe, bilateral, double-bubble malposition deformity subsequent to augmentation with saline implants followed by two attempted revision surgeries (Fig. 4.6). The cause of her double-bubble deformity was over-dissection of the lower pole and failure to stabilize the IMF at the initial surgery. Corrective surgery for double-bubble deformity would normally entail a site change to a neopectoral or a subfascial subglandular pocket. In this patient, a neopectoral pocket was created per patient preference. Following site change and collapse of the anterior capsule to the posterior capsule, sizers were utilized for appropriate positioning of the implant. The pocket was reinforced with acellular dermal matrix (Strattice™, LifeCell Corporation, Branchburg, NJ) followed by placement of round, smooth, silicone implants (Natrelle) (Fig. 4.7). There was no evidence of recurrence of inferior malposition at 25 months of follow-up (Fig. 4.8).

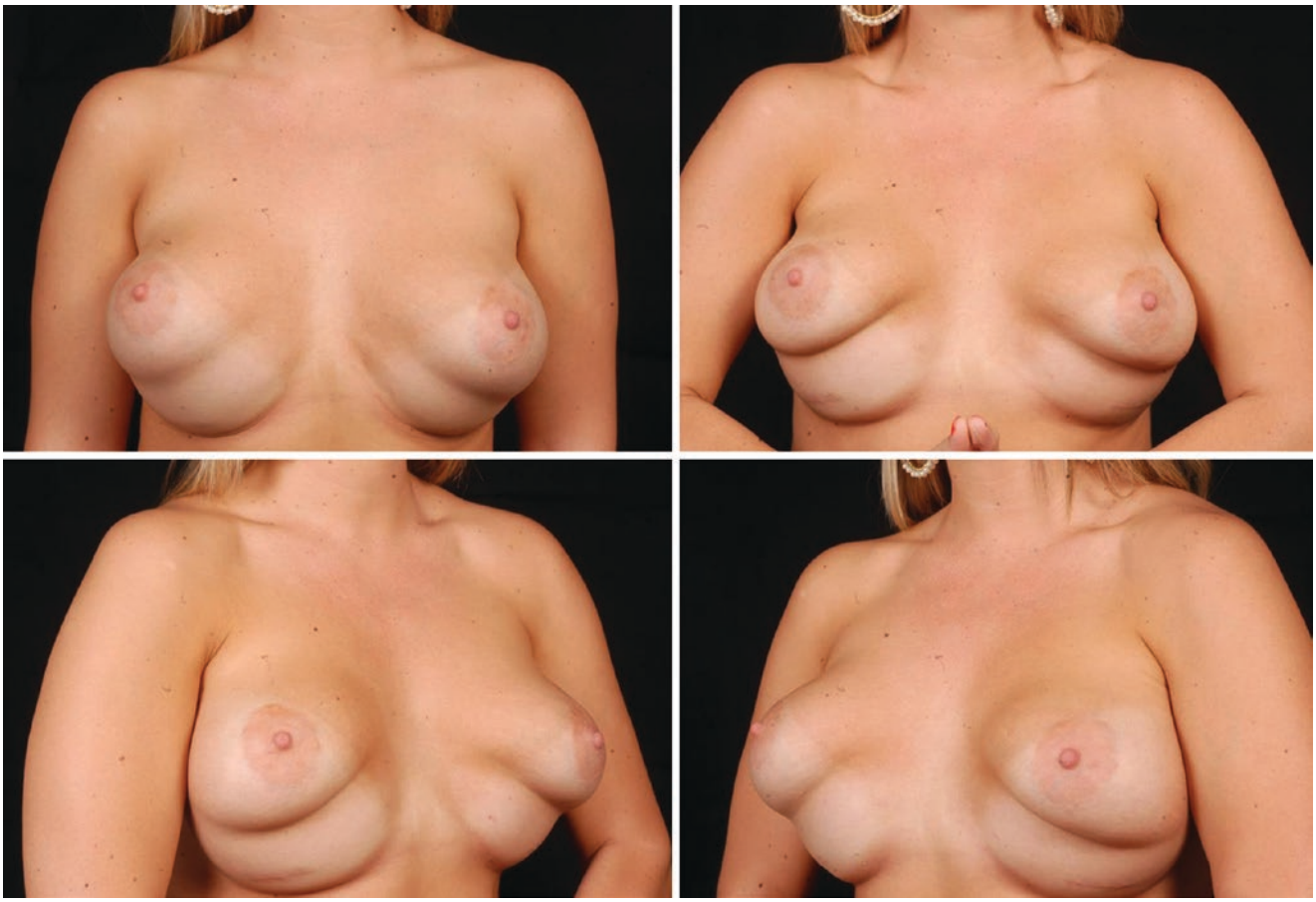

Fig. 4.6 Preoperative view of patient presenting with bilateral double-bubble deformity (inferior malposition)

Prevention of Implant Malposition

Prevention of implant malposition requires a thorough preoperative assessment of the patient's anatomic features and an operative plan that specifically addresses issues that may influence implant positioning. Chest wall asymmetries and deformities should be identified and documented. Chest asymmetry is very common in women undergoing breast augmentation; approximately 90% have some degree of chest asymmetry [20]. As asymmetries are often magnified after augmentation, it is important to inform patients so that patients have realistic expectations. Scoliosis, pectus excavatum, and pectus carinatum are the most important of the deformities, as they can affect the positioning of the implant relative to the chest wall (Fig. 4.9).

Breast mound volume, ptosis, presence of base diameter constriction, and nipple-areolar size and position are notable breast asymmetries that may influence implant positioning. Volume asymmetries can be corrected by adjusting the fill volume. Ptosis may be improved by proper positioning of the pocket and/or by adjusting the skin envelope. Base diameter constriction can be addressed by releasing or altering the IMF. Concurrent mastopexy may be needed to improve nipple-areola complex position on the breast mound.

The preoperative assessment should also include a thorough assessment of breast dimensions and glandular density which play an important role in implant selection. Relevant breast dimensions that determine implant selection include volume, shape, and base width. Improper implant selection at the preoperative stage can predispose patients to implant malposition. An appropriate implant should not be larger than the breast base width to prevent horizontal implant movement and should not be too heavy that it stretches the native breast tissues. However, given the concerns over textured devices and potential for acute large cell lymphoma (ALCL), it may be prudent to consider smooth implants even when contemplating revision surgeries. Breast volume and density also play a role in influencing the plane of implant placement – subglandular, submuscular, or dual plane. In general, subglandular placement is considered when there is ample dense breast tissue, while submuscular placement is considered when breast volume and density are lacking. Dual-plane implant placement may be considered

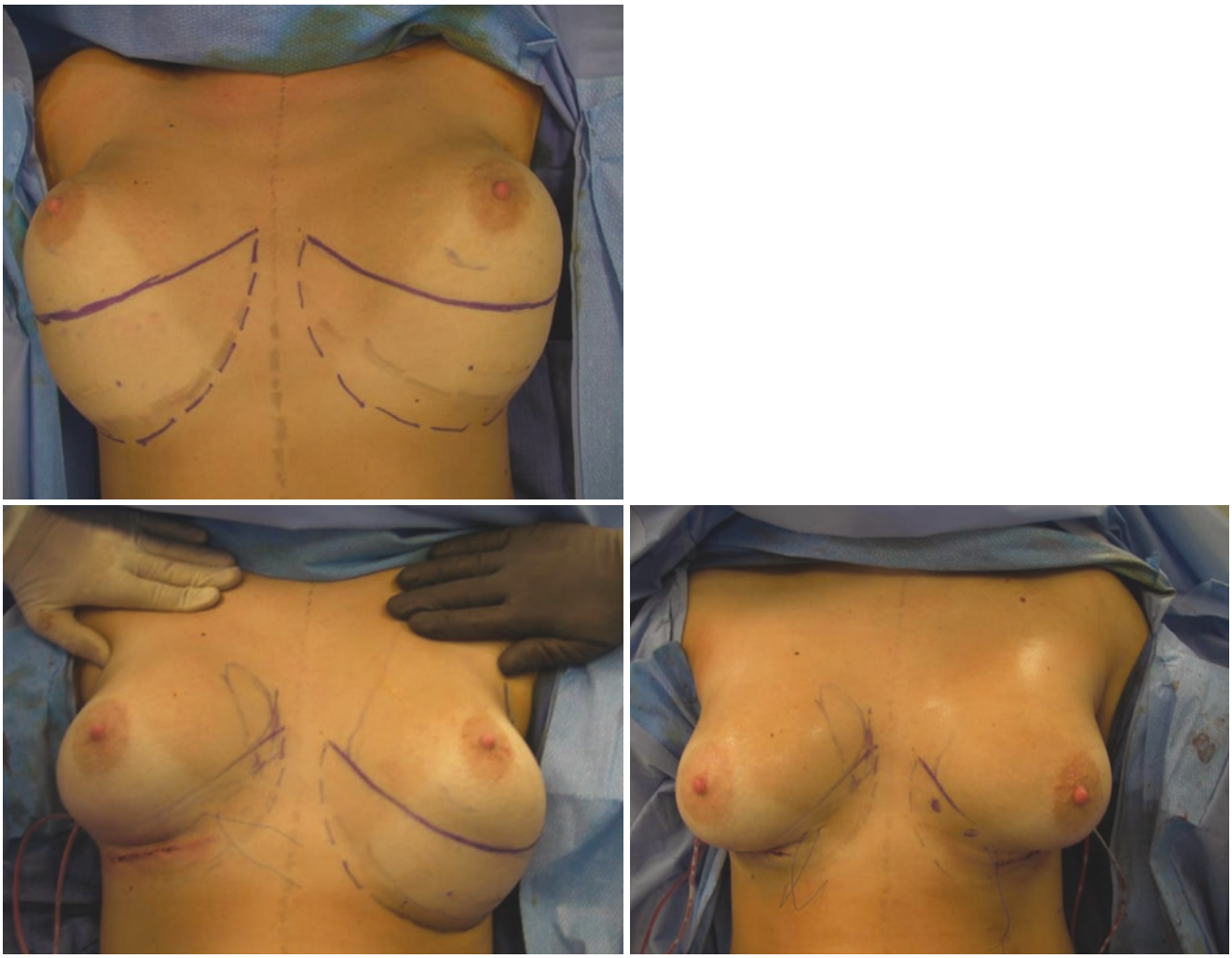

Fig. 4.7 Correction of double-bubble deformity. Site change to neopectoral pocket was performed followed by soft tissue support with acellular dermal matrix and placement of round, silicone implants. Patient is from Fig. 4.6

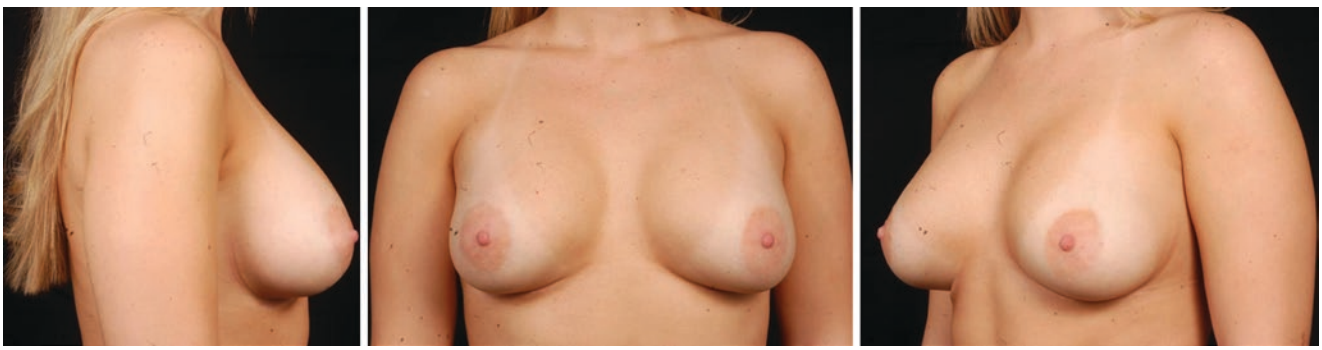

Fig. 4.8 Postoperative view of patient after correction of bilateral double-bubble deformity. Patient is from Fig. 4.6

for maximal expansion of the lower pole or to maximize soft tissue coverage.

Intraoperatively, attention should be focused on the technical issues associated with pocket creation that may predispose to implant malposition. Creation of a snug pocket for the selected implant is imperative to prevent implant movement. For submuscular pockets, caution should be exercised when dissecting and releasing the pec-

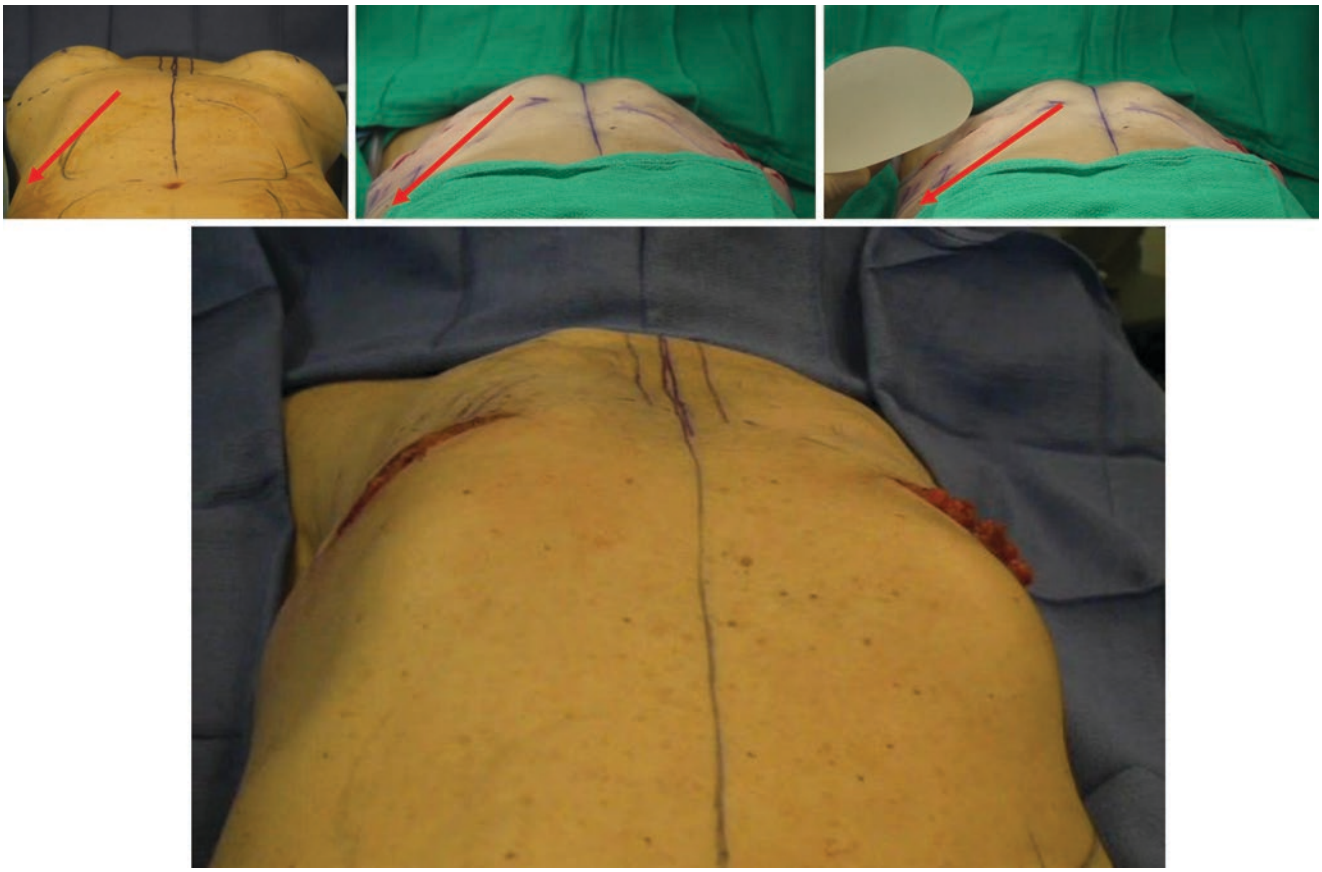

Fig. 4.9 Patient presenting with pectus carinatum. Chest wall contour deformity can affect the positioning of the implant relative to the chest wall. It is important, in this case, to add soft tissue support, preferably with bioresorbable mesh, at the initial surgery to minimize the lateral descent of the implant. The patient should be advised that some lateral descent will occur

toralis major muscle, which are major causes of implant malposition. Gentle blunt dissection of the pockets medially under direct vision helps to preserve the midsternal fascia and prevent medial malposition and symmastia [4]. In the event of lower pole hypoplasia, double-bubble deformity is a concern and may be prevented by subglandular release of the breast tissue from the pectoral fascia. If using a smooth-surface implant with lax overlying breast tissue or when the IMF is lowered from its original location, the use of acellular dermal matrix should be considered to provide lower pole support.

Postoperatively, patients should be advised not to massage their breasts as this may cause an inflammatory reaction, which, in turn, may lead to capsular contracture. A postoperative bra should be worn for 2 to 3 months to prevent implant movement and facilitate tissue adherence and tissue ingrowth if a textured-surface implant is used. To further prevent implant movement, sports and other types of exercise should be avoided for 6 weeks. Activities may be resumed after 6 weeks except those requiring substantial amounts of upper body movement or fast motion which should be avoided for up to 3 months.

Conclusion

Implant malposition is a common complication after breast augmentation mammoplasty. It may be caused by patient factors, operative techniques, and/or implant-related factors. Thorough preoperative planning, meticulous operative technique, and diligent postoperative care can prevent the occurrence of implant malposition. When malposition does occur, understanding the etiology is crucial for devising an operative plan that adequately addresses the cause(s).

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Implant Rupture: Pathophysiology, Diagnosis, and Management

5

Austin Y. Ha, David W. Grant, Marissa M. Tenenbaum, and Terence M. Myckatyn

Introduction

In 2017 alone, over 300,000 breast augmentation and 100,000 breast reconstruction procedures were performed by plastic surgeons in the United States (US) [1]. There have been numerous modifications to the implant fill material, outer shell, and shape with the goal of maximizing patient safety and satisfaction while minimizing complications. However, implant rupture continues to be a significant complication and is one of the leading causes for reoperations and explantations [2–4]. In this chapter, we review the pathophysiology, diagnosis, and management of saline- and silicone gel-filled breast implant ruptures.

Pathophysiology

Long-term follow-up data is available for all breast implants approved by the US Food and Drug Administration (FDA) in the form of Core Post-Approval Studies. Currently, there are six silicone gel-filled breast implants approved by the FDA for breast augmentation in women aged 22 or older and for breast reconstruction in women of any age: Allergan's Natrelle and Natrelle 410, Mentor's MemoryGel and MemoryShape, and Sientra's round and shaped silicone gel implants [2]. The three FDA-approved saline-filled breast implants are manufactured by Allergan, Mentor, and Ideal and can be used for breast augmentation in women age 18 or older and for breast reconstruction in women of any age. The Core Post-Approval Studies offer detailed information regarding the performance and safety of these devices, including rupture. Table 5.1 summarizes implant rupture rate data by type and manufacturer.

A. Y. Ha · D. W. Grant · M. M. Tenenbaum · T. M. Myckatyn (✉)
Division of Plastic and Reconstructive Surgery, Department of Surgery, Washington University School of Medicine, St. Louis, MO, USA
e-mail: myckatyn@wustl.edu

Incidence of Implant Rupture

Spear et al. reported the results of Allergan's 10-year Core Study data on Natrelle round silicone breast implants [5]. Two hundred and sixty-four subjects, approximately a third of the total study cohort of 715 patients, underwent magnetic resonance imaging (MRI) at 2-year intervals between years 1 and 9. The Kaplan-Meier rupture rate for patients who underwent primary augmentation was 9.3%; the rate for patients who underwent revision augmentation was 5.3%, and that for those who underwent primary reconstruction was 35.4%, with an overall rate of 13.0% by subjects (7.7% by implants). Importantly, this rate included both confirmed (by means of explantation; 71.4%) and unconfirmed (28.6%) ruptures.

Table 5.1 Implant rupture rates

Implant model and # of years at follow-up	Rupture rate (%, by patient)			
	Primary aug	Revision aug	Primary recon	Revision recon
Silicone implants				
Allergan Natrelle – 10 years [5]	9.3	5.3	35.4	NR
Allergan Natrelle 410 – 10 years [7]	17.7	14.7	12.4	19.6
Mentor MemoryGel – 6 years [9]	1.1	11.6	3.8	5.9
Mentor MemoryShape – 10 years [8]	6.6	9.6	18.9	0
Sientra round and shaped implants – 10 years [10]	8.5	6.8	16.5	NR
Saline implants				
Allergan Natrelle – 10 years [11]	13.8	NR	22.5	NR
Mentor saline implant – 10 years [12]	24.7	NR	33.2	NR
Ideal Structured – 6 years [13]	1.8	4.7	NR	NR

Abbreviations: *Aug* augmentation, *Recon* reconstruction, *NR* not reported

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Not surprisingly, the risk of rupture increased with time, with it near zero for the first 3 years after placement and gradually increasing by approximately 3–4% every 2 years. Neither the 10-year report nor the 6-year interim report [6] specified the etiology of ruptures. A similar 10-year Core Study report on Allergan's Natrelle 410 anatomical form-stable silicone breast implants by Maxwell et al. described rupture rates of 17.7%, 14.7%, 12.4%, and 19.6% for patients undergoing primary augmentation, revision augmentation, primary reconstruction, and revision reconstruction, respectively [7]. The overall rate was 16.4% by subjects and 9.7% by implants. Perhaps due to the greater cohesivity of the silicone gel, all ruptures were intracapsular.

Hammond et al. reported the results of Mentor's 10-year Core Study data on MemoryShape form-stable silicone breast implants [8]. The Kaplan-Meier cumulative incidence rates of suspected or confirmed rupture were 6.6%, 9.6%, 18.9%, and 0% for primary augmentation, revision augmentation, primary reconstruction, and revision reconstruction groups, respectively. Ten-year data are not yet published for Mentor's MemoryGel round silicone implants; 6-year risk rates of rupture were 1.1%, 11.6%, 3.8%, and 5.9% for primary augmentation, revision augmentation, primary reconstruction, and revision reconstruction, respectively [9].

Lastly, Stevens et al. summarized the findings of Sientra's 10-year Core Study data on its round and shaped silicone breast implants [10]. A subgroup of 571 patients out of a total of 1788 patients underwent MRI screenings every 2 years between years 3 and 10. The Kaplan-Meier rupture rates were 8.5%, 6.8%, and 16.5% for primary augmentation, revision augmentation, and primary reconstruction groups, respectively, with an overall rate of 8.6% by subjects. Interestingly, the three highest contributors to implant rupture accounted for a disproportionately high percentage of ruptures (41%) despite enrolling only 16% of total study patients; the overall rupture rate excluding these three sites was 5.8%.

In a 10-year prospective study of Allergan's Natrelle **saline** breast implants, Walker et al. reported Kaplan-Meier implant deflation risk of 13.8% and 22.5% for primary augmentation and primary reconstruction, respectively [11]. Patients were followed by office visits until 5 years postoperatively and by mailed questionnaires for years 6 through 10. A post-approval study of Mentor's saline implants reports 10-year implant deflation rates of 24.7% and 33.2% for primary augmentation and primary reconstruction, respectively [12]. The Ideal structured implant is a round, smooth, saline-filled implant with an internal structure consisting of a series of nested shells [13]. Deflation rates at 6 years postimplantation were 1.8% and 4.7% for primary augmentation and revision augmentation, respectively.

Whereas older data on incidence of implant rupture was often compromised with inconsistencies in the method of rupture detection (e.g., relying on product complaint data), the Core Study data was derived from subgroups of patients undergoing periodic MRI screenings at 2-year intervals. They also all employed the Kaplan-Meier analysis, which estimates the cumulative incidence of rupture over a time period and represents the most rigorous statistical method for calculating rupture risk rates [4]. Even with these improvements, however, one must exercise caution in making direct comparisons of the data reported by different manufacturers. For one, MRI and the radiologist interpreting it are not perfect at detecting implant rupture (please see section "Diagnosis") and can lead to false positives or negatives. It is also not feasible to surgically confirm all suspected ruptures as some patients elect to keep their devices despite concerns for rupture. Reoperations or explantations for reasons other than implant rupture, such as capsular contracture or seroma, may lead to incidental discovery of rupture—and these rates were variable in the above studies.

Etiology of Rupture

Data regarding the etiology of implant rupture is available through manufacturer device retrieval studies [4, 14, 15]. Iatrogenic damage by surgical instruments was identified as the most frequent cause of rupture, accounting for 51–64% of failures [4]. A significant proportion of failures (35–37%) was due to an unidentified opening or went without indication of cause [14, 15]. Fold flaw, delamination, and manufacturing defect accounted for a small percentage of implant ruptures. High-grade capsular contracture is also thought to contribute to implant rupture, but some groups have found no association between the two [16, 17]. Similarly, despite initial concerns that exposure to povidone-iodine (Betadine) may precipitate implant rupture, devices that were placed in Betadine-irrigated pockets were found to have no evidence of outer shell damage on explantation [18].

Each saline implant has a manufacturer's recommended filling volume, but it can be under- or overfilled by the surgeon. Proponents of overfilling suggest that it leads to decreased folds and wrinkles, particularly of the upper pole of the implant [19]. These folds and wrinkles may not only cause aesthetic deformities such as skin wrinkling but have also been cited as a potential contributor to deflation due to the excessive stress exerted on the folds—the so-called fold flaw. Al-Sabounchi et al. showed in a 2006 study of 96 saline implants that overfilling led to a statistically significant increase in 10-year survival rate [19].

Hammond et al. propose that the increased rupture rate seen in round silicone implants, compared to their shaped counterparts, is due to the folds and wrinkles that form in the upper pole of the device when the patient is upright and the implant assumes a teardrop shape with a relatively underfilled upper pole [8]. The increased cohesivity of the silicone gel in shaped implants is thought to be resistant to this fold flaw. Similarly, Nichter et al. attribute the low rupture rate seen with the Ideal structured saline implant to the absence of crease folds, which is in turn due to the underlying nested layers supporting the outer shell [13].

Hadad et al. recently reported in a retrospective study of 362 women with 700 silicone implants that placement in the submuscular plane was associated with an increased rupture rate [17]. Increased strain over the implant's upper pole and the shearing forces exerted by the pectoralis muscle were posited to have contributed to this finding. History of blunt trauma to the chest, such as a fall or a motor vehicle accident, is not an uncommon finding in patients who present with rupture, but it often precedes the diagnosis of rupture by months to years [20]. Either the ruptures are slow to develop or the traumatic event is rarely the true cause of the rupture. On the other hand, case reports citing mammography as the cause of implant failure were primarily associated with thinner shell, second-generation implants [21].

Diagnosis

Implant rupture is an identifiable injury to the outer shell leading to externalization of its fill material. Saline implant ruptures are easy to diagnose, as their deflation and subsequent reduction in breast volume become evident to the patient. No additional imaging or workup is required. As such, this section will focus on the diagnosis of silicone implant ruptures.

The majority of silicone implant ruptures are silent and imperceptible to the patient. They are also more likely to be intracapsular, wherein the externalized silicone remains confined within the capsule. This is in contrast to extracapsular ruptures, which are characterized by the silicone gel spreading beyond the capsule and therefore more likely to be symptomatic. Newer-generation cohesive gel with increased cross-linking is less likely to migrate outside of the capsule; in fact, no cases of extracapsular rupture were identified in Allergan's Core Study of its form-stable devices, and only 4 cases of definite extracapsular silicone were identified out of a total of 37 suspected or confirmed ruptures (10.8%) in Mentor's Core Study of its shaped implants [4, 7, 8]. Physical exam findings associated with rupture, such as asymmetry, palpable nodules or lymph nodes, capsular contracture, or palpable break in the implant shell, may not be present or become obvious to the patient or the surgeon in silent ruptures. Indeed, Hölmich et al. showed that physical examination had a sensitivity of 30%, specificity of 88%, positive predictive value (PPV) of 75%, and negative predictive value (NPV) of 49% in diagnosing silicone implant ruptures, when compared with MRI [22]. Given its low sensitivity and specificity, the authors concluded that physical exam by itself is not an acceptable diagnostic tool for ruptures.

MRI remains the gold standard for diagnosing implant ruptures. In the literature, its sensitivity is reported to be in the range of 58–100% and specificity in the range of 43–100% [23, 24]. The most commonly used sequences include T2-weighted, short tau inversion recovery, and chemical shift imaging, and the use of a dedicated breast coil is recommended for obtaining high-resolution images [25]. There are many well-documented radiographic criteria that indicate implant rupture. The "linguine sign" (Fig. 5.1) is the most reliable indicator of an intracapsular rupture and refers to the presence of multiple curvilinear low signal intensity lines within the high signal intensity silicone gel [25]. If there is a tear in the implant shell but the device remains

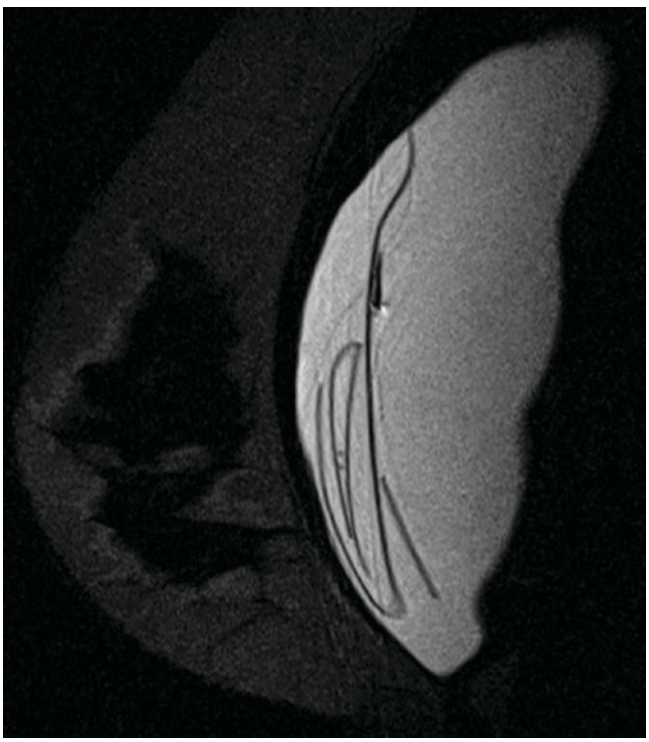

Fig. 5.1 The linguine sign. This refers to the presence of multiple curvilinear low signal intensity lines within the high signal intensity silicone gel and represents the most reliable indicator of an intracapsular rupture

uncollapsed—as is seen more commonly with the newer-generation cohesive gel implants—the free silicone can enter a radial fold and form the inverted "teardrop sign" (Fig. 5.2) [25]. On the other hand, extracapsular ruptures are often associated with focal areas of high signal intensity within the surrounding breast parenchyma that represent free silicone [25]. One or more of the signs described above may also be present.

Currently, the FDA recommends screening for silicone implant ruptures beginning 3 years after implantation and repeating every 2 years thereafter. This recommendation has been a topic of much debate, with many authors proposing that the potential benefits of screening do not outweigh the costs and potential risks to the patient [26]. In particular, financial costs associated with MRI scans are significant, and insurance is unlikely to cover such costs especially in cases of cosmetic augmentation. Ramifications associated with false positive results, such as unnecessary explantation, may be unacceptable. Furthermore, patients with claustrophobia and implanted metal devices such as cardiac pacemakers are unable to undergo MRI screening [25]. In such cases, computed tomography (CT) scans may be a good alternative, although consideration has to be given for its use of ionizing radiation [25]. For all these reasons and more, compliance with the FDA recommendation remains poor: 5.2% for the 3-year baseline exam and under 5% at 5 years and thereafter [27].

Ultrasound has been a popular alternative to MRI in literature, owing to its affordability and availability. Its reported sensitivity is in the range of 41–74% and specificity in the range of 57–92% [23, 24]. Its main disadvantages are that it is highly operator-dependent and has a steep learning curve [3]. With concomitant capsular contracture, there is a decrease in the sensitivity and NPV of ultrasound [28]. Intracapsular rupture is often associated with the "stepladder sign" (Fig. 5.3), a series of horizontal echogenic straight or curvilinear lines traversing the interior of the implant [25, 29]. Extracapsular rupture is characterized by the "snowstorm sign" (Fig. 5.4), where small amounts of free silicone mixed within the surrounding breast parenchyma resemble an echogenic snowstorm [25, 30].

A cost analysis comparing ultrasound and MRI showed that the expected cost per rupture detected, including management of the rupture, was significantly cheaper for ultrasound than it was for MRI ($1,089 vs. $2,066 for asymptomatic women and $1,622 vs. $2,143 for symptomatic women) [24]. Based on this data, and pooled sensitivity and specificity values for the two imaging modalities, the authors recommended screening asymptomatic women with ultrasound followed by confirmation with MRI and screening symptomatic women with ultrasound [24].

Mammography is relatively inexpensive and frequently performed on women with and without breast implants for cancer screening purposes. Extracapsular ruptures are readily diagnosed with mammography as irregular lobular or spherical densities remote from the implant (Fig. 5.5) [3]. Because the dense silicone is not easily penetrated by the x-ray energies used for typical screening mammograms, its sensitivity for intracapsular ruptures is low. As extracapsular ruptures

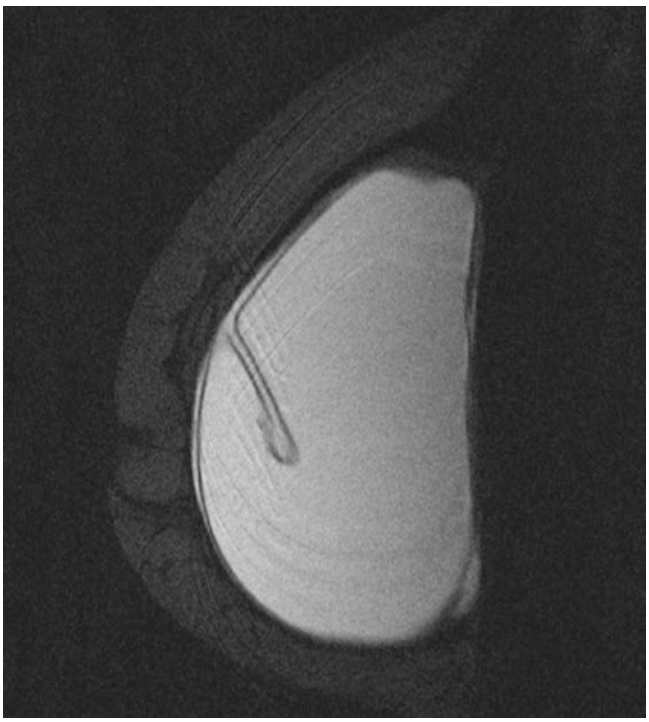

Fig. 5.2 The teardrop sign. This is most commonly seen in cases of intracapsular ruptures with uncollapsed implants, where free silicone enters a radial fold and forms the inverted teardrop

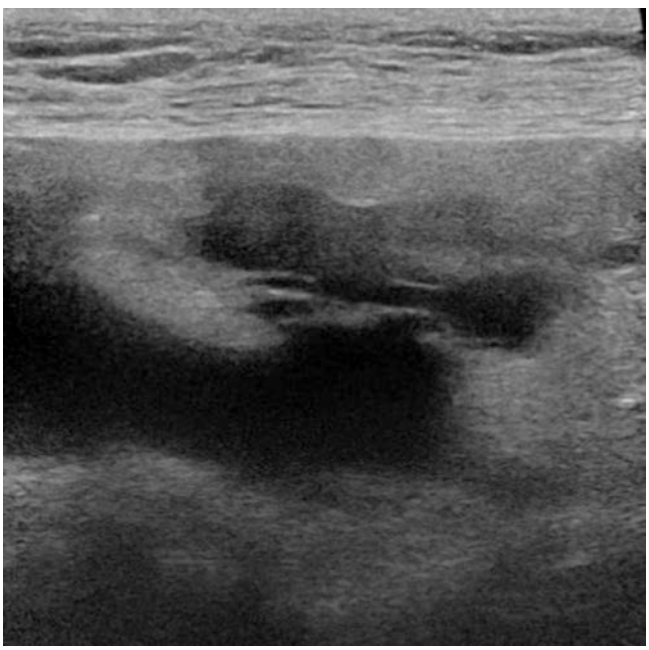

Fig. 5.3 The stepladder sign. This refers to a series of horizontal echogenic straight or curvilinear lines traversing the interior of the implant and is associated with an intracapsular rupture

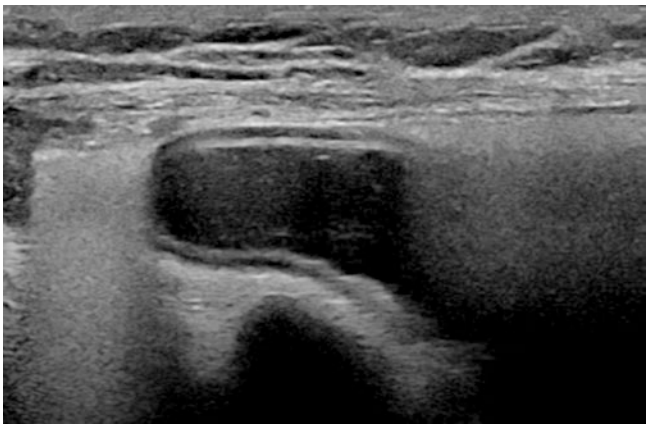

Fig. 5.4 The snowstorm sign. This is characterized by small amounts of free silicone mixed within the surrounding breast parenchyma resembling an echogenic snowstorm; it is associated with an extracapsular rupture

represent only a small minority of failures, mammography should not be used as the sole diagnostic tool for implant ruptures. History of previous implant rupture and silicone injections to the breast must also be ruled out before making the diagnosis of extracapsular rupture [25].

Management

As with the management of any other surgical complication, the surgeon must consider the risks, benefits, and alternatives of each option in cases of breast implant rupture. Discussions with the patient, particularly with regard to her goals, are also essential. The management of saline implant ruptures is relatively straightforward, as rupture leads to complete deflation, and removal of the silicone shell is typically recommended with or without replacement. Extracapsular silicone implant ruptures can be symptomatic, and explantation and silicone gel removal are recommended. On the other hand, there is no consensus on the management of intracapsular silicone implant ruptures. Notwithstanding the controversy over silicone implants and connective tissue diseases (CTDs), because there is (1) potential for conversion of intracapsular rupture to extracapsular spread (or extracapsular exacerbation) and (2) enhanced risk of inflammatory response to the silicone, explantation on a semi-elective basis is advisable.

Management of Saline Implant Ruptures

Soon after the rupture of a saline-filled implant, the device deflates, and the indwelling saline solution is harmlessly absorbed by the surrounding tissues. Because the device deflates completely after rupture, it can lead to significant distortions in the breast shape and contraction of the implant pocket and capsule. Typically, reoperation to remove the ruptured implant is recommended and can be combined with capsulotomy or capsulectomy, with or without implant replacement according to the patient's preference. The implant type, pocket plane, and access incision will depend on the discussions between the surgeon and the patient. Concomitant symmetry procedures can also be considered.

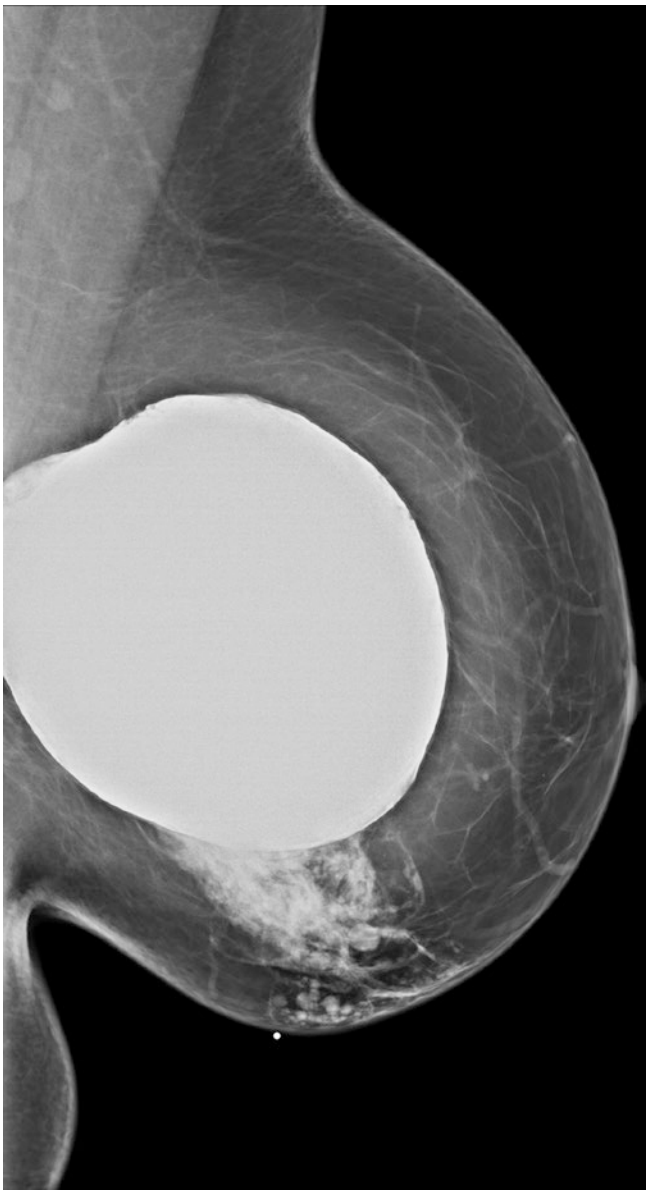

Fig. 5.5 Mammography evidence of extracapsular rupture. Note the irregular lobular and spherical densities remote from the implant

Management of Silicone Implant Ruptures

Patients with extracapsular silicone implant ruptures are likely to present with one or more of breast pain, asymmetry, palpable nodules or lymph nodes, capsular contracture, and a palpable break in the implant shell [3, 4]. Less commonly,

granuloma formation or silicone mastitis can also result. These patients are motivated to undergo surgical intervention for symptom relief, and explantation of the rupture implant, removal of externalized silicone gel—including excision of granulomas, if present—and capsulectomy, with or without replacement, should be offered to the patient. Because exposure to the silicone gel has been shown to have a dose-dependent relationship with capsule stiffness [31], the surgeon should consider placing the new implant in a virgin pocket to minimize cross-contamination.

Intracapsular silicone implant ruptures are often asymptomatic and discovered incidentally or during screening. The concern with intracapsular ruptures is increased exposure to silicone, which was suggested by earlier studies to cause CTDs and/or malignancy [32]. In 1992, the FDA placed a moratorium on silicone breast implants for primary augmentation over these concerns. Subsequent larger-scale epidemiologic studies did not demonstrate increased risks of CTDs [33] and both breast [34] and non-breast [35] malignancies, and the moratorium was lifted in 2006. From the currently available data, it is unknown whether there is a dose- and duration-dependent relationship between silicone gel exposure and the development of CTDs and/or malignancies and whether removal of silicone implants leads to a statistically significant and clinically meaningful reduction in risk.

What then should the plastic surgeon do in cases of intracapsular ruptures? It is the authors' opinion that in the absence of conclusive evidence to clearly support the benefit of removing an asymptomatic ruptured implant on an emergent basis, explantation can proceed in a semi-elective manner to limit the progression of inflammation or the extracapsular spread of silicone. The patient should receive the FDA and manufacturer recommendations, along with a full and unbiased disclosure from her surgeon about the potential benefits, costs, and risks of each option. Patients should be made aware of the extent of manufacturer warranty coverage, as well as the risks associated with additional anesthesia and surgical procedures. Those who elect observation should be monitored carefully with regular physical examination and imaging studies to determine whether the process is progressing and warrants intervention. Table 5.2 summarizes the etiology of implant rupture, as well as its diagnostic signs and management strategies.

Conclusion

Both saline- and silicone gel-filled breast implants are essential tools in the plastic surgeon's armamentarium for primary and revision augmentation and reconstruction procedures. Despite significant improvements in implant fill material, outer shell, and design, rupture continues to be one of the leading causes for reoperations and explantations. Device retrieval studies point to iatrogenic damage by surgical instruments as the most common etiology for implant ruptures; therefore, meticulous surgical technique should be a priority during implant placement. MRI is the gold standard in diagnosing implant ruptures, but if a team of experienced ultrasound technicians and radiologists is available, ultrasound may be a more cost-effective screening tool especially in symptomatic patients. Compliance with the FDA screening recommendations is at or less than 5%, and the scientific and clinical rationale for the recommendation is under much debate. The management of saline implant ruptures and extracapsular silicone implant ruptures is relatively straightforward and includes explantation and potential capsule modification, with or without replacement. The explantation of asymptomatic intracapsular ruptures may proceed in a semi-elective manner. Future post-approval studies should include patient-level data to allow for more detailed analysis of the association between silicone exposure and connective tissue diseases and malignancies.

Table 5.2 Summary of etiology, diagnostic signs, and management strategies by implant rupture type

Rupture type	Etiology	Diagnostic signs	Management strategies
Saline	–Iatrogenic damage –Unidentified –Fold flaw –Delamination –Manufacturing defect –Blunt trauma –Mammography	Deflation, decreased breast volume	Explantation, capsulectomy, with or without replacement
Silicone – intracapsular		–PE: possibly none; asymmetry, palpable nodules or lymph nodes, capsular contracture, or palpable break in the implant shell –MRI: linguine > teardrop –U/S: stepladder –Mammogram: not useful	–Close observation –Explantation, silicone gel removal, capsulectomy, with or without replacement
Silicone – extracapsular		–PE: pain, asymmetry, palpable nodules or lymph nodes, capsular contracture, or palpable break in the implant shell –MRI: extracapsular silicone –U/S: snowstorm –Mammogram: extracapsular silicone	Explantation, silicone gel removal, capsulectomy, with or without replacement

Abbreviations: *PE* physical exam, *MRI* magnetic resonance imaging, *U/S* ultrasound

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Capsular Contracture: Controversies in Etiology and Management

6

Karan Chopra and Joseph M. Gryskiewicz

Introduction

Cosmetic breast augmentation with the use of prosthetic devices is one of the most commonly performed cosmetic procedures [1]. This typically involves the use of either a silicone or saline implant being introduced into the submuscular or subglandular plane to augment the size and sometimes alter the shape of the existing breast. As with any elective, cosmetic operation, breast augmentation is associated with a number of risks and complications. Capsular contracture is a one of the most common complications following cosmetic breast augmentation [2]. In fact, it is frequently cited as the first or second most common reason for reoperation in these patients [3]. The exact magnitude varies, but estimates from premarket preapproval studies quote rates as high as 15% after primary breast augmentation and nearly 22% in revisionary augmentation cases [2, 4]. Other common causes for reoperation are implant rupture and malposition [5]. When taking into account the number of breast augmentations performed worldwide, there is no doubt that capsular contracture has a profound economic impact in both cosmetic and reconstructive settings. Despite many advances in technology and improvements in technique, capsular contracture remains among the most common complications after breast augmentation. It behooves the surgeon performing breast augmentation to also understand the current theories on the etiology and treatment strategies to fix capsular contracture.

Clinical Presentation

Formation of a capsule around non-biologic materials that surgically implant is a normal physiologic process. However, in the breast, this can sometimes be a severe, reactive, and fibrotic foreign body reaction [6, 7]. This not only leads to patient complaints of changes in breast shape, but patients may also complain of excessive firmness and pain. With the current state of implant technology and surgical technique, this clinical entity is typically a progressive postoperative phenomenon with most studies showing that the longer any groups of patients are followed, the greater their cumulative risk of developing capsular contracture will be.

Capsular contracture classification as described by the Baker system has four grades [8]. Grade I is a normal, soft breast. This is very similar to a normal or ideal normal capsule formation in that it is soft, thin, uncontracted, and soft. Types II, III, and IV represent true capsular contracture with signs of constriction and fibrosis. In Baker type II capsular contracture, the patient presents with minimal firmness on palpation but without obvious perceptible changes on visual exam. In Baker grade III, the breast is moderately firm with the beginning signs of visible implant deformation. Finally, in Baker class IV capsular contracture, the breast has an abnormal ball-like shape and is often accompanied by aesthetically displeasing malposition and pain.

Causes

The etiology of capsular contracture has been studied by many different groups around the world for many years. Multiple potential theories exist with varying levels of supporting data, and it is widely accepted that the pathogenesis is multifactorial [6, 9, 10]. The end result is excessive fibrosis, foreign body reaction, and distortion. The infectious theory is one theory with significant evidence in the literature and one that lends itself to decreased risk with improved surgical tech-

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K. Chopra (✉)
Department of Plastic and Reconstructive Surgery, Johns Hopkins University, Baltimore, MD, USA

J. M. Gryskiewicz
Cleft Palate and Craniofacial Clinics, University of Minnesota School of Dentistry, Burnsville, MN, USA

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nique and asepsis. The role of gram-positive biofilm and inflammation in the development of capsular contracture is well established in the plastic surgery literature [9].

The overall theme in capsular contracture formation is that of prolonged subclinical persistence of an inflammatory process in the periprosthetic pocket that converts a normal foreign body reaction to a pathologic contracture. The biofilm is thought to be polymicrobial with multiple gram-positive bacteria implicated in capsular contracture formation. The capsule of patients with capsular contracture shows predominantly macrophages, lymphocytes, and fibroblasts. In fact, the density of fibroblasts in the contact zone between the implant and capsule correlates with the Baker grade. Myofibroblasts are also thought to play a role in the development of the contractile fibrosis observed in these patients. These cells provide a contractile force leading to a decrease in the surface area of the overall capsule.

Other theories that were thought to play a role include trauma, blood, and silicone gel bleed. While these factors may not be enough to lead to capsular contracture alone, these serve as potentiators of inflammation and capsular contracture and should be minimized [10, 11].

Prevention

The best treatment always begins with prevention. There is reasonable data in the plastic surgery literature guiding practices that may lead to reduced capsular contracture. This includes both refinements in technique and surgical adjuncts to improve outcomes and minimize complications. Bacteria, especially *Staphylococcus epidermidis*, have been implicated in microbiologic studies of capsules affected with capsular contracture [6, 12, 13]. Other gram-positive bacteria have similarly been found to play a role in capsular contracture. A key characteristic of bacteria implicated in capsular contracture is their tendency to produce low levels of persistent and chronic inflammation rather than overt purulent infection. This is made possible by the formation of clinically relevant biofilms.

Biofilms represent an important but incompletely understood mode of bacterial growth. This is a form of protected growth, which can resist hostile environments such as antibiotics and host immune defense. There are four main stages of biofilm formation [14]. The first stage involves *reversible attachment*, which involves the free-floating (planktonic) bacteria encountering the surface of the breast implant. At this point, gene expression transforms these bacteria to progress to stage two, which involves *irreversible attachment*. This conversion from planktonic "swimmers" to irreversibly attached "stickers" may take only several minutes of contact between the microbe and the alloplastic surface. Once the bacteria are attached, stage three begins, which is that of *growth and differentiation*. Here, the bacterial colonies have produced abundant slimy protective extracellular matrix, and they begin to multiply. At this point, nutrients can diffuse into the matrix, but antimicrobials can only damage the outer most cell layers keeping the biofilm intact.

Implant Irrigation

Implant irrigation with antibiotic at the time of augmentation has been shown to be effective in reducing capsular contracture following breast augmentation. This is a common practice among plastic surgeons and can be easily incorporated with many other adjuncts to reduce capsular contracture formation. Since the infectious theory is believed to be polymicrobial, the ideal irrigant would have adequate coverage against multiple bacteria.

Historically, the most commonly used breast pocket irrigant with optimal broad-spectrum coverage was a combination of 50 mL Betadine solution, 1 g of cefazolin, 80 mg of gentamicin, and 500 mL of normal saline [15]. Later, the Food and Drug Administration (FDA) provided recommendations contraindicating any contact of the implant and Betadine solution. The merits of this recommendation have been widely criticized among plastic surgeons. Briefly, this recommendation was the result of several saline implant deflations reported by a single surgeon who was using intraluminal Betadine inside the saline breast implant. Multiple studies since then have demonstrated that there is no negative effect on shell integrity with extraluminal Betadine.

As a result of this FDA recommendation, the Adams group performed additional testing to determine a Betadine-free irrigant that was equally efficacious [15, 16]. These studies were both performed in vitro and subsequently studied in clinical trials. The resulting triple antibiotic solution consists of 50,000 U bacitracin, 1 g cefazolin, 80 mg gentamicin, and 500 mL of normal saline. A prospective clinical study studying the effect of triple antibiotic irrigation as compared to normal saline was performed with 6 years of patient follow-up. This work demonstrated 1.8% capsular contracture in the augmentation group receiving triple antibiotic irrigation versus 9.0% in the saline cohort [17].

In 2017, the FDA approved implant manufacturers' requests to remove warnings on Betadine in their directions-for-use label. Hence, surgeons may implement the use of Betadine irrigation without considering this "off-label" practice. The addition of Betadine to triple antibiotic irrigation may provide greater coverage against gram-negative bacteria such as *Pseudomonas aeruginosa* [12]. This stems from the ability of Betadine to amplify the efficacy of triple antibiotic irrigation by targeting the cell walls allowing antibiotics to enter the cells. The authors recommend addition of 10% Betadine with triple antibiotic solution.

Insertion Devices

Polymeric vinyl constructs are designed to deliver silicone breast implants into the pocket with minimal handling and patient skin contact. This is often referred to as the "no touch technique." The use of these constructs reduces implant contact with the skin and has been shown to significantly reduce rates of reoperation for capsular contracture. These devices may be beneficial when attempting to place large volume implants through limited access incisions, such as the periareolar incision [10]. The most notable drawback of this device is the added cost of the funnel.

Prophylactic Antibiotics

Prophylactic antibiotics can play a significant role in reducing the risk of biofilm formation when used in conjunction with triple antibiotic irrigation. It is the author's practice to administer a single dose of intravenous antibiotics within 60 min of incision and discontinue antibiotics 24 h after surgery.

Nipple Shields

The nipples may harbor bacteria even after adequate surgical preparation. Occlusive adherent film dressings can be placed over the nipple areolar complex as a barrier to bacterial contamination during breast augmentation.

Incisions

Incisions that avoid exposure of the implant to lactiferous ducts colonized by bacteria may reduce the risk of capsular contracture. Periareolar incisions are highly disruptive to the ductal system and may be associated with an increased risk of capsular contracture as compared to the inframammary and transaxillary approaches. A thorough discussion of the risks of each approach should be discussed with the patient, and the use of an insertion device should be considered with the periareolar approach.

Prevention of capsular contracture is multimodal, and all steps are aimed to minimize potentiators of inflammation and capsular contracture. Table 6.1 summarizes further recommendations for practices that may reduce the incidence of capsular contracture.

Specific attributes of various breast implants may influence the propensity toward developing capsular contracture. However, the contributions of differences among differing modern implants toward capsular contracture are likely negligible. Progressive generations of breast implants have been associated with a decreasing incidence of capsular contracture which may be related to improvements in implant design technology.

Table 6.1 recommended practices/techniques for capsular contracture prevention

Atraumatic pocket dissection
Soaking of implants in antimicrobial irrigation solution
Irrigation of pocket with antimicrobial irrigation solution
Glove change prior to implant insertion
Aseptic implant insertion

Although the authors do not use textured devices, there are a number of meta-analyses suggesting that textured devices may be associated with a reduced capsular contracture rate in the subglandular plane. These textured devices were introduced after a trend toward a lower incidence of capsular contracture was observed with implants covered with polyurethane which also imparted a more textured surface to the implants. The textured implants may have a lower incidence of capsular contracture because of the unique interaction that occurs in the implant-pocket interface. The textured surface may disrupt the contractile forces around the implant [17]. However, texturing of implants does not appear to have a beneficial effect when used in the submuscular plane.

Postoperative Care

The majority of patients who develop capsular contracture tend to present within 1 year after primary breast augmentation. Therefore, it is the authors practice to schedule several follow-up visits within the first year and once per year thereafter. Implant displacement exercises can be performed in the early postoperative period, but there is limited rigorous clinical data supporting their use.

Treatment

Unfortunately, even after strict adherence to sterile, hemostatic, atraumatic techniques and the use of antimicrobial agents, patients are still at risk for the development of capsular contracture. There are numerous techniques discussed in the literature. These can broadly be divided into nonoperative techniques and operative techniques.

Nonoperative treatments include closed capsulotomy, pharmacologic agents, and ultrasound therapies [18]. Closed capsulotomy is of historical relevance and is rarely indicated today. Pharmacologic agents such as leukotriene receptor antagonists [19–21], fish oil, and ultrasound therapies have all been described with varying degrees of clinical evidence supporting efficacy for clinically relevant grade III/IV

capsular contracture. It is the authors practice to follow the following techniques when treating capsular contracture: capsulectomy, implant site change, and implant replacement. These steps optimize the chances of eradicating biofilm impregnated capsules and implants while also providing a novel pocket which is less likely to have suffered tissue scarring and inflammation.

Leukotriene Antagonists

Pharmacologic inhibition of the inflammatory cascade is an attractive option because even surgery cannot guarantee a successful outcome for patients with capsular contracture. Recently, a meta-analysis demonstrated that leukotriene antagonists have significant effects in treating and preventing capsular contracture. Leukotriene antagonists work by inhibiting cysteinyl leukotrienes which are associated with the inflammatory process, smooth muscle contraction, and myofibroblast contraction. This is thought to prevent severe fibrotic reactions and arrest the inflammatory cascade of capsular contracture. Zafirlukast (Accolate) inhibits three different leukotrienes (C4, D4, and E4), while montelukast (Singulair) inhibits only leukotriene D4. In patients with an established capsular contracture or history of capsular contracture, we advocate for early and preventive consideration of off-label leukotriene antagonist therapy. Zafirlukast is commonly administered orally as 20 mg, twice daily. Montelukast is typically administered orally as 10 mg, once daily [19, 21, 22]. Patients need to be counseled preoperatively about the risks and benefits, including the need to monitor transaminase levels.

Capsulectomy

These contracted capsules are likely to be colonized with biofilm bacteria and should be excised to the greatest extent possible [5, 18, 23]. In addition to reducing recontamination of the new implant, the presence of increased myofibroblasts in a pocket affected by capsular contracture may be an independent risk factor for recurrent capsular contracture if an ineffective or inadequate capsulotomy is performed instead of total capsulectomy.

The decision to pursue total capsulectomy or selective capsulectomy is independently decided based on the particular clinical demands of the patient. Certain scenarios may present increased risks associated with an aggressive attempt at capsulectomy. Total capsulectomy for subglandular capsular contracture should be performed if adequate breast tissue is present. Anterior capsulectomy alone is recommended in subpectoral capsular contracture to avoid injury to the chest wall. In certain situations where implant-associated soft tissue atrophy thins both the overlying breast tissue and the pectoralis muscle, consideration may be given to capsulotomy alone with radial scoring to disrupt the contracting forces of the myofibroblasts within the capsule.

Implant Site Change

Moving the implant to a novel plane, also referred to as neopocket formation, is an important tool in the approach to revisionary breast augmentation for capsular contracture. If the primary augmentation was subglandular, then the submuscular pocket offers an excellent plane for implant placement after capsulectomy is performed [10, 23]. This submuscular pocket is supported by extensive primary breast augmentation literature associating the submuscular pocket with reduced capsular contracture.

If the initial augmentation was submuscular or dual plane, then the subglandular space offers an untouched space and may achieve results similar to that of a primary subglandular augmentation. Moreover, this frees the implant of distorting forces from the contracted capsule and the pectoralis major muscle.

Site change from subpectoral to subglandular may not always be possible. Occasionally, chronic pressure from the primary augmentation leads to extensive atrophy of the overlying pectoralis muscle and breast tissue that there is glandular soft tissue available (e.g., less than 2 cm). In these cases, the development of a neosubpectoral plane should be considered [23]. In this technique, a novel submuscular pocket is created deep to the pectoralis major muscle but superficial to the intact anterior capsule. The existing capsule is incorporated into the new pocket following obliteration of the capsular space. This technique can be more challenging if the capsular tissue is thin.

Acellular Dermal Matrices

In addition to the techniques above, rare challenging cases may require the use of acellular dermal matrices (ADMs). Proponents of ADM suggest that implant pockets with ADM have thinner capsules and lower levels of inflammation and serve as an antigen-free reinforcement layer in areas of thin breast tissue [24]. Since capsular contracture results from uninterrupted spherical contracture of an implant pocket, interruption of areas with total or partial use of acellular dermal matrices may prevent this cicatricial contraction.

The use of ADM to line the new implant pocket is ideally performed from a periareolar or inframammary approach to allow adequate lining from the pectoralis muscle to the inframammary crease. Therefore, the superior aspect of the ADM is sutured to the caudal margin of the pectoralis muscle, and inferiorly the ADM is sutured to the inframammary fold.

The implementation of ADM can achieve high levels of success for treating and preventing recurrent capsular contracture. However, ADM adds significant cost and operative time and should be carefully considered by the surgeon and patient.

Case Examples

Case 1

This case demonstrates a 61-year-old patient who presented with Baker III/IV capsular contracture (Fig. 6.1). She also had inferior malposition of her prior 270-cc textured implants in the submammary plane. She was treated with total capsulectomy, site change to the dual plane position, and implant exchange to 415-cc high profile smooth silicone breast implant. Postoperative images demonstrate improved breast aesthetics and elimination of painful capsular contracture (Fig. 6.2).

Case 2

This case demonstrates a 35-year-old patient who presented with painful right-sided Baker grade IV silicone breast implants after prior submuscular transaxillary augmentation (Fig. 6.3a) with contraction of the pocket superiorly (Video 6.1) leading to implant and nipple malposition (Fig. 6.3b). Treatment in this patient included an inframammary approach for anterior capsulectomy in the setting of a tightly adherent posterior capsule (Fig. 6.3c). Implant was exchanged in the dual plane position using a 380-cc smooth high-profile silicone implant (Video 6.2).

Conclusion

Capsular contracture is a common complication of breast augmentation. The etiology is not fully characterized but is likely multifactorial and thought to develop from an exaggerated foreign body response to chronic inflammation in the periprosthetic space. Prevention is centered around reducing bacterial contamination, minimizing tissue trauma, and optimizing hemostasis. Surgical treatment of capsular contracture will often require consideration to capsulectomy, implant site change, and replacement of a new implant with a no-touch technique.

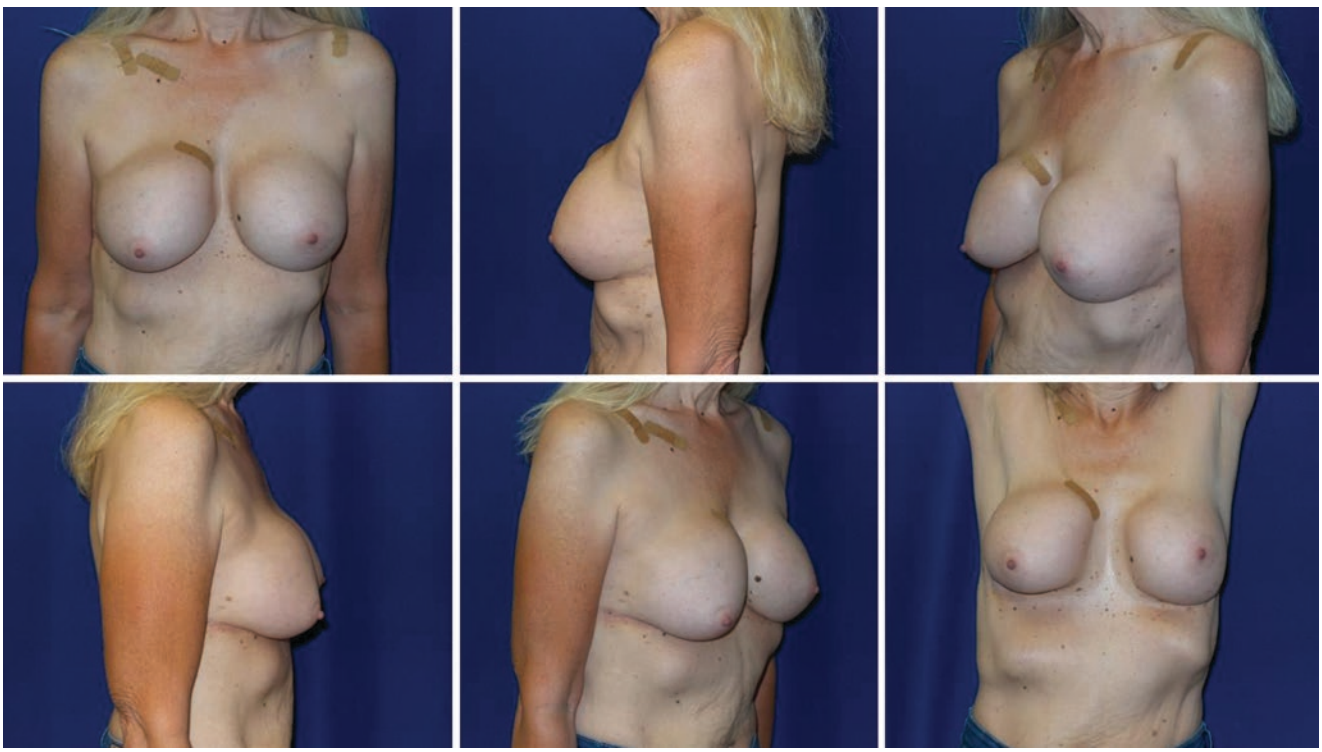

Fig. 6.1 A 61-year-old woman with Baker III/IV capsular contracture treated with total capsulectomy, site change to the dual plane position, and implant exchange to 415-cc high profile smooth silicone breast implant

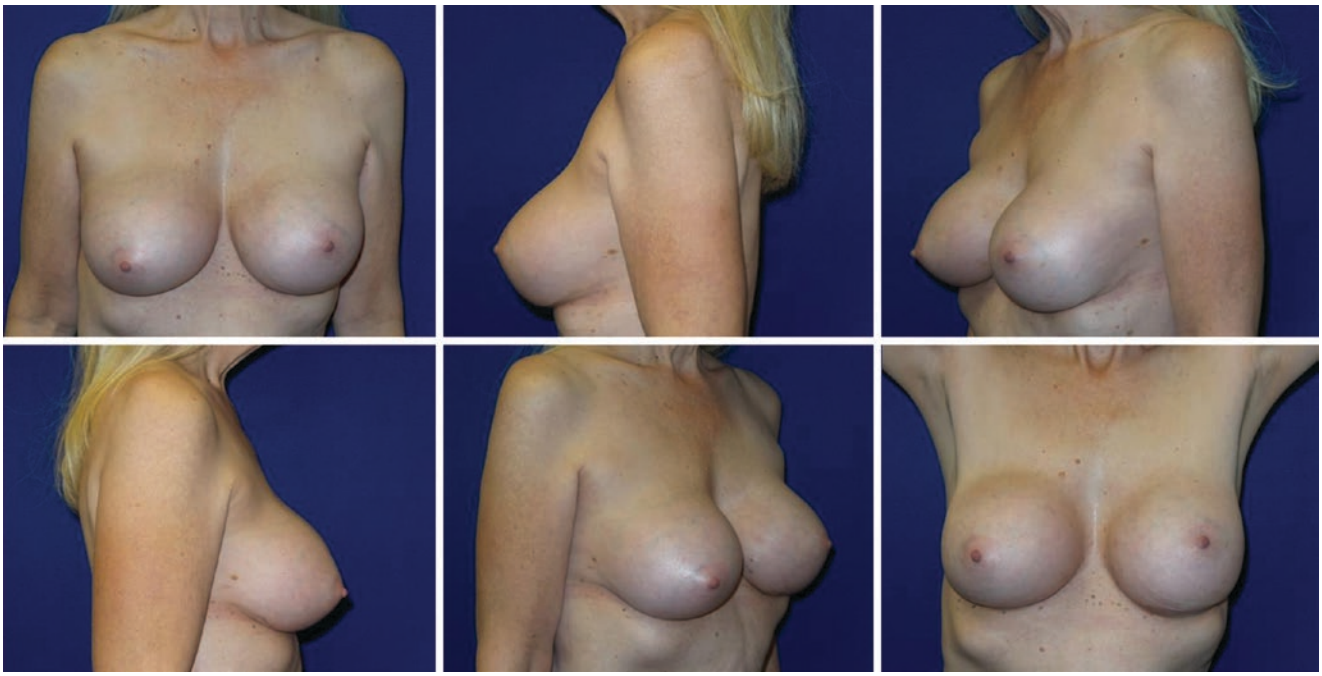

Fig. 6.2 Postoperative images of the patient in Fig. 6.1 with improved breast aesthetics and elimination of painful capsular contracture

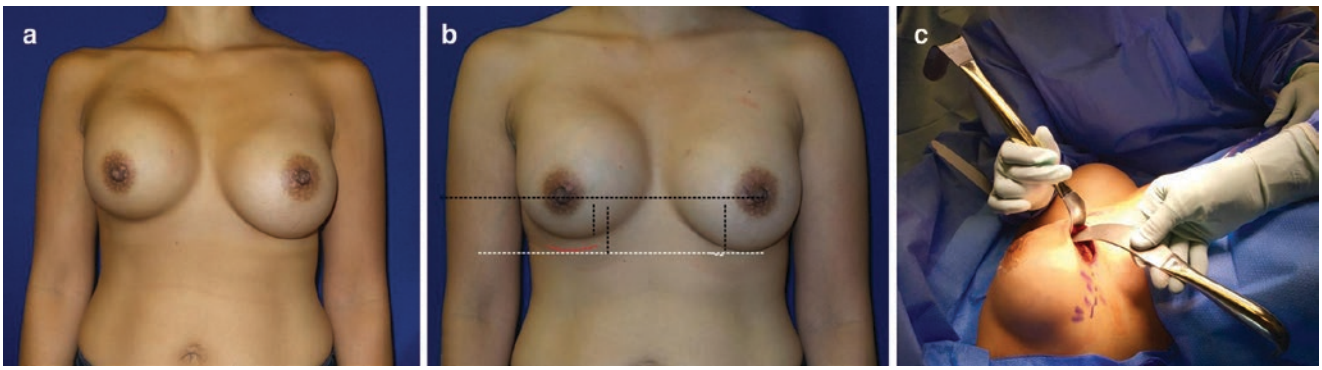

Fig. 6.3 (**a**) A 35-year-old woman with painful right-sided Baker grade IV silicone breast implants after prior submuscular transaxillary augmentation. (**b**) This figure illustrates the contracted breast implant pocket with superior implant and nipple malposition. (**c**) Treatment via inframammary approach for anterior capsulectomy and exchange to dual plane position

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Breast Infections

7

Timothy M. Rankin, Blair A. Wormer, and Kent K. Higdon

Introduction

Breast augmentation is the number one cosmetic plastic surgery procedure performed in the United States, where 300,378 procedures were performed in 2017 alone [1]. The beauty of the feminine form and emphasizing the female breast is not a new phenomenon – in fact, it has been ongoing in several different cultures for thousands of years [2]. However, it was not until the late 1800s that surgically invasive means of augmenting the breast became more commonplace. Many different media were used to attempt augmentation – from fat and dermis to even ivory and glass. These attempts at augmentation were frequently met with infection, fistulae, and disfigurement. By 1960, there were roughly 16,000 polyvinyl implants placed by a majority of the 294 plastic surgeons currently practicing at that time in the United States [3]. It was in 1963, when Thomas Cronin developed the first silicone-filled implant, that the breast implant era really began [4]. Since the advent of the silicone breast prosthesis by Cronin, there has been a dramatic increase in the frequency and popularity of surgical breast augmentation, as well as improvements in the safety of the surgical devices.

The very low rate of complications seen with primary breast augmentation is one of the reasons for its popularity. This procedure is in fact quite safe, and the most common complication is bleeding, which has been reported as a rate of 0.6–5.7% for any bleeding event after breast augmentation. One study, by Kaoutzanis et al. analyzed 41,651 breast augmentation procedures and found that the risk for major bleeding complications requiring admission to a hospital or emergency department or reoperation was very low at 1.0% [5].

Infectious complications are the second most common complication in breast augmentation, with a wide range of reported rates between 0.001% and 7% [5, 6]. From microbiological studies of the breast, we have learned that the ductal system allows for colonization of the gland, with over half of all specimens growing coagulase-negative staphylococci [7]. Of these pathologic specimens, 30% were sterile, but the remainder of the organisms cultured in order after coagulase-negative staphylococcal species included diphtheroids, lactobacilli, bacillus species, and streptococci.

Given that breast augmentation is the most common aesthetic surgery performed worldwide, minimizing complications is of critical importance to the safety of our patients [1]. At this point, pre-incision, prophylactic antibiotics, the correct type of antibiotic, and cessation of prophylactic antibiotics within 24 h are part of the Surgical Care Improvement Project (SCIP) guidelines, which were implemented in 2006 and were borne out of the 1999 Center for Disease Control and Prevention effort to minimize surgical site infections (SSIs). Since the inception of the SCIP guidelines, the proposed reduction of SSI by 25% within 4 years was not achieved, and it seems that though well intentioned, these guidelines may not apply to all surgical subpopulations [8, 9]. This continues to be a point of contention as there are more recent data that do not show significant differences in the rate of SSI following primary augmentation, demonstrating the need for a large prospective trial [10]. At this time, we do not have enough data to change recommended practice guidelines: use a single preoperative dose of an appropriate antibiotic (cefazolin, clindamycin, or vancomycin) and discontinue prophylaxis within 24 h for breast augmentation [11–14].

Sterile technique is not only important for preventing overt infection but also for decreasing risk of capsular contracture [15, 16]. Capsular contracture incidence overall after primary breast augmentation has been reported at 3.6% [9], but others have shown a range from 2.8% to 20.4% [10]. This complication can be seen in the early postoperative period, or later, which is usually defined as more than 6 weeks postoperatively. Capsular contracture is usually seen as a late complica-

T. M. Rankin · B. A. Wormer · K. K. Higdon (✉)
Department of Plastic Surgery, Vanderbilt University Medical Center, Nashville, TN, USA
e-mail: kent.higdon@vumc.org

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tion, with a 10-year incidence of 9.2% for cosmetic breast augmentation cases. Antibiotic irrigation has been explored since the 1980s when Burkhardt et al. attempted to reduce capsular contracture using Betadine (Purdue Frederick, Stamford, CT) to irrigate the retromammary pocket prior to augmentation [17]. Adams et al. found that the combination of 12.5% povidone-iodine and 80 mg gentamycin with 1 g of cefazolin was effective at killing all bacteria most commonly found around breast implant infections [18].

Practice patterns changed around the year 2000. The Food and Drug Administration (FDA) had expressed concerns about the potential negative impact of Betadine on the shell of breast implants [19]. These concerns were based upon studies performed by manufacturers of breast implants. The use of intraluminal Betadine in saline breast implants was found to delaminate the valve patch, and soaking of the fill tube in Betadine led to changes in elastomer strength and color change [20, 21]. However, it has been shown that the fill tube is manufactured differently than the elastomer shell of the implant, and since these initial publications, there are multiple reports of the safe use of Betadine as an irrigant for breast implant pockets [18, 22–26].

Other complications, such as implant rupture, implant malposition, asymmetry, wrinkling, or seromas, can occur, but these will be discussed elsewhere in this text [26]. Capsular contracture has multiple etiologies, including infectious causes, implant rupture, seroma, hematoma, multifactorial, among others; a commonality is the local inflammatory changes mediated by a host of immune mediators that ultimately affect the myofibroblast activity. This results in collagen deposition that distorts the breast around the implant and can cause pain [10]. There even appears to be a genetic component in which women are more prone to having capsular contracture and are likely immune-mediated. This immunogenetic cause, as well as several other etiologies, is the purpose of a vast amount of ongoing research.

Risk Factors for Infection in Breast Augmentation

When assessing risk factors for infection, various aspects must be considered, including surgical approach, type of antiseptic used to prepare the skin, perioperative antibiotics, patient factors, location of implant, postoperative care, and indication for surgery.

In a worldwide survey conducted in 1970, the incidence of early and late-onset (> 6 weeks post-surgery) infections in 10,941 women who underwent breast augmentation was 1.7% and 0.8%, respectively. The overall incidence of implant infections was 2.5% [27]. However, other potential risk factors exist, including patient factors (age, body mass index [BMI], diabetes), implant type, implant contamination, contaminated surgical environment, surgical approach, implant location, antibiotics, and antiseptic precautions. In fact, one study of 129,007 patients demonstrated diabetes to more than double the risk for infectious complications in aesthetic surgery, and increasing BMI was demonstrated to increase the risk for infectious complications. In this study, the BMI group <18.5 kg/m^2 had an infection rate of 0.1%, whereas the morbidly obese group with a BMI >40 kg/m^2 was 140% higher [7]. Brand's survey showed that route of implant insertion and location of implant pocket did not affect the rate of infection. Though there is no significant difference between infectious rates in implant type, there is a trend toward higher infection in textured and polyurethane implants (0.06% vs. 0.16% and 0.12%). Surprisingly, smoking, obesity, and diabetes did not increase rates of infection, but skin atrophy, scarring, simultaneous surgery, pregnancy, preceding lactation (within 3 months), vigorous exercise, and massage all did increase risks of infection. Additionally, the use of corticosteroids in a subglandular position also led to increase rates of infection. More recent data contends that obesity and diabetes contribute to increased rates of infection [28].

Araco et al. reported on 3000 patients undergoing aesthetic breast augmentation and analyzed rates of infection by implant manufacturer, implant location, surgical approach, use of electrocautery, antibiotic pocket irrigation, and use of drains [29]. Compared to the other manufacturers, though all implants used in the study were textured, Mentor (Mentor Corporation, Santa Barbara, CA, USA) decreased the risk of infection (RR −6.3) (Table 7.1) Additionally, the use of antiseptic or antibiotic pocket washing also reduced the risk of infection (RR −4.6), while the use of drains, left in place for 12 h, was associated with a fivefold increase in the rate of infection (Table 7.2).

Further factors contributing to the risk of infection and complications are the presence or absence of texturing on the implant surface. After polyurethane-coated breast implants were found to have an association with carcinogen (2,4-toluenediamine), an attempt was made to texture the surface of breast implants in an effort to disrupt a linear vector of myofibroblasts that may cause capsular contracture. These textures were an effort to improve tissue integration and decrease capsular contracture and implant malposition. The silicone shell texture can be created in a number of different ways based on the method of the manufacturer: vulcanization, salt loss, imprinting, and proprietary "nano" texturing [36]. However, it has also been found that a textured surface can support greater bacterial growth [37]. Clinically speaking, there is likely a threshold at which the bacterial burden will predispose an implant to capsular contracture, regardless of the surface texture. Recent work by Jones et al. has proposed a more objective method for grading the amount of texturing on a given implant as defined by surface area and roughness as these correlate with bacterial growth [36]. Therefore an implant's three-dimensional to two-dimensional surface area ratio

Table 7.1 Infectious rates by implant manufacturer per their respective core data for Food and Drug Administration (FDA) approval

Manufacturer	Infection primary aug (%)	Revision aug (%)
Allergan [30]	<1	3.2
Mentor [31]	1.5	1.4
Sientra [32]	0.9	1.5

Allergan: 715 women enrolled in the Natrelle Core Study. Primary augmentation patients most frequently used smooth implants (59%), and the most common incision site was inframammary (46%). Over half of primary augmentation patients (54.9%) enrolled for augmentation only, and the remaining patients enrolled for augmentation with accompanying conditions as follows: asymmetry, ptosis, and aplasia. For revision-augmentation patients, the most frequently used devices were smooth implants (57%), and the most common incision site was inframammary (64%). Mentor: The 697 women were enrolled in the augmentation arms of the Mentor Core MemoryGel Study, 551 primary augmentation patients and 146 revision-augmentation patients. Sientra: 1116 primary augmentation and 363 revision-augmentation patients were enrolled in the augmentation arms of the Sientra Core Study to assess the safety and effectiveness of Sientra's breast implants in augmentation

Table 7.2 Various types of breast pocket irrigation

Irrigant	Source	Note
Betadine 50%	Burkhardt et al. (1986) [33]	18% capsular contracture
10% Betadine/80 mg gentamycin/1 g cefazolin	Adams et al. (2000) [18]	Best irrigant prior to FDA decree in 2000
50,000 U bacitracin/1 g cefazolin/80 mg gentamicin/500 cc saline	Adams et al. (2001) [21]	Best irrigant devoid of Betadine
1 g Vancomycin/80 mg gentamicin/1 g cefazolin	Adams et al. (2001) [21]	6% growth of pseudomonas. Any bacterial contaminant may develop Vancomycin resistance and be hard to treat
115 mL 0.025% HOCl solution	Haws et al. (2018) [34]	Must be protected from light and must ensure low protein concentration of surgical field to avoid deactivation of HOCl
"Antibiotic irrigation" meta-analysis	Lynch et al. (2018) [35]	Infection RR = 0.52 compared to saline control

would be deemed "high" if the ratio was greater than 5, "intermediate" (3–5), "low" (2–3), and "minimal" (<2). Generally speaking, a polyurethane-coated implant has a "high" surface area ratio. Salt loss and vulcanization produce intermediate surface areas, and imprinting produces a low surface area. Smooth implants and "nano" textures produce the least surface area. Knowledge of the implant surface area is vital in the discussion about infections in breast implant surgery, as there exists a linear relationship between bacterial burden and surface area.

Additional techniques to minimize the risk of infection include the "no-touch technique" which was borrowed from orthopedists and was introduced into breast surgery by Mladick [38]. This report of 2800 implants over the course of 17 years alluded to decreases in the rate of capsular contracture and no reports of infection. More modern no-touch techniques involve the use of a funnel to minimize implant contact with the skin and breast tissue [39]. A recent survey of US surgeons revealed that just under one half of plastic surgeons were using a Keller Funnel (Allergan Pharmaceutical Co, Dublin, Ireland) to place their implants during breast augmentation [39].

At the time of use, the Keller funnel is to be trimmed to length so that the smaller end of the conical funnel has the appropriate diameter for a given implant size and shape. The funnel is then immersed in a sterile solution in order to lubricate the inside of the sleeve. The breast implant is then to be loaded into the funnel by transferring the implant from its sterile container into the funnel, or in the authors' preferred method, the implant may be grasped by the sterile paper covering of the implant's container and then placed into the funnel. In a small series, there have been reports of up to an 87% reduction in the rate of capsular contraction at 2 years postop [40].Various descriptions have been reported for the no-touch technique since that time [41].

Presentation

Infections following breast augmentation occur either acutely or less commonly in the subacute or even late postoperative period. Acute infections present in 0–4% of cases [27, 42–46] (Fig. 7.1) Due to the relative rarity of acute breast infections, most of the data we have is based upon retrospective analyses or self-reported surveys. Data on infections occurring in the late postoperative period is even harder to obtain and is likely biased by surgeon recall [46]. However, more recent data has shown that late infections occurring over 30 days from implantation make up the majority of infections in the reconstructed population [47]. Women usually present within the first month for acute infection following augmentation with a median time of 10–12 days [27]. There is then a dramatic decline in the number of infections during the second month and beyond. In the above study of the 54,661 breast surgeries, just over 70% of all infections occurred during month 1, 10% in month 2, 10% in months 3–6, and only 5% in month 7 or later. The clinical exam will yield breast erythema, fever, and pain. Diagnosis is typically a clinical one, while imaging modalities, such as computerized tomography, ultrasound, and magnetic resonance imaging, can be used to confirm suspicious clinical findings and can sometimes be used as adjuncts for fluid sampling to culture periprosthetic fluid collections. Typically, fluid collections around the implant are first studied with an ultrasound in the setting of implant infection due to its noninvasive and more cost-effective nature.

A rarer presentation of infection following breast augmentation is toxic shock syndrome. The median time to

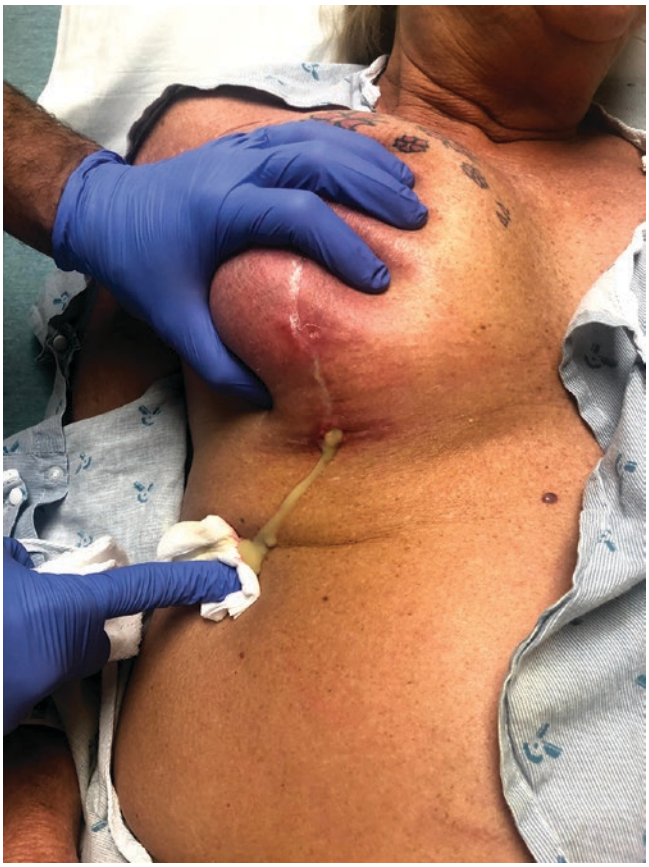

Fig. 7.1 Photo of acute implant infection after augmentation mastopexy

onset is 4 days but has been reported to occur within the first 24 h [48]. In these cases, the surgical site does not typically have the normal clinical findings of an acute infection though the patient presents with the tachycardia, hypotension, fever, and purulence around the implant. This can be caused by *Staphylococcus aureus* and has also been described with streptococcus. Mycobacterium has also been found in some late breast infections. It can present as a large, odorless effusion, and initial cultures are negative [49]. The source of this infection can be hard to identify, though it was found in contaminated skin markers in one particular case.

Management

The management of acute breast prosthetic infections follows that of any surgical site infection though the clinician must have a high index of suspicion of an infected foreign body. Once the diagnosis has been made clinically, an attempt to identify the causative organism should be made. Aspiration of periprosthetic fluid, if present, can be performed with ultrasound guidance. The fluid should be sent for gram stain and culture. The rare cases as discussed above may require acid fast stains and cultures in addition to the mandatory gram stain and aerobic, anaerobic, and fungal cultures. Lowenstein-Jensen media and BACTEC MB900 instrumentation may be required for rapid identification of mycobacteria [5]. Minor infections may be treated with oral antibiotics that have good coverage of typical gram-positive bacteria. In our facility, the microbiome data show that most infections are responsive to sulfamethoxazole/trimethoprim or doxycycline in the case of a sulfa allergy. If the erythema and pain do not respond within 48 h of conservative treatment or if the patient starts to show signs of systemic infection, then a more aggressive course of parenteral antibiotics will be needed [26]. If the erythema does not resolve within 48 h of initiation of parenteral antibiotics, then the patient is taken to the OR for explantation, though there have been descriptions of implant salvage [50]. Once the implant is removed, patients can be treated with a 10- to 14-day course of oral antibiotics. Parenteral antibiotics will certainly be required for patients presenting with toxic shock symptoms, and every effort should be made to explant the breast implants expeditiously (Fig. 7.2).

However, if implant salvage is planned, then the patient should be admitted for IV antibiotics. The implant must be removed and the capsule scrubbed, typically with a scrub brush, and irrigated extensively. Yii et al. described performing capsulotomies in order to increase the surface area of vascularized tissue about the implant and then placement of two drains that are used to instill antibiotic fluid postoperatively for 5 days. Salvage rates for breast implants range from 45% to 64% [50, 51]. These techniques are aggressive and require many resources. Their resulting high failure rate should be clearly explained and used with appropriate caution. It is the practice of these authors to aggressively treat any signs of infection with oral antibiotics for minor skin erythema and intravenous antibiotics for overt cellulitis. However, if the implant is believed to be infected and/or proven to be infected, then the implant is removed and the tissues allowed to heal for 6–12 weeks, depending on the circumstances, prior to any further attempts at augmentation.

Conclusion

Breast augmentation continues to be a highly sought-out procedure with a very good safety profile and very high rates of patient satisfaction. Modern no-touch techniques and a better understanding of potential contaminants and biofilms have allowed surgeons to keep the rate of breast implant infections very low. The majority of these infections occur within 10–12 days of surgery and present with typical findings of postsurgical infection including fever, incisional

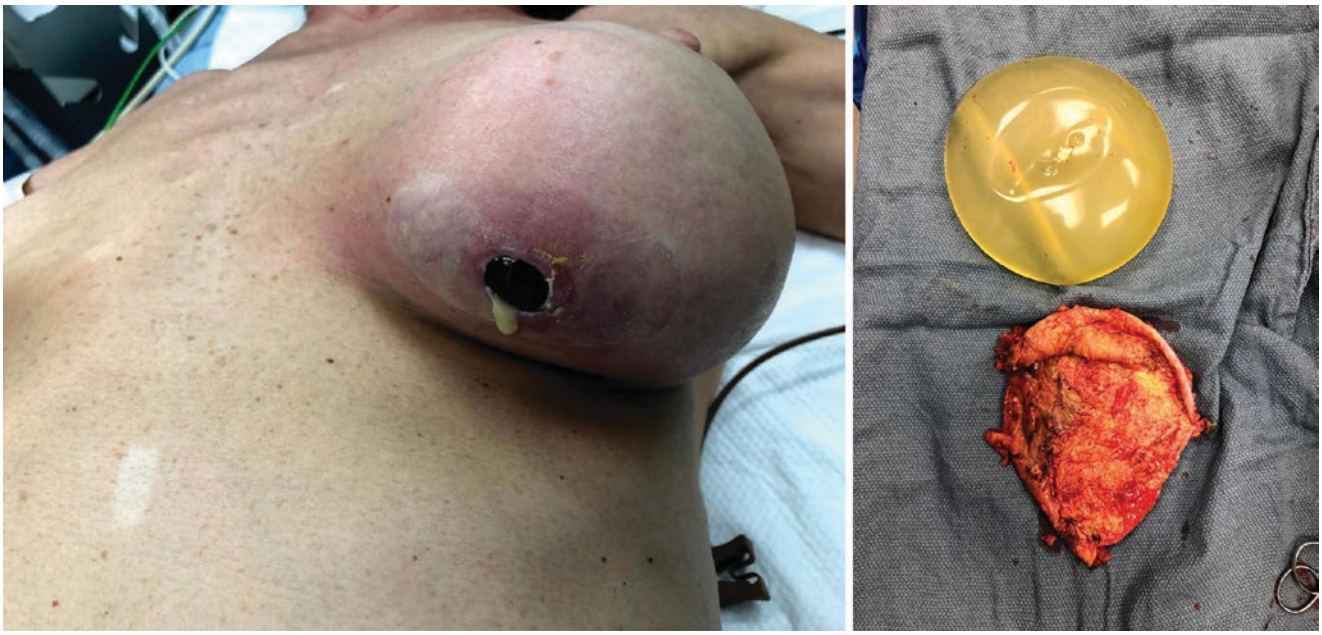

Fig. 7.2 Photo of chronic implant infection with exposure in immunocompromised patient. Unfortunately, the implant could not be salvaged

erythema, and pain. Though rare in occurrence, toxic shock syndrome, early septic shock, and atypical mycobacterial infections can be devastating complications and are diagnoses for which we must remain vigil. Staphylococcus and other gram-positive skin flora continue to be the predominant culprits for infectious complications in breast augmentation surgery, and adherence to good technique and surgical guidelines is critical in their prevention [52]. Once infection is identified, appropriate antibiotic treatment must be selected. Fourteen days of oral antibiotics are sufficient for most cases of surgical site infection, though IV antibiotics are necessary for severe cellulitis and cases of systemic illness or bacteremia. Most cases of implant infection are best treated in a stepwise fashion, with removal of the implant and administration of antibiotics, followed by a period of tissue healing and rest prior to placement of a new device.

Authorship Timothy M. Rankin, Blair A. Wormer, and Kent K. Higdon have all met ICMJE guidelines for authorship credit with substantial contribution, drafting, and approval and are accountable for all aspects of the work.

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When Does an Aesthetic Breast Problem Need a Reconstructive Solution?

8

Yoav Barnea, Or Friedman, and Michael Scheflan

Introduction

Implant-based breast reconstruction is a complex procedure in which innovative surgical technics and new technologies are being continuously introduced to facilitate and improve surgical outcome. Extreme challenges of aesthetic breast surgery, including congenital and acquired breast disorders, secondary aesthetic breast cases, and surgical complications, often require reconstructive solutions. These solutions can involve the provision of soft-tissue support and enhancement, implant support, and skin envelope adjustment. We present an array of surgical techniques and technologies used in breast reconstruction and applied for challenging aesthetic breast cases. They include autologous fat grafting to the breast, the use of meshes, and the use of local breast flaps in cases of breast asymmetry, soft-tissue laxity, implant malposition, and other breast disorders.

Autologous Fat Grafting to the Breast

The first description of fat grafting to the breast dates from 1893 with Neuber's attempt to transfer bulk volumes of fat [1]. In 1987, Bircoll described liposuction and the injection of autologous fat to the breast [2–4], and Coleman published the first standardized protocol that led to an increase in the use of this technique in 1995 [5]. This resulted in numerous studies, systematic reviews, and meta-analyses that described its efficacy and safety in terms of improving volume retention and acceptable oncological and radiological safety, respectively [6–10].

Fat grafting is commonly used in reconstructive breast surgery for volume filling, soft-tissue enhancement, and skin regeneration. The combination of the regenerative properties of autologous fat, ease of utilization, low complication rates, and high safety record make it the "ideal" filler. Fat grafting can be utilized as a composite supplementary to breast implants as well as a stand-alone filler [11].

Composite Breast Augmentation

Implant-based surgery has many disadvantages, including visibility, palpability, rippling, skin atrophy, firmness, capsular contracture, asymmetry, and an unnatural look [12–27]. The addition of fat allows the amelioration of many of those untoward sequelae. Fat grafting to the upper pole reduces the "step-off" deformity and provides a more natural upper pole slope and less visibility, palpability, and rippling (*Case Presentation 1*, Fig. 8.1). Furthermore, selective fat grafting to the upper pole can result in an "anatomic" appearance when using round implants, with no fear of implant malrotation [28]. Fat grafting can be done selectively in cases of breast asymmetry, using the same size implant but filling one breast with more fat or filling the chest well deformity defect (*Case Presentation 2*, Fig. 8.2). Implant firmness can be improved by fat grafting around the implant to thicken the surrounding soft tissue. Recent studies published encouraging results in treating patients with severe capsular contracture by means of fat grafting [29]. Implant surgery complications, such as animation deformity and double-bubble, can also be treated with fat grafting [29, 30]. Fat grafting is also becoming more accepted in primary breast augmentation with implants. The use of small (100–200 cc) implants for projection in combination with more fat (200–400 cc) for padding has been termed the "hybrid or composite breast." Less palpability, visibility, wrinkling, and overall

Y. Barnea (✉)
Plastic and Reconstructive Breast Surgery Unit,
Plastic Surgery Department, Tel-Aviv Sourasky Medical Center,
Sackler Faculty of Medicine, Tel-Aviv, Israel

O. Friedman
Department of Plastic Surgery, Tel-Aviv Sourasky Medical Center,
Tel-Aviv, Israel

M. Scheflan
Department of Surgery, Assuta Medical Center, Tel Aviv, Israel

J. Y. S. Kim (ed.), *Managing Common and Uncommon Complications of Aesthetic Breast Surgery*,
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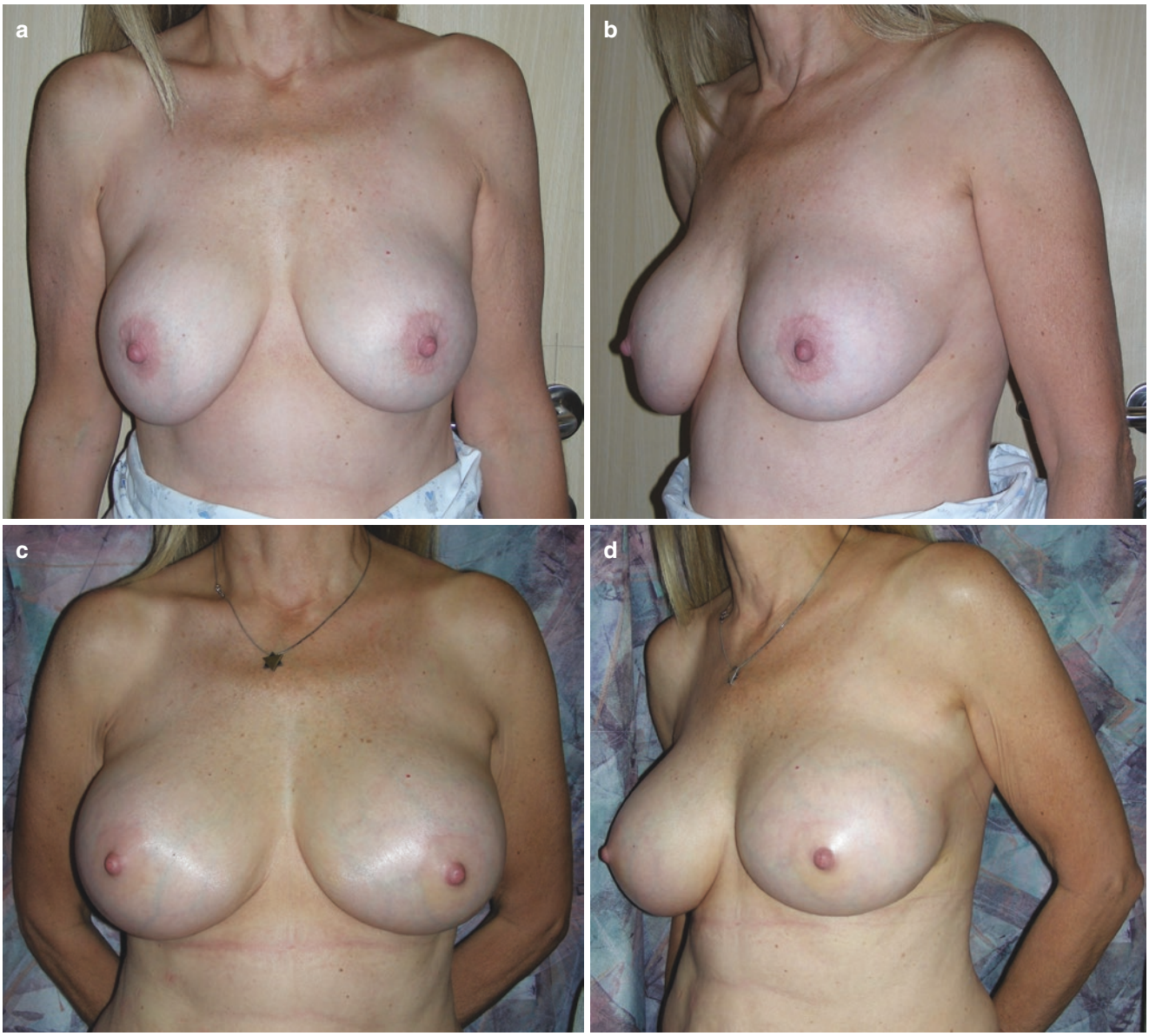

Fig. 8.1 Case Presentation 1: Fat grafting for upper pole contour defects. A 55-year-old patient, 30 years after bilateral subglandular breast augmentation. She was diagnosed with bilateral extracapsular silicone leak and rippling in the superior-medial pole (**a**, **b**). She underwent bilateral exchange of implants and 80 cc fat grafting in the upper-medial pole. The patient 6 months after surgery (**c**, **d**)

softer more natural results have been reported with more padding and smaller implants [27–31].

