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Atlas of Breast Surgery

Second Edition

Springer

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Dedicated to: Atifah, Isak, Fatima, Umar, Hanaa, Ibrahim, Yacoob

Ismail Jatoi

This Atlas is dedicated to my adoptive parents, George and Elsie

John Benson

To my amazing wife Seena, who always supports and inspires me

Hani Sbitany

Preface to Atlas

The first edition of the *Atlas of Breast Surgery*, edited by Professors Ismail Jatoi, Manfred Kaufmann, and Jean-Yves Petit, was published by Springer in 