Pure Autologous Breast Augmentation

Autologous fat grafting for breast augmentation is gaining popularity as an alternative to implants [11, 31]. First introduced in an anecdotal description [3], there are now many publications on the safety and efficacy of breast augmentation using fat alone. Furthermore, implant-related complications and high revision rates, as presented in breast implant core studies [24], together with a growing number of cases of breast implant-associated anaplastic large-cell lymphoma (BIA-ALCL) and breast implant pathologies, have led patients and surgeons to seek alternatives to implants. Patients with tight skin envelopes are not good candidates for fat-only breast augmentation, while patients with skin laxity or those who had implants and want to remove them are suitable, providing they have adequate donor sites. Advantages for pure fat breast augmentation include the absence of a foreign body, fewer scars, a more natural feel and appearance of the breast,

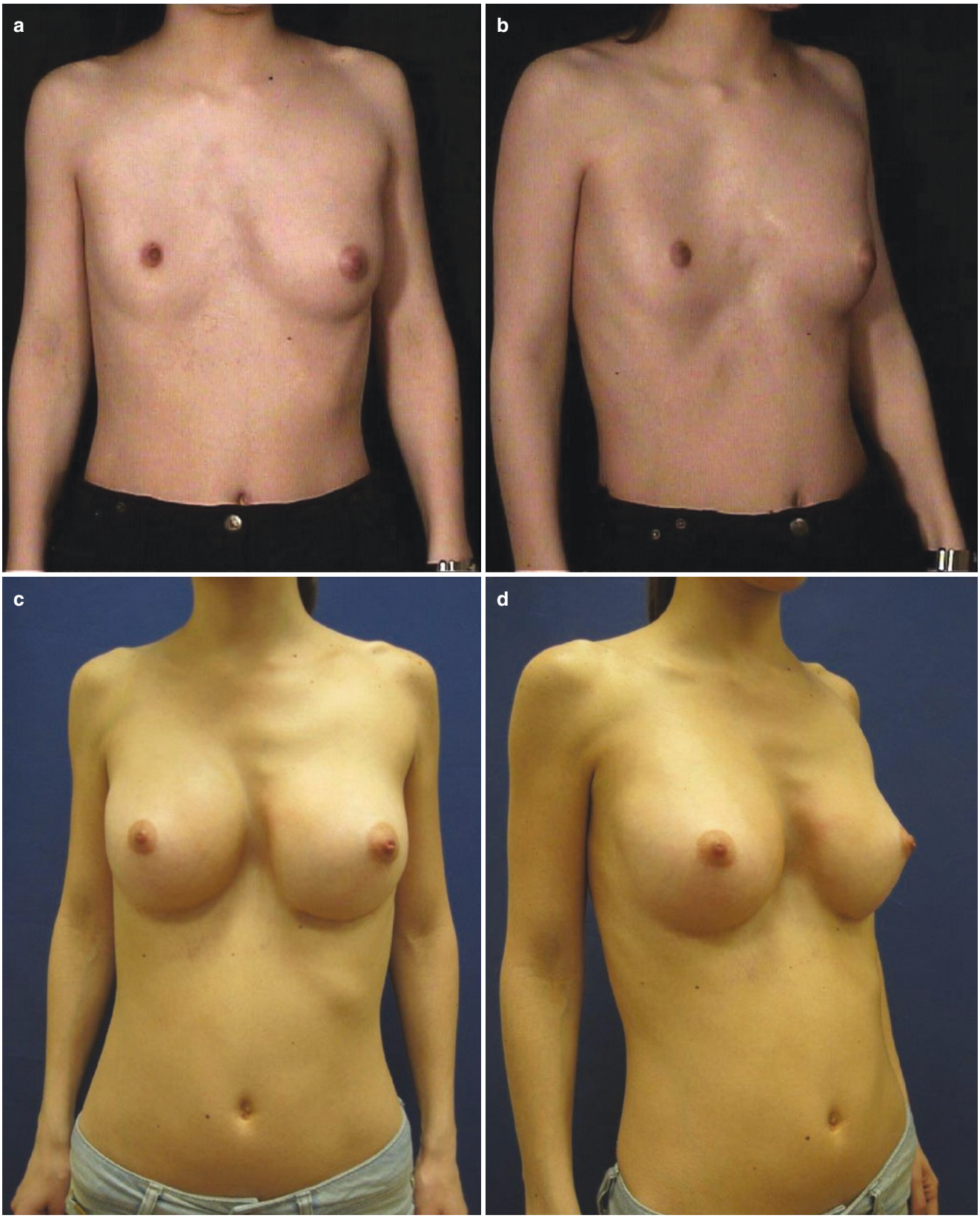

Fig. 8.2 Case Presentation 2: Fat grafting for volume and shape asymmetry. A 25-year-old patient with congenital breast asymmetry and chest wall deformity (**a**, **b**). She underwent bilateral augmentation with different size anatomic implants and fat grafting 90 cc each side. Follow-up 1 year after surgery (**c, d**)

longevity, softness, and donor site re-shaping. Although there is currently no optimal technique for fat grafting, as noted by Ross et al. [28], new technologies for better fat harvesting, fat processing, and grafting are on the rise.

Breast Surgery Using Mesh

Soft-tissue aging manifested by atrophy and thinning results in sagging and constitutes a major drawback for all types of aesthetic breast surgery. Various types of meshes have been described in aesthetic surgery procedures to try and reinforce the soft tissue for the past 35 years [32]. The first meshes had been acquired from abdominal wall reconstruction, but they are currently being taken from implant-based breast reconstructions. The matrices include biologic (acellular dermal matrix [ADM]) and synthetic absorbable and non-absorbable meshes. Góes reported various permanent and resorbable scaffolds used in mastectomies and described a mammoplasty procedure that incorporates a double-skin technique [32]. Currently, the use of meshes in breast surgery includes soft-tissue reinforcement, implant support, and soft-tissue modulation and regeneration (*Case Presentation 3*, Fig. 8.3). Mastopexy and reduction mammaplasty techniques are designed to lift, reduce the weight, and tighten ptotic breast tissue, as well as to restore a more pleasing and youthful breast contour.

Various techniques have been advocated over the years to improve breast shape, projection, and scarring [33–40]. However, recurrent ptosis continues to adversely affect initial satisfactory results in many patients. This problem has been addressed by using a loop of pectoralis muscle or fascia to suspend and support the breast tissues in the lower pole and maintain upper pole fullness [41, 42]. Numerous synthetic meshes and ADM are currently being used to suspend the breast [43–45]. Adams et al. recently described the use of poly-4-hydroxybutyrate (P4HB) mesh to reinforce the breast soft tissue during mastopexy [46].

Secondary revisions after breast augmentation also continue to challenge plastic surgeons [47]. Common etiologies for revision surgery include surface irregularities (i.e., rippling/wrinkling), capsular contracture, bottoming out, implant malposition, animation deformity, and waterfall deformity [47–53]. These patients are frequently thin and have a scarred breast envelope and a paucity of soft tissue [48]. Attempting to address one problem often begets another one. For example, suture plication of the capsule in a thin breast envelope can lead to dimpling and deformities, and it often recurs due to tissue weakness.

The use of an ADM to support the implant and reinforce the soft tissue helps to reposition and secure the implant and mask surface irregularities (see Fig. 8.3). Furthermore, the biologic properties of ADM modulate the inflammatory response, leading to reduced capsular contracture rates. These benefits of ADM have been well-reported for post-mastectomy reconstruction, with multiple reports describing short- and long-term success [54–64]. Numerous publications advocate ADM for mastopexy soft-tissue reinforcement [43] and provide support for implant plane conversion from subglandular to subpectoral and vice versa [65]. Synthetic meshes are significantly cheaper than ADM, and there is evidence for their safety and efficacy in secondary implant-based revisional surgery, although long-term studies are required to compare their performance with that of acellular dermal matrices [46].

Local Flaps and Tissue Re-arrangement

Local breast flaps and tissue re-arrangement have become an essential tool in oncoplastic breast reconstruction following breast-conserving surgery. These techniques were implemented in cases of breast asymmetry and tubular breast in order to locally re-distribute breast tissue from areas of excess tissue to areas of tissue deficiency [66]. This technique can be combined with fat grafting or implants in many cases. Rare cases of silicone extrusion to the skin that form granulomas involving the skin, however, require the use of local skin flaps to reconstruct the deficient skin envelope (*Case Presentation 4*, Fig. 8.4).

Conclusion

Aesthetic breast surgery can benefit from reconstructive methods and lessons learned from challenges posed by breast reconstruction. Complex aesthetic revision surgery may require the use of fat grafting, ADM or mesh support, pocket modification, and – in severe cases – autologous flap-based adjunct treatment. Matching the patient and appropriate operative technique can provide excellent cosmetic outcomes and high levels of patient satisfaction, even in the most challenging aesthetic cases.

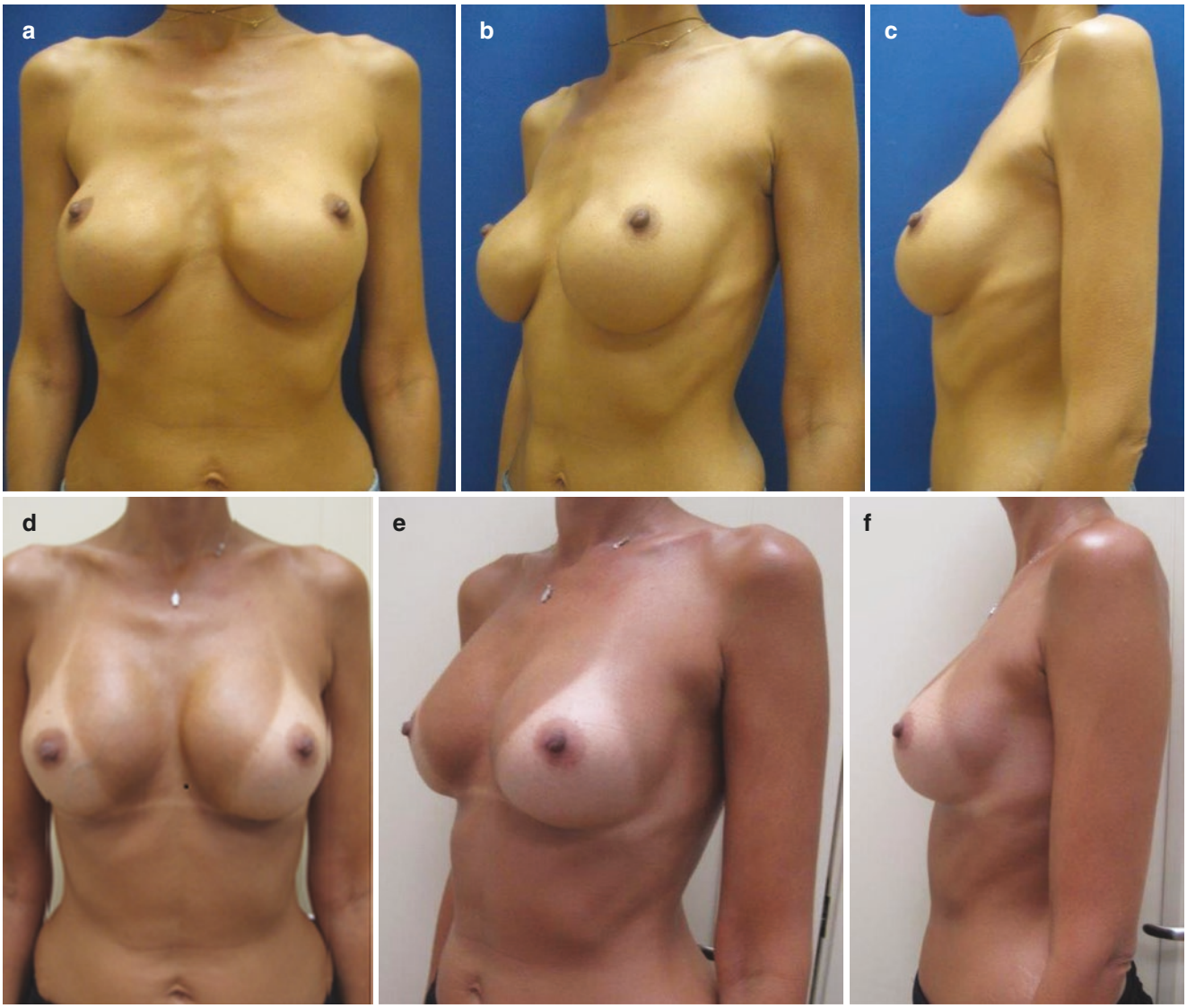

Fig. 8.3 Case Presentation 3: ADM for implant malposition. A 38-year-old patient, 10 years after bilateral subglandular breast augmentation and bottoming out of the implants (**a**–**c**). She underwent bilateral exchange of implants and lower pole reinforcement using bovine acellular dermal matrix (ADM). The patient 1 year after surgery (**d**–**f**)

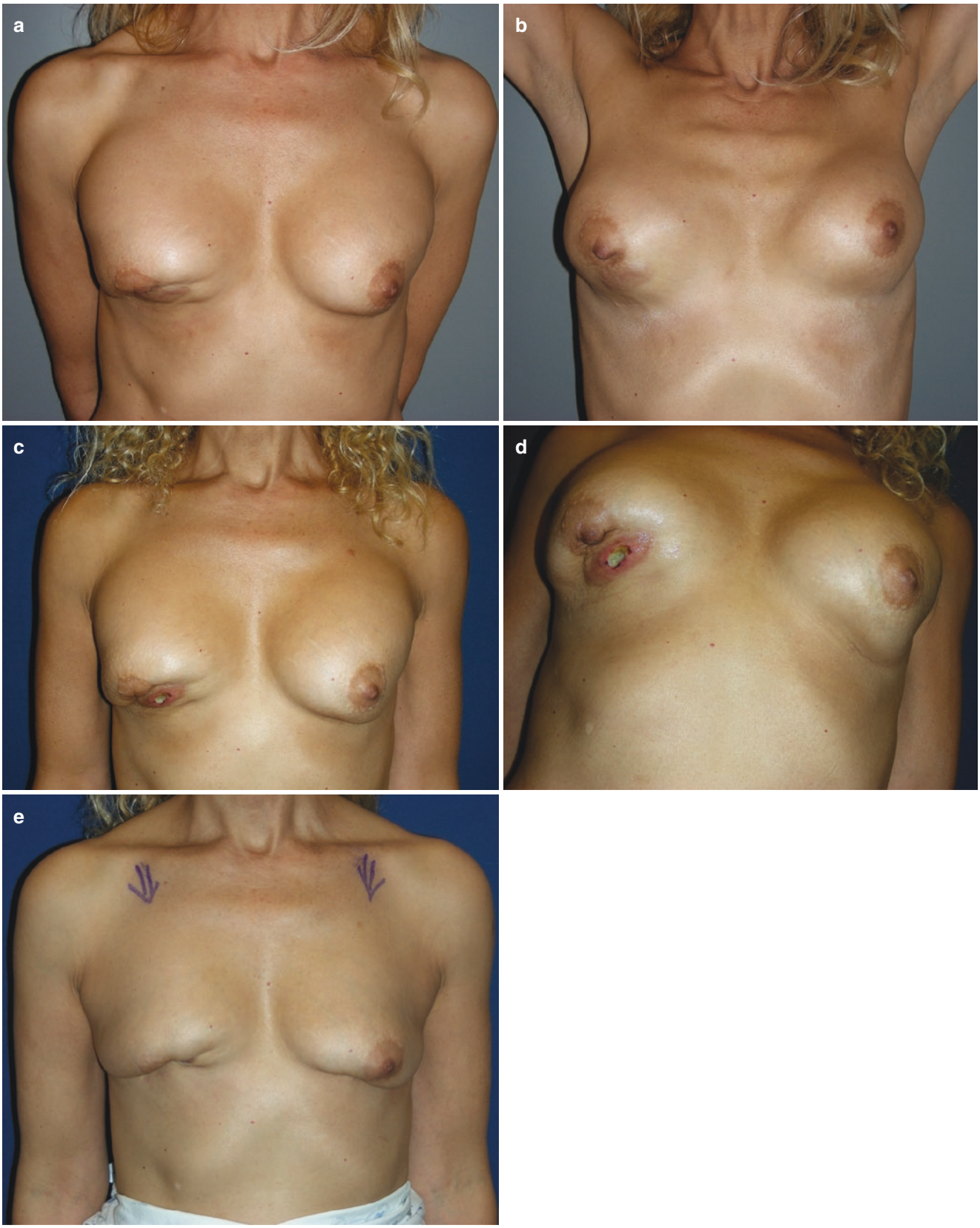

Fig. 8.4 Case Presentation 4: Perforator flap reconstruction of skin and volume defect. A 50-year-old patient, 30 years after bilateral breast augmentation (**a**, **b**). She was diagnosed by MRI with bilateral extracapsular silicone leak and silicone granuloma involving the right breast lower pole (**a**, **b**). She was planned for surgery but was lost to follow-up. She returned after a year with an open wound in the lower pole of the right breast (**c**, **d**). She underwent debridement of the wound, bilateral removal of the implants, and total capsulectomy (**e**, **f**). One year later she underwent re-insertion of an implant on the left breast and reconstruction of the right breast with a thoraco-dorsal artery perforator (TDAP) flap and an implant. Follow-up 1 year after surgery (**g–i**)

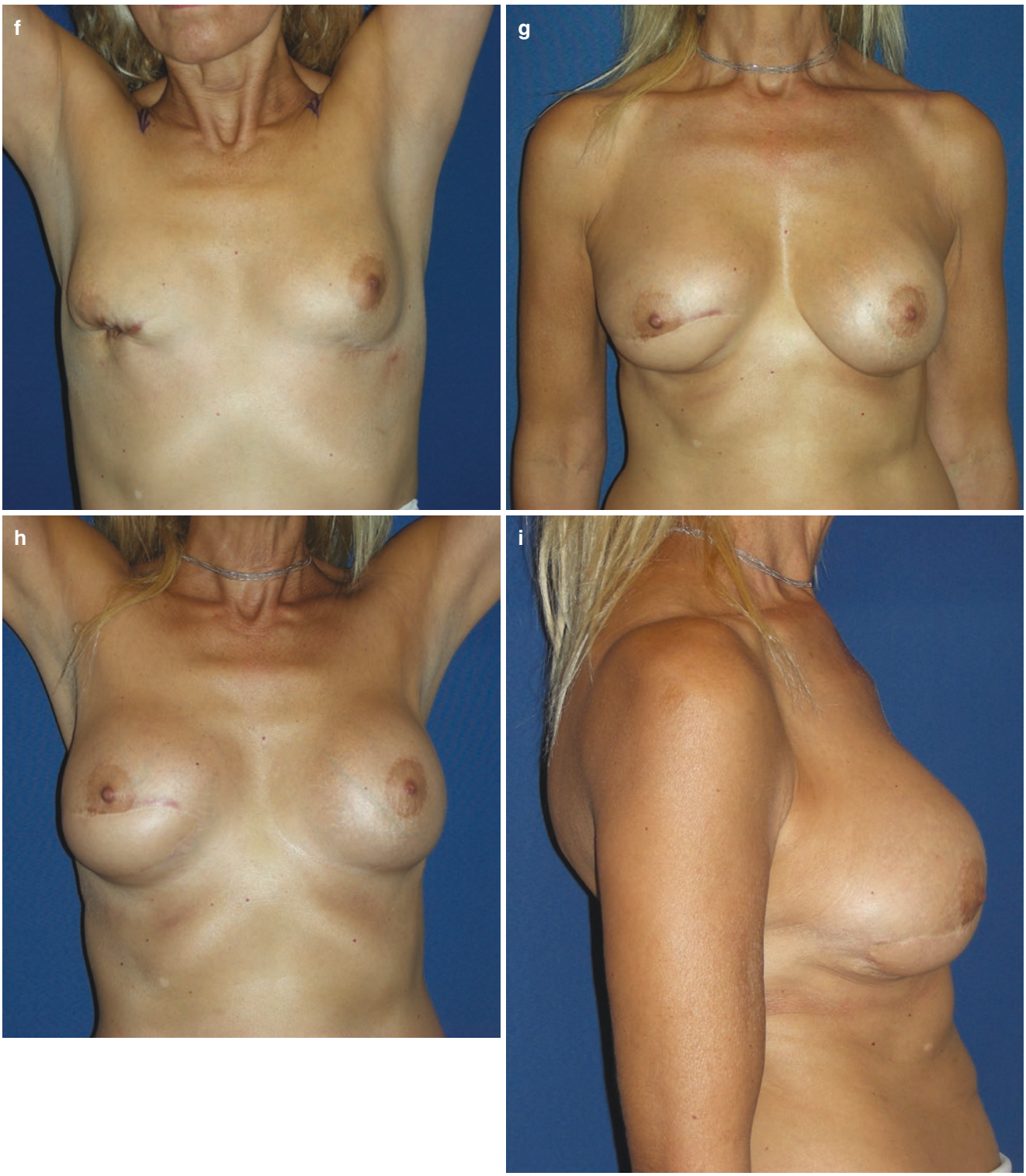

Fig. 8.4 (continued)

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9 Breast Implant-Associated Anaplastic Large Cell Lymphoma: Origin and Outcome

Mark W. Clemens

Breast implant-associated anaplastic large cell lymphoma (BIA-ALCL) is an uncommon T-cell lymphoma that can present as a delayed fluid collection around a textured implant or surrounding scar capsule [1–5]. While the first case report was in 1997, BIA-ALCL only came to limited national attention following an FDA safety communication in 2011 [6]. Awareness has exponentially grown following advisory statements by the World Health Organization [7, 8], the National Cancer Institute [9], the US Food and Drug Administration annually since 2016 [10], numerous government agencies worldwide [11–13], and media coverage [14]. While the exact mechanism of pathogenesis remains elusive, clear data has now been reported on the histopathology [15–23], epidemiology [24–28], imaging [29, 30], treatment outcomes [31, 32], and practice guidance [33]. This chapter will review current theories on the pathogenesis, diagnosis, and treatment of BIA-ALCL with specific focus on established consensus guidelines, published outcomes, and experience following over 800 unique confirmed cases worldwide.

Pathogenesis

Research efforts have focused on several theories of lymphomagenesis with most in agreement of an inciting multifactorial chronic inflammatory stimulus leading to T-cell dysplasia [34–40]. As breast implant ALCL has arisen in patients with either silicone- or saline-filled implants and not in smooth implants, textured shell surface rather than the implant contents is involved in pathogenesis. Chronic antigenic stimulation may lead to recruitment, proliferation, and expansion of T-cells, prolonging T-cell lifespan and leading to clonal expansion and eventually to malignant transformation. The shedding of silicone particles is more pronounced with textured implants [41]. In a study by Meza-Britez et al., inflammation predominantly with a T-cell phenotype around breast implants was statistically more common in patients with textured breast implants as compared to smooth implants [42].

In 2016, Hu et al. based on microbiome studies of textured implants in patients with breast implant ALCL have proposed that the trigger for chronic inflammation lies in the presence of high bacterial loads and biofilms, particularly from Gram-negative bacteria endotoxin [43]. Higher bacterial loads have been found on macrotextured implants. However, data regarding the identity of the causative bacterial species are controversial and remain to be elucidated. The authors detected *Ralstonia* sp., at higher levels at sites of BIA-ALCL-involved tumors compared to the contralateral breast although these data have since been disputed [44]. In particular, later studies by Walker et al. have shown that there is no difference in the bacterial species composition nor bacterial load in the breast tissue of women with or without BIA-ALCL, neither in the contralateral breast or in comparison to normal controls.

Particles, presumably shed from implants, have been detected in multiple cases of BIA-ALCL associated with a textured implant and encapsulated within macrophages. Particulates shed from orthopedic implants, and the associated inflammatory response has been shown although their effects on the body are debatable and only a small number of orthopedic implants have been associated with lymphoma in comparison to the rate of incidence in those with textured surface breast implants [45]. These inflammatory reactions involve the formation of granulomas with a high number of macrophages with and without multinucleated giant cells. In addition, cells were present indicative for delayed type hypersensitivity (DTH) otherwise known as Type IV hypersensitivity which has also been reported in the context of BIA-ALCL [46, 47]. Activated macrophages produce cytokines that induce the chronic proliferation of Th1 cells which could be a mechanism toward the development of BIA-ALCL [48].

M. W. Clemens (✉)
Department of Plastic Surgery, MD Anderson Cancer Center, Houston, TX, USA
e-mail: mwclemens@mdanderson.org

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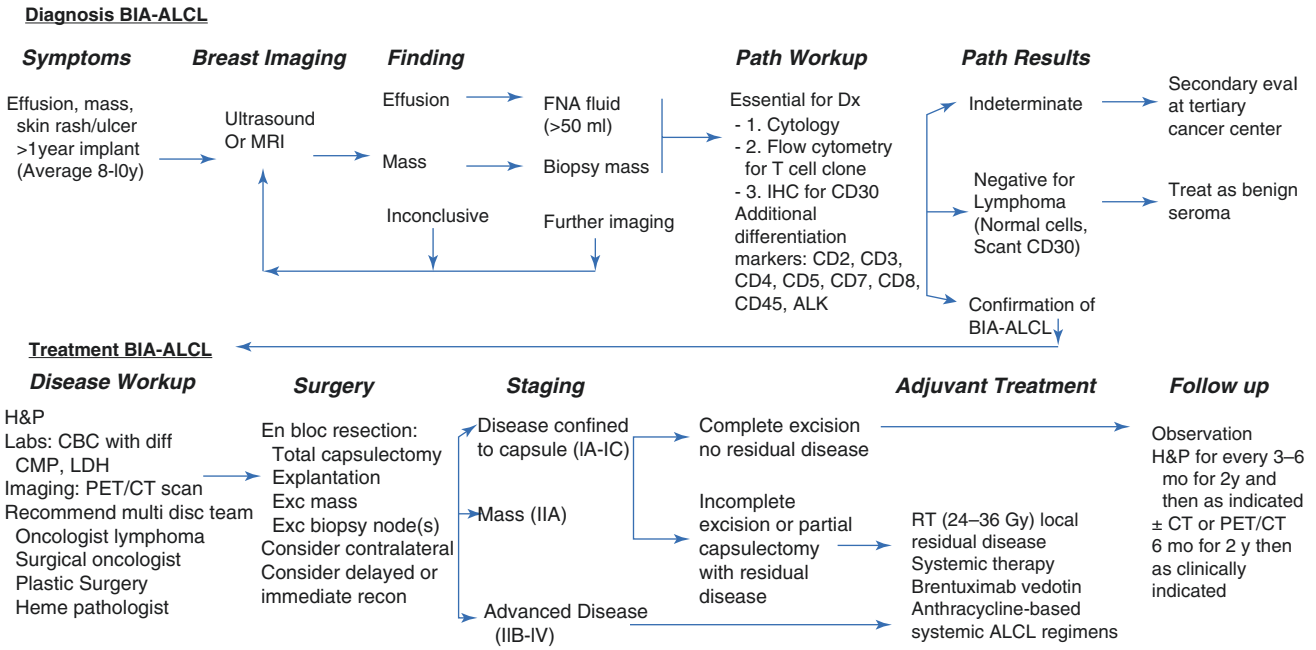

Abbreviations: MRI Magnetic Resonance Imaging, FNA Fine needle aspiration, CBC Complete blood count, PET/CT Positron emission tomography-computed tomography, CMP Complete metabolic profile, LDH Lactate dehydrogenase, RT Radiation therapy

Fig. 9.1 Diagnosis and treatment follows National Comprehensive Cancer Network (NCCN) Guidelines, which are available for free download from www.nccn.org. (Reprinted with permission from Clemens et al. [51])

NCCN Consensus Guidelines for Diagnosis and Disease Management

In 2016, the National Comprehensive Cancer Network (NCCN) established widely accepted consensus guidelines for the diagnosis and management of BIA-ALCL within their Clinical Practice Guidelines for Non-Hodgkin Lymphomas (NHL), now adopted by the American Society of Plastic Surgeons (ASPS) and the American Society for Aesthetic Plastic Surgery (ASAPS) [49, 50]. NCCN guidelines represent the authoritative oncology standards utilized worldwide and are also important in coverage justification by insurance providers. The guidelines are available for free from www.nccn.org, and the essential elements are summarized in Fig. 9.1. While NCCN guidelines represent the most up-to-date evidence-based approach to this disease, many treating physicians may never have encountered the variable disease stages, and therefore individual treatment plans are best formulated in a multidisciplinary fashion.

Approach to Suspected Patient

Delayed seromas greater than 1 year after implantation occur in approximately 0.1% to 0.2% of patients following implantation of textured implants [52]. In prospective studies, BIA-ALCL has been estimated to occur in 9–15% of delayed seroma presentations [50, 53]. Any seroma occurring greater than 1 year after implantation not readily explainable by infection or trauma should be considered suspicious for disease. An otherwise normal seroma is not part of the disease spectrum of BIA-ALCL. Patients most commonly present with the rapid onset of a spontaneous fluid collection (60%) or capsular mass (10–40%) at an average of 8–10 years following implantation with a textured breast implant and are distributed roughly equally between cosmetic and reconstructive indications [39]. All reported cases to date where a detailed implant history was available involved a textured surface breast implant [54]. Other rarer described symptoms have included skin rash [55], capsular contracture [56], and lymphadenopathy [39]. However, capsular contracture in isolation as the only disease manifestation has not been described, and therefore, its reliability as a symptom of the disease is questionable and may be coincidental. Disease is not isolated to female patients as three transsexual patients with textured implants have been confirmed [57]. Following NCCN guidelines, initial workup of an enlarged breast should include *ultrasound evaluation* specifically for a fluid collection, breast mass, or enlarged regional lymph nodes (axillary, supraclavicular, and internal mammary). For cases where ultrasound is indeterminate or requires further confirmation, physicians may also utilize magnetic resonance imaging (MRI). Adrada and colleagues reviewed 44 breast implant ALCL patients with imaging

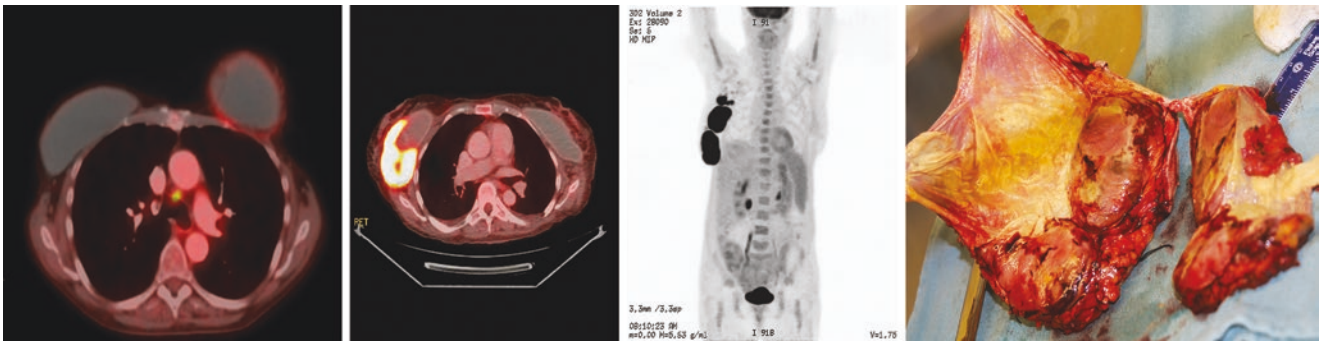

Fig. 9.2 A patient with effusion-limited (stage IA) left-sided BIA-ALCL is shown on an axial 18F-fluorodeoxyglucose positron emission tomography (PET)-CT image with increased metabolic activity of right capsule. (**a**) Note a paratracheal lymph node with small cell lung cancer was incidentally found as a second primary cancer. Both diseases were treated and patient achieved complete remission. (**b**, **c**) PET/CT images of invasive BIA-ALCL masses (stage IIA) growing radially out from the surface of a textured implant. (**d**) The same invasive masses upon surgical resection with the associated implant. (Reprinted with permission from Clemens et al. [58])

studies and reported on the sensitivity/specificity for detecting an effusion using ultrasound (84%/75%), computerized tomography (55%/83%), MRI (82%/33%), and PET/CT (38%/83%) [37]. Additionally, the sensitivity/specificity to detect a mass was reported for ultrasound (46%/100%), computerized tomography (50%/100%), MRI (82%/33%), and PET/CT (64%/88%). The sensitivity of mammography was found to be inferior for both effusion and mass and therefore is not considered an acceptable imaging modality for BIA-ALCL. Based on these findings, ultrasound evaluation is used as a *screening tool*, while PET/CT scan is utilized after an established diagnosis for *oncologic workup* prior to surgery (Fig. 9.2).

Periprosthetic fluid collections should undergo fine needle aspiration. At time of aspiration, ultrasound guidance may aid in implant protection and displacement and can be performed either in a clinic setting or by interventional radiology. A suspicious mass requires tissue biopsy and evaluation by an oncologist to rule out breast cancer. The US FDA, in collaboration with MD Anderson Cancer Center and the NIH, established standardized recommendations in 2020 for the diagnosis of BIA-ALCL [59]. Specimens should be sent for *cell block cytology* and *CD30 immunohistochemistry*. Pathologists will require a clinical history and directions to "rule out BIA-ALCL." Fluid specimens do not require storage in any specialized media and should be transported to a pathology lab within a reasonable amount of time (48 h). While cells may lyse if left for a prolonged time period, diagnostic protein markers do not degrade, and diagnosis is possible on fixed cell blocks years later. Fluid collections may be centrifuged down to a supernatant to concentrate cells for pathology evaluation. If after evaluation, diagnosis of lymphoma is indeterminate, secondary hematopathology consultation is recommended at a tertiary cancer center with disease experience. Surgeons investigating a suspicious seroma must supply a pathologist with an adequate volume (minimum 50 mL and ideally as much as possible) to thoroughly evaluate and perform further tests such as flow cytometry and molecular studies which are necessary for diagnosis.

Diagnostic Criteria

BIA-ALCL diagnosis requires a monoclonal T-cell expansion of large anaplastic (Reed-Sternberg) cells that express CD30, within a periprosthetic effusion or mass aggregate (Fig. 9.3) [5, 60]. CD30 refers to a cell membrane protein that serves as a lymphoma tumor marker, although CD30 can occur normally on activated T-cell lymphocytes. A background of CD30+ T cells is estimated to occur between 0.1% and 5% of circulating T cells and notes a higher concentration may exist in inflammatory states. Increased CD30 expression can be induced on both T cells and B cells as a result of viral infection [61]. CD30+ lymphocytes have been described temporarily increasing from a background of 0.1% to as high as 95% transiently [60]. Immunoblastic proliferation that occurs in infectious mononucleosis can develop Reed-Sternberg-like cells temporarily making differentiation from Hodgkin lymphoma difficult. BIA-ALCL, as well as the entire family of ALCL, display diffuse CD30 expression on their cell surface. Morphologic evaluation by a pathologist and determination of clonal expansion on flow cytometry are critical to diagnosis (see Fig. 9.3, inset). If the pathology is negative for ALCL, the patient can be referred to a plastic surgeon for management of a benign seroma. In accordance with the US FDA's recommendation, histologic confirmation of BIA-ALCL should be reported to the ASPS BIA-ALCL PROFILE registry (www.thepsf.org/PROFILE). The purpose of this important registry is to increase scientific data on breast implant-associated ALCL in women with breast implants as well as to support research to characterize the disease.

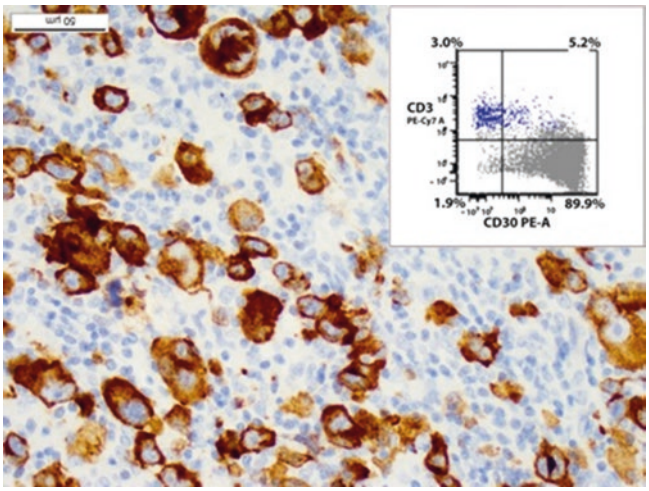

Fig. 9.3 A malignant effusion in a BIA-ALCL patient demonstrates large pleomorphic anaplastic cells with prominent horseshoe-shaped nuclei and nuclear folding and strong diffuse CD30 reactivity by immunohistochemistry. (CD30 immunohistochemistry with hematoxylin counterstain, 1000× magnification) Inset demonstrates a single T-cell clone on flow cytometry. Positive cytology, CD30 expression, and clonality demonstrated here are required for diagnosis. (Reprinted with permission from Clemens et al. [58])

Preoperative Oncologic Workup

Following confirmation of BIA-ALCL diagnosis, preoperative consultation with a lymphoma oncologist and consideration of a surgical oncologist are recommended. Oncologic workup should proceed prior to any operative intervention. A bone marrow biopsy may be indicated, but is only performed in rare select cases at the oncologist's discretion to differentiate from other peripheral T-cell lymphomas. Testing for anaplastic lymphoma kinase (ALK) translocation status also differentiates from ALK+ systemic ALCL, a much more aggressive disease with poor prognosis. Note that BIA-ALCL is always ALK negative, and therefore ALK is not a screening tool, but a descriptive tool for established disease. For confirmed cases, a PET/CT scan is beneficial for demonstrating associated capsular masses, chest wall involvement, regional lymphadenopathy, and/or distant organ metastasis [9]. A PET scan can act as a roadmap for surgical planning, resection strategy, and timing of surgery. For instance, unresectable chest wall invasion may become resectable following neoadjuvant chemotherapy.

Solid Tumor Staging

BIA-ALCL was formally staged as a liquid tumor; however, tumor biology has preferentially supported staging as a solid tumor. The Lugano revision to the Ann Arbor Staging System is a liquid tumor staging with stage IE disease limited to breast involvement only and stage IIE disease limited to the breast and ipsilateral axillary lymph nodes [62]. Using this system, nearly all BIA-ALCL patients have low-stage disease, either stage IE (83–96%) or stage IIE (3.6–18.8%) [39] (Table 9.1). An MD Anderson solid tumor TNM staging system is modeled after the American Joint Committee on Cancer (AJCC) TNM (Tumor, lymph Node, Metastasis) (Figs. 9.4 and 9.5). Using this system, BIA-ALCL is a spectrum of disease from IA (35.6%), IB (11.5%), IC (13.8%), IIA (25.3%), IIB (4.6%), III (9.2%), to stage IV (0–9%) [5] (see Table 9.1). The World Health Organization currently classifies BIA-ALCL as a lymphoma at all stages [7]. Clinical observation of effusion-limited (IA) disease demonstrates a typically indolent course, and therefore this stage may be more akin to a lymphoproliferative disorder. However, BIA-ALCL can become an invasive lymphoma and metastasize at more advanced stages. Other malignant lymphoproliferative disorders include lymphomatoid papulosis and primary cutaneous ALCL. Both can spontaneously regress and have an observed progression rate to invasive lymphoma of 5.6% to 9% and 10% to 27%, respectively [63, 64]. It is not yet possible to determine the progression rate of effusion-only (IA) BIA-ALCL to invasive lymphoma as the staging requires pathologic examination of the resected capsule, in

Table 9.1 Clinical and pathologic staging of BIA-ALCL follows the MD Anderson Solid Tumor Staging System modeled after the American Joint Committee on Cancer (AJCC) TNM (Tumor, lymph Node, Metastasis) stages

TNM or stage designation	Description
T: tumor extent	
T1	Confined to effusion or a layer on luminal side of capsule
T2	Early capsule infiltration
T3	Cell aggregates or sheets infiltrating the capsule
T4	Lymphoma infiltrates beyond the capsule
N: lymph node	
N0	No lymph node involvement
N1	One regional lymph node (+)
N2	Multiple regional lymph nodes (+)
M: metastasis	
M0	No distant spread
M1	Spread to other organs/distant sites
Stage	
IA	T1N0M0
IB	T2N0M0
IC	T3N0M0
IIA	T4N0M0
IIB	T1-3N1M0
III	T4N1-2M0
IV	TanyNanyM1

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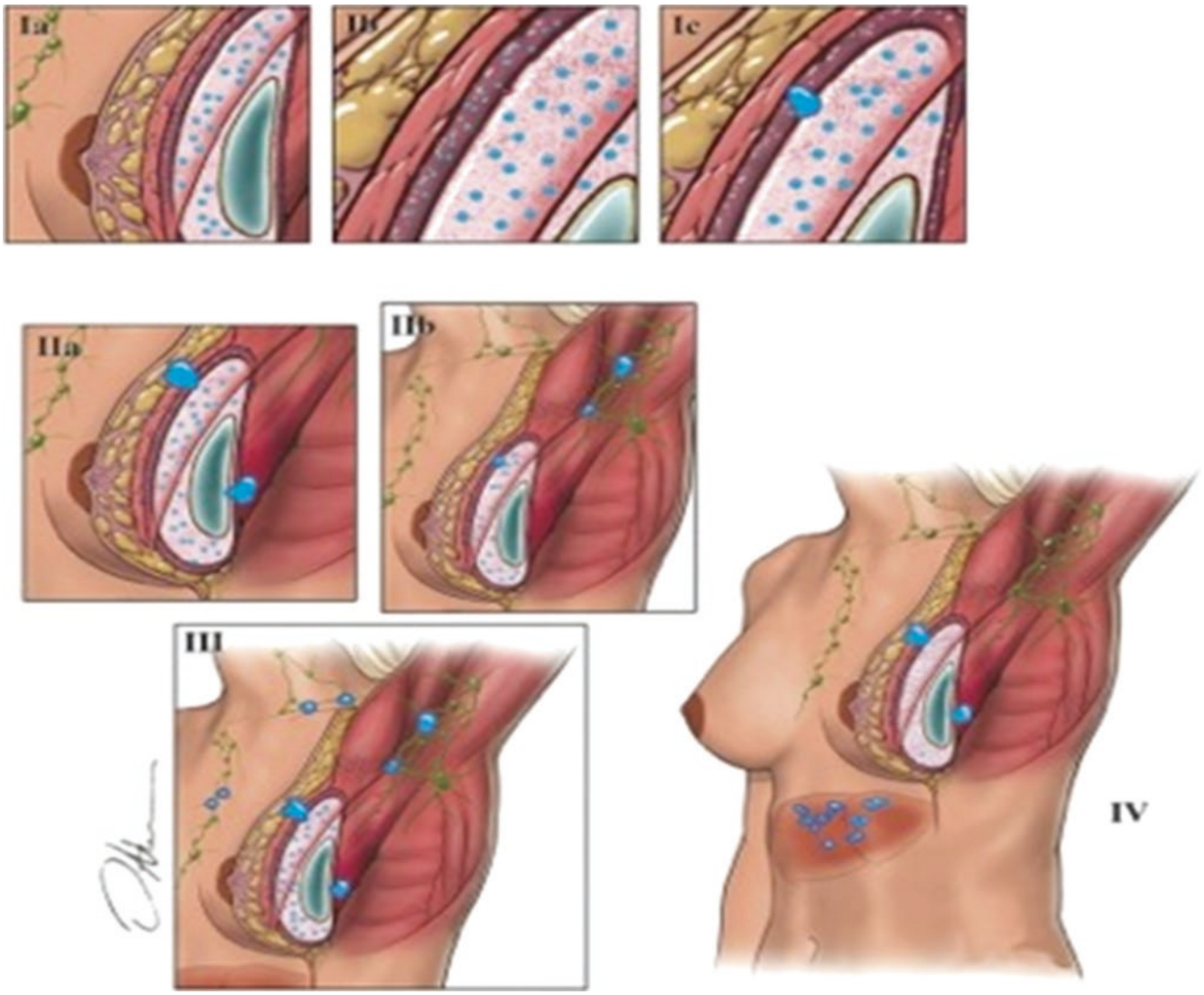

Fig. 9.4 Clinical and pathologic staging of BIA-ALCL follows the MD Anderson Solid Tumor Staging System modeled after the American Joint Committee on Cancer (AJCC) TNM (Tumor, lymph Node, Metastasis) stages. (From Clemens et al. [31]. Reprinted with permission. © 2016 American Society of Clinical Oncology. All rights reserved)

essence treating the disease. Therefore, how indolent the disease is or quantifying what amount of delay in treatment will lead to progression of disease is not yet possible. It is important to note that all of these designations and nomenclatures are still referring to a cancer. To date, spontaneous resolution of disease without any treatment intervention has not been reported. Patients with BIA-ALCL can have progression of their disease, lymph node involvement, and death of disease, particularly with significant delay in diagnosis or suboptimal treatment [65]. These patients are described as having local or regional extension of their disease or very rare distant organ metastasis, which is more similar to solid tumors. This emphasizes the solid tumor classification and that this is a distinct entity that progresses locally.

Surgical Treatment

Timely diagnosis and complete surgical excision of disease, implants, and the surrounding fibrous capsule is the optimal approach for the management of breast implant ALCL in the majority of patients. Disease localized to the capsule (Lugano IE, MDA IA-IIA) may be treated with surgery alone in the majority of cases (Fig. 9.6). Surgical goals are a total capsulectomy with removal of the breast implant, excision of any associated capsular mass, and excisional biopsy of suspicious lymph node(s) (Fig. 9.7). In retropectoral or dual plane implants, adherence to the rib cage may make resection difficult, and tumescence of the anatomical plane can facilitate capsulectomy [66]. Care should be taken when dissecting capsule off of intercostal muscles to avoid a

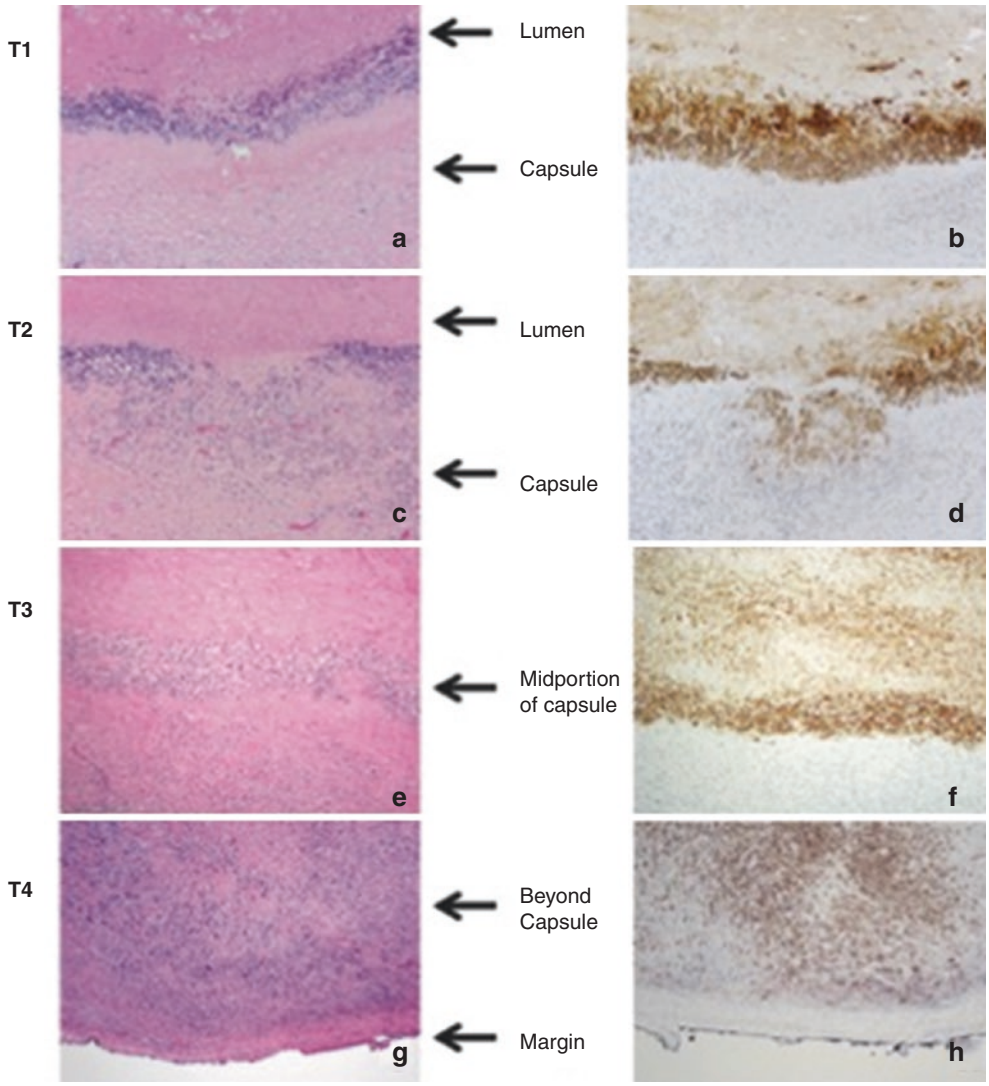

Fig. 9.5 Pathologic T staging. (**a**, **b**) T1: lymphoma cells confined to the effusion or a layer on the luminal side of the capsule. (**c**, **d**) T2: lymphoma cells superficially infiltrate the luminal side of the capsule. Arrows indicate the areas of invasion. (**e**, **f**) T3: clusters or sheets of lymphoma cells infiltrate into the thickness of the capsule. (**g**, **h**) T4: lymphoma cells infiltrating beyond the capsule, into the adjacent soft tissue or breast parenchyma. Left column, hematoxylin and eosin stain; right column, CD30 immunohistochemistry; magnification, 3100. (From Clemens et al. [31]. Reprinted with permission. © 2016 American Society of Clinical Oncology. All rights reserved)

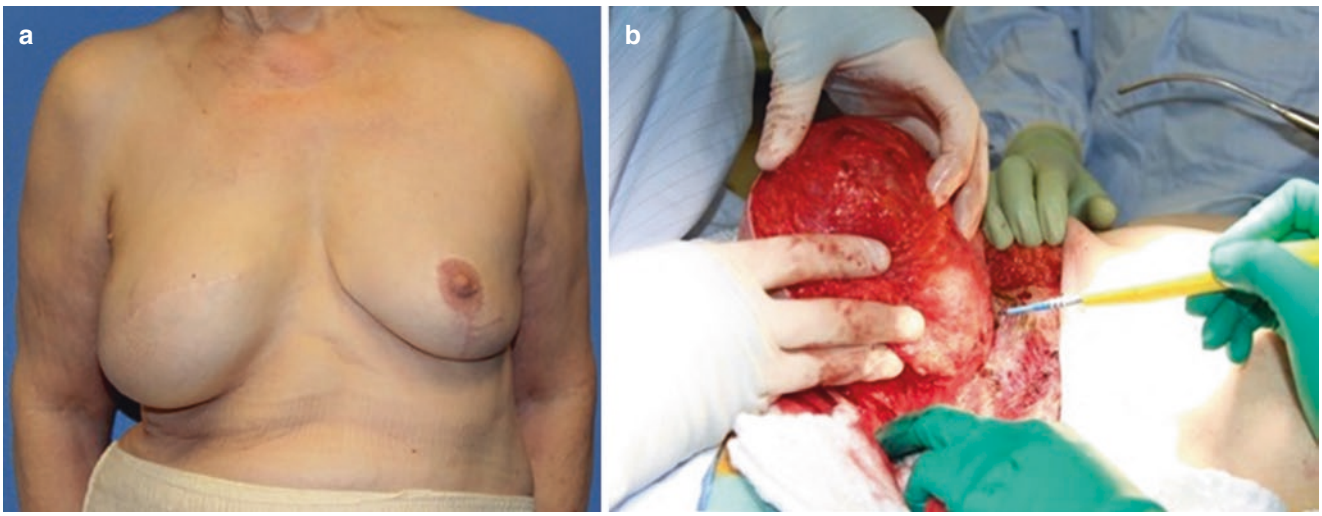

Fig. 9.6 A 77-year-old woman underwent post-mastectomy prosthetic reconstruction for breast cancer in 2003. (**a**) Eleven years after implantation, she developed rapid swelling of the right breast manifested as marked breast asymmetry. BIA-ALCL was diagnosed on fine needle aspiration. (**b**) Patient then received a total capsulectomy and implant removal. (Reprinted with permission from Clemens et al. [58])

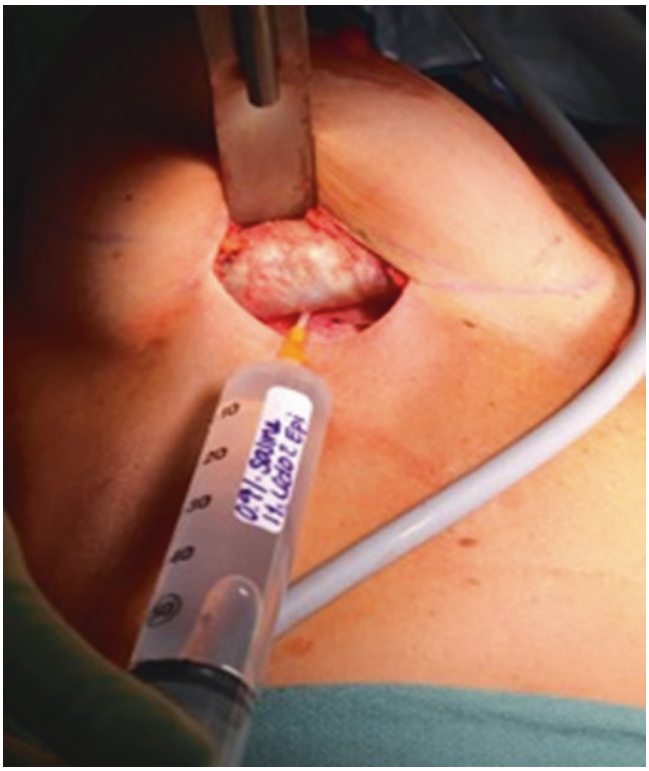

Fig. 9.7 Treatment of BIA-ALCL includes total capsulectomy with excision of any associated masses as residual disease left on the chest wall may continue to progress and require further treatment such as chemotherapy. With subpectoral implants, elevation of the posterior capsular wall off of the rib cage may be difficult, but is still essential. Pictured is standard tumescence being infiltrated by angiocath into the posterior capsule of a BIA-ALCL patient to facilitate complete removal of the capsule. Inframammary approach was utilized to allow for immediate reconstruction. (Reprinted with permission from Clemens et al. [58])

pneumothorax. It remains unclear what effect inadvertent spillage of the seroma during capsulectomy has on local seeding of disease; however clinically, this has not been observed to influence recurrence rates. Complete mass excision with negative margins is essential because retained disease likely will subject the patient to otherwise unnecessary adjuvant chemotherapy. At present, there is no role for radical mastectomy, sentinel lymph node biopsy, or full axillary dissection. Per NCCN guidelines, surgeons may consider removal of the contralateral implant as approximately 4.6% of cases to date have demonstrated incidental ALCL in the contralateral breast implant [5]. Consultation with a surgical oncologist may be beneficial for plastic surgeons unaccustomed to oncologic ablation and lymph node excisional biopsies.

Pathologic evaluation of both the periprosthetic fluid and the capsule are important for staging of the disease. Evaluation of the capsule may be performed by either widely sampling the internal lining with multiple punch biopsies, or alternatively, the capsule may be opened and set out flat, the implant surface scraped, and the cell block of the scraping evaluated for presence of lymphoma. Timing and type of reconstruction remain controversial and are currently being prospectively studied with institutional review board oversight. Replacement with textured implants should be avoided due to likely genetic predisposition and demonstrated susceptibility.

Indications for Adjuvant Treatments

Patients with advanced disease (2–18%) such as lymph node metastasis will frequently warrant adjuvant chemotherapy (Lugano II-IV, MDA IIB-IV) (see Table 9.1). Systemic ALCL is treated with an anthracycline-based regimen (cyclophosphamide, vincristine, doxorubicin, and prednisone: CHOP) for first-line therapy. Anthracycline-based multiagent chemotherapy with or without radiation therapy followed by autologous stem cell rescue is the standard approach for most patients with newly diagnosed peripheral T-cell lymphomas [67, 68]. However, NCCN guidelines allow physicians to consider following either systemic ALCL chemotherapy regimens with CHOP or preferably brentuximab vedotin as a first-line agent. Brentuximab vedotin is a toxin-antibody conjugate to CD30. Pro and colleagues reported 4-year survival data from an ongoing phase 2 study of brentuximab vedotin in patients with refractory systemic ALCL which demonstrated an objective response rate (ORR) of 83% and complete remission rate of 62% [68, 69]. A randomized phase 3 study is evaluating brentuximab vedotin in combination with cyclophosphamide, doxorubicin, and prednisone for frontline treatment of CD30-positive mature T-cell lymphomas, including systemic ALCL. Outcomes of chemotherapeutic regimens in BIA-ALCL are from case reports; however, complete remissions have been achieved in patients with organ metastasis when treated with brentuximab vedotin [70]. The drug may also have a role as a neoadjuvant targeted agent for downgrading chest wall invasion [71]. Stem cell transplant and external beam radiation therapy are only reserved for unresectable disease in a salvage setting.

Follow-Up and Disease Surveillance

Patients are best followed by an oncologist who may monitor for disease recurrence and evaluate for adjunctive therapy. Treated patients with no evidence of disease are evaluated every 3–6 months for 2 years and then as clinically indicated. Physicians may include CT or PET/CT scans every 6 months for 2 years and then only as clinically indicated.

Treatment Outcomes

BIA-ALCL generally appears to be a biologically indolent disease with an excellent prognosis when confined to the capsule and treated with complete surgical resection. No known cases of confirmed disease regression or complete spontaneous resolution without treatment have been reported to date. Statistically worse prognosis has been identified in patients with mass formation and extracapsular extension [23]. Miranda and colleagues reported on the long-term outcomes of 60 patients and found more patients without a mass achieved complete remission compared with those with a mass (93% of 42 patients compared with 72% of 18 patients) [23]. The median overall survival for patients with a discrete breast mass was 12 years, whereas the median overall survival had not been reached for patients who did not have a discrete breast mass. It remains unclear whether the worse prognosis associated with a mass is due to a more aggressive variant, more progressed disease, or perhaps a consequence of inadequate surgical ablation of tumor infiltration.

Clemens et al. reported on the outcomes of 87 patients treated with surgery alone (40%); surgery and radiation (9%); surgery and chemotherapy (19%); surgery, chemotherapy, and radiation (30%); or chemotherapy alone (2%) [39]. Both

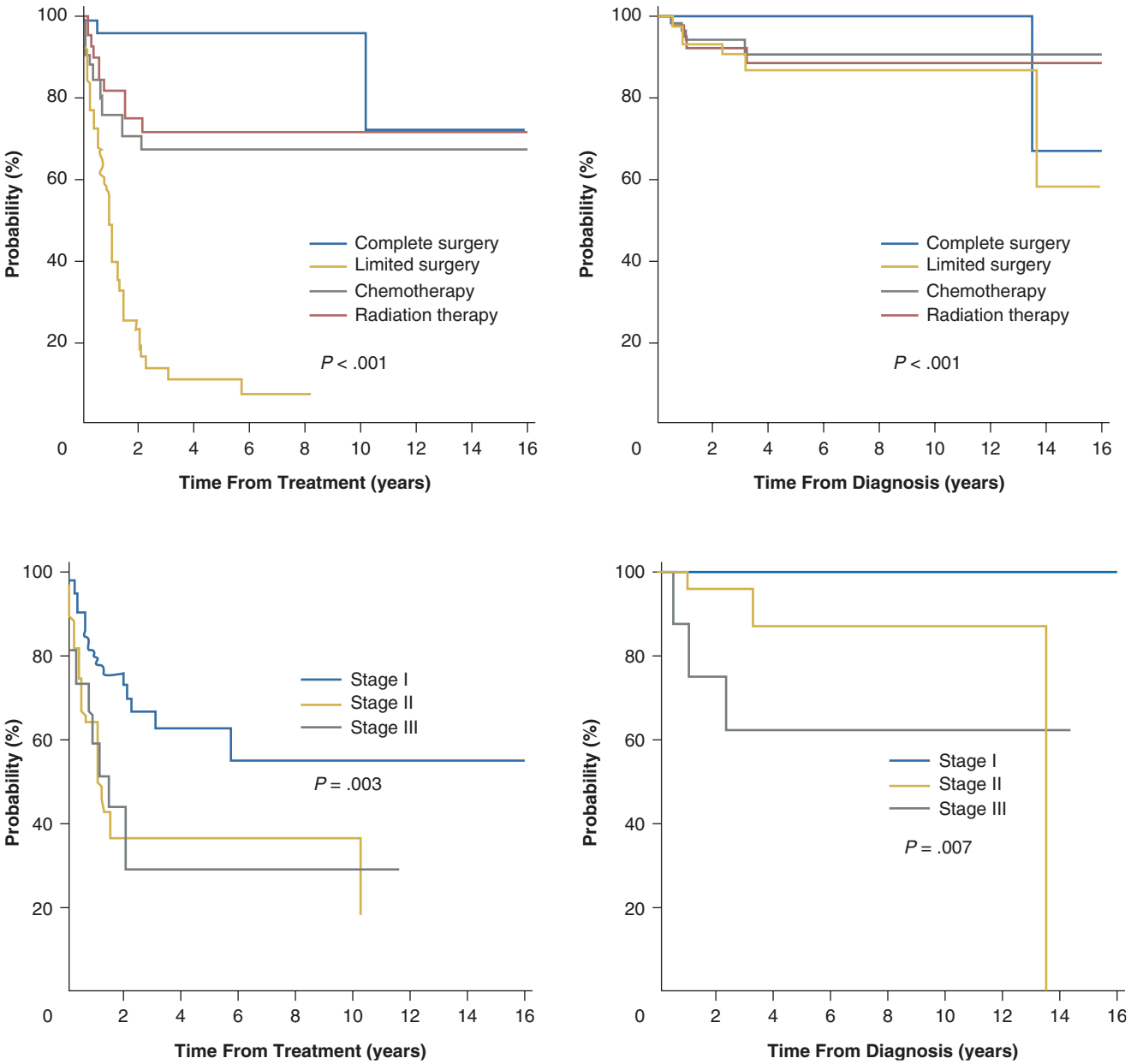

Fig. 9.8 Survival curves according to treatment approaches (top) and TNM solid tumor staging (bottom). Event-free survival (left), overall survival (right). (From Clemens et al. [31]. Reprinted with permission. © 2016 American Society of Clinical Oncology. All rights reserved)

the presence of a mass at the time of diagnosis and extracapsular disease extension were associated with an increased risk for recurrence and patient death. At a median follow-up of 45 months, 28% had recurrent disease, of whom 73% were treated with salvage chemotherapy. Complete surgical excision of the disease had the lowest recurrence rate of 4% at 1, 3, and 5 years. Kaplan-Meier survival curves by treatment modality are displayed in Fig. 9.8. At present, a total of 33 patients have been reported dead from BIA-ALCL disease in Australia, Brazil, France, Italy, the Netherlands, New Zealand, Sweden, Argentina, and the United States [11–13, 35, 62, 72, 73]. A recurring theme in these tragic outcomes is significant delay in diagnosis and/or chemotherapeutic treatment of the disease with limited or no surgical resection. In 2019, the US FDA reported that they were aware of 573 unique and confirmed cases of BIA-ALCL and that when device manufacturer history was known, Allergan BIOCELL was associated with approximately 91% of world cases. The FDA noted the risk of BIA-ALCL with Allergan BIOCELL textured implants is approximately six times the risk of BIA-ALCL with another textured implant (Mentor Siltex) manufactured in the United States [25]. Based upon the available information, the FDA requested a Class I device recall for Allergan Corporation for BIOCELL textured implants [74]. This decision was made after a prior Allergan ban in 38 countries. In response to the FDA announcement, Allergan performed a voluntary recall of BIOCELL textured implants and tissue expanders in remaining countries worldwide.

Conclusion

Breast implant-associated anaplastic large cell lymphoma (ALCL) was first described over 20 years ago [75], but only recently has it led to a wave of concern among the public, media, and physicians. BIA-ALCL appears to begin as an indolent disease with excellent prognosis in majority of patients. NCCN consensus guidelines have been established and widely adopted for the diagnosis and management of breast implant ALCL. Surgical ablation with explantation and capsulectomy is frequently curative, with disease confined to the capsule. Understanding and implementation of a standardized approach is critical to prevent delays in diagnosis, disease progression, and avoidable adverse sequelae.

Conflict of Interest The author has no relevant financial relationships or affiliations to disclose.

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The Use of 3D Imaging to Avoid Asymmetry and Aesthetic Problems in Cosmetic Breast Surgery

10

Patricia McGuire and Caroline A. Glicksman

Introduction

> In treating breast asymmetry, the best we can hope for is a different set of differences [1]. –Dr. John Tebbetts

Developing a process for patient education for any procedure can help to manage expectations and improve patient satisfaction [2–4]. Reoperation after breast augmentation often results from failing to meet the patients' expectations in regard to size, shape, and symmetry. It is often difficult for a patient to visualize the potential post-operative result, which can make her uncomfortable with her decision to have breast surgery and can lead to an unhappy patient after surgery. If a patient is directly involved in the decision-making process, she is more likely to understand what can and cannot be achieved within the limits of her underlying anatomy and tissue characteristics with cosmetic breast surgery [5]. Reviewing the patient's photos, showing her another patient's results who has similar anatomy, drawings, or breast sizers can be used to give the patient an idea of the potential results, but not all patients can visualize their results with those modalities [6].

Three-dimensional (3D) imaging is a tool that allows the surgeon and patient to review her own anatomy in order to appreciate her asymmetry, ptosis, shape, and size prior to undergoing surgery. Because you can almost never find another patient with exactly the same anatomy for the example photos, 3D imaging allows a patient to see her possible result and understand her inherent asymmetry and tissue characteristics. Simulations can then be performed with various implants of different dimensions and shapes to give the patient a visual idea of her potential outcome from surgery. This is especially important in patients with pre-operative asymmetry. These patients need to understand the cause of their asymmetry and that no asymmetry can be completely corrected. Even with our best efforts, we can never absolutely correct volume, chest wall, or nipple position asymmetry, and in improving some elements of asymmetry, we have to be willing to accept some tradeoffs [7].

Educating patients on those tradeoffs for improving symmetry with implants of different sizes and dimensions can help them in the decision-making process and manage post-operative expectations, which can lead to better patient satisfaction after surgery. By participating in the selection of the size and shape of the implant to be used, the patient will also have some "ownership" of final result which may lessen the tendency of second guessing the size implant chosen for cosmetic breast augmentation [5].

3D Imaging

3D imaging was initially used in plastic surgery for evaluation of facial symmetry over time in the late 1970s. The initial systems were expensive and time-consuming to use.

Stereophotogrammetry uses two cameras in specific arrangement to allow for depth perception giving a more realistic simulation. In newer systems, the raw images are converted using software specific to creating 3D images [8]. Over the past 30 years, software developments have evolved that allow rapid evaluation and 3D reconstruction of images, allowing images to be rotated for visualization of lateral and three-quarter views, and reliable distance and volume measurements can be performed. The most current systems use passive stereophotogrammetry, which can capture images in milliseconds. Systems are available now that use handheld cameras, iPads, or equivalent, which are portable and more cost-effective. Since 2005 3D imaging for breast measurements and assessment of surgical outcomes have been used with studies validating the accuracy of results [9]. Adams

P. McGuire (✉)
Washington University, and Parkcrest Plastic Surgery, St. Louis, MO, USA

C. A. Glicksman
Department of Surgery, Hackensack Meridian, School of Medicine at Seton Hall, Sea Girt, NJ, USA

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showed a 90% correlation between 3D imaging simulation and surgical results [10]. Myckatyn et al. also showed a 91% correlation between imaging and measured post-operative volumes [11].

Breast Asymmetry

Studies have shown that, if carefully examined, the incidence of breast asymmetry is over 95% if parameters such as volume, sternal notch to nipple distance, IMF location, N:IMF distance, width of the breast, and chest wall positioning are measured [12]. Some patients present for consultation with the specific goal of improvement of asymmetry; however, most patients are unaware of subtle differences which may be magnified in their larger post-operative breast and can be a cause of patient dissatisfaction after surgery. Developing a consultation process which allows the patient to be educated on her pre-operative anatomy with a discussion of what can and cannot be changed and what tradeoffs she may be willing to accept to achieve improved symmetry or improve the size and/or shape of her breast can help to avoid post-op dissatisfaction.

Patient Consultation Process

Having a process in place allows consistency in the consultation process. What works for any surgeon or patient differs, but basic principles should be followed for each consult with adaptations as indicated [14].

Some surgeons use 3D imaging during the initial patient consultation; others will have the patient return for imaging at a second consultation; the utilization needs to fit the surgeon's style of consultation. Patient portals can be set up for patients to be able to review their simulations on their own computers which can be useful if a spouse or significant other was unable to attend the patient's consultation. Some surgeons charge a fee for 3D imaging, which is discounted from the surgeon's fee if the patient schedules a procedure; others do not. Some surgeons allow patients to have copies of their imaging photos and the size implants chosen; others do not for fear the patient will take the images to another surgeon who does not have 3D imaging available in their practice. These are all factors that each surgeon needs to decide for him/herself. Patients like new technology, and studies have shown that availability of 3D imaging can influence a patient's choice of the surgeon they seek for consultation [7].

Whether 3D imaging is used or not as part of the consultation process, a defined consultation process including history, physician examination, measurements, patient education, and surgical planning with a post-operative plan has been shown to lower reoperation rates and improve patient satisfaction. This will be briefly covered in the context of utilizing 3D imaging in the entire consultation process for cosmetic breast surgery.

Medical History

One should obtain a clinical history of medical issues, medications, smoking history, allergies, personal and family history of breast disease, and bleeding or clotting disorders. Pregnancy and breast-feeding history as well as previous surgery and anesthesia history should be obtained. Mammograms pre-operatively should be performed per the recommendations of the American Cancer Society. Height, weight, and bra size should also be documented [2–4, 13].

Patient Concerns with Her Breast and Surgical Goals

A patient's desired results and motivations for surgery should be assessed. The patient should put in writing her specific concerns about her breast pre-operatively. Is it size, shape, or sagginess? Asymmetry? What bothers her the most? Does she have goals that are realistic within the framework of her current anatomy? Is she more concerned about how she looks in clothes or out of clothes? What are her goals for cleavage and position of the breast on the chest wall? Is she concerned about being too large? Or not large enough?

Examination

- Height, weight, BMI
- Quality of patient's tissues
- Measurements: SN:N, BW, soft tissue coverage (pinch test), N:IMF
- Breast footprint (location of the breast on the chest wall)

3D Imaging as Part of the Consultation

Simulation Process

The order of the consultation process utilizing 3D imaging will vary depending on each surgeon's style and how her/his office is structured. It is not a substitute for a good physician examination and measurements to allow for dimensional planning.

After physical examination, the patient can be imaged in the 3D imaging system used by the surgeon. Some surgeons do imaging in the same room the patient is examined; others have a photography room where photos and imaging are both performed; this will depend of the configuration of the office and size of exam rooms. There are many 3D imaging systems available; each surgeon and staff need to determine which system best meets their needs in terms of cost, portability, and compatibility with the surgeon's electronic medical records systems. After the imaging and photos are completed, it is best for the patient to get dressed so she can be comfortable reviewing the images with her surgeon or some practices use a trained patient consultant for the image review. The surgeon, or patient consultant depending on the specifics of the practice, should sit down with the patient and review the 3D images on the computer screen (Fig. 10.1). Systems vary, but generally the simulation shows volume measurements for each breast, base width, nipple position measurements, and chest wall anatomy. These measurements should be explained to the patient and what asymmetries may exist in volume, nipple position, width, and her chest wall. The image can be rotated to allow the patient to see her anatomy in various positions. Simulation of various sizes and shape of implants can then be visualized with the patient's participation showing her the possible outcomes when implants of different volumes, shapes, or projections are used (Fig. 10.2). This allows implant selection to be performed in a transparent fashion with the patient understanding the reasons for choosing the implant used. Some systems allow visualization of mastopexy so patients can see the shape of the breast with and without mastopexy if indicated in the patient. Some systems also allow a swimming suit top or t-shirt to be placed on the simulation so the patient can also see a simulation with clothing.

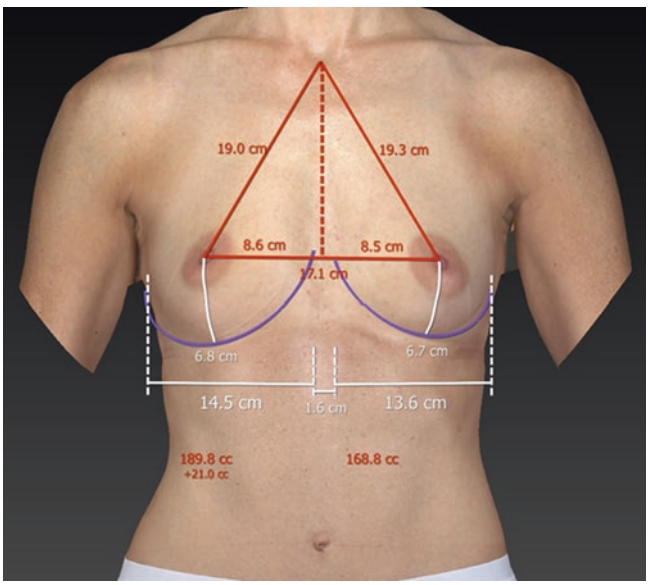

Fig. 10.1 The assessment screen on the Vectra 3D imaging system. This is used to show the patient the measurements and point out asymmetry and can be used in surgical planning

Ultimately, the surgeon controls the simulation and must use those parameters which work with that patient's anatomy. A patient may keep asking to see the next bigger size, and although the simulation allows any size implant to be used within the simulation, the surgeon must be able to educate the patient as to why she must stay within the size range that fits the measurements obtained within the computer simulation to give her a long-lasting result [19].

What Can the Simulation Be Used for?

Size Selection

After reviewing the patient's anatomy, simulation can be performed with various size implants using the same or asymmetric implants with the patient's input as to her satisfaction with the size and shape of the breast. Size change accounts for a significant number of reoperations after cosmetic augmentation [17]. Patients often second guess the size of their implants and may be influenced by social media and pressure by significant others, family, and friends. With 3D imaging the patient sees her measurements on the computer screen and can better understand how the width of the implant may or may not work with her specific anatomy. Using the Vectra system, the implants that are within the measured base width of her chest are highlighted in the implant selection program on the computer screen; this allows patients to see how specific volumes may not work with her anatomy. Simulation can also be performed using implants of different sizes, shapes, or projections in each breast, so the patient can get an idea of the appearance of the breast when using asymmetric implants and understand what can and cannot be corrected in terms of asymmetry of her breasts. The patient contributes to the decision-making process, making her comfortable with the choice of implant size and less likely to second guess that choice after her surgery [5, 11, 17].

Shape/Projection Selection

Implants of different projections and shapes can also be used and compared within the 3D simulation. A patient may come in for a consultation specifically requesting a shaped implant, but when she sees the simulation, she may determine that she wants more upper pole fill or more sloped upper pole. Various projections can be placed in the simulations and evaluated in side-by-side comparisons so the patient can choose which is more appealing to her.

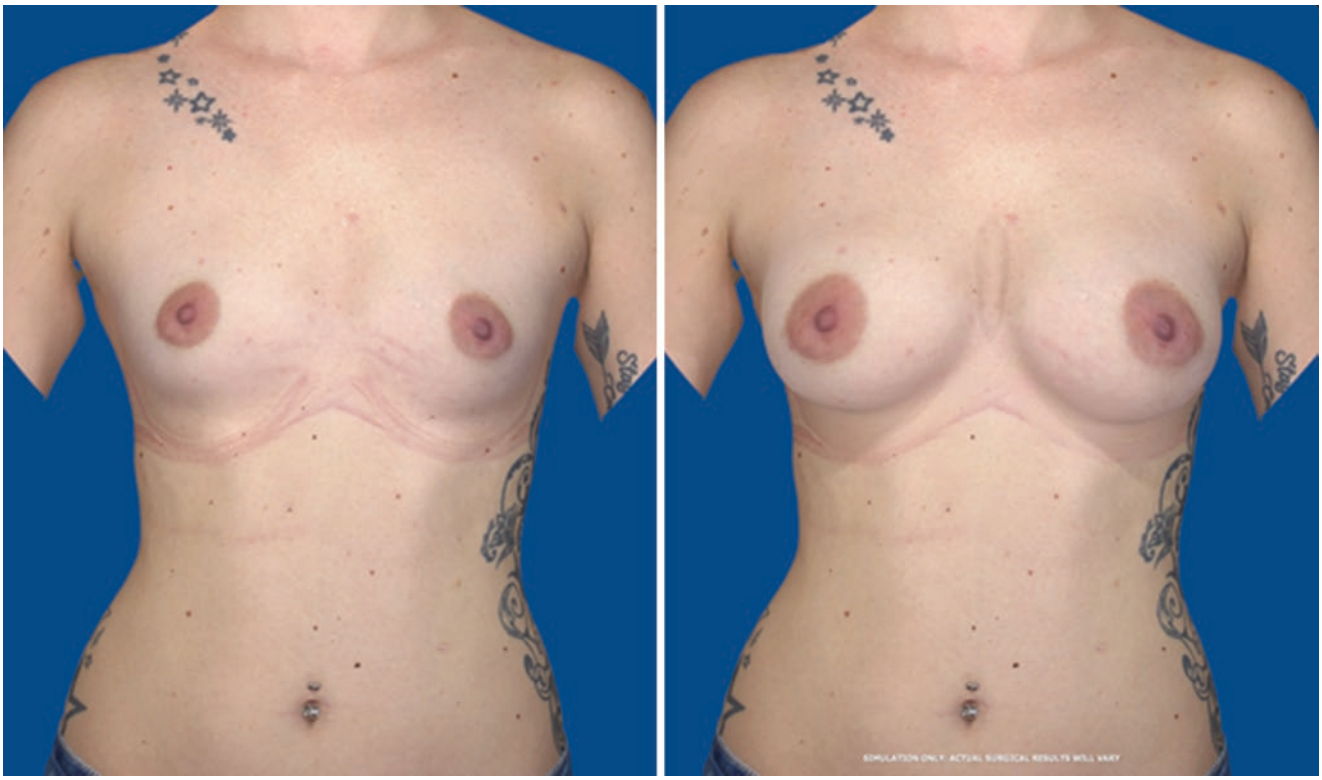

Fig. 10.2 Various implants can be used to simulate the potential result with the patient and visualized in the simulation

Asymmetry

All women's breasts have asymmetry; it is important to make a patient aware of any asymmetry PRIOR to her surgical procedure. Evaluation for structural asymmetry of the chest wall and spine such as scoliosis, pectus excavatum or carinatum, and thoracic hypoplasia is important as part of the pre-operative education process. 3D imaging gives the patient an estimate of the volume asymmetry between breasts, although these measurements should not override surgical judgment as studies have shown that the accuracy of volume measurements varies between systems and with patient anatomy. During simulation, asymmetric implants can be used to camouflage the patient's volume asymmetry. IMF asymmetry can be assessed, and implants adjusted in the simulation to show what can and cannot be done to adjust the asymmetry parameters [3, 4, 11].

Adams recommends using a written acknowledgment of each element of the patient's breasts that are not symmetric and having the patient sign off on those differences before surgery. It is better to be sure that a patient is aware of her asymmetries prior to surgery rather than to point them out after surgery when a patient expresses dissatisfaction [2, 14].

Specific Asymmetry Evaluation Using 3D Imaging

IMF Asymmetry

Maxwell showed 95% IMF asymmetry in patients presenting for breast surgery when evaluated in the Vectra system [18]. Many patients are unaware of mild asymmetries, which may be magnified with a larger breast. 3D imaging allows the patient to see the degree of IMF asymmetry in position and also depth of the fold (i.e., well-developed fold on one side versus the other). Asymmetric folds are often associated with chest wall asymmetry, which may not be correctable. It is better to point this out to patients prior to surgery with measurements of N:IMF distance, photographs, and imaging than to have an unhappy patient after surgery because she did not understand her pre-operative asymmetry.

Volume Asymmetry

Mild asymmetry of breast volume is common and would seem to be an easy fix by placing implants of different volumes. Implants with different volumes have different dimensions, so

volume asymmetry could become a shape asymmetry; placing a larger implant in a tighter pocket can cause changes in the shape of the breast as a tradeoff for volume symmetry, and the patient has to be able to visualize those tradeoffs to see if it is worthwhile for her. How do you determine the volume differences? 3D imaging can be used for volume estimates and to determine breast volumes. Simulations can give the patient an idea of the tradeoffs involved in using implants of different dimensions, although volume measurements have been shown to be the least consistent in 3D measurements. After imaging within the 3D system, the patient should sign off on the size and shape implants chosen using the system. The measurements obtained with imaging can help the surgeon and patient determine the amount of volume asymmetry and visualize the potential results of using different sized and/or shaped implants with the simulation. 3D imaging has been shown to be 90% accurate in post-operative simulations, although recent publications have shown that volume assessment is not always accurate [5, 10, 19], so the use of intraoperative sizers is recommended for patients with significant asymmetry in breast volume. Having an idea of the asymmetry, and therefore the ability to develop a surgical plan, can shorten operative times, requiring fewer implants to be ordered with lower costs of shipping.

Nipple Position Asymmetry

Almost all women have some degree of nipple position asymmetry, which can be caused by asymmetric ptosis, chest wall asymmetry, and asymmetry of the footprint of the breast on the chest wall. Patients are often unaware of mild nipple position asymmetry prior to surgery, and again, it is best to point this out to the patient prior to surgery. For ptosis, 3D imaging can be used to simulate mastopexy so the patient can appreciate the tradeoff of scars for nipple position asymmetry [4, 14].

Chest Wall Asymmetry

Pre-operative evaluation of chest wall asymmetry allows the patient to see what she may be completely unaware of and lower the risk of post-operative dissatisfaction with the results of her surgery. Chest wall asymmetry can be difficult for the patient to appreciate. The asymmetry can be illustrated using different positions in the 3D imaging that cannot be appreciated using only her photographs. Using different heights and projections of implants can help to camouflage some chest wall asymmetry but can be more difficult to correct than other forms of asymmetry. Visualizing with 3D imaging can help with surgical planning and manage the patient's expectations.

Mastopexy

Patients with ptosis that cannot be corrected by filling the envelope with an implant alone may not be willing to accept scar from a mastopexy as a tradeoff. Those patients may say that they prefer to have implants and accept the loose skin, only to change their mind after surgery, when their lower pole is not adequately filled by an implant. For those patients, 3D imaging can be invaluable as part of the pre-operative educational process. Mastopexy simulation can be done on one or both sides for asymmetry and as a periareolar, vertical, or Wise pattern mastopexy in some systems. Simulations are not as accurate in patients with any degree of ptosis, and the breast volume cannot be decreased, so the use is limited. 3D imaging can give the patient an idea of the possible size/shape of the breast with and without mastopexy and could also be valuable for a patient to determine not to have surgery if her desires cannot be met or she is willing to accept the tradeoffs, such as scars or a volume that is larger or smaller than she may desire [15].

Potential Benefits from Using 3D Imaging

Reoperation Rate Reduction/Patient Satisfaction [16]

There are many reasons for reoperation after breast augmentation surgery. Some factors are related to surgical decisions, and others are related to patient factors such as age, weight gain or loss, pregnancy, and patient wish for a different sized or shaped implant. Oversized implants can lead to soft tissue stretch, atrophy of the breast tissue, and malposition [2]. Including the patient in the decision-making process and using her anatomy as the template to determine the implant most appropriate for her may reduce the incidence of reoperation. Although there are no studies that confirm a higher patient satisfaction rate or lower reoperation rate, there are studies that show that the majority of patients who underwent simulation felt that the simulations accurately reflected their result [3, 10, 11].

Conversion Rates

Heden et al. showed an increase in conversion rates in patients who had 3D imaging as part of their consultation

[5]. For any cosmetic procedure, issues that may keep a patient from scheduling surgery include safety, cost, and concern about the resulting appearance. Giving the patient an idea of the possible results by using her anatomy can help a patient feel more comfortable about moving forward with the process and scheduling her surgery.

Studies have shown that patients use the availability of 3D imaging to influence their choice of surgeon for breast augmentation [5, 11]. Although surgeons who use 3D imaging anecdotally feel they have higher conversion rates and lower dissatisfaction post-operatively, there have been no definitive studies thus far that have shown if reoperation rates decline or if patient satisfaction is higher in patients who have undergone pre-operative imaging. What may be as important to increasing conversion rates for cosmetic consultations is to discourage patients who have unrealistic expectations from undergoing a cosmetic procedure for which their goals may not be met. The patient who needs a mastopexy, but does not want scars, may think that a larger breast will meet her needs, but when faced with the result of an augmentation without mastopexy with 3D imaging, she may rethink whether she is willing to accept mastopexy scars, or if she is better off not having a procedure at all.

Alternatives to 3D Imaging for Patient Consultation with Asymmetry

Fewer than 15% of plastic surgeons in the United States use 3D imaging as part of their consultation process, so there are other options available for patient education [3]. Reviewing the patient's 2D photos with her, pointing out any asymmetries, and having her sign off on the asymmetries help the patient to understand the size and shape of her pre-operative breasts, but it does not give the patient an idea of her potential results. Another common technique used in consultation is to show patients before and after photos of other patients with similar anatomy to show the limitations of what can be done. Stand in front of a mirror with the patients to point out her anatomic variations. Use a checklist and have the patient sign off on the noted asymmetries. Drawings and annotations on the patient's own photographs can also be used as part of the educational process. Bra sizers are often used in conjunction with 3D imaging to give the patient another perception of her result, such as how she will look in clothes [6, 17].

Tips for Using 3D Imaging

Limitations

Patients with a loose skin envelope or any degree of ptosis will not give as accurate a result in the simulation. Often the nipple position and cleavage may seem more lateral than they will be in person. Having a before/after book with patients' simulations and their actual results can be useful, especially for patients who have any ptosis or who have a wide pre-operative cleavage [15, 20].

Using the 3D Images in Clinical Practice

Patient Consultation

3D imaging is not a substitute for a physical examination; it is a tool that allows communication with the patient about her anatomy and how that anatomy can or cannot be surgically altered to meet her surgical goals. Using the imaging, reviewing the patient's photos, and having an honest discussion make the patient a part of the surgical decision-making process and help her to understand the potential outcome and limitations of her surgical result. This can manage expectations and lead to better satisfaction with the results and potentially lower the risk of reoperation. Imaging with the patient's own anatomy potentially shortens consultation time, since the patient can see her own anatomy; this eliminates time spent explaining the differences in results from photos of other patients who did not have the exact anatomy of the patient, which can lead to long explanations of the differences between her and another patient with similar, but not duplicate, anatomy. Also, the use of bra sizes can be time-consuming and not always accurate, because what can fit in a bra cannot always fit in the body [21].

Using 3D Imaging in Surgical Planning

Although 3D imaging systems are made to be easy to use and are straightforward in most cases, there are tricks for getting the most out of the individual images. Although the algorithms in the systems are mathematical, there is a degree of "art" in getting the most useful images. Most systems use landmarks for the imaging simulation; these usually include the sternal notch, nipple position, IMF position, medial and lateral border, or the breast. Some systems "auto landmark" the patient's breasts. These marks are generally adequate for patients with relatively normal breasts, without significant asymmetry. However, for a patient with a constricted breast, it is best to lower the landmark in the IMF; otherwise, the implant will image in an abnormally high position using the patient's high, tight fold, when surgically that fold will be lowered, by necessity, in correcting that patient's deformity. Implants can also be repositioned on the screen to adjust to the patient's breast footprint. For surgeons just beginning to use a system, practicing on the built-in simulations in the system can be useful to allow the surgeon to feel comfortable when doing consultations early in the implementation process.

The systems contain example cases, and before utilizing systems with patients, surgeons and patient consultants should perform practice simulations to be comfortable with the system, including placing asymmetry implants, repositioning implants within the simulations, and adjustment of the landmarks.

Case Examples

Case 1 (Fig. 10.3a, b)

This 22-year-old woman has congenital asymmetry. She has volume, nipple position asymmetry, N:IMF asymmetry, and base width asymmetry. The 3D imaging shows a volume asymmetry of almost 200 cc, which was more volume asymmetry than expected by her physical exam. In the simulation, a 335-cc implant was chosen for the smaller right breast and 160 cc for the larger left breast. In surgery, sizers were used, and it was determined that the sizes chosen during the simulation gave the best asymmetry. Using pre-operative images, the appropriate implants were ordered and available in the operating room. The post-operative photos are 5 years post-op.

Case 2 (Fig. 10.4a, b)

This patient has asymmetry in the footprint of her breast on the chest wall. The left breast sits lower on the chest wall, and she has a longer N:IMF distance on the left than the right, which the patient was unaware of prior to seeing the 3D imaging, Reviewing this with the patient on a screen allows her to see her own anatomy and understand the limitations on achieving absolute symmetry. She also has some volume asymmetry. The patient participates in the process of implant selection, which can improve patient satisfaction post-operatively. Different volume and projection implants were used to improve symmetry. Photos are 2 years post-op.

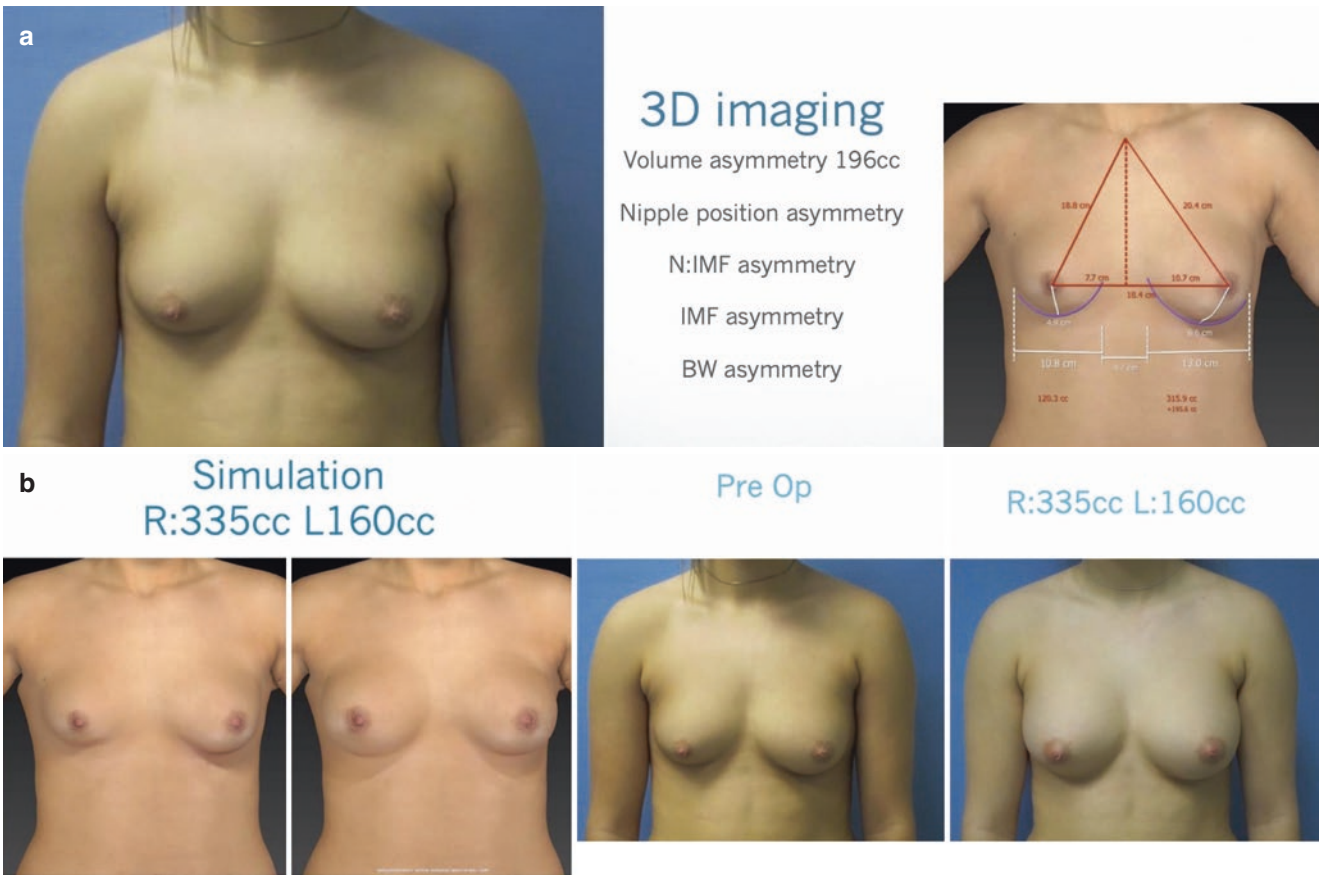

Fig. 10.3 (**a**) Pre-operative and 3D assessment with measurements. (**b**) 3D simulation of asymmetric implants and 5-year post-operative images of a 22-year-old woman who has congenital asymmetry

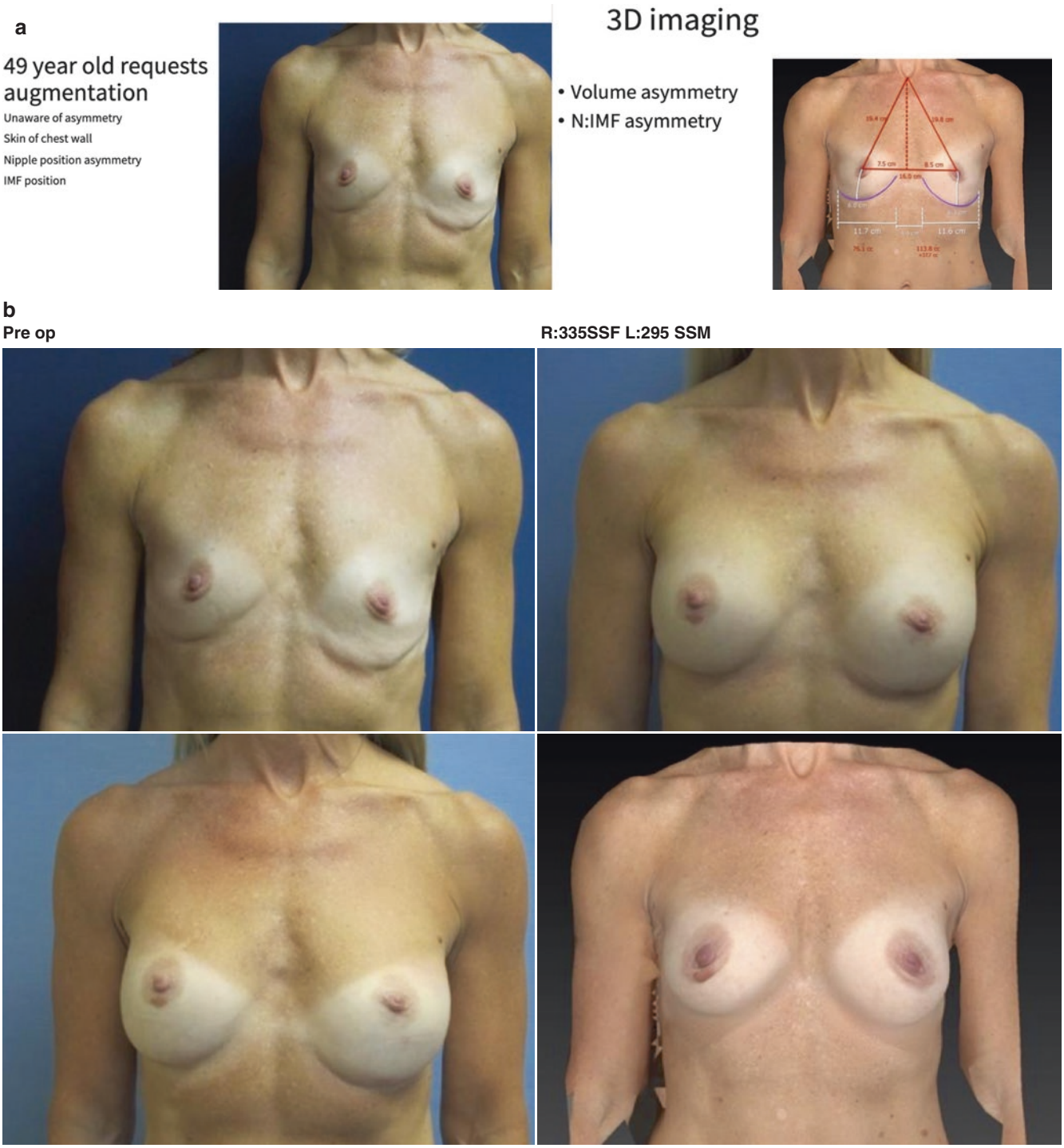

Fig. 10.4 (**a**) Pre-operative and (**b**) post-operative images of a patient who has asymmetry in the footprint of her breast on the chest wall and 3D assessment with measurements. (**b**) Pre- and post-op photos and simulation

Case 3 (Fig. 10.5a, b)

This patient was unaware of her chest wall asymmetry, which caused a 2-cm difference in the position of her IMF. Simulation was performed; the patient could see the pre-operative asymmetry and understands that she will not have absolute symmetry. The patient is educated prior to surgery on the expected result, which is key to patient satisfaction.

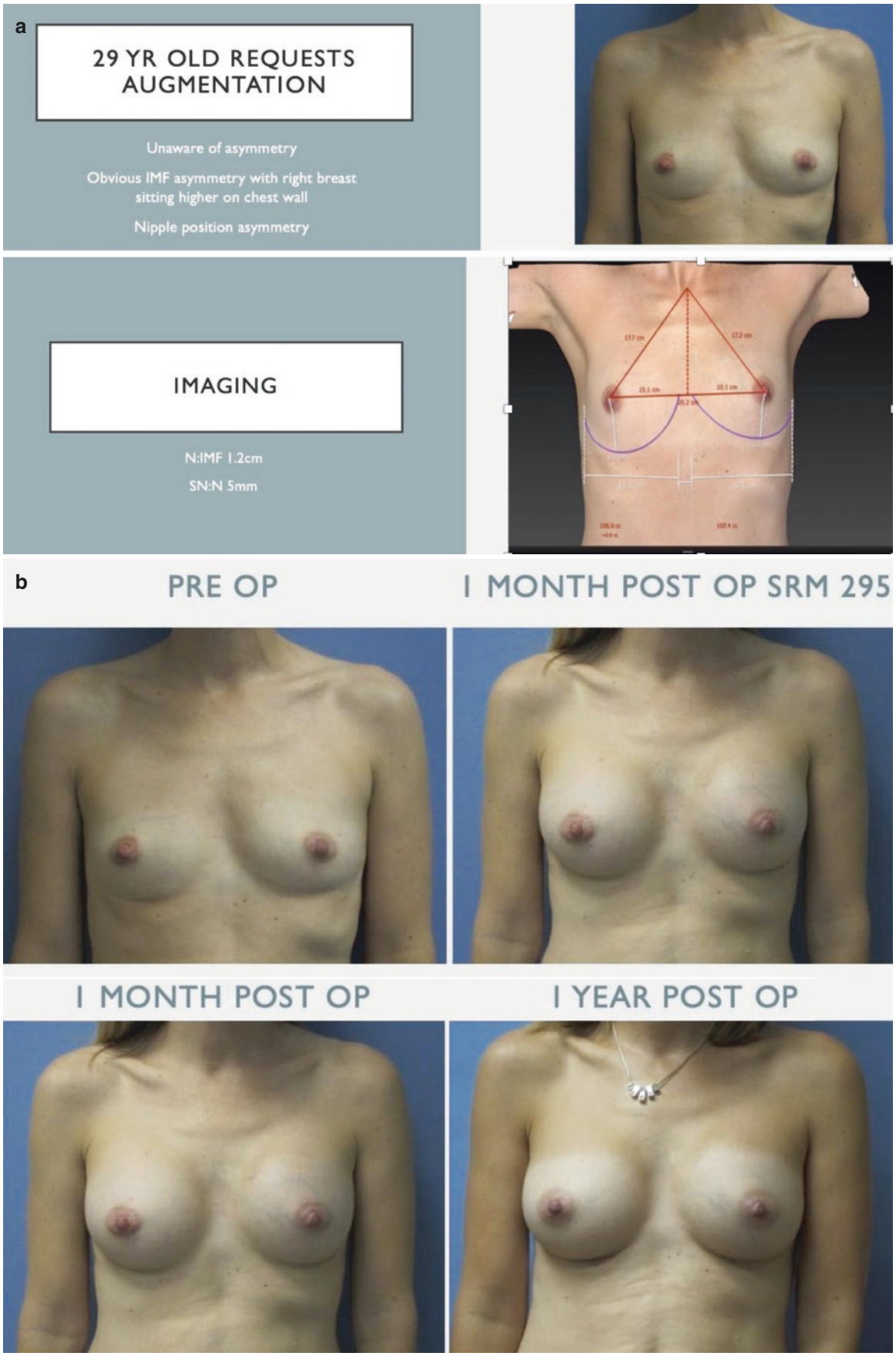

Fig. 10.5 (**a**, **b**) Patient with chest wall asymmetry, pre-operative photo, and 3D assessment. Notice the asymmetry of the costal margin (**b**) pre-op, 1 month, and 1 year post-op

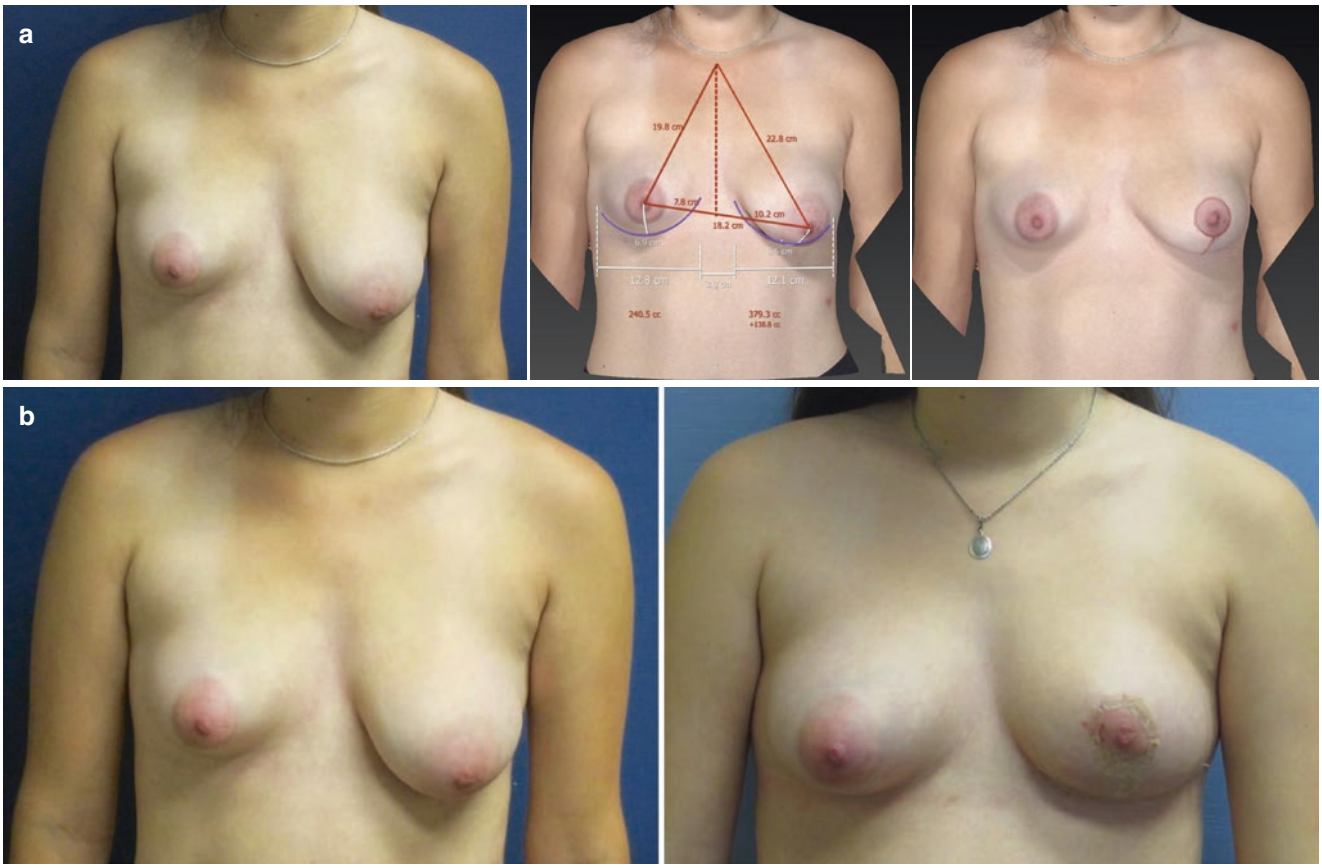

Fig. 10.6 (**a**, **b**) Pre-operative; simulation, with a mastopexy; and post-operative images of a 17-year-old patient who has significant breast asymmetry with differences in volume, nipple position, and tissue envelope

Case 4 (Fig. 10.6a, b)

This 17-year-old patient has significant breast asymmetry with differences in volume, nipple position, and tissue envelope. Simulation showed volume, nipple position, N:IMF, and chest wall asymmetry. The volume asymmetry was 130 cc, and there was a 3-cm nipple position asymmetry. Simulation was performed with a unilateral mastopexy. The measured volume asymmetry can be useful in surgical planning. The patient elected to have mastopexy only without an implant. The post-operative photo is 1 year post-op.

Case 5 (Fig. 10.7a–c)

This 32-year-old woman is evaluated for cosmetic augmentation. She has volume asymmetry that she is unaware of. The assessment showed a 30-cc volume difference. Simulation can be performed with implants of the same or different volume in a patient with mild volume asymmetry, and the patient can visualize the different options and participate in implant selection. The patient elected to have implants with a 30-cc volume difference. The post-operative photos are 3 years post-op.

Conclusion

3D imaging is a useful tool in evaluation of a patient with asymmetry for surgical planning and patient education. It does not replace a good physical examination and communication with the patient using other tools such as 2D photos, reviewing photos of patients with similar anatomy, or using breast implant sizers in a bra. For those patients who learn and understand using visual means, it can be an invaluable tool for surgeons in surgical planning and patient education and in managing patients' expectations. It can be done in a cost-effective and time-efficient manner to enhance the patient consultation process.

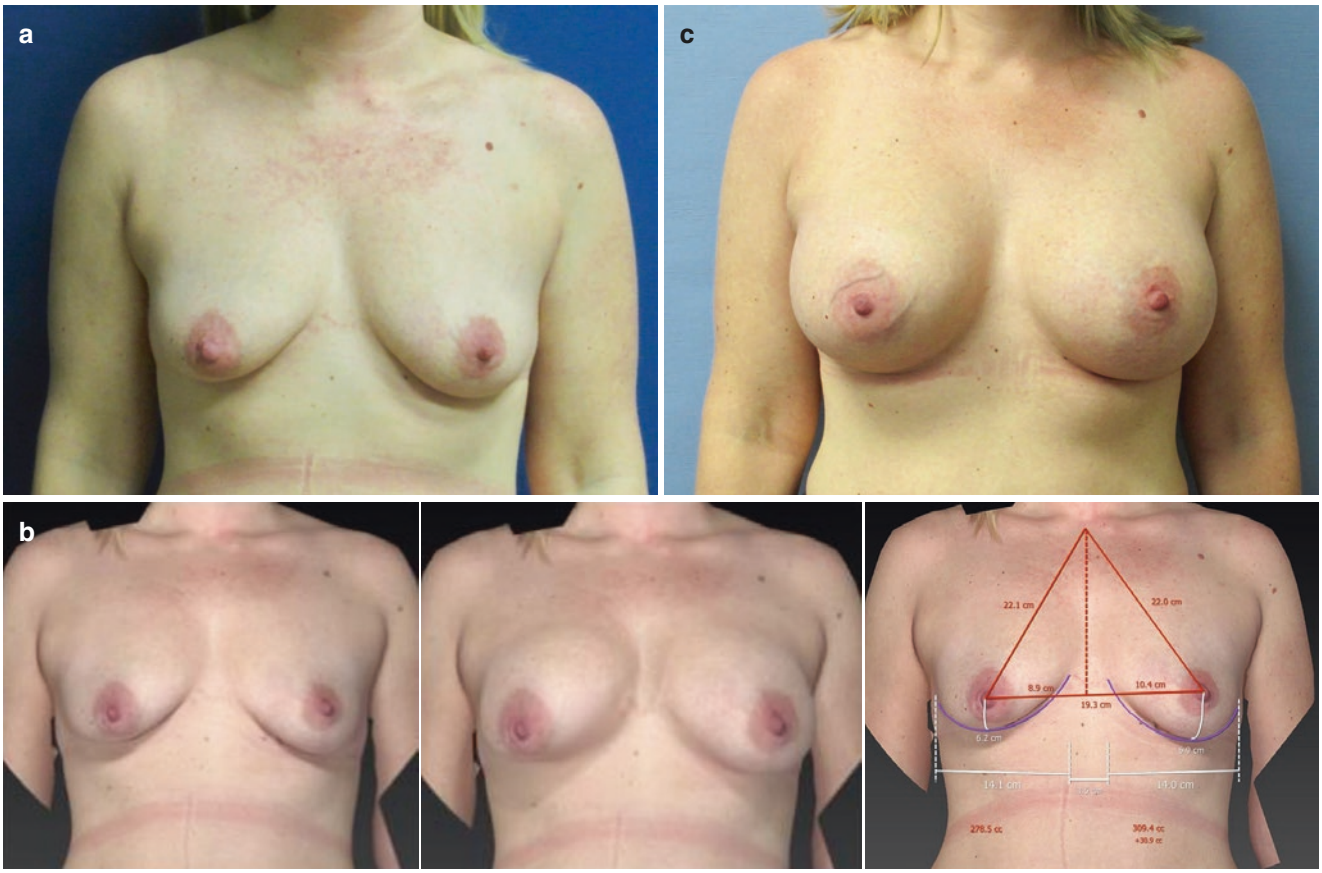

Fig. 10.7 (**a**–**c**) Pre-operative, simulation, and post-operative images of a 32-year-old woman with volume asymmetry evaluated for cosmetic augmentation

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11 Solving Problems Before They Occur: Making Transaxillary Breast Augmentation Work for You

Lauren M. Mioton, Neil A. Fine, and Clark F. Schierle

Introduction

Endoscopic approaches to conventional surgical problems have significantly enhanced treatment options since their introduction in the latter half of the twentieth century [1]. The endoscope allows for less traumatic tissue dissection in conjunction with smaller surgical incisions, which translates into reduced post-operative pain, expedited recovery, and improved cosmesis for patients [2]. Unlike intra-abdominal or thoracic applications, plastic surgery frequently involves extensive soft tissue and neurovascular dissection within enclosed potential spaces. Limited surgical apertures and confined optical cavities have therefore inhibited the development and widespread usage of minimally invasive plastic surgical techniques. Widespread availability of endoscopic equipment and refinements in technique have improved the relevance and utilization of endoscopic approaches in a wide variety of plastic surgical applications in recent years. As endoscopic approaches to the breast and other areas of plastic surgery have gained acceptance, it is important to have a fundamental understanding of the basic concepts of surgical endoscopy. These include the principle of the optical cavity, support systems, illumination equipment, imaging technology, incision planning, and some basic technical considerations [3–7]. Awareness of these concepts when performing transaxillary breast augmentation will allow for more predictable outcomes and reduce the risk for complications.

The Optical Cavity

The development and maintenance of an optical cavity is the primary technical challenge of endoscopic surgery. Optical cavities may be formed from preexisting, potential, or dissected spaces and can vary greatly with bony and soft tissue anatomy. Optical cavities are characterized by space, support, medium, and pressure. Space refers to the anatomic space which they occupy and may be existing, potential, or dissected. Support may be provided by existing bony or soft tissue anatomy, by mechanical retraction, or through the infiltration of an optical medium. The optical medium refers to the gaseous or liquid contents of the cavity which allow for transmission of visible light. The pressure within the cavity can be modulated in closed endoscopic systems depending on the anatomic constraints of the space in which the surgeon is working. In approaches to cosmetic breast surgery, the optical cavity is a mechanically maintained, dissected space with room air providing the optical transmission medium.

Support Systems

As the optical cavity in endoscopic augmentation mammaplasty is continuous with the ambient air of the operating room, support cannot be provided by an optical fluid medium under pressure. Additionally, there is no inherent anatomic support for maintenance of the optical cavity, since the planes are ones which are dissected rather than preexisting. Therefore, mechanical retraction is the only option for creation and maintenance of the optical cavity. Internal mechanical retractors apply a centrifugally directed force on the roof of the optical cavity. This provides the lift necessary to deepen the space for optimal visualization and manipulation of the surgical field. The force applied must be sufficient to counteract the elastic and gravitational forces acting to collapse the optical cavity. Mechanical

L. M. Mioton
Department of Plastic and Reconstructive Surgery, Northwestern Memorial Hospital, Chicago, IL, USA

N. A. Fine · C. F. Schierle (✉)
Northwestern Specialists in Plastic Surgery, Chicago, IL, USA
e-mail: drschierle@northwesternplastics.com

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https://doi.org/10.1007/978-3-030-57121-4_11

retraction for cosmetic breast surgery can be free or coaxial with the camera. A single, well-designed coaxial retractor allows a single surgeon to control both the visual field and optical cavity with relative ease. If necessary, an assistant may use a free retractor to briefly enhance the optical cavity during a particularly challenging or distant portion of the operation.

Illumination and Imaging

Several technological advances in illumination and imaging technology have proven instrumental in the development of surgical endoscopy. Glass fiberoptic cables allow for the use of distant light sources bright enough to provide full-spectrum illumination of the surgical field.

History

Use of the Surgical Endoscope in Cosmetic Breast Surgery

The transaxillary approach to breast augmentation was first described by Troques in 1972 and Hoehler in 1973 [8, 9]. This approach is advantageous by providing a hidden incision and facilitates direct access to the subpectoral plane [5, 10–12]. The technique, as originally described, involved altering the inframammary crease and dissecting the origin of the pectoralis muscle blindly, leading to a significantly higher incidence of implant malposition. Specifically, the limited exposure of the blind technique did not allow complete division of the prepectoral fascia, resulting in the tendency of high-riding implants or the double-bubble appearance of the inframammary crease.

Endoscopic plastic surgery gained interest in the 1990s, as endoscopic cholecystectomy procedures proved to be successful in general surgery. The application of the endoscope was then expanded to breast surgery. The Emory group reported their experience with endoscopic breast augmentation through an axillary incision in 1993 using a specialized retractor and an air-filled optical cavity [13]. Ho reported a technique that used glycine irrigation to create a liquid-filled optical cavity, although he now also uses a specialized retractor and an air-filled optical cavity [14]. The endoscope allowed for direct visualization of the dissection and provided surgeons increased control of the subpectoral pocket, obviating many of the aforementioned downfalls associated with the blind axillary approach. Literature has supported these findings as Howard et al. demonstrated the benefits of the endoscopic transaxillary approach with a decrease incidence in implant malposition from 8.6% to 2% when the endoscope was used [15].

Endoscopic Augmentation Mammaplasty

Basic Science/Disease Process

The female breast spans the anterior chest wall from approximately the second rib superiorly to the fourth or fifth rib inferiorly. Its upper one half overlies the pectoralis major muscle, the serratus anterior of its lower one half, and some of the axillary fascia laterally. It is attached intimately to the skin by suspensory ligaments (Cooper ligaments). This is because developmentally it forms from the ectoderm of the anterolateral body wall, and epithelial proliferation from that site creates the gland. For this reason, opening the natural plane between the muscle and the breast is easy; an implant can be inserted into this space. The blood supply of the breast is derived from branches of the axillary artery, the intercostal arteries, and the internal mammary artery. Few if any vessels penetrate into the gland from the underlying muscle. Its nerve supply comes from the anterior and lateral cutaneous branches of the fourth, fifth, and sixth thoracic nerves. One of the larger lateral cutaneous branches often can be visualized and preserved during augmentation surgery.

Diagnosis/Patient Presentation

Micromastia or mammary hypoplasia is the chief complaint in patients seeking an enlargement procedure. Significant breast asymmetry, ptosis, or tubular breast deformity is difficult to address through the transaxillary approach and, as such, must be attempted only after gaining high proficiency in the endoscopic, transaxillary technique.

Avoiding Complications

Complication rates for transaxillary breast augmentation are comparable with other techniques for breast augmentation. The risk for adverse outcomes can be reduced through proper patient selection, meticulous surgical technique, and appropriate post-operative care, as detailed below [16–18].

Patient Selection

Indications for endoscopic breast augmentation include the patient's desire for a remote incision and the absence of a well-developed inframammary crease to hide a crease incision below the horizontal visual axis. Patients with symmetrical breasts and no ptosis are ideal candidates. This minimizes the need for excessive manipulation or dissection during creation of the implant pocket from a remote site. A constricted lower pole with a short distance from the infra-

mammary crease to the areola is significantly more difficult and can require radial scoring of the breast parenchyma. The potential exists for inferior implant displacement from over-dissection (lowering) of the inframammary crease and superior implant displacement from under-dissection of the inframammary crease. In experienced hands, the transaxillary approach can be used for this type of anatomy. Tubular breast deformities also present a significant challenge to endoscopic transaxillary augmentation mammaplasty. It is not possible to correct the herniated areola, and it can be challenging to score the constricted lower-pole parenchyma; thus, the periareolar access incision is more ideal for tubular breast deformity. Some degree of ptosis can also represent a relative or absolute contraindication to the technique. Mild pseudoptosis and Regnault grade one ptosis may be addressed during a transaxillary, endoscopically assisted dissection, but this anatomy requires manipulation of the inframammary crease to control the vertical descent of the breast. Due to the need for control and accuracy in this dissection and concerns over the risk of under- or over-dissection, aggressive management of ptosis via this approach is not recommended for the inexperienced surgeon. Both silicone and saline devices may be introduced through the transaxillary approach, although due to the physical constraints of the transaxillary tunnel, introduction of silicone gel implants larger than 250 cc may be challenging and require special care to avoid damage to the device or surrounding anatomic structures during insertion. The use of a funnel or other delivery device facilitates the placement of larger silicone implants from this approach. While it is possible to insert shaped implants through a transaxillary approach with similar outcomes in comparison to an inframammary access incision [19], it is a more challenging technique.

Surgical Technique to Avoid and Manage Complications

Pre-operative considerations include accurate marking of the native and proposed placement of the inframammary crease as well as anticipated areas of release of the pectoralis major muscle. The pectoralis muscle should be completely divided along its inferior origin from the rectus fascia. This complete myotomy is transitioned gradually to a partial thickness release as the dissection approaches the medial origins along the sternal border until the level of the nipple is reached. Mark the first axillary crease with an incision behind the anterior axillary line. The incision should measure 3 cm if a saline implant is planned and 4.5–5 cm if silicone is to be used. If concealed in a natural skin crease within the hair-bearing portion of the axilla, the incision will typically be extremely favorable when fully mature and be difficult to distinguish from the native skin crease (Fig. 11.1). Also, in the uncommon occurrence of an unfavorable scar, it is our opinion that an unfavorable scar in the axilla is preferred over an unfavorable scar on the breast as the breast is more likely to receive close visual inspection.

While it is possible to perform endoscopic transaxillary breast augmentation under conscious sedation, a general anesthetic will be preferred until high proficiency is reached with both the surgical technique and the placement of local anesthesia. Regardless of anesthetic technique, a wetting solution with lidocaine and epinephrine is injected into the site of the axillary tunnel extending to underneath the pectoralis major muscle as well as along the lateral, inferior, and medial boundaries of dissection (Fig. 11.2). A spinal needle may be utilized to minimize sites of needle puncture. The needle is directed tangentially to the ribcage to prevent penetration of the chest wall. The epinephrine is important to decrease bleeding as blood vessels are transected during the dissection. Visualization of these vessels is very good, but rapid bleeding from an injured vessel will quickly impair visualization and subsequent cauterization. With vasoconstriction from epinephrine, cut vessels should be easy

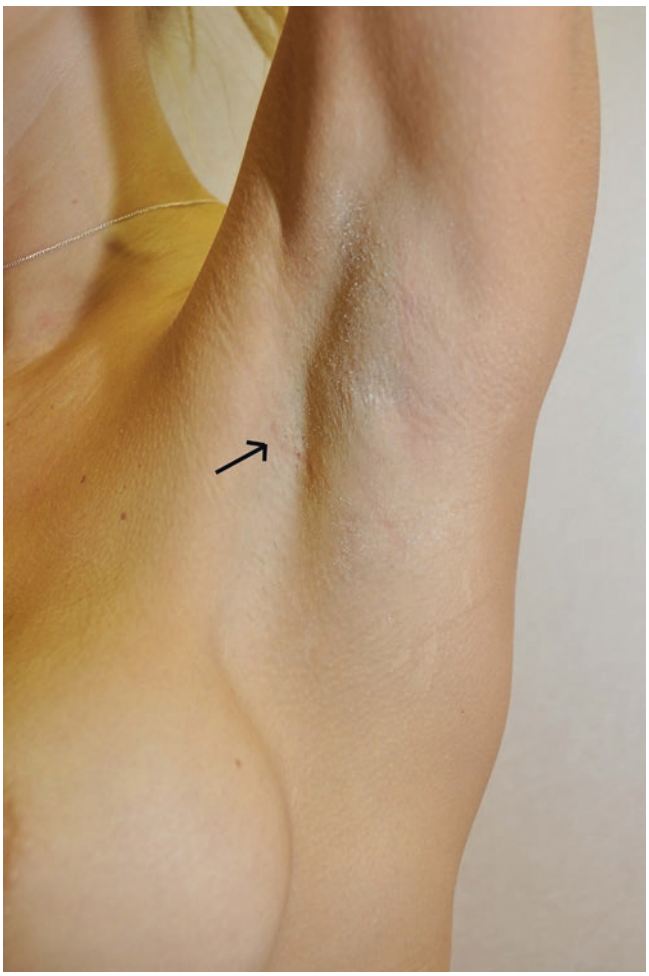

Fig. 11.1 Post-operative view of a transaxillary access incision scar

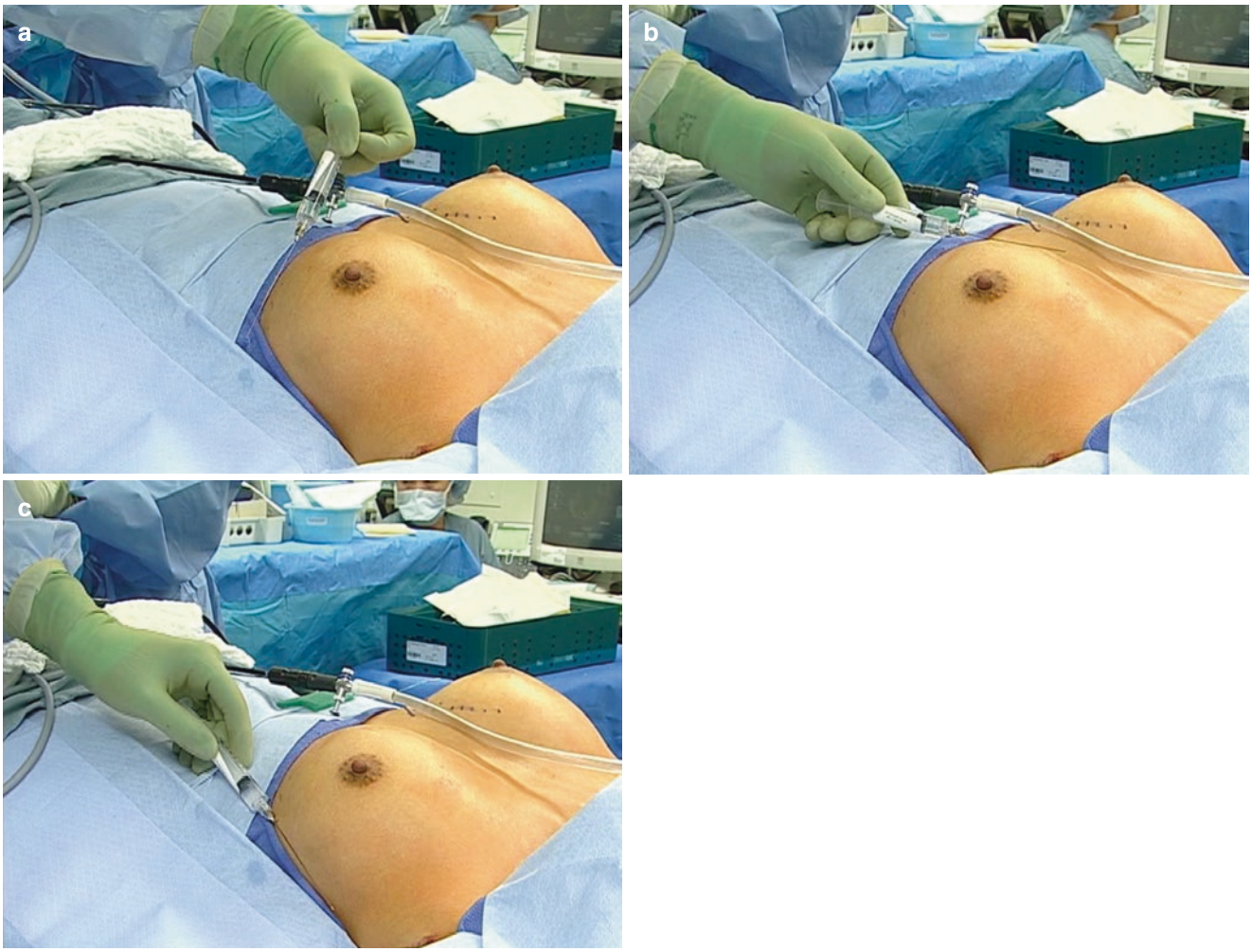

Fig. 11.2 Photographic representation of the location of anesthetic administration along the (**a**) inferior, (**b**) medial, and (**c**) lateral aspect of the breast. It is key to inject down low along the chest wall and not subcutaneously. And to inject at an acute angle to the chest to avoid potential for the needle to slip between the ribs without hitting them

to cauterize. Care should be taken to divide the vessels at least 1 cm above the chest wall to avoid retraction of the vessel which will then make the cauterization more difficult. The lidocaine will assist with post-operative pain control. Injection of this solution will add 10–15 min to the beginning of the procedure, but will be invaluable if you injure a vessel and do not achieve immediate cauterization of a blood vessel.

After making the initial incision in an axillary skin crease, place two skin hooks and use spreading or cautery to go through the subcutaneous tissues to a depth of 5–10 mm. At this depth, angle toward the lateral border of the pectoral fascia. Create a skin flap and follow the undersurface of this skin flap to the fascia to avoid injury to the intercostal brachial nerve (Fig. 11.3). Take extreme care during this initial tunnel dissection not to create more than one subcutaneous dissection plane. This will greatly facilitate insertion and reinsertion of retractors, instruments, and the implants later. Insert the index finger, identify the underside of the pectoralis major muscle, and perforate the fascia to allow access to the submuscular plane (Fig. 11.4). This space can be entered bluntly with a fingertip in most cases. If the fascia is strong and the division between pectoralis major and minor is not clear, a narrow retractor can be used to directly visualize the lateral pectoral fascia, and this fascia can be opened with scissors to reveal the muscle and ease the blunt entry into the space between pectoralis major and minor.

If inserting a silicone implant, it will be important to have an adequate tunnel that doesn't constrict within the tunnel. Spreading with two retractors inserted to the border of the pectoralis fascia can safely open this space. The tunnel should be the same width as the skin incision all the way to the pectoralis to avoid difficulty with silicone implant insertion as well as to facilitate direct visualization of the plane between pectoralis major and minor. When the space between the muscles is entered, a finger can easily open this potential space and sweep to the level of the nipple areolar complex.

After bluntly entering the space between the pectoralis muscles, the endoscopic retractor is introduced, followed by

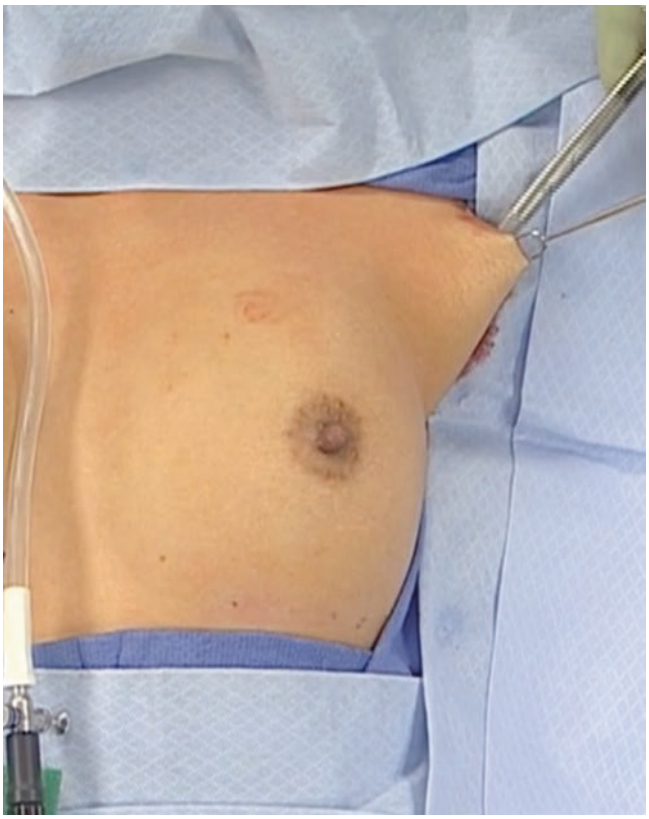

Fig. 11.3 Intra-operative photograph showing development of the subcutaneous tunnel from the axillary access incision to the chest wall

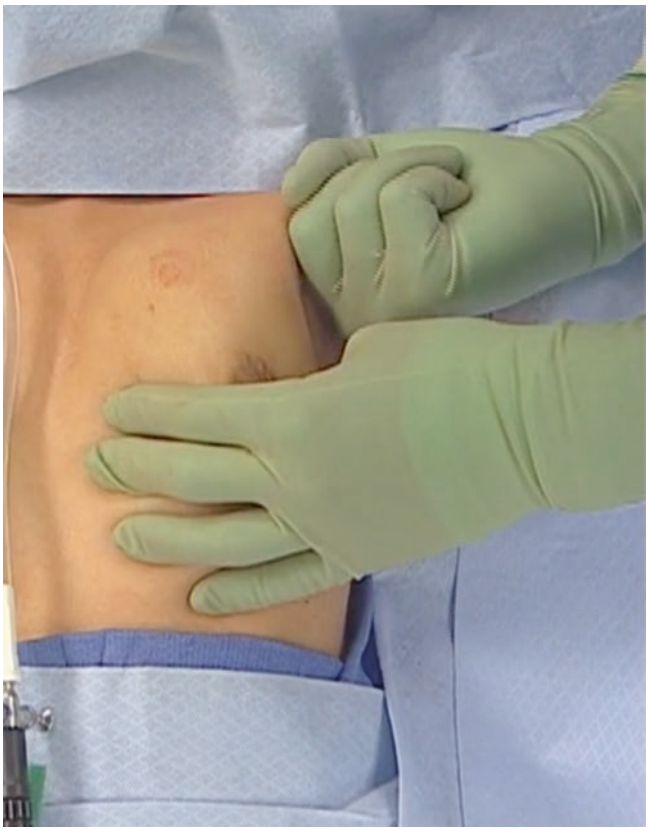

Fig. 11.4 Intra-operative photograph showing blunt elevation of the pectoralis muscle and development of a submuscular pocket

the surgical endoscope. This order, first retractor and then endoscope in the retractor, will minimize blood contacting the endoscope and obscuring visualization. It is preferable to have both a 0-degree and a 30-degree endoscope. These two angles will allow for different angles of view and degrees of upward retraction. The 0-degree endoscope is less complicated as the view doesn't change if it is rotated; however, the retraction needs to be straight up, and it may be more difficult to achieve tension on the muscle to facilitate cautery transection. A 30-degree endoscope allows for an upward, "toeing in of the retractor" which places more distal tension on the tissues, but the endoscope must be maintained in an upright position or the angle of view will move 30 degrees to the side rather than the desired 30 degrees down as the retractor is angled 30 degrees up that results in a strait view of the tissues being retracted. At this point it is also good to remember that with either endoscope in, it is important to keep the camera oriented straight up and down so as to maintain proper orientation of up and down on the video screen. If there is confusion on up and down orientation, it is possible to divide the intercostal muscle and enter the pleural space while thinking that it is the pectoralis major muscle that is being divided. If you always divide muscle in a low to high manner, dividing muscle only in an upward direction, this problem can be avoided. Dividing in an upward direction requires that you are aware of what is up and down on the video screen. This comes naturally with time and experience with an endoscope, but when starting out, it is best to check up and down by checking the camera orientation and palpating the breast while visualizing the depression of the optical cavity, thus assuring the orientation and confirming division of the overlying pectoralis muscle rather than the underlying intercostal muscle. The operating surgeon should constantly reassess the internal position of the retractor with relation to the breast external anatomy by looking at the scope's transillumination through the skin and by watching the tissues move through the scope during manipulation of the external breast tissues.

After establishing the optical cavity with upward retraction, a monopolar electrocautery dissector is utilized for both dissection and hemostasis (Fig. 11.5). The retractor or dissector may be fitted with a port to allow attachment to low wall suction to assist in evacuation of smoke from the optical cavity during dissection. It is best to use the dissector for the suction as it can be turned on and off more easily. It will need to be on to remove smoke, but turned off to avoid collapsing the optical cavity. An assistant may hold the retractor during dissection; however, the need for this assistance is diminished with experience. Dissection may then proceed in a sequential fashion lateral to medial to completely release the pectoralis major origin inferiorly and partially release the

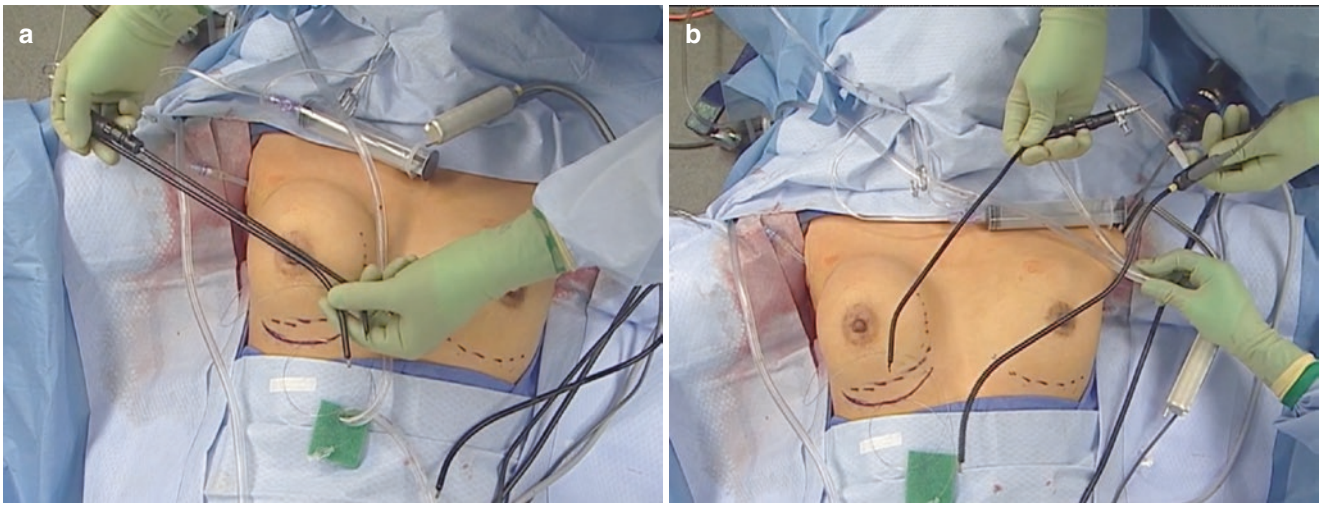

Fig. 11.5 (**a**) Electrocautery dissectors that provide the ideal ergonomics for dissection of the right breast pocket. (**b**) Ideal electrocautery dissectors for the left breast. Note the difference in curvatures for these dissectors. While these dissectors have been designed as left and right, you may find it easiest to use the simpler, single curved right dissector on both sides

pectoralis major muscle origin inferomedially. Again, be sure to check orientation and divide the overlying pectoralis major muscle, rather than the underlying intercostal muscle. The presence of a rib that is more protruding can put the intercostal muscle more "straight ahead," so be certain to sweep open the areolar potential space and confirm up and down orientation before dividing muscle. Complete release of the pectoralis and pectoralis fascia is confirmed by the clear visualization of subcutaneous, yellow fat during the dissection (Fig. 11.6). Partial thinning of the pectoralis muscle origin inferomedially is critical to improve cleavage, but care must be taken to avoid over-dissection which can result in visible rippling or symmastia. The medial area is also the location of the intercostal perforating blood vessels. If necessary to divide, cauterize them 5–10 mm above the chest wall, and again the infiltration of an epinephrine solution should avoid significant bleeding and the difficulty with visualization that comes with active bleeding in the optical cavity. Transcutaneous supplementation of wetting solution under direct endoscopic vision helps minimize blood loss and improve visualization during dissection as well as improve pain control. This last step is particularly important if you are not using general anesthesia.

After dividing the inferior margin of the pectoralis major muscle, it is possible to create a dual plane pocket by cauterizing and releasing the inferior edge of the pectoralis major muscle. The muscle will naturally retract upward during the cauterization of its lower border and "ride upward." This can be done as far as necessary to achieve the result you desire, often releasing to the level of the nipple areolar complex. It is also possible to vertically divide the muscle or divide the lower glandular tissue with the cautery as the scope is angled upward. These maneuvers are as easy to do with the endoscope as they are with direct vision as one gains experience with the endoscopic approach.

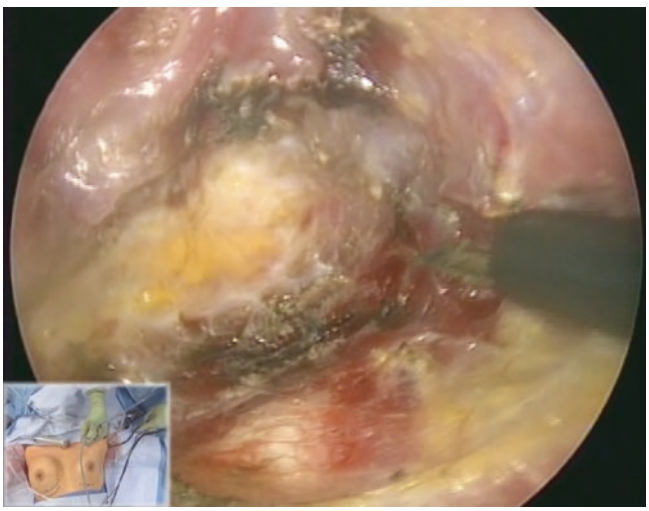

Fig. 11.6 Intra-operative screen capture of pectoralis muscle release using the endoscope and electrocautery dissector

After meticulous hemostasis is confirmed, the endoscope is removed and the pocket irrigated with antibiotic irrigation. In our practice, a local anesthetic catheter is then introduced for post-operative pain control, taking care to tunnel the path of the catheter subcutaneously with the introducer needle. This prevents leakage of anesthetic fluid and translocation of skin flora into the implant cavity. The implant is then introduced through the axillary tunnel and position confirmed. Again, you will find it helpful to have a single tunnel that has no constrictions and the use of a funnel insertion device if you are using a silicone implant. Saline implants are easily inserted empty and then inflated with the use of a closed system. At this point additional blunt dissection may be performed with either the surgeon's finger or a large urethral dilator. The patient is flexed to 90 degrees upright to assess final implant positioning and symmetry. The patient is then

laid back down and the axillary incision closed. Closure of the tunnel is typically not performed in the case of saline implants. If a silicone implant is used and the tunnel seems overly dissected, sutures may be used to close this space to avoid implant migration. The skin of the axillary incision is closed in standard fashion with absorbable deep dermal sutures followed by a permanent running intradermal monofilament suture. Skin glue is then used for the final dressing as it is difficult to keep tape or steri-strips in place in the axilla.

Post-operative Care

Outcomes are shown in Fig. 11.7. A light ACE wrap is applied for support and comfort. Walking and daily living activities, including hair combing and teeth brushing, are encouraged immediately. Low-impact aerobic activity may be resumed after 2 weeks. More strenuous physical activity, including lifting, is restricted for 4–6 weeks.

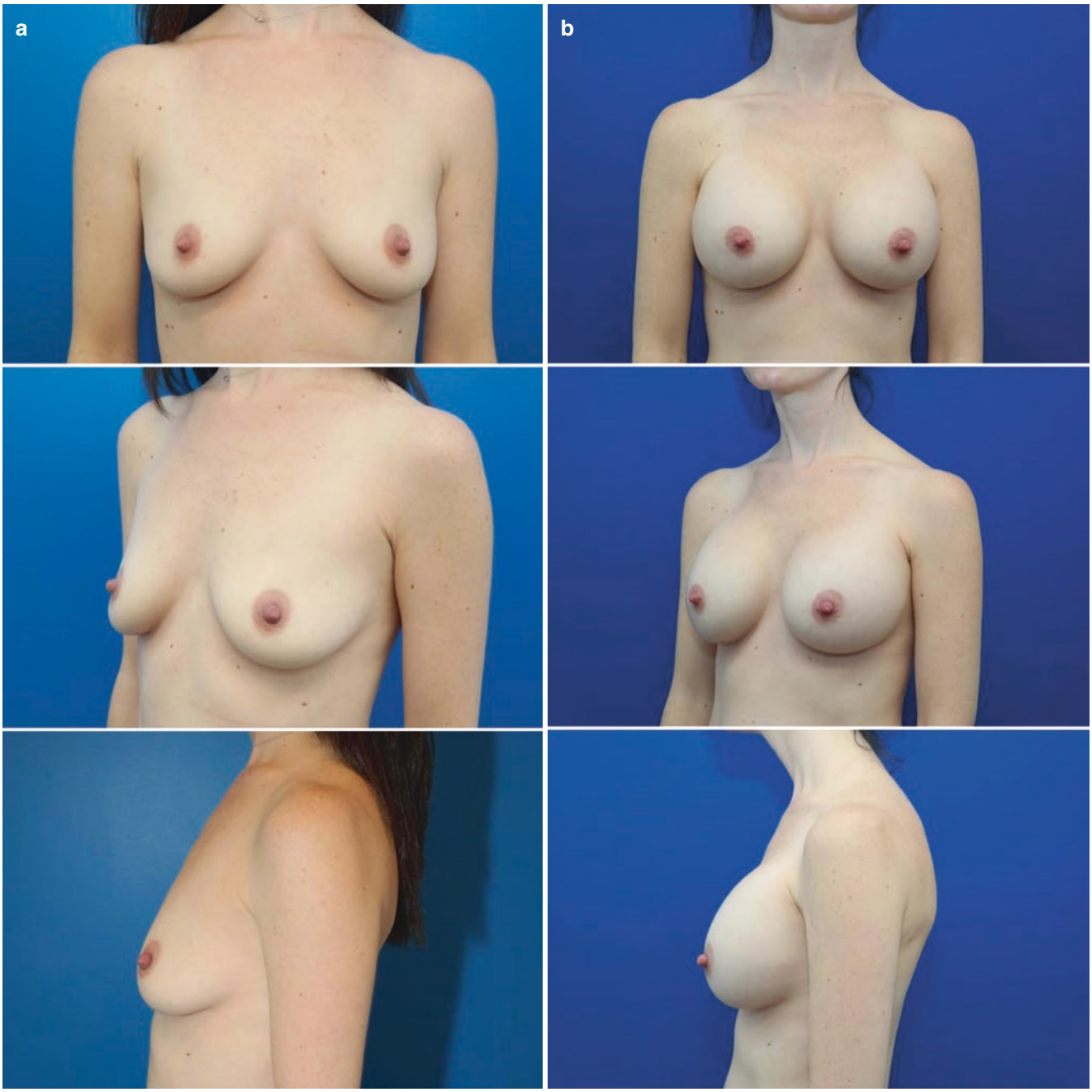

Fig. 11.7 (**a**) Pre-operative and (**b**) 2-month post-operative photographs following transaxillary breast augmentation with saline implants using an endoscope

Most implant malpositions following transaxillary breast augmentation are related to superior displacement; however, inferior displacement with bottoming out is more difficult to treat. This occasionally cannot be corrected remotely and requires an inframammary incision. Axillary banding across the axillary incision may be related to hypertrophic scarring, lymphatic channels, or thrombophlebitis (Mondor disease). Although meticulous hemostasis is one of the benefits of the endoscopic approach, axillary hematoma has been described, although rarely. Published reports suggest rates of deflation and capsular contracture to be similar to those of any other technique. The treatment algorithms for such complications remain similar to those patients who have undergone breast augmentation through a different access incision.

Complications are best managed by avoidance. You can avoid a pneumothorax by injecting at an acute angle to the chest, making it hard for a needle to pass between ribs without hitting them, as well as being certain to only divide muscle in an upward angle, away from the chest, insuring that you divide only the pectoralis and not the intercostal. By injecting local anesthesia with epinephrine, you can avoid excessive bleeding and loss of visualization and all of the subsequent problems that can come from dissection in a poorly visualized field and post-operative pain and contracture from blood in the implant pocket. In the unfortunate situation of capsular contracture, standard treatment regimens apply, but if extensive capsulectomy or capsule work is required, then an alternate IMF approach may be considered. Similarly, simple capsule adjustment can be done through the axillary incision, but more extensive revision may require an alternate approach.

Conclusion

Transaxillary breast augmentation has potential advantages for standard IMF or periareolar breast augmentation. However, there is a learning curve, and specific attention should be paid to patient selection. Ptotic, tuberous breasts may require more advanced technique and may not be suitable for a less experienced surgeon. Similarly, caution should be exercised for larger implants and situation requiring correction of significant IMF asymmetry.

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Management of Double Capsule

12

Yoav Barnea and Daniel J. Kedar

Introduction

Capsular contracture and implant displacement are the leading causes for reoperations in breast implant surgery, according to core studies submitted to the FDA by breast implant manufacturers [1, 2]. Texturing of the implant surface was initially developed to stabilize the implant in the breast pocket with the aim of minimizing movements against the chest wall and surrounding tissue. Accumulated long-term data revealed textured implants to have a lower incidence of capsular contracture compared to smooth ones [3–6].

There are a number of techniques for texturing the initially smooth implant during the manufacturing process. The Allergan Biocell texturization (Allergan Inc., Dublin, Ireland), created by the "salt lost technique," is achieved by applying the implant shell with pressure onto a layer of fine salt. This creates cuboid-shaped wells in dimensions of 200- to 500-μm width and 100- to 200-μm depth, termed "macrotextured." The Mentor Siltex surface (Mentor Worldwide LLC, Irvin, CA, USA) is formed by negative contact imprinting from textured foam. This creates nodules that have an approximate height of 40–100 μm and a diameter of 50–150 μm. This surface is described as being "microtextured," and it is considered to be a less aggressive form of texturization compared to the Allergan Biocell surface [6–10].

The surface of the implant has a key effect on the interaction between the implant and the breast in the formation of a fibrous capsule. Tissue adherence is achieved by periprosthetic capsular tissue ingrowth into the pores of the textured shell surface, thereby essentially anchoring the implant to the surrounding breast tissue. The more aggressive the texturing of the surface, the more prominent the tissue ingrowth [6–10].

A double capsule occurs when two distinct layers form around the breast implant: one is an inner layer that firmly attaches to the implant device, and the other is an outer layer that adheres to the surrounding breast tissue (Fig. 12.1) [6–12]. The capsule layers are separated by the intercapsular space (ICS). This double capsule phenomenon may be partial or complete. A double capsule formation appears around the entire implant in the complete type (see Fig. 12.1). Consequently, the textured implant essentially behaves as a smooth surface, and may cause the implant to be in malposition and malrotation due to the new, smoother interface between the inner and outer capsule layers (Video 12.1) [6–12]. Furthermore, the inner capsule wraps the implant tightly and can cause a feeling of hardening of the implant, mimicking capsular contracture.

The smooth surfaces of both layers which are in contact with the ICS are responsible for micromovements within the double capsules. The clinical relevance of this dynamic relationship, aside from the risk for malposition, is the increased risk of synovial metaplasia, chronic infection, late seroma, and possible breast-implant-associated anaplastic large cell lymphoma (BIA-ALCL) [7].

Pathophysiology

The pathophysiology of the formation of a double capsule is still undetermined, but it is likely to be multifactorial. One potential route involves the macrotexturing of the implant surface, such as that seen in Biocell devices, which has been associated with higher rates of double capsule formation compared to other textured or smooth implants. The Biocell

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Y. Barnea (✉)
Plastic and Reconstructive Breast Surgery Unit, Plastic Surgery Department, Tel-Aviv Sourasky Medical Center, Sackler Faculty of Medicine, Tel-Aviv, Israel

D. J. Kedar
Plastic and Reconstructive Surgery Department, Tel-Aviv Sourasky Medical Center, Sackler Faculty of Medicine, Tel Aviv, Israel

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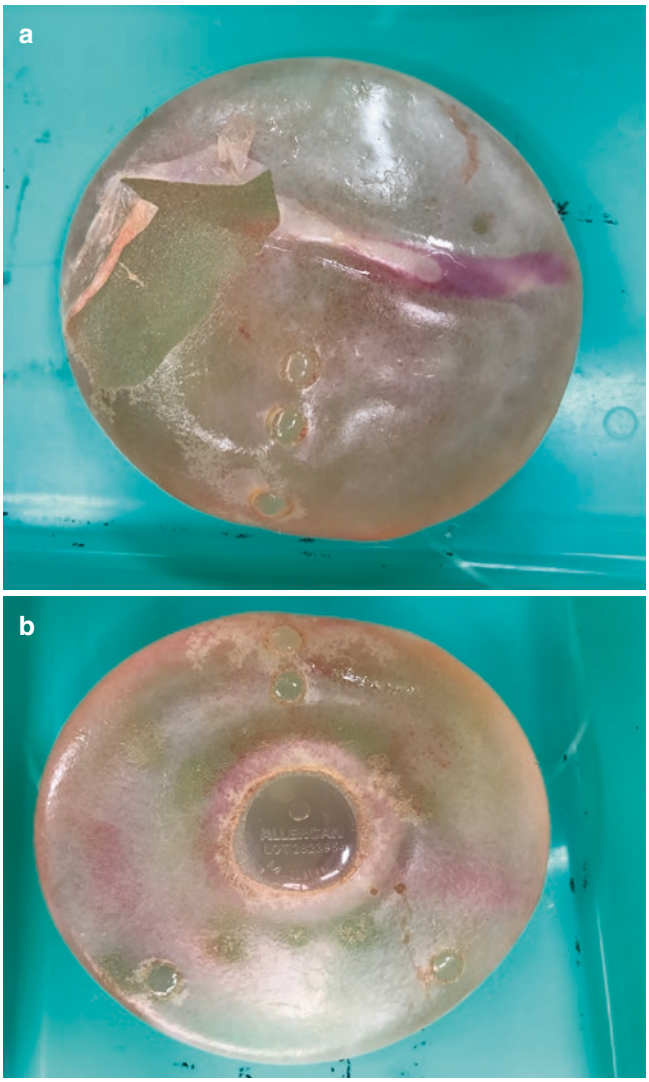

Fig. 12.1 Complete double capsule over an Allergan Biocell macrotextured shaped implant. The inner capsule totally covers the implant except over the smooth tabs (**a**) in the 6 o'clock position and over the smooth posterior filling port and posterior tabs (**b**)

macrotextured topography promotes cellular ingrowth, with histological analysis of capsules demonstrating an almost mirror imprint of the implant's surface [10]. The end result is adherence of the implant to the surrounding breast tissue and reduction of its movement. Disruption of the tissue ingrowth together with the integration of the implant may lead to the formation of two parallel capsules.

Several hypotheses regarding the formation of a double capsule have been described in the recent literature. The first one is based upon movement of the implant inside an oversized pocket. The macro- and micromovements of the implant prevent adhesion of the textured implant surface to the surrounding tissues, leading to the formation of two layers of the capsule [11]. The second hypothesis involves a mechanical etiology in which shear stress applied to the implant capsule complex forces the implant away from the capsule. This separation leads to the subsequent creation of a new inner layer of capsule in direct contact with the implant. Histological studies of double capsules on Biocell expanders have revealed the presence of intracapsular fractures on all tested specimens from the lateral aspect of the expanders. These fractures in the collagen matrix occurred in conjunction with signs of an inflammatory response, as evidenced by the proximity of macrophages on the ICS [12].

The third hypothesis proposes that fluid in the form of a seroma forms around the implant, and that it subsequently leads to the development of a new inner capsule. Such an association between double capsules and late seromas has been proposed by some authors [13–15]. It has also been postulated that continued friction between the textured implant shell and the original capsule leads to a seroma-like fluid accumulation. Secondary seeding of cells derived from that fluid onto the implant surface initiates the development of the new inner layer of adherent capsule [16, 17]. The origin of the serous exudate could be infectious, allergic, or hemorrhagic [7]. Spear et al. found that 96% of their cases of late seroma formation occurred in Biocell textured implants, which further supports this association [13]. Seroma formation can be attributed to bacteria that adhere to the surface of the implant in the form of biofilm [18]. It has been shown that capsular contracture can be potentiated by subclinical infection, as first hypothesized by Burkhardt et al. [19] and later validated by the results of additional studies [20–22]. Furthermore, it was speculated that chronic bacterial activation around the implant might play a role in the development of ALCL. Hu et al. postulated that chronic biofilm infection is associated with T-cell hyperplasia in pigs and humans, and that it is possibly correlated with ALCL [18]. This is especially relevant to textured implants rather than smooth ones because the larger surface area creates an increased risk for the formation of biofilms. The presence of biofilms around breast implants in association with ALCL was reported in 26 patients in a recent multicenter collaborative investigation [23]. Current data have led to speculation that there could be a continuum between double capsules, late seromas, and BIA-ALCL.

The fourth hypothesis is also mechanically based and suggests that shear forces cause detachment of the implant capsule complex from the surrounding breast tissue, thereby leaving the original capsule intertwined with the textured implant. A new outer capsule layer then develops, thus producing the double capsule phenomenon [24–26]. This hypothesis is supported by the electron microscopic findings in double capsule samples from Biocell expanders that show a very low bacterial load and biofilm presence within the ICS in contrast to bacteria having been seen repeatedly in the prosthesis interface (i.e., between the prosthesis and the inner capsule). This finding indicates that the prosthesis

interface and the ICS were not sharing the same initial fluid, as would necessarily be the case in the other three hypotheses [27].

Double Capsule Incidence

There are sparse data in the literature on the actual incidence of a double capsule since most articles refer to it as an incidental finding in reoperations for other reasons. Most publications describe double capsules occurring in macrotextured Biocell implants and very rarely in microtextured devices or smooth implants. Two cases of double capsules were reported with the use of the Trilucent (soya bean oil-filled) breast implant [28].

Allergan's 3-year postapproval studies reported very low rates of double capsules with the Biocell implant (2/10,000). Robinson described a 2% double capsule rate in his 100 cases of primary subglandular breast augmentations with Biocell implants [26], and Maxwell et al. observed double capsule incidence of approximately 1% in over 7000 patients with Biocell implants [7]. Contrarily, Hall Findley described 14 cases of double capsules out of 105 (13.3%) in Biocell textured breast implants for primary breast augmentation or augmentation mastopexy. The double capsule cases were discovered during reoperations for other reasons (e.g., size change, implant malposition, capsular contracture, and late seroma) [16]. Van Slyke et al. reported a much higher rate (36.6%) of double capsule in their 123 cases of Biocell implant removals for various reasons during a 13-year study period and noted that double capsule was not observed with any other implant type in their practice [29]. Their cases of double capsule typically were unilateral.

Management

Since most cases of double capsule are asymptomatic and not associated with any complication, they do not require any surgical or nonsurgical intervention. In cases of symptomatic capsular contracture or late seroma, the management is according to the conventional treatment protocols that include a preoperative assessment, surgery involving the implant (removal or exchange), the implant site (neo-pocket), the capsule (capsulectomy, capsulotomy), and appropriate postoperative management [13, 17, 30, 31]. The capsule and fluid are analyzed for pathology and bacteriology. Other procedures can be combined to the surgical management and include fat grafting, addition of meshes (biologic or synthetic), and other surgical and nonsurgical procedures.

Cases of implant malposition caused by a double capsule and nonadhesion of the device to the surrounding tissue require surgical intervention for correction. Although nonadhesion can occur with macrotextured implants in the absence of double capsule formation, greater tissue adhesion reduces the likelihood of seroma. Maxwell et al. published a consensus list of recommendations for promoting tissue adhesion with Biocell macrotextured implants [6]. The surgical recommendations included formation of an inframammary fold skin incision for creating a subpectoral pocket that accommodates the implant precisely, use of an atraumatic operative technique and meticulous hemostasis, and leaving a drain to minimize fluid collection. Postoperative management emphasized immobilization of the implant and surrounding tissue for up to 3 months. These recommendations follow the concept of minimal implant movement and friction to promote tissue adhesion.

In cases of implant exchange to a new and similar macrotextured device, the implant is placed in a new pocket, leaving a drain. A subglandular implant is shifted to a subpectoral plane, and a subpectoral implant is shifted to a neo-subpectoral pocket formed between the underlying muscle and the anterior surface of the old implant capsule [32]. Another option is to exchange the implant by a microtextured or smooth surface device, thus reducing the likelihood of recurrent double capsule. In the latter option, the implant can be inserted in the previously formed pocket after excision of the old capsule. Exchanging the implant to one with a smoother textured surface reduces the amount of tissue adhesion of the device and, thus, may require device support and tissue reinforcement in the form of a mesh or acellular dermal matrix to reduce the risk of implant malposition [6, 7, 33–35].

Conclusion

A double capsule occurs primarily with macrotextured implants. It is largely asymptomatic and a finding, usually incidental, that is not necessarily associated with complications. Intervention is reserved for complications and otherwise symptomatic cases, and usually entails implant exchange and implant pocket shift.

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Inframammary Fold Dynamics: Problems and Solutions

13

Charles Randquist and Robert Cohen

Anatomical Considerations

Anatomy of the Inframammary Fold

The anatomy of the breast has been well defined and consists of an intermixing of fibrofatty tissue and glandular tissue, with ducts leading from the deeper parenchyma to the nipple-areolar complex (NAC). The breast is surrounded by the deep and superficial components of the superficial fascial system and is further stabilized by Cooper's ligaments [1], which vary in strength between patients and can be damaged by breast changes due to weight gain, hormonal changes, aging, and pregnancy.

A beautiful, youthful breast is defined by a centrally located and slightly lateralized NAC, a linear slope of the upper pole to the NAC, and a gently curved lower pole without the presence of ptosis, all in accordance with the Fibonacci curve and the Golden Ratio (Fig. 13.1). The ideal proportion of breast mound above and below the NAC varies depending on cultural norms and patient preference, but generally will equate to a 50/50% or 45/55% ratio. Like the nipple position, the ideal intermammary distance will vary based on personal aesthetic ideals but should generally show approximately 2–3 cm of separation. Laterally, the breast should extend just beyond the lateral chest wall on the AP view to create the hourglass curve of the torso.

The inframammary fold (IMF) is a key anatomical feature of the breast of which proper management is critical to success after breast augmentation surgery. The IMF delineates the transition from the breast to the abdomen, and a well-defined, stable IMF adds to the beauty of the breast mound itself. The anatomical structures that create the IMF consist of the fusion point of the breast fascia and a condensation of the superficial fascial system (SFS) of the chest wall. More specifically, the fold was determined by gross and histological studies to be an intrinsic dermal structure of collagen arrays fused via a dense zone of the superficial fascial system adherence to the underlying pectoralis fascia, which is generally concentrated at the 5th rib [2, 3].

Variations in Inframammary Fold and Lower Breast Pole Anatomy

Although the inframammary fold in most cases is densely adherent and located at the site overlying the 5th rib, a wide variation of IMF strength and locations can be seen between different patients that must be properly assessed and managed during aesthetic breast surgery. In some instances, such as with tuberous breasts / lower constricted poles, the IMF is tighter and more constricted than normal with a higher than typical starting location (Fig. 13.2) [4]. On the other end of the spectrum, some patients will have genetically weaker ligaments resulting in low IMF positions or poorly defined inframammary folds where the skin of the abdomen can be easily pulled up and onto the breast footprint (Fig. 13.3). Events that affect the elasticity and ligamentous support of the breast such as significant weight loss and pregnancy can also be contributing factors to a low position or loss of IMF definition. All these factors are imperative in the analysis and risk assessment regarding various postoperative complications like bottoming-out and malpositioning.

Although there is a limit to how much an abnormally located IMF can be surgically manipulated, the surgeon should always be aware of the ideal IMF location and should strive to recreate this with as much stability as possible. Asymmetry in

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C. Randquist (✉)
Department of Plastic and Reconstructive Surgery, Victoriakliniken, Saltsjobaden, Sweden
e-mail: charles.randquist@victoriakliniken.com

R. Cohen
Scottsdale Center for Plastic Surgery, Paradise Valley, AZ, USA

J. Y. S. Kim (ed.), *Managing Common and Uncommon Complications of Aesthetic Breast Surgery*,
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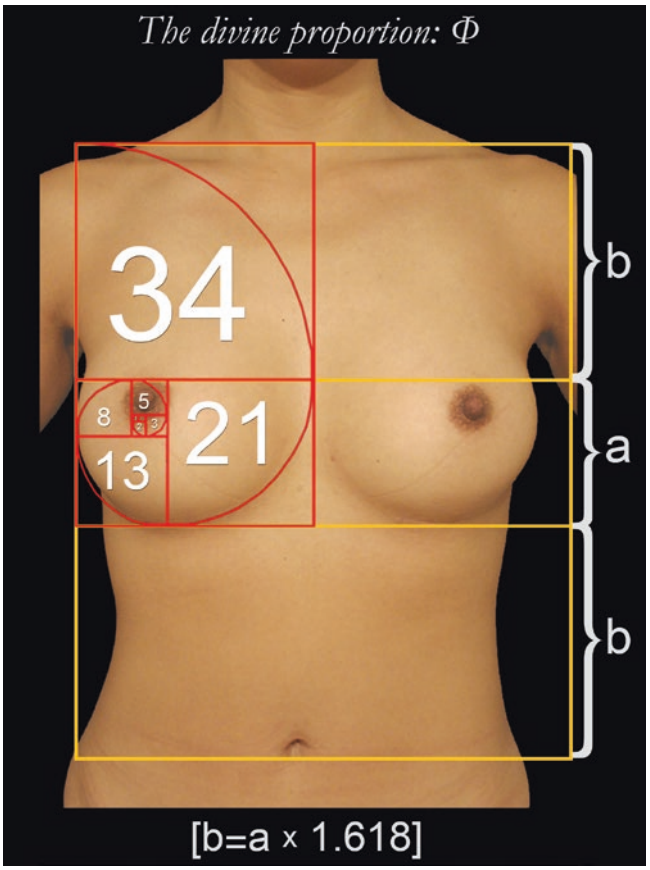

Fig. 13.1 The divine proportion. (Courtesy of Dr. Charles Randquist)

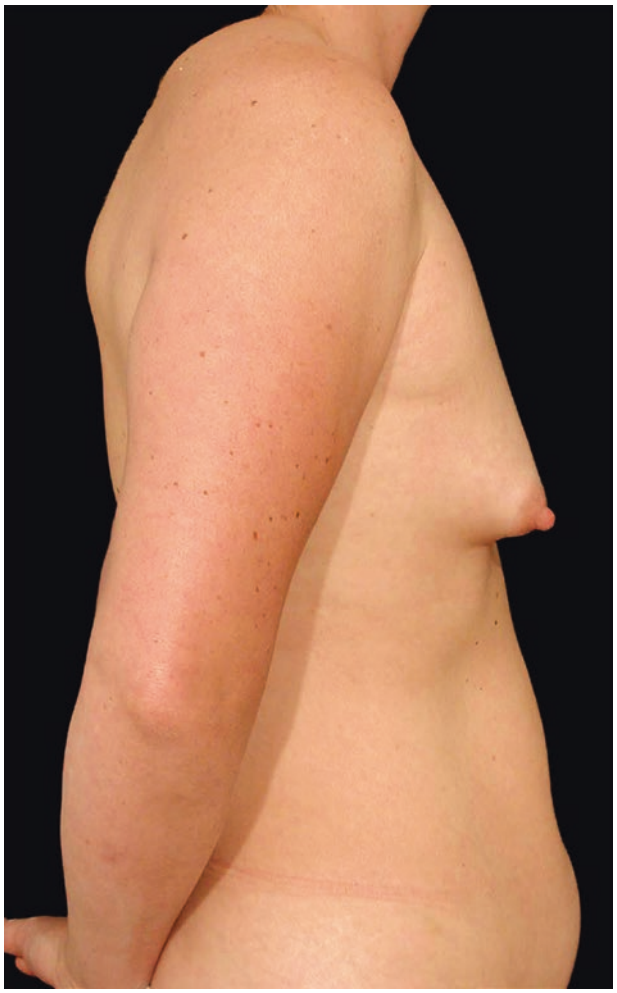

Fig. 13.2 Lower constricted breast pole. (Courtesy of Dr. Charles Randquist)

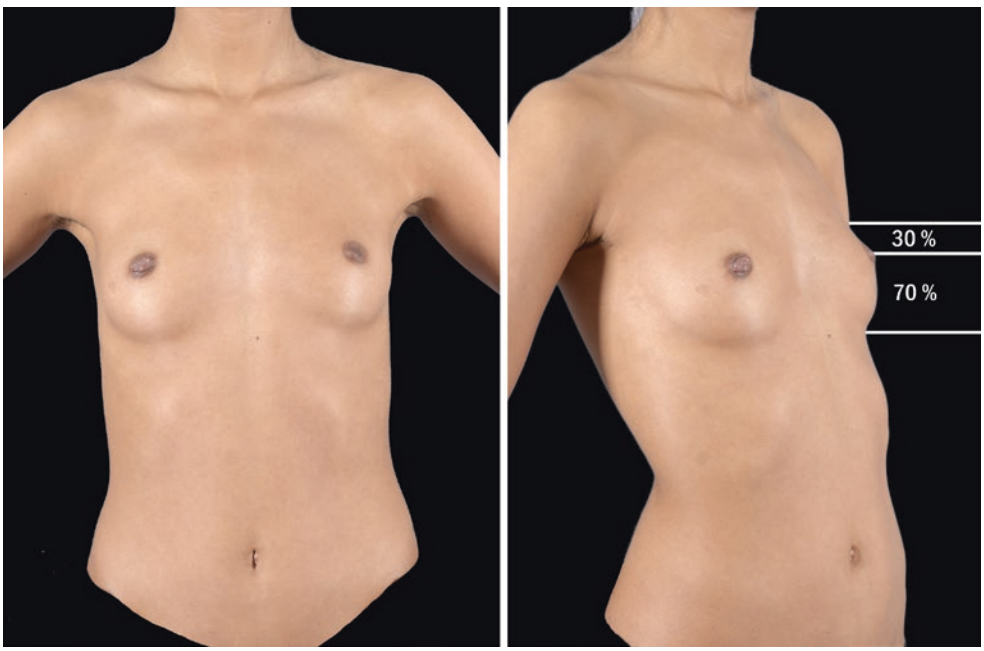

Fig. 13.3 Low-situated and poorly defined IMF, anterior and 45-degree views. (Courtesy of Dr. Charles Randquist)

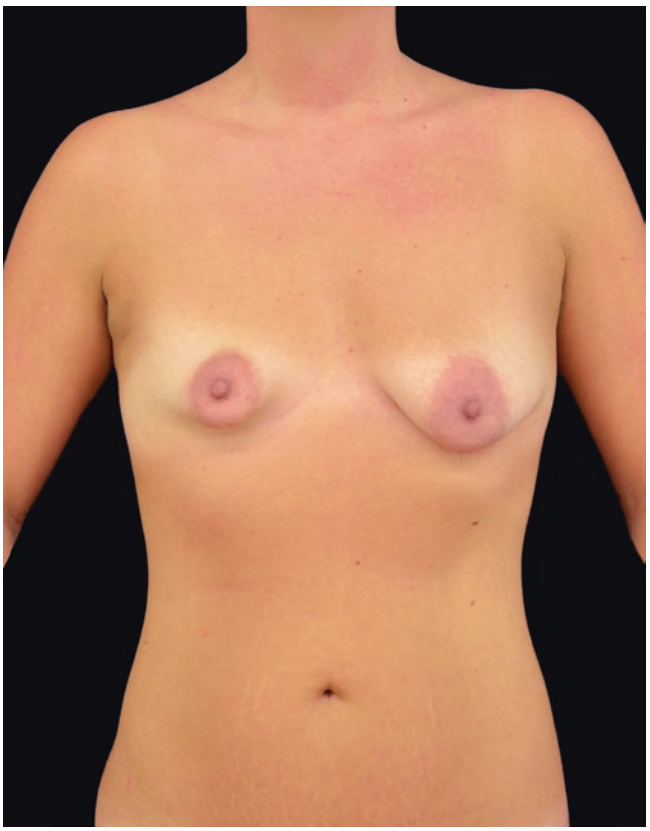

Fig. 13.4 IMF and chest wall asymmetry, lower constricted poles and ptotic breasts. (Courtesy of Dr. Charles Randquist)

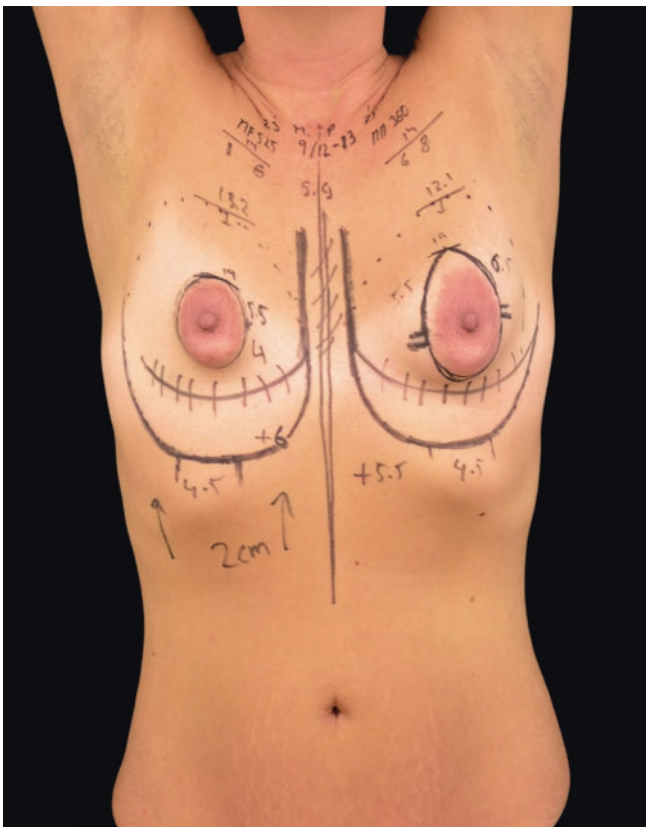

Fig. 13.5 Surgical planning: bilateral circumareolar mastopexy, different shaped and sized anatomical implants, 525 g right, 360 g left, lowering of the IMF, recruitment and repositioning of chest wall tissue. (Courtesy of Dr. Charles Randquist)

fold positions should also be noted, addressed, and equalized to the greatest degree possible (Figs. 13.4, 13.5, and 13.6).

Proper Preoperative Planning

Determining the Ideal Inframammary Fold Position

Determining the optimal implant selection for a given patient is outside the scope of this chapter; however, this process has been delineated in many scientific articles [5, 6] and should be familiar to surgeons performing breast augmentation. Once an implant has been selected based on biodimensional principles, the proper location of the IMF can be determined and set for surgery.

Proper positioning of the inframammary fold during placement of implants is a crucial decision and may require lowering (or possibly even raising) the preexisting IMF. These calculations involve the nipple to inframammary fold (N-IMF) distance, the implant width, and the patient's unique features such as tissue elasticity and parenchymal thickness. To achieve consistency in measurements, the N-IMF distance assessment and the IMF adjustment should always be performed under maximum skin stretch, with the patient standing up. Adjustment of the inframammary fold can provoke anxiety in some surgeons due to a perceived unpredictability of this maneuver; however, a proper nipple-to-fold distance is critical to aesthetic success, and many patients do not have an optimal N-IMF distance unless it is created by the surgeon. With the IMF "Lucky 8" stabilizing techniques that will be described in this chapter, these concerns should be vastly reduced.

Determining the ideal nipple to IMF distance for any given implant has often been left to ambiguous or "artistic" systems where the surgeon would select the best location for an inframammary incision based on what "looked right." In some cases, the patient already has an ideally located IMF; however, in many situations the surgery requires controlled lowering of the inframammary fold for optimal implant placement.

In 2005, after many years of study and observation focused on standardizing techniques and educating surgeons, the author

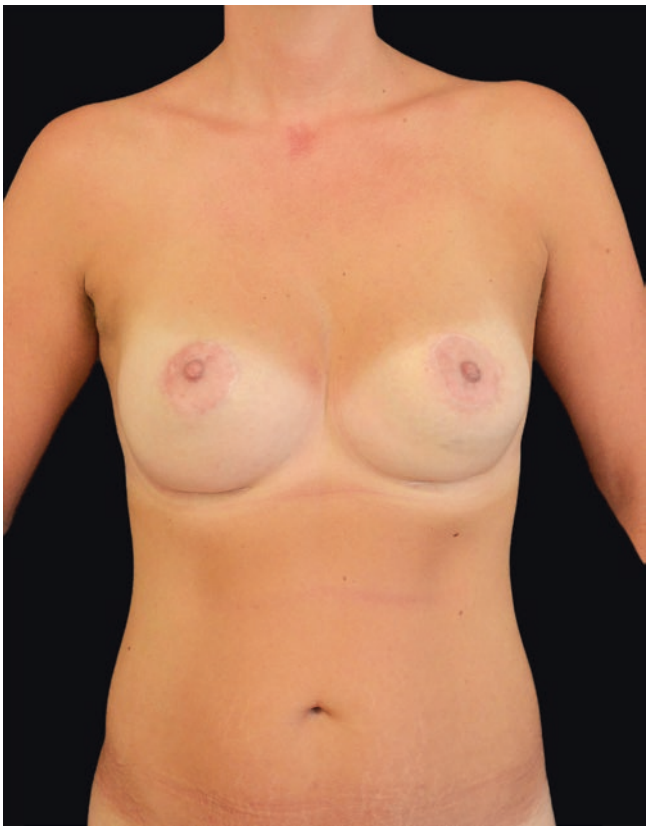

Fig. 13.6 Surgical result after 9 months. (Courtesy of Dr. Charles Randquist)

(CR) developed a simple and easily memorized system – the "Randquist Guidelines" – in order to calculate the position of the IMF based on any given implant's base width, regardless of height, projection, or LVC (length of the ventral curvature).

Optimal IMF placement can be determined by the Randquist formula that stipulates where the ideal IMF fold should be once the breast settled and stabilized itself 6 months postsurgery: (tissue pinch test/2) + (implant width/golden ratio of 1618) = ideal distance from nipple to IMF (N-IMF) under maximum skin stretch. The Randquist Guidelines is a simplified and more user-friendly distillation of this formula (Fig. 13.7). In this algorithm, the base width of the implant determines the proper N-IMF distance and the new position of the inframammary fold. Choosing the base width of the implant as a parameter enables the surgeon to determine the right IMF position regardless of implant height, and, hence, the use of various heights, if necessary, for asymmetry corrections. Further considerations beyond the implant base width are made for characteristics such as skin elasticity, parenchymal thickness, and the degree of upper pole convexity desired by the patient.

As an example, for a macro-/microtextured or polyurethane implant with a 12 cm base diameter, the surgeon would subtract 3.5 cm from the implant width and set the fold at 8.5 cm (± 0,5 cm) below the nipple on *maximum stretch*. In the case of a smooth implant, due to a higher degree of movement in the pocket and no integration or friction to the surrounding tissue with subsequent stretching of the capsule, the surgeon would subtract 4 cm from the implant width and set the fold at 8 cm (± 0,5 cm) below the nipple on *maximum stretch*. Each additional 0.5 cm in implant base width would necessitate 0.5 cm added to how much the IMF is lowered, and, conversely, each 0.5 cm decrease in implant base width would necessitate subtracting 0.5 cm from how much the IMF is lowered.

As mentioned earlier, other factors that affect the optimal fold position include parenchymal thickness and skin elasticity. Regarding parenchymal thickness, for patients with >3 cm of parenchymal pinch in the lower pole (the area most likely to stretch), an additional 0.5 cm of IMF lowering should be performed, while patients with thinner tissues may need a 0.5 cm subtraction in the IMF lowering to account for future tissue stretching. With regards to skin elasticity, patients with tight, inelastic skin envelopes, such as those with tuberous breasts, require the addition of 0.5 cm lowering. On the other hand, patients with loose, weak skin (such as postpartum or weight loss patients) should have 0.5 cm subtracted.

At first glance, this formula and its multiple variations can appear difficult to remember. However, it should be noted that although these additional adjustments provide the highest degree of aesthetic precision, this planning system in its simplest form (i.e., simply subtracting 3.5 cm from the width of textured implants or 4 cm from width of smooth implant to determine the N-IMF distance on maximum stretch) still results in a highly aesthetic IMF placement.

Regarding different implant profiles with the same base width, the measurement system remains the same, thus adding to the system's simplicity. Higher profile implants result in more volume distribution, energy, and expansion in the area of projection [7], which elongates the N-IMF distance proportionally. Upper pole fullness can be adjusted based on patient preferences by selecting different implant heights or projections. That being said, the most direct degree of influence on the upper pole can be obtained with implant selection. For thin patients with a low BMI that desire a more natural appearing upper pole, anatomical implants or softer, more moderate profile implants can be selected. For those that prefer a fuller upper pole, round, higher profile implants with a greater degree of cohesiveness may be selected (Fig. 13.8).

Implant width		Subtract		Ideal positioning of IMF
11.0	Smooth	4.0 cm	=	7.0 cm ± 0.5
	Textured	3.5 cm	=	7.5 cm ± 0.5
11.5	Smooth	4.0 cm	=	7.5 cm ± 0.5
	Textured	3.5 cm	=	8.0 cm ± 0.5
12.0	Smooth	4.0 cm	=	8.0 cm ± 0.5
	Textured	3.5 cm	=	8.5 cm ± 0.5
12.5	Smooth	4.0 cm	=	8.5 cm ± 0.5
	Textured	3.5 cm	=	9.0 cm ± 0.5
13.0	Smooth	4.0 cm	=	9.0 cm ± 0.5
	Textured	3.5 cm	=	9.5 cm ± 0.5

- 0.5 cm = Loose skin envelope
+ 0.5 cm = Tight skin envelope

- 0.5 cm = Subglandular
+ 0.5 cm = > 3 cm PT

- 0.5 cm = > Upper pole fullness
+ 0.5 cm = > Lower pole fullness

Fig. 13.7 The Randquist Guidelines. (Courtesy of Dr. Charles Randquist)

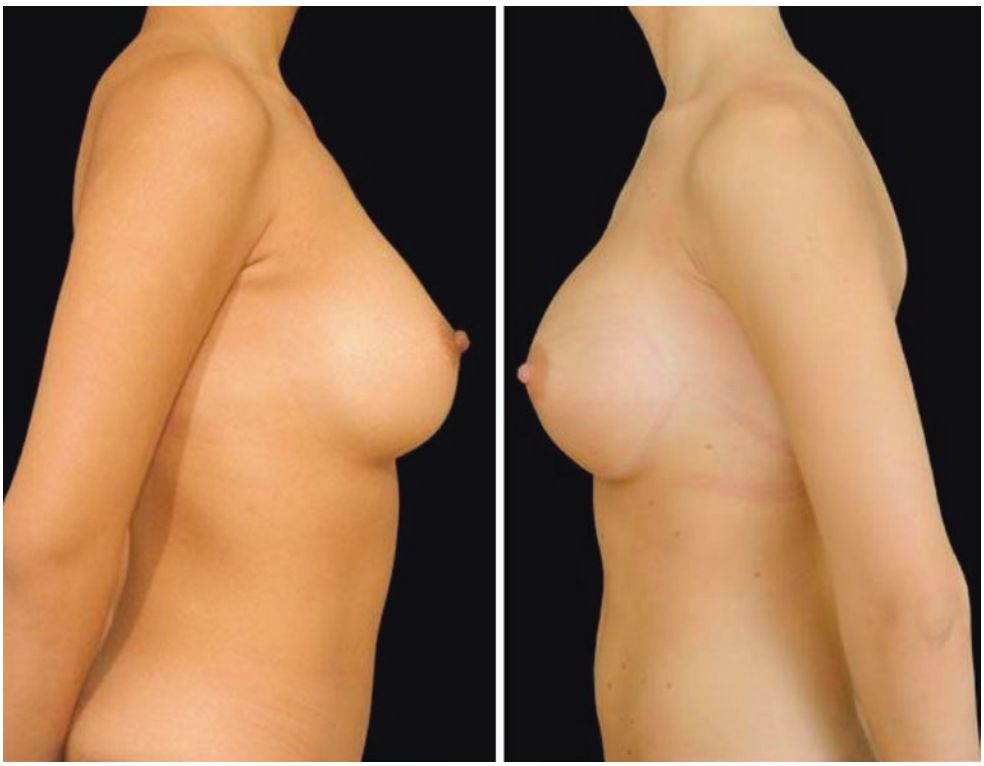

Fig. 13.8 Comparison: Patient with anatomical vs. patient with round implants. (Courtesy of Dr. Charles Randquist)

Prevention of Lower Pole Complications Via Preoperative Planning

By utilizing standardized planning and surgery, many potential future complications can be avoided. The most notable complications in the lower pole tend to be inferior and lateral implant malpositions leading to a bottomed-out appearance, high-riding scars, uncontrolled lower pole tissue stretch, rippling, double-bubble deformities, and breast hyperanimation deformity/window-shading issues (Figs. 13.9, 13.10, 13.11, and 13.12).

Malposition and stretch deformities are generally a result of implant instability, implant size greater than the tissue can handle, or a combination of these two issues. A double-bubble deformity is generally due to underappreciation of a high, tight inframammary fold and/or lowering of the fold

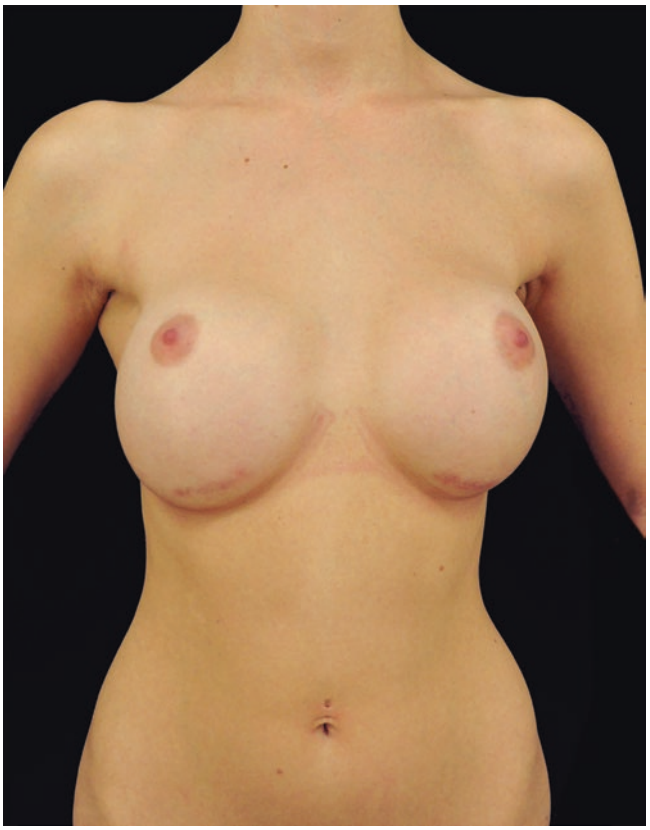

Fig. 13.9 Bottomed-out appearance, high-riding scars. (Courtesy of Dr. Charles Randquist)

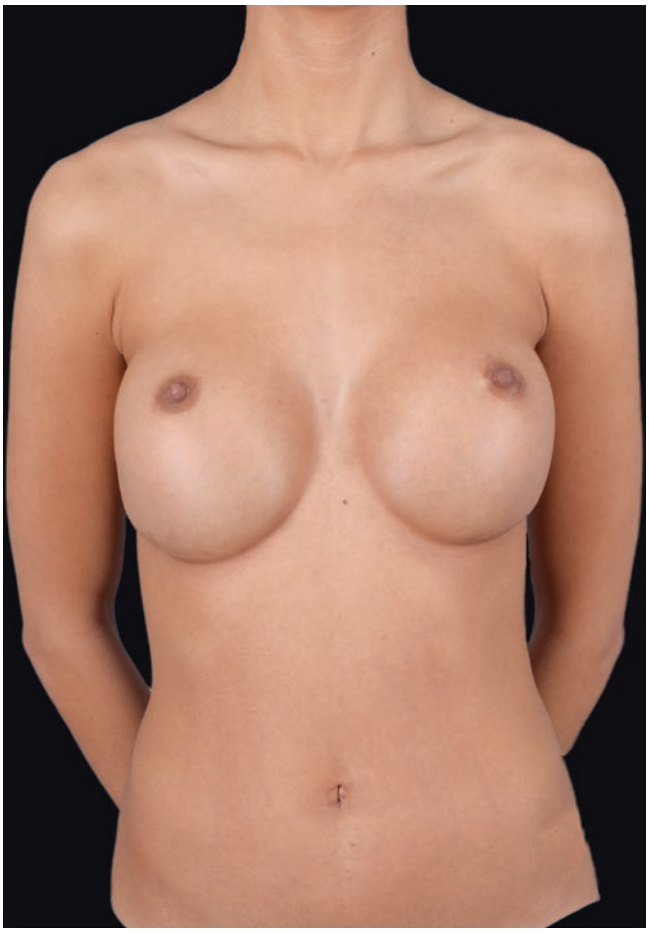

Fig. 13.10 Uncontrolled lower breast pole tissue stretch. (Courtesy of Dr. Charles Randquist)

with inadequate release of the structures of the fold (Figs. 13.13, 13.14, 13.15, and 13.16). Finally, hyperanimation or window shading is generally caused by strong muscle activity in combination with a poorly executed dual plane release, weakening and thinning of the muscle, and/or unfavorable capsule formation. This issue may also be caused by excessive dissection (in the superior direction) of the inferomedial origins of the pectoralis.

Control of the implant and implant pocket is the key to long-term success after breast augmentation, and maximum control should be maintained in every way possible. For example, larger and higher projecting implants, especially when combined with a smooth shell, apply more force to the tissues and increase the risk of excessive tissue stretch [7], particularly in patients with weaker, less elastic skin. As a result, these factors must be considered when choosing implants for any given patient. Additionally, each patient's size goals should be balanced with what their tissues can realistically handle. This is the essence of biodimensional planning and should be studied in detail by surgeons performing breast augmentation.

In addition to proper selection of implant size and profile, other characteristics such as textured surface can be selected in order to stabilize the implant in the pocket [8], particularly in patients with unfavorably sloped ribcages, weaker tissues, or those who desire larger sizes. For those patients or surgeons that choose to avoid texturing due to concerns about breast-implant-associated anaplastic large cell lymphoma (BIA-ALCL) [9, 10] or other reasons, reinforcement materials such as ADM or mesh can be added for strength and stability when needed [11, 12].

For patients with high or constricted poles where the IMF will need to be lowered significantly, the risk of a double-bubble deformity should be anticipated and avoided as much as possible. A double bubble generally occurs when the connective tissue of the IMF does not expand as much as expected, often due to insufficient surgical release of the IMF and/or a suboptimal selection of the shape and cohesiveness of the implants. The planning for patients at risk for a double bubble can include the use of higher cohesivity textured anatomical implants for a more controlled and preferential expansion of the lower pole, breast tissue scoring of the lower pole, and use of a

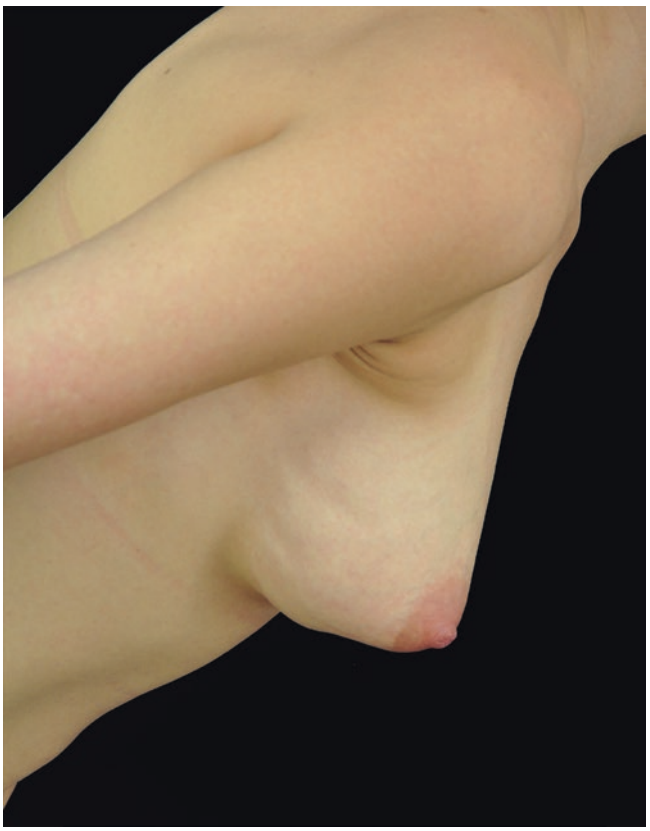

Fig. 13.11 Rippling. (Courtesy of Dr. Charles Randquist)

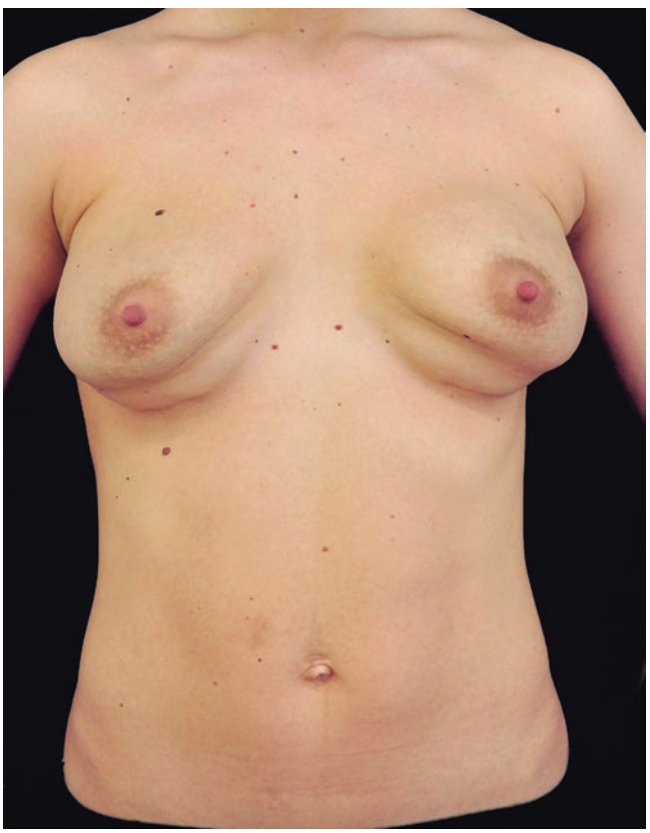

Fig. 13.12 Hyperanimation deformity/window shading. (Courtesy of Dr. Charles Randquist)

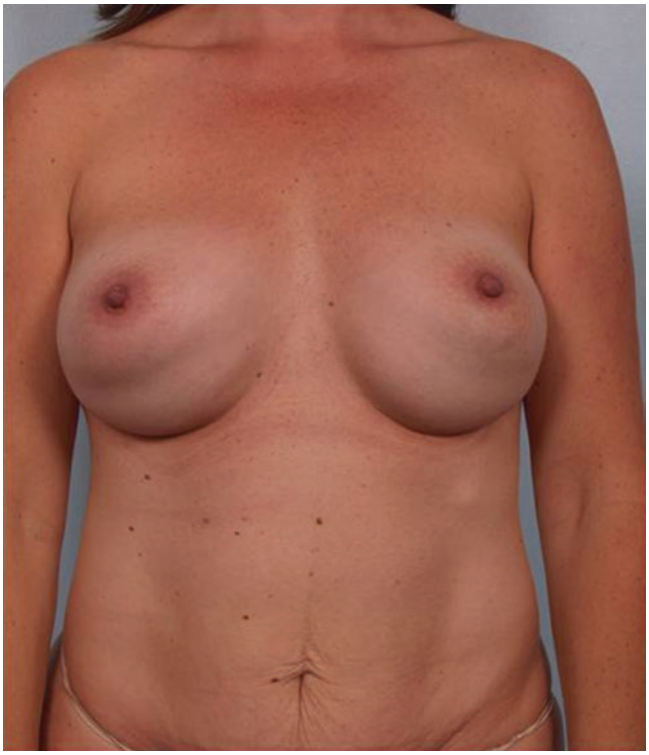

Fig. 13.13 Double-bubble deformity before revision, anterior view. (Courtesy of Dr. Robert Cohen)

dual plane 2 or 3 dissection. The benefit of a dual plane 2 or 3 in these situations is that there is greater direct contact between the implant and the parenchyma, which assists in the creation of adequate lower pole contouring and controlled tissue expansion. Additionally, a circumareolar mastopexy [13] can be planned to improve the shape of the breast and pull the tissue tighter on the breast mound as well as possible fat grafting in the lower pole to equalize any tissue thickness step-offs or contour irregularities [14].

As opposed to a double bubble, which is generally due to an underexpansion of the lower pole and preexisting IMF, a "bottoming out" or lower pole stretch deformity is due to "uncontrolled tissue stretching" of the lower pole of the breast. Once again, the use of textured implants can be helpful to control implant movement and stability, thus reducing the risk of a stretch deformity.

As noted earlier, control is key, and if a textured implant is not used in patients with weaker lower pole tissues, consideration should be given to using reinforcement materials, and certainly implant size and weight should be planned carefully based on what the tissues can handle safely.

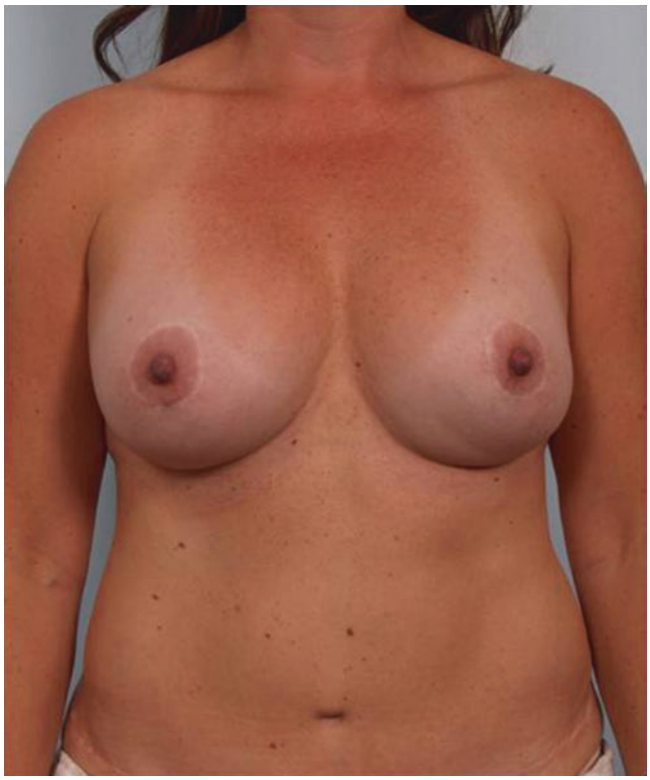

Fig. 13.14 Double-bubble deformity after revision, anterior view: smooth round silicone implants in the dual plane with popcorn-style inferolateral pocket tightening, suture reinforcement, and superomedial mirror image capsule release. Anterior internal breast tissue scoring with bilateral circumareolar tightening. (Courtesy of Dr. Robert Cohen)

Fig. 13.16 Double-bubble deformity after revision, 45-degree view: smooth round silicone implants in the dual plane with popcorn-style inferolateral pocket tightening, suture reinforcement, and superomedial mirror image capsule release. Anterior internal breast tissue scoring with bilateral circumareolar tightening. (Courtesy of Dr. Robert Cohen)

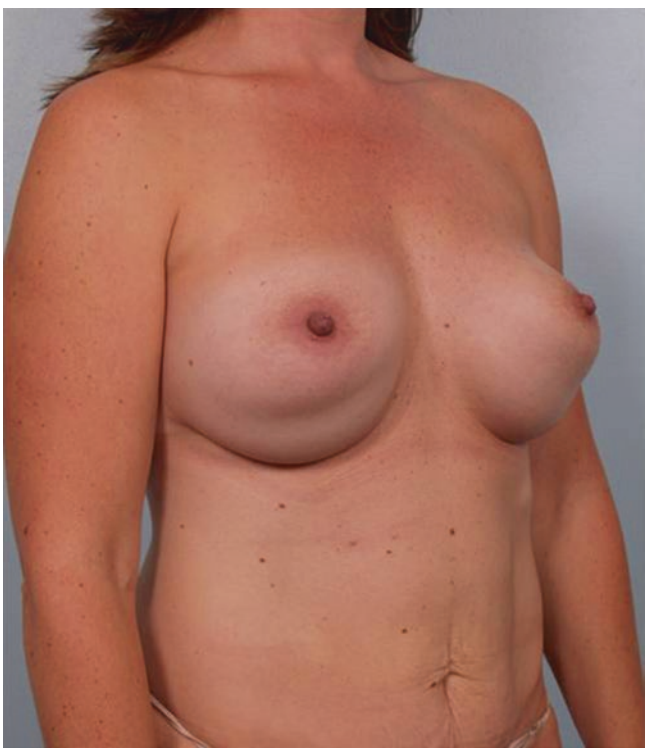

Fig. 13.15 Double-bubble deformity before revision, 45-degree view. (Courtesy of Dr. Robert Cohen)

Application of Best Surgical Technique

Intraoperative Technique: Dissection and Implant Placement

Preferred placement of the implants by the authors is performed via an inframammary fold incision to minimize risk of implant contamination from the milk ducts or axillary glands [15] and thus reduce the risk of capsular contraction. The nipple-areolar complexes should be covered with nipple shields prior to incisions. The mark for the IMF incision is placed based on the Randquist Guidelines as noted previously. The length of the incision can vary depending on implant size, type and texturing, surgeon experience level, and use of a funnel device. Smooth, smaller or less cohesive implants generally require less incision length than larger, textured or more cohesive implants. Dissection then proceeds perpendicularly through the dermis, subcutaneous fat, and Scarpa's fascia until the chest wall is reached and the lower border of the pectoralis major muscle is identified.

If submuscular (dual plane) implantation is intended, the muscle can be incised perpendicularly to the muscle fibers at

a point approximately 5 mm above its insertion on the chest wall. Leaving a thin strip of muscle fibers at the insertion prevents blood vessels within the muscle – often intercostal perforators – from retracting into the underlying tissue. The pectoralis major is elevated, and dissection should proceed into the thin, white areolar web tissue of the retropectoral space in order to create a precise dual plane pocket based on the implant dimensions and resulting preoperative markings. Care should be taken to leave the pectoralis minor and serratus anterior muscles down during dissection to minimize bleeding. All blood vessels should be meticulously cauterized to maintain a clean, dry pocket.

Once the pocket space is opened, the abdominal and caudal sternocostal origins of the pectoralis muscles are totally divided with cautery to the four o'clock position on the right side and the eight o'clock position on the left breast. In addition to the full inferior muscle release bilaterally, an additional thinning of the higher pectoralis muscle origins is performed to weaken the muscles. This is done by partially dividing the muscle fibers to two o'clock on the patient's right side and to ten o'clock position on the patient's left side. This release and weakening of the muscle is critical in order to allow full expansion of the lower pole, achieve proper implant positioning, and to avoid animation/ window shading (Fig. 13.17). Full muscle dissection superior to the four and eight o'clock positions on the right and left breasts, respectively, should be avoided to minimize window-shading of the muscle, animation deformities, and implant visibility over time. A guideline 3 cm "no-touch" zone on the sternum (1.5 cm from the midline on each side) should also be maintained to avoid symmastia and medial rippling.

After the dissection has been performed on both sides, the surgeon should take time to palpate the pockets with both index fingers simultaneously. This maneuver helps to assess symmetry, ensures that all surfaces are even, and confirms that the pockets are wide enough with sufficient tissue release in the anterior direction. Prior to implant placement, an antibiotic and/or iodine-based irrigation is advised to minimize the risk of bacterial contamination or biofilm [16]. Excellent hemostasis should be confirmed prior to final implant placement. Gloves are changed and implants can be placed with a funnel device or with a skin barrier to avoid skin bacteria contact during placement. A final assessment is made to ensure a smooth, symmetrical appearance of the implants.

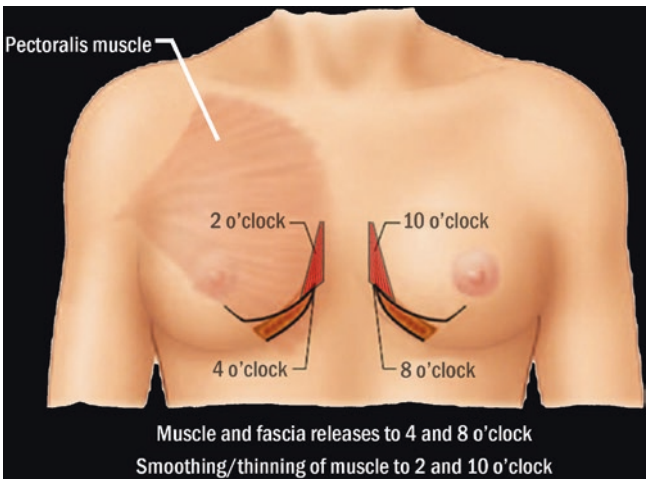

Fig. 13.17 Dual-plane release and thinning of the pectoralis major muscle for minimizing muscle animation. (Courtesy of Dr. Charles Randquist)

Intraoperative Technique: Closure and Stabilization of the IMF, the "Lucky 8" Stitch

Proper closure of the incision is not an afterthought to the procedure. Rather, it is a critical component of the surgery that provides long-term implant stability and maintains a sharp, aesthetic inframammary crease. Ideally, multiple soft tissue layers are closed over the implant to minimize the risk of implant palpability or exposure. Firm anchoring of the IMF to the chest wall will also maintain the scar directly in the crease to minimize scar visibility. Finally, stabilization of the IMF will vastly reduce the incidence of inferior implant malpositions.

On the lower and upper skin flaps, the deep layer of closure should involve Scarpa's fascia and subcutaneous fat, which is sutured to the chest wall at the desired position (based on the Randquist measurement system) to stabilize the IMF. The chest wall suturing can be to periosteum or pericondrium for maximum IMF stability.

As long as the underlying principles of closure are respected, multiple techniques and suture materials may be used. The authors differ slightly in their closure technique, but for brevity's sake, CR's specific "Lucky 8" closure technique will be described. To start, three 2.0 vicryl sutures are placed which begin at the chest wall and incorporate the stronger tissues of pericondrium, periosteum, and/or muscle fascia depending on what is at the chest wall where the new IMF is set. These sutures continue from deep to superficial (including Scarpa's fascia) in the caudal skin flap followed by the same maneuver in the cranial skin flap, thereby avoiding the needle tip going in the direction of the implant and thus creates a "figure of eight" loop, rotating a sturdy segment of subcutaneous tissue into the new IMF (Fig. 13.18 and Video 13.1).

This layer should stabilize the skin at the desired fold position exactly in the IMF and significantly close the wound before final skin sutures are placed. A shorter-acting dissolving suture (as opposed to a longer lasting or permanent suture) is used to avoid a long-term irregularity or flattened

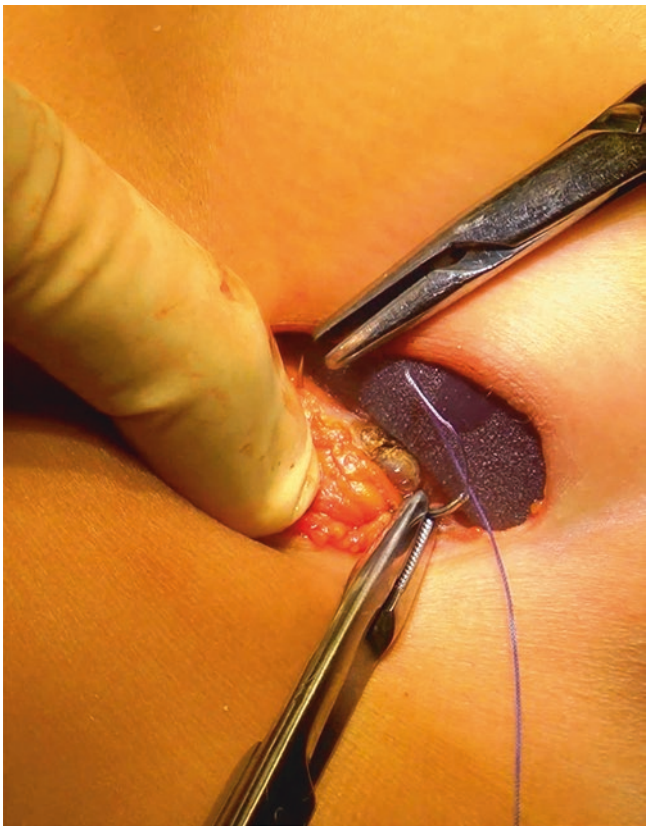

Fig. 13.18 "Lucky 8" stitch. (Courtesy of Dr. Charles Randquist)

area at the site of closure. The mild distortion in the IMF where the Lucky 8 sutures are placed will resolve around 3 weeks postoperatively as the vicryl is resorbed, but these sutures are important to stabilize the implants and IMF as the early capsule forms.

For the final layers of closure, a row of three inverted 3-0 absorbable sutures are passed through the subcutaneous fat superficial to the Scarpa's fascia into the deep dermis and back into the most superficial subcutaneous fat. The subcuticular layer is completed with a 2-0 non-absorbable nylon suture on a straight needle, which is removed two to three weeks after the operation.

Intraoperative Technique: Bandaging/External Stabilization of the IMF

Postoperative care will vary surgeon to surgeon, but the most important physical aspect of this care is proper stabilization of the inframammary fold while it is healing. Specifically, a supportive bra should be utilized (with additional taping if needed) to provide further strength to the IMF during the healing process. Additionally, any downward massage of the implants or forces that could disrupt the IMF (such as heavy lifting or impact exercise) should be avoided for 6 weeks postoperatively. Implant pocket massage should generally be avoided as there is little data to support its role in capsular contracture prevention, and it may overstretch the capsule during its formation.

Intraoperative Technique: Additional Considerations

Modern data emphasize the importance of proper dissection and implant/tissue handling to minimize complications such as malposition and capsular contracture [17]. It is imperative that the surgeon minimizes tissue damage and bleeding. Dissection should be performed under direct, well-lighted visualization and (after the skin incision) should be performed almost exclusively with electrocautery such as monopolar forceps. Blunt finger dissection or sharp scissor or scalpel dissection should be avoided, and meticulous hemostasis is essential to minimize postoperative pain, edema, and to avoid hematomas or increased capsular contracture risk. Use of antibacterial (antibiotic and/or iodine based) pocket irrigation with particular attention to gram negative coverage is also very important for long-term success [18].

Review of Revisionary Techniques for the Inframammary Fold

Initial Assessment and Plan

Avoiding complications by following a meticulous and scientific approach to breast augmentation should be the focus of any aesthetic breast surgeon; however, complications can still occur. Additionally, patients that were operated on by other surgeons can present with lower pole and IMF complications that they would like to have corrected. Revision surgery often presents unique challenges to the surgeon due to issues such as unfavorable prior scar location, excess scar tissue, improper dissection, and tissue stretch deformities among other issues. Understanding how these issues occurred in the first place will help the surgeon reverse and prevent the reoccurrence of these issues.

Inframammary fold issues are usually related to loss of control over the implant and breast pocket, often due to miscalculations or poor choices by the surgeon, particularly with regards to implant selection and pocket dissection or lack of IMF stabilization. Poor patient compliance with regards to postoperative behavior and activity levels can also be a factor in the loss of implant control. Finally, issues can also occur due to genetically weak tissues that were underestimated or not recognized, and life changes that occurred such as a pregnancy or weight change. For patients with specific con-

nective tissue disorders such as Ehlers-Danlos, surgery should proceed only after extensive discussion of the additional risks with the patient, and extra care should be taken to minimize implant weight. Internal reinforcement with mesh or ADM should generally be performed in patients with known connective tissue disorders to offload the weight of the implant from the soft tissues.

During the initial evaluation of a revision patient with IMF issues, an in-depth understanding of prior breast surgery is very important in order to avoid repeating errors. This surgical history should include understanding prior implant styles and volumes, the number of previous breast surgeries, prior dissection planes and incision locations, the presence of mesh or ADM, and any history of prior complications such as bleeding, infections, or seromas.

Existing implants are evaluated to see if the size and base width matches the patient's anatomy. The breast tissue and skin is checked for tissue thickness and degree of elasticity, ptosis, and asymmetry. An assessment should be made to determine if implants are subglandular or submuscular. If subglandular, a judgement can be made if the tissue is excessively weak as a root cause of a lower pole/IMF issue. If submuscular, the forces of the muscle are assessed to see if the pectoralis is contributing to an inferolateral migration of the implant. For the best accuracy, assessment should be performed in both the standing and supine positions as some chest wall asymmetries or malpositions may be much more evident with the patient supine. After a detailed evaluation and examination is finished, a comprehensive plan for correction and stabilization of the breasts is made.

Selection of New Implants in Revision Surgery

Issues and complications of the lower pole and inframammary fold are frequently due to a combination of poor tissue assessment and suboptimal implant selection. Saline implants and softer, underfilled silicone implants can contribute to irregularities such as rippling. Excessively large implants can result in malpositions, lower pole stretch deformities, and traction rippling, especially in breasts with poor tissue quality. Smooth implants, particularly when combined with weak tissue quality or unfavorable ribcage anatomy, can lead to a higher incidence of malposition. Macrotextured implants, unless placed in a precisely fitted pocket with adequate postoperative stabilization, can lead to a higher incidence of malposition as a result of double capsules causing a lack of adherence and seroma formation. Issues that resulted in complications must be understood so they can be specifically avoided with revision surgery.

As noted earlier, biodimensional planning should be used with implant selection to accurately match the implant to the ideal base width of each patient and to avoid excessive stretching of the tissues. Implant quality should be improved when possible, such as switching from saline to silicone implants when possible. For patients with pocket stretch and malposition issues, implants can also be changed from smooth to textured or polyurethane surfaces if needed with a precise neopocket creation [19] or by utilizing the popcorn technique to adjust the pocket size (Figs. 13.19, 13.20, 13.21, 13.22, 13.23, and 13.24) [20, 21].

Control of the IMF/Lower Pole Via the Implant Pocket

The breast pocket determines the dynamic between the implant and the patient, and many complications with the IMF and lower pole are due to loss of control over the pocket.

Oversized or stretched pockets generally result in malpositions and stretch deformities. It is important to distinguish the differences between these two issues. In the case of an inferior malposition, the stability of the actual IMF is lost, which allows the implant to settle below the fold with a high-riding scar. With stretch deformities, also referred to as "uncontrolled lower pole tissue stretch," the fold position can remain stable while the skin between the IMF and nipple stretches and elongates, or patients can experience a combination of these two issues. Restabilizing the IMF and/or reducing the distance from the nipple to the fold are strategies for correcting these problems.

Despite multiple described techniques to reduce pocket size, including capsulorrhaphies, material reinforcements, plane conversions and other such options, both the authors rely heavily on a simple and effective capsular tightening method called the popcorn technique, which was developed by CR [20]. This technique is performed by tenting the thin capsule away from the chest wall inside the pocket and applying cautery via monopolar forceps or with "isolated forceps" with a 3-mm wide tip to avoid cutting the tissue. The capsule will contract dramatically as a white blister, creating controlled capsular tightening. As the blister forms, gas is released and often creates a loud popping noise, hence the name of the technique. Spot cauterizations spaced at approximately 1-cm intervals are applied to the capsule wherever pocket size reduction is needed (Figs. 13.25, 13.26, and 13.27 and Video 13.2).

Most commonly this technique is used on the inferior and lateral pocket, but the entire capsule can be tightened in this fashion if needed for extremely overstretched spaces [21]. The degree of contraction with the popcorn technique depends on the quality of the capsule, as particularly thin or thick capsules tend to lessen the degree of contraction. In cases where further support is desired, adding resorbable mesh or ADM as an additional reinforcement is an option depending on the surgeon's preference and choice of implant and surface type. If the decision is made to

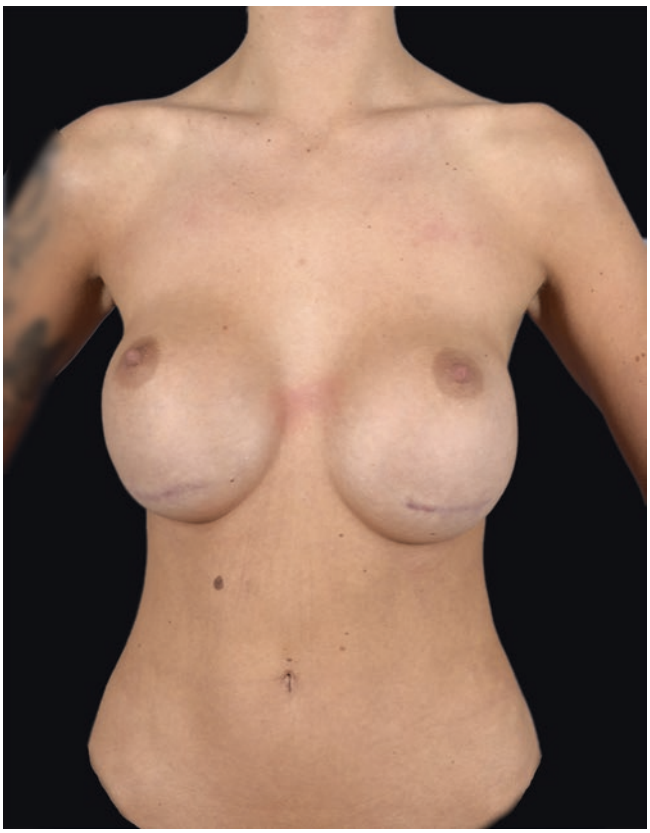

Fig. 13.19 Patient before revision with PU implant, anterior view. (Courtesy of Dr. Charles Randquist)

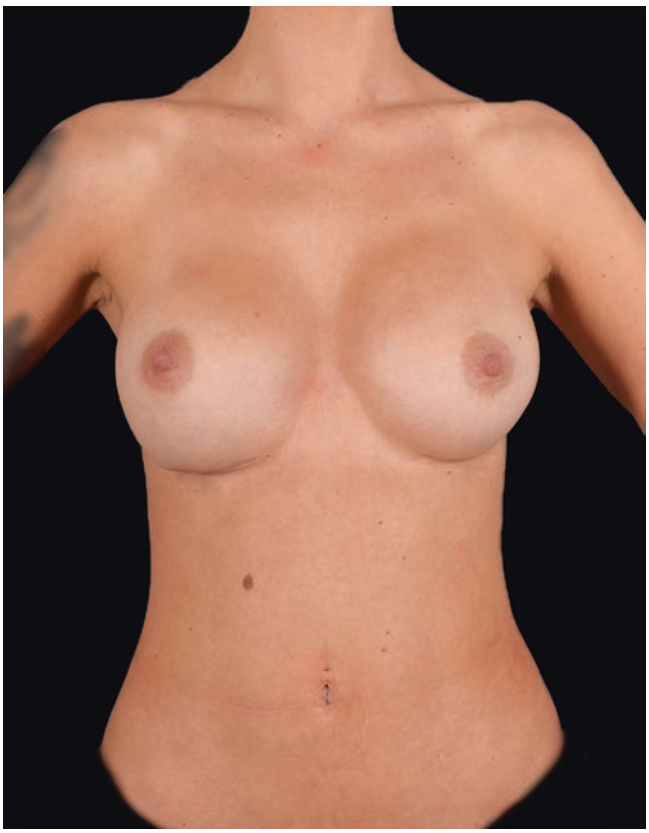

Fig. 13.20 Patient after revision with PU implant, anterior view. (Courtesy of Dr. Charles Randquist)

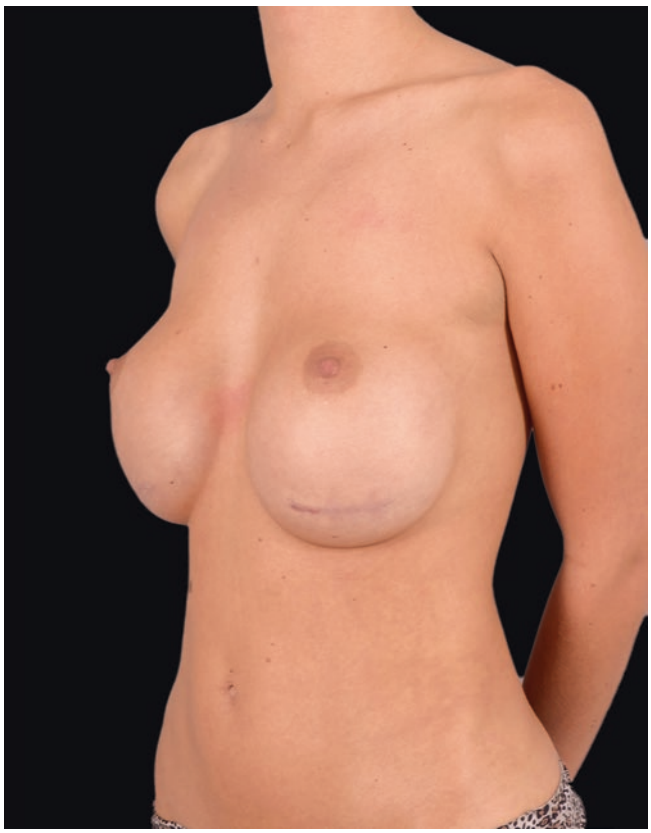

Fig. 13.21 Patient before revision with PU implant, 45-degree view. (Courtesy of Dr. Charles Randquist)

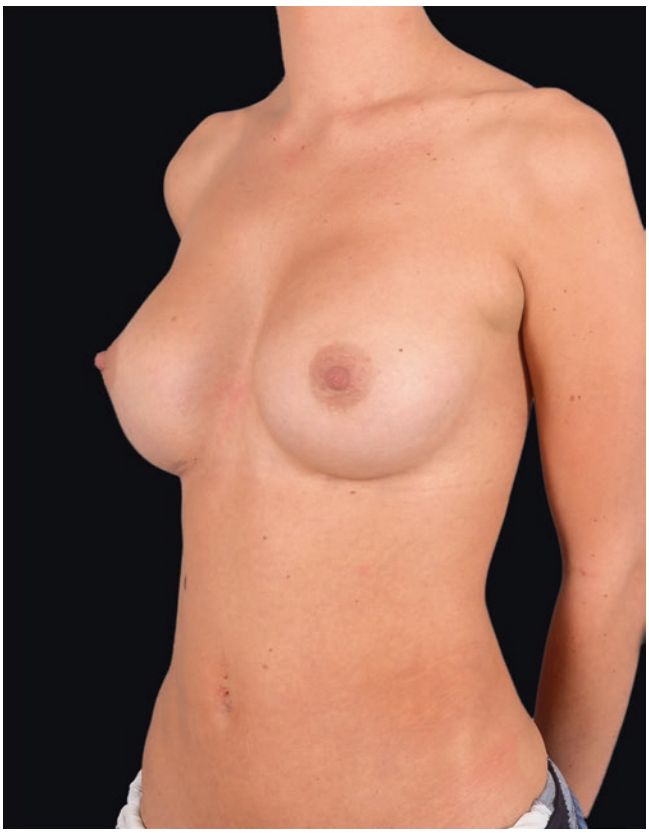

Fig. 13.22 Patient after revision with PU implant, 45-degree view. (Courtesy of Dr. Charles Randquist)

avoid reusing the original implant space, a neopocket combined with a textured implant is a reasonable alternative to create a properly sized space and reestablish control of the implant position. Once precise pocket location, size, and IMF positioning are achieved, the IMF must be restabilized with a strong suture technique. As stated earlier, reinforcement materials can also be used for this purpose if deemed necessary by the surgeon. For cases where strength and stability are the primary concerns, a reinforcement mesh is the first choice of the authors due to its rigidity and relative ease of use (Fig. 13.28). When softness and capsular contracture prevention are of high priority, ADM might be an alternative.

Impact of Soft Tissue Coverage in IMF/Lower Pole Revision Surgery/Short IMF

Soft tissue coverage has a major impact on revision surgery of the lower pole and inframammary fold. The presence of weakened or attenuated tissues will increase the risk of stretch deformities, malpositions, and rippling. Conversely, patients with heavy, lax breast tissue will have a higher risk of a waterfall deformity if the parenchyma rotates inferiorly over a stable implant and IMF position [22].

For patients with thin-tissue-related problems, tissue reinforcement and possible fat grafting are ways to stabilize the breast and improve the appearance of the lower breast pole. For patients with excessively thick tissues who are at higher risk for ptosis and waterfall deformities from the breast tissue rotating off the implants, the surgeon can decrease implant size and projection, remove excess internal tissue bulk, and tighten and redrape the breast skin with a mastopexy when needed.

Tissue Reinforcement in Revision Surgery of the IMF/Lower Pole

Poor tissue elasticity is a common issue among patients dealing with a malposition or stretch deformity. A reduction in the weight of the implants and debulking of excess tissue can help reduce the tissue load. However, in certain cases the best option is to add extra strength via reinforcement material to control the implant position. Many variations of meshes and acellular dermal matrices are available on the market, and the pros and cons of each are outside the scope of this chapter and will be discussed elsewhere in the textbook. Any surgeon performing revision surgery should be familiar with the unique benefits and limitations of each material, in addition to the

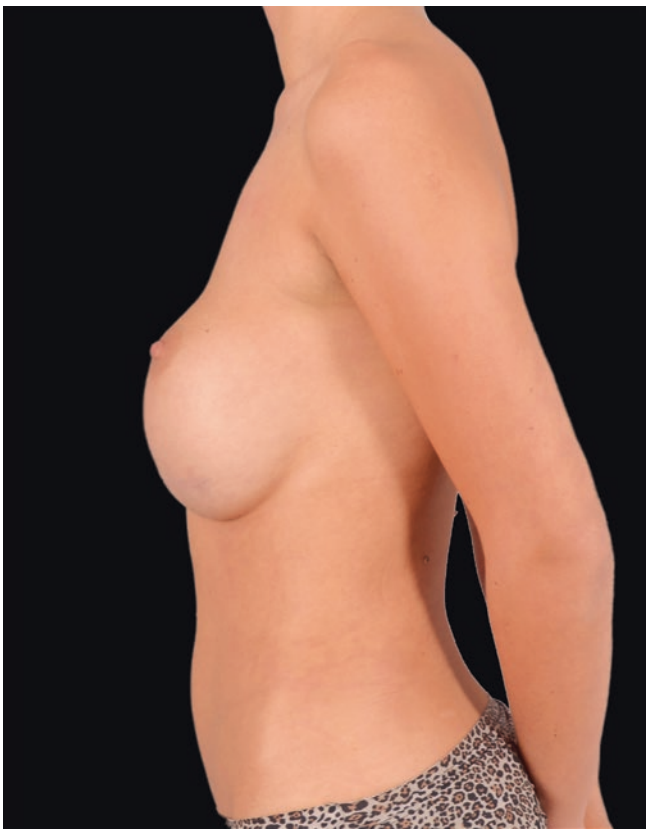

Fig. 13.23 Lateral view of bottomed out breasts (secondary to oversized implants)

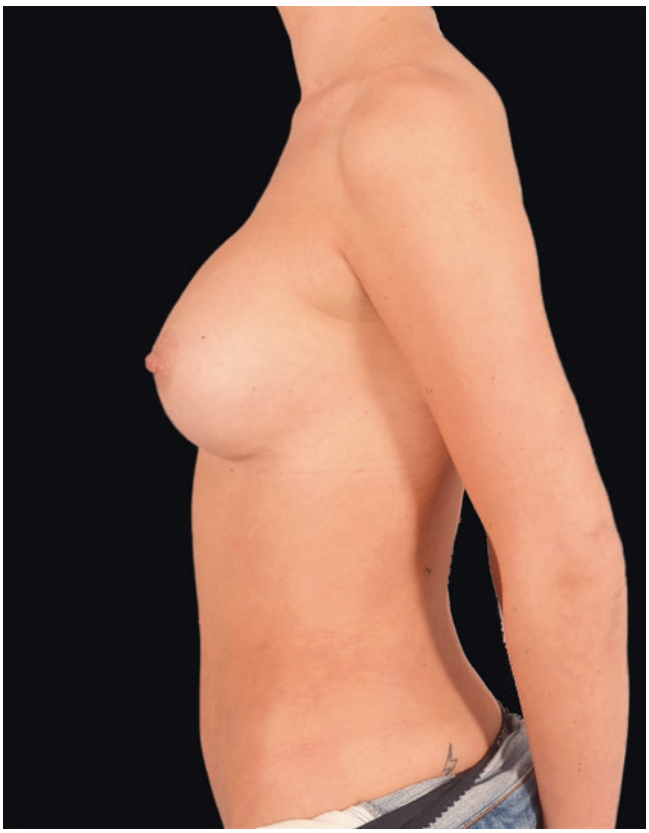

Fig. 13.24 Lateral view of patient after revision with popcorn technique and macrotextured implants

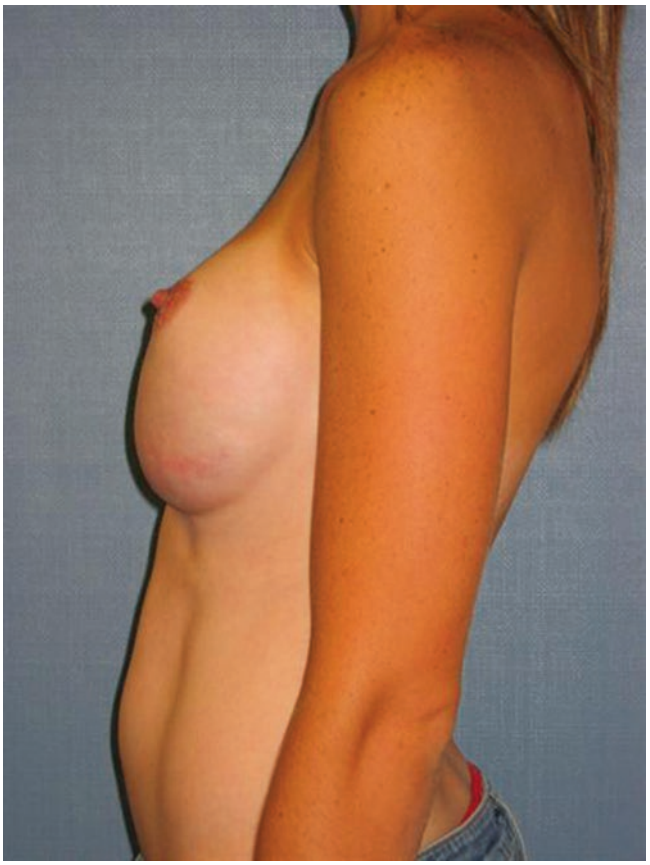

Fig. 13.25 Bottomed-out appearance due to oversized implants, lateral view. (Courtesy of Dr. Robert Cohen)

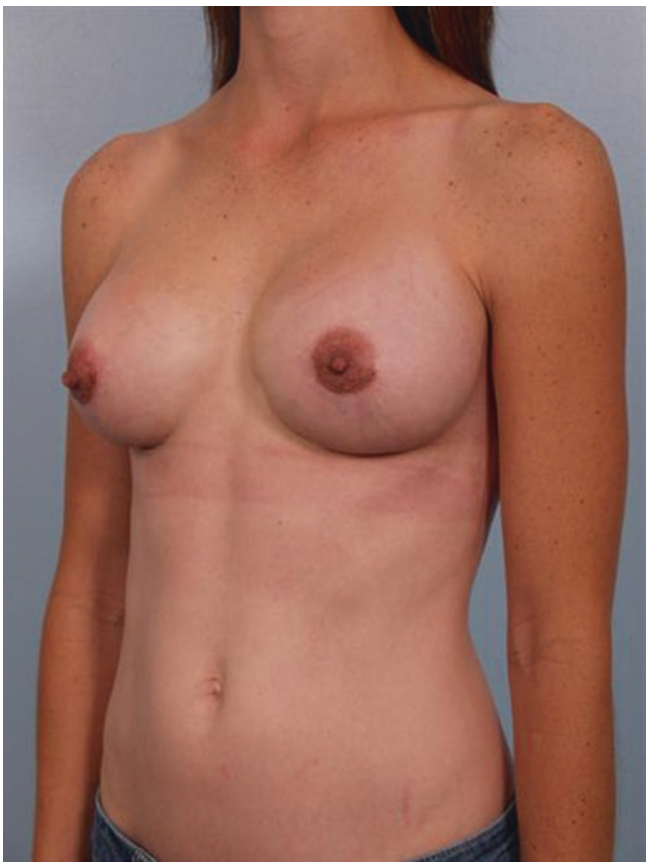

Fig. 13.26 Bottomed-out appearance after revision with popcorn technique, lateral view: change to smaller, different sized, smooth round silicone implants in the dual plane. Popcorn-style inferolateral pocket tightening, suture reinforcement, and superomedial mirror image capsule release. Surgical result after 1 year. (Courtesy of Dr. Robert Cohen)

techniques used to install the material properly. While additional materials add expense, they are less costly than extra, unnecessary surgery and should be considered for reinforcement whenever the tissues are deemed high risk for a recurrent stretch deformity or malposition.

Skin Envelope Adjustment

After placement of appropriate implants, pocket adjustment, and possible tissue reinforcement, the patient's skin envelope should be reassessed for residual laxity on the underlying implant framework. The use of mastopexy techniques can tighten the skin, reduce nipple to fold skin excesses with an inframammary skin resection, and can center the nipple-areola complexes on the breast mounds and create an appropriate areolar diameter when needed.

Conclusion

The IMF and lower pole are key aesthetic components of the breast and are often the first areas to demonstrate issues if not managed properly during surgery. By understanding the anatomy and function of this portion of the breast, the surgeon can anticipate and avoid complications with appropriate implant dissection, proper placement of the incision, and precise pocket dissection. In cases where issues occur or are inherited from another surgeon, a careful analysis of the IMF and lower pole combined with the application of various techniques that allow the surgeon to regain control of the breast will lead to a better early outcome and reduced risks for further complications.

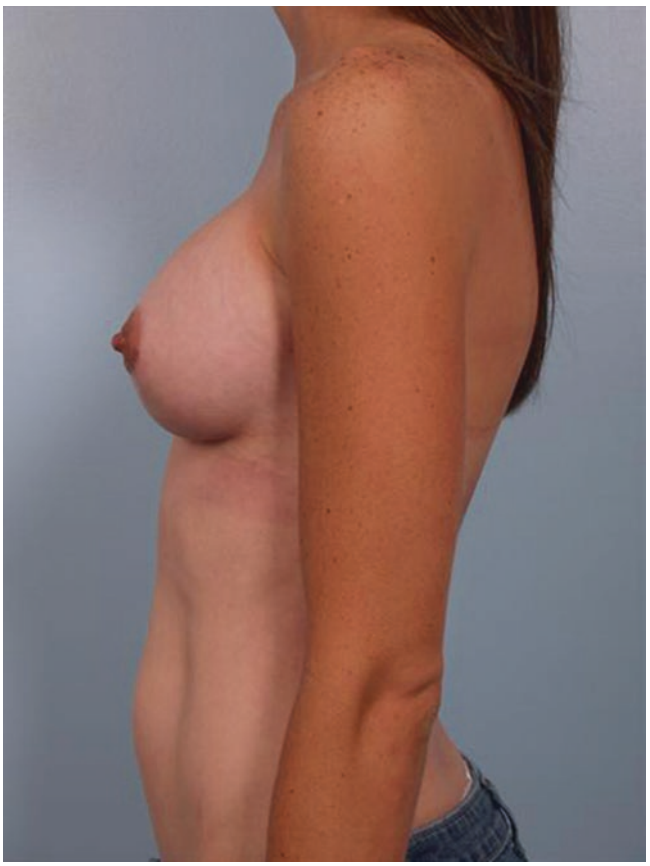

Fig. 13.27 Bottomed-out appearance after revision with popcorn technique, 45-degree view: change to smaller, different sized, smooth round silicone implants in the dual plane. Popcorn-style inferolateral pocket tightening, suture reinforcement, and superomedial mirror image capsule release. Surgical result after 1 year. (Courtesy of Dr. Robert Cohen)

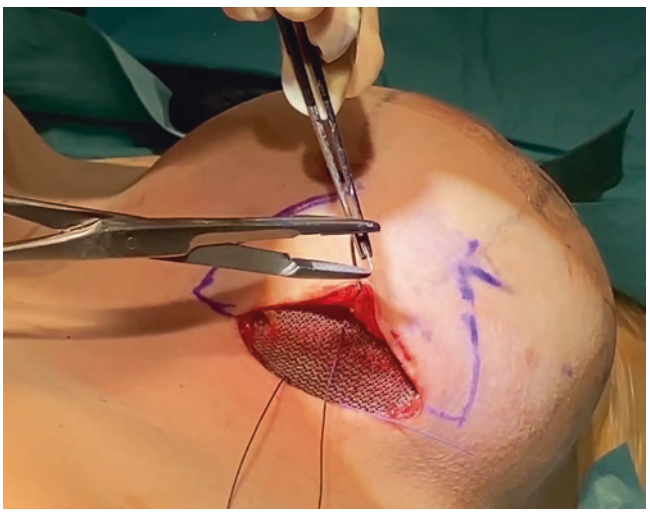

Fig. 13.28 Revisional surgery with a bioresorbable, monofilament scaffold. (Courtesy of Dr. Charles Randquist)

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Late Seroma and Hematomas in Aesthetic Breast Surgery

14

Blair A. Wormer, Timothy M. Rankin, and Kent K. Higdon

Introduction

Overall complication rates for aesthetic breast surgery vary greatly with reports of 1.8% in all types up to 54% in breast reduction [1–3]. Although minor complications (Clavien-Dindo Grade I) such as wound breakdown or unsightly scar may occur in up to half of cases, few require operative intervention [1, 2, 4, 5]. Operative or procedural intervention is more commonly linked to fluid accumulation complications such as seroma and hematoma. A large analysis of 73,608 cases of aesthetic breast surgery revealed that the overall rate of major hematoma was 0.99% [6]. Seroma rates vary in publications but the largest reports available are from 10-year silicone implant safety trials and range from 0.2% to 1.6% [7, 8]. Although seromas may only need percutaneous drainage [4], hematomas have been shown to be the most common complication necessitating operative intervention (Clavien-Dindo Grade III) following breast surgery with rates up to 2.9% [2]. Knowing this, it is essential that both surgeons and patients be well educated about the risk factors, presentation, and management of delayed seroma and hematoma following aesthetic breast surgery, which will be discussed in detail within this chapter.

Risk Factors

When discussing surgical complications, it is essential to evaluate potential risk factors attributable to the patient population or surgical technique that can be modulated to improve outcomes. Prevention is of paramount importance when assessing surgical complications and identifying risk factors or strategies to reduce risk of hematoma and seroma will be discussed in this section.

From a broader scope, hematoma in aesthetic surgery is rare but can require operative intervention and cause significant patient distress. A study of 129,007 aesthetic surgery patients identified that hematoma rates were higher in breast procedures compared to body, extremity, or face procedures (RR 1.81). Additionally, the combination of multiple aesthetic surgeries was found to be an independent risk factor for hematoma (RR 1.68) [9]. Also, surgeons and patients must be prepared that if additional surgeries are added, such as the concomitant abdominoplasty or liposuction in the now popular "mommy makeover surgery," then the risk of hematoma is even higher.

Numerous studies have identified active smoking status, longer duration of operation, and surgical technique as risk factors for increased rates of hematoma [1, 2, 4, 10]. Further, patients' preoperative breast volume, BMI, and resection weight (in the case of reduction) all have been shown to increase the rate of complications, which is understandable as these three factors are often increased in unison. Cunningham et al. took an in-depth analysis on this process and found that each tenfold increase in resection weight increased the risk of complications 4.8 times [1]. These findings bring to light the importance of patient counseling on weight loss preoperatively and underscore the significance of preoperative counseling.

Less commonly discussed risk factors for hematoma include underlying hematologic disorders. A devastating report of numerous hematomas and breast skin necrosis occurred in a young woman with antiphospholipid syndrome treated with a vitamin K antagonist [11]. The patient required negative-pressure wound therapy and skin grafting with subsequent reconstruction due to the loss of tissue. Screening for known or unknown hematologic disorders is an essential step for every plastic surgeon's evaluation of a patient undergoing aesthetic breast surgery.

B. A. Wormer · T. M. Rankin · K. K. Higdon (✉)
Department of Plastic Surgery, Vanderbilt University Medical Center, Nashville, TN, USA
e-mail: kent.higdon@vumc.org

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It is important to note that certain patient risk factors for complications do not appear to affect rates of hematoma or seroma. A study on age in aesthetic surgery found no major difference in overall complication rate between young and old and no effect on rates of seroma or hematoma [12, 13]. The ovulatory phase at the time of breast reduction has also been implicated with certain complications due to fluctuations in hormone levels. Lopez et al. [14] found that breast surgery during the postovulatory phase (day 15–28 after last menstrual cycle) had higher complication rates but no specific effect on hematoma or seroma rate.

An important component in the discussion of seroma and hematoma in aesthetic breast surgery is the use of drains, with evidence that differs based on the specific surgery type. For example, sufficient evidence now exists to debunk the effect of drains and their prevention of seroma and hematoma following breast reduction [15–20]. Two randomized controlled trials showed that drains had no effect on rates of seroma or hematoma, and drains were more often detrimental with higher postoperative discomfort score and longer postoperative stays [16, 17]. A study in 2018 reevaluated this misconception and even found there was no effect on the formation of late seroma or hematoma, with follow-up average of 10 months in their breast reduction patients [20]. We can now counsel patients that routine drainage following breast reduction does not affect their risk of early or late seroma or hematoma. Drains are frequently used in aesthetic breast surgery when capsulectomy is performed or acellular dermal matrix is used to prevent seroma; however, rates of late seroma can still be seen 4 years later [21, 22]. They may help in initial fluid collection management, but this questions the ability of drains to prevent late fluid collections.

A final note on a common misconception in breast surgery is the effect of ketorolac (Toradol ™) on bleeding and hematoma rates. Historic reports and anecdotal experiences for many years have affected surgeons' comfort with perioperative ketorolac use for pain control due to concern for increased bleeding or hematoma. A 522-patient series published on postmastectomy implant patients found no increased risk of hematoma formation in patients who received Toradol [23]. Nguyen et al. also published in 2018 a series of patients and found no difference in those who received ketorolac (4%) versus those who did not (3.2%) [5]. Additionally, for breast reductions, the use of low molecular weight heparin (LMWH) for venous thromboembolism prophylaxis did not appear to impart higher risk [24]. However, there is still some ongoing controversy about the risk and benefit of LMWH in aesthetic breast surgery. Ketorolac has become an important tool in the multimodal armamentarium to decrease postoperative opioid use and can be safely used without increasing hematoma rates in the aesthetic breast population. Additionally, the use of low molecular weight heparin for venous thromboembolism prophylaxis shares a reported rate of hematoma evacuation similar to the rates previously cited and can safely be used [24].

Presentation

Accumulation of fluid in a postsurgical dead space continues to elude surgeons of all specialties. The most common fluids that accumulate after aesthetic breast surgery are blood (hematoma) and serous fluid (seroma). As discussed in the preceding sections, these common complications will present in different temporal periods following surgery. As acute presentations of hematoma typically arise in the immediate postoperative setting and respond best to surgical evacuation, this section will be focused on discussing late presentations of hematoma and seroma.

Late presentations of seroma typically arise in the postoperative setting upon presentation to the office in the initial weeks following surgery. When fluid pockets accumulate, precipitating symptoms reported by patients will differ by the presence of either a closed or open surgical wound. The closed surgical wound will typically be accompanied by a sound and sensation of free fluid in the breast on movement. Large seromas may be associated with pressure or firmness as the serous cavity matures over weeks following surgery. Open surgical wounds can have the additional sign of serous drainage from the wound via accumulation to the seroma cavity. These are of particular note as lack of recognition and treatment can lead to colonization of the seroma with skin flora and lead to local soft tissue infection and subsequent abscess. If no signs of infection exist, then the fluid color in the seroma or its drainage can range from clear yellow serous to darker serosanguinous.

On physical examination, the patients will typically have a ballotable fluid wave within the breast. This is typically found in the lower outer quadrant and lateral chest/axilla, given its dependent location and potential for dead space not filled by an implant or breast tissue. If the seroma has had time to mature weeks to months, the cavity can become firm and palpable on examination. Silicone can also have a delayed rupture phenomenon that can migrate around the implant, breast, and even more distant [25]. This must be something considered on physical exam in the differential diagnosis of palpable findings.

Delayed presentation of breast hematoma differs slightly from seroma in a few key components. Given the proximity of hematomas to breast skin and soft tissue, there is typically significant ecchymosis of the breast skin at the site of the hematoma (Fig. 14.1). This differs greatly from seroma, which is more indolent compared to the serous nature and less obvious on initial visual appearance. Also, the hema-

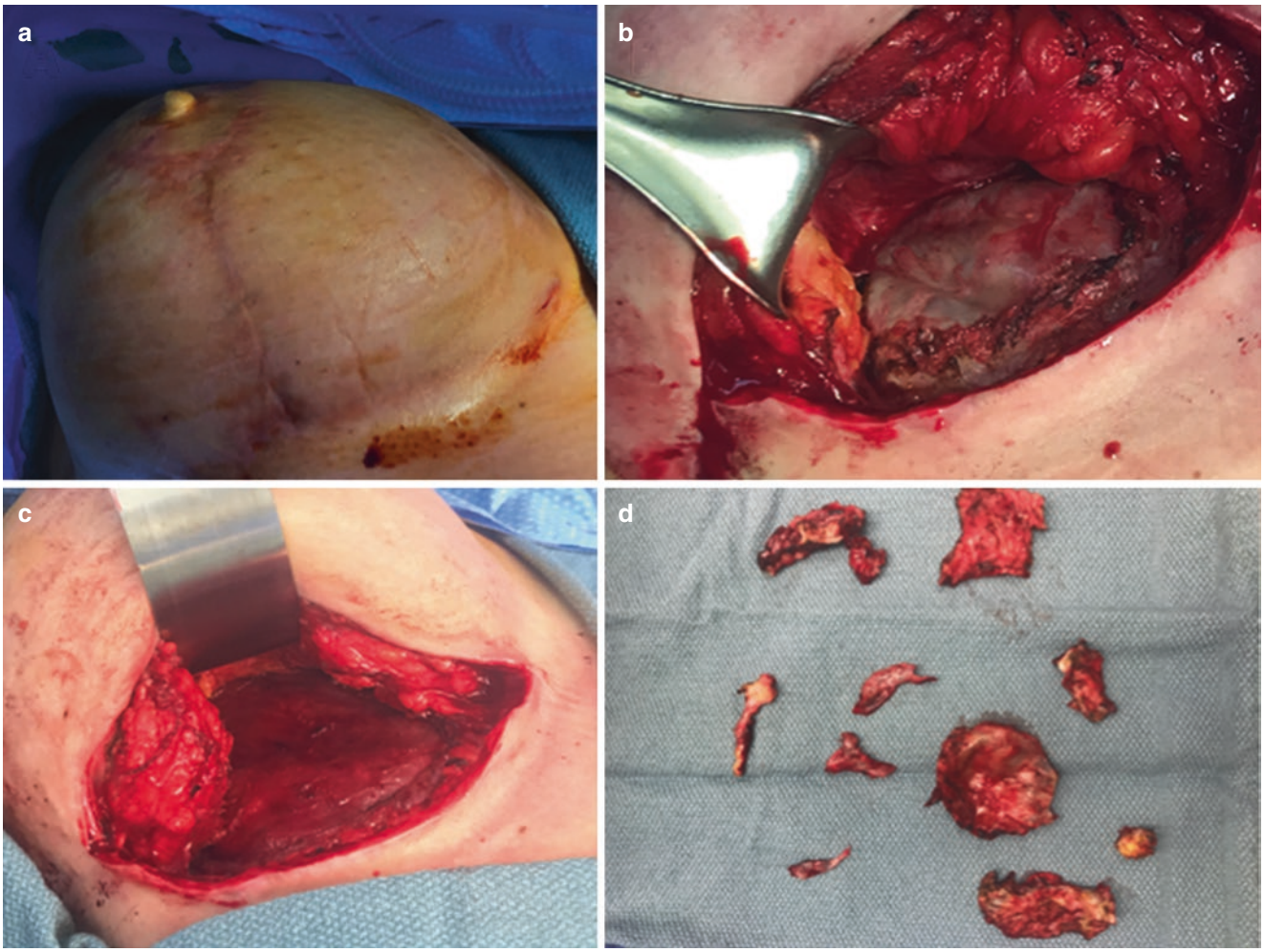
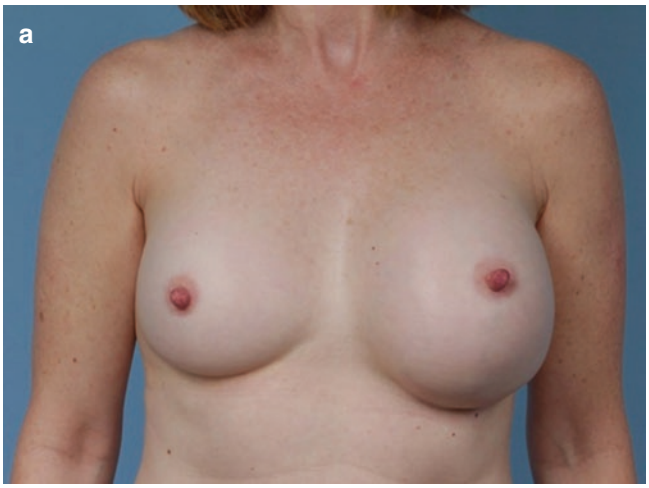


Fig. 14.1 Delayed hematoma clinical presentation with significant tissue ecchymosis and swelling. (**a**) Right breast with delayed hematoma after augmentation mastopexy. (**b**) Fluid collection capsule after evacuation of hematoma and implant removal. (**c**) Breast pocket after capsulectomy. (**d**) Portions of capsule excised during capsulectomy

toma will typically not have a fluid sound or ballotable wave on exam in the initial weeks after surgery as it will usually be solidified with some component of coagulation. The body will eventually attempt to reabsorb the hematoma after weeks have passed as it begins to liquefy. This will present more like a seroma as the bruising will have resolved and only a dark black or serosanguinous collection will remain, depending on the degree of breakdown of the hematoma components within the cavity. This can be seen in Fig. 14.2a, where the patient has a late left breast seroma after breast augmentation with implants. Figure 14.2b shows a typical intraoperative specimen with chronic hematoma and capsular inflammation and reaction. These situations can mandate both late hematoma debris removal and capsulectomy. Figure 14.3 shows the postoperative view following corrective surgery for the patient in Fig. 14.2a. The chronic hematoma has been evacuated, and some excess skin expansion has been excised from the IMF and capsulorrhaphy sutures have corrected the preexisting significant IMF asymmetry.

Breast implants have been associated with late hematomas with presentations years after placement [26, 27]. These can appear as an insidious late swelling or firmness in addition to the implant that is noticeable to the patient prompting evaluation. The swelling is typically unilateral, and a series reporting these late hematomas noted that they arise from acute hemorrhage from small vessels that have formed within the capsule demonstrated on microscopic and macroscopic analyses [28, 29]. This is important to note in the lifetime of a patient with history of implants as there have been case reports of delayed hematomas presenting as far out as 26 years after implant placement [30].

More concerning than a delayed hematoma in a patient with a history of breast implants is a late seroma anytime over 6 months from placement. Textured implants have been implicated in breast-implant-associated anaplastic large cell



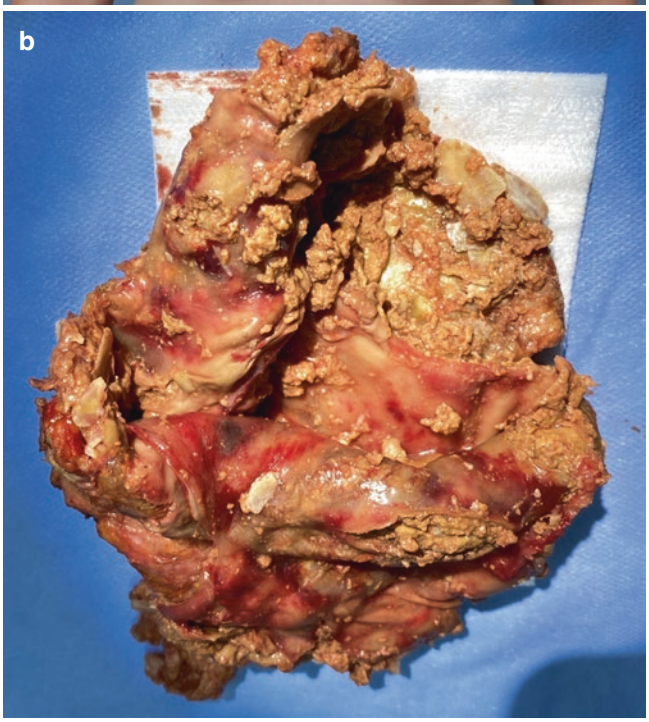


Fig. 14.2 (**a**) Patient 1 year after breast augmentation with implants presenting with chronic left soft tissue swelling and periprosthetic fluid and concern for hematoma. (**b**) Intraoperative specimen from another patient showing chronic hematoma debris and associated capsule calcification. (Photos courtesy of Dr. John Kim)

lymphoma (BIA-ALCL) and typically present with the insidious onset of unilateral swelling and seroma anywhere from 9 months to even 28 years after surgery, with an average time from implantation to BIA-ALCL diagnosis of 8 years [31, 32]. Treatment requires seroma capsulectomy and cytology for diagnosis and management. This will be discussed in Chap. 8 on BIA-ALCL. Regardless, delayed seroma over 6 months out in aesthetic breast surgery should bring attention to the surgeon to ensure no underlying pathology or undiagnosed breast cancer is the inciting cause.

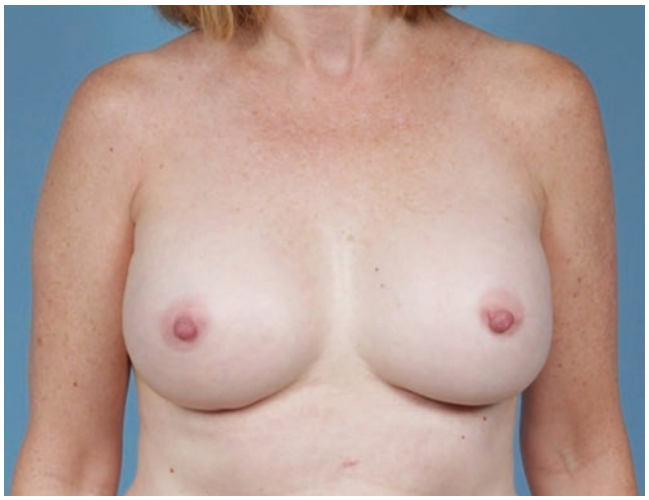


Fig. 14.3 Postoperative photograph showing correction of the patient in Fig. 14.2a. The chronic hematoma has been evacuated, some excess skin expansion has been excised from the IMF, and capsulorrhaphy sutures have corrected the preexisting significant IMF asymmetry. (Photo courtesy of Dr. John Kim)

Management

Once the clinical presentation of delayed hematoma or seroma has been recognized then a management algorithm can be followed for appropriate treatment (Fig. 14.4). Initial treatment is based on timing of presentation, the distinctions of which have been discussed in the preceding section. If the initial swelling in the first days to weeks after breast reduction is associated with ecchymosis it should increase suspicion for hematoma. This is relevant to note because initial management is percutaneous drainage, which may be unsuccessful if a subacute hematoma is present due to clotting. This clotted hematoma may take time to liquefy and may require evacuation if large or symptomatic. Otherwise, percutaneous drainage is performed in the office with a 22-gauge or smaller butterfly needle through an insensate portion of the surgical wound into the palpable fluid collection. The area is prepped with antiseptic solution prior to insertion of the butterfly needle, which is connected to a 60-cc syringe for evacuation. The evacuated fluid can be discarded in these subacute collections, and the patient should be counseled on compression of the area with compressive bra and padding. Exercise and activity should be avoided after aspiration to avoid repeat accumulation.

It should be noted that hematoma does have a closer relationship with development of capsular contracture and concurrent propensity for infection. This is a distinct finding that many surgeons cite when advocating for immediate operative washout of an early hematoma or more aggressive treatment of a late hematoma to prevent these subsequent complications.

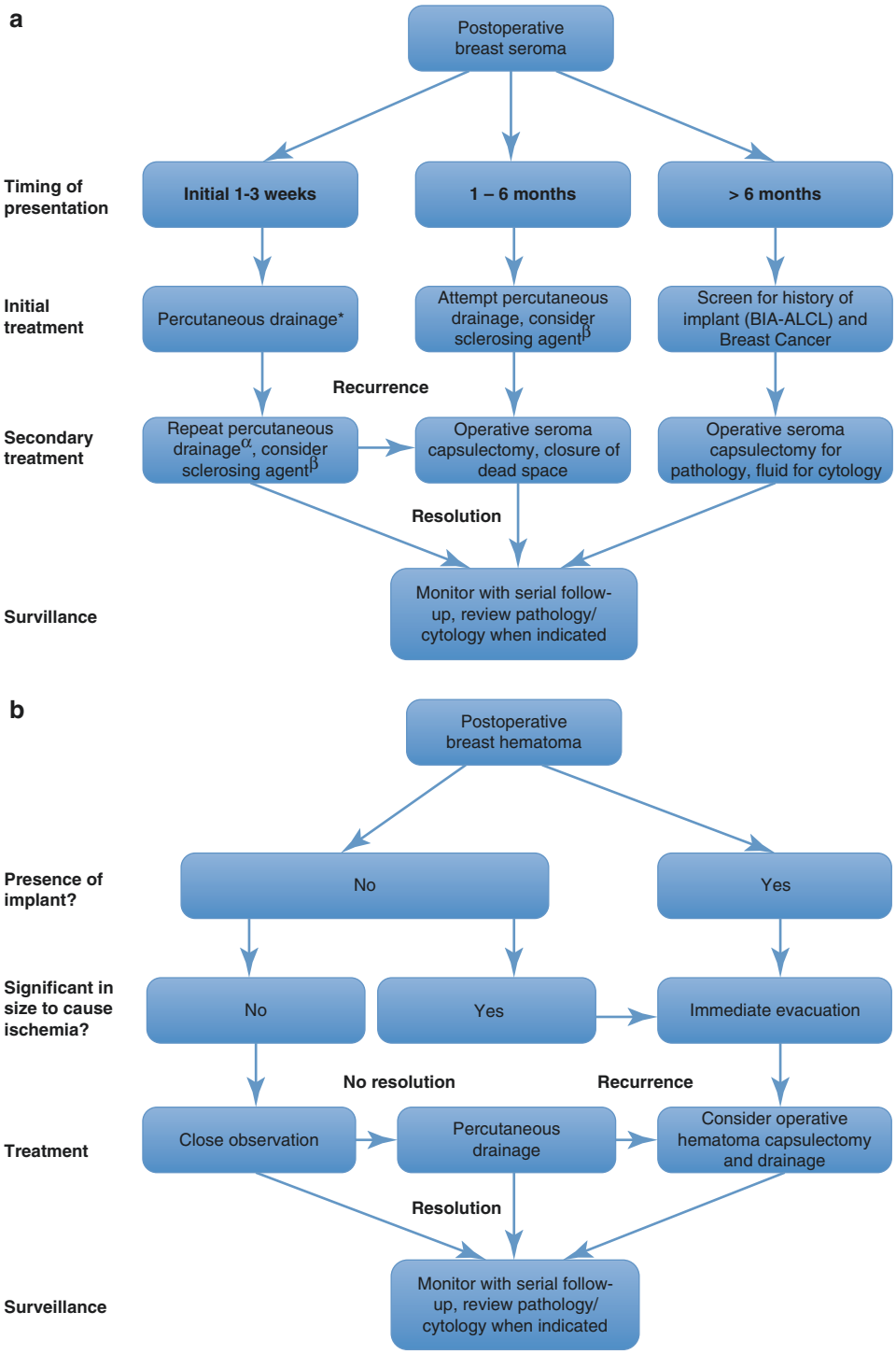


Fig. 14.4 Management algorithm for delayed presentation of seroma or hematoma following aesthetic breast surgery. BIA-ALCL, breast-implant-associated anaplastic large cell lymphoma. † If associated ecchymosis or delayed trauma has increased suspicion for hematoma, consider more aggressive treatment, given the risk of capsular contracture and propensity for infection as compared to seroma. * Percutaneous drainage may not be successful in hematomas appearing in the initial weeks due to clotting and may require evacuation if large or symptomatic. ᵅ Percutaneous drainage can be repeated numerous times in seromas appearing in the initial weeks. This is up to the discretion of the surgeon and patient tolerance. ᵝ Sclerosing agents such as doxycycline or steroid may be instilled into the cavity after drainage to help prevent recurrence (**a**) Treatment Algorithm for Postoperative Breast Seroma (**b**) Treatment Algorithm for Postoperative Breast Hematoma

Seromas will tend to have a more delayed presentation as we have mentioned and if the seroma has returned after initial nonoperative treatment, percutaneous drainage can be repeated in these fluid collections that occur in the initial weeks of wound healing, as the cavity may still have the opportunity to collapse before a mature capsule develops. The number of aspirations and frequency are up to the discretion and comfort of the patient before proceeding to operative intervention. During these repeat aspiration events, the butterfly needle can be left in place upon completion of seroma fluid aspiration, and then a sclerosing agent can be instilled in hopes to help scar down the cavity to prevent return (e.g., Kenalog as seen in Fig. 14.5). Two well-described agents used are doxycycline and steroids (Kenalog or triamcinolone) [33–38]. Both of these agents have had success in breast surgery and can be used as an adjunct to

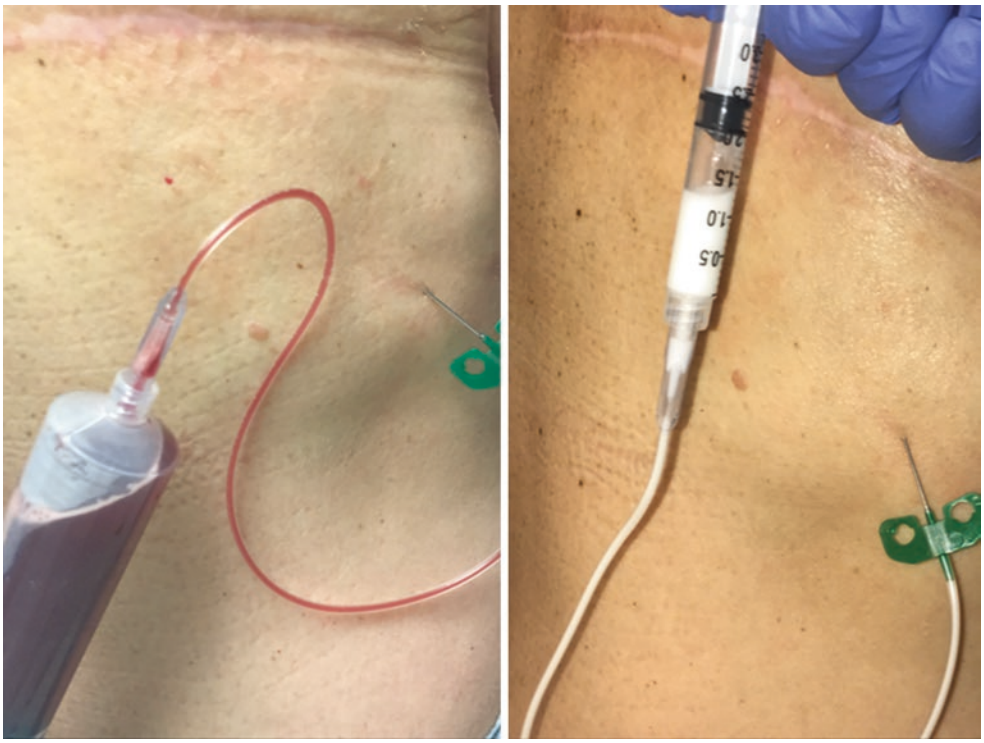


Fig. 14.5 Example of percutaneous aspiration of delayed seroma followed by Kenalog steroid instillation into a cavity to prevent recurrence

aspiration to prevent recurrence with little added risk or discomfort. If during these aspirations the patient still feels that there is the feeling of fluid or sensation of more fluid on exam, consider the presence of loculations. Loculations in the seroma cavity can require multiple passes and attempts to completely drain. Ultrasound guidance can be of assistance with deeper collections or larger patients to reach the loculated fluid not immediately palpable below the skin.

Fluid collections that fail multiple attempts at aspiration or are presenting over 1 month out are more likely to have a mature capsule preventing the cavity from collapsing. In these situations, aspirations or sclerosing agents may not be successful and an operative approach should be planned. In these cases, the cavity will need to be excised in its entirety and the dead space filled. This typically requires general anesthesia and the cavity closed with multiple layers of absorbable suture or volume replacement with adjacent breast tissue depending on the defect size. Unless there are concerning signs of the seroma cavity or adjacent tissue, pathology is likely unnecessary in the first 6 months after surgery. When a new seroma presents more than 6 months after surgery, the surgeon should be concerned of an underlying pathology. Although uncommon, the surgeon must ensure there has been no history of textured implant placement to prompt investigation for BIA-ALCL and all breast cancer screening is up to date. The surgeon should also perform another breast exam and regional lymph node exam and screen for any new systemic symptoms. Given the ever-evolving state of our understanding of BIA-ALCL, at this time we recommend sending the fluid for cytology (CD30 immune staining) and complete seroma cavity excision for pathology. Distinctive algorithms have been published regarding this and are discussed elsewhere in this book [39].

Conclusion

Aesthetic breast surgery can be complicated by delayed hematoma or seroma. Although they rarely require surgery, attention to temporal presentation and subsequent management are essential for plastic surgeons to provide optimal care. Identifying risk factors for these complications is important along with recognizing evidence that using surgical drains or withholding ketorolac will not always prevent them. Once recognized, percutaneous drainage and instillation of sclerosing agents can provide outpatient treatment of these complications in the initial weeks to months. It must be noted that a more urgent treatment of hematomas should be considered over seromas in the subacute or delayed period given the propensity for capsular contracture and infection with hematoma. However, refractory seromas that persist despite repeat aspiration or seromas with delayed presentation and a concomitant mature cavity may require operative intervention. In the evolving era of BIA-ALCL, delayed swelling of a breast mandates further investigation with evaluation of texture implant history, imaging, and potential cytology and biopsy.

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Animation: Etiology, Classification, and Treatment

15

John Y. S. Kim, Megan Fracol, and Wen-Kuan Chiu

Animation: Anatomy and Pathophysiology

Implant asymmetry and malposition can be passive or dynamic in nature. The focus of this chapter will be on implant asymmetry that is dynamic in nature, and the most obvious manifestation of this is animation deformity. Moderate or severe animation occurs in approximately 10–15% of breast augmentations [1]. Other than submuscular implant placement, risk factors for animation in aesthetic breast surgery include a possible association with exercise activity [2]. In reconstructive surgery, identified risk factors that increase the magnitude of animation deformity include release of the pectoralis muscle, bilateral reconstructions, and smooth implants [3]. Computer-assisted image analysis of animation motion video also suggests that the predominant vector angle of displacement of the nipple in this particular setting is 62 degrees in the superolateral direction, which is in alignment with the direction of the inferior fibers of the pectoralis and an axis from the xiphoid to the acromion (Figs. 15.1 and 15.2).

The pattern of nerve supply to the pectoralis has been debated over the years, largely due to variations in individual anatomy and whether the nerve branching pattern is being described based on its origin from the brachial plexus or its peripheral insertion into the muscle. Most authors agree there are two to three nerve branches supplying the pectoralis major, and the muscle is undoubtedly supplied in a segmental pattern – meaning that the nerve branches to the clavicular portion are distinct from the nerve branches to the sternal portion, which are distinct from the nerve branches to the inferior-most costal portion [4–6].

The clinical pathway by which animation occurs is believed to be release of the pectoralis muscle with subsequent displacement cephalad [7]. The muscle then adheres to the underside of the breast and forms scar attachments. When there is ensuing muscle contraction, the overlying skin will then move in concert (Fig. 15.3). Significant implant displacement can occur as the enveloping capsule around the implant moves with these adhesions, and we hypothesize greater displacement occurs with smooth implants due to lack of tissue ingrowth and a resultant "laxer" pocket. Presumably, the greater the amplitude of muscle action and the more pervasive the scar process into the breast parenchyma, the greater the animation deformity and the greater the degree of implant displacement. Notably, it has been assumed that animation deformity occurs in conjunction with pain; however, recent findings suggest this relationship may not be as clear cut. Utilizing the BREAST-Q, it was found that patients with higher severity of animation actually had lower pain responses on the BREAST-Q, in particular, with less nagging, pulling, and aching sensations in the breast [8]. In other words, pectoralis release – while associated with animation severity– may be inversely associated with pain. By releasing the pectoralis, the implant pocket is expanded and the pectoralis contraction proceeds unrestricted – there is no fixed point against which the muscle pulls. Accordingly, the freer, unrestricted pull of a released pectoralis creates less pain because it is not pulling against the fixed structures of an intact pectoralis. Quixotically, a breast with more severe animation may, therefore, have less pain associated with it vis-à-vis a breast with less animation but more fixity on contraction.

J. Y. S. Kim (✉)
Feinberg School of Medicine, Northwestern University, Chicago, IL, USA
e-mail: john.kim@nm.org

M. Fracol
Department of Surgery, Northwestern University, Feinberg School of Medicine, Chicago, IL, USA

W.-K. Chiu
Department of Surgery, Taipei Municipal Wanfang Hospital, Taipei City, Taiwan

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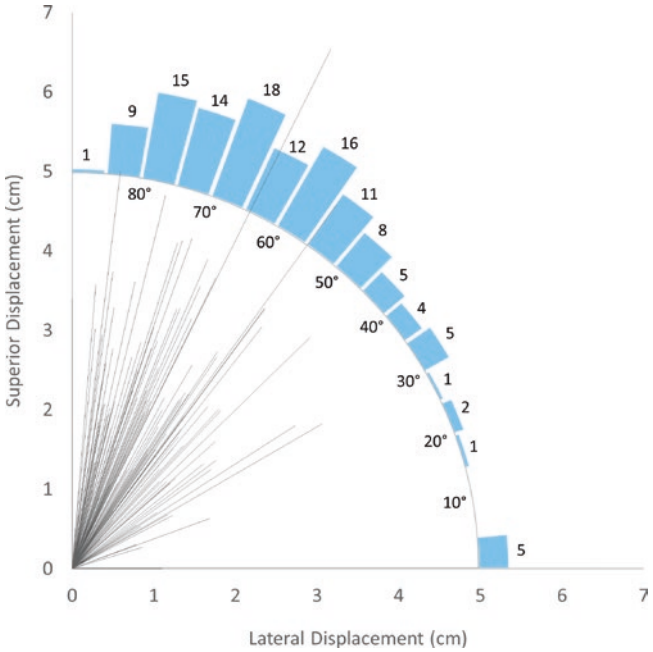

Fig. 15.1 Direction of nipple displacement on the chest wall in a cohort of 145 breasts with subpectoral implant-based reconstruction. Each line represents the net displacement of one nipple in the superior and lateral directions at rest (zero displacement) and with full pectoralis contraction. The histogram (blue bars) illustrates the count of breasts by angle of displacement, with 0 degrees being the lateral direction. The average angle of displacement was 62.5 ± 20.6 degrees in the superolateral direction

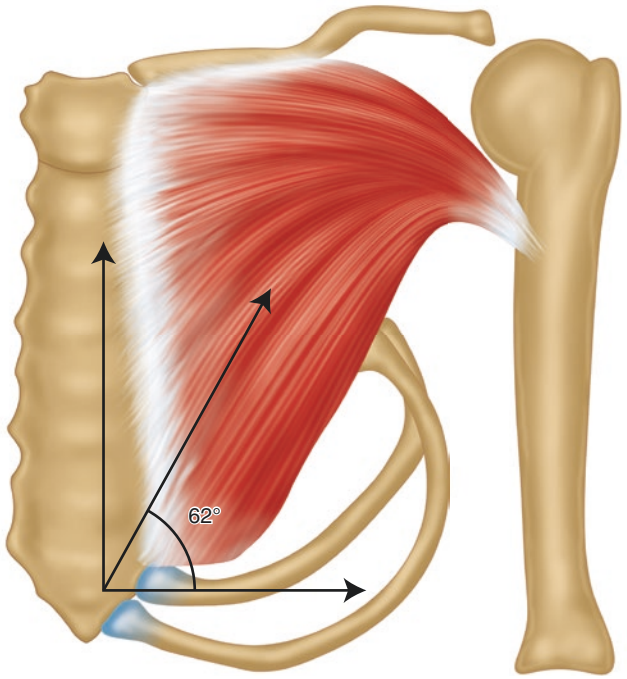

Fig. 15.2 The average vector of nipple displacement was 62 degrees in the superolateral direction. This is approximately parallel to the direction of action of the inferior-most fibers of the pectoralis muscle, indicating their key contribution to animation deformity

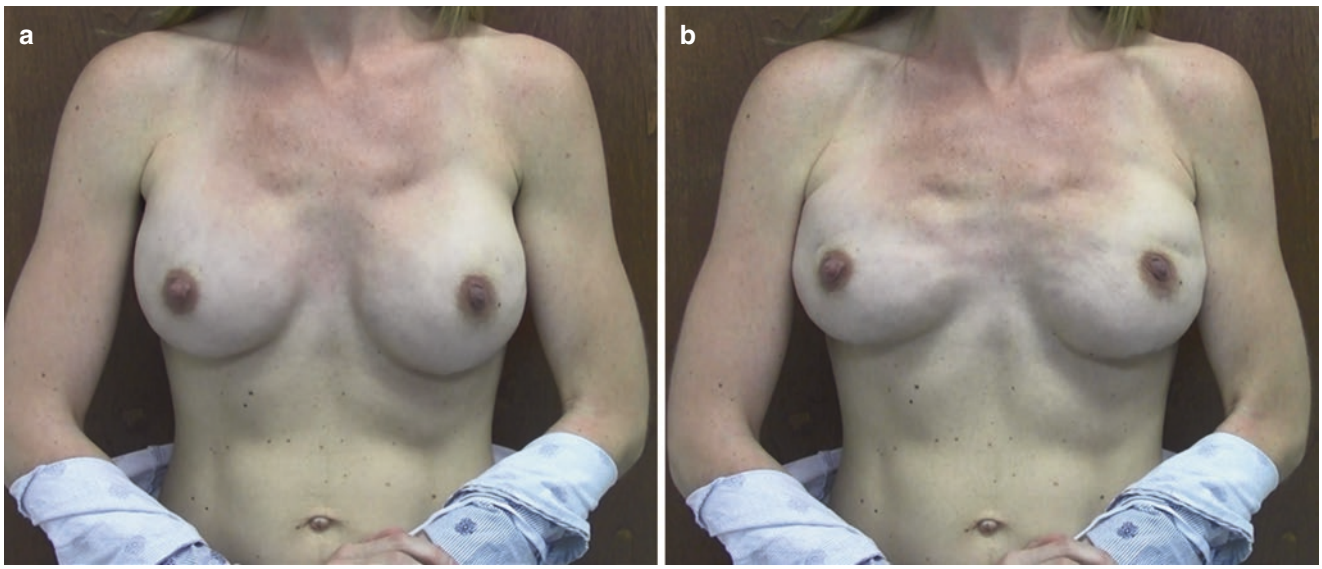

Fig. 15.3 Example of dynamic implant asymmetry due to animation deformity. (**a**) Implant position at rest. (**b**) Implant position changes with pectoralis contraction

Classification of Animation Deformity

Two common classification systems for grading animation deformity exist, described by Becker and Vidya [9, 10]. Both scales separate animation deformity into four grades, with grade I representing the least deformity and grade IV representing the most deformity. Becker's scale takes into account the amount of breast distortion, lateral displacement of the

Table 15.1 Becker's grading scale for animation deformity [1]

Grade	Breast distortion	Lateral displacement	Skin rippling
I	Minimal	Minimal	Minimal
II	Moderate	Moderate	Minimal
III	Moderate to severe	Moderate to severe	Evident
IV	Severe	Severe	Severe

Table 15.2 Vidya's grading scale for animation deformity [3]

Grade	Distortion or displacement	Patient noticeability
I	None	N/A
II	Minimal	Unnoticed by patient
III	Moderate	Noticed by patient
IV	Severe	Disturbing to patient

Table 15.3 Kim et al.'s quantitative grading scale for animation deformity [5]

Grade	Nipple displacement	Contour irregularity (%)
I	< 2 cm	<25
II	> 2 cm	<25
	< 2 cm	>25
III	> 2 cm	>25

implant, and skin rippling (Table 15.1). Vidya's scale takes into account the amount of distortion/displacement and patient noticeability (Table 15.2).

A newer, quantitative scale has been developed by the authors, which separates patients into three grades by severity of animation (Table 15.3) [3]. In this scale, the practitioner measures the amount of nipple displacement with pectoralis contraction and the approximate percentage of skin surface area that wrinkles with pectoralis muscle contraction. Nipple displacement less than 2 cm and skin rippling less than 25% of the breast mound are classified as grade I; nipple displacement greater than 2 cm *or* skin rippling greater than 25% of the breast mound is classified as grade II; nipple displacement greater than 2 cm *and* skin rippling greater than 25% of the breast mound are classified as grade III (Figs. 15.4 and 15.5).

Management of Animation Deformity

While conservative approaches to treatment of animation deformity have been suggested through the use of botulinum toxin, this unfortunately is only a temporary solution [11]. Neurectomy of the thoracodorsal nerve has been described for the correction of animation deformity after latissimus flap breast reconstruction [12]. While a similar technique has been suggested via pectoralis denervation, this is not well established and is technically more challenging due to multiple motor nerve branches [13]. Adequate correction of animation deformity generally requires surgical revision of the

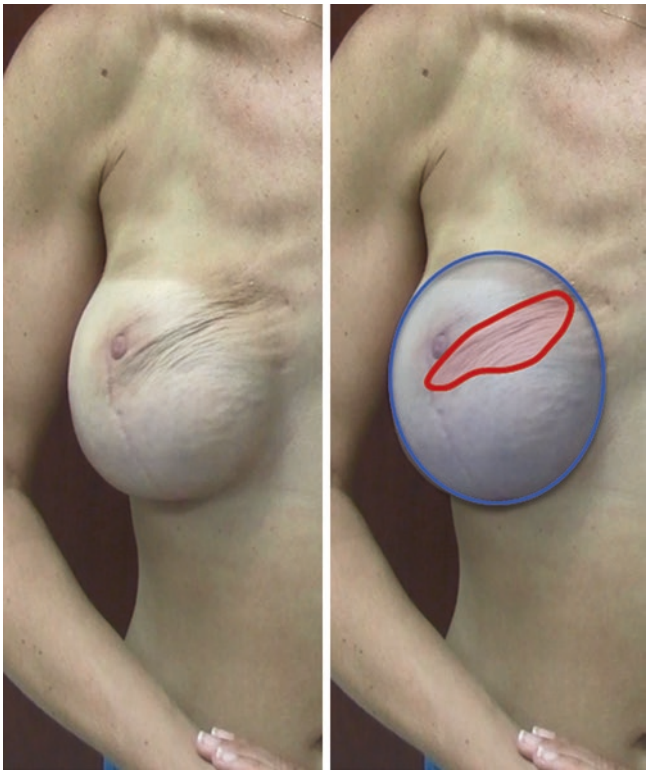

Fig. 15.4 With the authors' proposed grading scale, the area of skin contour irregularity (shaded red) is estimated as a percentage of the total breast mound (shaded blue). Severity can be stratified by whether or not more than one-fourth of the breast mound is involved with skin contour irregularity, which will stratify patients into grades 1, 2, or 3 animation deformity (see Table 15.3)

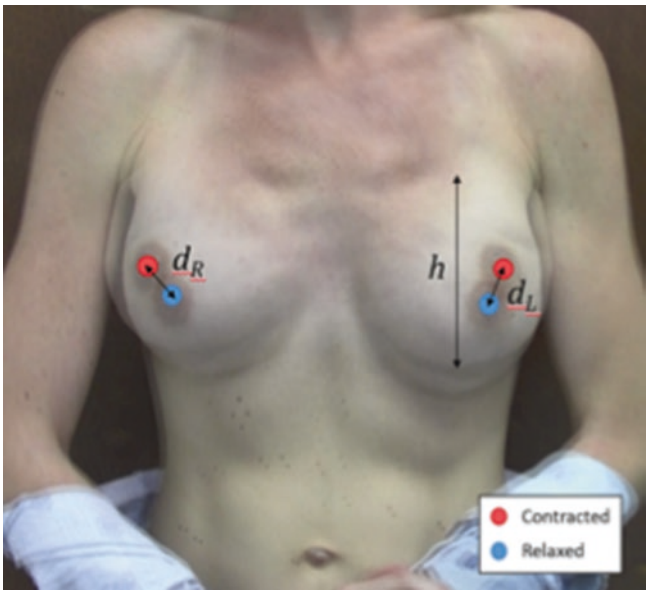

Fig. 15.5 With the authors' proposed quantitative grading scale, the distance of nipple displacement with pectoralis contraction can be measured and used to quantify the severity of animation deformity. Nipple displacement greater than 2 cm will put patients into grade 2 or grade 3 animation deformity (see Table 15.3)

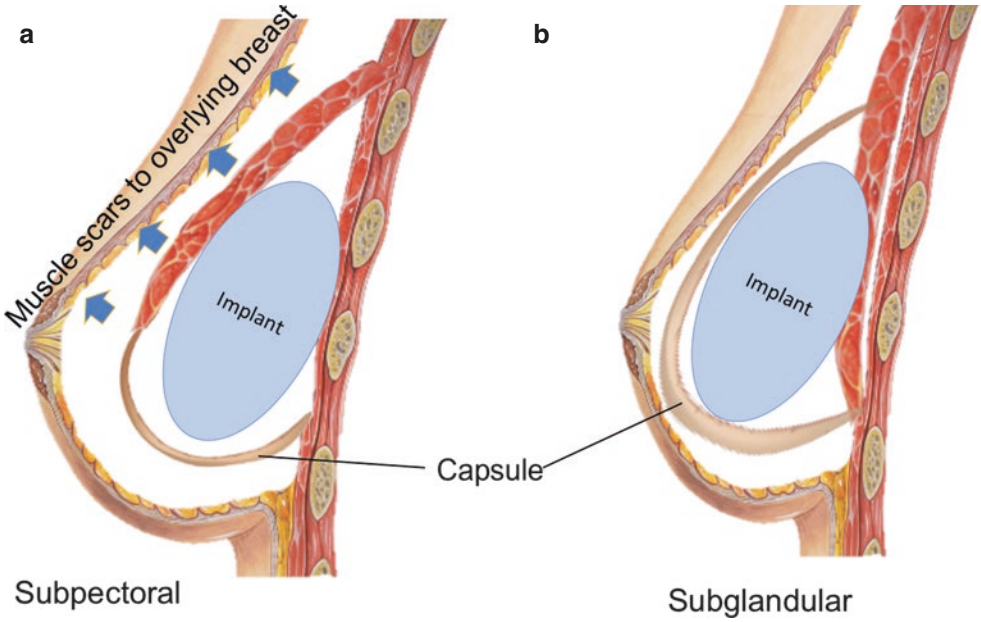

Fig. 15.6 In a submuscular augmentation, the inferior most pectoralis fibers that have been released scar to the overlying breast gland, resulting in unattractive animation deformity with pectoralis contraction (**a**). By converting the implant to a subglandular position, the implant and capsule now block the action of the pectoralis on the more superficial soft tissues, thereby eliminating animation with pectoralis contraction (**b**)

implant pocket. While multiple surgical modalities have been described, they all share in common a change of pocket with concomitant recreation of the original pectoralis attachments to the lower chest wall. This presumably allows reconstitution of the function of the pectoralis with contraction that does not interfere with the implant located in a separate anatomic plane. Moreover, the adhesion of the pectoralis to superficial subcutaneous and dermal attachments is severed, and the pectoralis is now buffered from the overlying skin by the intervening implant (Fig. 15.6).

There are several options for changing the pocket and reconstituting the pectoralis muscle to its native chest wall configuration, including a pectoralis splitting biplane technique, subglandular conversion, and subfascial pocket conversion. The following sections discuss specifics of some of these techniques, including the author's preferred approach [14].

Pectoralis Splitting Biplane Technique

A split-muscle approach has been described for correction of animation deformity, which places the implant in a partial submuscular plane [15–18]. In the muscle splitting biplane technique, a new pocket is created for the lower pole of the implant by dissecting anterior to the pectoralis major. At the junction of the middle and lower third of the pectoralis, however, a muscle-splitting dissection is performed parallel to the direction of the pectoralis muscle fibers, with dissection cranial to this point proceeding underneath the pectoralis (Fig. 15.7) [15]. The benefit of this approach lies in continued muscle coverage over the upper pole to prevent implant visibility and rippling, while eliminating lower pectoralis fibers that seem to contribute most to animation deformity. The one caveat here is that depending on the level of the split pectoralis, there could be residual animation as the upper pectoralis fibers retain their relationship to the underside soft tissues of the upper pole of the breast.

Subglandular Technique

The most straightforward way to correct animation deformity is to eliminate the pectoralis altogether and simply place the implant in a subglandular pocket. To do this, the breast parenchyma is elevated off the pectoralis muscle, and the muscle is tacked back down to the chest wall, with the implant pocket now residing anterior to the muscle (Fig. 15.8). When doing this, however, one has to be aware of the IMF location and avoid disruption to this structure as this pocket conversion requires dissection through the more superficial tissues. Given the revision and secondary attention of these supporting tissues, a pocket change may be subject to more "bottoming out." To ameliorate this, additional capsulorrhaphy may be prudent. It may also be necessary to support the implant with a biologic or synthetic mesh in the lower pole to prevent attenuation of the IMF from the weight of the implant in this new plane (Fig. 15.9). Studies reporting on the management of animation deformity with conversion to a subglandular plane have reported a 100% success rate in correcting the animation [19–23]. Levasoy and colleagues reported on 36 patients with unwanted movement of the implant after subpectoral augmentation. All 36 patients had resolution of animation deformity at an average 20 month follow-up with conversion to a subglandular plane [19].

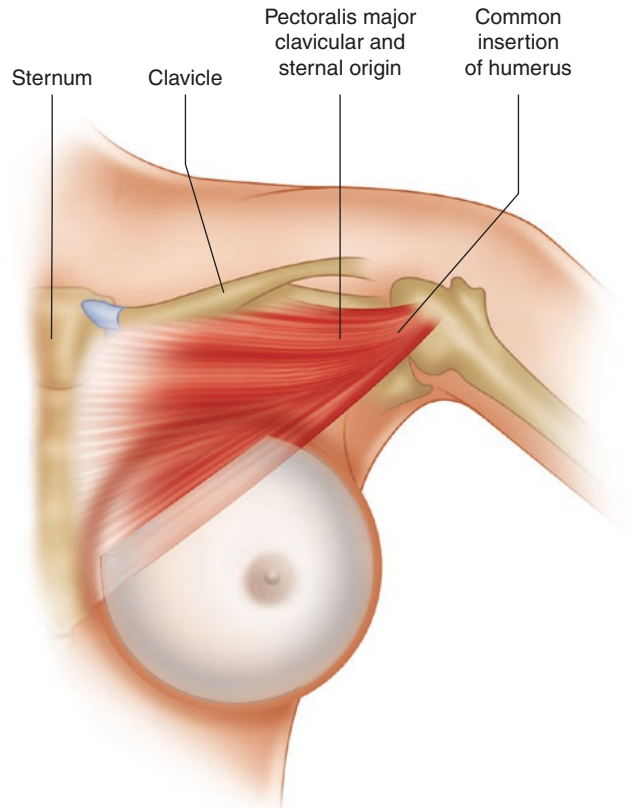

Fig. 15.7 Demonstration of the muscle splitting biplane approach, which still allows the superior pole of the implant to be covered by pectoralis muscle while eliminating lower pole pectoralis coverage (which now sits behind the implant)

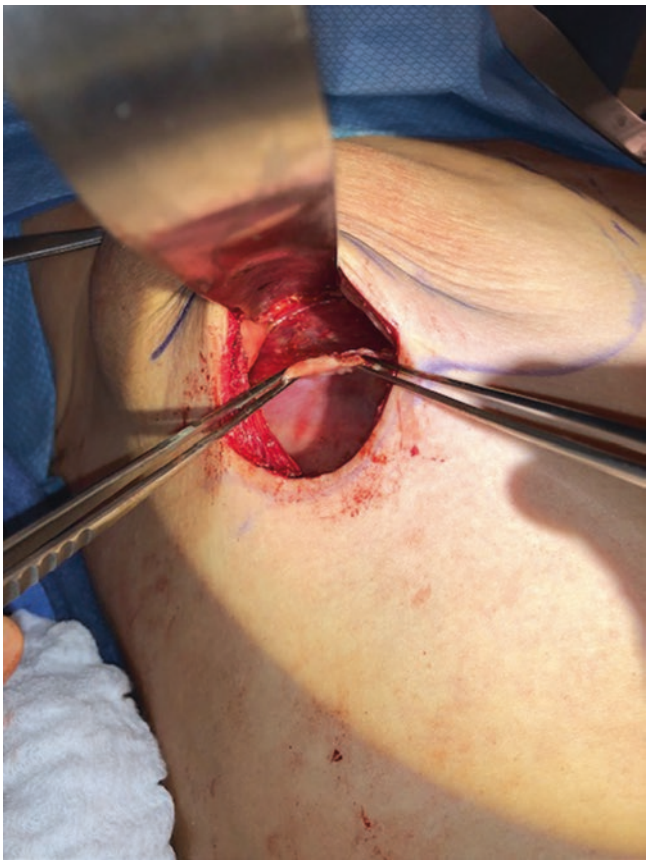

Fig. 15.8 Intraoperative dissection of the pectoralis muscle off the overlying breast parenchyma. The old implant pocket was under the pectoralis, but the new implant pocket will reside above the pectoralis after it is tacked back down to the chest wall

Similarly, Gabriel and colleagues reported on 102 breasts postreconstruction in the subpectoral plane with complete resolution of animation deformity after conversion to a prepectoral pocket with acellular dermal matrix reinforcement (average 17 month follow-up) [23]. More granular studies using semiquantitative scales to measure the improvement in animation have not been performed.

While conversion of the implant from a submuscular to a subglandular plane eliminates the pull of the pectoralis on the implant, subglandular placement is associated with higher rates of capsular contracture and is contraindicated in women with a poor skin envelope [24, 25]. The subfascial plane (above the pectoralis muscle but deep to the investing pectoralis fascia) provides another anatomic boundary between the skin and the implant, potentially masking implant edge visibility in the superior pole. It also guards the implant from the glandular ducts, which may decrease biofilm formation and subsequent capsular contracture. However, there is a paucity of studies directly comparing subglandular and subfascial techniques; the downside to going subfascial is the additional dissection directly over the muscle fibers with concomitant risk of additional bleeding.

Author's Preferred Technique

The author's preferred technique is a subglandular pocket conversion with absorbable mesh support. There can be less secure peripheral boundaries medially, laterally, and inferiorly with the subglandular change so care must be taken to ensure that overdissection does not occur. Secondly, with the preponderant use of smooth implants, there is a propensity for micromotion to result in erosion of those initially created surgical boundaries. Hence symmastia, bottoming out, and lateral migration are all concerns with the pocket change to the subglandular plane. The judicious use of capsulorrhaphy with absorbable mesh helps secure the position and placement of the implant. Occasionally, the animation will occur in conjunction with a double bubble and correction and release of the investing superficial fascial fibers, and condensation to superficial breast tissue may be needed (see Chap. 1 for additional details).

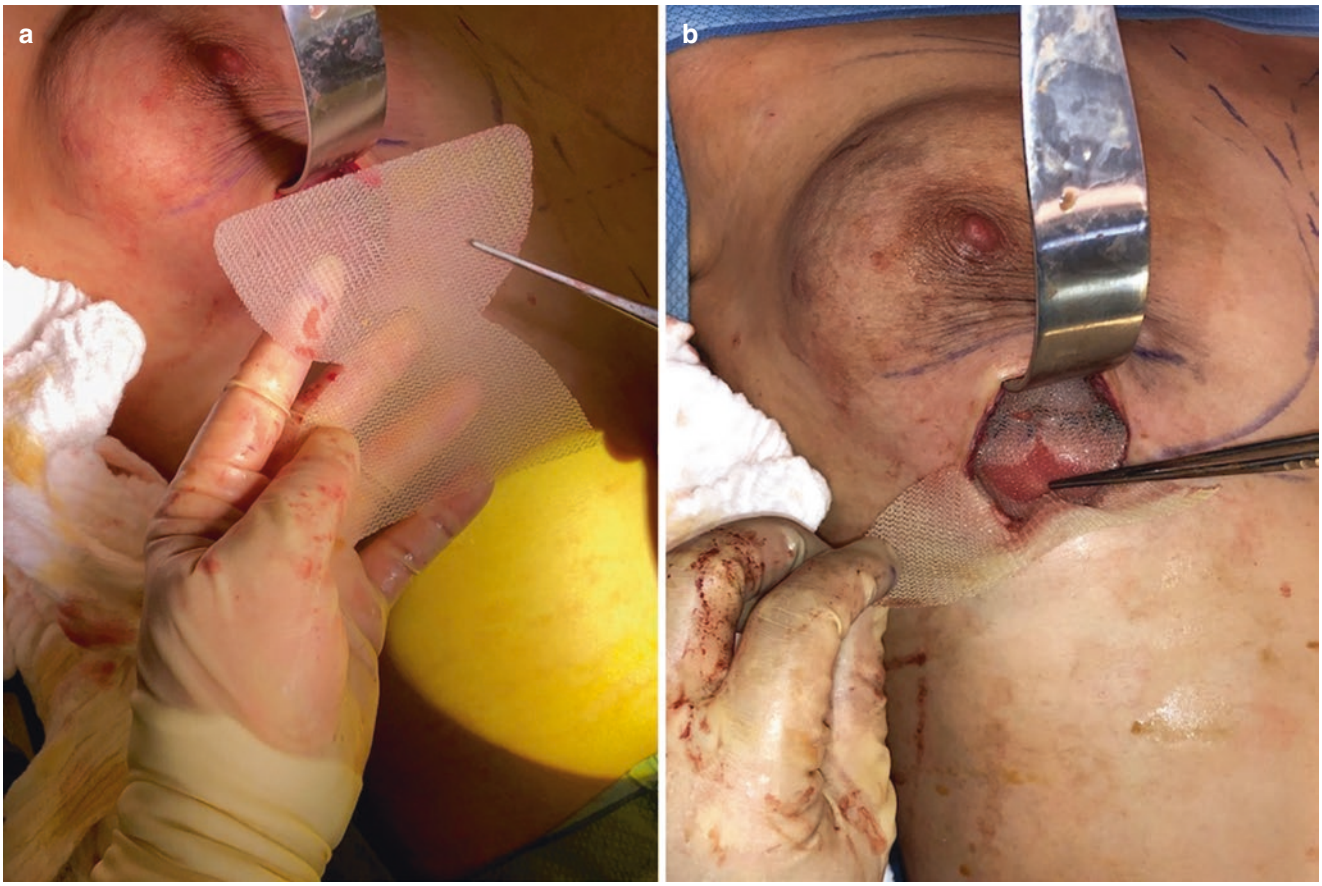

Fig. 15.9 Subglandular conversion of the implant pocket may require support with mesh to prevent downward migration of the implant with time on the attenuated IMF. (**a**) We prefer to use a butterfly-shaped mesh, with one wing of the butterfly tacked to the chest wall, the thorax of the butterfly tacked at the level of the IMF, and the other wing of the butterfly sitting anterior to the implant against the breast parenchyma. (**b**) This creates a hammock to support the implant at the level of the IMF

Conclusion

Animation occurs from the biomechanical alterations to soft tissue and muscle that arise from a subpectoral placement of an implant. The pectoralis muscle– released from its inferior and deep attachments– will adhere at varying degrees to the superficial breast parenchyma and concomitant capsule. This, in turn, will generate a distortion of surface anatomy and implant position when muscle contraction occurs. There are varying degrees of animation, and an anatomic classification scheme is presented based on classic pathophysiologic features. Clinically significant animation deformity may be addressed facilely and effectively by changing the position of the implant to a pocket superficial to the pectoralis and reconstituting the pectoralis attachments to the lower chest wall.

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Part II

Breast Reduction, Mastopexy, and Augmentation-Mastopexy

Principles for Pedicle Choice: Avoiding Vascular Compromise

16

David W. Grant, Austin Y. Ha, Marissa M. Tenenbaum, and Terence M. Myckatyn

Introduction

Reduction mammaplasty, or breast reduction, is a very common procedure, with over 102,000 reconstructive (59,200) and aesthetic (43,600) procedures performed in the United States in 2017 [1]. This compares to 330,000 augmentation mammaplasties, 105,000 mastopexies, and 106,000 breast reconstructions (performed by ASPS members) in 2017 [1].

Symptomatic hypermastia has a considerable burden on a woman's quality of life, and data support this effect is on par with other severe chronic medical conditions [2, 3]. Reduction mammaplasty can, therefore, provide significant improvement for a woman's quality of life, alleviating symptoms like back pain, neck pain, bra strap grooving, dermatologic complaints, and psychosocial distress [4–7]. Indeed, reduction mammaplasty is a procedure with very high postoperative patient satisfaction scores, almost on par with augmentation mammaplasty [8–10].

Successful reduction mammaplasty is understood to achieve three goals. Understanding these separate goals is a useful way to understand vascular compromise:

1. Aesthetic appearance: nipple-areolar complex (NAC) position, parenchymal shape, and acceptable scars
2. Viable NAC, with preserved pigmentation
3. Sensate NAC

A fourth goal is achieving lactation, although this specific goal of breast reduction surgery in the prepartum patient is outside the scope of this chapter. A recent systematic review found that preserving a subareolar column of tissue can greatly improve the chance of postoperative breast feeding in women undergoing reduction mammaplasty and is a resource for further reading [11].

What does vascular compromise mean in the setting of reduction mammaplasty? It can be practically broken down into minor complications and major complications. "Minor" complications do not preclude achieving these three goals and include postoperative surgical site infections, often managed nonoperatively, minor wound dehiscence treated with local wound care, epidermolysis not involving depigmentation of the NAC, and minor areas of fat necrosis. All of these complications are affected by patient factors like smoking and diabetes [12], and surgeon factors, like tissue handling as well as vascularity of the reduced breast; so an understanding of breast vascularity and specifically avoiding vascular compromise can help prevent these minor complications, although encountering them does not preclude successful reduction mammaplasty.

Major complications are understood to interfere with achieving our goals: aesthetics (shape, NAC position, scars [13]), viable NAC, and sensate NAC. An important concept to understand when considering *vascular compromise* is the degree to which it compromises each of the three goals: encountering vascular compromise while performing pedicle-based reduction techniques might only affect the viability of the NAC itself – resulting in loss of two of three goals (viable NAC, sensate NAC) [14], it can also affect the entire pedicle – meaning a potentially significant parenchymal loss as well, causing potentially significant distortion of the entire breast parenchyma and significant asymmetry, equating with a failure of all three goals (also the overall aesthetic shape). Said another way, losing the NAC

D. W. Grant · A. Y. Ha · M. M. Tenenbaum · T. M. Myckatyn (✉)
Division of Plastic and Reconstructive Surgery, Department of Surgery, Washington University School of Medicine, St. Louis, MO, USA
e-mail: myckatyn@wustl.edu

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constitutes failure of only two of three goals of breast reduction, but significant pedicle loss constitutes failure of all three goals. This can be very difficult to fix and often requires reconstructive surgery and scars outside the normal scope of reduction mammaplasty. The surgeon therefore has the choice – do they attempt to achieve all three, or compromise, and settle on choosing two more reliably. Like all areas in plastic surgery, this comes down to patient selection. A systematic review identified a rate of partial nipple necrosis to range from 0 to 13.1%, with most studies clustering lower than 5%; total nipple necrosis was rarely reported [15]. Therefore, an understanding of avoiding vascular compromise is critical to successful reduction mammaplasty.

Common Techniques in Reduction Mammaplasty: Vascular Supply and Safety Tips

Many techniques have been reported to achieve successful breast reduction. The common techniques are:

1. Suction lipectomy – used alone or in combination with the below
2. Parenchymal wedge resections
3. Pedicle-based techniques
4. Free nipple graft techniques – including both pedicled and non-pedicled techniques

The chosen technique should match the patient's goals, expectations, tolerance for complications and reoperation, as well as the surgeon's familiarity with each technique and her assessment of a patient's candidacy for each technique, all while recalling the three goals of successful reduction mammaplasty: (1) aesthetic shape, (2) viable NACs, (3) sensate NACs.

The most important consideration when matching the reduction technique to the individual patient is considering what goals are desired, versus what goals are likely. It can be reasonably assumed all women want to achieve all three goals: an aesthetic breast with NACs that are perfused and sensate. It is the surgeon's role to identify women in whom operative plans designed to achieve all three goals can result in achieving none – secondary to vascular compromise. These women must be identified and compromise is necessary.

Generally speaking, the larger the needed reduction, the more aggressive the technique needs to be. Therefore, a useful structure in which to frame breast reduction techniques is the degree of control over NAC position, parenchymal reshaping, and skin redraping:

1. Less control, allowing more modest changes to breast aesthetics:
   (a) Suction lipectomy
   (b) Wedge resection
2. Full control, allowing substantial changes to breast aesthetics:
   (a) Pedicle-based techniques
   (b) Free nipple grafting techniques

Techniques with less control are safer because the NAC and breast parenchyma are perfused by more than one pedicle; therefore, the chance of vascular compromise is unlikely. Such techniques offer less control so patient selection is critical – patients must have modest deformities and require modest corrections. Presence or absence of significant pseudoptosis drives the surgeon toward or away from needing a wedge resection in addition to suction lipectomy.

Techniques offering full control come with risks of vascular compromise but can produce a more substantial change. Typically, the safest choice moves from pedicle-based techniques to free nipple grafting as the degree of breast reduction increases.

Suction Lipectomy

Suction lipectomy is a very valuable technique alone or as an adjunct in breast reduction. Used alone, suction lipectomy gives the surgeon less control over aesthetic NAC position and parenchymal shape, with more guaranteed NAC viability and sensation. If enough fat is removed, suction lipectomy alone should alleviate symptoms, and surgeons with extensive experience using suction lipectomy alone for breast reduction even report success with moving the NAC position. For example, Lawrence Gray reported his experience in 1998 and again in 2001 [16, 17], in which 204 breast reductions were performed with liposuction only, obtaining substantial reduction: 300–2250 cc per side, averaging 850 cc removed. He reported 100% resolution of symptoms, improvement in nipple position 2–12 cm, average 6 cm, and stable at 6 months postop, zero infections or skin loss, and presumably zero NAC losses, although this was not specifically reported. He reported no microcalcifications on mammograms. These data suggest suction lipectomy to be a reasonable choice in the appropriately selected patient: conservative ptosis correction, minimal excess skin, and/or a surgeon very experienced in this technique.

Suction lipectomy can also be used as an adjunct in primary and secondary breast reductions, allowing less skeletonizing of the pedicle with consequently less risk of vascular compromise.

Parenchymal Wedge Resection

In patients with pseudoptosis only, and who do not need elevation of the NAC, an inferior wedge resection offers a simple and safe procedure to reduce volume while maintaining blood supply primarily by the second and third IMA perforators, hiding the scar in the inferior pole [18]. Lateral wedge resections have also been described [19]. Since the NAC is not being skeletonized on a narrow pedicle, the chance of vascular compromise is unlikely. Patient selection with specific reference to selecting patients with pseudoptosis and avoiding patients with real ptosis is critical. Inferior wedge resection is a valuable tool for secondary breast reductions, as discussed later.

Pedicle-Based Reduction Mammaplasty

The majority of plastic surgeons perform breast reductions using pedicle-based techniques, as reported in Maintenance of Certification Data from 2014 [8]. Pedicle techniques gives the surgeon full control over parenchymal shape, NAC position, and skin redraping, and can offer significant transformations in breast aesthetics. In general, the authors prefer pedicle-based techniques for primary breast reductions. It is our strategy therefore to identify those women who may fail pedicle-based techniques, usually because the pedicle is too long, and instead perform free nipple graft techniques. We therefore are choosing to compromise on achieving only two of the three goals: aesthetic shape, viable NAC, and not achieving a sensate NAC is to identify what women might fail pedicle-based techniques. Within this frame of reference, the trade-off is between achieving goals (1) *aesthetic shape* and (2) *viable NAC*, with goal (3) *sensate NAC*. In most patients, all three can be achieved. Our goal is to identify those patients in which compromise is necessary, where sensate NAC is sacrificed in order to achieve perfused NAC and aesthetic reconstruction. In those women, we elect for free nipple graft techniques.

Traditional teaching is that pedicle techniques should not be used when:

1. Either resection volumes are above 1000 g, although this recommendation ranges from a little as 700 g [20], 1500 g [21], to greater than 2500 g [22]
2. Or pedicle length exceeds 20–25 cm – for inferior pedicle, the pedicle length is also the nipple to IMF. For superior/superomedial techniques, the pedicle is arising from the second or third intercostal space, which corresponds to a suprasternal notch to nipple (SSN-N) distance of roughly 35–40 cm it is important to understand that in the same patient pedicle length is usually longer for inferior pedicle designs than superomedial designs.

The decision to use a superomedial versus inferior pedicle in breast reduction is largely surgeon preference. Some evidence exists of equality between the two techniques [23, 24], while other evidence suggests long-term superiority of superomedial breast reductions in specific domains of projection, contour, and overall satisfaction, measured at 1 year postoperatively [25]. Our practice is to choose a superomedial pedicle for most reductions because we have found pseudoptosis, or bottoming out, and true ptosis is less common long-term with superomedial pedicles than inferior pedicle reductions, likely because the breast weight is held by the pedicle, while the skin envelope is holding the breast weight in inferior pedicle designs The superomedial pedicle also typically produces a shorter pedicle than the inferior pedicle in the same breast, as mentioned earlier, and so it for these reasons taken together that the authors prefer superomedial reduction techniques.

Inferior Pedicle Techniques

Most plastic surgeons use inferior pedicle-based techniques with wise-pattern skin excisions [8, 26], which is likely why most data exist for inferior pedicle techniques. There is controversy over what measurement is most important in inferior pedicle breast reductions – is it specimen weight, SSN-N distance, or pedicle length? Most of the published literature reports specimen weight as the key variable for NAC necrosis. It is our and others' opinion that a basic principle in plastic surgery dictates the pedicle length is most important: until we can better identify pedicle vessel course preoperatively, dermoglandular flaps are random flaps and guided by length to width restrictions as are other tissues in the body. The factor we think about most importantly when performing inferior pedicle breast reductions is not SSN-N – which does not measure pedicle length – but nipple to IMF distance. This has been shown to vary less than SSN-N [27].

Some authors have evidence for the more conservative need of free nipple grafting when resection specimens approach 700 g. Hawtof et al. retrospectively reviewed 268 patients undergoing inferior pedicle-based breast reduction versus free nipple graft techniques [20]. When they specifically looked at patients with specimen weight >700 g (54 of 268), they found six "significant" complications (defined as wound dehiscence, and nipple or skin loss) in 35 patients treated with inferior pedicle techniques, whereas zero in 19 patients treated with free nipple grafting. The authors concluded free nipple grafting is safer in large reductions, defined as greater than 700 g [20]. They did not separate

wound dehiscence from NAC loss, and there was no patient satisfaction reported in the study. Of note, the suprasternal notch to nipple distance was only 2 cm different between patients with and without partial nipple loss.

Data also exist that reduction specimens >1000 g do not necessitate free nipple grafting. Al-shaham [28] reported a series of 66 patients and 132 breasts that underwent inferior pedicle reductions of >1000 g per side, using a base of 8–10 cm. The purpose of the study was to understand causes of nipple necrosis in large reductions >1000 g. Two patients (four breasts; 3.03%) exhibited vascular compromise to the NACs *intraoperatively*, and conversion to free nipple graft was performed. The ischemic NACs were different from nonischemic NACs: specimens with ischemic NACs weighed more, i.e., 1950–2250 g, which was also at the authors' very highest end of specimens, with only four breasts weighing above 2000 g and most weighing <1500 g. But the pedicle lengths were also longer in ischemic NACs, measuring 23–25 cm, which was at the very highest end of the authors' sample, most measuring 17–20 cm. This study demonstrates that the traditional teaching of free nipple grafting over a specimen weight of 1000 g is likely too conservative when using an inferior pedicle technique with base width of 8–10 cm. It also suggests a pedicle length >20cm can identify women at risk of NAC loss, and would benefit from a discussion of converting to free nipple graft techniques either preoperatively or intraoperatively. It is also helpful to note that using inferior pedicle techniques allows the surgeon to measure pedicle length *preoperatively* and can have a more risk-adjusted discussion with the patient about needing to convert to a free nipple graft.

In our practice, inferior pedicle techniques are done with a base width of 8 cm, erring on narrower – somewhat counterintuitive – to prevent excessive kinking during the closure. If the nipple to IMF distance is >25 cm, we counsel the patient that she will likely need a free nipple graft. Of note, other authors have argued that inferior pedicle lengths of up to 28 cm as safe [22]. The decision is made intraoperatively, with a low threshold to convert. This is done by removing the NAC as a full-thickness skin graft, then dividing the distal pedicle to a length closer to 15–20 cm. Since we do not commit to the NAC position at the start, we can place it where it looks the most appropriate after closure. A bolster is used for 5–7 days. Specific risks and complications we discuss with patients are below.

Superomedial Pedicle Techniques

Superomedial pedicle length is not the same as SSN-N distance – it is quite shorter, arising not from the SSN but from the second or third intercostal spaces – but this pedicle length is most often not reported in the literature. Final specimen weight is reported, making an a priori candidacy decision for superomedial pedicles versus free nipple grafting less precise; therefore, clinical experience with anticipated reduction volumes and actual reduction volumes becomes imperative.

Brownlee et al. retrospectively reviewed 135 breasts undergoing superomedial reductions at a single institution and found an NAC necrosis rate of 0% in the groups where 1200 g or less of tissue was removed and 2.3% ($n = 1$) in the group where greater than 1200 g of tissue was removed. Since the results were not statistically significant, the authors concluded that increasing reduction specimens, up to 2569 g, does not increase risk of NAC necrosis [15].

In our practice, the pedicle can be safely made 2–3 cm thick based on the vascular anatomy described elsewhere in the text, allowing reduction of breast parenchyma beneath the pedicle (it does not have to remain attached to the chest wall beneath the NAC). The total reduction is a C-shape, well described elsewhere, leaving medial fullness (Fig. 16.1).

Free Nipple Grafting

Free nipple grafting is a useful technique for massive breast reductions. The procedure consists of taking the NAC as a full-thickness skin graft (FTSG), thinning it beneath the nipple, and transferring it to a recipient site that has been de-epithelialized. Postoperative care is done in the standard fashion. The grafts are rarely lost and can produce a good outcome [20]. The advantage is the surgeon has full control over reshaping the breast parenchyma, using shorter pedicles where vascular compromise is not a concern because the pedicle has been shortened to a safer length, or techniques involving no pedicles at all, such as a more aggressive inferior wedge resection or even breast amputation.

Patients do need to be warned about specific issues:

1. Dyspigmentation – an important drawback to free nipple grafting is the potential for permanent hyper- or hypopigmentation of the NAC. This is different from the predictable healing phase of a full-thickness skin graft that involves sloughing of the epidermis and depigmentation, giving the false sense that the grafts have failed, so patients need to be warned of this and supported through dressing changes while things heal. The pigmentation eventually comes back, although it can take up to a year, and patchy areas of dyspigmentation can be permanent. Nipple tattooing can address this.
2. Lack of sensation – only pedicled techniques will preserve nipple sensation. Free nipple grafts will be insensate, although the degree to which patients are bothered by this is decreased with appropriate preoperative counseling.

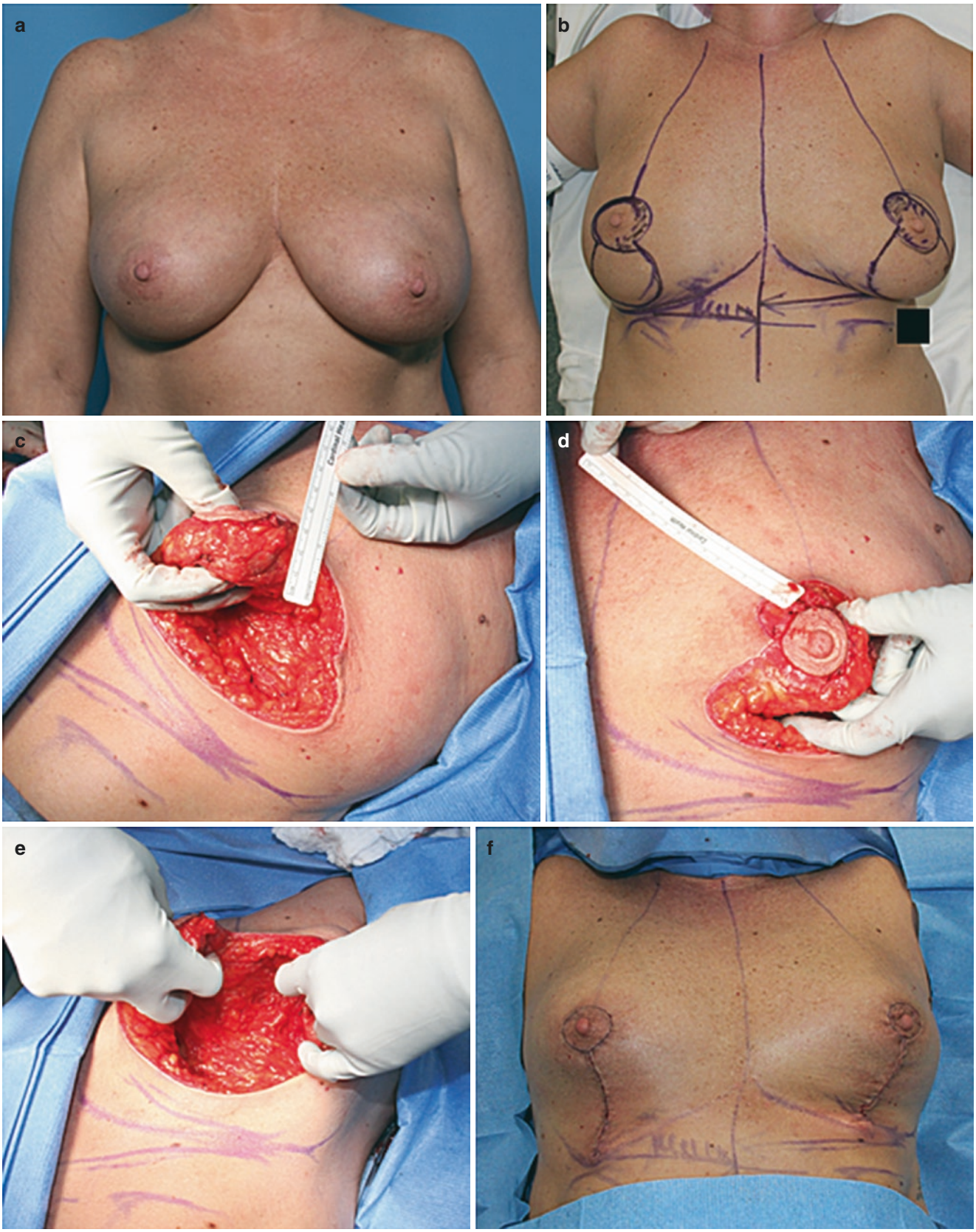

Fig. 16.1 Superomedial pedicle breast reduction with circumvertical skin resection. (**a**) Preoperative photographs, standing. (**b**) On-the-table markings showing a right-sided medial pedicle to achieve a modest NAC elevation and a left superomedial pedicle for more NAC elevation. Note IMF asymmetry; left is higher than the right, so right side was thinned more inferiorly to raise the IMF. (**c**) Pedicle is 2–3 cm thick. (**d**) Pedicle length is 12–14 cm from the second interspace, corresponding to the main blood supply for the superomedial pedicle. (**e**) C-shaped resection of breast parenchyma. (**f**) On-table result

3. Lack of projection – free nipple grafts will have much less nipple projection than before surgery, although, generally speaking, the less projecting NACs will be symmetrically less projecting.
4. Inability to breastfeed – If a patient is felt too high risk for pedicle-based reduction mammaplasty but still wishes to breast feed after surgery, we recommend delaying surgery until she is finished breast feeding. Free nipple grafts do not allow breast feeding.

Special Considerations

Secondary Reduction Mammaplasty: The Rereduction

The most important consideration in secondary breast reduction surgery is identifying the reason the patient is seeking rereduction. Generally, the reasons are as follows:

1. Size
2. Shape
3. NAC position
4. Asymmetry
5. Presence of lateral chest fullness
6. Spreading scars

The surgeon must rule out breast cancer first and foremost with mammography and referral to oncologic surgeons as necessary. This is considered most important in the women who was initially happy with her reduction, perhaps for many years, and now presents with recurrent macromastia. Otherwise, the patient's specific complaints will guide treatment.

Considering vascular compromise and its avoidance, two specific situations deserve attention:

1. Rereduction – characterized by the patient who was never happy with her reduction, even after early postoperative edema resolved.
2. Mastopexy – characterized by the patient initially happy with their reduction, but in whom ptosis or pseudoptosis develops years later. Recurrent ptosis after breast reduction can be common [29].

The key considerations return to the main goal of reduction mammaplasty: aesthetic shape, including parenchyma and NAC position.

1. Is it a shape or volume problem? Will volume-only reduction achieve the patient's goals, without adjusting NAC position?
2. Is it a problem with NAC position? Does the NAC need to be moved so much that transposition is required, or can local skin removal or rearrangement fix the problem?

If volume alone is the problem, volume reduction may be achieved with suction lipectomy, or wedge-resection techniques. In the more common case of a woman unhappy with volume and shape due to pseudoptosis, an inferior wedge resection will address her complaint. In this case, the NAC is not repositioned, so avoiding vascular compromise is achieved by not undermining the NAC while performing the wedge resection, and being conservative with suction lipectomy near the NAC [18]. It is, therefore, very important to distinguish between ptosis and pseudoptosis in the preoperative assessment, as correctly diagnosing pseudoptosis can avoid repositioning of the NAC and the inherent vascular risk in doing so.

If the NAC must be transposed, typically to raise it, the consideration most obvious is location of previous reduction pedicle. If the primary pedicle is known, it can be reelevated and used to drive the secondary reduction. If the primary pedicle is unknown, opinions are divergent: free nipple graft is recommended, citing the high rate of complete NAC loss [29]. Other authors have performed re-reduction using a pedicle known to be different from the first reduction, and report zero long-term complications in 10 cases [30]. A review by Austin, Ahmad, and Lista was recently published on this topic [31], and the authors argued their technique based on IMA perforators has been successful in over 40 patients undergoing rereduction, even when the primary pedicle is unknown.

It is the authors' opinion that rereduction is safe, even when the prior pedicle is unknown. Practical tips for those starting out are to discuss the potential need for a free nipple graft, err on smaller rereductions, and avoid rereductions in smokers or the radiated breast.

Management of Vascular Compromise

How to manage vascular compromise depends primarily on timing: if the compromise is recognized early, it can be potentially reversed. In this framework, "early" is fundamentally related to whether you can convert to a free nipple graft after salvage maneuvers have failed. If compromise is not recognized and the patient presents with frankly necrotic tissue, this represents "late" vascular compromise and is managed by reconstructive techniques. Typically, "early" vascular compromise is recognized either in the operating room or in the recovery area. If recognized in the recovery area, it is generally advised to return to the OR as needed, after a discussion with the patient.

The first determination is whether the compromise is arterial insufficiency or venous congestion. Recognizing *arterial insufficiency* intraoperatively has only a few causes.

- Hypoperfusion – ensure the patient's blood pressure is adequate and is producing urine, reflecting adequate perfusion. Warm the patient.
- Pedicle kinked – can be ruled out by taking down all sutures.
  - If the NAC becomes perfused, can attempt securing the pedicle with a suture to prevent kinking and reclosure.
  - Can reclose loosely with a sterile dressing, and then when edema resolves in a few days, finalize the closure.
- Pedicle divided – in this case, converting to a free nipple graft is the safest option, with resection of nonperfused pedicle, and performing requisite symmetry procedures on the contralateral side, after discussion with the patient.

Recognizing *venous insufficiency* should alert the surgeon to compressive phenomenon:

- Hematoma – return to the OR for evacuation, take down all sutures.
- Pedicle is kinked – take down all sutures/staples and reexamine after a few minutes, then carefully reclose, ensuring pedicle does not become kinked.
- Too tight of closure – loosen the closure. If loose closure is successful, it is likely tissue edema is contributing, and waiting a few days will enable reclosure.

Typically, *late* vascular compromise is identified in the clinic. If the patient comes to the clinic and has a frankly necrotic NAC, the surgeon should empathize that this is an undesired outcome, begin local wound care to prevent infections (our practice is Silvadene twice daily with meticulous hygiene), and observe the patient until the full extent of tissue loss has been determined. Secondary reconstruction can be planned depending on which of the three goals of reduction mammaplasty has not been achieved:

- *Failed to create a viable NAC that is sensate – no parenchymal loss*: Sometimes local wound care is all that is needed, and the NAC will recover on its own to an acceptable degree [14]. If this is unsuccessful, the simplest treatment is likely adequate debridement and a short course of local wound care, followed by full thickness skin grafting. The resulting NAC will be of similar shape to the contralateral side but will have a different color and will not support nipple reconstruction. It can, however, support tattooing, and with 3D tattoos now this result can be quite aesthetic. If the patient desires autologous nipple reconstruction, there are two general options. In the right patient, she can subsequently undergo a nipple sharing procedure a few months after the skin graft has taken. Otherwise, the index debridement will have to include moving healthy breast parenchyma and skin to close the defect. Goals in this situation are to minimize shape/volume distortion and place the final scar all within the final areolar footprint, which can be hidden with tattooing after nipple reconstruction by standard techniques.
- *Failed to create a viable NAC that is sensate as well as significant parenchymal loss*: If the amount of parenchymal loss is significant, appropriate debridement and closure will result in significant shape and volume differences. In our opinion, it is better to debride and close the breast, settling for a smaller size but less distorted shape, then debriding and letting the resulting wound heal by secondary intention. While the goal may be at first to minimize the amount of tissue debrided and maximize the resulting symmetry, our opinion is that contraction will cause distortion that will be much harder to fix, than if the surgeon shapes the breast at this secondary stage. Subsequent reconstruction to match volume and shape rely on techniques from postoncologic breast reconstruction, namely, contralateral rereduction, and/or ipsilateral fat grafting, implant placement, and local flaps. Fat grafting can potentially produce a beautiful result but will take multiple stages if the volume loss is significant and comes with risks of fat necrosis and a lumpy breast if the technique is not done correctly with patience. Implant placement is conceptually the most straight forward way to fix a volume asymmetry but getting insurance approval becomes challenging. We have no personal experience in this situation. Local pedicled flaps like the intercostal artery perforator (ICAP) flap can potentially be used to augment volume while hiding scars in places similar to Wise pattern incisions.

Management of Parenchymal Fat Necrosis

Reports from the early 1990s indicated a low incidence of parenchymal fat necrosis following breast reduction but also underscored how undesirable this complication is, considering how hard it is to distinguish from breast carcinoma [32]. Newer studies have identified rates of fat necrosis between 2.7% and 8.4% with reoperation rates as low as 1.4% [33–35]. Avoidance by good surgical technique is best, but if fat necrosis develops, treatment is guided by timing. It is best to closely observe, and if persistent by 6 month, an excisional biopsy is both diagnostic and therapeutic [36].

Future Directions

Authors have described ways of determining patient-specific perfusion to the NAC in vivo, including laser Doppler flowmetry [37] and fluorescein angiography [38]. These evaluations were performed after pedicle division and NAC inset.

In our opinion, the opportunity exists in identifying patient-specific NAC perfusion *before* choosing the reduction technique. Such women with grade III ptosis and extreme notch to nipple distances, who might otherwise be candidates for free nipple grafting and success in two of three goals, could conceivably undergo safer pedicle techniques and achieve all three goals. Given the rarity of NAC loss with established methods, such a technology would have to be inexpensive, noninvasive, accurate, reliable, and likely done outside of the operating room.

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Modern Solutions to Traditional Problems and Complications of Gynecomastia

17

Dennis J. Hurwitz and Ahmed Taha Darwish

Introduction

The problems following correction of gynecomastia relate to poor healing or treatment that is inadequate or unsatisfactory. Gynecomastia is benign enlargement of the male breast, with a 36% incidence [1]. The psychological burden is depression, anxiety, and social phobia [2, 3]. The aesthetic goal is subtotal glandular reduction, with proper position and shape of the nipples, obliteration of inframammary folds, and tightly adherent chest skin reflecting underlying the musculoskeleton [4]. Extensive skin reduction scars detract and pectoralis muscle expansion enhances the result.

Poor healing may be caused by hematoma, seroma, wound separation, or necrosis of skin or fat. A high incidence of hematoma and seroma are due to operating through a confined approach and leaving widely undermined tissues. Avoidance is through meticulous electrocautery hemostasis and diligent compression through drains and elastic garments. Through reduced bleeding and retention of considerable fibrous connective tissue, ultrasonic-assisted lipoplasty (UAL) is rarely complicated by hematoma or seroma. As such, suction drains are reserved for open resections. The treatment of hematoma is by liposuction evacuation or seroma by sterile needle aspirations. Recurrent seroma is treated by percutaneous drain insertion. Secondary infection demands drainage and perhaps debridement with appropriate antibiotics. Mature seroma cavities require resection of lining and suture closure of the dead space. Nipple areola (NAC) or skin loss along closure and contour deforming require reconstructive surgery. Even with excellent primary healing, hypertrophic scars and/or asymmetry may follow periareolar and medial chest closure (Fig. 17.1).

Unsatisfactory treatment includes incomplete or excessive resection, residual skin laxity, and disturbing scars. Aggressive ultrasonic probes can remove some fibrograndular tissue, but the residual mound of palpable gland must be directly excised via a transareolar glandular pull-through resection. Overresection leaves contour depression, typically either a central doughnut hole or a perimeter step-off. A thick button of subareolar breast tissue needs to be left on the areolar flap to avoid a central depression. An illustrative case is a 43-year-old who requested correction of this postsurgical deformity, which embarrassed him so much that for the 26 years since his gynecomastia operation, he would not take off his shirt in public (Fig. 17.2, *upper*). Upon raising his arms, the depression was obvious (Fig. 17.2, *middle*). On the left chest, nearby inferior excess tissue served as an advancement flap to fill under the areola. The right chest depression was improved by 9 cc of lipoaugmentation. Even with arm elevation, there was no depression (Fig. 17.2, *lower*). Grade I and II patients are reluctant to accept scars beyond the NAC and seek alternative skin tightening technology or pectoralis muscle lipoaugmentation.

With more complex cases, appropriate surgical intervention needs to be taken to correct deformity of the NAC, constriction of the breast, Grade III ptosis of the breast, severe sagging skin of the chest, and under development of the pectoral muscle. An initial recognition of the deformity and its extent leads to a directed approach and success.

Gynecomastia's variety of presentations dictates treatment and sequelae. Our modified Simon progressive deformity classification, based on breast size and tissue laxity, sorts out treatment options. Our modification accounts for constricted breasts, severe ptosis, misshapen areola, and skin laxity of the chest (Table 17.1). Our modified three-grade Simon classification [4] assigns *Grade I* as *minor enlargement* without skin redundancy; *Grade II a* as *moderate*

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D. J. Hurwitz (✉)
Department of Plastic Surgery, UPMC Magee Woman's Hospital, Pittsburgh, PA, USA
e-mail: drhurwitz@hurwitzcenter.com

A. T. Darwish
Department of Plastic Surgery, University of Cairo, Cairo, Egypt

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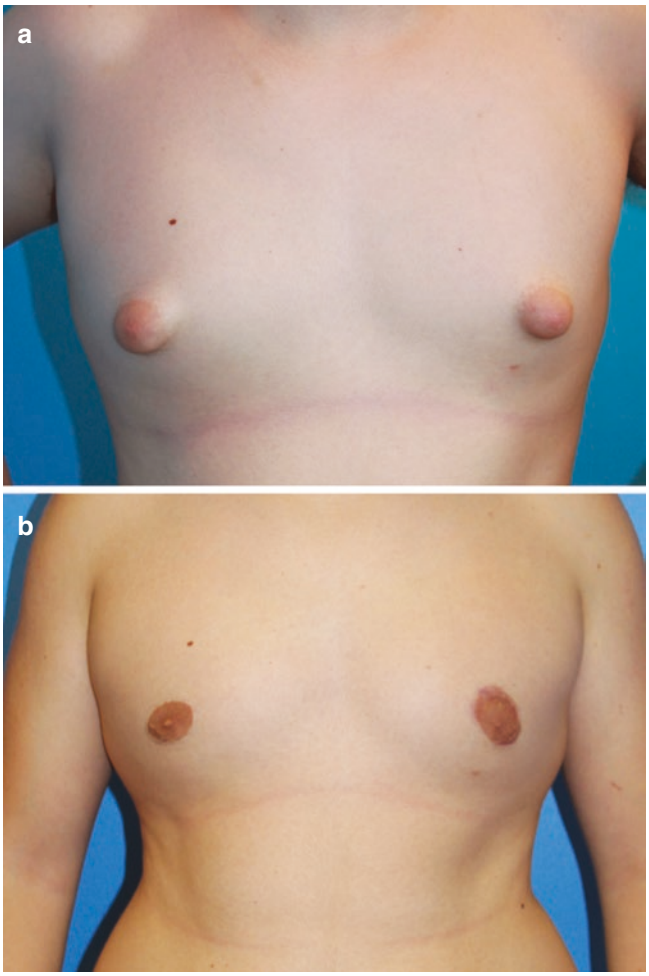

Fig. 17.1 Gynecomastia with asymmetrically constricted areola in an 18-year-old. (**a**) Prior to circumareolar mastopexy with direct excision of gynecomastia. (**b**) Complete correction of gynecomastia with plans to revise asymmetrical areolas

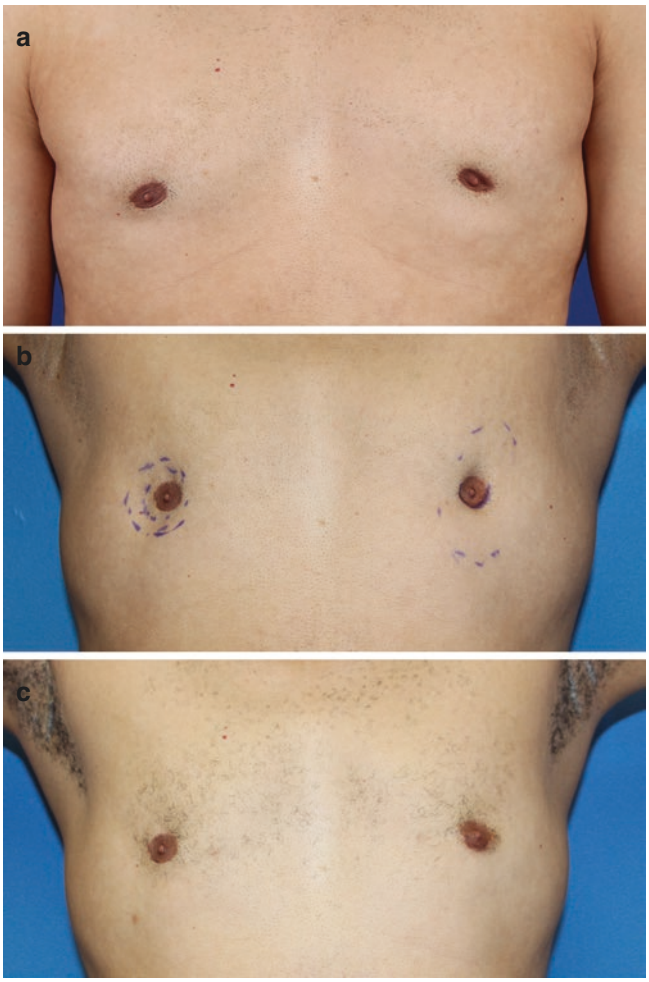

Fig. 17.2 Postgynecomastia depression. (**a**) Depressed areolas 26 years after his direct excision of gynecomastia. (**b**) Depression is worse with his arms elevated. (**c**) After correction with 9 cc lipoaugmentation under his right areola and inferior subcutaneous flap advancement under the left

enlargement without skin redundancy; *Grade II b* as *moderate enlargement*, with nipple ptosis/deformity, and minor skin redundancy; *Grade III a* as *marked enlargement* with nipple ptosis/deformity with skin redundancy or glandular deformity; and *Grade III b* as *marked enlargement* with sagging breasts and considerable upper torso skin redundancy as in the now common torso presentation after massive weight loss.

For Grades I and II, minimal scarring can be achieved by transareolar direct resection [5] or by wide area of liposuction, depending on retraction of the decompressed skin envelope [6]. Ultrasonic-assisted lipoplasty is considered a more effective removal technique for dense glandular and fibroconnective tissues [7]. Nevertheless, pull-through resection of the fibrous gland is often required [7, 8]. When liposuction leaves behind a mass of firm glandular tissue, a pull-through excision through an infraareolar incision completes removal of the fibrous portion of the gland.

Traditionally minor skin excess with nipple ptosis, Grade IIb is treated by periareolar mastopexy removal of a ring of excess skin. At times, the purse string closure heals with faded radiating pleats. Male breast skin does not shrink as smoothly as a female's. A periareolar resection is performed to reduce oversized areola and for hernia-like protrusion. Residual areola asymmetry may need to be corrected (see Fig. 17.1).

For moderate skin laxity, Grade IIb generally exhibits increased skin excess after excision of the gynecomastia and as such in the past has required lower breast transverse skin excision. That excision can usually be avoided through subcutaneous bipolar radiofrequency-assisted lipolysis with connective tissue tightening [9]. Over the past 3 years, this author has been proactively reducing skin laxity by the application of BodyTite® (InMode, Yoakum, Israel). Innovative patterns for necessary large skin resections for Grade IIIb

Table 17.1 Treatment options for the grades of gynecomastia

Grade	Excision	VASERlipo	BodyTite®	Pectoralis lipoaug.	Periareolar/lat. torsoplasty	Boomerang pattern	J-torsoplasty
I	X						
IIa	X	X					
IIb	X	X	X	X	X		
IIIa	X	X	X	X	X	X	
IIIb	X	X				X	X

have been both effective and aesthetic [10]. Measures may be taken to augment the pectoralis muscle through flaps or lipoaugmentation to both increase visible masculinity and take up slack skin. Sculpting liposuction of adipose excess is followed by lipoaugmentation directly into or deep to the pectoralis major muscle (Fig. 17.3).

With the inclusion of BodyTite® in 2017, the current approach for gynecomastia consists of six options: (1) transareolar excision of breast tissue, (2) VASERlipo, (3) radiofrequency tightening, (4) a variety of skin excision patterns, (5) lipoaugmentation of the pectoralis muscle, and (6) combination therapy. The therapeutic options are arrayed across the modified Simon classification (see Table 17.1).

BodyTite® utilizes a bipolar handpiece connected to a radiofrequency energy-generating console. A solid, slightly malleable 17-cm long, 3-mm diameter probe with a protective end plastic hub is inserted under the dermis through a 14-gauge needle puncture. Emanating continuous preset magnitude of radiofrequency energy, the probe slowly traverses, like one would a suction cannula, through all layers of saline-infused subcutaneous tissue, emanating a steady cadence of clangs. On the pull-back, continuous probe focused radiofrequency energy is directed to the coupled 3-cm receiving disc gliding on the skin surface. As the preset temperatures are reached, the clangs rapid fire and then the power stops when reaching the preset temperatures of around 40 degrees Celsius for the surface and 70 degrees internally. At that time, a palm-sized region has absorbed from 7 to 10 kJ. Up to 20% tissue contraction is visualized. If not, then the treatment is repeated after cooling. Early postoperative swelling masks the collagen injury and shortening, but with proper splinting and maturation of healing, the final roughly 20% contracted state is evident 6–12 months later [9].

VASERlipo utilizes the well-known third-generation ultrasonic-assisted lipoplasty VASER (Solta Medical, Bothell, Washington) system, which reliably evacuates all excess adipose along with dispersed glandular tissue. Except for the solid core of fibrous-like subareolar tissue, all gynecomastia can be evacuated when VASERlipo is combined with BodyTite®. Subsequent transareolar pull-throughs are either eliminated or reduced to a relatively rapid, small, and bloodless excision.

The popularity of bariatric surgery has greatly increased the demand for correction of gynecomastia. Massive weight loss (MWL) can result in severely ptotic breasts and considerable residual gland and skin laxity that include the entire torso. Compared to other presentations of gynecomastia, the deformity after MWL is severe, the procedures complex, and the risks high. Through an edited video, this chapter ends with a total body lift that features a boomerang pattern correction of gynecomastia with J-torsoplasty to treat Grade IIIb gynecomastia. Following these lengthy procedures, there may be devastating complications, such as cellulitis with sepsis and DVTs with pulmonary embolism.

Chest Aesthetics and Deformity

A barrel-like rib cage is draped by large flat pectoralis major, trapezius, and latissimus dorsi muscles. Lower anterior chest definition features obliquely lateral and inferior pectoralis border adherences. The rounded superior pole of the pectoralis muscle tapers rapidly to thin under the NAC. As there is no breast, there should be no defined inframammary fold (IMF). Therefore, creating an IMF through an inferior chest transverse scar is not masculine. Our observation is a minority opinion, not shared by most plastic surgeons writing on gynecomastia surgery. The minimally projecting static male nipple, surrounded by horizontally oriented 2–3-cm oval areola, lies just medial and superior to these pectoralis landmarks. Ignored by most plastic surgeons, but not by our body-conscious patient, are the dynamic changes of the areola as the pectoralis morphs from relaxation though full contraction, and during arm and body position changes.

Idiopathic gynecomastia is thought to arise from hormone imbalance favoring estrogen with super sensitivity of the glandular bud to increased circulating sex hormones of puberty. Inversely related to the degree of adiposity, glandular gynecomastia varies from slight to considerable firm masses emanating from the areolas. Minimal adiposity gynecomastia is an obliquely oriented, easily isolated firm tube with more mass lateral than medial. Adipose-laden gynecomastia is nearly spherical with less-defined borders. Pseudogynecomastia exhibits little palpable firmness and presents in obese patients and after massive weight loss.

The relationships of the areola to the pectoralis muscle position and shape are demonstrated in a 49-year-old male with Grade IIb moderate enlargement and nipple ptosis with moderate skin redundancy (see Figs. 17.4 and 17.5)

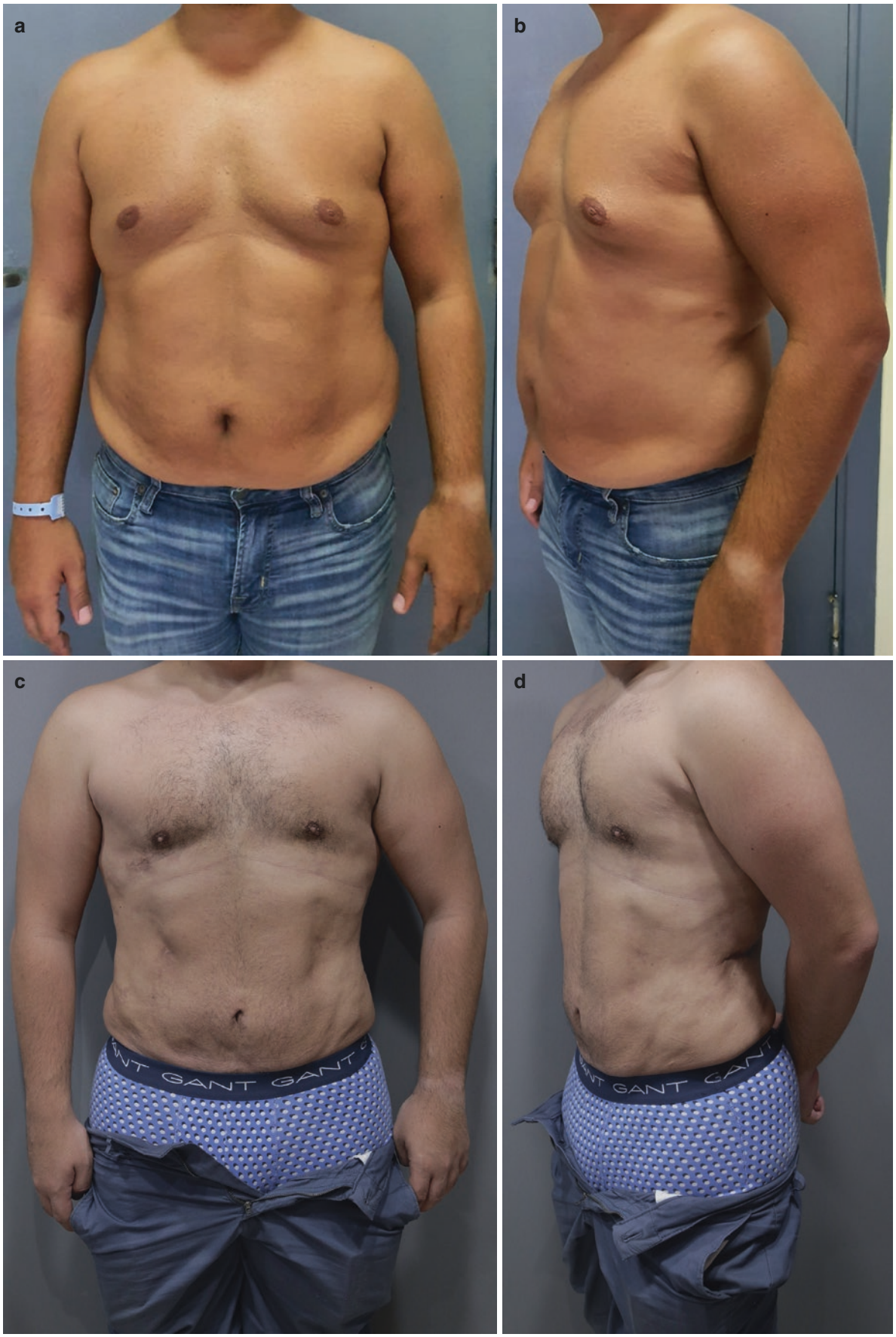

Fig. 17.3 (**a**, **b**) A 31-year-old with BMI 32.8 presented with Grade III gynecomastia and underdeveloped pectoralis muscles. (**c**, **d**) Three months following transareolar resection of the gynecomastia and 400 cc lipoaugmentation of the pectoralis muscles

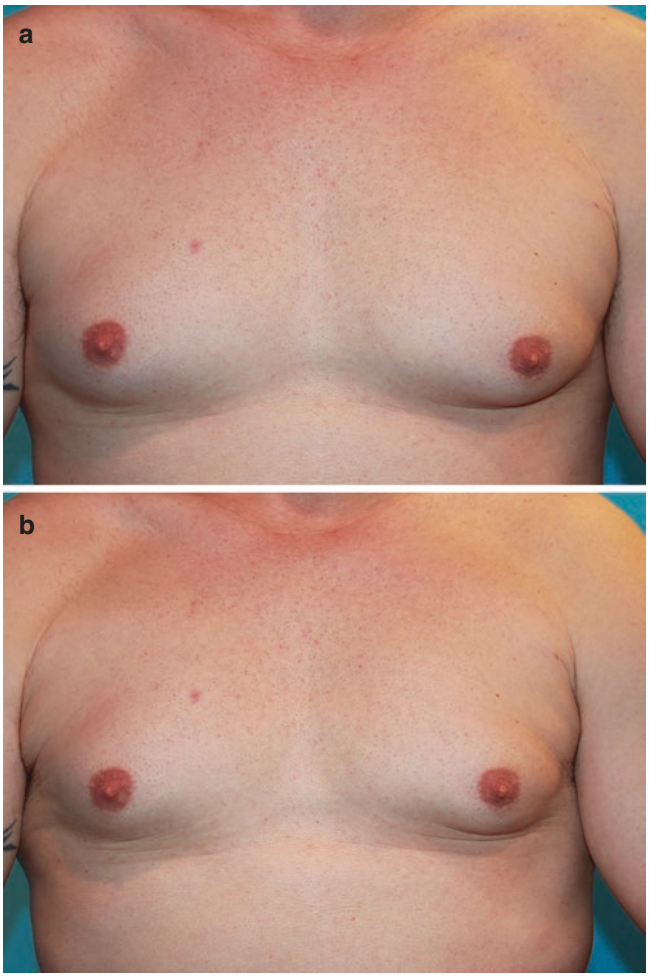

Fig. 17.4 Grade IIb gynecomastia in a 45-year-old man who is 6 feet 3 inches tall and 200 pounds, frontal view. (**a**) With the pectoralis muscle relaxed the postareolar skin and inferior is filled with breast and muscle. (**b**) With the pectoralis muscle contracted, the muscle is elevated, leaving only the gynecomastia to shape behind the areola and inferior

The lax pectoralis muscle will descend for added fill deep and inferior to the areola. The medial infraclavicular area is flat. The contracted pectoralis major rises and bulges above the NAC so that only the now isolated rounded gynecomastia protrudes the areola and inferior skin. Raising the arms stretches, elevates, and flattens the pectoralis muscle to visually isolate the glandular prominence. Upon leaning over in the diving position, the loosely adherent gland droops, which increases with skin laxity. For a thorough visual appraisal of results, clinical photographic documentation of gynecomastia and its treatment should include arms to the side, contracted pectoralis muscle, extended arms, and diving position.

Correcting Deformity and Improving Aesthetics

Since the contracted pectoralis muscle or raised arm leaves no fullness deep and inferior to the areola, corrective surgery should empty that space. Hence, I reject the commonly recommended inferiorly based deepithelialized buried dermal pedicles that vascularizes a ptotic nipple placed through an opening in the chest skin. Bulk, due to these pedicles, leaves unaesthetic fullness most apparent when contracting the pectoralis muscle or raising the arms.

The repositioning of a ptotic nipple relates to the dynamic pectoralis muscle rather than skeletal landmarks or absolute numbers or ratios. The repositioned NAC is planned several centimeters medial and superior to the junction of the lateral and inferior borders of the pectoralis major muscle. Extending the arms raises the flattened nipples. To satisfy both static and dynamic appearances, nipples must relate to that muscle or else they will not optimally animate. Large areolas should be reduced.

The primary objective of gynecomastia correction is to remove nearly all breast glands. That should include disruption of the inframammary fold. The inframammary fold is a condensation of fibrous adherences between the dermis and the muscular fascia through a reduced adipose area along the inferior portion of the breast. The female inframammary fold tends to lie about the fifth and six ribs, whereas the adherences of skin in the male relate to the inferior and lateral borders of the pectoralis muscle, which are at least one interspace higher and less distinct than the usual IMF. To obtain that aesthetic goal, the fold is obliterated by stretching the tissues and advancing them a short distance.

Aside from being the least traumatic removal of fat, VASERlipo also disrupts the adherent IMF. The boomerang excision pattern for gynecomastia includes extensive indirect inferior chest undermining of the skin to disrupt the IMF. Low transverse excisions of redundant skin create an IMF, which we believe the surgeon should avoid. When closed in layers, a suture line contour depression may be avoided, but when the patient leans over any skin laxity abruptly stops along that line and billows over the adherent scar, which sadly for the patient simulates a breast.

Management of Grades I and IIA

Until this era of laparoscopic bariatric surgery, plastic surgeons generally treated three populations of gynecomastia. There is the typical mostly glandular gynecomastia persist-

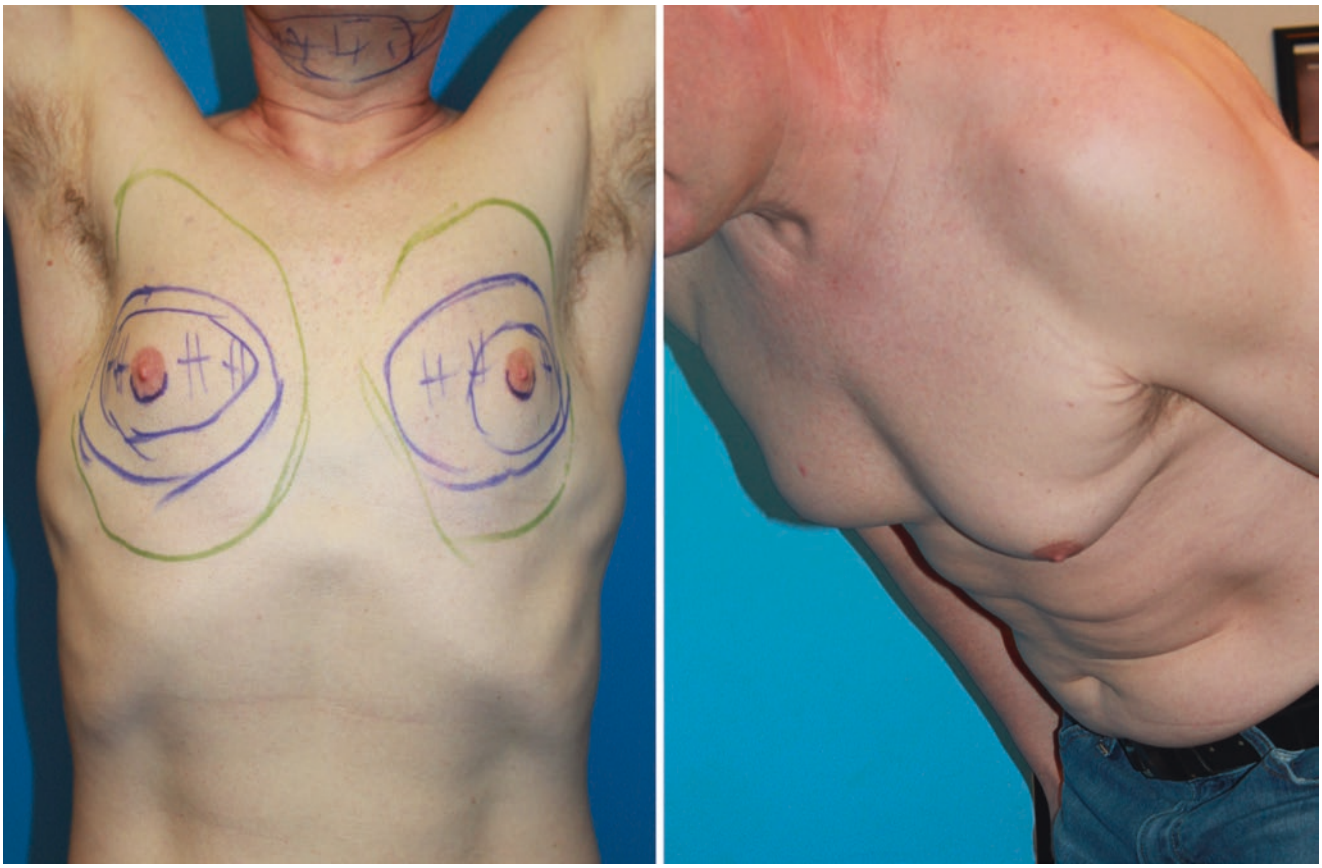

Fig. 17.5 Additional views of patient in Fig. 17.4. (Left) Extending the arms raises the pectoralis muscle to isolate the gynecomastia, which is encircled in blue. The area encompassing BodyTite® application is in green. (Right) The patient's left anterior oblique diving view shows skin laxity hanging from the weight of gynecomastia

ing beyond adolescence. The second group is fuller adipose-laden breasts in older men, usually with weight gain. The final group is bodybuilders who, with or without the use of exogenous steroids, develop disturbing completely glandular minor gynecomastia.

Typically, breast hypertrophy is not tender, but sometimes pain and tenderness are significant. Direct excision of the offending hypertrophy gland reliably removes the gland and relieves the pain. After careful mapping of the sausage-like firm mass, a transareolar excision with tapering of the perimeter subcutaneous tissues is performed.

Traditional glandular excision of gynecomastia for Grades I and IIa is typically performed through infraareolar or transareolar incisions [5]. While confining the scar, this poor exposure risks hematoma, seroma, delayed healing, and contour deformity. Also, residual sagging skin occurs. Accordingly, early surgical reintervention or secondary correction is common. In recent years, the introduction of sophisticated energy technologies has greatly reduced those sequelae. Ultrasonic-assisted lipoplasty (VASERlipo) has supplanted traditional liposuction, and radiofrequency lipolysis (BodyTite®) has obviated minor skin resections. Moreover, together these technologies have virtually eliminated hematoma, seromas, and surgical drains.

With a predominately adipose mass without skin laxity, VASERlipo alone may be enough. After generously infiltrating hundreds of cubic centimeters of saline with xylocaine and epinephrine, the offending gland can be sonically emulsified and then aspirated through strategically placed stab wound incisions with care to taper the perimeter. Sponge and elastic garment compression retard hematoma. Extending VASERlipo over most of the anterolateral chest improves skin redraping across the chest wall. Evacuation of large glands and/or detectable skin laxity prompts preemptive BodyTite® treatment.

Grades IIB Through IIIA

Advanced technologies of VASERlipo and BodyTite® are combined for the treatment of Grade IIb and IIIa deformities. Periareolar excisions are limited, and lateral chest or long transverse scars are avoided.

Along the way, there has been a stressful learning curve. Since VASERlipo leaves intact most of the subcutaneous tissue supporting the connective network, which is my target for the radiofrequency energy, for efficiency I complete the fat extraction before starting BodyTite®. It is imperative to adequately and uniformly heat the tissues as indicated by the gauges on the console without overtreatment thermal injury to any spot. During complicated multiple-procedure body-contouring surgery, my experienced physician assistant can effectively and safely perform the tedious numerous traverses of the handpiece. Postoperative scarring does not limit secondary treatment for further tightening after 6 months.

The Simon classification and its associated treatment algorithm assume that tissue characteristics and their behavior can be diagnosed and predicted based on the history and physical examination. Nevertheless, there are subtle transitions between grades of severity. When in doubt as to tissue laxity, apply BodyTite®. Large breasts with and without ptosis will exhibit some postoperative skin laxity. Mild to moderate laxity is amenable to radiofrequency treatment, whereby severe laxity especially with atrophy does not. Patients with several hundred pounds of weight loss and advanced age will not adequately respond to radiofrequency tightening. Care must be taken to avoid immediate subdermal energy in Fitzpatrick 4 and above pigmentation because of hyperpigmentation. A cardiac pacemaker is another contraindication.

While 18 cases of gynecomastia have been treated with BodyTite®, the treatment has evolved to a point of consistency for the last seven cases. There have been no seromas, skin necrosis, neuropathy, or infections. All patients recognized skin tightening, but many had hoped for more and some may undergo in-office repeat treatment at a reduced charge.

A favorable case for radiofrequency tightening is a 45-year-old, whose ptotic gynecomastia, Grade IIb, was presented in Figs. 17.4 and 17.5. After both prominent gland and excess chest adipose were fully reduced through extraction of 350 cc's of VASERlipo, they were exposed to 9.2 kJ of BodyTite®. Despite the anticipation to pull through additional gland through a marked infraareolar incision, that was not necessary. Avoiding the excision saved time, reduced swelling, and eliminated a postoperative drain. The 9-month postoperative views show scarless correction of the gynecomastia with ideal nipple and torso aesthetics (Figs. 17.6 and 17.7) One should anticipate that correction of Grade II gynecomastia will leave loose skin that could be tightened by BodyTite® therapy.

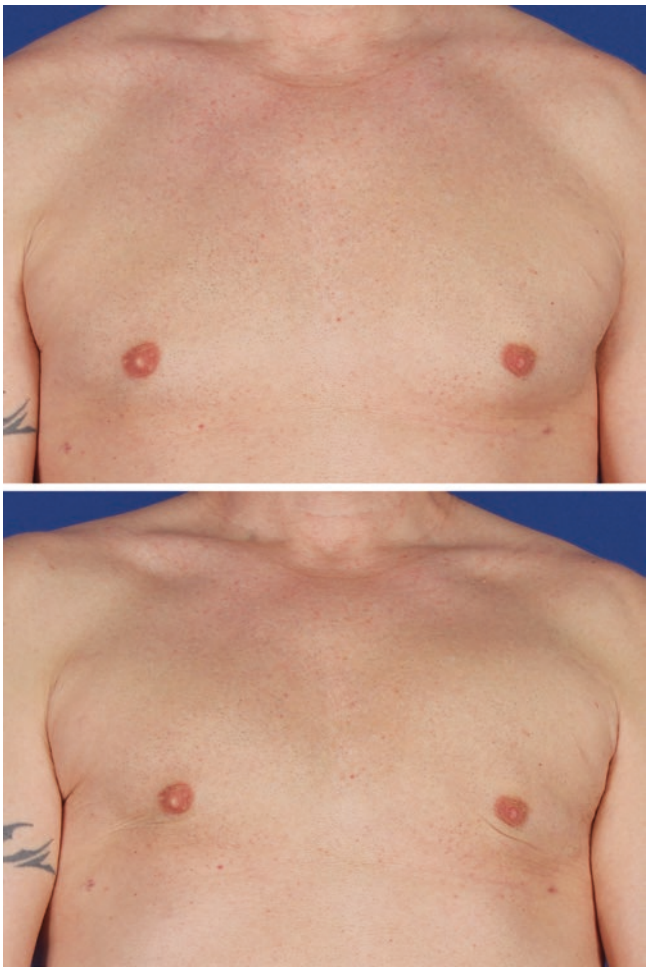

Fig. 17.6 The same patient in Figs. 17.4 and 17.5, 7 months after VASERlipo and BodyTite®, frontal view. (Upper) With a relaxed pectoralis muscle, there is fullness behind and inferior to the areola. (Lower) Upon pectoralis contraction, the upper chest bulges; the slightly tilted areola is flat

A larger Grade IIb gynecomastia is seen in a 190-pound 29-year-old patient who lost 40 pounds (Figs. 17.8 and 17.9) He underwent lipoabdominoplasty, 550 cc Vaserlipo of the flanks, 1350 cc VASERlipo of the breasts followed by superior areolar incision pull-through of residual gland, and then 30 kJ BodyTite® treatment per breast. Nine months later both the gynecomastia and skin laxity of the torso were corrected with minimal scars.

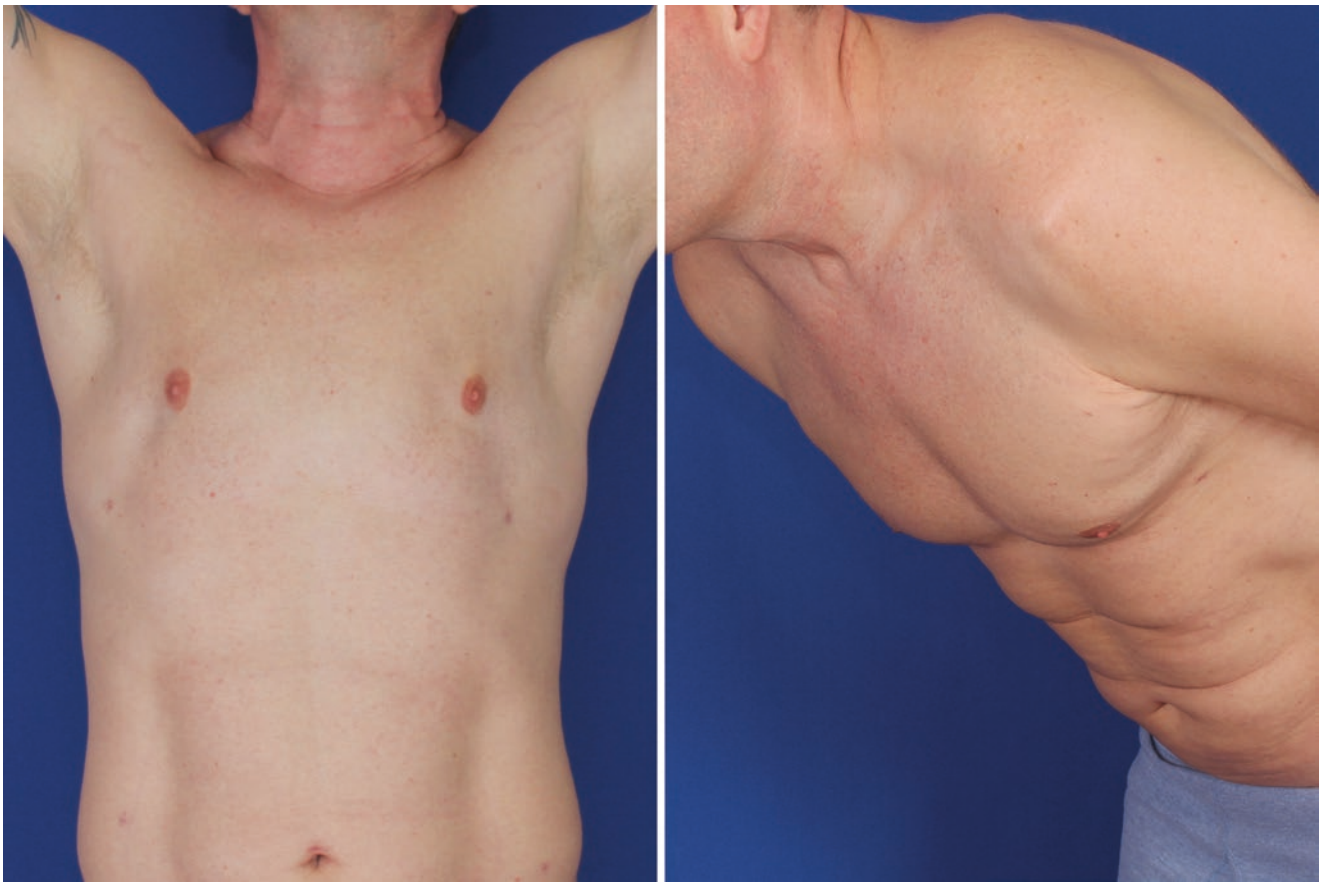

Fig. 17.7 The same patient in Figs. 17.4 and 17.5, 7 months after VASERlipo and BodyTite®. (Left) With the arms extended, the pectoralis raises above the areolas, revealing no residual breast gland. (Right) As the patient leans, the areola and inferior are filled with muscle but the skin does not sag

VASERlipo followed by BodyTite® left a reasonable but somewhat disappointing result after a 200-pound weight loss in a 49-year-old patient with Grade IIIa gynecomastia. In addition, he underwent lipoabdominoplasty with VASERlipo of the flanks (Fig. 17.10). Six months later, further BodyTite® provided some further skin tightening but also left an adherent thin roll. In a final attempt to avoid scars, we plan lipoaugmentation of the pectoralis muscle. As long as prolonged application has been avoided, the subcutaneous scarring will be minimal, allowing repeat BodyTite® with further skin tightening up to three sessions spaced 6 months apart. After the rolls are effaced, we will start 3 months of continuous foam and elastic wrap pressure to maintain a smooth shape.

Thus, we find healthy young men with minimal glandular tissue (Grade I, IIa) will respond incredibly well with no residual deformity through either transareolar direct excision and/or VASERlipo. For patients with Grade IIb up to IIIa, VASERlipo is followed by BodyTite®. If needed, glandular pull-through excision completes the correction. Either VASER® or BodyTite® can cause thermal injury leading to hyperpigmentation or hypertrophic scar near entry sites. Thus, parasternal inferior chest entry should be avoided. One young MWL male with pigmented skin had an excellent nonexcisional glandular reduction but exhibited a periareolar dark and wide hyperpigmentation response necessitating an excision (Fig. 17.11). Scattered abdominal hyperpigmentation due to tape and dressings are indicative of his hyperpigmentation response even to external pressure.

Grade IIB Through Grade IIIB

For older men with involutional gynecomastia, skin laxity, and mild nipple ptosis, a lateral chest hockey stick skin excision toward the axilla tightens the skin and allows access to

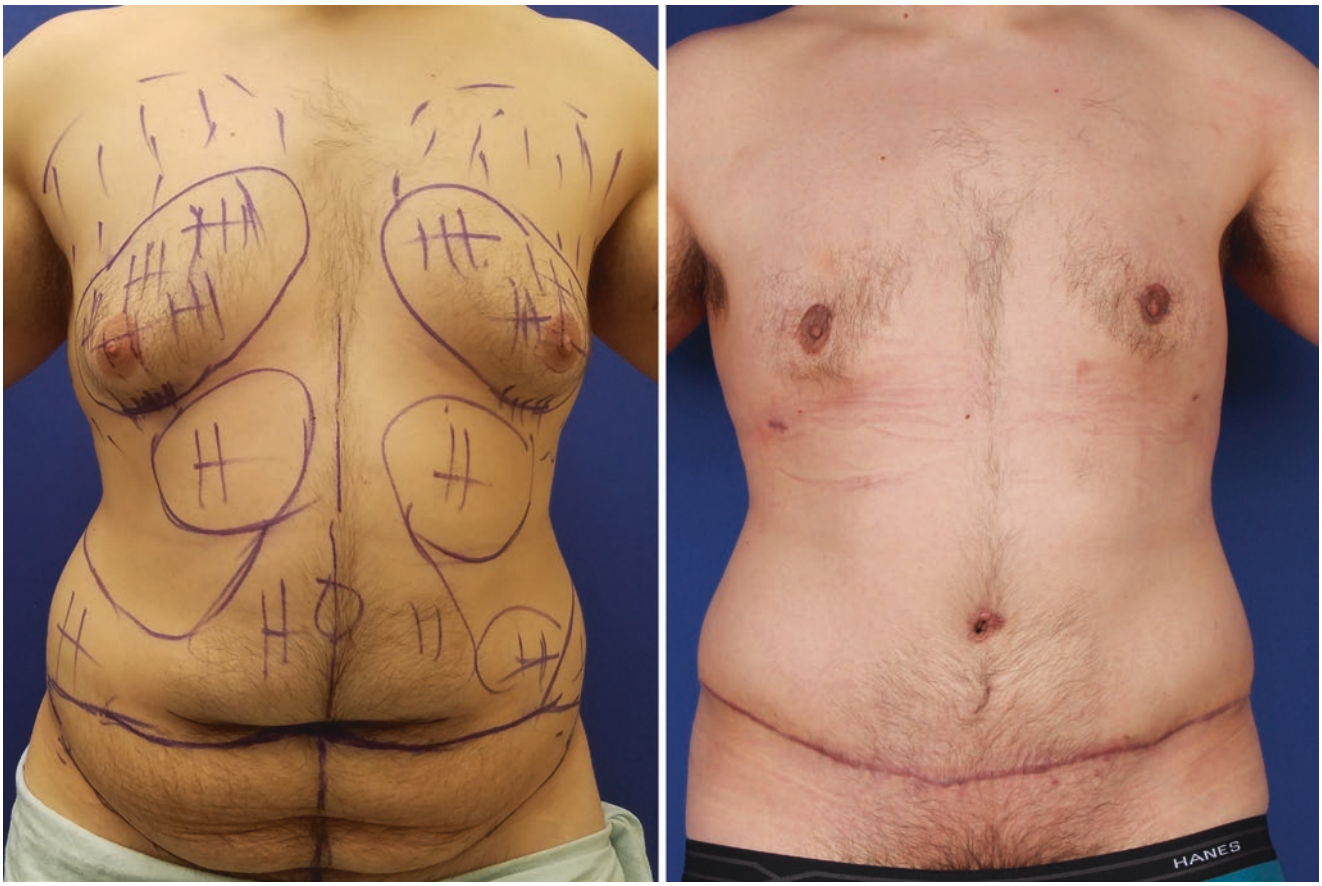

Fig. 17.8 A 190-pound, 29-year-old man with a 40-pound weight loss seeks abdominoplasty, VASERlipo of the flanks, and correction of his gynecomastia with minimal scars. (Left) preoperative markings for his lipoabdominoplasty, VASERlipo of the flanks, 1350 cc VASERlipo of the breasts, followed by 30 kJ BodyTite® treatment of each breast. (Right) The 10-month result has excellent contours and no loose skin of the torso

excision of the breast mass (Fig. 17.12). Lateral deviation of the areola is countered with a medial crescent advancement of the NAC. Some residual skin laxity is expected. This limited scar operation is especially indicated when radiofrequency tightening is unavailable.

For Grade III deformity, a boomerang pattern correction of gynecomastia corrects the nipple ptosis, glandular hypertrophy, and excess anterior chest skin [10]. The procedure removes two unequal obliquely oriented ellipses that superiorly straddle the areolas. Considerable tissue can be removed with the long closure visually interrupted by the areola. Originally extended by a transverse upper body lift, for the past 10 years, the boomerang has been combined with J-torsoplasty for Grade IIIb after MWL [11].

The boomerang design leaves the NAC attached to a triangular, broad-based, non-deepithelialized inferior pedicle that may be defatted through VASERlipo. The two ellipses surrounding the NAC at right angles suggest a flying boomerang. The obliquity of the elliptical excision removes both vertical and horizontal excess tissues. With a C-like extension of the lateral chest excision, the J-torsoplasty tightens both the midback and the chest. A bonus is the scar lies under the relaxed arm and not across the back (Video 17.1) (Fig. 17.13).

Upon elevation of the descended NAC to its proper location, both inferior pole breast and upper abdominal skin laxity are taken up. The limitation of this operation is that if there is too much skin for skin contouring and nipple relocation, then a skin graft nipple placement is necessary. A severe case of

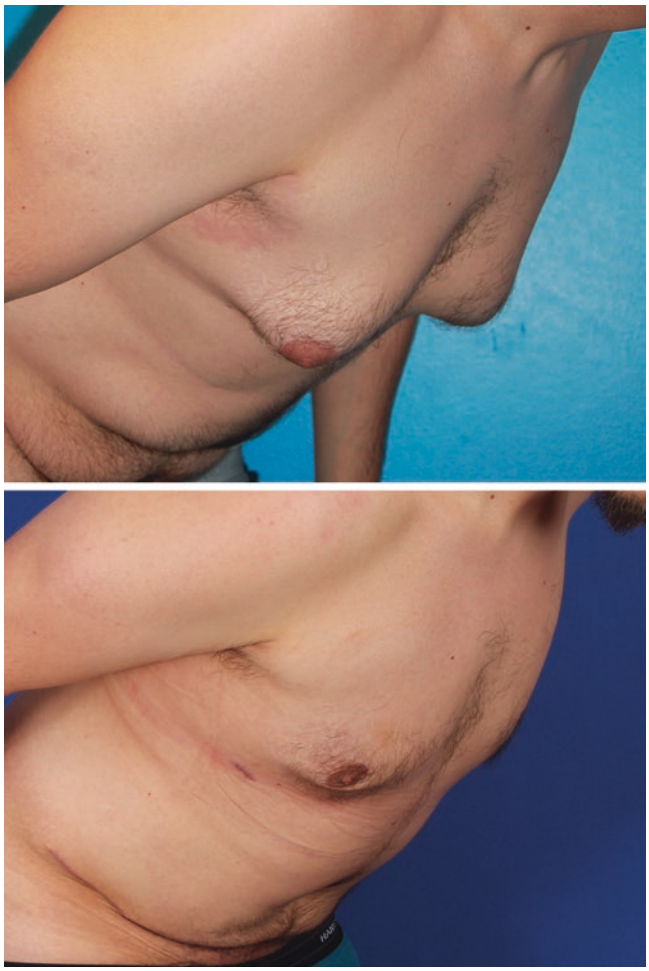

Fig. 17.9 Right anterior oblique diving view before (upper) and 10 months after (lower) in the patient presented in Fig. 17.8

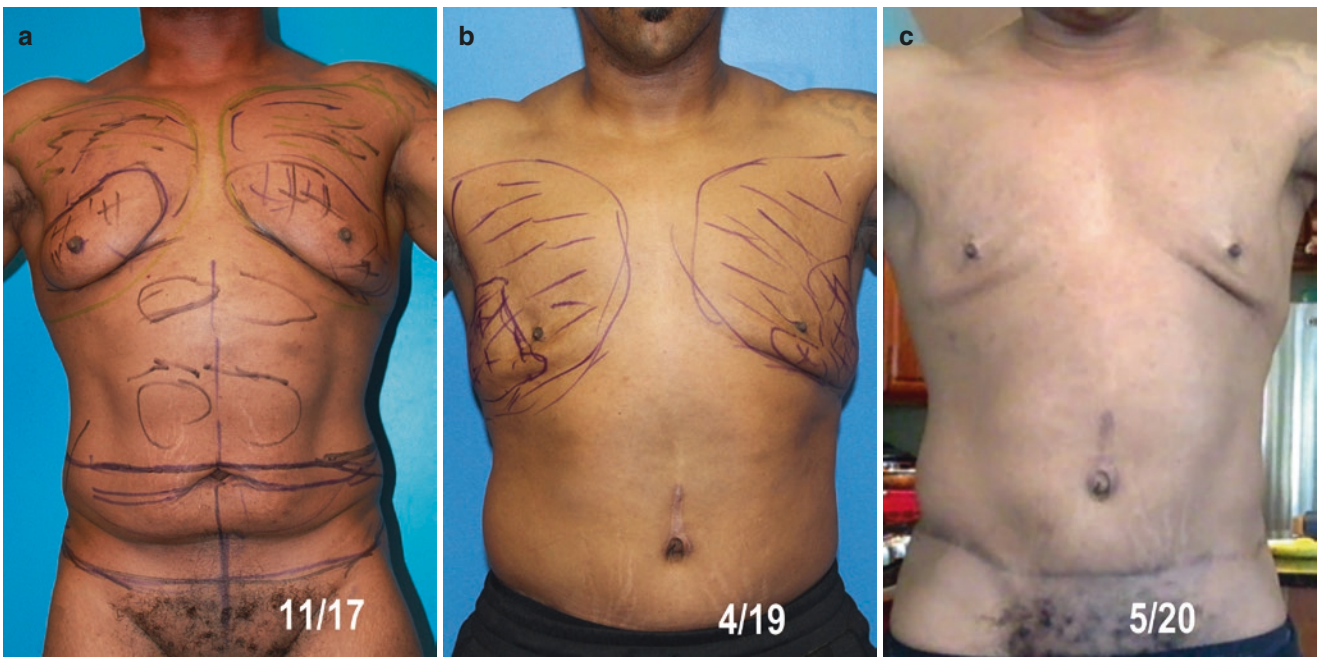

Fig. 17.10 A 48-year-old MWL patient with residual chest skin laxity. (**a**) Patient underwent the marked lipoabdominoplasty with oblique flankplasties along with VASERlipo and BodyTite® of his anterior chest. (**b**) Marked for repeat BodyTite® of chest. (**c**) Cell phone photo sent 4 months later, showing unacceptable adherent transverse chest rolls

tissue excess of the chest recently succeeded (Fig. 17.14). In addition, limited brachioplasty and VASERlipo with BodyTite® of the distal arm were done. Unfortunately, this 28-year old sustained a saddle pulmonary embolism that responded to systemic heparin anticoagulation.

This complicated operation, which corrects all aspects the gynecomastia as well as chest and back laxity, has a lot of moving parts and as such, even for the most experienced surgeons, needs to be done with some forethought and progressive attack. As shown in Video 17.1, it is best to make the inferior incision first, particularly when a concomitant abdominoplasty is done. The precise width of elliptical resection can be made after the abdominoplasty closure is started. Then after indirect undermining of the lower chest with a LaRoe dissector (Accurate Surgical & Scientific Instruments Corporation, Westbury, New York), the areola is advanced up to the upper markings and they are adjusted as needed for the optional tension at closure. Once the boomerang has been closed, the lateral chest skin excision of the J-torsoplasty can be completed. Otherwise, the closures across the chest may be either too loose or too tight.

Owing to the high quality of chest wall skin, when the closure is tight, there will be no secondary laxity as is seen commonly in the lower torso. The resection over the pectoralis muscle is essentially bloodless but not so with the lateral chest wall, which is also tedious, but most expeditious after early identification of latissimus muscle. Dissection over the muscle posteriorly provides proper orientation and depth of resection.

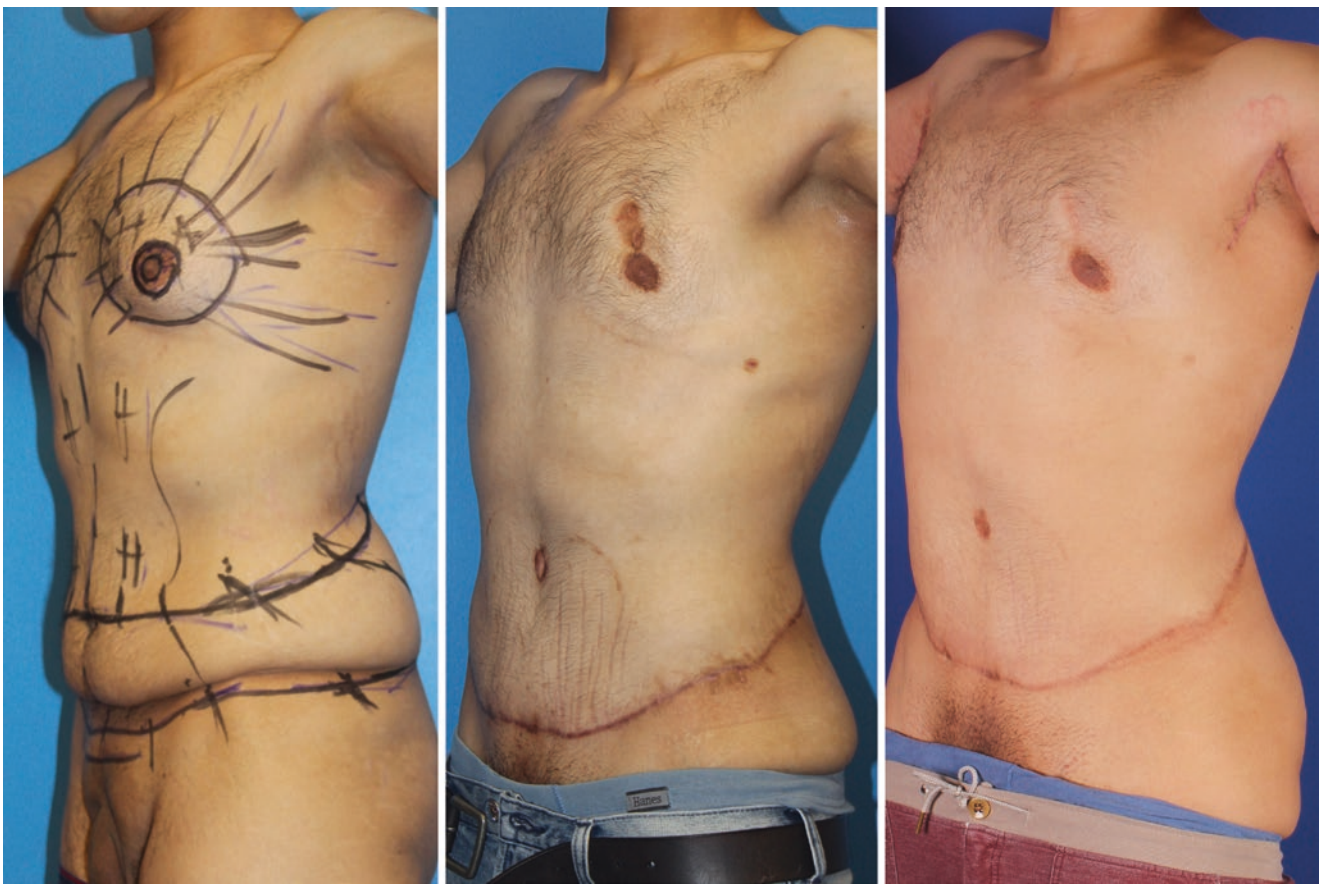

Fig. 17.11 Hyperpigmentation. VASERlipo followed by BodyTite® gynecomastia correction in a 23-year-old Arabian patient with massive weight loss. (Left) Marking for lipoabdominoplasty with oblique flankplasty, areolar reduction, and VASERlipo and BodyTite® of Grade IIb gynecomastia. (Middle) Eighteen months postop with scattered hyperpigmentation of scars and from binder pressure on tubing. (Right) Six months after excision of depressed hyperpigmentation of left chest. Torso contours are excellent, with minimal skin laxity

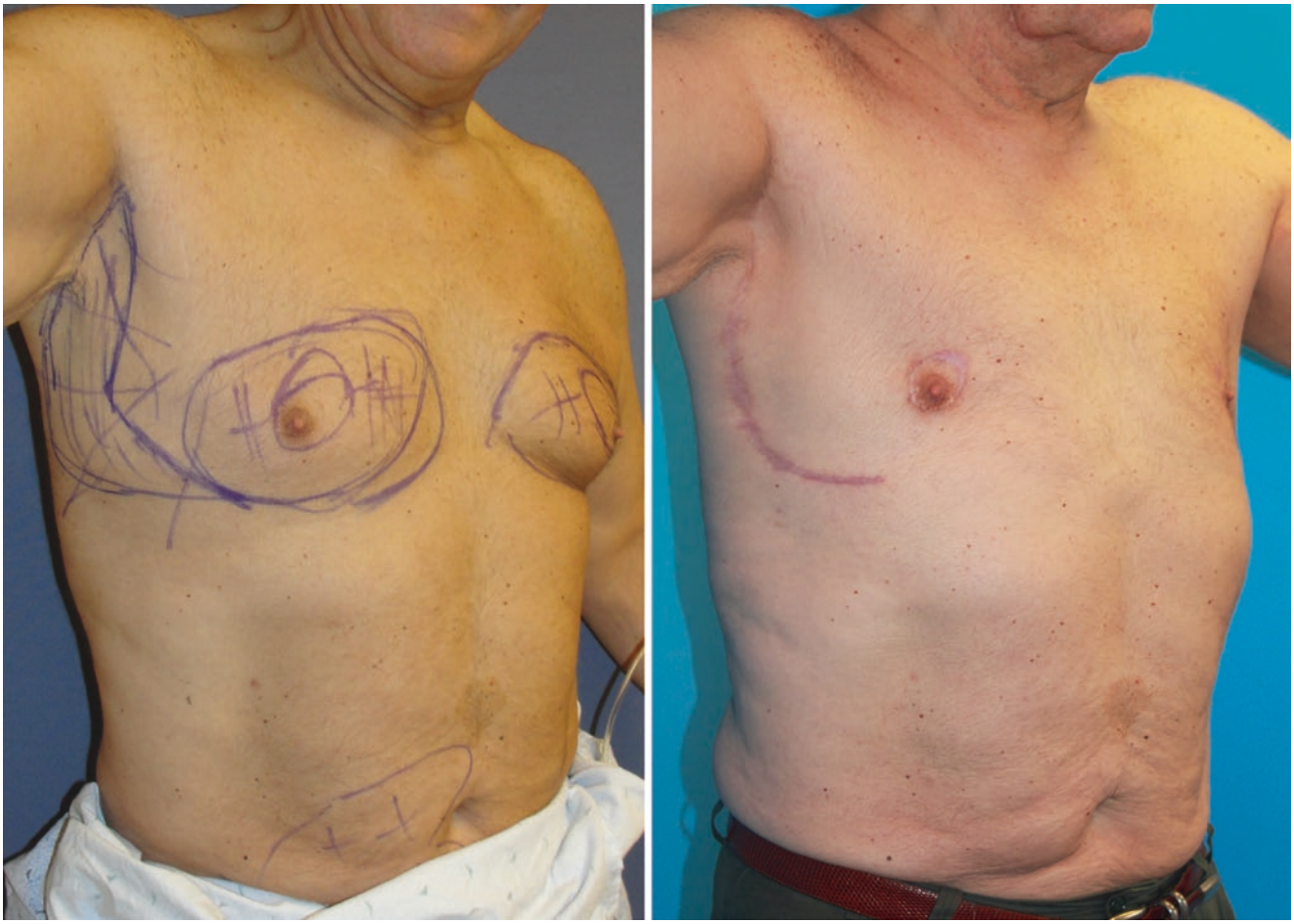

Fig. 17.12 (Left) Combination of a hockey-stick-shaped lateral torsoplasty and anteriomedial advancement of the nipple areolar complex in a 64-year male with 20-pound weight loss that resulted in Grade IIb gynecomastia. (Right) Satisfactory result

Then the dissection proceeds anteriorly across the serratus muscle. The closure with #2 barbed sutures of the different lengths of limbs of the J-torsoplasty is a challenge in wound edge justification.

With tissue resections going in a variety of directions, the operation is technically demanding but usually works out that the tissue contours are all smoothly adherent to the chest. There have been a few instances of unevenness requiring further liposuction or lipoaugmentation. Secondarily, inferior areola excess has rarely been reduced by inferior crescent excision. Overall, boomerang scars are thin and fade. Scar hypertrophy and hyperpigmentation can be a problem in densely pigment skin, most often in the medial limb. After performing over 30 cases, one entire NAC sustained necrosis. I over-thinned the areola and made the pedicle to the NAC too narrow.

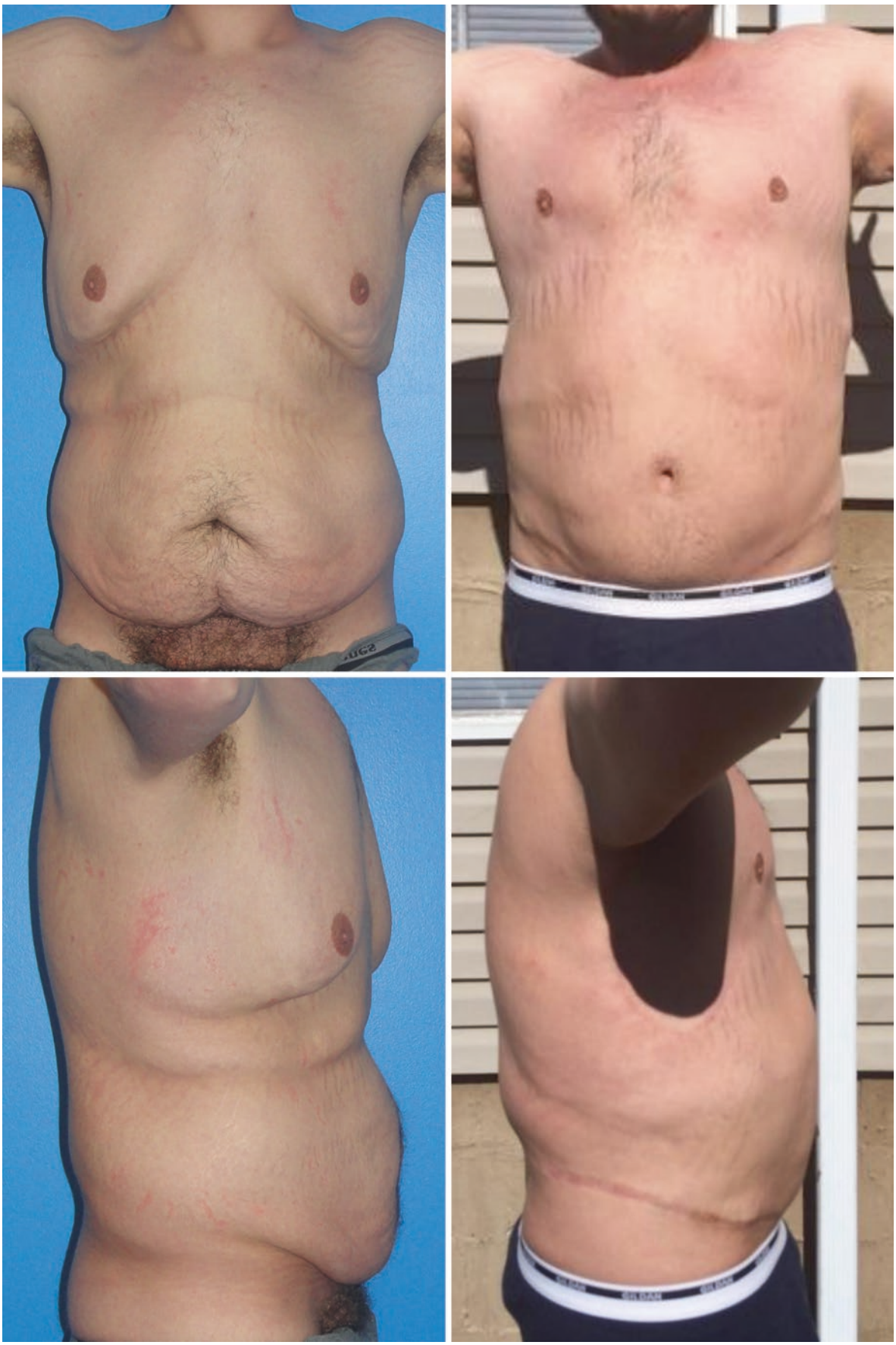

Fig. 17.13 (Left) A 32-year-old underwent the second stage of his total body lift with boomerang correction of his gynecomastia and J-torsoplasty. (Right) Photos of his result sent from home 5 years later. The gynecomastia is corrected and the scars are barely perceptible

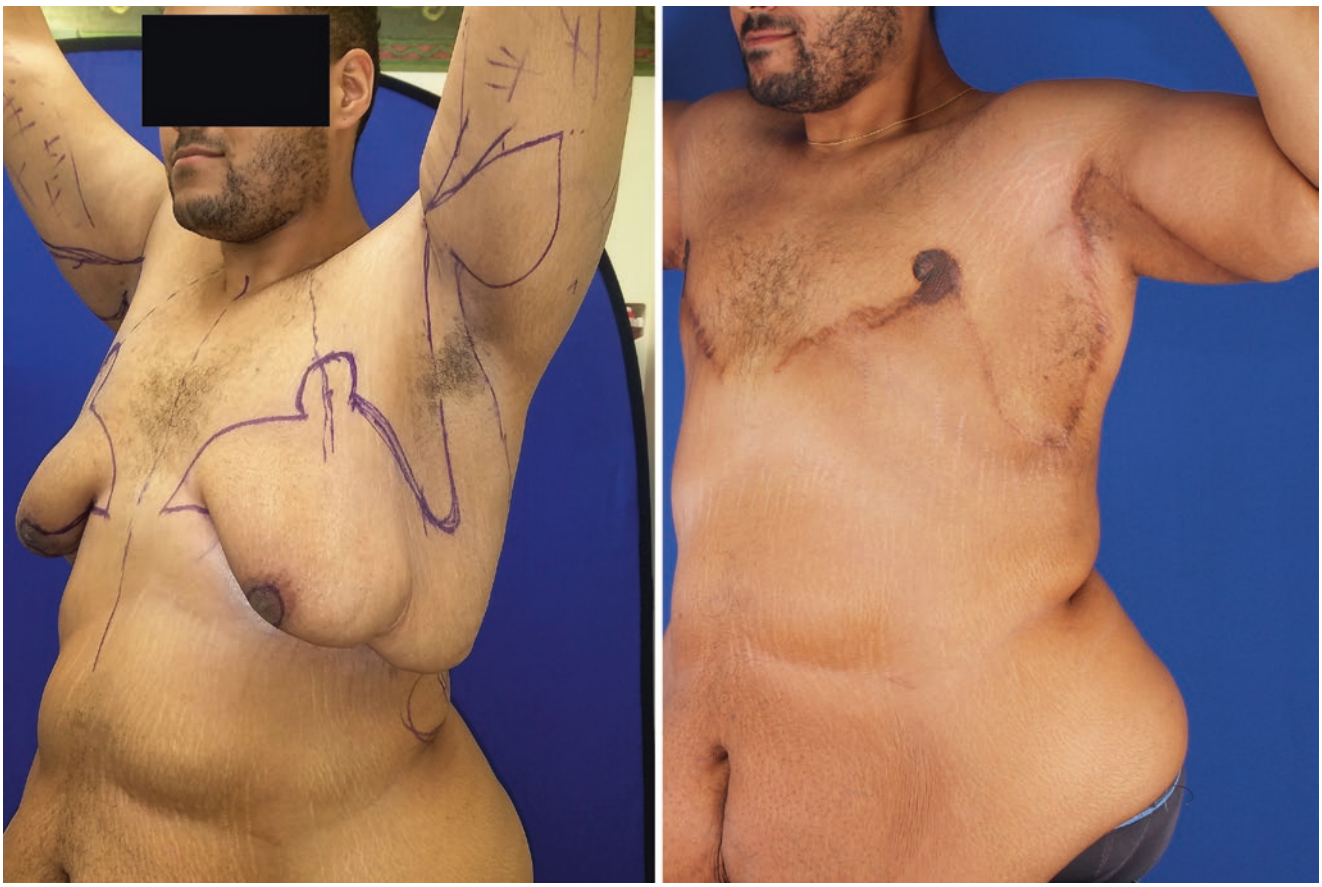

Fig. 17.14 A 29-year-old after gastric bypass resulted in a 140-pound weight loss to 240 pounds, requesting upper body and arm surgery. Left anterior oblique view before (left) and 17 months after (right) marked boomerang pattern correction of gynecomastia with J-torsoplasty and limited L-brachioplasty supplemented with VASERlipo and BodyTite® of distal arm

Conclusion

Advanced treatment of gynecomastia is fraught with challenges, including scarring, wound healing issues, contour irregularity, and unmet patient (or surgeon) expectations. These problems will be predicated to some degree on the magnitude of the gynecomastia deformity. In this chapter, the senior surgeon presents his novel fusion of diverse new techniques – such as pectoralis lipoaugmentation and his boomerang pattern technique – with novel technologies, including radiofrequency-based treatments, to enhance gynecomastia outcomes.

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18 Avoiding Aesthetic Problems of Breast Reductions with Implants: When and How?

Eric Swanson

Introduction

The functional benefits of breast reduction are well-known. However, many women after a breast reduction resemble candidates for augmentation mastopexy [1]. This observation is especially true after a Wise pattern inferior pedicle reduction, which can leave the breasts looking deflated and boxy. No degree of surgical proficiency can prevent this geometric consequence of a horizontal elliptical resection, which (illogically) trades projection for width. These women tend to be satisfied functionally, but they may be disappointed with the aesthetic result [2]. The vertical method trades width for projection.

Measurements show that an inverted-T (Wise pattern), inferior pedicle mammaplasty does not improve breast projection or upper pole projection [3]. By contrast, a vertical reduction provides a modest boost in breast projection and upper pole projection, and tighter, more conical lower poles than a Wise pattern [4]. In patients who wish to restore upper pole volume, breast implants are most effective because they are less prone to shape deformation than native breast tissue [4]. The combination of lower pole resection and upper pole augmentation creates the illusion of a breast lift, in keeping with the "minus-plus" principle [5].

Combining breast reduction and implants might strike some surgeons as contradictory and even unethical [6]. An increasing number of plastic surgeons, however, believe that this combination has a proper place in the plastic surgeon's armamentarium [7]. The label "breast reduction plus implants" is preferred, avoiding the possibly confusing term "augmentation reduction" [8].

It might seem that a simultaneous breast tissue resection and implant insertion would produce a result similar to a small mastopexy because the two maneuvers largely offset each other. However, the profound changes in the proportions of the upper and lower poles are not reflected in the smaller overall reduction in mass [8].

Indications

Originally, a breast reduction was intended to be a functional procedure, meant to reduce breast mass and elevate the nipple position. These goals were achieved a century ago [9–11]. Today, expectations are higher and include aesthetic considerations. Patients having breast reduction are concerned about their symptoms, but outcome studies show that the majority quite understandably wish to improve their breast appearance as well [12]. With the undeniable importance of the appearance of the female breast to self-esteem and sexuality, plastic surgeons can no longer regard breast reduction as a purely functional procedure.

In the author's practice, women who are seen in consultation for a breast reduction are given the option of simultaneous breast implants. Some women simply do not wish to have breast implants, or they are satisfied wearing a bra to provide upper pole fullness. If a woman wishes to look perky in a bikini or naked, she may well consider breast implants. The total breast volume will be reduced, but the implants restore lost (or never there to begin with) upper pole volume and convexity, which is considered attractive by most women [13]. In the author's practice, approximately 30% of breast reduction patients elect to have implants [14].

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E. Swanson (✉)
Private Practice, Leawood, KS, USA
e-mail: eswanson@swansoncenter.com

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Pedicle Selection

Nipple sensation is sometimes overlooked by plastic surgeons. Courtiss and Goldwyn [15] reported persistent nipple sensory loss in 35% of women 2 years after an inverted-T, inferior pedicle reduction. The vertical reduction removes a keel-shaped wedge of breast skin and parenchyma from the midline of the lower pole where there is no important sensory nerve (Fig. 18.1) or axial blood supply to the nipple.

Schlenz et al. [16] found that a superior pedicle produces a higher rate of nipple numbness than other pedicle designs. A superior pedicle sacrifices deep innervation. An advantage of the medial pedicle is that the anterior cutaneous branches of the third through fifth intercostal nerves may be preserved (see Fig. 18.1). The author endeavors to preserve a parenchymal base under the nipple and areola (Video 18.1) so as to capture deep innervation from the deep branch of the lateral branch of the fourth intercostal nerve, which ascends to the nipple through the breast parenchyma [17].

Blood Supply

In addition to sensation, blood supply must be considered in pedicle selection. An inferior pedicle jeopardizes blood supply to the nipple/areola because of its length and random design. There is no artery that courses vertically to the nipple from the inframammary fold (IMF). A central mound technique (recently resurgent among surgeons using a mesh overlay [18]) sacrifices superficial skin perfusion and innervation [19]. There are no measurement data supporting any benefit from mesh implanted at the time of mammaplasty [19].

The intercostal perforating arteries from the internal mammary artery (as opposed to laterally based vessels) provide the dominant superficial circulation to the nipple and areola in 70% of women [20, 21].

Many surgeons using a vertical mammaplasty prefer a superior pedicle or superomedial pedicle. Hall-Findlay [22] notes that a superomedial pedicle can preserve the second intercostal perforator from the internal mammary artery. In many cases it is possible to extend a medial pedicle partially around the superior areola border. The author places a premium on maintaining the dominant superficial medial innervation and blood supply, so that the medial pedicle is preserved in all patients.

Breast Implants

The author uses exclusively smooth, round implants. In the subpectoral location, there is no advantage in capsular contracture rate from texturing [23, 24]. There may be exceptions. For example, a woman with previous surgery and a

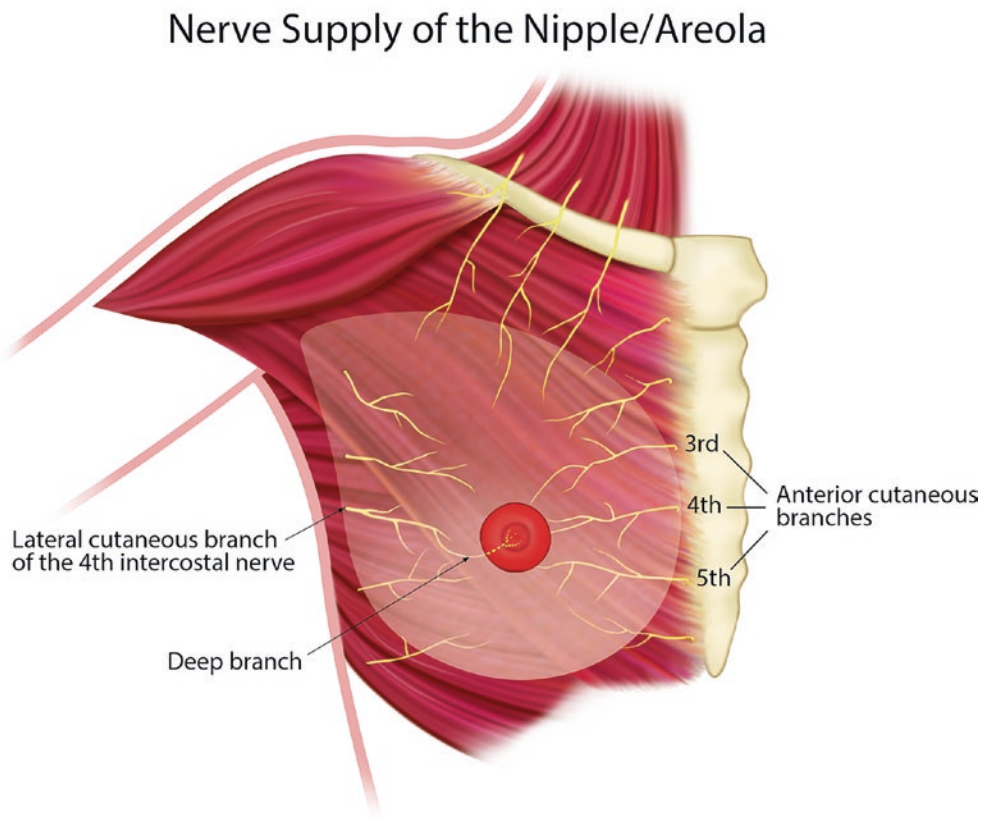

Fig. 18.1 The predominant superficial nipple innervation is provided by the medially based third, fourth, and fifth anterior cutaneous branches. A deep branch of the lateral cutaneous branch of the fourth intercostal nerve consistently provides deep innervation to the nipple. (Reprinted by permission from Springer Nature: Evidence-Based Cosmetic Breast Surgery, by Eric Swanson. Copyright 2017)

scarred pectoralis major muscle or a bodybuilder who does not wish to accept the risk of an animation deformity may choose a prepectoral pocket. Either saline or silicone gel implants may be used. In women with large breasts, any advantage in feel characteristics from a silicone gel implant is mitigated by the tissue cover. Of course, plastic surgeons are well aware of the problems with shaped, textured implants – malrotation, firmness, double capsules, late seromas, increased cost, and most importantly the risk of BIA-ALCL [25–28].

Preoperative Marking

Preoperative marking is demonstrated on the video (see Video 18.1). A tape measure is draped around the neck to mark the breast meridians. Next, the same distance is marked on both sides from the sternal notch to approximately the level of the elevated nipple, typically 19–22 cm. This level is unlikely to correspond to the actual site, which will be determined intraoperatively. A vertical elliptical pattern is then drawn on the breast, including the nipple/areola and extending inferiorly but stopping short of the IMF. The width of this vertical ellipse depends on the degree of existing glandular ptosis and implant volume and is a subjective assessment. The markings serve as a guide only; actual incisions are unlikely to match the markings exactly. The lower end of the marking is checked to be sure that it is equidistant from the sternal midline, typically 10–12 cm.

Anesthesia

Almost all breast reductions plus implants may be performed as outpatients in a state-licensed ambulatory surgery center using "SAFE" (spontaneous breathing, avoid gas, face up, extremities mobile) intravenous anesthesia [29]. Patients are monitored for venous thromboembolism using ultrasound surveillance [30]. No chemoprophylaxis is used. Sequential compression devices are ineffective and unnecessary if the procedure is performed without muscle relaxation because there is no relaxation of the calf muscle pump [30]. Some surgeons are concerned that the pectoralis muscle is not relaxed. True, and the muscle does twitch when a vessel is cauterized, but it is easy to become accustomed to it. Muscle relaxation is unnecessary.

After induction of anesthesia, the author injects the breasts with a saline solution containing 1/4% lidocaine, 1/8% bupivacaine, and 1:300,000 epinephrine [31]. Typically, 100 cc is injected into each breast. By injecting both sides first, sufficient time is allowed for the local anesthetic and epinephrine to take effect. Vasoconstriction limits blood loss and makes electrodissection unnecessary.

Surgery

The surgical approach for a breast reduction plus implants is the same as for an augmentation mastopexy. The procedures are arbitrarily differentiated only by the weight of breast tissue removed. The vertical mammaplasty is performed using a medially based pedicle [32] and intraoperative nipple siting [1, 3, 33]. A mosque-dome or keyhole preoperative pattern is not used, because it is impossible to predict, before the implant is inserted and the new breast mound is created, exactly where the nipple will sit and how much skin to remove.

A supra-IMF approach preserves the inframammary ligaments, reducing the risk of bottoming out and a double bubble deformity [34]. The level of the IMF is often elevated using the vertical mammaplasty (see Video 18.1), so there is no reason to dissect inferiorly. The pectoralis muscle is released inferiorly along the IMF and along its lower medial origin on the sternum, taking care to stop immediately after dissecting the muscle fibers to avoid symmastia. This limited muscle release helps to avoid an animation deformity [34].

Breast implants are inserted subpectorally, although some surgeons may prefer a prepectoral plane. A vertical keel-shaped resection is performed (Fig. 18.2, see Video 18.1). The nipple/areola site is determined after creation of the new breast mound. The nipple is positioned just inferior to the breast apex, anticipating postoperative settling of the breast. It is inclined slightly laterally. No measurement (e.g., to the sternal notch or IMF) is used to site the nipple.

An inverted-T modification is used when the vertical scar extends below the level of the new IMF (see Fig. 18.2, Video 18.1). A scalpel and scissors are used for dissection. Electrocautery is reserved for individual bleeders. Avoiding electrodissection reduces the risk of seromas by creating less tissue injury [35]. The mean operating time for a vertical breast reduction is 2 h [8]. Simultaneous implant insertion adds only 18 min of operating time, on average [8].

Safety

The same synergistic advantages for augmentation mastopexy (compared with either operation performed individually) are available for this combination [1]. Contrary to conventional wisdom, performing implants and a vertical mammaplasty does not create opposing forces; the two procedures complement each other [1]. Although the combination procedure has been considered dangerous [36] (and indeed may be dangerous when other mammaplasty methods are used), this is not the case when combining a vertical breast reduction with implants [1]. The breast implant adds volume, making tissue approximation along the vertical limb easier. There is no need to resort to ineffective and time-

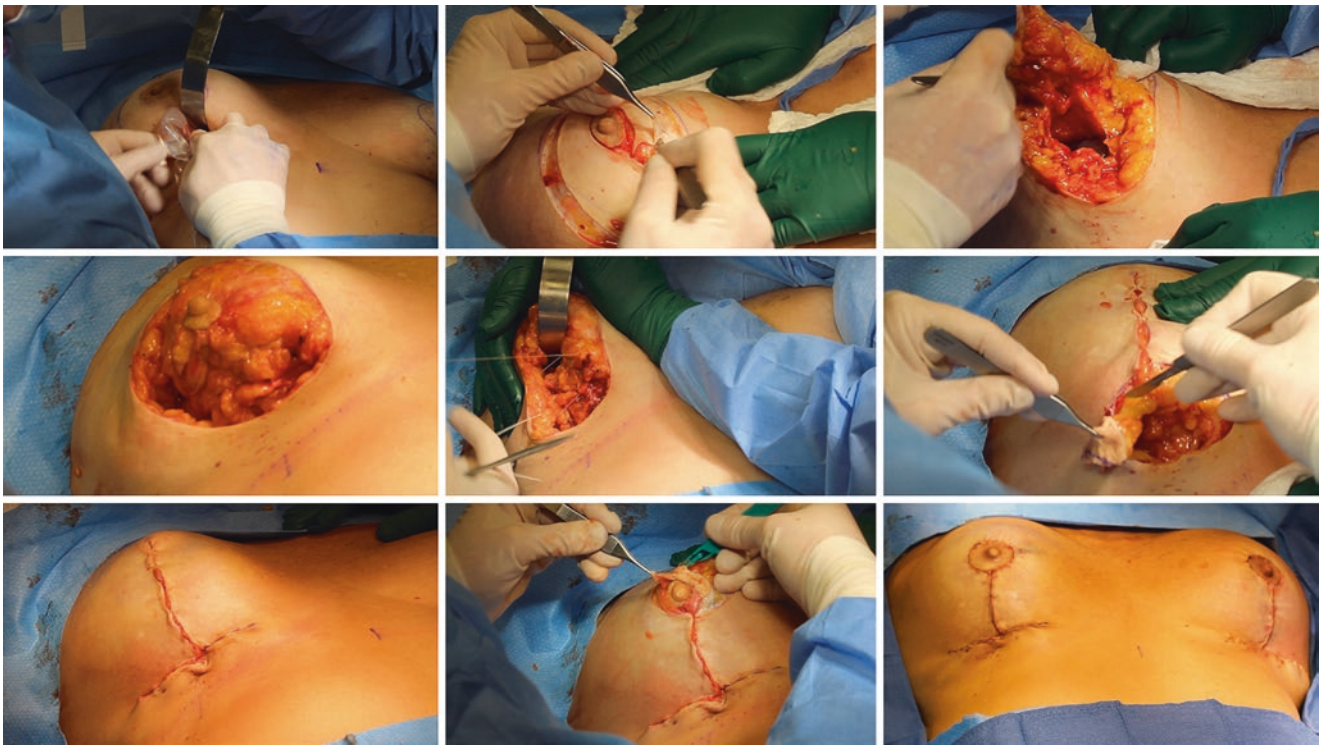

Fig. 18.2 Intraoperative photographs of a 58-year-old woman showing subpectoral insertion of a saline implant (above, left), medial pedicle dissection (above, center), lower pole resection (above, right), preservation of the parenchymal base (center, left), pillar approximation with 2-0 Vicryl (Ethicon, Bridgewater, N.J.) sutures (center), and inverted-T modification (center, right). The vertical and horizontal limbs are closed, with the nipple/areola temporarily oversewn (below, left). The nipple/areola is brought through a new circular opening, with trimming of the superior dog ear (below, center). Note that minimal nipple repositioning is required. The nipple is sited slightly below the apex and inclined laterally. The patient is seen after skin closure on both sides (below, right). This patient was also featured in the intraoperative video (see Video 18.1). Her before-and-after photographs are provided in Fig. 18.4

consuming autoaugmentation alternatives, such as the pectoral loop [37]. A laser perfusion study demonstrates that breast implants inserted at the time of a vertical augmentation mastopexy do not interfere with intraoperative nipple/areola perfusion [38].

The conventional wisdom is that very large breasts are better suited for an inverted-T, inferior pedicle reduction because more skin resection is needed [39]. However, adequate skin resection may be accomplished using the vertical technique with the inverted-T modification. The risk to nipple viability is much reduced because the pedicle is short and superficial, and transposition is minimized (nipple repositioning rather than transposition). There is no undue pressure on the pedicle from an implant [1]. Nipple grafting should be used rarely, if ever, because of its debilitating effect on this structure, leaving it insensate and without function.

Inverted-T Modification

In her seminal description of the vertical breast reduction with a medial pedicle, Hall-Findlay [32] described a vertical parenchymal resection with no horizontal component at the inferior end. My procedure modifies her method, using intraoperative nipple siting rather than a preoperative mosque-dome pattern, and (frequently) incorporating a horizontal modification at the inferior end (see Fig. 18.2 and Video 18.1).

A powerful advantage of the vertical mammaplasty is elevation of the IMF, which can produce the appearance of a longer torso – an aesthetic benefit that women appreciate, and yet is overlooked by most plastic surgeons [1]. By contrast, the IMF level remains unchanged using the traditional inverted-T, inferior pedicle method. The vertical method can elevate the IMF several centimeters [40]. Such an elevation is possible because the medial pedicle is not tethered at the IMF, but rises with the breast mound as it is cinched and elevated. This means that there will likely be a vertical scar extending below the new, elevated IMF. The horizontal excision is meant to avoid any vertical scar that might otherwise be visible just below the bra or bikini. It also allows for more skin resection, similar to a Wise pattern.

Some authors refer to a "vertical scar" breast reduction. However, this label does not properly describe the vertical breast reduction that includes a horizontal scar, which can resemble a Wise pattern scar. Importantly, the parenchymal

dissection is completely different: incorporating a vertical elliptical parenchymal resection rather than horizontal; emptying the lower pole rather than preserving it; and using a superficial medial pedicle rather than a long inferiorly based pedicle. The horizontal scar is just long enough to remove the dog ear of skin and fatty tissue at the lower end, with gathering, so that the horizontal scar remains tucked within the IMF and not visible in a bikini either medially or laterally (see Fig. 18.2 and Video 18.1).

Clinical Examples

Clinical examples are provided in Figs. 18.3 and 18.4.

Measurements

A vertical breast reduction increases breast projection and upper pole projection even without implants. However, upper pole projection is increased approximately 2 cm, on average, when implants are used, compared with <1 cm for women who do not receive implants [8].

A vertical reduction, with or without implants, reduces the lower pole area and elevates the lower pole level (the lowest point on the breast) because the lower pole resection is the same [8]. The lower pole ratio is defined as the lower pole width divided by lower pole length (height) and is an indicator of the boxiness of the lower poles [41]. Values exceeding 2.0 start to appear boxy; values <2.0 appear conical. The overall mean lower pole ratio after a vertical breast reduction is 2.0, with or without implants (Fig. 18.5) [8].

The breast parenchymal ratio is defined as the upper pole area divided by the lower pole area and is a measure of the "perkiness" of the breast [41]. The breast parenchymal ratio increases, mostly because of the substantial reduction of lower pole area. Breast mound elevation represents the vertical change in position of the most projecting point on the breast [41]. The breast mound is effectively elevated. Before surgery, areola diameters average about 7.0 cm in diameter in women with hypertrophic breasts. These diameters are reduced to 4.7 cm after surgery. Women prefer areola diameters <5 cm [33].

Complications

In the author's study, the most common complication of breast reduction plus implants was delayed wound healing in six patients (25%) [8]. One woman (4.2%) underwent secondary surgery for persistent ptosis. There were no seromas or hematomas in a series of 24 women. No patient returned to have her breast implants removed. One patient with asymmetry returned to have one breast implant replaced with a larger size. Notably, there was no difference in the complication rate comparing women undergoing breast reduction with or without implants [8]. The author has not encountered a case of nipple loss after vertical augmentation/mastopexy or its higher resection weight analog, breast reduction plus implants. Figure 18.6 demonstrates a patient who developed partial areola necrosis that healed spontaneously, without a need for scar revision.

Patient-Reported Outcomes

Pain ratings are slightly greater for patients who have implants (5.6 vs. 4.8 for women without implants, on a scale of 1–10), but the difference is not significant [8]. There is no significant difference in reported nipple numbness. Almost all women (93.8%) are self-conscious about their breast appearance before surgery; 31.2% are self-conscious after surgery – values almost identical to breast reduction alone. All patients would repeat the surgery or recommend it to someone else. The mean result rating is 8.6 on a scale of 1–10 (range, 6–10). All surveyed patients who elected to have implants were pleased with their decision. An improvement in self-esteem was reported by 87.5% of women. An improved quality of life was reported by 80% of patients [8].

Functional Benefit

It is reasonable to ask whether breast implants compromise the functional benefit of a breast reduction. One might assume that a tissue resection of 500 g and insertion of a 300-cc implant is functionally equivalent to a 200 g mammaplasty [6]. This intuitive argument assumes that only total breast mass, and not its distribution, is relevant to symptoms. Surprisingly, Thoma et al. [42] reported that even relatively small breast reductions (<400 g per breast) often alleviate symptoms, and the resection weight is not significantly related to quality of life improvement. These authors concluded that not just size but an unfavorable tissue distribution (i.e., glandular ptosis) may contribute to symptoms. Subsequent outcome studies reveal that patients with resection weights <375 g per breast [43] and even <300 g per breast [12] often experience physical symptoms that are relieved by surgery. Most patients (56.3%) who elect to have implants at the time of breast reduction also experience physical symptoms [8]. After surgery, symptoms of back, shoulder, or neck pain are reported by only 21% of women undergoing breast reduction alone and 19% of women who also receive implants (difference nonsignificant) [8]. The data suggest that implants do not compromise the functional benefit of reduction mammaplasty.

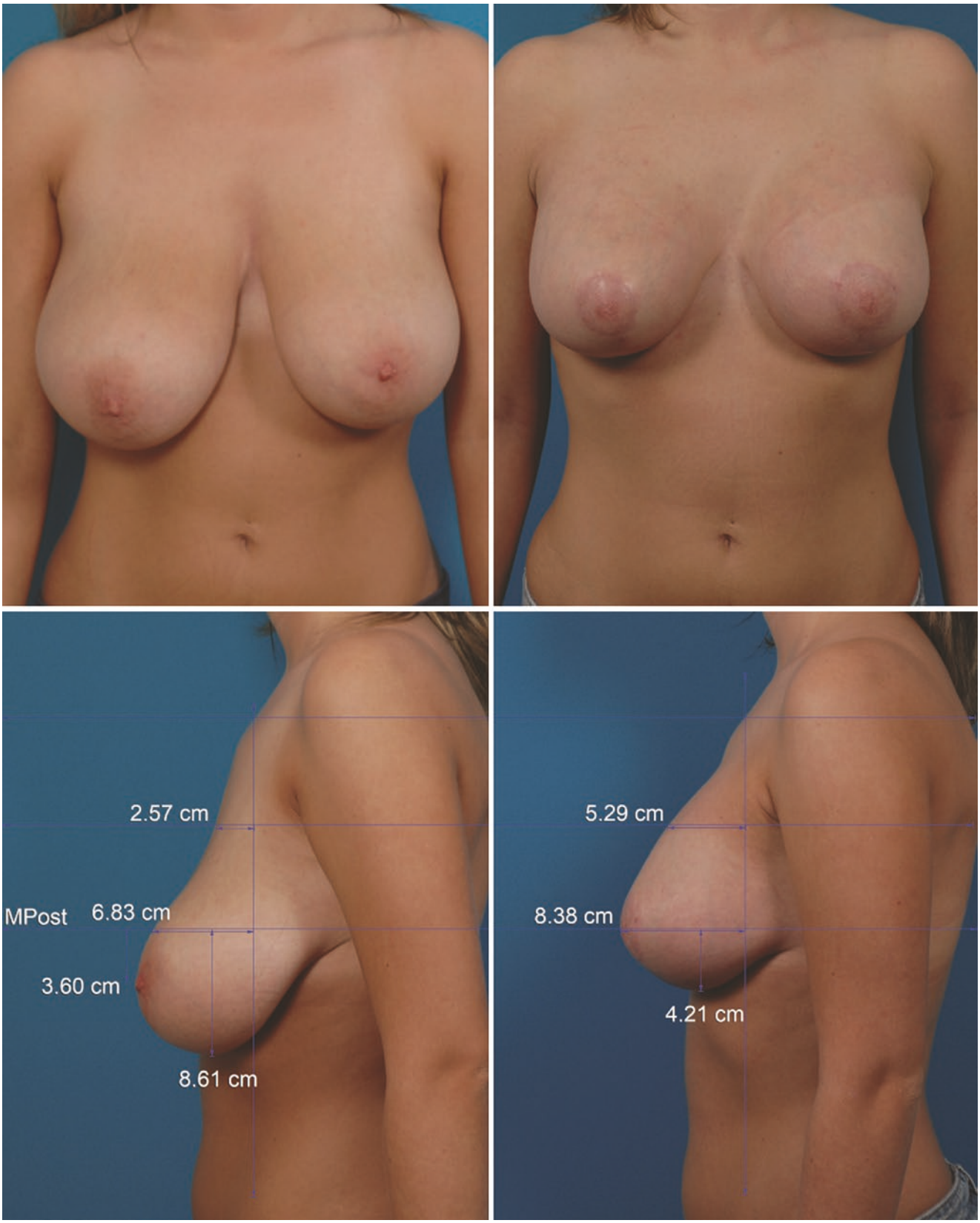

Fig. 18.3 This 23-year-old was aware of her asymmetry. She wanted to feel comfortable wearing a bikini. She is seen before (left) and 3 months after (right) a breast reduction plus implants. The same implant was used for both breasts, a smooth, round Moderate Plus profile 240 cc saline implant (Mentor Corp., Irvine, Calif.). The resection weights were 466 g on the right side and 314 g on the left side. Her photographs are matched for size and orientation using the Canfield 7.4.1 Mirror imaging software (Canfield Scientific, Fairfield, N.J.)

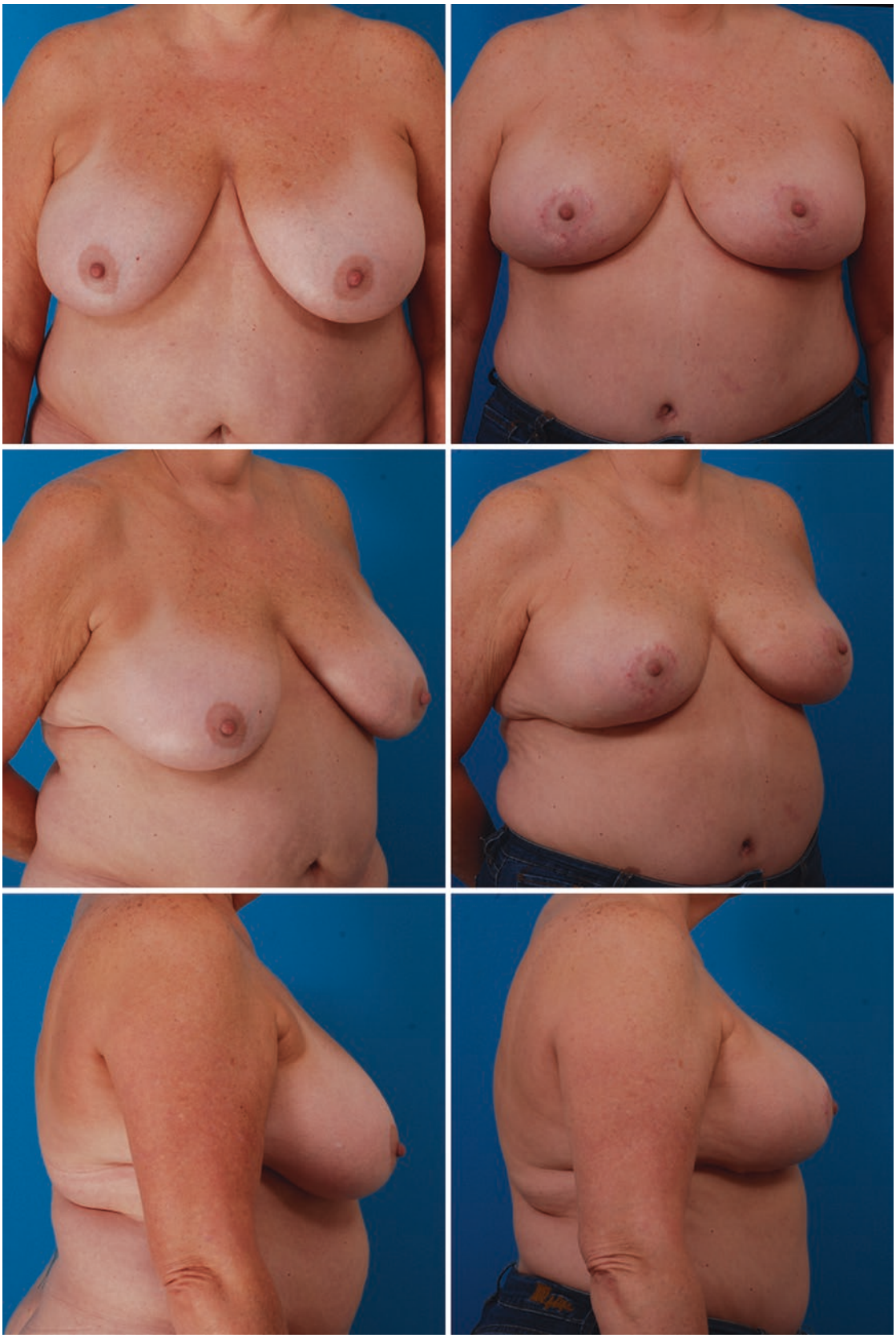

Fig. 18.4 This 58-year-old woman is seen before (left) and 3 months after (right) a breast reduction plus implants. She also had an abdominoplasty and liposuction of the lower body, arms, and axillae. She received Mentor smooth, round saline implants inflated to 210 cc. The resection weights were 332 g from the right breast and 367 g from the left breast. This patient's intraoperative photographs are provided in Fig. 18.2 and her video is available (see Video 18.1)

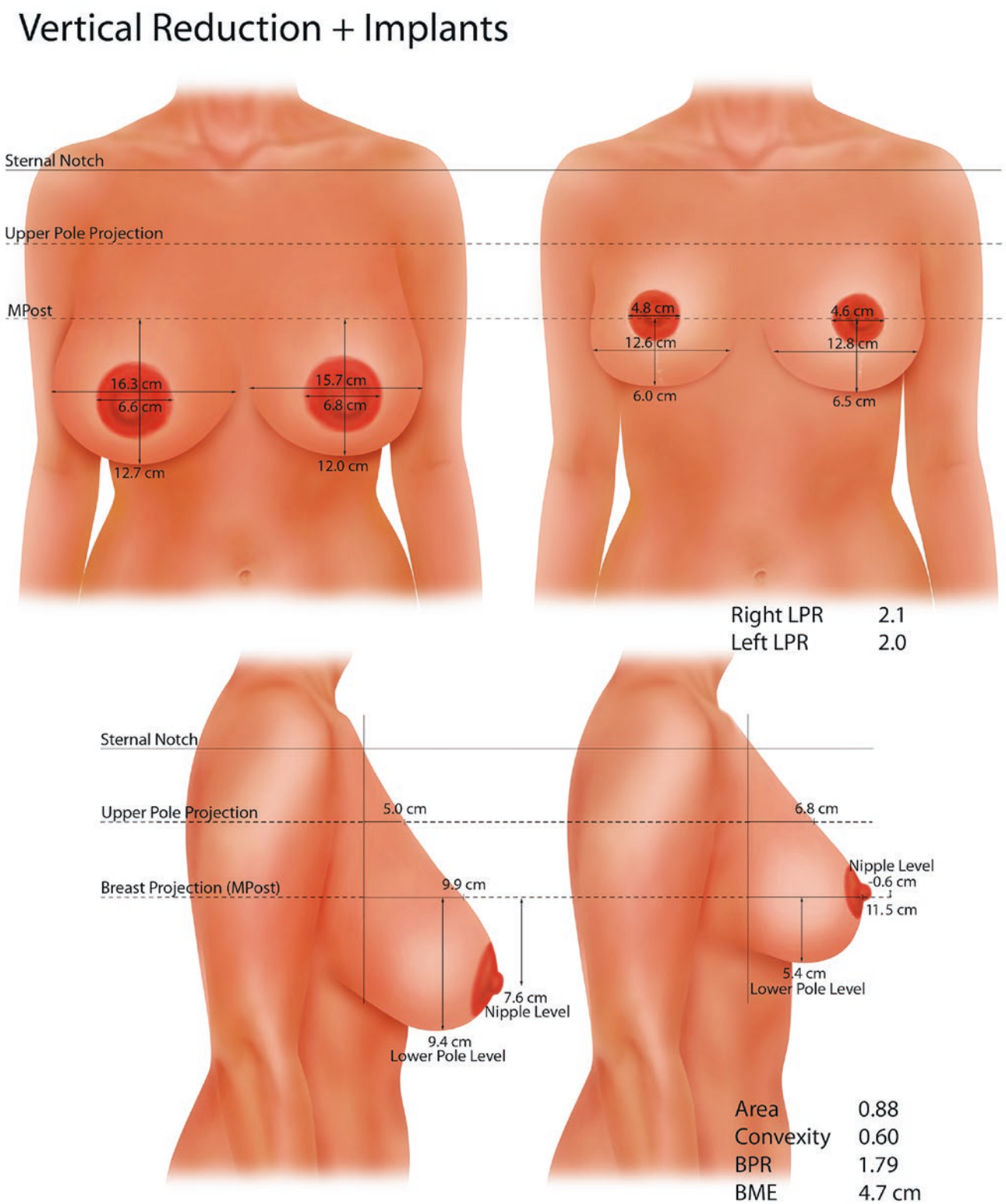

Fig. 18.5 This mammograph provides a two-dimensional rendering of the mean breast measurements for women undergoing a breast reduction plus implants. The frontal views (above) demonstrate nonboxy lower poles. The areolae are reduced in size. The lateral views (below) show a 12% reduction in total breast area. There is a greater increase in breast projection (1.6 cm) and upper pole projection (1.8 cm) compared with breast reduction alone. The breast parenchymal ratio is favorable (i.e., >1.5). The nipple is slightly (and nonideally) overelevated (0.6 cm above the apex). MPost = maximum postoperative breast projection, LPR = lower pole ratio, BPR = breast parenchymal ratio, BME = breast mound elevation. (Reprinted from Swanson [8], with permission of Wolters Kluwer Health)

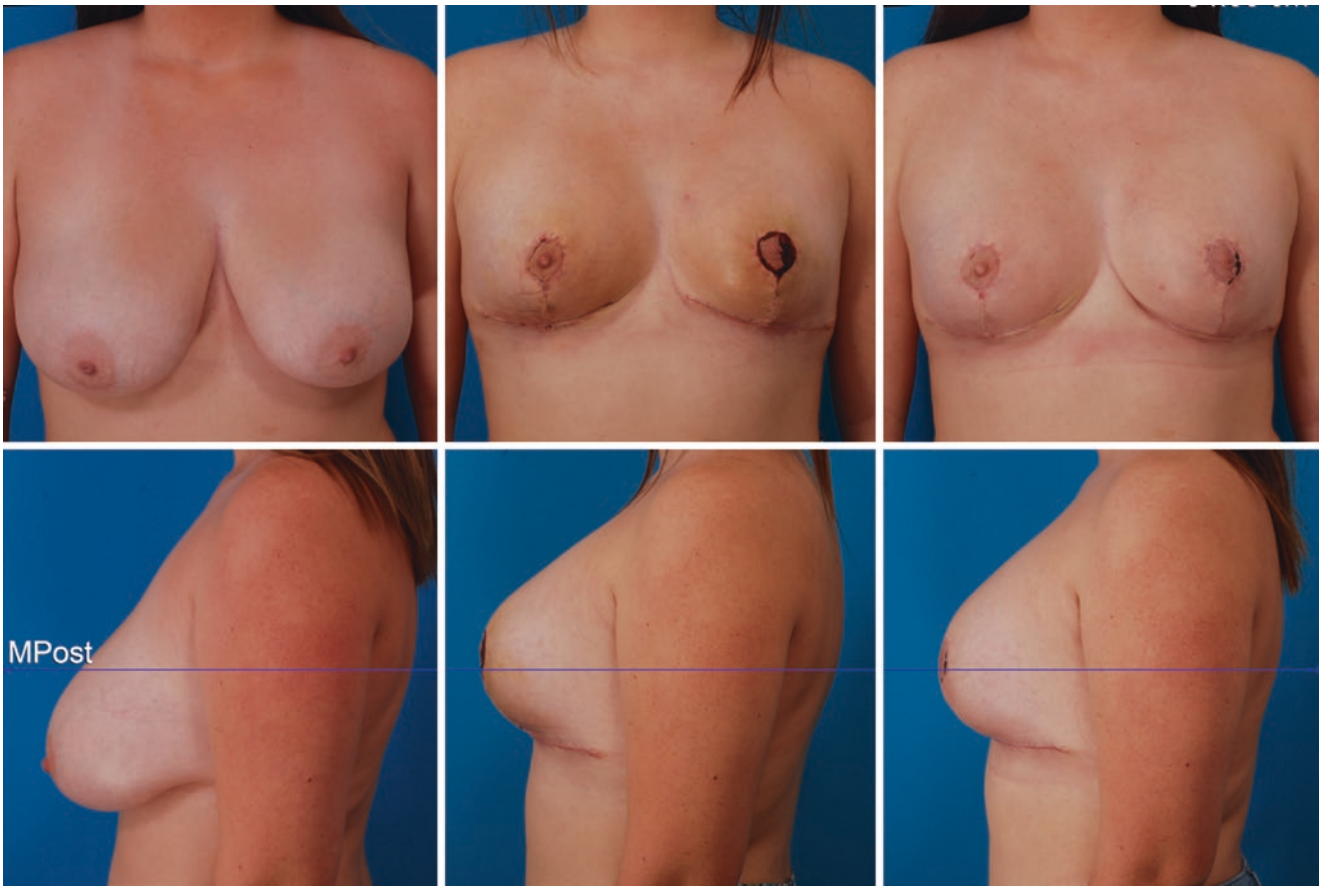

Fig. 18.6 This 18-year-old woman underwent a breast reduction plus implants, using Mentor smooth, round saline implants filled to 220 cc. Her resection weights were 631 g on the right side and 623 g on the left side. She is seen before surgery (left), 12 days after surgery (center), and 4 weeks after surgery (right). She developed partial left areola necrosis, sparing the nipple. This area of delayed wound healing healed spontaneously in 5 weeks. Note that the patient's inframammary scars resemble scars from a Wise pattern resection but are not quite as long. MPost plane of maximum postoperative breast projection

Secondary Surgery

The breast may become pendulous again over time and require a secondary mastopexy [1]. It may be possible to simply remove extra parenchyma from the lower pole, replacing the original scars with new ones. In some cases, the vertical mastopexy may be redone, with creation of a new site for the nipple/areola. In patients who have been treated previously with an inverted-T, inferior pedicle design, it is not necessary to replicate the original design [1]. However, it is important to preserve as much superficial blood supply to the nipple/areola as possible. Usually these patients do not require nipple elevation (indeed, the nipple is often overelevated already), so that a 270-degree superior/lateral/medial pedicle may be possible. In patients treated previously with an inverted-T design, the horizontal scar may be shortened, concealing it better within the IMF [1].

Insurance Coverage

Insurance companies may insist upon a numerical figure (e.g., 500 g) or calculation based on body weight and height to authorize the procedure. Without insurance coverage, many women find the cost prohibitive. In fact, there is no scientific basis for insurance companies insisting on a certain resection weight.

For women electing to have simultaneous implants, insurance preauthorization is requested, based on the patient's functional complaints. The additional anesthesia time for implant insertion is not billed to insurance. The facility bills only for a breast reduction, and of course there is no insurance billing by the surgeon for breast implants. The component of surgery devoted to breast implants, including the implants, anesthesia, facility, and surgeon, is paid by the patient separately.

Conclusion

The author presents his novel approach using a vertical reduction and breast implants to improve the boxiness and deflation that can be seen with traditional breast reduction techniques. Indications, technical pearls, and postoperative management are detailed along with case examples.

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Managing Significant Loss of Skin and Nipple Compromise in Breast Reductions

19

Rafael Mendoza, Ji-Cheng Hsieh, Chitang J. Joshi, and Robert D. Galiano

General Complications: Epidemiology

In the United States, reduction mammaplasty in 2017 was the seventh most common surgical procedure in females, performed 71,422 times [1]. Reduction mammoplasty offers significant benefits for patients, particularly in physical symptom and psychosocial domains, but this, as with any other procedure, has its associated risks [2]. According to one of the largest studies to date in the United States, the incidence of complications after reduction mammaplasty was 8.7% [3], but complication rates have been reported by single studies to be as high as 52% [4]. This study variability is due to the many factors that influence patient outcomes, including lifestyle factors, differences in reporting, and, in some cases, the lack of standard definitions and scales [5]. Though uncommon, the complications addressed in the following discussion are concerning to both the patient and the surgeon and can negatively affect esthetic results; risk factors associated with these complications are summarized in Table 19.1. Additionally, these complications lower patient satisfaction and increase the likelihood of requiring further intervention, leading to higher costs, longer recovery times, and additional risks for the patient.

Skin Ischemia, Necrosis,, and Loss

Epidemiology and Risk Factors

Studies report varying incidences of skin necrosis due to the many differences between individual studies, particularly in surgical technique assessed, study timeframe, and the lack of an overarching standard definition of skin necrosis. Nevertheless, drawing from a large patient study of 2492 patients from the National Surgical Quality Improvement Program from 2006 to 2010, the overall incidence of skin necrosis was 0.1% [6].

General risk factors for skin ischemia, necrosis, and loss include size of the reduction, smoking history, previous breast surgery, and the use of epinephrine in tumescent solution. There is an increased risk of overall flap complications in overweight and obese patients, with incidences of <0.5% flap loss and 2.2% partial loss [7]. Additionally, pedicle and incision pattern selection play key roles in surgical planning since lateral and medial pedicles are able to provide better vascularity than superior and inferior pedicles, and techniques based on the inverted-T pattern tend to have a higher incidence of flap ischemia, ranging from 1.5% to 5.55% [8–12] due to greater compromise of the vascular supply to the flaps. Both tissue tension and the distance from vascular supply contribute to ischemia, and with an inverted-T approach, tension on skin flaps at closure leads to ischemia at the distal part of skin flaps of the central lower breast and the T-junction, the latter of which notably is the point of greatest stress on the closure and the furthest from the blood supply. Flap ischemia may progress to partial wound dehiscence or necrosis [13]. The resulting hypoxia is concerning not only because it delays healing but also because it impairs leukocyte bactericidal activity [14]. In contrast, techniques based on smaller incisions, such as vertical or periareolar, have an incidence of skin necrosis less than 2% [15–17].

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R. Mendoza · R. D. Galiano (✉)
Department of Surgery, Plastic and Reconstructive Surgery Division, Northwestern University, Chicago, IL, USA
e-mail: eswanson@swansoncenter.com

J.-C. Hsieh
Department of Surgery, Plastic and Reconstructive Surgery, Northwestern University, Chicago, IL, USA

C. J. Joshi
Division of Plastic and Reconstructive Surgery, Northwestern University, Chicago, IL, USA

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Table 19.1 Incidence and risk factors associated with uncommon complications of reduction mammoplasty

Complication	Incidence	Risk factors
Skin necrosis	0.10%	Smoking Prior breast surgery Tissue resection weight Inverted T-pattern Superior/inferior pedicle use Use of epinephrine in tumescent solution
Nipple compromise	Partial 0.99–10.5% Complete 0.28–6%	Smoking Pedicle dimensions Medial/central pedicle selection Tissue resection weight Presence of intercostal perforators Hematoma Ptosis grade 3
Wound dehiscence	2.2–18.75%	Age > 65 BMI > 30 COPD Diabetes Prior radiation/chemotherapy Smoking Skin tension Surgeon experience Emergent surgery
Fat necrosis	0.8–15%	Smoking Tissue resection weight BMI > 35 Cardiac disease Ptosis Increased age Use of Wise pattern with inferior pedicle or periareolar pattern with inferior pedicle

Risks of Epinephrine

Epinephrine is a α1 and α2 adrenergic agonist that mainly promotes vasoconstriction. Its use in tumescent solution offers several benefits in breast surgery. Its vasoconstrictive effect both decreases the passage of solution into the bloodstream and reduces the use of electrocautery, respectively, decreasing blood loss and pain and reducing the risk of seroma [18–20]. Despite these benefits, epinephrine has several disadvantages. Vasoconstriction interferes with the clinical assessment of vascularity and tissue viability [21], and in mastectomy studies, epinephrine exerted an additive negative effect to other risk factors to a greater degree than being a risk factor by itself [20]. In immediate breast reconstruction, for example, epinephrine, radiotherapy, age, and body mass index were risk factors for skin flap necrosis [22, 23].

Prevention

Intraoperative and postoperative clinical evaluation is the standard of care for the majority of surgeons. This includes assessments of intraoperative skin color, dermal edge bleeding, capillary refill time, and skin temperature. There is, however, no data regarding its sensitivity and specificity. As an inherently subjective method, clinical evaluation is prone to bias, and new methods from other types of surgery have been suggested as a reliable replacement:

- Optical diffusion imaging spectroscopy measures ratio of oxyhemoglobin to deoxyhemoglobin over 1 cm^2, making it a reliable tool to measure vascularity, but not tissue viability [24].
- Intravenous injection of fluorescein followed by evaluation with Wood's lamp has been available for a long time but is limited due to errors in up to 30% of the cases [25].
- Laser-assisted indocyanine green angiography is a choice growing in popularity due to its ability to detect poorly perfused areas and significant correlation with the criteria defining necrosis [26–29]. This assessment method offers 88% sensitivity and 83% specificity, but some of the false positives found exhibited a smoking history and/or had an epinephrine tumescent solution used during their procedures [28]. Additionally, thresholds for nonviable tissue remain controversial, postoperative evaluation is not usually assessed, and the cost of laser-assisted indocyanine green angiography limits its availability for wider use.

Prior mastectomy studies offer important insights applicable to preventing and managing skin necrosis in a reduction mammaplasty. In general, it is critical to avoid skin tension and periareolar incision [30]. Ultimately, conservation of vascularity and the presence of good support that affords tension distribution will lead to less ischemic-related complications. Thus, approaches such as wider and shorter flaps or the use of deepidermized flaps underneath the T-junction have shown better results than the classic technique [31].

Ultimately, a thorough evaluation that identifies risk factors and plans a safe surgical technique constitutes the best approach in preventing skin necrosis, particularly in larger breast reductions. Additionally, several techniques have been proposed as adjuvants to minimize the risk of ischemia:

- Local heat application is a simple and low-cost method serving as a preconditioner for surgery. Thirty-minute cycles of water at 43 °C in bottles are applied 24 hours before surgery, which upregulates heat shock proteins such as HSP-32, which in turn maintains capillary perfusion and increases tissue tolerance to ischemia [32]. Laser Doppler imaging has demonstrated an increase in vascularity achieved through CO, a metabolite of HSP-32 [32].
- The synthetic heat shock protein HSP90α has a history of testing on venous congested flaps to assess its preventative effect on ischemia-reperfusion injury. This protein showed better results when used before the surgical intervention

compared to postoperative application [33]. Epinephrine reversal is another option. Exogenous epinephrine peaks after 1–4 h from the beginning of infiltration [34]. Therefore, its vasoconstrictive effects may not be fully noticed during the procedure or even during the immediate postoperative period, when the assessment for bleeding and tissue viability is typically performed. As previously mentioned, the persistent vasoconstrictive effect, particularly if unnoticed, negatively impacts tissue viability and has an additive effect to other risk factors. For this reason, phentolamine, a nonselective α1 and α2 adrenergic antagonist, has been used by the senior author, based on results of its prior use in digital and dental applications [35–39]. Phentolamine typically restores perfusion and improves associated symptoms within 60–85 min [40, 41], making it the most common and successful agent for direct epinephrine reversal [35, 40]. Direct local infiltration of 5–10 mg in 10 ml of saline is the most effective dose [42] and could be given up to 13 hours after epinephrine infiltration [41]. Other alternatives for epinephrine reversal include nitroglycerin paste and terbutaline. Nitroglycerin paste was initially found successful in a 45-mg dose at 9% concentration [43]. Recently, a 2% concentration 15-mg dose has also demonstrated effectivity in mastectomy flap necrosis prevention, which is promising for its application in reduction mammaplasty [44].

Management and Treatment

Multiple interventions facilitate wound contraction and reepithelialization, including the maintenance of a moist environment for dusky or ecchymotic skin, applying an antibiotic ointment that can penetrate the eschar, preventing infection and promoting separation, and, finally, utilizing wet-to-dry dressing changes over a granulating surface to maintain a clean and moist environment to facilitate wound contraction and reepithelialization [45].

Hyperbaric oxygen therapy (HBOT) may prevent progression of ischemia into necrosis. HBOT has been shown to provide an efficacious treatment for a variety of soft tissue injuries by addressing reactive oxygen and nitrogen species, inhibiting of β2 integrins, limiting production of inflammatory cytokines, enhancing endogenous antimicrobial activity, promoting collagen production by fibroblasts, mobilizing stem cells from the bone marrow, augmenting stem cell growth factor synthesis, and promoting secretion, angiogenesis, and vasculogenesis that lead to neovascularization [46–48]. Unfortunately, evidence for HBOT after breast surgery is scarce, and most comes from case reports and anecdotal experience. Recently a case where five sessions were administered, starting the day of the surgery, demonstrated full resolution with no complications, further reinforcing the idea that acute wounds respond best when HBOT is initiated early [49]. Nevertheless, no significant difference on long-term effects has been seen with HBOT when compared to conservative management, but it seemed to accelerate the rate of recovery in the short term. As a result, the timeline for progression or healing may be difficult to predict. It is during this time period that adjunct methods aimed at improving tissue perfusion are often attempted, such as topical vasodilators, local wound care with hydrating gels, and/or antibacterial compounds [50]. Protocols regarding HBOT vary from 60- to 120-min sessions of high concentration oxygen delivery by face mask to tent or endotracheal tube at 2–2. Atm [51, 52].

In a more involved surgical management of skin ischemia, several approaches and modifications have been explored since the original techniques for breast reduction surgery were conceived. When tissue viability is already compromised, it is to the discretion of the surgeon to use a conservative approach.

Skin flap necrosis can present as dry or moist necrosis, and the therapeutic approach will vary depending on this. Dry necrosis usually represents an ischemic injury that has advanced to an irremediable stage. The general recommendation is to allow unviable tissue to demarcate and follow its natural course as far as possible. This approach has been proven to have better outcomes, including preserved esthetics. Furthermore, early debridement and skin graft creates contour and volume abnormalities more difficult to correct later on, and avoiding these avenues leads to fewer subsequent operations and a skin-graft "patch" appearance [45]. On the other hand, moist or wet necrosis is usually related to an ongoing infection, mandating an operative debridement. Experience in our department and a previous study has found the use of negative pressure therapy in these cases to be useful, particularly in greater reduction weights [11]. The mechanisms involved with negative pressure include the reduction of lateral tension to skin flaps, the increase of tissue perfusion and angiogenesis, exudate and edema draining, tissue granulation enhancement, and contraction of wound edges [53].

Nipple Compromise

Epidemiology and Risk Factors

Complications related to nipple and nipple-areolar complex (NAC) range from ischemia to necrosis and have been reported inconsistently, often lacking specific descriptions. For example, grouped with pedicle necrosis, incidences have varied from 0.1% to 1.92%, with one of these studies highlighting an association with higher BMI groups [2, 6, 54]. Partial epidermolysis of the NAC has an incidence of 6.25% [55].

Individually, the incidence of partial epidermolysis of the areola has been reported to be 5.5% in a series of patients with massive ptosis [56]; while partial and complete areolar necroses are 3.1% and 0.6%, respectively [57]. Partial nipple necrosis incidence ranges from 0.99% to 10.5%, with higher incidence in a series of severe hypertrophy [12, 17, 58–64]. The incidence of complete nipple necrosis ranges from 0.28% to 6%, increasing to 12% in the case of repeated mammaplasty [9, 12, 17, 61, 65–68].

The main cause of nipple/NAC ischemia and necrosis is vascular compromise. Several factors impacting vascular viability have been identified, including the base, width and length of the pedicle, and presence of intercostal perforators. Sternal notch to nipple distance (SN-N) and diabetes have recently been identified as independent predictors of NAC necrosis [63, 66]. Hematoma alone poses a risk of inducing necrosis and infection [69]. Ptosis grade 3, which indirectly affects the length of the pedicle, also seems to have a negative effect on viability [63]. The amount of resection is a controversial risk factor, but several studies have shown an increased overall risk and risk of NAC ischemia with larger tissue resection [11, 66, 70, 71]. Pedicle selection seems to also play a key role as a risk factor. The viability of the NAC has been reported to be 100% for superomedial pedicle, 98% for inferior pedicle, 94% for medial pedicle [72], and 90% for central pedicle [73]. In the presence of severe hypertrophy, the viability of the NAC with the superomedial pedicle dropped to 89.5% [60].

Prevention

Preoperatively, a thorough history can help identify risk factors and design an ideal pedicle with regard to the anatomical variations, attempting to preserve the internal breast septum. Optimizing the clinical status of a patient by enhancing nutritional state and ensuring optimal cardio pulmonary status is helpful prior to surgery. In higher risk cases, such as repeated reduction or a previously radiated breast, limited undermining and a wider pedicle may be a safe approach to be considered during the planning. Current data suggest that when performing reduction surgery in obese patients, performing a relatively conservative resection leads to safer outcomes and general patient satisfaction [74].

Intraoperatively, the anatomy must be appropriately cared for. NAC viability must be rechecked after closure. Several methods have been suggested like checking capillary refill, bleeding skin edges, intravenous fluorescein, or using indocyanine-green-based perfusion assessment systems [69]. If ischemia is suspected, the surgeon should open the incision, release the sutures, and examine the pedicle for torsion. Color assessment when possible can be helpful, with a white areola meaning a significant arterial insufficiency, a gray-blue hue meaning an incomplete arterial insufficiency, a pale areola a sign of vasospasm (for which warm irrigation or papaverine could be helpful) and a dark red areola indicating venous congestion [75].

If truly ischemic, the NAC should be converted to a full-thickness skin graft and inset to a well-vascularized portion of the pedicle or placed on the breast skin after closure [69]. This can preserve an acceptable result; however, recognizing the severity of the ischemia and deciding when to act requires thoughtful judgment guided by experience. Once the immediate changes after surgery related to cooling and epinephrine effect have subsided, the decision to proceed with removal of the ischemic nipple-areolar complex and reapplication as a free graft can be made.

In the postoperative period, close observation of the sutures and NAC warrants a quick intervention when necessary. In large reductions, the pedicle may be folded and compressed, which can lead to decreased perfusion. When tension is suspected, the surgeon can release that tension with surgical interventions similar to the ones described before. If these interventions are insufficient, a reasonable approach is to allow the nonviable nipple to declare itself over time and allow any devitalized areas to demarcate before any definitive treatment is attempted. This approach would allow the surgeon to identify nipples that only appear to be threatened versus those which really are. Some nipples will show viability, especially if the surrounding areola tissue is still viable [13].

Management and Treatment

In the event of complete or partial loss of the nipple-areolar complex, conservative wound management with debridement and secondary healing are indicated followed by standard techniques of nipple-areolar complex reconstruction, although scarring can compromise the ability to create a nipple of adequate projection [13].

Wound Dehiscence and Delayed Healing

Epidemiology and Risk Factors

Similar to the rest of complications addressed in this chapter, wound dehiscence has a wide range of occurrence and unclear definition among available publications. Data regarding incidence of wound dehiscence range from 2.2% to 18.75%, but the sample size and the selection criteria were different in these studies [8, 55, 76, 77]. Delayed healing in our previous study with a heterogeneous population was defined as any incision not 100% closed by postoperative day 7, reaching a 45%

incidence. Other reports with a focused population, post-bariatric and massive ptosis subjects, and an unclear definition of delayed wound healing range from 11% to 19.44% [12, 56].

There is no formal definition of wound dehiscence, and studies' definitions have ranged from any breakage of skin at all to >1 cm^2 surface area of open skin, but recently a proposal by the World Union of Wound Healing Societies defined wound dehiscence as any breakage of skin [78, 79]. Wound dehiscence may result from wound infection, may increase mortality, requires additional corrective procedures, and increases hospital stays and costs [79, 80]. As with other subtypes of poor wound healing such as fat necrosis and infection, the incidence of wound dehiscence is modified by multiple risk factors, divided into demographic factors, past medical history, and the type of surgery [79]. Demographic factors include being female, age > 65, and BMI >30 [79]. Risk factors in the past medical history include COPD, diabetes, prior radiation or chemotherapy, and smoking [79–81]. Risk factors associated with the procedure include the specific type of procedure and incisions used, the skin tension of the procedure location, the attending surgeon's experience, and whether the surgery was elective or emergent [79, 80]. For example, skin tension plays a part especially in sternal wound dehiscence, especially in women with large breasts [82] (Fig. 19.1).

Prevention

Evolving modalities to prevent wound dehiscence include closed incision negative pressure wound therapy which putatively keeps the wound sealed, reduces edema, and promotes angiogenesis and collagen remodeling [79].

Management and Treatment

A continuous intradermal suture to gather the skin of the vertical wound may be a source of wound-healing problems due to constriction of the blood supply to the skin edges. Some authors advocate for the use of the four-point box suture,

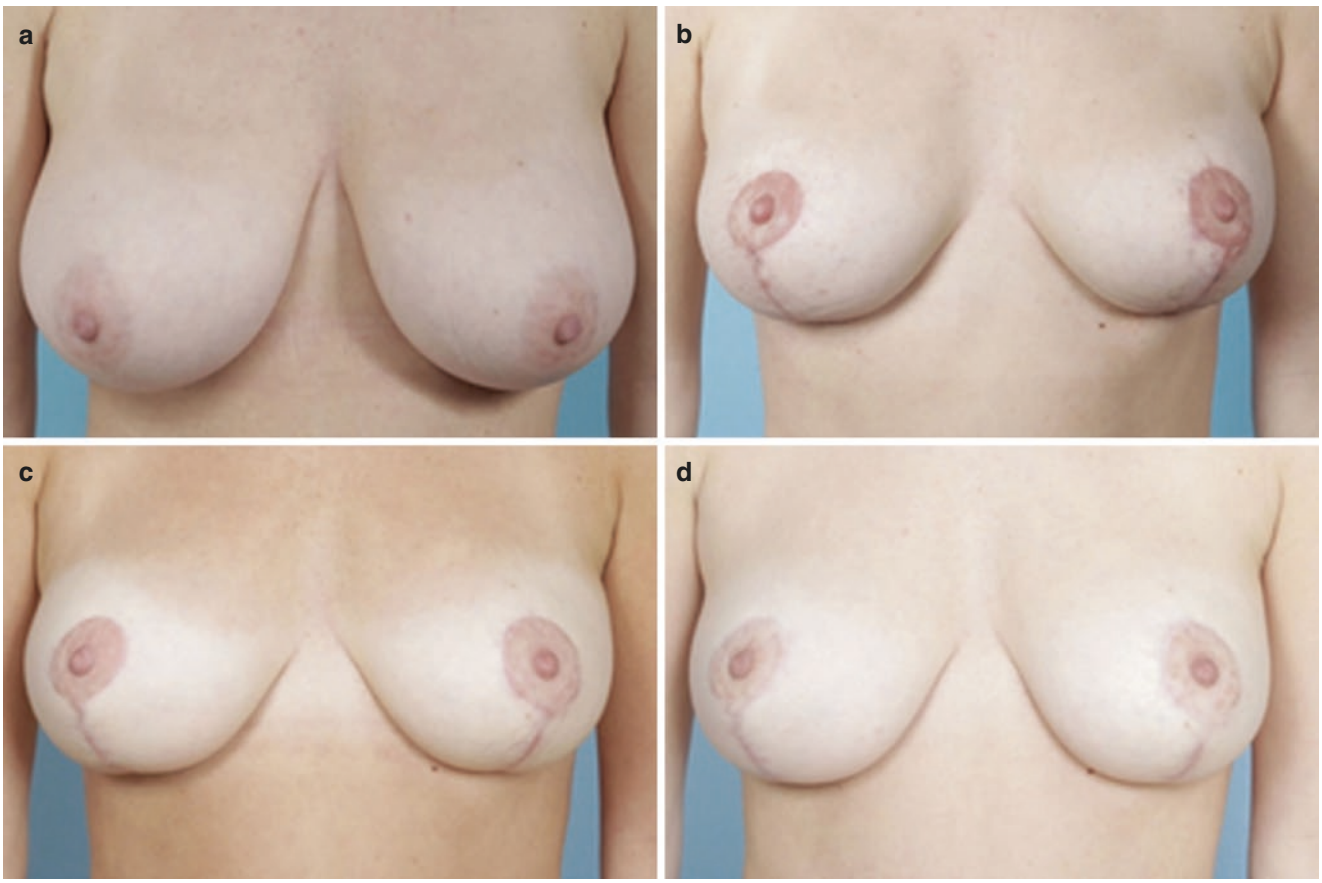

Fig. 19.1 Delayed wound healing course. (**a**) Preoperative status. (**b**) Four months postoperation with delayed wound healing bellow the left areola. (**c**) Seven months postoperation with minimal healing defect on the same area. (**d**) Twelve months postoperation with wound completely closed

which gathers the skin of the vertical wound effectively while causing less skin edge ischemia (Video 19.1). Staples provide further approximation of the skin edges without causing additional ischemia but can leave unsightly visible staple marks [70]. Negative pressure wound therapy has a preventative effect on wound dehiscence compared to standard care (adhesive and nonadhesive dressings) which is more evident in subjects with BMI over 25 or resection weight over 500 g [11].

Fat Necrosis

Epidemiology and Risk Factors

Fat necrosis following reduction mammaplasty has a variable rate (0.8–15%) (Fig. 19.2). Although relatively low, it is still concerning for both surgeons and patients, particularly due to the potential risk for additional diagnostic and/or therapeutic procedures these patients may need to undergo.

Poor tissue perfusion is the main cause, which is supported by its common presence at the distal end of a pedicle. Other mechanisms have been considered as contributing factors such as thermal injury, infection, elevated parenchymal pressure after closure, and surgical technique.

The amount of tissue resected seems to play a key role in its pathology, reported in several studies as being present either exclusively or higher rates in the larger reduction groups [57, 70, 76, 83, 84]. Additionally, fat necrosis has been associated with specific techniques more than others, such as the Wise pattern with inferior pedicle [70, 85] or periareolar pattern with inferior pedicle [59]; however, current data are controversial.

Tobacco use has been identified as an independent predictor of all types of complications, including fat necrosis. Other risk factors have been analyzed and mixed data have been reported. However, a single-center, retrospective study with the largest number of patients in this category [86] pointed out that BMI > 35 kg/m^2, cardiac disease, increasing ptosis (nipple-to-sternal notch distance >37 cm, nipple transposition > 16 cm), and age were found in association with fat necrosis and other complications. Cardiac disease, in particular, was a strong predictor of reoperation for fat necrosis.

Prevention

Modifications in pedicle width, length, and thickness, as well as the surgical technique should be considered in the presence of previously mentioned risk factors. Several surgeons would recommend weight loss and smoking cessation ahead of surgery. Assessing the viability of the fatty portion of the breast at the time of reduction poses a great challenge as the devascularized tissue would be noticeable when scar tissue develops encapsulating it. In that case, a round palpable mass will present most likely at the terminal end of the pedicle, which is farthest away from the blood supply. It usually takes approximately 6 months to fully mature [87] and develop into a solid calcified mass [69].

Intraoperatively, breast tissue should only be approximated; excessive suture tension should be carefully avoided as well as large suture bites [2, 13, 15].

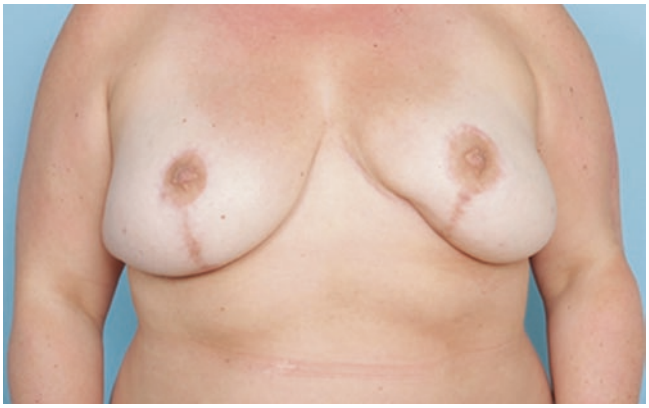

Fig. 19.2 Left breast deformity caused by fat necrosis

Management and Treatment

Initial treatment consists of observation as resolution of edema, and absorption of the necrotic fat can occur resulting in disappearance of the mass in more than two thirds of the patients with fat necrosis. The senior author has periodically utilized triamcinolone acetonide (Kenalog) in the past for cases of fat necrosis as according to the standard of care use for hypertrophic scars. A subset of patients will require debridement only, and others additional intervention (0.36–4.3%) [59, 84, 88]. If a mass persists up to a year postoperatively, biopsy and removal are recommended simply to avoid any potential for delay in diagnosis should an actual tumor ever develop [89].

Nipple-Areolar Complex: Unsatisfactory Esthetic Results

Despite careful preoperative planning as well as intra- and postoperative observation of skin and/or nipple-areolar complex changes, several unsatisfactory outcomes can present in the short or long term.

Nipple Asymmetry

The pedicle, technique, tension, skin retractability, undermining, and breast vascularity are known factors to impact the outcomes, but tissue accommodation can slowly and subtly affect position and symmetry. Particularly in larger volume resections, the lower pole can migrate caudally, which can distort the inframammary line, create a breast asymmetry or a NAC asymmetry or malposition.

Evidence on breast tissue migration after reduction mammaplasty is still scarce. A study based on Wise pattern and superomedial pedicle showed that NAC position dropped 1.61–1.79 cm in 15 months. Length from NAC to inframammary fold increased 3.31–3.59 cm [90]. Thus, superior malposition, the most common malposition, can be avoided by placing the nipple slightly lower than the preoperative IMF. When the residual breast volume is relatively large, this strategy can reduce the occurrence of a superior malposition.

In order to avoid NAC asymmetry and volume discrepancies, preexisting asymmetries have to be identified, with a subsequent appropriate operative planning. Intraoperatively, it is always best to compare the residual tissue than the resected tissue. Additionally, before closure, the surgeon can have the patient raised into the sitting position at 90 degrees and compare the residual breasts from the foot of the table. The superior pillar suture should not be closer than 2 cm from NAC to avoid deforming of the NAC [91].

Nipple Retraction

Nipple retraction results after overresection of the breast parenchyma beneath the nipple. Avoiding overresection and performing resection away from the NAC in all directions is a helpful strategy, taking into account that the NAC should be at or slightly above skin level with no tension from the sutures.

Nipple Reconstruction

In the case of breast reductions presenting with postoperative complications involving the nipple, such as NAC necrosis, despite methods of prevention and use of other less involved interventions, nipple reconstruction is a helpful corrective measure [92]. Nipple reconstruction serves an important role in breast reconstruction surgeries in order to fully restore a breast to its "natural" shape, and the procedure, typically performed a few months after other major corrective surgeries in order to allow the new breast to settle into shape, increases overall patient satisfaction post-breast reconstruction [92, 93]. Recommendations regarding nipple reconstruction post-breast reduction would follow those seen in breast reconstruction. Unilateral nipple reconstruction relies upon the existing nipple for reference, while bilateral nipple reconstruction utilizes standard values of nipple diameter – 0.3 cm, areolar diameter – 4 cm, and nipple projection – 0.9 cm, and it is important to adjust for a natural 45–75% decrease in nipple projection postoperatively [92]. Accepted ratios for nipple to areola and areola to breast are respectively 1:3 and 1:3.4 [94]. Despite these standard values, some parameters, such as the positioning of the nipple on the breast, is subject to physician judgment and necessitates discussion between the physician and patient, but typically the nipple is placed at the point of maximal projection [92, 94]. Especially in unilateral nipple reconstruction, the symmetric position may not necessarily be the most aesthetic position [94].

Utilization of local tissue flaps, tissue grafting, and tattooing are three primary methods of nipple reconstruction, and local flaps are the most popular method of nipple reconstruction [93, 94]. Following the progenitor skate flap, >30 flaps are available for use in nipple reconstruction. Although each is pedicled; involves epidermis, dermis, and subcutaneous tissue; and is perfused by the subdermal plexus, each contains unique pros and cons [92, 94]. Tissue grafting is another option, and in the case of a unilateral nipple reconstruction, nipple sharing is an effective procedure where the surgeon utilizes the existing nipple to supply tissue for the reconstruction, but due to the nature of this technique, it is only useful in patients with large nipples. The downside is the potential for scarring on the donor nipple – with concomitant issues related to numbness, cosmesis, and inability to breastfeed [92, 94]. Tattooing is another option available for both nipple and areolar reconstructions [94]. In all patients, tattooing may be necessary in order to restore the areola to a satisfactory and familiar appearance for the patient, and for patients who do not wish to have or in lack the skin necessary for a projected nipple, 3-D tattooing is a viable option for nipple reconstruction and can be done in-office [92]. Tattooing, however, needs to be repeated at least once a year in order to maintain appearance [94]. As nipple reconstruction constitutes another procedure, it too has the risk for surgical complications, particularly necrosis, and complications are as follows with tissue grafting (46.9%) and local flap use (7.9%) [93]. The most common complication of tissue grafting was sensation loss while the most common in local flap usage was partial necrosis [93]. The rate of complication for areolar reconstruction via tattooing is 1.6% and via grafting, 10.1% [93]. The most common complication in areolar grafting was partial necrosis, while the most common in tattooing was skin swelling [93].

Conclusion

Loss of skin and nipple compromise are uncommon complications of breast reduction. The etiology is a function of patient factors, anatomy, and surgical planning or lack thereof. The root cause is the loss of blood supply to the aforementioned structures. Limiting undermining and being respectful of pedicle anatomy and avoiding constriction or aggressive concomitant liposuction are ways to prevent such problems. Once they occur, judicious wound care is the best initial option followed by serial debridement as needed. Table 19.2 summaries the preventative and treatment strategies available for reducing the risk of postreduction mammaplasty complications.

Table 19.2 Summary of prevention and treatment strategies for uncommon complications after reduction mammoplasty

Complication	Prevention	Treatment
Skin and nipple compromise	Thorough history Smoking cessation Comorbidities control Limiting undermining Wider, thicker pedicle Intra- and postoperative clinical evaluation (skin color, dermal edge bleeding, capillary refill time, skin temperature) Local heat application Synthetic heat shock protein Topical nitroglycerin ointment Phentolamine (if epinephrine-based tumescent solution was used)	Hyperbaric oxygen therapy Negative pressure therapy Dry necrosis: Natural demarcation of unviable tissue with subsequent debridement/ reconstruction Wet necrosis: OR debridement
Wound dehiscence	Negative-pressure wound therapy	Four-point box suture
Fat necrosis	Thorough history and communication with the patient Detailed surgical planning Modification of pedicle dimensions and surgical technique Weight loss Smoking cessation Avoiding excessive suture tension	Observation of edema and absorption of necrotic fat Triamcinolone acetonide Debridement Biopsy and removal

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Breast Reduction and Cancer Surveillance and Risk

20

Ara A. Salibian, Jordan D. Frey, and Nolan S. Karp

Oncoplastic Reduction

Introduction

With one in eight women diagnosed with breast cancer [1], screening mammography remains one of the most important components of preventative healthcare for women. The effects of reduction mammoplasty on the interpretation of screening mammograms have long been a topic of discussion [2]. As a procedure that significantly manipulates the breast skin, fat, and parenchyma, there is a question of whether postoperative changes after breast reduction hinder the analysis of mammograms. Furthermore, reduction mammoplasty often removes a significant portion of glandular tissue and, therefore, should reduce the risk of developing breast cancer.

National organizations provide guidelines on the recommended timing of screening; however, little is addressed with regards to the implications of prior surgical procedures on the breast, particularly breast reduction. Understanding the environment of breast cancer surveillance after breast reduction requires comprehension of the risk reduction secondary to reduction mammoplasty and the effects of postoperative changes on surveillance imaging. Plastic surgeons should be familiar with these changes in order to properly counsel patients prior to and after breast reduction.

Cancer Surveillance After Breast Reduction

Mammographic changes after breast reduction have been extensively studied. Understanding the radiographic sequelae of postoperative changes and differentiating these from potential proliferative or neoplastic lesions are critical in the preventative healthcare of reduction mammoplasty patients. Interpretation of these differences will not only appropriately identify lesions of concern, but also prevent the overdiagnosis of otherwise benign changes that can lead to unnecessary interventions.

Mammographic Findings

Reduction mammoplasty involves significant surgical manipulation of the breast skin envelope, parenchyma, and nipple-areolar complex. Postoperatively, healing of this soft tissue disruption has transient and permanent effects of the structures of the breast that have important implications for imaging. New tissue planes are formed and subsequently scarred to each other, edema can alter structures, damaged tissues calcify, fluid collections form, necrosis of the fat or parenchyma may result in new masses, and foreign bodies such as sutures can perpetuate localized inflammation.

Common mammographic findings after reduction mammoplasty include skin thickening, fibrotic bands behind the areola, lipid/oil cysts, and areolar skin calcification (Table 20.1) [3, 4]. Transverse retroareolar fibrotic bands parallel the skin and can be explained by the dermis of the deepithelialized pedicle. A thickened areola is also likely secondary to the periareolar suture line and subareolar edema. Similarly, skin thickening is observed due to the vertical scar between the nipple and the inframammary fold. Oil cysts tend to be the most common finding associated with fat necrosis and are, therefore, associated with scars and suture lines. They appear as a radiolucent cyst with a calcified, "eggshell" capsule (Fig. 20.1).

Focal calcifications are also relatively common and have been reported in the range of 8–45% (Fig. 20.2) [5–8]. The majority of these benign calcifications likely arise from areas of fat necrosis. As fat necrosis is highly dependent on surgical technique, breast morphology, and postoperative healing, the incidence of calcifications can be highly variable. However, the appearance of benign calcifications can typically be differentiated from malignant lesions [5].

A. A. Salibian · J. D. Frey · N. S. Karp (✉)
Hansjörg Wyss Department of Plastic Surgery, NYU Langone Medical Center, New York, NY, USA
e-mail: Nolan.karp@nyumc.org

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Table 20.1 Mammographic findings after breast reduction

Skin thickening
Retroareolar fibrotic bands
Subareolar edema
Oil cysts
Calcifications
Lower pole retraction
Breast parenchyma redistribution
Superior nipple-areolar complex displacement

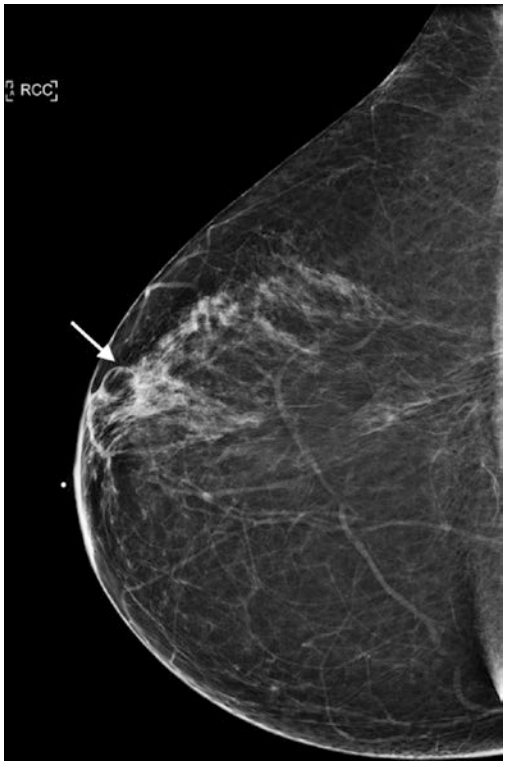

Fig. 20.1 Screening mammogram after reduction mammoplasty demonstrating fat necrosis in common periareolar location with an oil cyst (*white arrow*)

Calcifications secondary to fat necrosis tend to be round, well-defined, and coarser than calcifications secondary to malignancy [4]. These lesions also tend to be closer to the skin as opposed to deeper, parenchymal neoplasms. However, certain lesions can also mimic spiculated microcalcifications seen with malignancy [9] and, therefore, may require tissue diagnosis.

Of note, these radiographic changes can also evolve over time. For example, skin thickening has been shown to diminish over time and is not recognizable after 2 years [2, 5]. Calcifications, on the other hand, have been noted to increase over time in certain studies [8]. Morphologic changes can also be seen on mammography. These changes include retraction of the lower pole of the breast, redistribution of the breast parenchyma with downward displacement of the glandular tissue, and movement of the nipple-areolar complex superiorly [6]. While the majority of these changes are predictable and, therefore, reliably differentiated from malignant lesions, any concerning or otherwise equivocal findings require meticulous further workup.

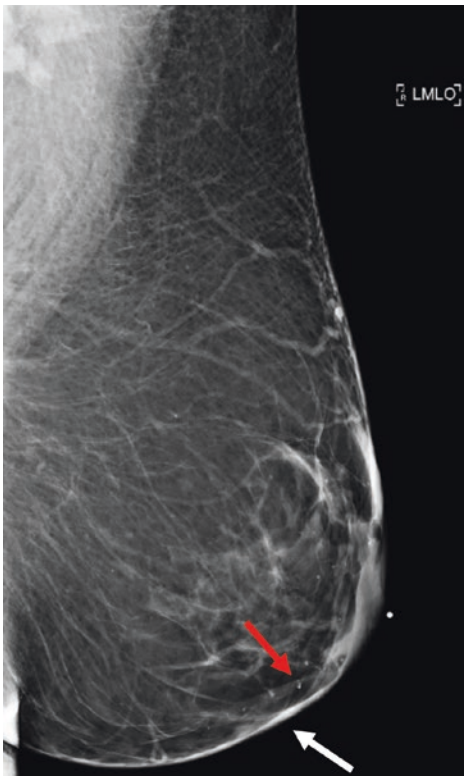

Fig. 20.2 Screening mammogram after reduction mammoplasty demonstrating typical postoperative changes including benign calcifications (*red arrow*) and skin thickening (*white arrow*)

Implications for Cancer Screening

Mammography

Many studies have confirmed the safety of breast reduction with regards to future mammographic screening. Symmetrizing reductions contralateral to mastectomies have been shown to have an equal accuracy, sensitivity, and specificity of mammographic screening compared to nonreduced breasts [10]. In this same study, Nava et al. demonstrated similar Breast Imaging Reporting and Data System density scores between breasts with and without reduction mammoplasty. Such findings suggest that the ability to detect proliferative or neoplastic lesions is not affected by the manipulation of the breast skin and parenchyma.

There is concern that increased scarring and fat necrosis in postsurgical breasts may lead to a greater incidence of mammographic findings requiring biopsy. As previously discussed, while most calcifications secondary to fat necrosis are distinguishable from malignant calcifications, certain

patterns of fat necrosis mimicking neoplastic calcifications have been reported [9]. A comparison of postreduction mammographic changes to those seen after fat grafting showed a higher rate of masses warranting biopsy in patients that have undergone breast reduction [11].

The majority of postsurgical radiographic changes, however, are thought to be distinctive from mammographic signs of malignancy. Several studies have examined the incidence of additional workup secondary to imaging findings after breast reduction and have found similar rates of additional testing compared to controls. Comparison of postoperative mammograms with a cohort of preoperative control mammograms demonstrated no significant difference in the percentage of abnormal mammograms, the need for additional imaging, the need for follow-up imaging, or the need to biopsy lesions found on mammography [12]. Similarly, a review of 4473 women who had breast reduction found no difference in the rate of recall after screening mammography compared to 239,404 patients who did not have a reduction, further suggesting the ability to appropriately interpret screening mammograms despite postsurgical changes [13].

Screening mammography after reduction mammoplasty requires interpretation of imaging findings in light of known postsurgical changes while also maintaining a heightened suspicion for any lesions that may fall outside of the postsurgical norms. Timing of imaging is also critical, as the presence of "appropriate" postoperative changes must be established and tracked over time to differentiate from new lesions. A 6-month postoperative mammogram is recommended to establish the presence of postsurgical changes after which a one-and-a-half-year study can be performed, typically after resolution of transient postoperative changes to create a baseline for future screening [4].

Other Imaging Modalities

In the event of equivocal findings on mammography, other imaging modalities can be utilized to further characterize indeterminate lesions. Magnetic resonance imaging (MRI) has been increasingly used as not only a diagnostic but also a screening tool for breast cancer [14]. Breast MRI can be useful to further evaluate certain lesions that appear to be equivocal on mammography (Fig. 20.3). Ultrasonography and stereotactic tissue sampling can also be utilized for evaluation of suspicious mammographic findings [7].

Oncoplastic Reduction

These implications are moreover critical in cancer surveillance after oncoplastic reduction. Oncoplastic reduction mammoplasty has demonstrated good outcomes in achieving appropriate margins for excisions while maintaining an aesthetic breast that would otherwise be distorted by larger excisions [15]. More vigilant postoperative surveillance is commonplace in oncoplastic cases given the concern for recurrence in addition to primary malignancy. Losken et al. demonstrated similar mammographic findings in a cohort of oncoplastic reduction patients compared to those undergoing just breast conservation therapy [16]. However, oncoplastic patients required additional diagnostic testing in the form of tissue sampling compared to controls.

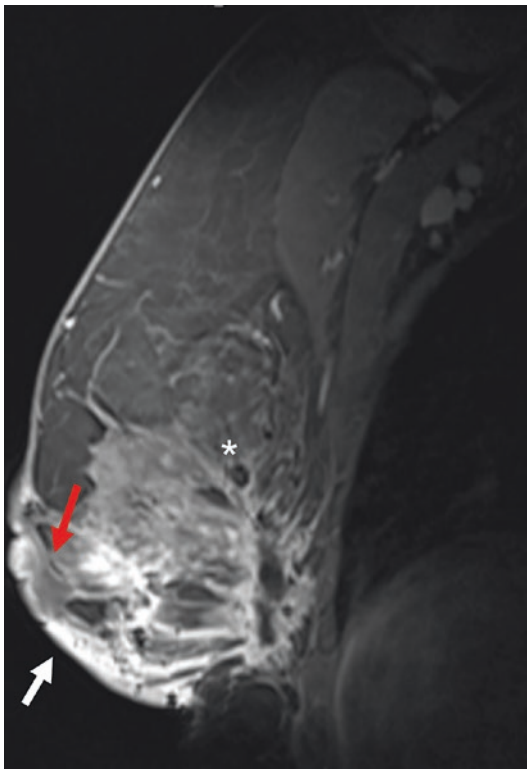

Fig. 20.3 Breast MRI after reduction mammoplasty demonstrating postsurgical changes including skin thickening (*white arrow*), subareaolar edema (*red arrow*), nipple-areolar complex displacement, and small fluid collections (*white asterisk*)

Cancer Risk After Breast Reduction

Reduction mammoplasty also influences the incidence of breast cancer. Early studies demonstrated a risk reduction in patients who had previously undergone reduction mammoplasty [17]. Large European registry studies have found 28% decreased risk of breast cancer after an average of 7.5 years following reduction mammoplasty [18]. Notably, this risk reduction was most notable in patients that underwent mammoplasty after the age of 50 and with an average follow-up length greater than 5 years, suggesting an important role for age and timing in the process. A later study of over 30,000 women similarly demonstrated a significant standardized incidence ratio of 0.71 in patients that underwent breast reduction [19]. This decreased incidence of breast cancer has been demonstrated in other independent studies [20] to the

extent where reduction mammoplasty has been suggested by some as a primary preventative tool for breast cancer.

Several theories have been formulated in attempts to explain the decreased incidence of breast cancer after reduction mammoplasty. The removal of a significant amount of glandular tissue may inherently reduce the number of cells that can undergo neoplastic transformation. This theory is supported by studies showing a link between risk reduction and the amount of tissue resection, with decreased risk occurring when more than 800 g of tissue is resected at the time of breast reduction [21]. Changes in breast composition have also been suggested to influence cancer rates though breast density is similar in patients with and without breast reductions. Lifestyle and systemic factors may also play a role in these observed differences. Women who have undergone reduction mammoplasty have lower rates of other cancers as well, including lung, cervical, and gastrointestinal neoplasms [13]. While multiple studies have confirmed the decreased risk of breast cancer after reduction mammoplasty, the etiology of these changes still has not been fully elucidated.

Importantly, despite these notable decreases in the risk of breast cancer after reduction mammoplasty, patients should be counseled to maintain routine cancer surveillance with screening mammography. This includes annual mammograms after the age of 40 according to The American College of Obstetricians and Gynecologists and the American Cancer Society [22, 23], and biennial mammograms between the age of 50 and 74 according to United States Preventive Service Task Force [24].

Conclusion

Reduction mammoplasty has important implications in both the risk of and surveillance for breast cancer. Postoperative changes after breast reduction are readily noticeable on screening mammography and must be differentiated from signs suspicious for proliferative or neoplastic lesions. While postoperative imaging findings can result in additional testing to rule out malignancy, evidence from multiple studies has confirmed that traditional reduction mammoplasty does not result in higher rates of unnecessary testing or diminish the ability to efficaciously diagnose malignant lesions. These outcomes are likely due to consistent patterns of imaging findings; however, a high index of suspicion must be maintained with a low threshold for tissue biopsy in the appropriate cases. Reduction mammoplasty additionally reduces the risk of developing breast cancer; however, adherence to national screening guidelines should still be followed. The effects of breast reduction on cancer incidence and its implications for cancer surveillance should be discussed with patients preoperatively as an important component of informed, preoperative shared decision making.

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Revision of Asymmetry and Adverse Scarring in Breast Reduction

21

Ian Chow, Carolyn DeLaCruz, and Kenneth C. Shestak

Breast reduction is one of the most commonly performed procedures in plastic surgery with 103,098 reduction mammaplasties being performed in 2017 [1]. The vast majority of patients experience resolution of their preoperative symptoms and satisfaction with their results. Nonetheless, revision in breast reduction is not uncommon with rates as high as 12% being reported in the literature [2–4]. In the majority of cases, revision surgery is employed to address adverse scarring, while postoperative asymmetry severe enough to warrant surgical revision is rare, occurring in less than 1% of cases [4, 5]. Plastic surgeons must be adept at managing both the common complications of adverse scarring requiring scar revision and the relatively uncommon complication of breast asymmetry requiring more invasive interventions.

In order to understand the causes of adverse scarring and asymmetry, one must have a basic understanding of common skin resection patterns and pedicle designs and their consequences on shape and scar. In this chapter, we will review common skin resection patterns and breast-reshaping techniques; and discuss commonly encountered presentations of adverse scarring and suboptimal breast shape and techniques to address these complications when they occur.

Skin Resection Patterns

Choice of skin resection pattern determines the final skin scar pattern and is critical to creating a proportional relationship between the residual breast skin and the reduced breast volume. While it is an often-quoted truism, we believe that the skin resection pattern contributes very little to breast reshaping unless the breast skin is highly elastic with good tone. Balancing the skin resection and parenchymal reshaping is an important element of planning and performing breast reduction because over-exuberant skin resection results in excess tension at the line of final closure. This often produces wound-edge ischemia, potentially leading to wound healing complications such as partial wound dehiscence and more commonly hypertrophic scarring [6].

While a number of skin resection techniques have been described, we will focus our discussion on the two most commonly utilized techniques: the inverted-T pattern (Wise pattern) and the vertical pattern. While the Wise pattern is classically associated with an inferior pedicle technique and the vertical breast reduction with a superomedial or medial pedicle technique, it is important to be cognizant of the fact that the skin resection pattern is independent of the ultimate pedicle selected.

The Wise pattern has become the most popular method for moderate- to large-sized breast reduction in the United States with up to 83% of plastic surgeons using it as their primary technique [7] despite the high scar burden. Since it relies on the remaining skin envelope to maintain the breast shape and provide projection, significant controversy exists as to whether the skin can act as a brassiere [6]. The phenomenon of "bottoming out" or pseudoptosis following breast reduction owing to recurrent laxity of the skin envelope and descent of the residual breast parenchyma provides evidence to the contrary, particularly in patients with larger postoperative breast sizes and poor skin quality (Fig. 21.1) [8, 9].

In addition, the Wise pattern has been criticized for its propensity to create a flat, boxy shape to the lower pole of the breasts and hypertrophic scarring (Fig. 21.2). The etiology for the flat, boxy shape of the lower pole of the breast following Wise pattern skin resection is due to the nature of its design. The horizontal resection of skin in a Wise pattern forms medial and lateral tissue excesses. The total length of the inframammary fold incision is greater than the native

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I. Chow (✉) · C. DeLaCruz · K. C. Shestak
Department of Plastic Surgery, University of Pittsburgh Medical Center, Pittsburgh, PA, USA
e-mail: chowi@upmc.edu

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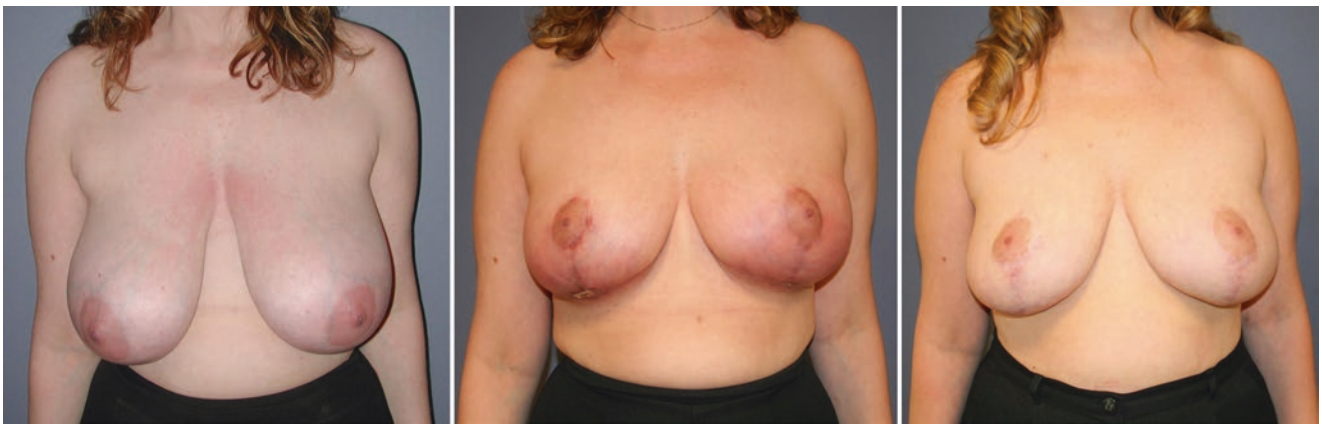

Fig. 21.1 A 38-year-old female with large breasts with grade III ptosis underwent bilateral inferior pedicle breast reduction via a Wise pattern incision with an excellent initial result. She subsequently developed pseudoptosis of her breast due to recurrent skin laxity and descent of residual breast parenchyma with the need for eventual breast re-reduction

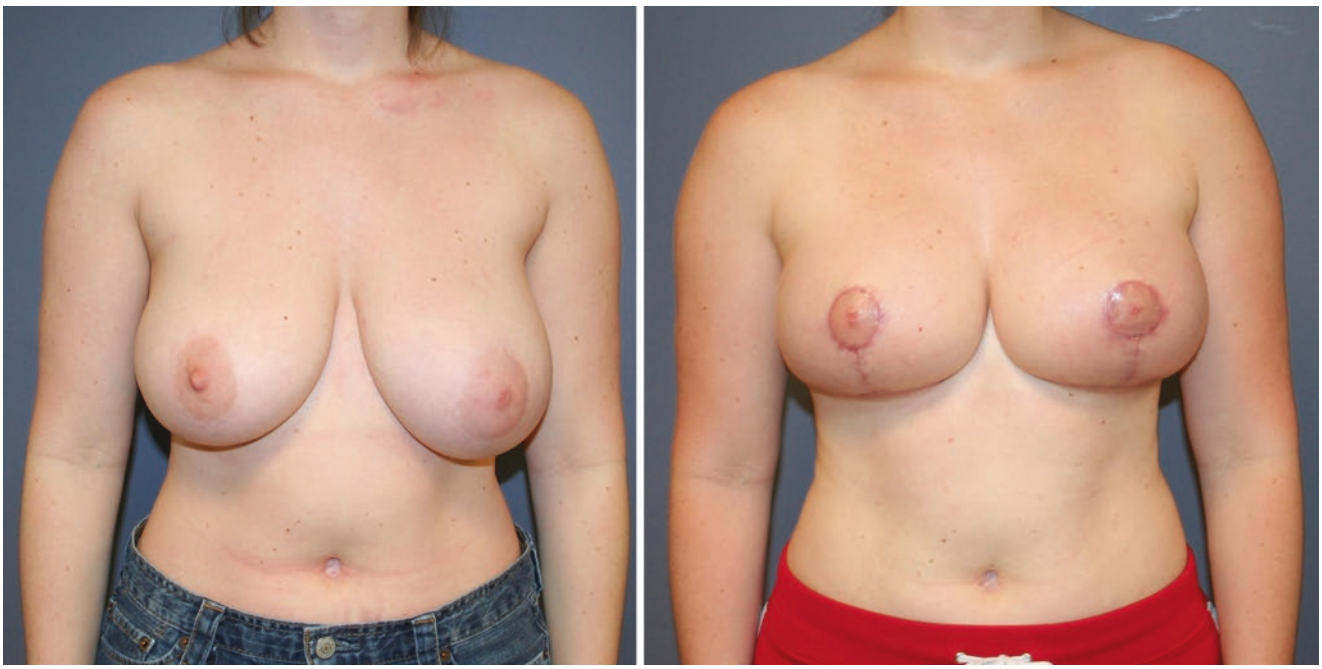

Fig. 21.2 A 23-year-old underwent bilateral inferior pedicle breast reduction via a Wise pattern incision with removal of 158 g of tissue from the right breast and 166 g of tissue from the left breast. Excess skin resection can result in a flattened boxy shape as the residual parenchymal tissue fills the skin envelope laterally

breast base width with residual parenchymal tissue filling the skin envelope laterally. This can result in a flat and boxy appearance to the reduced breasts (Fig. 21.3). Further compounding the issue can be a vertical limb design that is too short. Shorter limbs of 4–5 cm have been routinely advocated with the thought that less skin left behind prevents bottoming out and can prevent the nipple from being too high [10, 11]. As previously discussed, this thought process relies on the idea that the skin envelope is the major contributor to creating and maintaining long-term breast shape. Unfortunately, shorter vertical limbs create a smaller skin envelope that can result in a squared lower pole and increases tension on the T closure region, while potentially contributing to parenchymal over resection. Instead, longer vertical limbs of 6–10 cm allow the skin envelope to drape over the pedicle, reduce the need for undermining of the skin flaps, and mitigate tension particularly in patients with firm, fibrous breast tissue.

In contrast to the Wise pattern skin resection, the vertical skin resection pattern is based on the principle that the parenchymal pedicle design and position are responsible for producing the breast shape, while the skin envelope drapes and

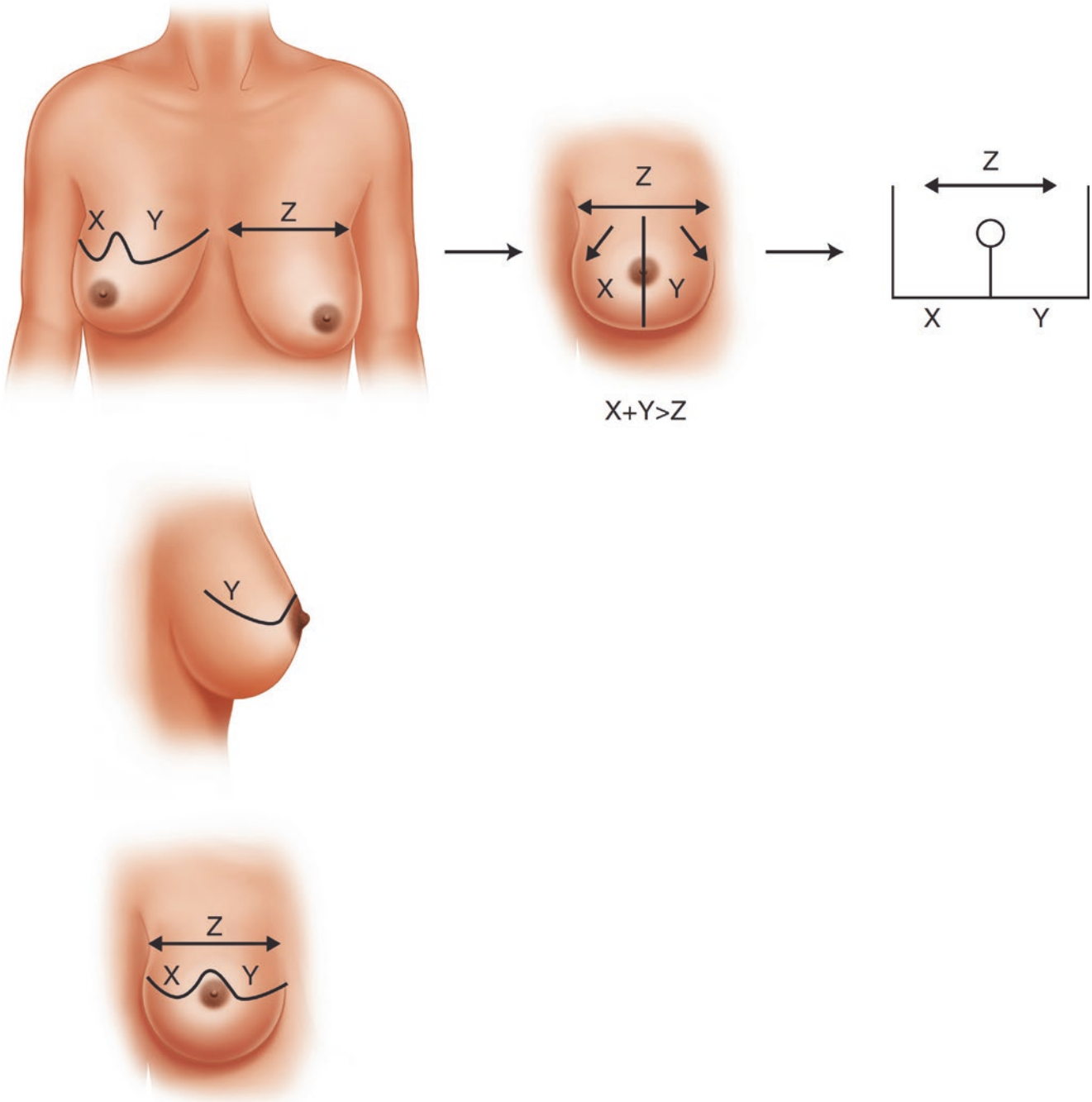

Fig. 21.3 When performing a Wise pattern skin resection in breast reduction, the breast IMF is defined by the length of limbs x and y (left). The total lengths of x and y are greater than the native breast base width (z, right). As a result of this length discrepancy, the remaining breast tissue naturally fills the space defined by the lateral portions of this length, which can result in the "boxy" appearance of breasts following Wise pattern breast reduction (center)

contours to the shape of the remaining parenchyma. This produces a distorted appearance initially, which requires the surgeon to have a keen understanding of the skin quality and behavior in order to predict a good aesthetic result.

The improper management of the excess skin following a vertical skin resection pattern can also result in wound-healing complications and adverse scarring. As the skin is resected as a vertical wedge, excess skin is produced superiorly and inferiorly. Superiorly, this is not an issue since the excess is absorbed by the areolar opening, but inferior skin excess can require revisional surgery especially when symptomatic. If inferior skin excess is felt by the surgeon to be a problem at the initial surgery an additional J-, L-, or T-shaped excision of skin can mitigate postoperative issues. A study

by Matthews et al. compared patients in which the vertical incision was gathered or not gathered and demonstrated that while gathering resulted in a significant reduction in initial incision length, the length of the areola to inframammary fold distance gradually increased with a concomitant increase in wound-healing complications. In contrast, the failure of the skin to gradually stretch over time did not result in a significant decrease in the rate of revision for pleating or puckering despite the closure technique chosen [12]. Instead, Hall-Findlay advocates terminating the inferior extent of the vertical incision at least 2–4 cm above the level of the inframammary fold allowing the surgeon to extend the excision inferiorly or inferolaterally to minimize skin redundancy in the lower pole and potential migration of the resulting scar onto the chest wall [13].

While providing conceptual benefits compared to a Wise pattern skin resection, vertical skin resection requires significant patience and understanding of the patient's skin quality and elasticity. Improper management of the vertical limb of the skin resection pattern can result in wound-healing complications and, ultimately, the need for revision surgery.

Comparative Outcomes

Several studies have directly compared outcomes in patients undergoing either vertical skin reduction techniques or Wise pattern skin reduction techniques. In a randomized controlled trial by Cruz-Korchin et al., patients presenting for moderate-sized breast reductions (average 500 g per breast) were randomized to either a vertical pattern skin resection combined with a medial pedicle breast reduction or a Wise pattern skin resection with an inferior pedicle breast reduction. The authors demonstrated that patients in the inferior pedicle/Wise pattern breast reduction group had significantly fewer surgical revisions than patients who underwent medial pedicle/vertical pattern breast reductions (0% vs. 11%) [3]. Conversely, patients who underwent medial pedicle/vertical pattern breast reductions rated their satisfaction significantly higher with regard to scarring and overall aesthetic results. A single surgeon series by Zoumaras et al. demonstrated higher rates of wound dehiscence and subsequent scar revision following inferior pedicle/Wise pattern breast reduction [4]. Finally, a retrospective analysis of patients comparing techniques using the Breast-Q questionnaire demonstrated no significant differences in mean scores of all of the scales, but interestingly demonstrated increased global satisfaction with a Wise pattern skin resection with larger tissue resections while global satisfaction decreased in vertical pattern skin resections with increasing resection weight [5].

The Wise pattern results in a larger burden of scars, but it is a powerful technique for large breast reductions where significant skin resection is required. On the other hand, the vertical skin resection pattern relies more on parenchymal reshaping but can create a highly aesthetic result with a low burden of scars. In summary, both the Wise pattern skin resection technique and the vertical pattern skin resection technique are widely accepted techniques that should be in every breast plastic surgeon's armamentarium. As stated by Hall-Findlay and Shestak, the best breast reduction results are produced when the surgeon utilizes the technique with which he or she is most experienced [6].

Pedicle Design

The most commonly utilized pedicle designs are the inferior pedicle, medial pedicle, superior pedicle, and superomedial pedicle, while the central pedicle (a modification of the inferior pedicle) and the lateral pedicle are more infrequently utilized [14]. The blood supply and reliability of each of these pedicles have been extensively described in the literature [15, 16]. Free nipple grafting may be employed when the surgeon believes that the circulation to the pedicle will not be reliable which results in a flatter nipple that lacks sensation, the ability to breast feed, the possibility of graft loss, and an increased risk of hypopigmentation particularly in dark skinned patients. The inferior pedicle is the most common pedicle design in breast reduction with 69% of plastic surgeons utilizing the technique [14]. Some surgeons have advocated and adopted a strategy of utilizing this technique for larger breast reductions while utilizing other techniques for smaller breast reductions [17].

Management of Adverse Scarring

Adverse scarring is the most common complication and cause for dissatisfaction following breast reduction surgery [18]. In the case of an uneventful incision, adverse scars may take the form of hypertrophic, painful, or keloid scars. In cases that required prolonged healing, scars may also present as widened or with obvious evidence of healing by secondary intention. Standing tissue cones or "dog ears" are a form of adverse scars that frequently require revision surgery [6]. The avoidance and management of adverse scarring are complications that all plastic surgeons who perform breast reductions will contend with during their career as hypertrophic scars occur in over 2.5% of patients and over 30% of patients experience wound-related complications [19].

Hypertrophic scars are best managed via a preventative approach and surgeons should avoid closing incisions under undue tension. For patients at high risk for adverse scarring or at the first sign of scar hypertrophy, silicone-based products are the preferred preventative measure with the highest degree of evidence. They should be applied and maintained

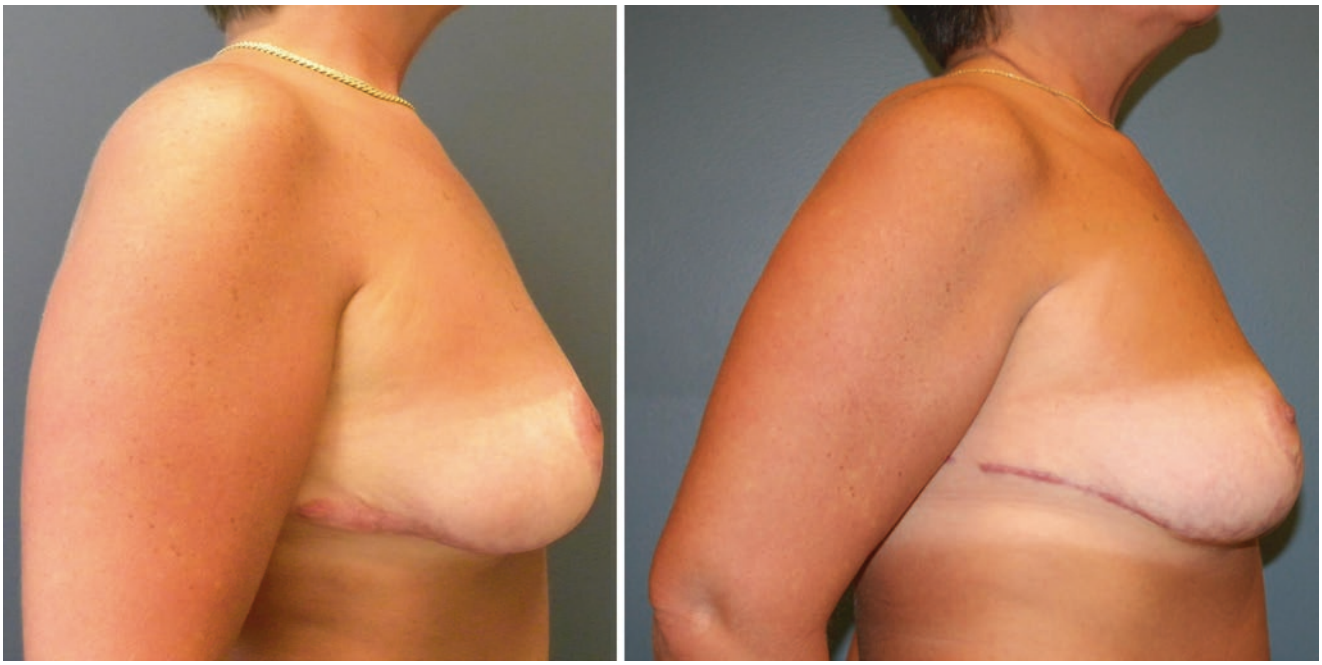

Fig. 21.4 The patient developed a significantly widened hypertrophic scar at the lateral aspect of her incision (left). The scar was excised and revised after allowing the scar to mature with significant improvement in scar appearance following revision (right)

for at least one month with wear for a minimum of 12 hours a day [20]. When the scar is recalcitrant, pruritic, or both, then the adjunctive use of intralesional corticosteroid injections or 5-fluorouracil is indicated with the usage of pulsed-dye or fractional laser therapy as a second-line treatment option [20, 21].

We believe that surgical excision can be a highly effective means of managing adverse scarring but recommend that surgeons await final scar maturation at 12 months prior to proceeding to surgical intervention. This time period is also important as many hypertrophic or widened scars following breast reduction are secondary to excessive tension or wound-healing complications along the surgical incision. Patience in proceeding to a scar revision can improve results by not only allowing for scar maturation but also allows the native breast skin to stretch reducing potential tension on the closure following scar excision (Fig. 21.4).

Standing tissue cones colloquially referred to as "dog ears" are a frequently encountered complication following breast reduction surgery due to the presence of excessive skin and subcutaneous tissue. The majority of dog ears less than 1 cm will resolve on their own [19]. Surgical excision with standard techniques and local anesthesia is warranted after 12 months of watchful waiting or when they cause significant distress to the patient. It is important to recognize that the presence of residual tissue cones is due to a combination of excess skin and subcutaneous tissue, often requiring excision of excess fat. The management of dog ears is largely dependent on their location relative to the inframammary fold. Medial dog ears following Wise pattern skin resections can be particularly difficult to correct as the required lengthening may require carrying the scar across the midline of the chest, which is not typically recommended due to the resultant scar contracture [13]. When the dog ear is along the vertical incision and is above the inframammary fold, then a vertical correction should be utilized with a horizontal excision of excess fat. If the dog ear is located at or below the inframammary fold, then a horizontal excision (curved upward) of fat and subcutaneous tissue is required so that the scar retracts up and off of the chest wall, regardless of whether the incision was initially oriented vertically or horizontally.

Management of Shape Asymmetry

In comparison to revision for adverse scarring, revision for postoperative breast asymmetry is relatively rare and accounts for less than 1% of revisions in breast reduction surgery [22]. While the management of adverse scarring is relatively straightforward, the revision of breast asymmetry requires an accurate assessment of the etiology for asymmetry, a thorough discussion with the patient on goals and what is and is not possible, and the application of multiple different techniques in order to achieve symmetry. While issues of asymmetry may be evident to the plastic surgeon, it is important to discuss points of dissatisfaction with the patient in order to identify the breast that is unsatisfactory to the patient

and to determine whether any additional procedures will be required on the contralateral breast. Revision of asymmetry requires an understanding of the current breast footprint of each breast with attention to the upper breast border, the inframammary fold, the medial breast border, and the lateral breast border; the position of the nipple-areolar complex; and the location of the glandular tissue within the breast. Each of these landmarks must be analyzed prior to determining the appropriate surgical procedure. Asymmetries commonly associated with breast reduction include problems with shape, contour, or volume, and nipple malposition or asymmetry.

Principles of Breast Re-reduction

While liposuction and resection of skin can be valuable adjuncts in the management of breast asymmetry, excision of parenchymal tissue may be required in order to achieve symmetry between the breasts. While surgeons are typically reticent to perform breast re-reduction either when the pedicle is unknown or when addressing asymmetry requires removal of tissue from the previously utilized pedicle, we have found that breast re-reduction can be performed safely and predictably as long as surgeons adhere to several key principles. When performing breast re-reduction, blood flow must be maintained to the nipple-areolar complex in order to prevent nipple ischemia and potential loss; this must either be done by recreating the original pedicle or allowing the nipple to survive on a random pattern blood supply (Video 21.1). Creating a new pedicle is not reliable as the blood vessels supplying a new pedicle would have been transected during the creation of the original pedicle. In a retrospective study of 90 patients, Mistry et al. developed a series of key principles for breast re-reduction; principles include that the nipple-areolar complex should not be moved by more than 6 cm and should be moved with deepithelialization rather than by recreating or developing a new pedicle, and that breast tissue should be removed where it is in excess typically inferiorly and laterally regardless of the original pedicle utilized [23]. When nipple positioning greater than that achievable with deepithelialization alone is required, some authors advocate for movement of the nipple on either the original pedicle or a random pattern blood supply [24, 25], while others have shown that even utilizing the original pedicle can result in significant complications and advocate for the usage of full nipple grafts [26, 27].

Management of Nipple Malposition and Asymmetry

Nipple malposition is a commonly encountered problem following breast reduction and typically involves overelevation of the nipple-areolar complex with an incidence as high as 41% (Fig. 21.5) [28]. It is important to identify the etiology of the nipple overelevation prior to proceeding with surgical intervention. Spear et al. developed a classification system based off of the sternal notch and upper breast border, nipple-areolar complex, and inframammary fold with relative malposition being caused by lower pole excess resulting in the nipple appearing too high on the breast, absolute malposition due to the nipple being placed too high on the breast with a shortened distance to the upper breast border, and complex malposition involving an element of both [29]. The management of relative malposition involves addressing the lower pole excess rather than the nipple and requires a wedge resection of lower pole breast tissue. Removal of lower pole fullness will result in the nipple appearing more centralized on the breast mound (Fig. 21.6). Another method of centralization is to raise the upper breast border. This is a more technically challenging prospect and requires either fat grafting to the upper pole of the breast or placement of a small implant. Attempts to reattach the inframammary fold are unpredictable, painful, and often prone to failure. Unilateral or absolute malposition in the setting of adequate breast shape and appearance is more challenging and requires placing unsightly scars in the upper pole of the breast above the areola using techniques involving transposition of local flaps [30–32] or skin grafts. The nipple is rarely too low on the breast, but the majority of cases can be dealt with via deepithelialization and transposition. Significant transpositions require the surgeon to either recreate the original pedicle or convert to free nipple grafts.

The nipple-areolar complexes may also be asymmetric due to differences in the postoperative circumference or the shape of the areola as a result of differences in skin tension at the time of closure. Correction of these asymmetries requires careful planning of the upper areola level and location on the breast in order to achieve symmetry. When altering the size or repositioning the nipple-areolar complex, deepithelialization is critical to maximize blood supply. The area between the desired areolar diameter and the surrounding skin should be deepithelialized to provide a stronger wound closure. An extremely useful technique was described by Hammond who utilizes a buried purse-string Gore-Tex suture in order to equalize the tension around the areola with maintenance of the desired areolar diameter in hundreds of patients (Fig. 21.7) [33, 34]. Becker also notes success with a periareolar scar reduction technique [36].

Management of Glandular Asymmetry

Glandular asymmetry may be a result of volume differences, movement of the breast mound due to gravitational or attritional effects, and contour abnormalities. Correcting

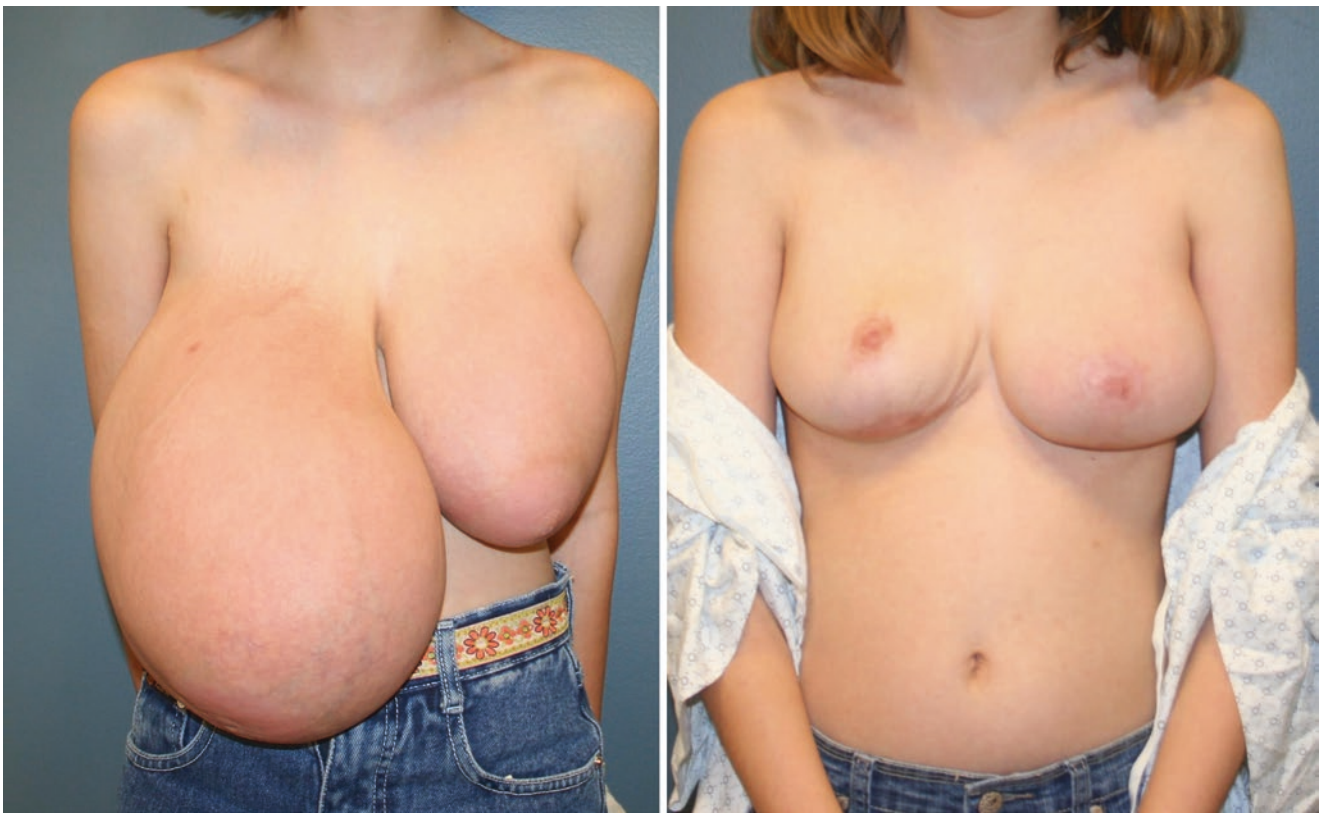

Fig. 21.5 A patient who presented with right-sided gigantomastia underwent bilateral inferior pedicle breast reduction via a Wise pattern incision. The patient had good skin quality with an elastic skin envelope, and the right nipple appears elevated relative to the left nipple due to asymmetric skin retraction due to a higher preoperative tension on the skin envelope in the larger left breast

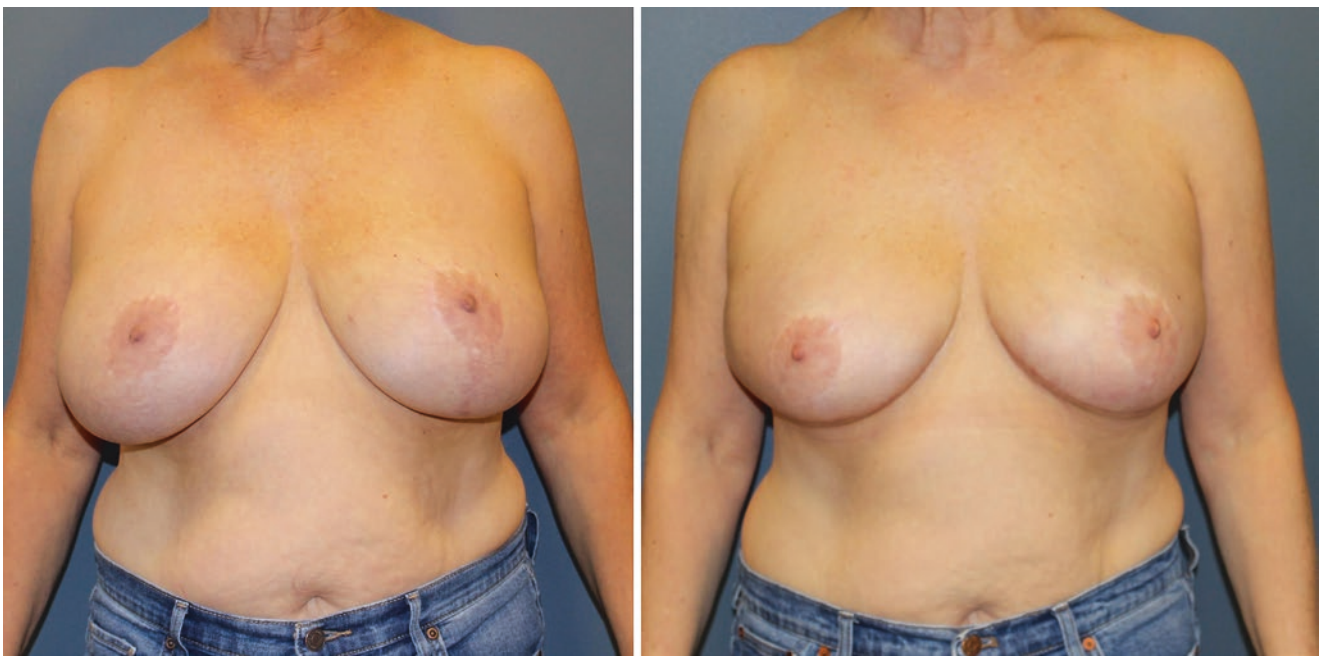

Fig. 21.6 A 60-year-old patient presented for revision of nipple and glandular asymmetries after a breast reduction performed at 43 years of age via an unknown technique. The patient has asymmetric pseudoptosis with a greater degree of glandular descent on the right. Her nipples appear high relative to her breast footprint due to excess inferior breast tissue. She underwent inferior wedge resection without significant nipple repositioning with significant improvement in her glandular asymmetry and nipple position

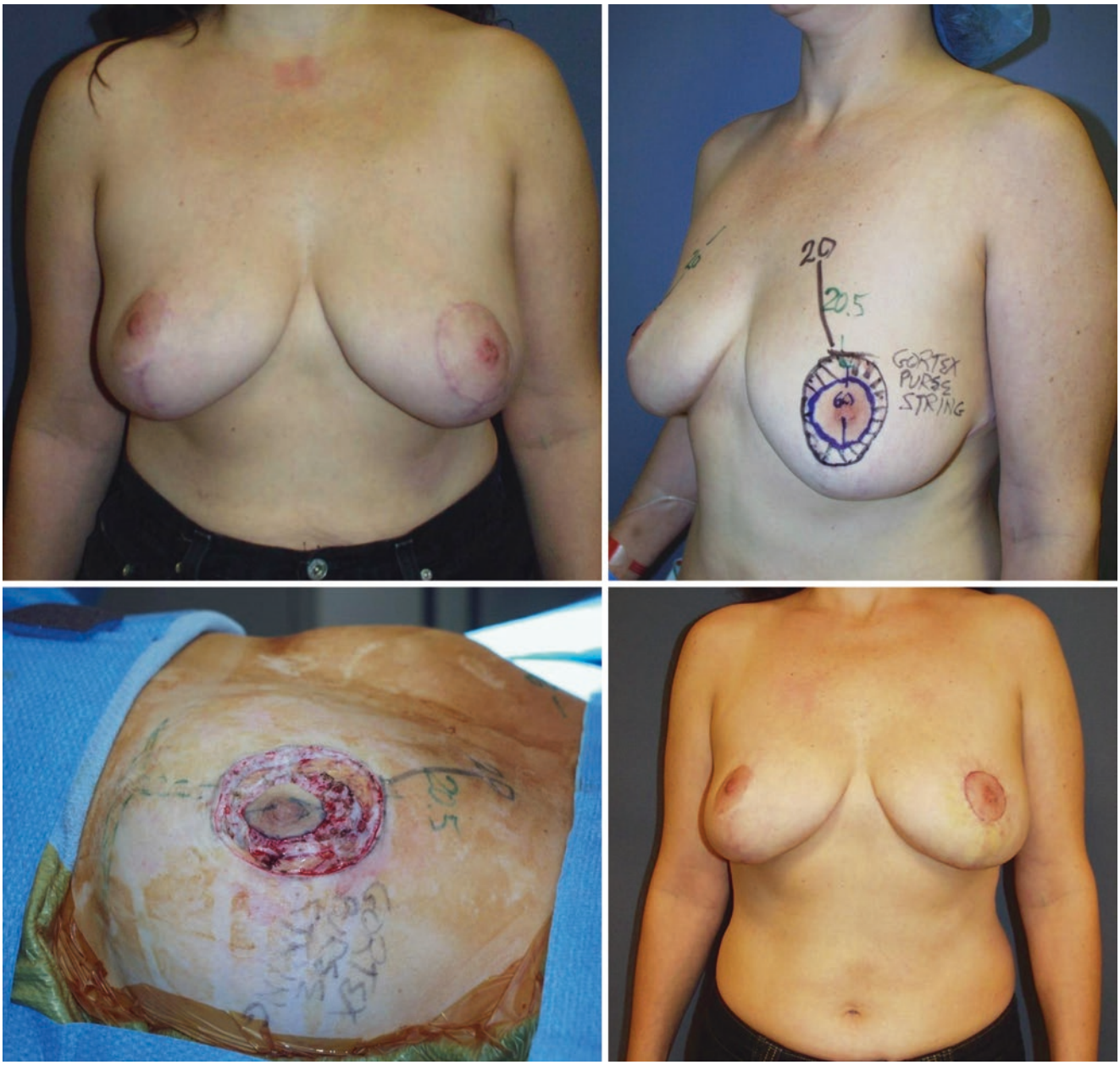

Fig. 21.7 A patient who developed significant nipple size, and positional asymmetry with repositioning and resizing of the nipple-areolar complex being performed by using a combination of deepithelialization and a buried purse-string Gore-Tex suture with excellent long-term results

volume abnormalities requires the surgeon to determine the difference in volume between the two breasts and attempt to match the breast volume to the patient's breast. Minor volume abnormalities due to underresection can be corrected with liposuction and by tightening of the skin enveloped to enhance symmetry and breast shape by "tailor tacking" to optimize skin envelope symmetry, deepithelialization, and skin approximation. Minor volume abnormalities due to overresection can be corrected with autologous fat grafting.

When a breast needs to be significantly increased in size, surgeons can either place a tissue expander with asymmetric expansion to achieve the ideal breast volume followed by placement of a permanent implant or place a permanent implant. Implant placement can also result in improvements in both shape and nipple position by enhancing the volume in the central breast mound and producing fullness in the upper breast border. Underresection of breast tissue can be managed utilizing the principles of breast re-reduction discussed previously in combination with liposuction.

The management of the bottoming out phenomena is commonly encountered following breast reduction and requires particular attention in cases of asymmetry. When bottoming out is due to excess lower pole volume, Hall-Findlay advocates for removal of a vertically oriented inferior wedge of skin and breast tissue above the horizontal scar as well as liposuction between the scar and the inframammary fold in order to unweight the breast and result in elevation of the inframammary fold [6, 13, 23]. Hammond prefers to correct the deformity by performing a vertical scar revision and plicating any excess skin along the vertical incision [35]. While attempts to reattach the inframammary fold to the chest wall can be unpredictable, placement of a sheet of acellular dermal matrix or an absorbable mesh may be helpful in reinforcing the fold and providing lower pole support, particularly when volume reduction is neither required or desired [9, 22].

Conclusion

Adverse scarring and breast asymmetry following reduction mammoplasty can be a distressing concern to patients in an operation with otherwise high patient satisfaction. The ideal management of these problems requires in-depth knowledge of breast anatomy, breast landmarks, the behavior of breast tissue following surgery, and the pearls and pitfalls of the techniques utilized to achieve skin and parenchymal reductions. The ideal method of managing these complications is through prevention as many of these complications are due to improper technique or poor surgical planning. When problems do occur, a thorough analysis of the problem is required and the development of a coordinated surgical plan using common techniques must be employed to address each of these problems both individually and in concert.

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Managing Common and Uncommon Complications in Gender-Affirming Masculinizing Chest Surgery

22

Loren S. Schechter and Alexander R. Facque

Introduction

Gender non-conformity is the experience of a person's gender identity, role, or expression that is different from cultural norms or expectations [1] whereas gender dysphoria refers to the discomfort or distress that is caused by a discrepancy between a person's gender identity and that person's sex assigned at birth [2]. A transgender individual may not experience gender dysphoria and may not seek medical or surgical therapies. However, for those individuals who do seek surgical therapy, it is the surgeon's responsibility to create an affirming environment within the office and hospital context. Population estimates as to the prevalence and incidence of the transgender and gender diverse communities vary widely. Due to structural and methodological limitations of data collection, the true size of these communities is likely underestimated. Current estimates indicate a range from between 2.8 per 100,000 [3] to 23.6 per 100,000 [4] depending on the country and time of publication. Population estimates for the United States have been reported at 4.3 to 22.9 per 100,000 [5] or, in other estimations, 0.6% of the population [6], approximately 1.4 million adults [7]. For those individuals seeking surgical intervention, subcutaneous mastectomy, or chest surgery, is one of the most commonly requested surgical procedures [8]. As awareness and acceptance of the transgender and gender-diverse communities increases, so too do requests for surgical procedures.

According to version 7 of the World Professional Association of Transgender Health (WPATH) Standards of Care (SOC), the recommendations for mastectomy and creation of a male chest include persistent, well-documented gender dysphoria (one referral letter from a mental health professional), capacity to make a fully informed decision and to consent for treatment, age of majority in a given country (although surgical treatment of adolescents is permitted), and, if significant medical or mental health concerns are present, they must be reasonably well controlled. Hormone therapy is not a prerequisite for surgery [1].

General goals of masculinizing chest surgery include aesthetic contouring of the chest wall by reduction of breast tissue and excess skin, reduction and positioning of the nipple-areolar complex (NAC), obliteration of the inframammary fold (IMF), and minimization of chest wall scars and other stigmata of surgery [9]. In consideration of these goals, it is important to appreciate the diversity of the transgender community. For instance, NAC reconstruction may not be requested by all patients. It is important to discuss surgical options, such as incision choice and/or management of the NAC with the patient, in order to maximize individual patient goals and manage expectations.

Surgical Technique

Selection of the surgical approach plays a significant role in reducing complications. Numerous incisions are described, ranging from periareolar techniques to concentric circumareolar techniques to "double incision" techniques. Additionally, the NAC may be repositioned using free grafts (FNG) or pedicled transposition techniques [9–12]. Factors that influence surgical technique include breast volume, skin excess, skin elasticity, and degree of breast ptosis. Some of these factors, such as skin elasticity and breast ptosis, may be affected by preoperative chest binding.

In the senior author's practice, two incision choices represent the majority of cases: a periareolar ("limited") incision and the double incision with free nipple graft. Candidates for a limited-incision approach are those individuals in whom it is anticipated that skin retraction following resection of breast parenchyma will be sufficient. In general, these are younger patients (perhaps with a history of pubertal suppression) with good skin elasticity and minimal to moderate

L. S. Schechter (✉) · A. R. Facque
The Center for Gender Confirmation Surgery, Louis A. Weiss Memorial Hospital, Chicago, IL, USA
e-mail: lss@univplastics.com

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glandular volume. The presence of breast striae (or a prolonged history of chest binding) may indicate that the patient is not a candidate for this approach. For the majority of patients, a double incision with free nipple areolar graft technique is chosen. While other incision choices are an option (i.e., circumareolar with vertical or horizontal extensions), these incisions may confer a feminine appearance to the chest. These issues should be addressed with the patient preoperatively when discussing various techniques. Furthermore, although it may be possible to preserve NAC sensation with the use of a pedicled NAC transposition technique, the resulting residual chest bulk may be unacceptable. Of course, secondary contouring operations are an option, but this too should be discussed preoperatively. Liposuction is a useful adjunct for chest wall contouring and for obliteration of the inframammary fold (IMF).

Markings for the double incision technique are demonstrated in Fig. 22.1. The midline, the midbreast meridian, and the inframammary crease are marked. The boundaries of the breast tissue, as well as breast tissue located at the anterior axillary fold (cross-hatched), and the lateral border of the pectoralis muscle are outlined. Lateral and equidistant to the midline, two vertical lines are drawn; these lines represent the medial extent of the incision. Figure 22.2a, b demonstrates pre- and postoperative photos (different patient). Figure 22.3 demonstrates a patient undergoing chest masculinization through a periareolar approach.

Identifying and minimizing modifiable risk factors is an important part of surgical planning. While the senior author has no absolute body mass index (BMI) limit, obese individuals have a higher likelihood for secondary or revision operations [13]. Extrapolating from cisgender women undergoing reduction mammoplasty, increasing BMI is correlated with increasing postoperative complications [13–15]. In the author's experience, successful weight loss prior to chest surgery is unlikely. This may be related to physical and/or psychological discomfort with exercising. Therefore, in obese individuals undergoing surgery, they should be counseled as to the possibility of issues such as residual skin, residual bulk, and "dog ears," in addition to a higher likelihood of revision surgery.

Perioperative tobacco use is well known to be associated with increased intra- and post operative complications [16]. Patients are counseled of the risk of increased postoperative complications, and smoking cessation is required 6 weeks prior to surgery. This is often confirmed by a urine cotinine test in the week prior to surgery.

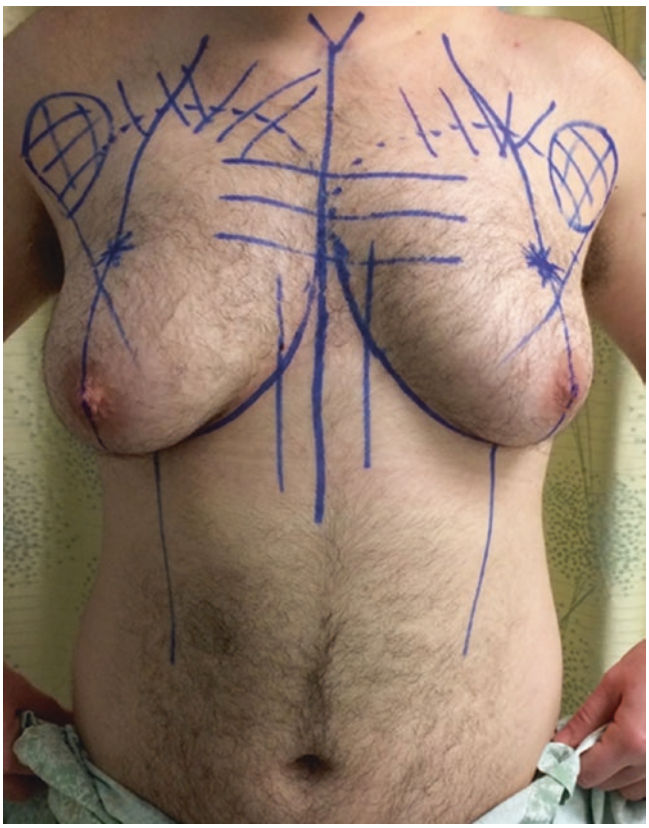

Fig. 22.1 Preoperative markings for a "double incision" mastectomy. The markings, as described in the text, are made in the standing position. (©Loren Schechter)

Common Complications

The complication rate following chest surgery is approximately 10% [11, 12]. Hematoma is among the most frequently reported complications and is likely higher in "limited" incision techniques [11, 12]. Surgical intervention depends upon size and symptomatology; while small hematomas may be managed with observation, compression, and aspiration, expanding hematomas necessitate return to the operating room. The presence of a "stable" hematoma treated nonoperatively may lead to an increased chance of wound separation, nipple loss, contour irregularity, and/or infection.

Seromas rates with the double incision-FNG technique are approximately 0.6% [12]. In the senior author's practice, closed-suction drains are used and remain in place until a value of less than 20 cc for two consecutive days (approximately 1 week postoperatively) is drained. While the oncologic mastectomy literature does not support the use of tissue sealants in preventing seroma formation [17, 18], tissue sealants are utilized in our practice for both hematoma and seroma prevention. Additionally, quilting sutures may be beneficial; however, there are conflicting reports as to their utility [19, 20]. The senior author does not employ quilting sutures but rather uses postoperative elastic compression, closed-suction drains, and shear reduction through activity restrictions (limit upper extremity movement to below shoulder level and no lifting above 10–15 lb). Should a

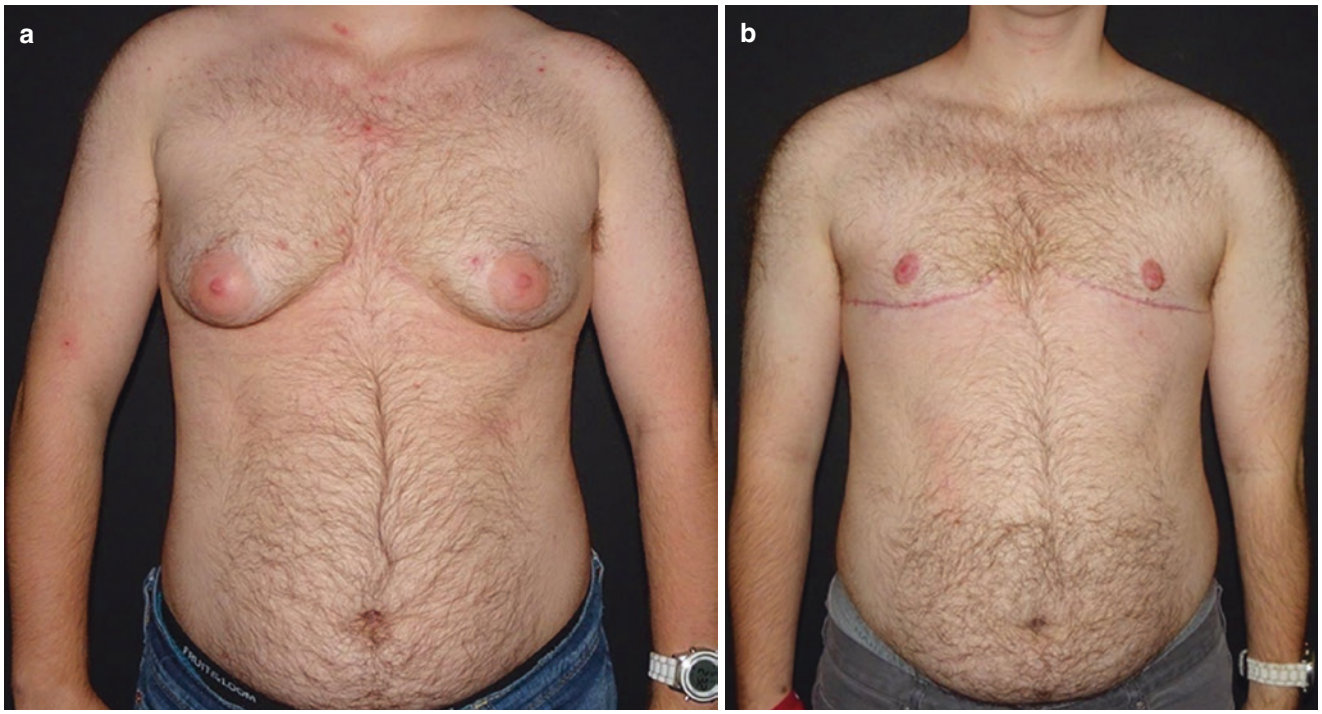

Fig. 22.2 Pre- and postoperative results after double incision mastectomy with free nipple-areolar grafting. (**a**) Preoperative. (**b**) Postoperative. (©Loren Schechter)

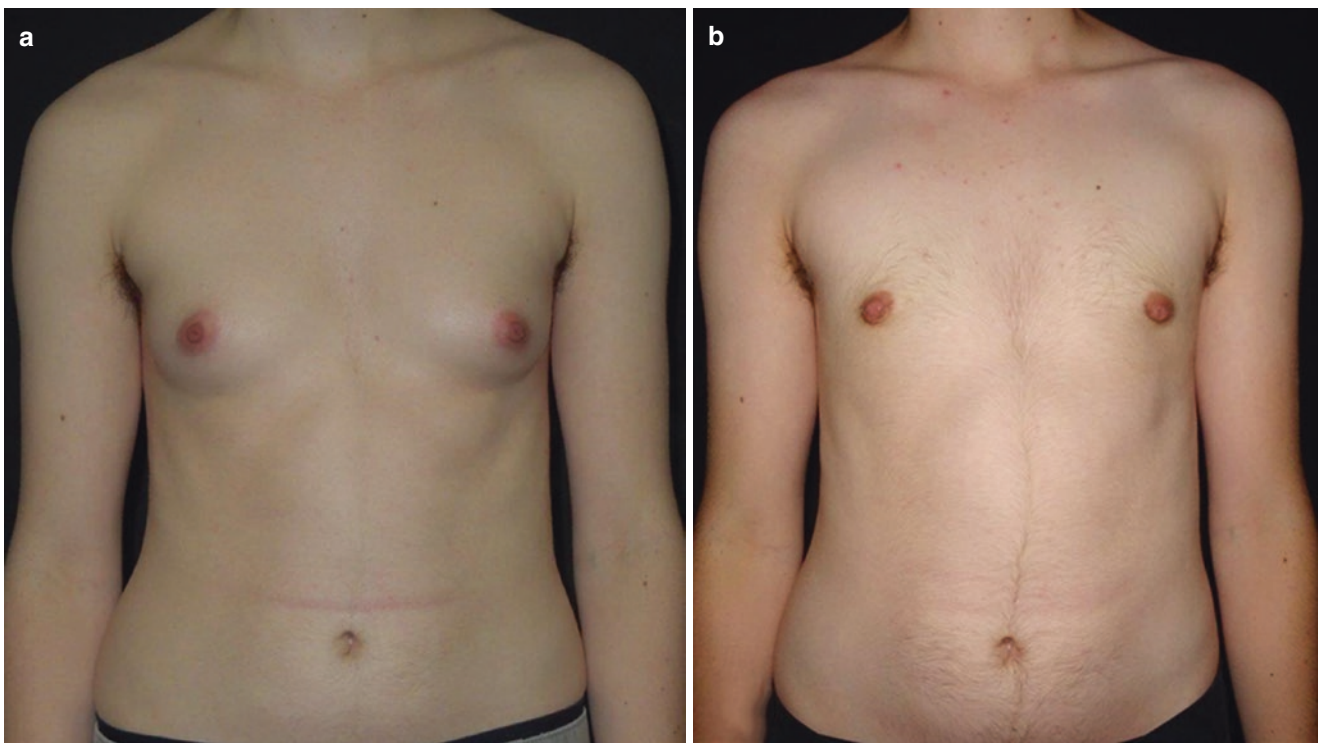

Fig. 22.3 Pre- and postoperative images utilizing a periareolar approach. (**a**) Preoperative. (**b**) Postoperative. (©Loren Schechter)

seroma occur, standard management includes aspiration, compression, and activity restriction. Recurrent seromas may require operative intervention.

Wound separation and/or delayed healing is not a frequent occurrence and is less common than in cisgender reduction mammoplasty or oncologic mastectomy. During chest sur-

gery, flap elevation is performed along the breast capsule in order to preserve the superficial vasculature supplying the skin flaps: all macroscopically identifiable breast tissue is typically removed. Undue tension on the skin flaps is avoided by careful surgical planning and intraoperative technique. Final skin resection and flap tailoring are performed following glandular excision. This includes placing the patient in an upright position in order to assess skin tension. Should there be an area of delayed healing, nonoperative management with topical antimicrobials is typically recommended. In isolated circumstances, operative intervention may be required.

While hypertrophic scarring may occur, reports of scar revision are less than 2% [12]. Incisions which cross the midline of the chest (overlying the sternum) may have a higher rate of hypertrophy. The senior author will extend incisions across the midline if required due to chest contour and/or redundant skin. Postoperatively, patients are instructed to perform scar massage, avoid direct sun exposure, and apply silicone sheeting. Hypopigmentation of the NAC may occur following free NAC grafts. This is more commonly seen in individuals of color. While pigment may return over time, persistent hypopigmentation can be treated with tattoos (Fig. 22.4).

A more common request for surgical revision relates to postoperative contour irregularities, including skin excess or chest asymmetry (Wolter et al. 2015 report their revision rate at 5.5%) [12]. Claes et al. state that approximately one-third of patients undergo additional procedures to improve the cosmetic result [11]. The so-called dog ear, or excess tissue at the initiation or termination of an incision, can be managed with observation and scar massage in the early postoperative period. If persistent, surgical scar revision may be required. Managing patient expectations is an important part of the preoperative process; depending upon the patient's body habitus, residual axillary skin excess may be inevitable. While liposuction may minimize tissue bulk, skin excess may remain. Figure 22.5 demonstrates lateral extension of the incision to reduce the likelihood of a "dog ear."

A persistent IMF may result in a feminized appearance to the chest wall. Hage and van Kesteren describe undermining the fold and severing the "fibrous strand" that is present [9]. The senior author prefers to use liposuction for discontiguous undermining over the lower and lateral chest wall. It is our opinion that liposuction may also assist in smoothing the transition from trunk to chest.

Uncommon Complications

Surgical site infection (SSI) is not frequently reported. The author's practice is to prescribe antibiotics covering skin flora, such as a first-generation cephalosporin or clindamycin, and are continued until drains are removed. A hematoma increases the chance of SSI.

Nipple necrosis, either partial or total, is a possible complication. Specifically, partial NAC loss was reported in 0.9% of patients, whereas total NAC loss occurred in 1.2% of subcutaneous mastectomies (concentric, pedicled, and free nipple graft employed) [12]. Delayed NAC healing, seen clinically as skin slough, can lead to altered skin pigmentation (which may benefit from postoperative tattoo). In the immediate postoperative period, partial nipple loss is treated with topical antimicrobial ointments and local wound care. Total NAC loss, or loss of nipple projection that is bothersome to the patient, may be treated with secondary nipple reconstruction using described techniques [21, 22]. NAC revision in chest surgery is reported in less than 2% of cases [12].

NAC size and position are important considerations. There are numerous reports regarding the "ideal" masculine nipple position using different anatomic landmarks. Lindsay described placing the nipple at the level of the fifth rib, 10–11 cm from midline and 2.5 cm from the lateral border of the pectoralis major [23]. According to Peck, the NAC lies within a line that extends from the ASIS to the medial corner of the infraclavicular fossa [24]. In 1996, Beckenstein et al. studied NAC position and size of cisgender males aged 17–30. In their study, the average distance from the nipple to the midclavicle (MC-N) was 18 cm, and the distance of the sternal notch to the nipple (SN-N) was 20 cm. In order to account for height, the formula 7.9 + .17x height (inches) is used to determine the distance of MCL-N and 11.1 + .13× height for SN-N. Average areolar diameter was 28 mm with a range of 25–30 mm [25]. Figure 22.6 depicts postoperative NAC distortion following double incision mastectomy with free NAC grafts. Distortion of the NAC may be reduced by (1) minimizing tension on the skin closure and (2) inserting the NAC in an elliptical fashion, perpendicular to the line of tension on the skin closure.

In 2001, Beer et al. studied 100 cisgender males aged 20–36. They used the thoracic circumference and sternal length to triangulate nipple position, and found that 75% of nipples were over the fourth intercostal space. These researchers could not correlate the ASIS or umbilicus with nipple position. They also recommended against using limb-related points, such as the mid-humerus, due to variability of respective limb and torso lengths [26]. In terms of areolar shape, an oval areola was most common (91%), while a round shape occurred in 7% of cases. Areola shape asymmetry was noted in 2% of cases, with patients having one round and one oval NAC. Oval NAC were identified as obliquely oriented, perpendicular to the fibers of the pectoralis major muscle. The average oval areolar dimensions were 27 × 20 mm, and the mean diameters of the round areolae were 23 mm.

Breast cancer remains a possibility following subcutaneous mastectomy; the degree of risk reduction following sur-

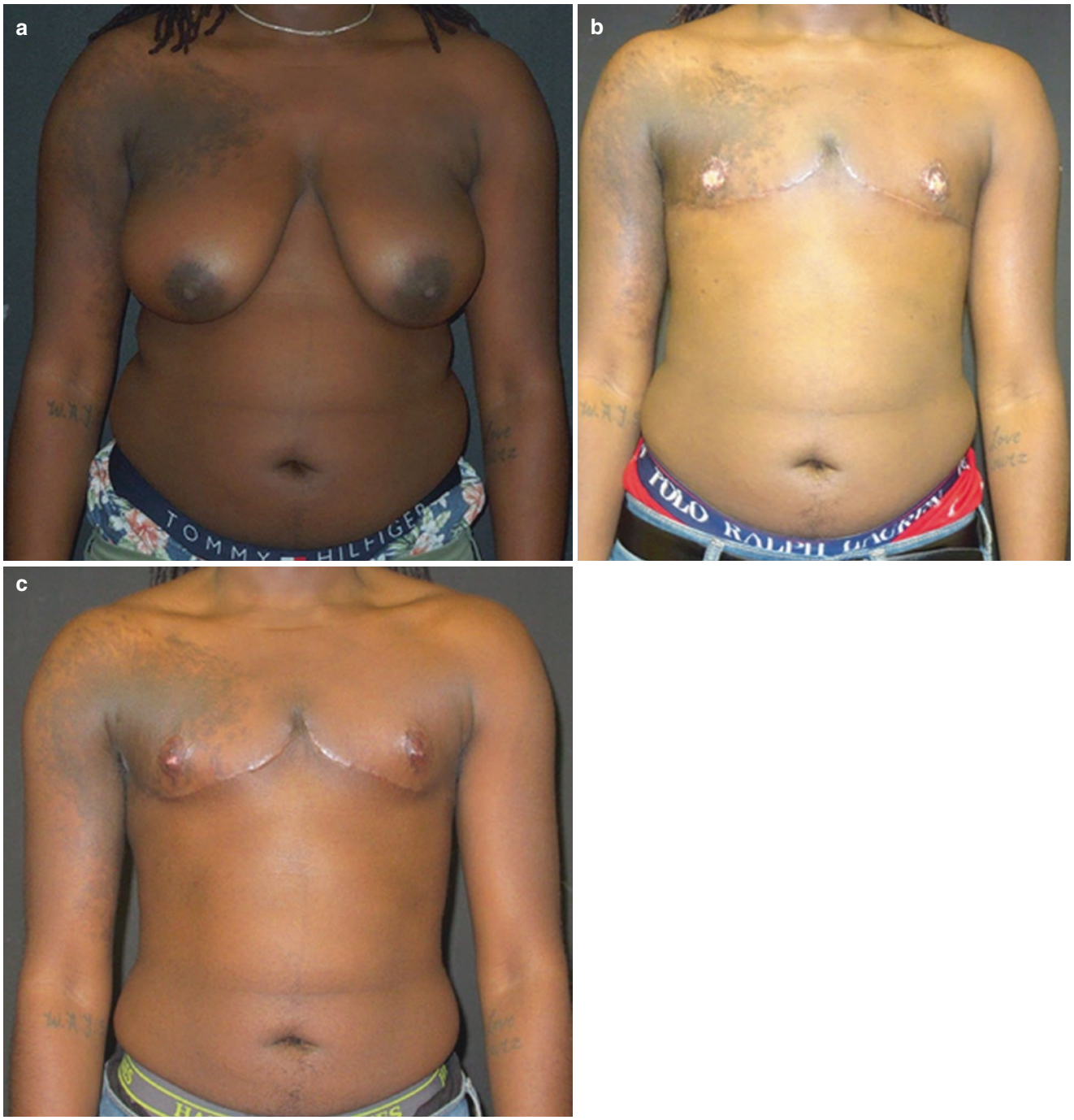

Fig. 22.4 A double incision mastectomy with free NAC grafting was performed. Postoperatively, hypopigmentation of the NAC was noted. (**a**) Preoperative. (**b**) Postoperative result at 3 months. (**c**) Postoperative result at 6 months, without additional treatment. (©Loren Schechter)

gery, and the role of androgens remains unclear [27, 28]. The role of androgens as a risk for breast cancer in cisgender pre- and postmenopausal women is unclear. However, the association between high androgen levels and breast cancer risk is documented [27, 29–32]. High androgen levels have the potential to increase circulating estrogens through peripheral aromatization of dehydroepiandrosterone. While prolonged and unopposed estrogen stimulation could theoretically increase the risk of breast cancer, studies in transgender individuals have demonstrated a risk of breast cancer commensurate with cisgender men [33]. Ultimately, ongoing follow-up with primary care providers is recommended [11, 27]. As of the time of writing, guidelines regarding breast screening follow the recommendations of cisgender females in terms of age, family and personal history, and physical examination.

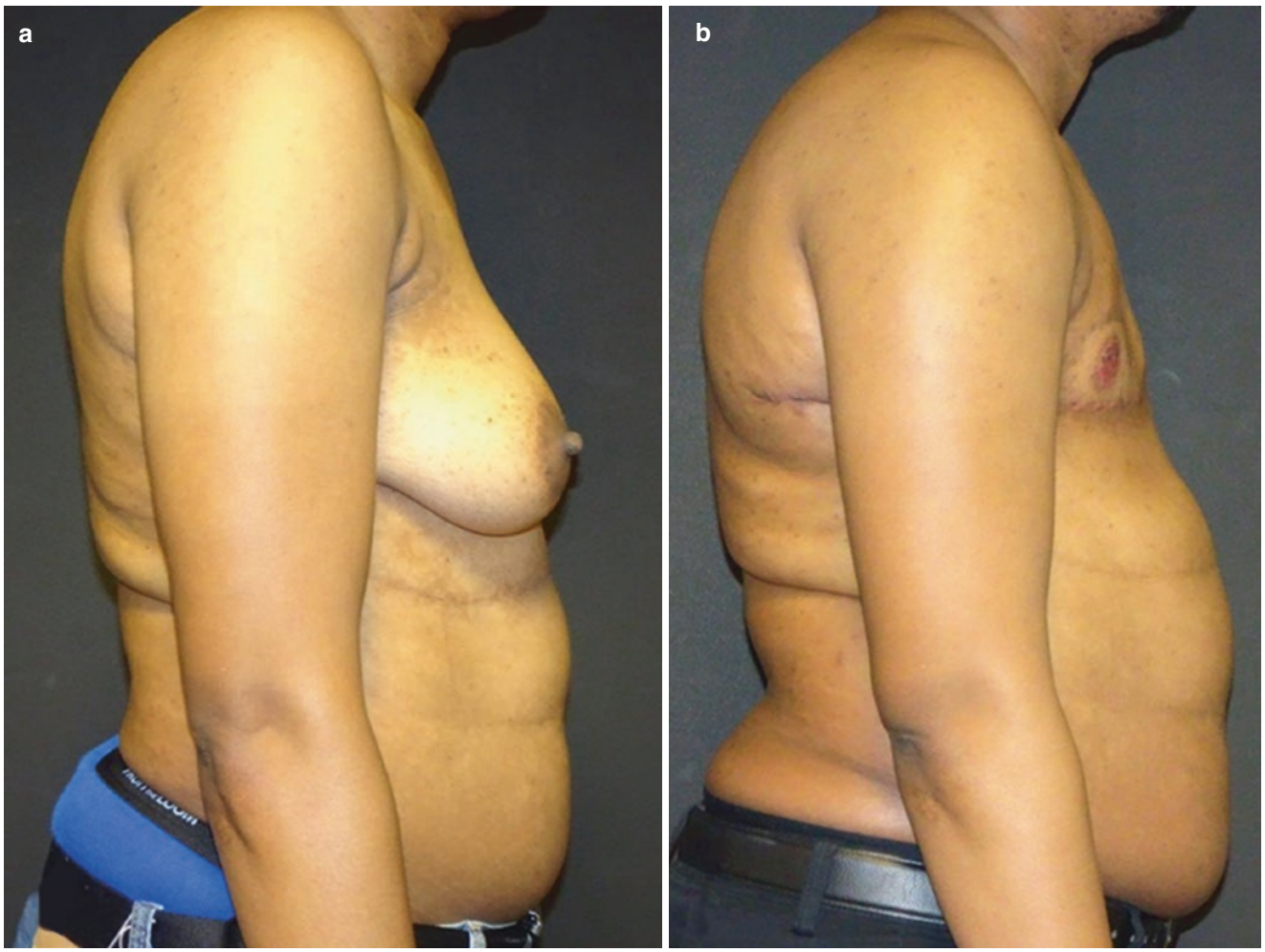

Fig. 22.5 The patient had excess lateral chest skin. The IMF incision was extended posteriorly in order to prevent a "dog ear." (**a**) Preoperative. (**b**) Postoperative. (©Loren Schechter)

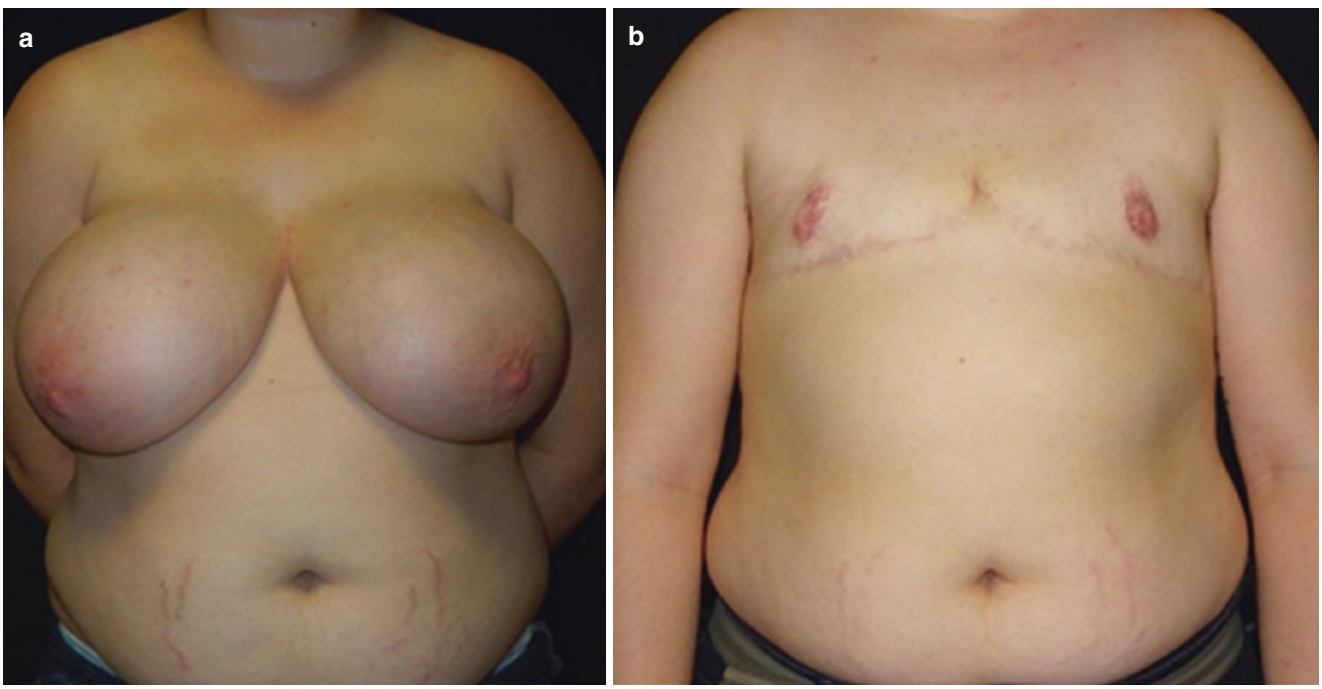

Fig. 22.6 (**a**) Pre- and (**b**) postoperative images following double incision mastectomy with free NAC grafts. Note the postoperative distortion of the right NAC. (©Loren Schechter)

Conclusion

Masculinizing chest surgery remains an important, medically necessary procedure for many transgender and gender-diverse individuals. A discussion should be held with each patient regarding their individual goals and expectations. The majority of patients undergoing chest masculinization rate their satisfaction as "good" or "very good" following surgery [12]. The risk profile of chest surgery is similar to or less than comparable fields of nongender-related breast surgery. Complications are uncommon and may be reduced with careful preoperative planning and choice of surgical technique.

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Pearls to Avoid Pitfalls with Mastopexy and Mastopexy-Augmentation

23

Ali A. Qureshi and W. Grant Stevens

Background

Mastopexy and mastopexy-augmentation are common aesthetic breast procedures that seek to create a beautiful, youthful breast. Once considered highly unpredictable and fraught with complications in the wrong hands, these procedures have become more reproducible and safer because of patient and surgeon education [1].

In order to minimize the pitfalls with mastopexy and mastopexy-augmentation, the surgeon must appreciate tissue dynamics, the natural history of the aging breast, and the advantages and limitations of a breast implant. Within this chapter, we describe our techniques to minimize or avoid common pitfalls associated with rejuvenating the breast. This chapter will focus on the single stage mastopexy-augmentation described by the senior author (W.G.S.) and not the two-staged approach to this operation [2–4]. Most commonly mastopexy-augmentations are performed using a circumvertical technique with a "T" at the base and implants placed in a dual plane fashion, though the techniques used are customized to the needs of the patient.

Mastopexy manipulates the existing skin envelope and breast tissue to alter the shape of the breast and elevate the nipple-areola complex's (NAC) position [1]. While the rearrangement of breast tissue can give the illusion of a fuller breast, particularly in the superomedial quadrant of the breast, the total breast volume is not increased. Mastopexy treats breast ptosis, but not breast volume.

Mastopexy-augmentation takes advantage of the structure of a breast implant to increase the volume of the breast and to provide a scaffold around which the skin can be redraped and the NAC repositioned [1]. It is a challenging operation because the volume of the breast is being increased while the skin envelope is being decreased. Hence, two competing forces are at play. The implant and its weight will follow gravity down, while the skin envelope redraping aims to bring the breast up. Additionally, the plane of placement of the implant can affect blood supply to the NAC requiring careful thinking about the pedicle preservation for the NAC [5]. All these competing factors and considerations are what make mastopexy-augmentation challenging and rewarding but with potentially serious complications if not thought about carefully.

Pitfalls can be "tissue related," "implant related," or both (Fig. 23.1). In the senior author's experience (W.G.S.), mastopexy alone had 8.6% revision rate while mastopexy-augmentation had 5.4% tissue-related and 11.2% implant-related revision rates [2–4]. We here describe some of the pitfalls and reasons for revision, ways to potentially minimize risk of complications, and management strategies [6].

Tissue-Related Pitfalls

Nipple, Nipple-Areola Complex (NAC) Position, and Markings

Surgeons often use the terms nipple and nipple-areola complex (NAC) interchangeably, but patients desiring nipple and/or areola reduction may have very different meanings in mind. It is always important to clarify and differentiate the nipple from the areola complex when discussing what will be altered in a mastopexy or mastopexy-augmentation. For example, some patients may desire a nipple reduction and not a reduction in the areola.

Issues associated with the nipple or NAC are "tissue-related" pitfalls. Inherent to the operations, the NAC is made smaller with an areolar marker that is between 38 and 42 mm. Our goal has always been a perfectly rounded areola that sits on the most projecting point of the breast mound. A NAC

A. A. Qureshi (✉)
Marina Plastic Surgery, Marina del Rey, CA, USA

W. G. Stevens
University of Southern California, Marina Plastic Surgery, Marina del Rey, CA, USA

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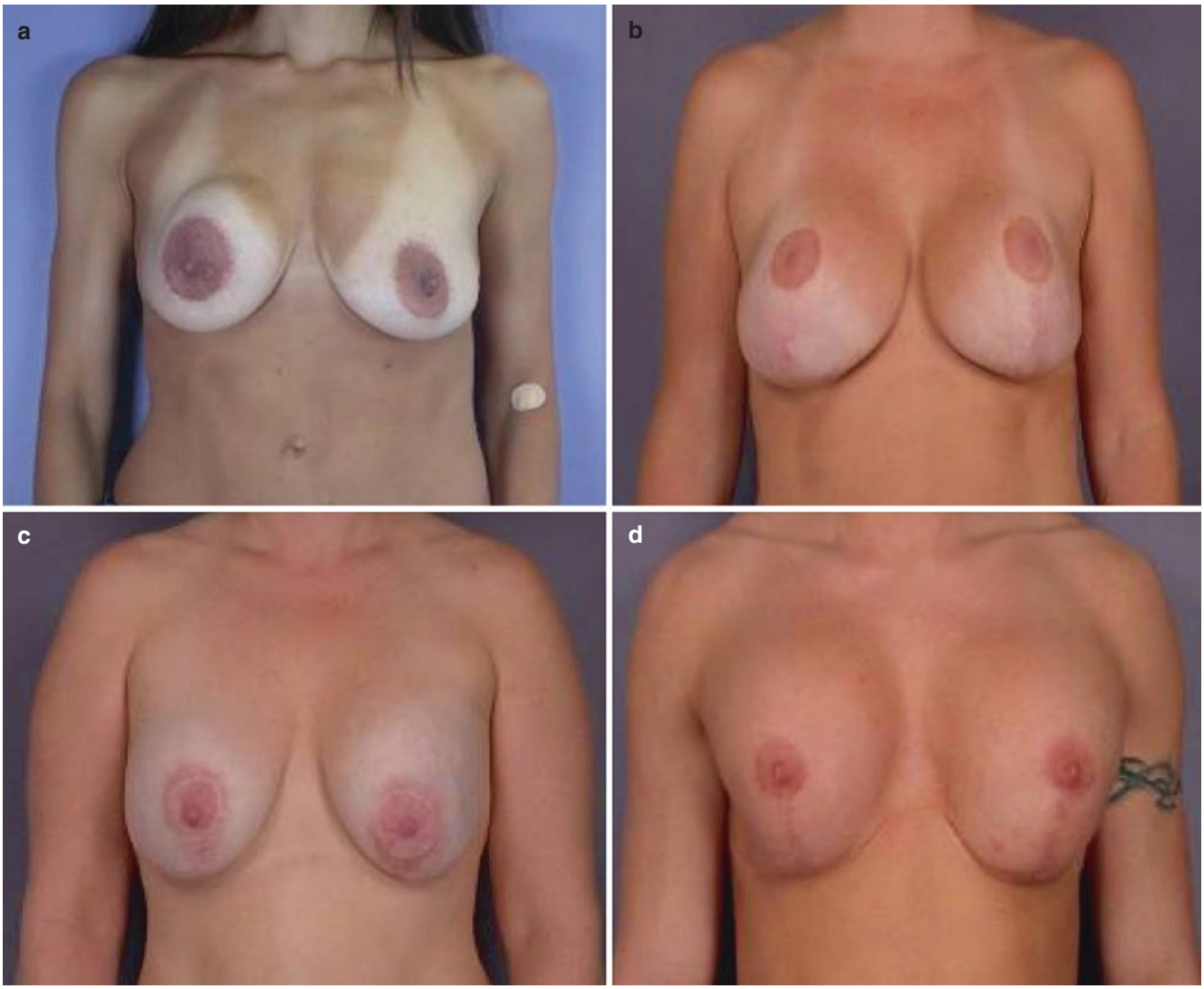

Fig. 23.1 Pitfalls of mastopexy and mastopexy-augmentation include "tissue-related" and/or "implant-related" issues including capsular contracture (**a**), bottoming out (**b**), poor scaring and waterfall deformity (**c**), which can all lead to distortion of size and shape (**d**)

that rides too high may give the appearance of a pseudoptotic breast even though the nipple to inframammary fold (IMF) is not elongated. One that is too low may require a revision to elevate the NAC. Medial and lateral displacements of the NAC are rare unless the meridian of the breast was not well established at the time of markings. A teardrop-shaped NAC is also unappealing, and there should be no tension on the 6 o'clock position of the areola at the time of closure with the vertical limb of a circumvertical mastopexy as this can lead to distortion.

When picking where to place the nipple and the superior border of the NAC, the surgeon needs to pay attention to tan lines. No matter what measurements are made and compared to "ideals," a NAC that extends beyond the tan lines means that the patient will have a visible NAC in her bikini. This is not a successful outcome. For the novice surgeon, it may be helpful to mark the tan lines before marking the NAC position as an extra measure of caution to not make this amateurish and potentially devastating effect as lowering the NAC position is nearly impossible surgically.

Standard measurements at the time of mastopexy and mastopexy-augmentation include sternal notch to nipple (S-N), nipple to IMF (N-IMF), internipple distance, and base width. However, we also measure sternal notch to IMF (S-IMF) distance, which is not a routine measurement for most surgeons. The delta between S-N and S-IMF tells the surgeon just how much the nipple needs to be elevated. For example, a woman with grade III ptosis who has an S-N distance of 30 and an S-IMF distance of 23 needs 7 cm of nipple elevation. In the case of asymmetric ptosis, we match the nipple position based on the less ptotic breast ensuring the S-N distance is the same on both sides. This is because the less ptotic breast will be the limiting factor as the nipples should not be too high or above the tan lines.

The vast majority of our mastopexy and mastopexy-augmentations are done in a circumvertical pattern (Fig. 23.2). It is rare, though not uncommon, to use a crescentic or circumareolar mastopexy alone as this is often not powerful enough to raise the nipple more than 2 cm [1] (Fig. 23.3). Further elevation and large concentric patterns tend to distort the NAC with pleating that does not readily disappear. It can also deproject the breast mound giving the appearance of a breast squashed against a glass or amputated look rather than an aesthetically pleasing conical breast with a natural slope above and rounded bottom below the NAC.

In the case of mastopexy, the nipple is positioned at the level of the IMF or 1 cm above the IMF. We mark the NAC border free-handedly making sure the superior border of the NAC is no greater than 2 cm above the marked nipple position and within the tan lines. This is drawn as a "mosque." Sometimes the NAC is laterally or medially displaced, and the mosque design can be drawn in a such a way to medialize the laterally displaced or lateralize the medially displaced NAC, although there is a limit to how much this can be done.

In the case of mastopexy-augmentation, the nipple is positioned at the level of the IMF and no higher. The NAC border is drawn free-handedly again making sure the superior border of the NAC is no greater than 2 cm above the marked nipple position and within the tan lines. The remainder of the vertical limbs is drawn with a width commensurate with expected skin excision. The markings for skin excision are conservative as more skin can always be excised after the implant is placed. In the case of too much skin excision and inability to close the breast, the surgeons may find themselves in a tough situation where the only option is to downsize the implant or stage the operation. The vertical limbs are tailored based on the overall dimensions of the breast but in general the goal is an N-IMF distance of between 7 and 9 cm. Dog ear excisions are carried out to reduce the vertical length with a horizontal excision of tissue between the new and old IMF.

Tumescent Technique and Avoiding Nipple Necrosis

All of our primary and secondary mastopexy-augmentations are done using a tumescent technique, which has been previously described [2]. In brief, we inject 250 cc of normal saline solution containing 1 mg of epinephrine and 30 cc of 2% lidocaine. The injection is made in the intradermal plane of the planned incisions and the areola. Dissection is carried out sharply with a blade. Cautery is only used for hemostasis and subpectoral dissection.

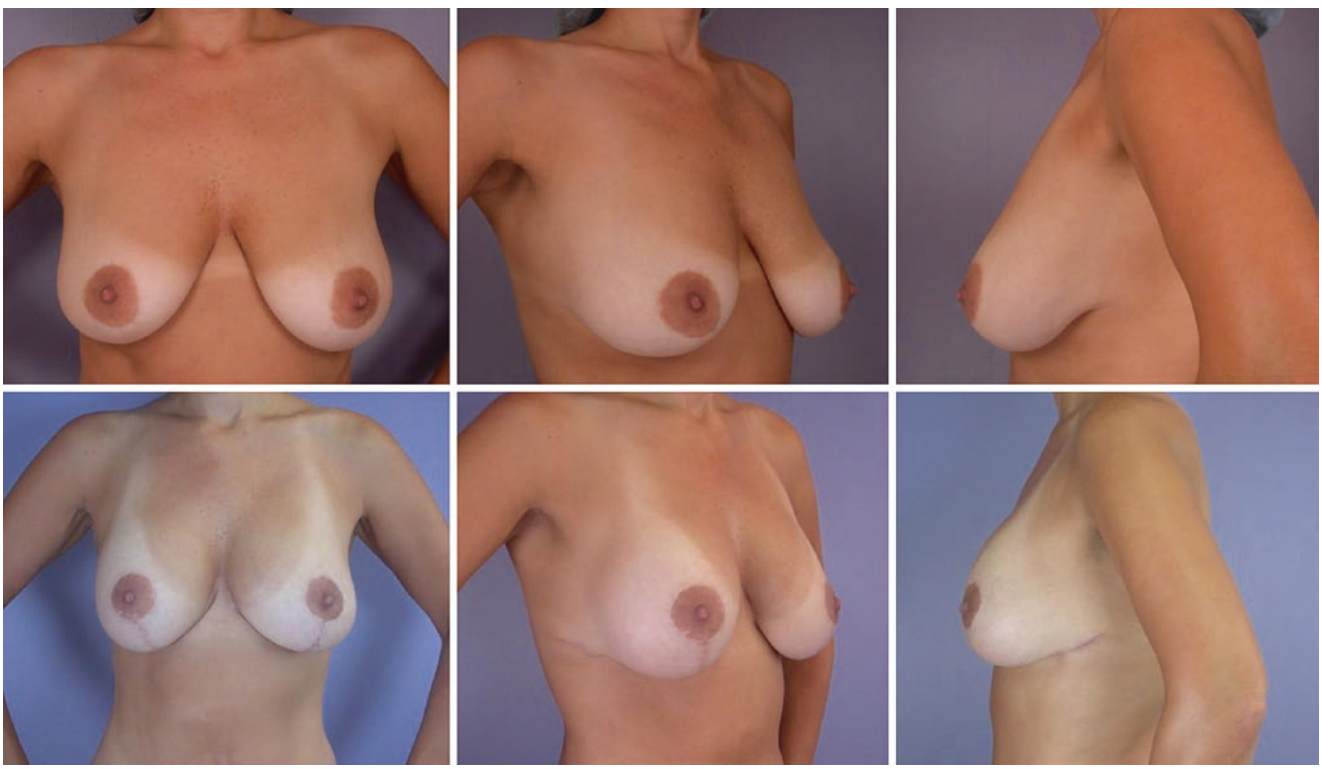

Fig. 23.2 A 34-year-old woman with slight breast asymmetry desired more superomedial fullness and had glandular ptosis. She underwent a dual plane, primary right circumvertical mastopexy-augmentation with a 200-cc silicone gel implant and a left circumvertical mastopexy-augmentation with a 150-cc silicone gel implant

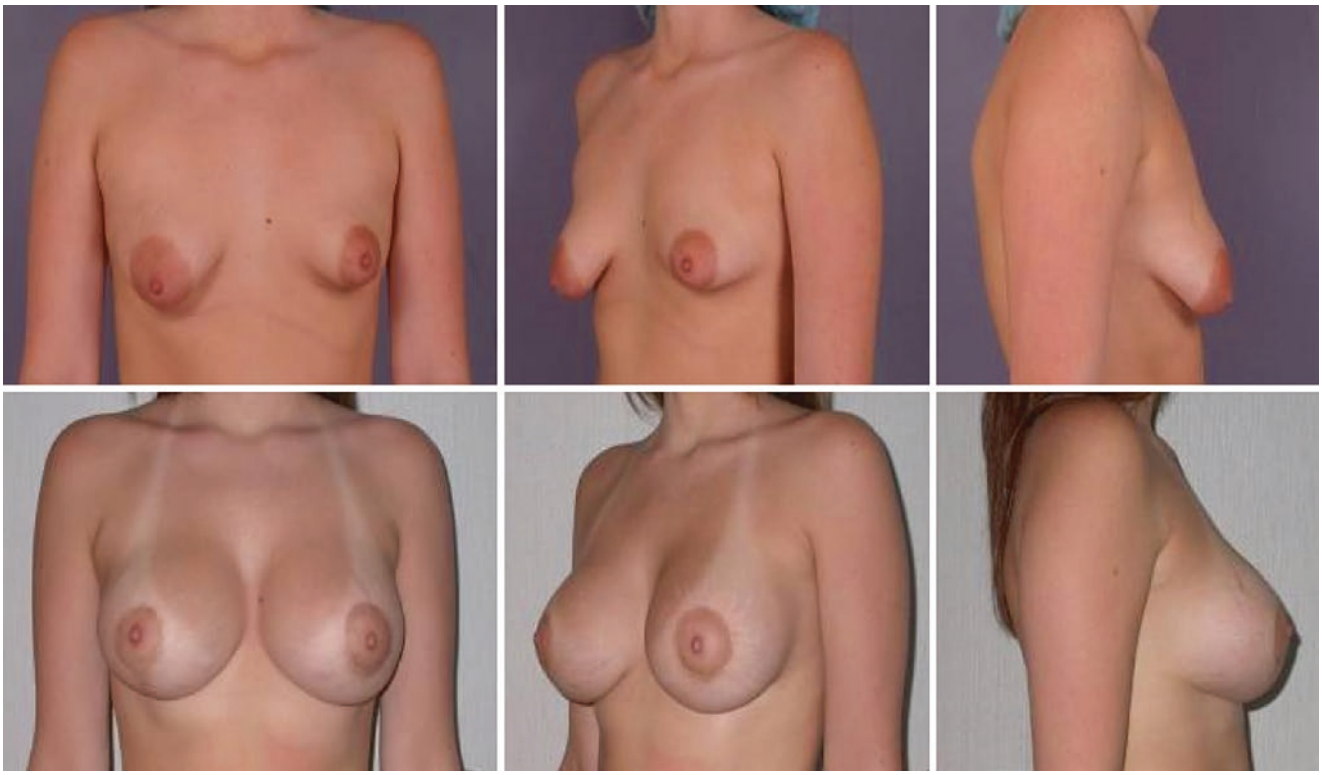

Fig. 23.3 A 27-year-old woman with breast asymmetry and ptosis underwent a primary right subfascial, circumvertical mastopexy-augmentation with a 354-cc silicone gel implant and a left circumareolar mastopexy-augmentation with a 372-cc silicone gel implant

Many may fear injection of an epinephrine-containing solution to the NAC and survival of the NAC as surgeons long feared epinephrine injections to the ear and digits. In our experience, we have not witnessed nipple necrosis attributable to injection which would be a major "tissue-related" pitfall. Rather, what is imperative is maintaining an adequate dermal pedicle to the NAC for survival. In mastopexy and mastopexy-augmentation, adequate mobilization of the pedicle as to not distort the NAC must be balanced with maintaining enough of a dermal pedicle to preserve both arterial inflow and venous outflow.

We predominantly use the superior and superomedial pedicles, which rely on the second and sometimes third intercostal perforators traveling about 1–2 cm below the dermis at the level of the NAC. Inadvertent transection of this may not necessarily comprise arterial inflow as the NAC may then rely on a central pedicle, but concurrent transection of the dermis can significantly impact venous outflow and lead to venous congestion. If there is concern of vascular compromise to the NAC before inset, a loose closure and placement of nitroglycerin paste can help a struggling NAC. Adequate fluid resuscitation can also improve perfusion to the NAC. In our experience, we have not had to use medicinal leeching or anticoagulants in such cases.

No cases of complete nipple and/or NAC necrosis have been experienced by the senior author (W.G.S.). Partial nipple necrosis or areolar loss can occur on occasion. While the temptation may be aggressive surgical debridement, experience has shown that conservative management and patience lead to better cosmesis including repigmentation of the depigmented partial areolar loss. This often requires frequent communication and visits between surgeon and patient, but our experience has led us to proceed with conservative management in anticipation of excellent results from the body's own ability to heal.

Management of the Aging Periareolar and Circumareolar Scar

Patients who have previously had a periareolar augmentation or circumareolar mastopexy-augmentation often present for a mastopexy-augmentation when the breast ages or scars widen. This is a "tissue-related" pitfall. In women unwilling to accept a circumvertical scar or who do not need narrowing of the breast, the previous scars can be used. However, prior inadequate closure of the layers of the breast can lead to a number of contour irregularities. In the senior author's experience, a previous, depressed, and rotated circumareolar scar from the 3 to 9 o'clock positions of the breast can be managed by entering the breast from the superior half of the scar or areola. The temptation is to enter the breast from the lower half of the scar, but this will simply exaggerate the deformity

and not correct it. An inferiorly based capsular flap can be dissected and sutured to the lower half of the scar and thereby derotating the scar and ameliorating the depression. Additionally, with the advent of fat grafting, such depressed scars can be managed with rigotomy and fat grafting. In general, it is not our preference to use a circumareolar mastopexy for the shortcomings mentioned.

Others have described the use of permanent sutures to manage areolar widening when using a circumareolar approach alone [1]. In our experience this has not held the test of time and the redundancy around the new areolar diameter is best carried downward into the vertical limb of a circumvertical mastopexy.

Implant-Related Pitfalls

Capsular Contracture in Patients with Previous Mastopexy-Augmentation

The management of capsular contracture is beyond the scope of this chapter and while not a unique pitfall of mastopexy-augmentation, it is a known sequela associated with prosthetic breast augmentation and an "implant-related" pitfall. The management of Grade III and IV capsular contractures is heavily debated and includes open capsulotomy, partial to total capsulectomy, and creation of neo-subpectoral pockets. The literature supports that exchanging the previous breast implant for a new breast implant is associated with lower rates of capsular contracture, regardless of the surgical management of the capsule [7].

When there is Grade IV capsular contracture associated with a rupture, removal of part of the capsule or the entire capsule may be warranted. However, an alternative in Grade III and IV capsular contracture without rupture is to remove the existing implant and replace with a new implant and perform capsulotomies as appropriate. Most commonly this includes a superomedial capsulotomy and inferior capsulotomy with radial scores of the lower pole. Maintenance of the capsule may maintain collateral blood flow that has been established through the capsule, which is important to preserve if a secondary or tertiary mastopexy is being performed at the time of removal and replacement of an implant. Additionally, because of less dissection, these procedures tend to be much less bloody than capsulectomies, and increased heme exposure to the pocket and blood loss increase the risk of recurrent capsular contracture. We do not use drains for such cases (Fig. 23.4).

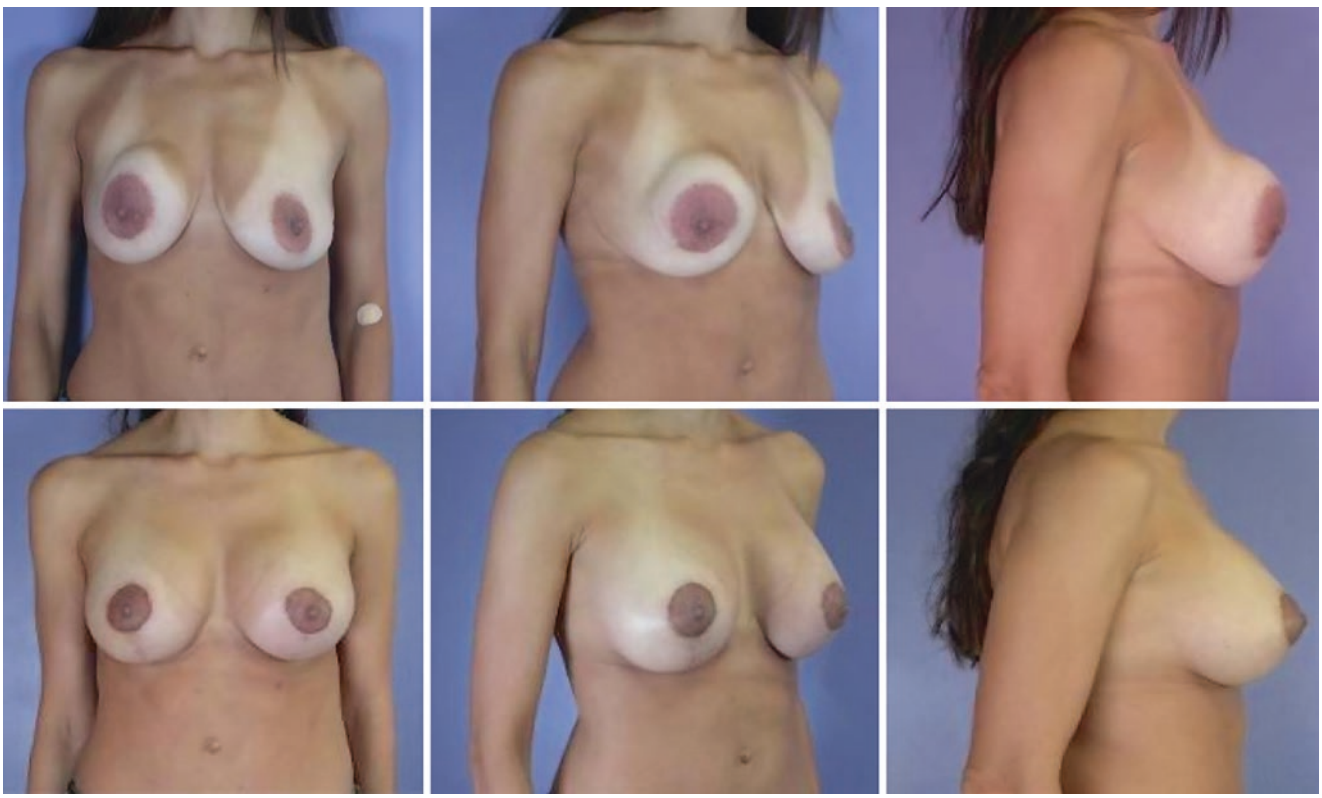

Fig. 23.4 A 36-year-old woman had a previous circumareolar mastopexy-augmentation with subglandular saline implants. She presented with right-sided Grade IV capsular contracture and a left-sided deflation (implant-related issues). She underwent a secondary mastopexy-augmentation with a circumvertical technique with pocket change to dual plane with 350-cc round, smooth silicone implants

The vast majority of our primary mastopexy-augmentations is done with the augmentation in a dual plane. At the time of a secondary mastopexy-augmentation, we rarely change the pocket from subglandular or subfascial to submuscular for a number of reasons including the fact that this pocket change would disrupt blood supply from perforators through the pectoralis muscle into the breast parenchyma.

Tissue- and Implant-Related Pitfalls

Bottoming Out and the Pseudoptotic Breast

Bottoming out and the pseudoptotic breast can appear together. This can be due to the weight of a large implant or vertical limbs with an N-IMF distance that was too long at the time of the initial operation. In other words, these problems can be "tissue-related" or "implant-related" pitfalls, or a combination of the two. Management of this pitfall depends on the diagnosis.

The case of a caudally displaced implant without an elongated N-IMF distance is rare, but when it occurs can easily be fixed. This often involves some sort of manipulation of the IMF and lower pole of the breast with rows of suture or a tissue support material like mesh or acellular dermal matrices. The exact techniques of repair are beyond the scope of this chapter, but the reader should be well-versed in how to manage this problem prior to embarking on implant-based surgeries. When it is a pure implant malposition problem, the implant does not necessarily need to be downsized although it can be if the patient desires. Our current method of repair for bottoming out is to use tissue support devices [8, 9].

More commonly, the weight of the implant has stretched the lower pole of the breast leading to a pseudoptotic breast. When the S-N and S-IMF distances are measured they may not be discrepant and require NAC elevation. However, the N-IMF distance is often longer than the initial 7–9 cm at the time of a primary operation. In this case the vertical length needs to be shortened with a horizontal skin excision. This can be done with a horizontally designed elliptical excision or a "smile mastopexy."

We prefer to deepithelize the skin and close the breast so as to preserve as much tissue as possible and not expose the implant or manipulate the capsule unless necessary. Because the internal capsule is left undisturbed, there is no risk of implant exposure even if wound dehiscence occurs at the "T junction."

More commonly than not, the pseudoptotic breast has also expanded in the horizontal dimension and a vertical ellipse of skin can be removed as well to narrow the breast and "reset the clock" so to speak while rejuvenating the breast. It can also be performed to simply revise the vertical scar which may have widened with time. When both vertical and horizontal ellipses of skin are removed, we call this sort of mastopexy an "owl with feet" mastopexy. When just a circumvertical mastopexy is being performed, we refer to this as an "owl" mastopexy but find it more helpful to remove a small amount at the caudal end horizontal as an "owl with feet" and not have to worry about settling of the caudal dog ear (Fig. 23.5).

Waterfall Deformity

Waterfall deformities can occur after a primary augmentation performed in a subpectoral plane or dual plane I procedure. This problem is not seen in implants placed in a subglandular or subfascial plane, where bottoming out and double bubble can be more common. In this deformity, the breast parenchyma appears to fall off the implant and is both a "tissue-related" and "implant-related" pitfall (Fig. 23.6).

In a secondary mastopexy-augmentation, both the implant and the tissue can be addressed. The implant can be dropped with further release of the pectoralis muscle allowing the pectoralis to window shade up, the implant to drop, and the breast parenchyma to directly contact the lower pole of the implant. A circumvertical technique can be used to narrow the breast and reduce the N-IMF distance as well as adjust nipple position and NAC diameter.

Management of Existing Asymmetries

We commonly tell patients that "breasts are sisters, not twins" and they are likely to be sisters even after surgery. Asymmetries can be of nipple position, NAC diameter, breast shape, breast volume, and IMF position. These are both potential "tissue-related" and "implant-related" pitfalls.

Asymmetric nipple position and NAC diameter are readily managed with the areolar reduction and marking nipple height preoperatively. Asymmetric shape and size are more challenging to fix but are often why patients are even seeking the help of a plastic surgeon.

When two breasts differ in volume, this should be noticed by the surgeon and pointed out to the patient preoperatively. Several options exist to make the breasts more symmetric. In the case of mastopexy alone, reducing the larger breast is often the easiest way to match size.

If a patient desires the breasts to be the same or bigger, an implant should be considered. In this case, the larger breast can have a smaller implant and the smaller breast can have a larger implant placed. Depending on the volume discrepancy, this may be the only way to address the volume

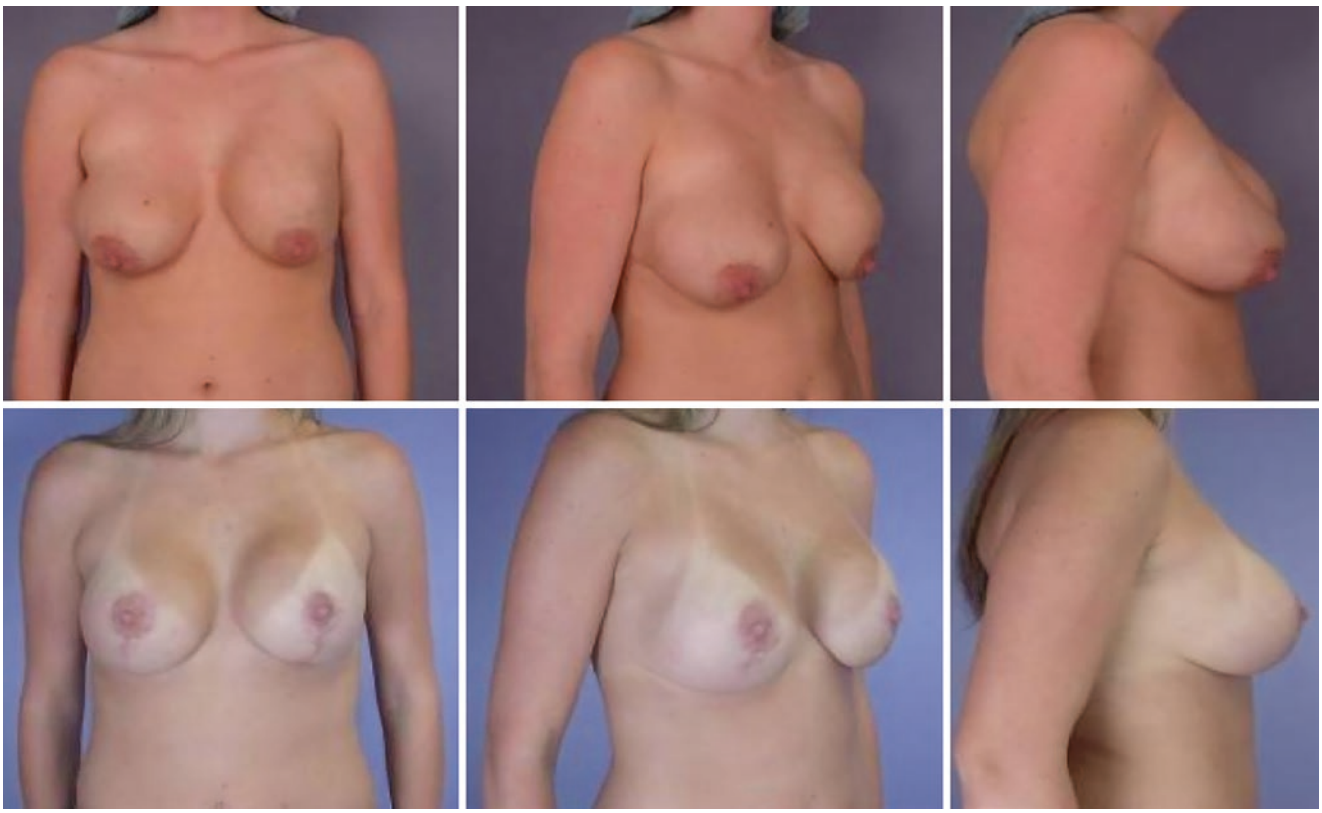

Fig. 23.5 A 23-year-old woman presented 2 years after a previous 325-cc smooth saline subglandular breast augmentation with breast ptosis and capsular contracture (combination of tissue- and implant-related issues). She underwent bilateral circumvertical mastopexy-augmentation in a subfascial plane with larger, textured 378-cc implant

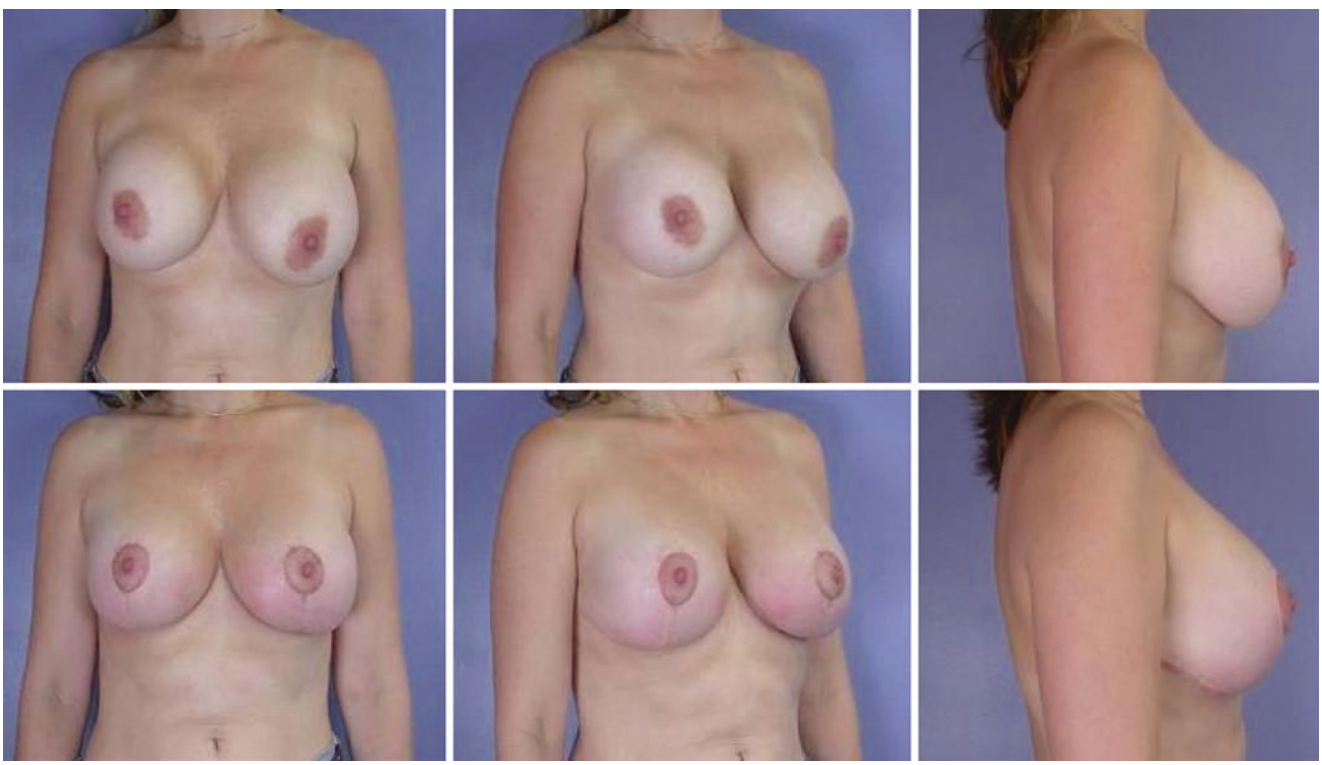

Fig. 23.6 A 42-year-old woman presented with a waterfall deformity and capsular contracture 5 years after a previous dual plane, circumareolar approach breast augmentation with 375-cc round, silicone gel implants (combination of tissue and implant related issues). She underwent bilateral capsulotomies and circumvertical mastopexy-augmentation with 395-cc round, silicone gel implant

asymmetry. The caveat is the following: the greater the volume difference of the implants the more likely the implants are to age at different rates due to differential gravitational pull. An alternative is that the larger breast can be reduced slightly and the same size implant can be placed on each side. A third alternative, and least desirable, is to accept the asymmetries and place the same size implants on both sides and temper expectations about being able to achieve symmetry at all.

In general, patients who have asymmetric inframammary folds will have more symmetrical folds after surgery than before, although some asymmetries may still persist. When a mastopexy-augmentation is being performed, we rarely drop the fold unless it is a case of a tuberous breast (Fig. 23.7). More often, the IMFs are within 1–2 cm of each other and the higher fold can be dropped slightly and carefully to match. Dropping the IMF can lead to disastrous consequences, including severe implant malposition in the dropped side with bottoming out of the implant. Even if the fold is dropped 1–2 cm, this is often countered with a horizontal elliptical excision when the final N-IMF distance is being set around 7 cm so a "plus-minus" effect usually leads to symmetry of the folds at the conclusion of the case. Of note, the surgeon should be particularly careful when performing this procedure in combination with a tummy tuck in a mommy makeover. Manipulation of the folds can then be impacted by the downward pull from the abdominoplasty and progressive tension sutures. In our experience, we perform the "clean" part of a mommy makeover with the implants first and may even secure the IMF with absorbable sutures to protect the location of the IMF from the downward pull of the abdominal flap.

Conclusion

Mastopexy and augmentation-mastopexy are challenging procedures but are some of the most gratifying surgeries plastic surgeons can do. They are some pitfalls and challenges, including asymmetry, malposition, adverse scarring, capsular contracture, persistent ptosis, and incongruities of breast tissue relative to implant. This chapter details extensive experience with avoiding and treating these common and uncommon complications through a prism of "implant-related" versus "tissue-related" issues. Practical tips based on thousands of surgeries performed by the authors are presented to help enhance outcomes and manage rare complications.

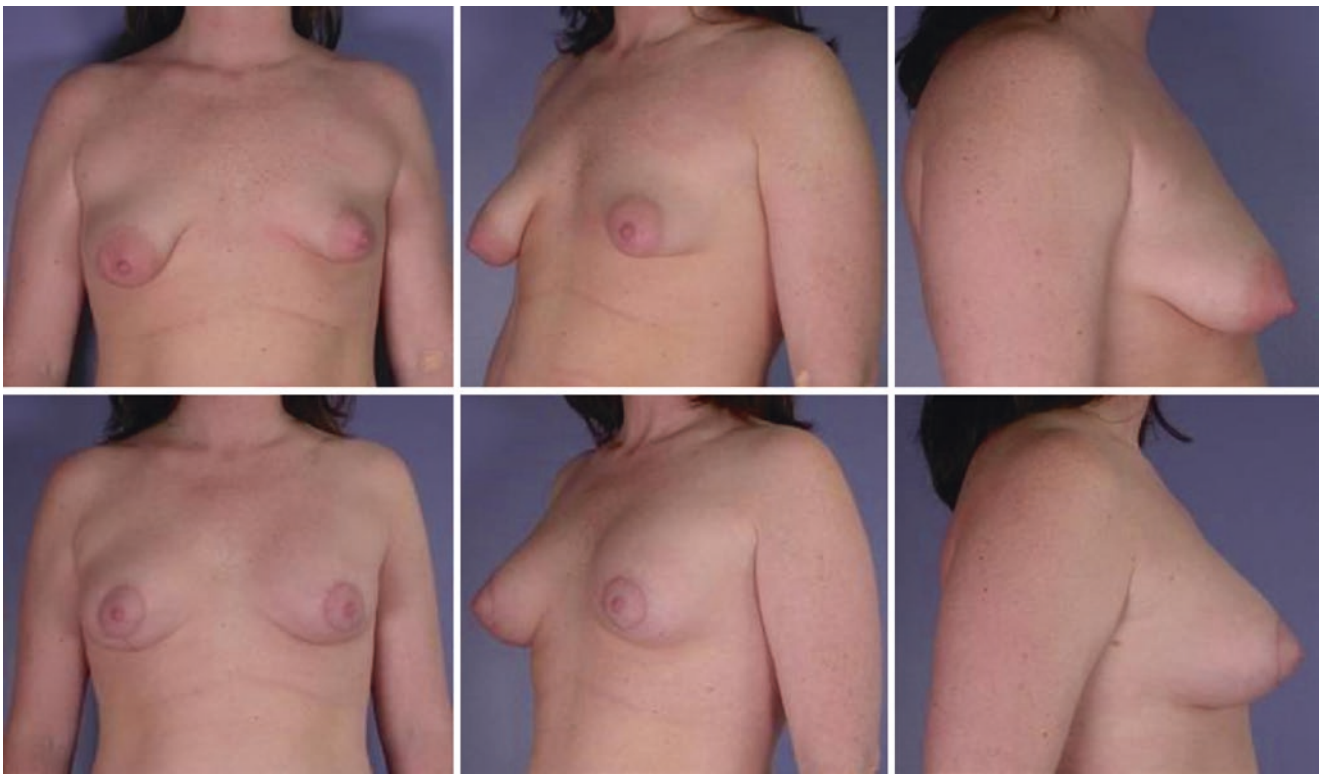

Fig. 23.7 This 29-year-old woman with tuberous breast deformity, breast and NAC asymmetry, underwent a primary right dual plane, circumvertical mastopexy-augmentation with 272-cc silicone gel implants and a left dual plane, circumareolar mastopexy-augmentation with a 322-cc silicone gel implant

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24 Avoiding and Solving Problems with Augmentation Mastopexy: The Impact of Blood Supply on Decisions for Mastopexy and Pocket Selection

M. Bradley Calobrace and Chet Mays

Introduction

Breast ptosis is one of the most common complaints heard by plastic surgeons. It can be developmental or, more commonly, acquired via secondary to weight loss, hormonal changes, pregnancy, and aging. When evaluating a patient with ptosis, it is important to determine the volume status and soft tissue quality of the breasts. A mastopexy alone without the use of an implant is reserved for a patient in whom the major concern is breast ptosis and not an issue of desiring additional breast volume or upper pole fullness. Patients with volume deficiencies or desiring significant upper pole volume often require placement of an implant with the mastopexy to achieve their desired result.

Staging an augmentation and mastopexy may provide the safest option with potentially a more optimal outcome in certain clinical scenarios [1–3]. However, a simultaneous mastopexy is an excellent option in most patients with breast ptosis and can be performed safely with high patient satisfaction [4–7]. The surgical approach to the patient with ptotic breast desiring or requiring a breast implant for correction is determined following a thorough evaluation. Appropriate breast measurements, breast tissue density, quality of skin, NAC (nipple-areolar complex) and breast ptosis, chest wall characteristics, breast footprint, and the patient's expectations all must be considered in planning for the procedure. For the patient with limited ptosis, a breast augmentation alone may provide adequate rejuvenation. If a mastopexy is deemed necessary with the augmentation, many types of mastopexy techniques described to address the ptotic breast can be utilized, including circumareolar, circumvertical, circumvertical with horizontal wedge, or the inverted-T scar technique [8–12].

In preoperative planning, one must plan the implant pocket including dual-plane submuscular, subfascial, or subglandular. The pocket selection can impact the surgical approach, the vascularity of the skin flaps and NAC, and long-term outcome. Likewise, a wide variety of breast implants options are available to optimize final results. Implant characteristics including implant fill, shell texturization, silicone gel cohesiveness, gel-to-shell fill ratios, projections, and shape can impact the final results [13, 14].

Perioperative decision making is critical to a successful outcome in augmentation mastopexy surgery. In this chapter, we will focus on appropriate patient selection, determination of mastopexy approach, pedicle selection and skin pattern excision, pocket determination, and implant selection, thus creating a foundation for decision making to optimize results in the augmentation mastopexy patient.

Preoperative Evaluation

The evaluation should begin with a breast exam with breast measurements, including base width, sternal notch to nipple position, soft tissue thickness (pinch test), intermammary distance, IMF to nipple distance, breast height, areola width, and any unusual masses or lumps (Fig. 24.1).

Importantly, the amount of ptosis present should also be assessed. Ptosis has classically been described as per Regnault based on the relationship of the NAC to the inframammary fold [15]. Although this provides some information about the degree of breast ptosis, it in of itself is insufficient to describe the true extent of breast ptosis. A more complete assessment of ptosis is summarized in Table 24.1.

M. B. Calobrace (✉)
Clinical Faculty, Division of Plastic Surgery, University of Louisville, Louisville, KY, USA

Clinical Faculty, Division of Plastic Surgery, University of Kentucky, Louisville, KY, USA

C. Mays
Clinical Faculty, Division of Plastic Surgery. University of Louisville, Louisville, KY, USA
e-mail: drbrad@calobrace.com

J. Y. S. Kim (ed.), *Managing Common and Uncommon Complications of Aesthetic Breast Surgery*,
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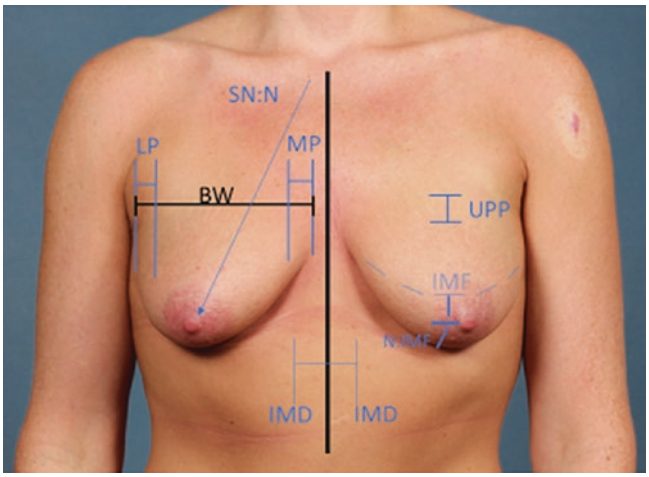

Fig. 24.1 Breast base width (BW), Sternal notch-to-nipple distance (SN-N), Intermammary distance (IMD), Nipple-to-fold distance (N-IMF) at rest and under maximal stretch, Intermammary distance (IMD), Soft tissue coverage: UPP (upper pole pinch), MP (medial pinch), LP (lateral pinch)

Patients with different grades of ptosis per the Regnault's classification may have completely different breast compositions including the quality of breast tissue and skin, the quantity of breast tissue present, and the vertical excess present (Fig. 24.2). Determining the amount of vertical excess that is present will assist in determining the type of mastopexy that should be accomplished (Table 24.2). It also can assist in determining the appropriate patients for staging. To avoid an unsatisfactory result, we are more likely to stage when the vertical excess is 8–10 cm or greater [5].

Assessment should also include evaluation of the skin thickness and elasticity, the quantity and distribution of subcutaneous fat, the composition and firmness of the breast parenchyma, the integrity of the Cooper's ligaments, the nature and position of the underlying musculature, and the shape and slope of the underlying chest wall. All these aspects of the breast composition influence the shape of the breast and, ultimately, the outcome after the augmentation mastopexy.

Blood Supply as it Impacts Decisions in Mastopexy and Pocket Selection

An understanding and assessment of the vascular anatomy are critical to performing a breast procedure safely. This is particularly important when performing augmentation mastopexy [16]. The breast has a rich blood supply from multiple sources, including the internal mammary artery perforators, the lateral thoracic arteries, the thoracoacromial, and the anterolateral and anteromedial intercostal perforators. The blood supply to the NAC and breast skin flaps is impacted by multiple factors including, implant selection, pocket selection, mastopexy performed, and the extent of skin undermining.

Table 24.1 Assessment of breast ptosis

Relationship of the NAC to the IMF (Regnault's degree of ptosis)
(a) Grade 1: Nipple at the level of the inframammary fold, above the lower contour of the gland
(b) Grade 2: Nipple below the level of the inframammary fold, above the lower contour of the gland
(c) Grade 3: Nipple below the level of the inframammary fold, at the lower contour of the gland
Amount of breast tissue overhanging the fold
Location of the NAC on the breast mound
Amount of vertical excess and horizontal excess
Footprint of the breast on the chest wall – low, medium, high
Quality and quantity of breast parenchyma and skin

The inferior pedicle and central pedicle are supplied by the fourth branch of the internal mammary artery (IMA) that courses deeply across the medial breast to enter through Wuringer's septum just above the fifth rib and medial to the breast meridian approximately 1–2 cm above the IMF. In some patients there may be additional IMA and lateral thoracic perforators through the septum. The inferior pedicle also has additional blood supply through contribution from intercostal perforators along the IMF. In the augmentation mastopexy procedure, the implant pocket development includes division of the fourth branch of the IMA and any perforators through Wuringer's septum, and, thus, the central pedicle and a significant portion of the inferior pedicle blood supply may have been sacrificed.

To ensure the most reliable blood supply to the NAC and skin flaps, the superior pedicle and, occasionally, the superomedial pedicles are utilized. The superior pedicle is supplied by the second branch of the IMA that emerges deep from the second interspace and courses superficial across the medial upper breast to enter the NAC slightly medial to the midline and approximately 1 cm deep. The medial pedicle is supplied by the second or third branch of the IMA that emerges from the third interspace and similarly courses superficially across the breast parenchyma to the medial aspect of the NAC. The superficial position of these vessels in the upper pole allows the implant placement and mastopexy without interfering with the blood supply. However, a word of caution: these vessels take origin along the sternal border in the medial aspect of the implant pocket and can be inadvertently sacrificed when aggressive medial pectoral muscle division is performed (Fig. 24.3).

Additionally, implant and pocket selection affect the blood supply to the overlying breast. The subpectoral pocket maintains the musculocutaneous perforators (unless an extensive dual plane is performed) and is less likely to interfere with the blood supply compared to a subglandular/subfascial pocket. Likewise, larger implants placed in any pocket, but especially the subglandular/subfascial pocket, can create undue tension on the mastopexy closure that can accentuate vascular compromise to the NAC or overlying skin flaps.

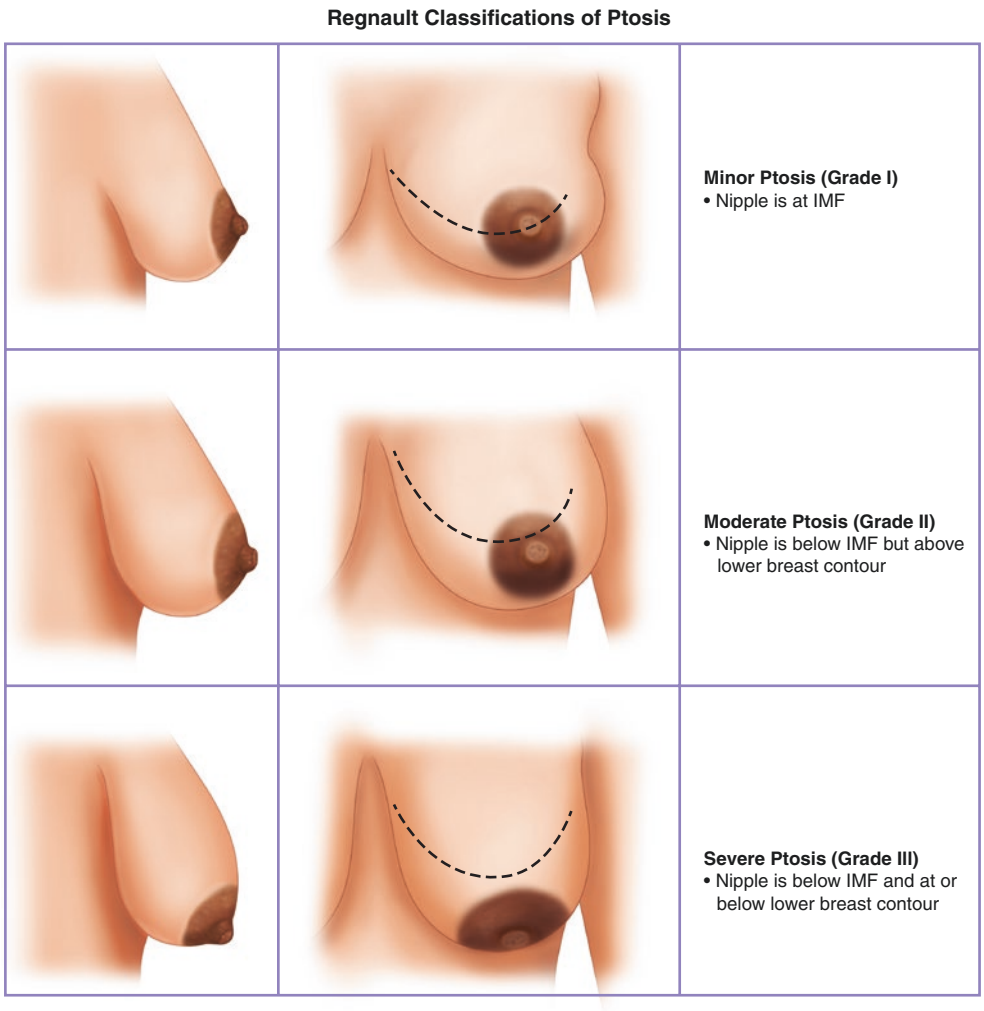

Fig. 24.2 Regnault classification and degrees of ptosis

Table 24.2 Determining vertical excess

Vertical excess (VE)
VE = New nipple to actual IMF – new N to new IMF
VE > 8–10 cm consider staging augmentation mastopexy

Patient Expectations

Patient education and the need to spend some time understanding the patient's desired outcome and expectations with the operation are often the most important components to ensure patient satisfaction and a successful outcome. Patients requiring an augmentation mastopexy are more likely to have undergone changes to the breast from weight loss or postpartum changes and suffer from lax tissue, stria, nipple and breast ptosis, and loss of parenchymal volume and/or firmness. Thus, the need to manage expectation in these challenging cases cannot be overstated.

Patients often are unaware of asymmetries, the significant atrophy of the breasts, and differences in the chest wall that affect the final outcome. During the evaluation, it is important to determine what "look" the patient would desire, especially in terms of nipple position and volume in the upper pole. Patients need to be informed and fully comprehend the limitations in achieving a desired look to the breast compared to a breast augmentation alone. In a recent quality of life study comparing breast augmentation patients to augmentation mastopexy patients, breast augmentation patients were significantly more satisfied with the aesthetic outcome and the quality of life on many psychosocial aspects. In contrast, the augmentation mastopexy patients reported dissatisfaction with shape, scarring, symmetry, and the nipple-areolar complex [17].

The operative design can be tailored to account for the patient's desired outcome taking into consideration the limitations present. A patient desiring a more natural look may benefit more from a subpectoral implant, a less cohesive implant, or a shaped device, whereas a patient desiring more volume and roundness in the upper pole may require a more cohesive higher profile implant and potentially the implant placed above the muscle. Undoubtedly, there are limitations in what can be achieved in augmentation mastopexy but good perioperative decision making with an operative approach specifically designed to meet the patient's

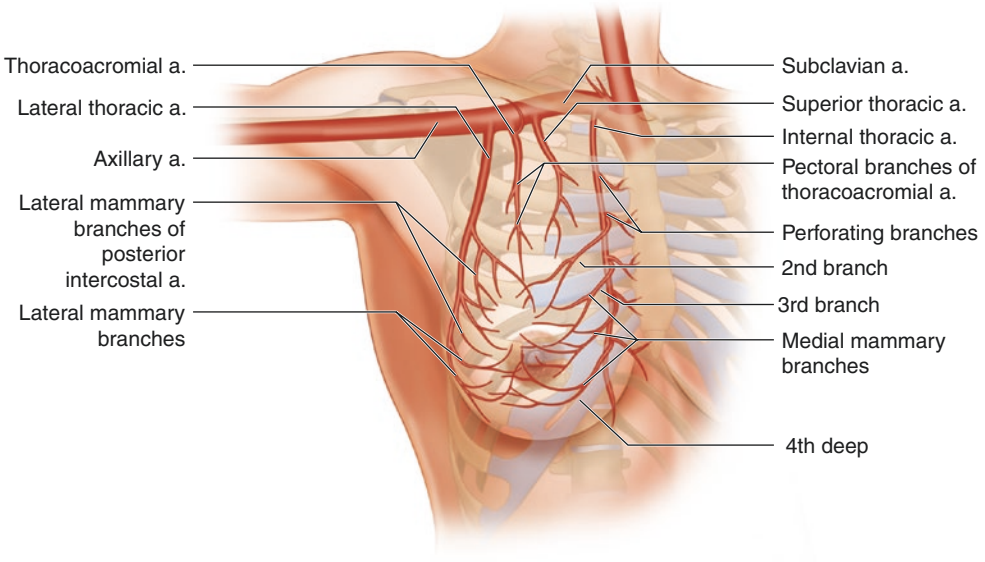

Fig. 24.3 Breast blood supply

goals is more likely to provide optimal results for each patient.

Given that the results of an augmentation mastopexy are not the same as a breast augmentation in most patients [17], particular attention must be paid to managing patient expectations. The unique challenges of the augmentation mastopexy need to be understood by the patient, with an understanding that a revision rate exceeds 20% and that revisions may be necessary to achieve the ideal outcome [5]. In addition to these potential aesthetic complications that require revision, standard "common" complications such as scar location, adverse scarring, altered nipple sensitivity, and asymmetry should be disclosed. Moreover, patients should be made to understand the uncommon complications from issues such as compromised pedicle or capsular contracture or infection.

Operative Decision Making

Selection of Procedure

Augmentation Without a Mastopexy

Patients with deflated breasts often describe their breasts as "droopy" and often come to the consultation with the impression they need a breast lift. If the patient has pseudoptosis or Grade 1 ptosis and the stretched nipple-to-fold distance does not exceed 9.5–10 cm, a breast augmentation alone without a mastopexy may provide satisfactory correction and meet the patient's goals [18]. Based on the clinical setting, the NAC may be positioned slightly lower than is ideal, and the upper pole may be less full depending on implant type and size and pocket selection. The subglandular/subfascial pocket may facilitate expansion and lift of the breast in borderline cases. In these patients, there must ultimately be harmony in the volume of the breast and the overlying skin envelope. If the patient's desired breast size is less than what can satisfactorily fill out the skin envelope or if the NAC position desired is greater than what can be accomplished with the breast augmentation alone, some type of mastopexy is indicated. Thus each patient's desired outcome can determine the surgical approach, which might be different for patients with similar preoperative breast appearance.

Mastopexy Without Augmentation

The ideal candidate for a mastopexy alone is a patient that is relatively satisfied with her volume and is mainly looking for correction in her breast ptosis and improvement in breast shape. The ideal candidate has adequate breast volume and enough ptosis to warrant a mastopexy and the scars associated with these procedures. The patient is looking for a more natural upper pole. A more rounded upper pole with significant cleavage is not a goal of these patients. Patients with high breast footprints or dense breasts are optimal for mastopexy alone.

Augmentation Mastopexy

A patient desiring more volume or significant upper pole volume and cleavage would be better served with an augmentation mastopexy technique. The exception would be the patient desiring those attributes, but the simultaneous procedure is deemed inappropriate or unsafe (Table 24.3). In these cases, a mastopexy can be performed at the initial procedure, followed at least 6 months to 1 year later with a staged breast augmentation.

Table 24.3 Relative indications for staged augmentation mastopexy

Obesity: BMI >30
Large, pendulous breasts – need volume reduction
Significant breast ptosis – NAC elevation >5–6 cm
Vertical excess >8–10 cm
Unrealistic expectations – understands reoperation rate > 20%
Smokers who refuse to quit

Mastopexy Selection

When it is determined that a simultaneous augmentation mastopexy is appropriate, the approach to the mastopexy is based on the preoperative evaluation. The assessment of the level of ptosis (see Table 24.1) guides the surgeon in assessing the need for NAC elevation as well as skin envelope reduction and possibly parenchymal excision.

Circumareolar

Patients with borderline ptosis, Grade 1 ptosis or pseudoptosis (N-IMF under maximal stretch 10 cms), low NAC (such as constricted breast deformity), or tuberous breast deformity may benefit from a circumareolar mastopexy. This can elevate the NAC modestly (less than 2 cm) and can reduce the areolar diameter. There should be minimal overhang of breast over the fold and limited horizontal laxity. The circumareolar mastopexy should be used very selectively as it can create widening and flattening of the breast, which may prove beneficial in a tuberous breast deformity but undesirable in a deflated, flattened breast.

Circumvertical

Patients with moderate ptosis, Grade 1 or 2, requiring NAC elevation of usually less than 4 cm, with modest amounts of breast overhanging the fold can be addressed with a circumvertical mastopexy with or without removal of a small amount of skin along the fold (horizontal wedge). These patients tend to have more horizontal laxity requiring breast narrowing with only a modest amount of reduction in the vertical component.

Circumvertical with Inverted-T Skin Excision

For patients with more severe ptosis, Grade 2 or 3, with significant vertical excess and overhang over the fold, a circumvertical with inverted-T skin excision is more appropriate to achieve optimal results. The greater the vertical excess and laxity, the greater the horizontal wedge and the longer the incision becomes along the inframammary fold.

When planning the type of mastopexy, it is important to distinguish between the pedicle design and the skin excision design of the mastopexy [19]. In augmentation mastopexy, the design of the more ptotic breast is always a circumvertical approach with the superior or occasionally the superomedial pedicle as the pedicle blood supply. The only difference in the approach is whether skin needs to be excised along the fold. Thus, even in the more ptotic breasts with significant laxity requiring an inverted-T skin pattern excision, the parenchymal and pedicle design is still a circumvertical approach with a superior pedicle. In these patients, if the breasts are heavy with excessive ptotic parenchyma, a lower pole parenchymal resection is the key to long-term success with this approach with a reduction in the likelihood of recurrent ptosis postoperatively [20].

Lower Pole Mastopexy

There is an occasional patient, especially in secondary cases, in which the NAC is in satisfactory position, but a significant amount of lower pole stretch deformity, glandular ptosis, or pseudoptosis is present. These patients may benefit from simply an inframammary fold resection (smile mastopexy) or vertical-horizontal resection (sailboat mastopexy) without transposing the NAC [21]. This can address both vertical and horizontal laxities without jeopardizing NAC circulation and placing an unnecessary scar around the areola.

Implant Selection

In augmentation mastopexy, implant selection can significantly impact the outcome in the case. The implant selection has greater impact as the augmentation is performed in the face of a mastopexy with soft tissue envelopes which are more lax, stretched, thinned with stria, and less tolerant to the effects of the underlying implant.

Implant Profile and Size

Tissue-based planning proves very beneficial in augmentation mastopexy just as it does in augmentation alone [18]. The base width of the breast provides a general guide as to the appropriate sizing of the implant for the breast. In considering implant width, critical to that calculation is determining how much the native breast itself will contribute to the final width of the breast. Optimal implant width is calculated by determining the desired final breast width (usually anterior axillary line to 1 cm from the midline of the chest) minus the soft tissue contribution from the native breast using the medial and lateral pinches (Fig. 24.4).

$$\text{Optimal implant width}\left(\text{OIW}\right) = \text{Breast base width} - \left(1/2\,\text{medial pinch} + 1/2\,\text{lateral pinch}\right)$$

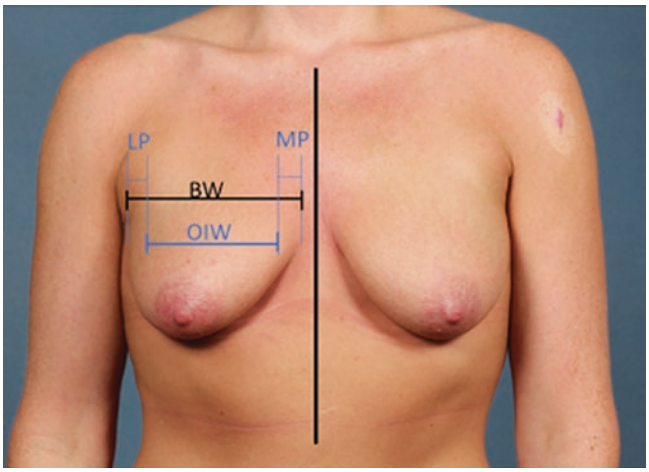

Fig. 24.4 OIW optimal implant width, BW breast base width, MP medial pinch, LP lateral pinch

In a patient with ptosis and a thin skin brassiere with minimal breast tissue, the implant determination will be identical to a straightforward breast augmentation. In breasts with more significant volume and heavier breasts, this calculation might lead to a smaller implant compared to a breast augmentation alone. When trying to achieve a desired volume with limited base width, a higher profile implant may be deemed as appropriate in these patients. However, the skin envelope laxity with the planned mastopexy must be taken into consideration. The effect of a high-profile implant on the skin envelope immediately on the skin flaps and over time with potential for stretch deformity must be balanced against the patient's desire for more volume [22]. In the heavier breasted patient requiring an augmentation and mastopexy, an implant with a lower profile and more width/height to add volume to the upper pole but to minimize the impact on the overlying breast is often selected as the implant of choice. Oversized implants not only create long-term effects but the undue tension created when mastopexy flaps are closed around a larger implant can also impact circulation to the NAC and overlying breast skin flaps – leading to ischemia and necrosis. The pocket selection with these implants can also impact circulation. Because of stretch and weight of the implant on the overlying breast tissue, the author prefers silicone implants over saline implants as saline leads to greater lower pole stretch, palpability, visibility, and higher revision rates.

Smooth Versus Textured Implants

Not only the size and profile but also the implant shell that makes up a silicone implant can affect the outcome. Silicone implants are available as smooth or textured devices. In the United States, smooth implants are utilized in the vast majority of cases, whereas textured implants predominate in the rest of the world. Smooth implants have several advantages, including a natural mobility and an extremely low risk of wrinkling or palpability. The implants tend to settle at the bottom of the breast pocket and continue to descend with the overlying breast tissue naturally. When performing a mastopexy with the augmentation, the smooth implants can be translocated superiorly taking the tension off the closure and will naturally descend over time back into the newly lifted skin envelope. Due to the laxity of the skin envelopes, surgeons often cite the mobility of the smooth implants as an advantage when there is instability in the overlying breast envelope.

Table 24.4 Implant texture levels

Grade	Method	Brand
4	Polyurethane foam coating	Bristol-Meyers Squibb (removed from US market 1991)
3	Salt-loss processing	Biocell of Allergan
3	Ammonium carbonate processing	Sientra
2	Imprinting process	Siltex of Mentor
1	Nanotexturing	Motiva

Textured implants have more stability in the breast pocket. Whereas it has been proposed that adherence of the implant is necessary for stability, it appears that frictional coefficient alone created by the texture provides significant stability [23]. In cosmetic procedures, even the most aggressively textured device rarely actually achieves adherence and depends mostly on friction for its stability. It is important to understand each of the textures and what impact these implants might have on the result. Implant texturization can be considered in gradients 1–4, with the most aggressively textured implants being a 4, such as polyurethane foam (Table 24.4). Grade 3 texture is seen in salt-loss processing (such as the Biocell implant) or with the ammonium carbonate processing (Sientra), Grade 2 with implant imprinting process (Siltex of Mentor), and Grade 1 with nanotexturing (such as the Motiva) and a smooth implant [24] (Fig. 24.5).

The more aggressive the texture, in general, the more stable the implant. In the author's opinion, textured implants can significantly improve the quality of results in many augmentation mastopexy patients. The stability translates to less lower pole stretch deformity over time. Textured implants allow not only for placement of round implants but also the possibility of using an anatomically shaped implant. The textured devices, when placed subglandular or subfascial, have been correlated with a lower capsular contracture rate compared to smooth devices [25, 26]. This can liberalize the use of many different pockets in selected patients.

When selecting between a smooth and textured device, the challenge is in trying to determine the optimal implant for each patient while minimizing unwanted sequelae. In the author's experience, textured devices can provide excellent stability in an otherwise unstable breast envelope. Patients with sloping chest walls are ideal for textured devices as the

Process	Polyurethane foam	Salt Loss (Biocell/ Eurosilicone)	Vulcanisation	Salt Loss (Nagotex)	Imprinting	Smooth/Nano
Surface Area	High	Intermediate	Intermediate	Low	Low	Minimal
Roughness	High	Intermediate	Low	Low	Low	Minimal
SURFACE TYPE	4	3	3	2	2	1

Fig. 24.5 Implant surface classification relating manufacturing method, surface area, and surface roughness [24]

texture stabilizes the implant and minimizes migration, especially lateral slip of the implant into the axilla. Patients with firm parenchyma and good soft tissue coverage are ideal for a textured implant. When the laxity is too great, as in a weight loss patient, it can be challenging to stabilize the skin envelope adequately over the textured implants. There is an increased risk of waterfall deformity when textured implants are placed under very lax skin envelopes, and the benefits of stability have to be weighed against this possibility (Fig. 24.6).

Textured implants are more likely to wrinkle compared to a smooth silicone implant. When the skin envelope is thin and wrinkling is a possibility postoperatively, a smooth device may prove advantageous. The newer, more cohesive implants with optimal fills have significantly decreased the amount of wrinkling seen; thus the difference between smooth and textured as it relates to wrinkling may be more theoretical than reality.

However, this discussion of textured implants is predicated on their safe and widespread use which has been significantly impacted by concerns over BIA-ALCL, which are addressed elsewhere in this book. Other concerns, including double capsule formation and late seromas, will have to be evaluated with emerging evidence for less textured devices as well [27–29]. The advantages of the textured device in any clinical situation must therefore be weighed against the possibilities of these unfortunate sequelae and the possibilities discussed openly and frankly as part of the consent process.

Bioresorbable Scaffold

One way we are trying to create a textured environment in lieu of textured devices is to use smooth implants supplemented with surgical scaffolds to support the soft tissue. The use of bioresorbable scaffolds using poly-4-hydroxybutyrate (P4HB) or polydioxanone (PDS) concomitantly with a smooth implant can give or mimic the stability of a texture implant as it becomes incorporated with the surrounding soft tissue.

Shaped Implants

Shaped implants can provide advantages in certain types of patients and may be appropriate in an augmentation masto-

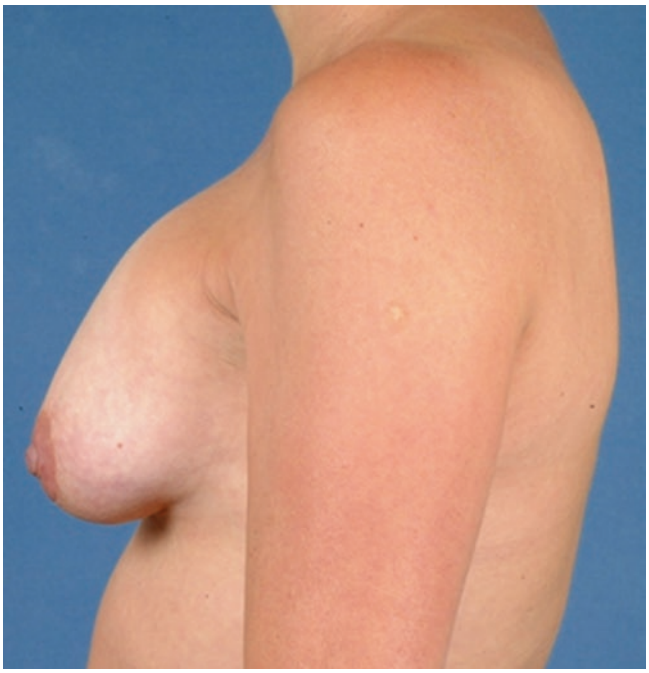

Fig. 24.6 Waterfall deformity

pexy. Of course, all shaped implants are textured so the advantages and disadvantages of textured devices apply when considering a shaped device.

There are many varieties of shaped devices, and all manufacturers have a matrix of choices available to accommodate different shaped breasts and chest walls. Shaped implants in general create a more natural sloping upper pole with a lower point of maximal projection with more volume distributed in the lower pole. Due to the increased cohesiveness of the gel, however, the upper pole volume is more stable compared to other implants. An implant that is taller than it is wide can provide a nice volume distribution for a long-chested patient with a low breast footprint without over augmenting the breast. A patient with a high footprint or a very wide base width can benefit from a shaped implant that is wider than it is tall, allowing improved cleavage without over-augmenting the breast and/or upper poles of the breast.

Shaped implants are uniquely beneficial when performing an augmentation mastopexy on patients with constricted breast or tuberous breast deformities. These augmentations are often performed in conjunction with a circumareolar mastopexy to optimize results. The shaped implant provides a point of maximal projection lower than a round implant allowing improved expansion and nipple positioning with the augmentation. The increased cohesiveness of the gel and the texturization of the implant provide stability that tends to improve the expansion of the lower pole and allows the implant to shape the breast rather than the tight breast tissue distorting the implant.

Additional Implant Characteristics

Silicone implants have continued to evolve over the last few years, providing enhanced choices for the surgeon. The performance of an implant is multifactorial and dependent on many features. The design of the implant, the shell, the gel cohesiveness, the gel-to-shell fill ratio, the gel cohesiveness, and the gel-to-shell interaction all affect the ultimate performance of the implant in-vivo [13, 14]. Silicone implants are now available as fourth-generation and fifth-generation devices, based on the cohesiveness of the gel within the implant. All shaped devices are fifth-generation devices. Round implants can either be fourth generation, such as the Allergan Natrelle or Mentor MemoryGel implants, or fifth generation, such as the Sientra HSC and HSC+ or Allergan Soft touch and Cohesive implants. The greater the cohesiveness, the more stable the gel is within the device [14]. This can impact the appearance of the upper pole, stabilizing the sloping look of a shaped device or the rounded look of a round device. The fourth-generation gels will provide less stability in the implant shape, leading to a more natural upper pole or even failure to maintain the volume in the upper pole over time.

An additional feature has been to increase the gel-to-shell volume ratio, optimizing the fill of the implants. This can create a more stable volume in the upper pole as well, in addition to potentially reducing the amount of wrinkling seen with any given implant. All manufacturers have developed and offer implants with optimal fill ratios. In the augmentation mastopexy patients with more lax, thinner skin, the optimally filled implants have provided a much more predictable result with less upper pole failure and wrinkling of the implant.

Pocket Selection

Pocket selection for the augmentation mastopexy is often one of the most overlooked aspects and may have the greatest impact on the final results. The pocket choices include the submuscular, subfascial, and subglandular (Figs. 24.7, 24.8, and 24.9). The dual-plane submuscular pocket is by far the most common implant pocket utilized.

The dual-plane submuscular pocket is preferred if the upper pole pinch test is less than 2 cm in order to avoid upper pole implant visibility and wrinkling (Fig. 24.10). The dual-plane pocket also allows for submuscular upper pole coverage while the subglandular lower pole allows for greater expansion inferiorly [27]. Interestingly, the tighter or looser the lower pole, the greater the level of dual plane needed. The constricted, lower pole breast requires greater dual plane, level 2 or 3, to allow for maximal expansion of the tight lower pole (Figs. 24.11 and 24.12).

Muscle in the lower pole would limit the amount of expansion possible in this tight tissue envelope. The additional parenchymal exposure with the dual planes allows for

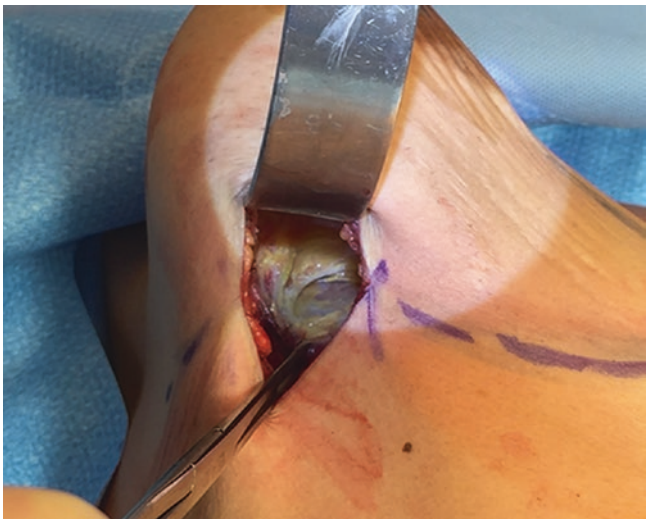

Fig. 24.7 Subglandular pocket creation noting the breast tissue being lifted off the pectoralis major muscle

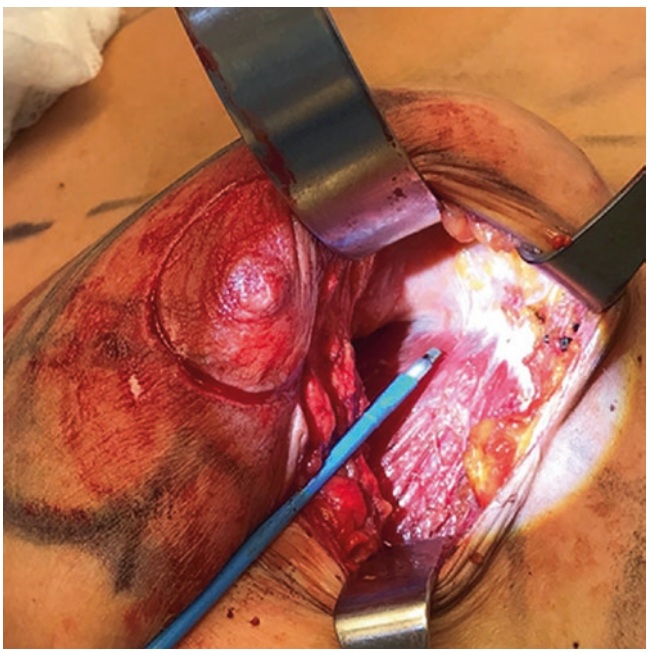

Fig. 24.8 Subfascial pocket creation. Note the elevation of the fascia off of the underlying pectoralis major muscle

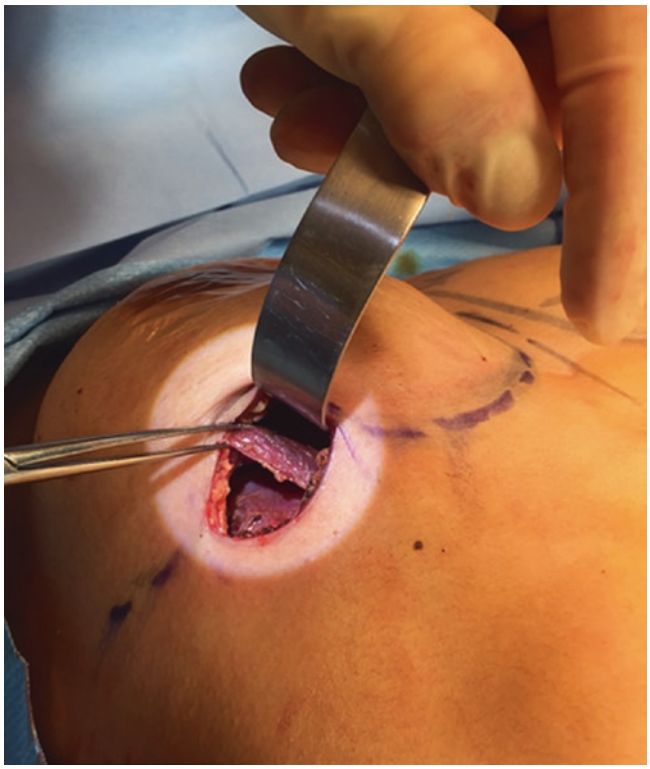

Fig. 24.9 Submuscular pocket creation. Note the elevated lateral border of the pectoralis major muscle with underlying ribcage

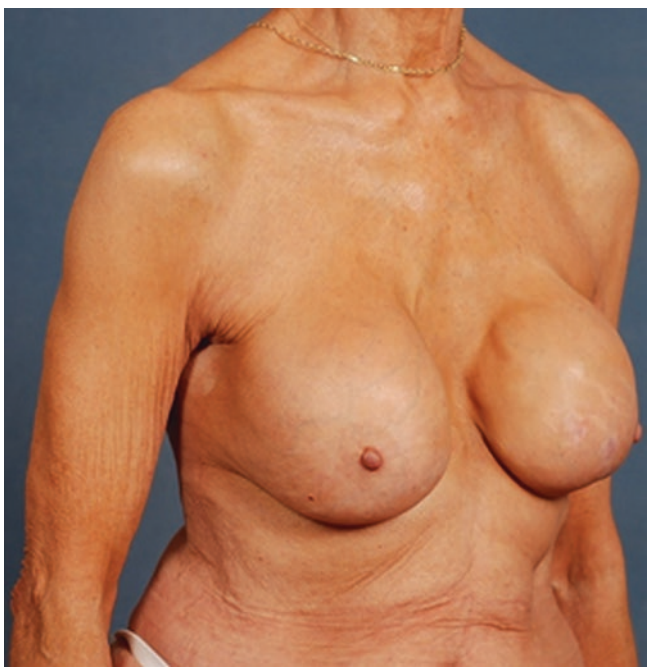

Fig. 24.10 Patient shown with upper pole visibility and wrinkling

parenchymal expansion techniques such as radial scoring. The very lax, loose breast also requires greater expansion for correction. Whereas one might think this is not necessarily due to the overlying mastopexy that is capable of tightening the tissue over the implant, the very lax breast even after a mastopexy will often fall off of the under expanded lower pole and implant, leading to a waterfall deformity. The ability of the implant to have some influence over the overlying breast tissue is an important and yet often misunderstood concept for achieving long-term success in augmentation mastopexy. The most lax and thin breast envelopes, such as the weight loss patients, require the lifting effect of the implant with lower pole expansion to avoid a waterfall deformity with time.

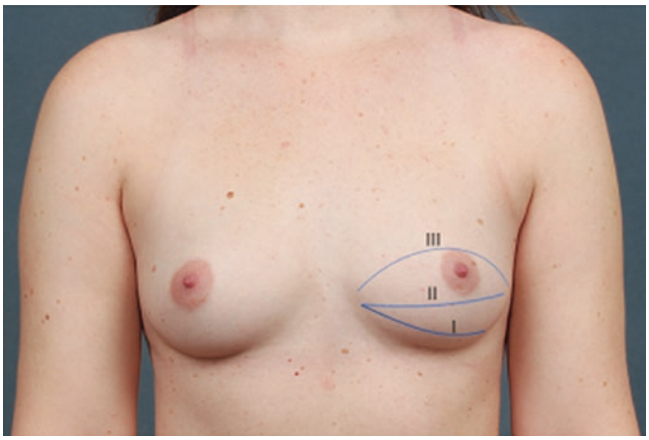

Fig. 24.11 Dual-plane levels shown based on the level of the release of the breast tissue. Dual-plane 1 is release of the pectoralis off the inferior costal attachments seen with all submuscular augmentations. Dual-plane 2 is release of the breast tissue off the pectoralis muscle to just below the NAC. A dual-plane 3 is release of the breast tissue to above the NAC

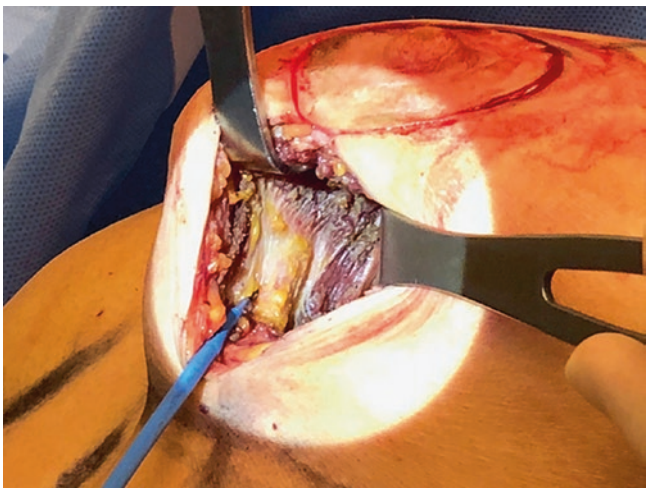

Fig. 24.12 Creation of a dual plane with release of the breast tissue off the underlying cut edge of the pectoralis muscle

A subfascial pocket is possible if the upper pole pinch is 2 cm or greater. In the authors' opinion, the subglandular pocket should be reserved for those with upper pole pinch of 3 cm or greater. These are guidelines and many other factors contribute to pocket decisions, including not only the thickness of the soft tissue coverage, but also the quality of the tissue. Additionally, the implant decision impacts the appropriateness of placing the implant above the muscle. There is good evidence that when a subglandular/subfascial pocket is utilized, a textured device has a lower capsular contracture rate compared to a smooth implant [26]. Likewise, the size of the implant can impact the development of a stretch deformity when placed without muscular support [30]. Finally, implants placed above the muscle have less coverage in the upper pole compared to submuscular implants. Thus, when above the muscle, implants with greater cohesiveness, optimal fills, and possible texture provide a more optimal implant for limiting lower pole stretch over time and maintaining upper pole volume.

Conclusion

When determining the appropriate procedure for a patient, their overall breast goals are very important. There are both common and uncommon complications of augmentation mastopexy that can be mitigated by careful operative planning and management of patient expectations. The treatment for breast ptosis and loss of volume often requires two key procedures: a mastopexy and an augmentation. While most patients are candidates for a simultaneous augmentation mastopexy, some may need a staged procedure. When the upper pole volume of the breast after a mastopexy alone is still deficient even though the shape and contour have been improved, the addition of an implant can adequately fill this upper pole deficit. The implant type, pocket location, and mastopexy approached are dictated by a variety of patient factors that must be considered. Knowing which patients are reasonable candidates for a staged versus simultaneous augmentation mastopexy is key to a great outcome with low revision rates in a procedure that is challenging and historically known for higher revision rates. Through an elaboration of our technique, we delineate some key pearls to optimize outcomes while minimizing complications.

Pearls for Success

- Analyze the ptotic breast.
- Determine patient goals for aesthetic appearance of the breast.
- Determine single versus staged augmentation mastopexy.
- Determine mastopexy technique and pedicle choice, most commonly superior or superomedial.
- Avoid large implants to prevent stress on the soft tissue envelope.
- Consider texture when a sloping chest wall is present.
- Use a submuscular pocket if the upper pole pinch test is <2 cm.
- Avoid texture in a massive weight loss patient or with excessive skin laxity to prevent rippling or a waterfall deformity.

Case Examples

Case 1

A 24-year-old female with Grade 3 ptosis (Fig. 24.13). Bilateral augmentation periareolar mastopexy with submuscular smooth round moderate profile 350-cc saline implants filled to 390 cc.

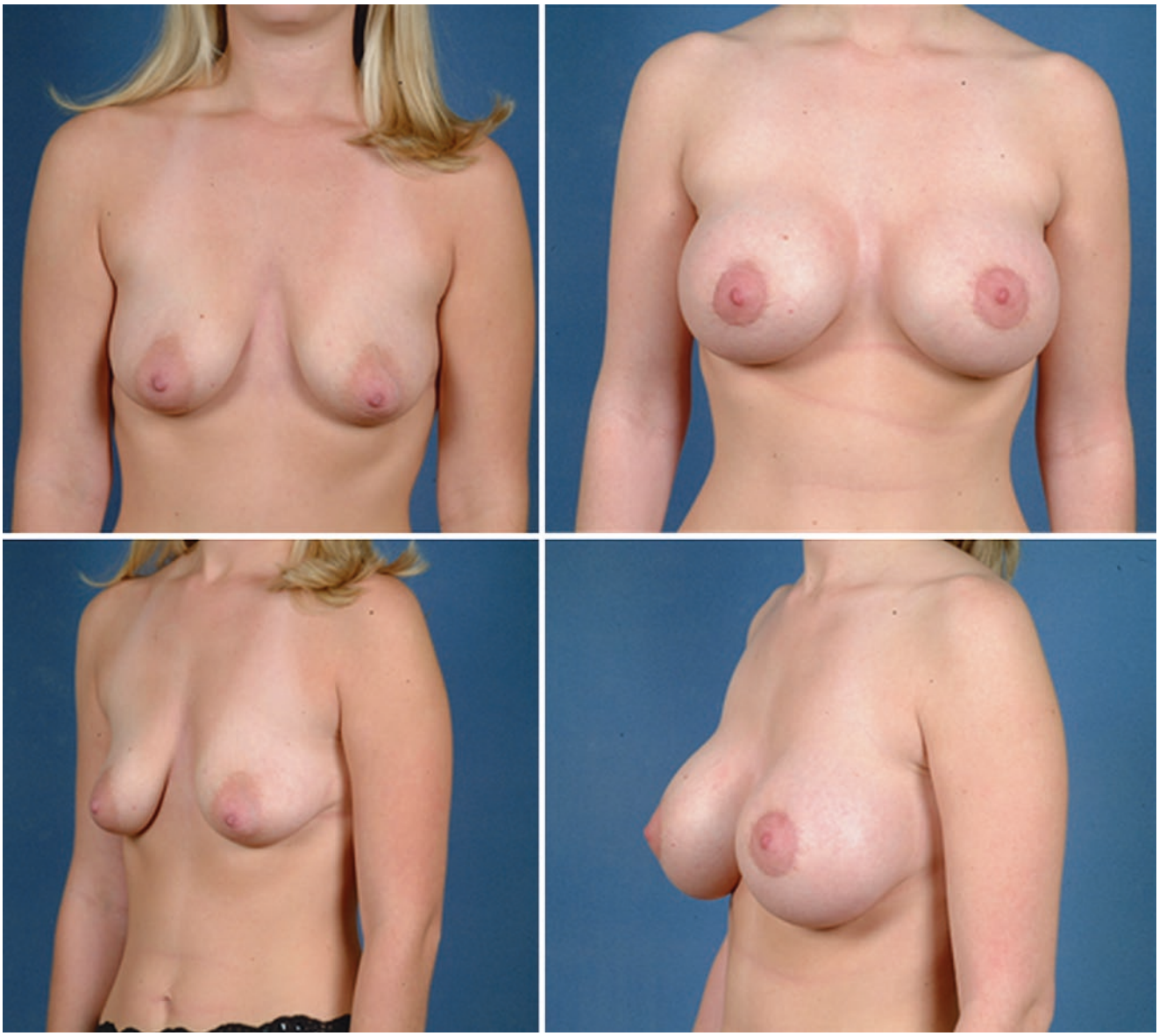

Fig. 24.13 A 24-year-old female with Grade 3 ptosis. Bilateral augmentation periareolar mastopexy with submuscular smooth round moderate profile 350-cc saline implants filled to 390 cc

Case 2

A 21-year-old female with Grade 3 ptosis (Fig. 24.14). Bilateral inverted-T mastopexy with submuscular augmentation with 350-cc high profile textured round silicone implant on the left and 330-cc high profile textured round silicone implant on the right.

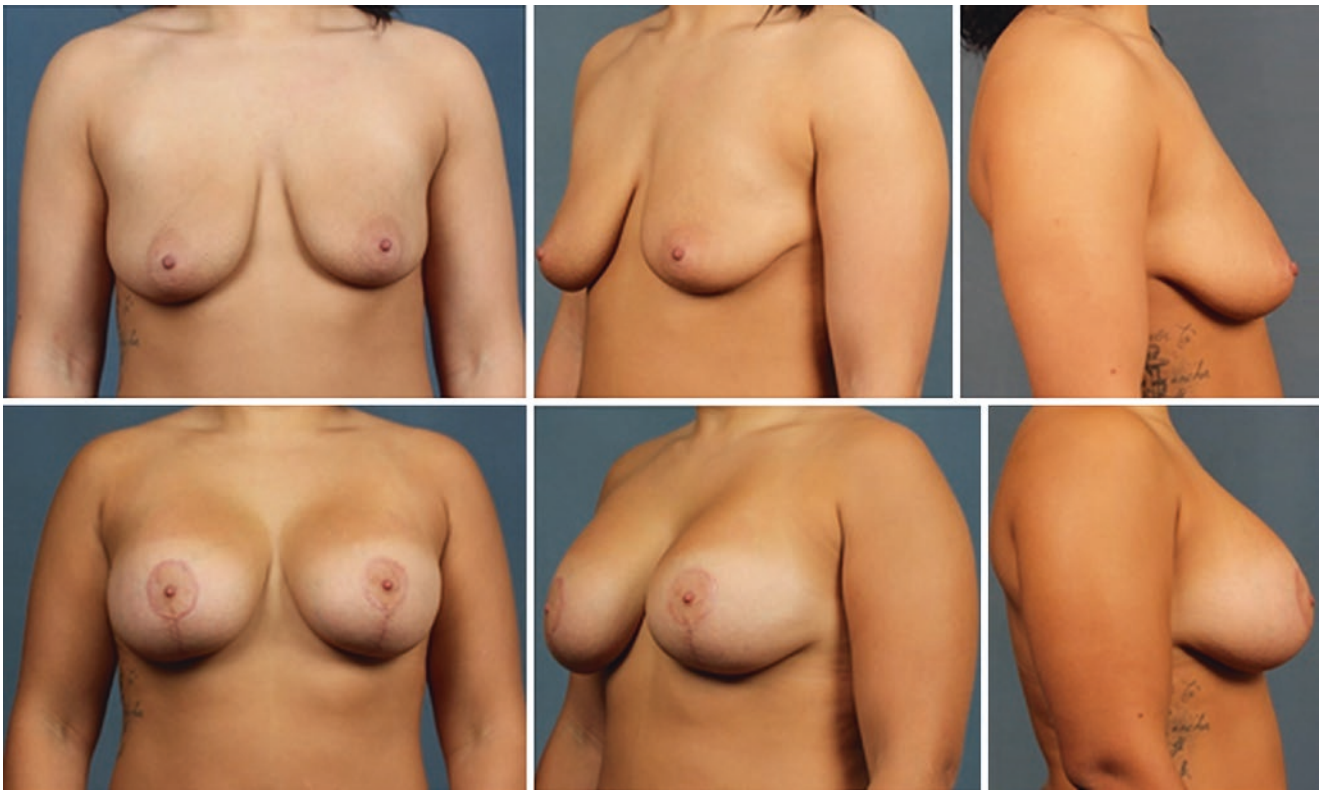

Fig. 24.14 A 21-year-old female with Grade 3 ptosis. Bilateral inverted-T mastopexy with submuscular augmentation with 350-cc high profile textured round silicone implant on the left and 330-cc high profile texture round silicone implant on the right

Case 3

A 42-year-old female with Grade 3 ptosis after massive weight loss (Fig. 24.15). Bilateral full Wise mastopexy with submuscular augmentation using round smooth moderate plus 400-cc silicone implants.

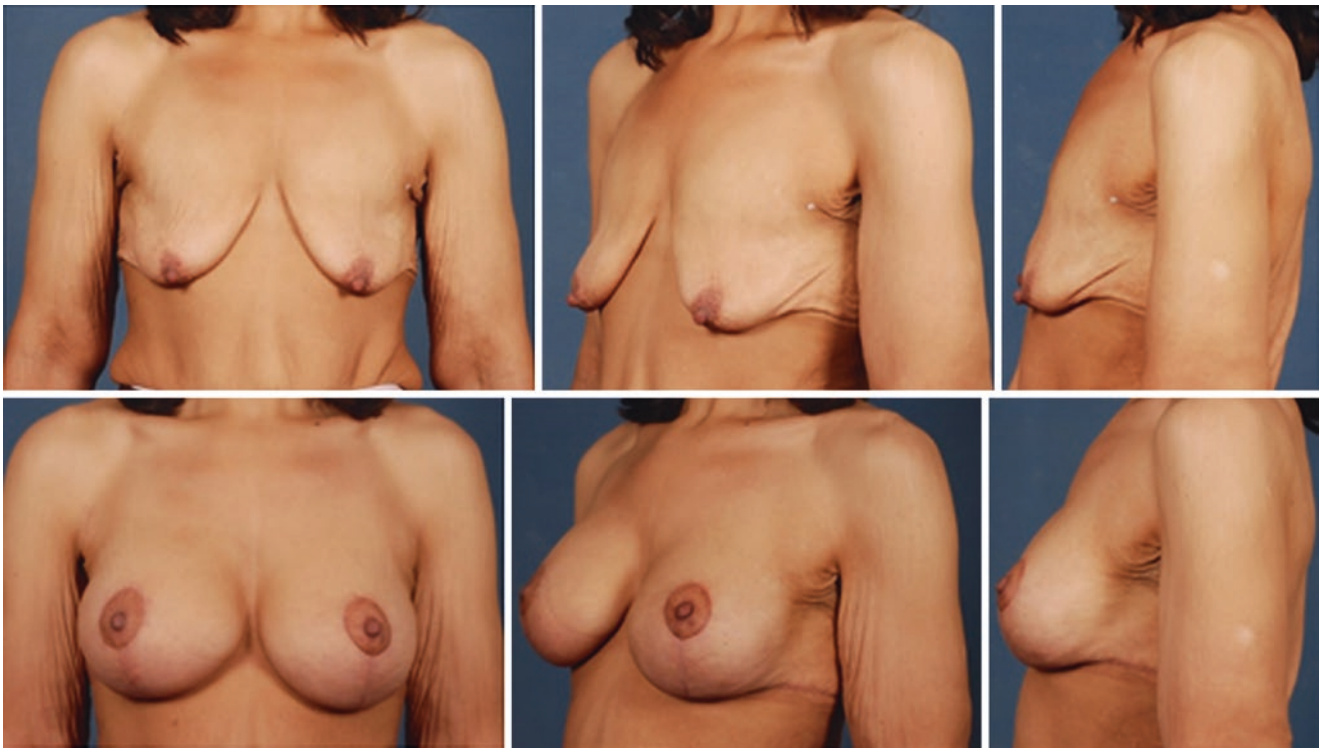

Fig. 24.15 A 42-year-old female with Grade 3 ptosis after massive weight loss. Bilateral full wise mastopexy with submuscular augmentation using round smooth moderate plus 400-cc silicone implants

Case 4

A 30-year-old female with Grade 3 ptosis (Fig. 24.16). Bilateral augmentation periareolar vertical short horizontal mastopexy with 305-cc moderate profile textured round silicone implants.

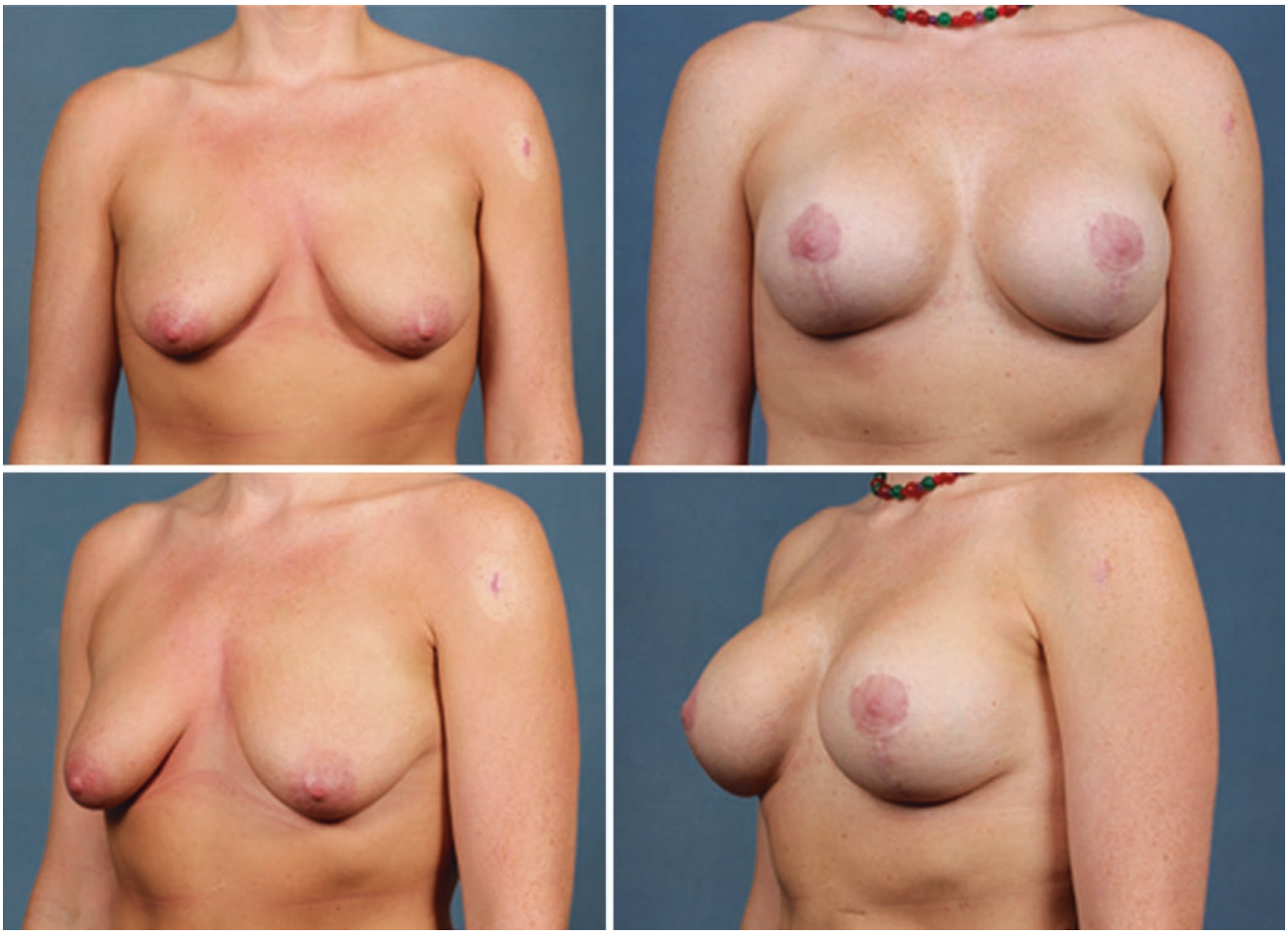

Fig. 24.16 A 30-year-old female with Grade 3 ptosis. Bilateral augmentation periareolar vertical short horizontal mastopexy with 305-cc moderate profile textured round silicone implants

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Minimizing Scars in Mastopexy

25

Hilton Becker and Jeena M. Easow

Introduction

Breast ptosis is a common complaint in women seeking aesthetic breast enhancement. In 2017, mastopexy was the third most commonly performed aesthetic surgical procedure among women in the United States [1]. A main concern for these patients is the resultant scarring. Women will often accept less of a lift in exchange for a smaller scar. Over the past century, several techniques have been employed to reduce scarring ranging from periareolar to vertical techniques; however, classic patterns resulting in more lengthy scars are still popular among surgeons today such as the inverted-T technique that allows for the greatest amount of lift and predictable results [2]. Benelli and Goes addressed the need for parenchymal reshaping through a periareolar incision [3–5]. These techniques broadened their application to larger more ptotic breasts with limited scars. Disadvantages included a steep learning curve associated with creating the optimal breast shape and projection. Although great strides have been made by limiting the incision to around the areola in cases of moderate breast ptosis, recurrent widening of the scar and flattening of the areola are undesired sequelae.

Patient Selection

Patients will often request a smaller scar pattern; however, careful patient selection is key in achieving expected results [6]. The shortest scar may not yield the best result. Patient factors include skin laxity, parenchyma volume, degree of nipple-areolar complex elevation needed, history of prior surgeries, scarring, and overall expectations [7]. Surgeon factors include experience and technical ability. The ideal patient will have normal breast parenchyma volume with a minimal to moderate excess of skin. Alternatively a patient with minimal glandular mass and ptosis should be considered for an augmentation-mastopexy. A patient with an excess of breast parenchyma and ptosis should be considered for a reduction mammoplasty.

Methods

Subareolar Mastopexy Technique

The authors' preferred technique is a subareaolar mastopexy (Figs. 25.1 and 25.2 and Video 25.1) [8]. The patient is marked in the standing position. The amount of skin to be excised is estimated by using the pinch test, and this skin is outlined around the existing areola; most, if not all, of the areola is maintained. The areola contracts when it is partially elevated, and it is preferable to have the areola skin bunch up, rather than be sutured under tension. The marked excess periareolar skin is removed by deepithelialization, and the areola is elevated approximately 20–50% of its surface area. The dermis is then incised circumferentially and partially undermined. If augmentation with implant will be performed, the pocket is created through this incision. The prepectoral space can also be entered through this incision for internal plication or mesh insertion. Cautery can be applied to the dermis to increase contraction and adherence. Several permanent braided purse-string sutures are used for the

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H. Becker (✉)
Boca Raton Regional Hospital, Hilton Becker MD, Clinic of Plastic Surgery, Boca Raton, FL, USA
e-mail: Hilton@beckermd.com

J. M. Easow
University of Miami/Jackson Memorial Hospital, Division of Plastic, Aesthetic and Reconstructive Surgery, Miami, FL, USA

DeWitt Daughtry Family Department of Surgery, University of Miami, Leonard M. Miller School of Medicine, Miami, FL, USA

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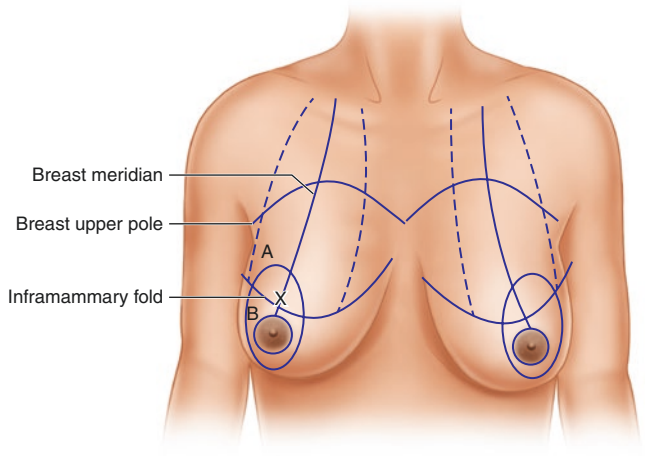

Fig. 25.1 Patient with bilateral ptosis. Preoperative markings. Patient is marked in the supine position. Midline, breast meridian, inframammary fold, and breast upper pole are marked. The nipple-areolar complex (**b**) is marked, and the inframammary fold is transposed onto the breast mound (X); the new height of the nipple-areolar complex (**a**) is determined from this point. Dotted lines are marked medial and lateral to the breast meridian to depict the location of suture placement to resuspend the breast parenchyma at the level of the clavicle

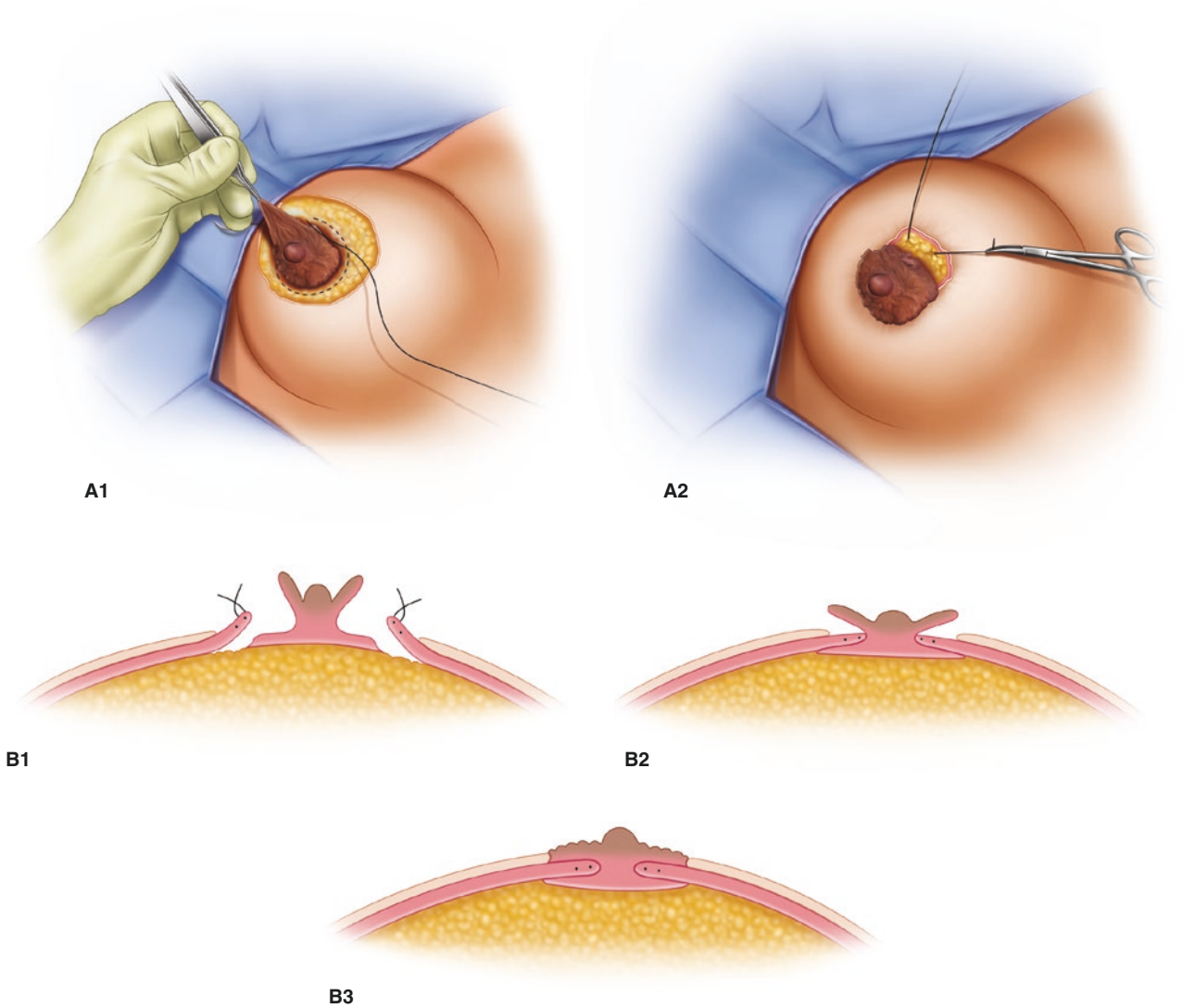

Fig. 25.2 (**a1**) The areola is partially undermined, the first purse-string suture placed. (**a2**) Second purse-string suture placed. (**B**) Cross-sectional diagram of the procedure. (**b1**) Areola raised. Dermal flaps to be advanced beneath the areola. Alternately, the dermal flap can be plicated. (**b2**) Two purse-string sutures placed. Tension taken up by the dermal flaps. (**b3**) Areola flap sutured back in position tension-free

subareolar closure. A 3-0 Nurolon (Ethicon, Inc., Somerville, NJ) purse string suture is placed along the dermal flap edge and tied to recreate the desired nipple size. The surgeon's finger is placed in the center of the areola when the purse string sutures are synched to avoid constriction of the blood supply. The first purse-string suture is under the most tension, while the subsequent 2–3 purse-string rows are placed with less tension. These tension-free rows allow the suture to be integrated and fixed within the tissues. The skin now has a tension-free closure with a 5-0 Monocryl (Ethicon, Inc., Somerville, NJ) in a running subcuticular fashion (Fig. 25.3).

For further lift or elevation, internal suspension can be performed. The dermis is incised circumferentially, and the total anterior flap undermined. The breast parenchyma is plicated with sutures and anchored to the pectoral fascia inferior to the clavicle (Figs. 25.4 and 25.5). The gland can be cauterized to help encourage contraction. The inferior glandular flap can be incised and overlapped. A breast implant can be inserted in the submuscular or subfascial pocket as needed for superior pole fullness. A mesh can be added inferiorly for additional support. Postoperatively the breast is maintained in an elevated position using postoperative garments to facilitate adhesion of the undermined skin flap.

Discussion

Mastopexy techniques overall achieve high patient satisfaction with low complication rates [9]. The inverted-T technique is the most utilized technique for patients with moderate to severe ptosis. The major disadvantages are its incisions resulting in large scars. Periareolar techniques are best suited for patients with mild to moderate ptosis. Its main advantage is a camouflaged skin incision. Disadvantages include limited nipple elevation and breast projection as compared to other techniques. The major disadvantage of the traditional circumareolar mastopexy is the risk of hypertrophic scarring because of excessive tension at the areolar edge or widening of the areola as a result of suture failure. Scar widening is related to the tension placed on each side of the incision. A single permanent suture is ineffective in preventing stretch since it is prone to cut through tissues until there is no longer any tension. An alternative method to reduce the tension on the skin edges in a circumareolar incision is to partially elevate the areola as a myocutaneous flap and plicate the dermal base with several nonabsorbable sutures, thus eliminating tension on the areolar skin. Satisfactory results are achieved with few complications, including less areolar stretching and improved nipple areolar projection (Fig. 25.6) [8]. The degree of ptosis correction is not as significant as that achieved with a vertical limb or anchor mastopexy; however, in the ideal patient with limited to moderate ptosis and without large skin excess, this technique offers excellent results for patients desiring to limit their scars.

Conclusion

Periareolar scars can be a source of frequent dissatisfaction after mastopexy or reductions. The authors delineated a novel technique to minimize such scars while maintaining optimal nipple aesthetics.

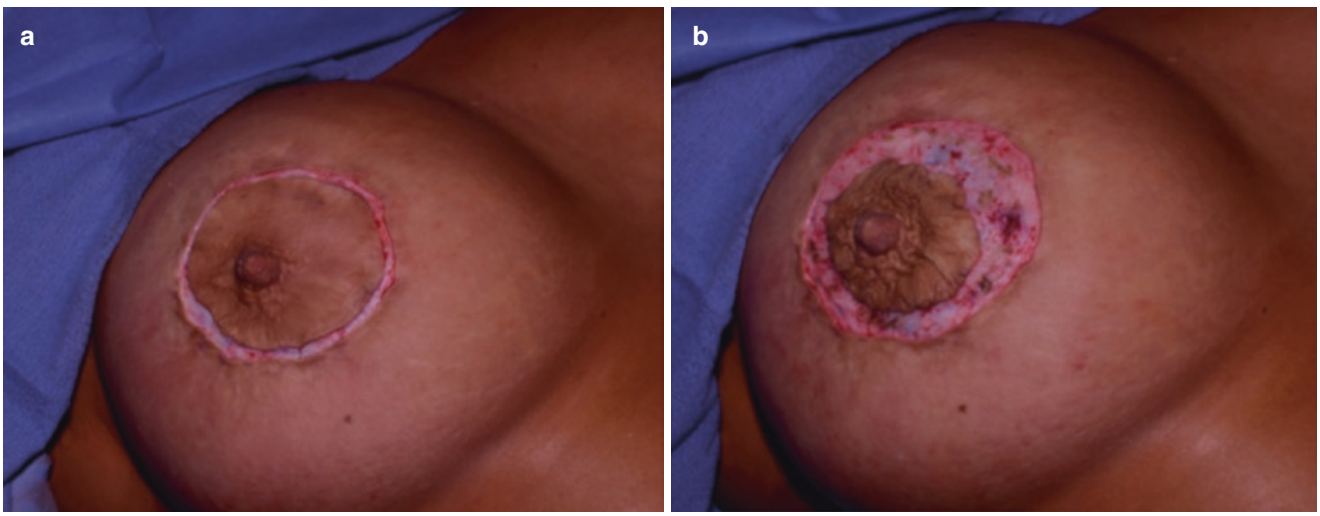

Fig. 25.3 Intraoperative photos of a subareolar mastopexy: (**a**) Circumareolar incision, preserving the entire nipple-areolar complex. (**b**) The excess skin edge is deepithelialized. (**c**) The dermal edge is incised. (**d**)The dermal layer is closed: (**e**) first deep dermal purse-string suture, (**f**) second purse-string suture placed, (**g**) dermal edge to NAC, (**h**) final skin closure

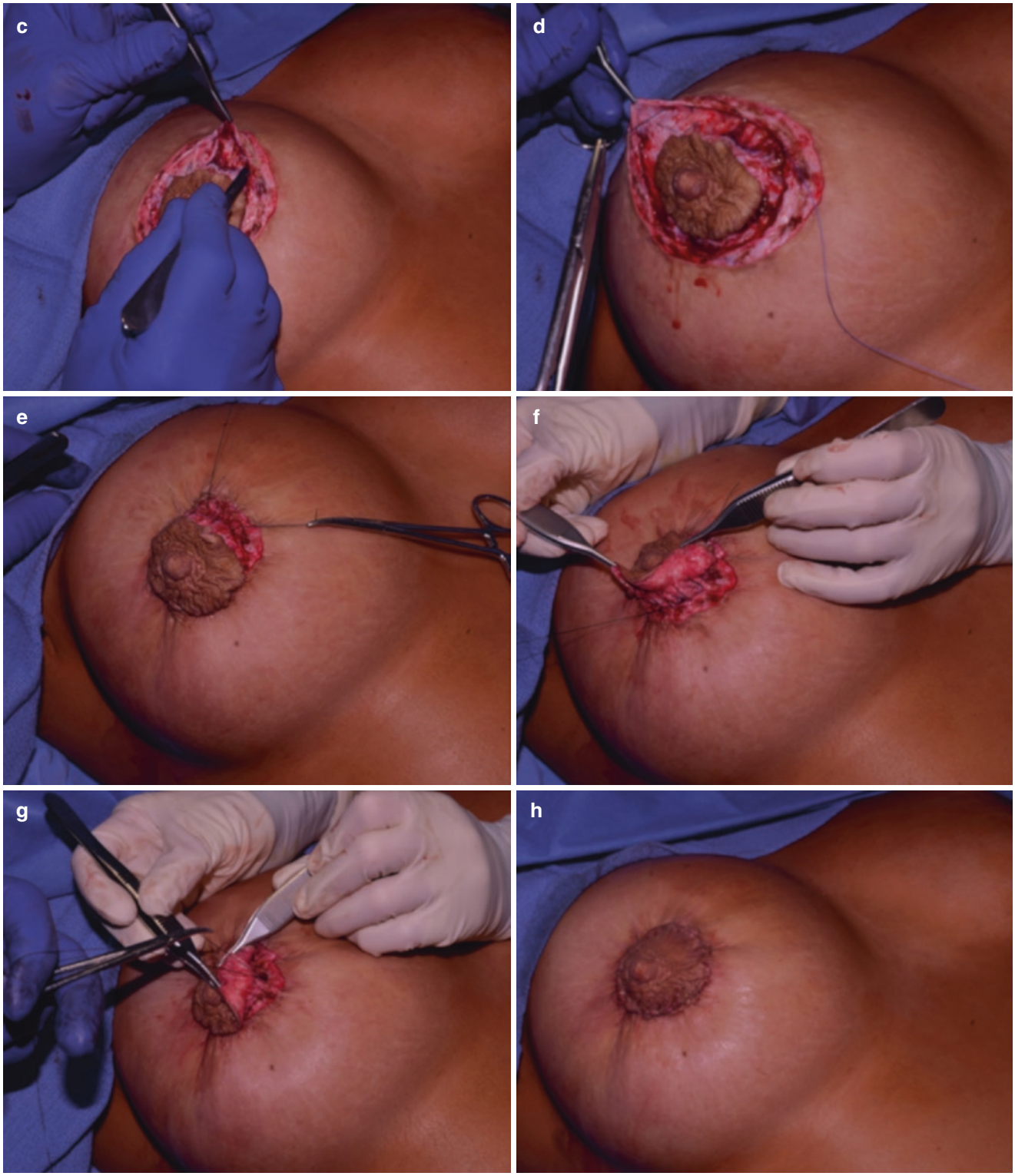

Fig. 25.3 (continued)

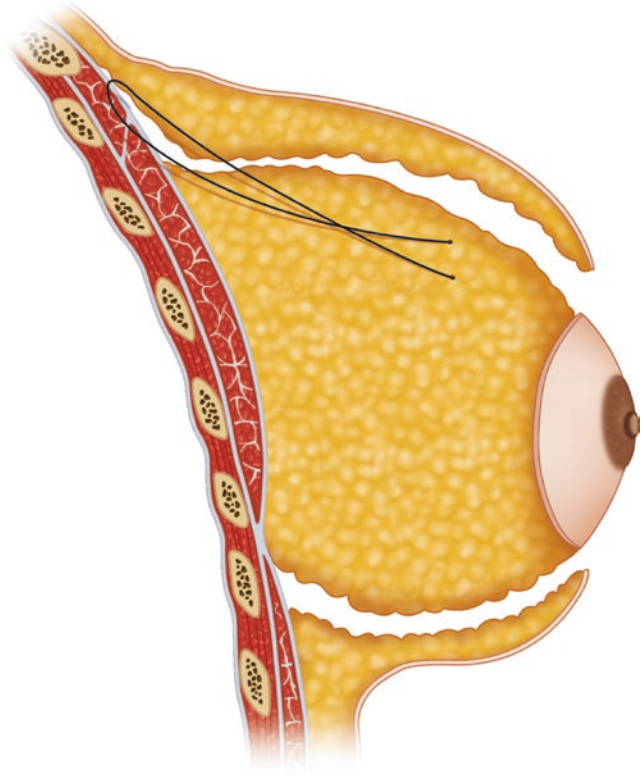

Fig. 25.4 Superior and inferior flaps elevated. Upper glandular tissue placated to pectoral muscle

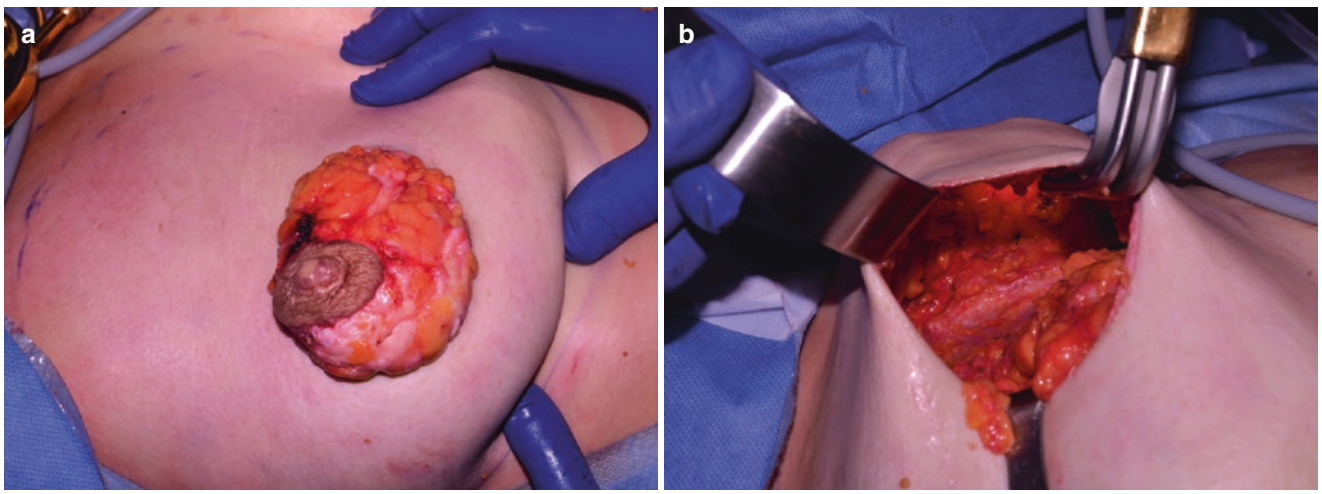

Fig. 25.5 Intraoperative photos of a subareolar mastopexy: (**a**) Through a circumareolar incision, the flap is raised the level of the clavicle. (**b**) Elevation of breast mound. The superficial breast flap is elevated. The parenchyma is cauterized to help with upward contraction. Three tacking sutures are placed from the superior breast mound to the prepectoral fascia at the level of the clavicle

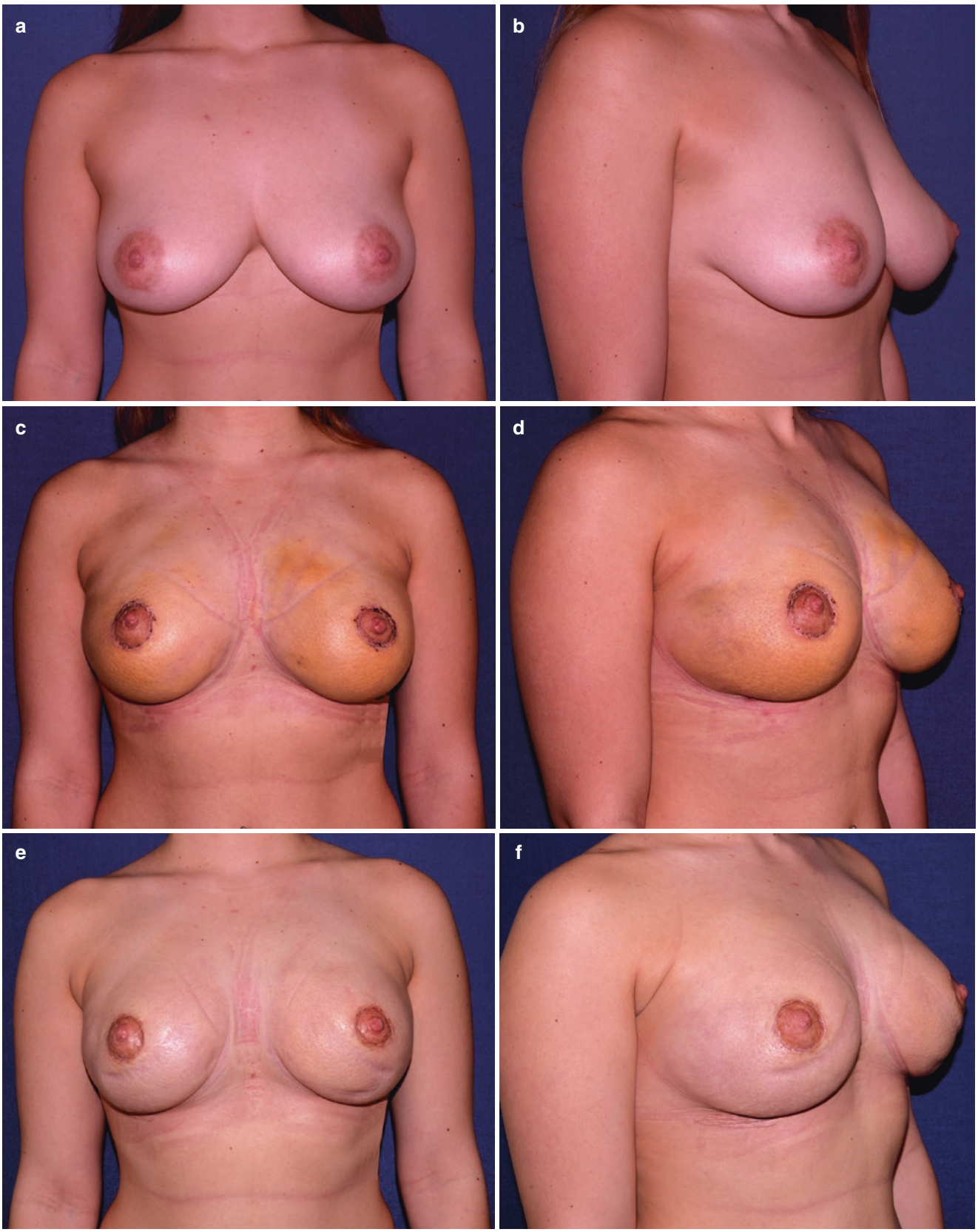

Fig. 25.6 (**a**, **b**) Preoperative photos. (**c**, **d**) One week postoperatively. (**e**, **f**) Four weeks postoperatively

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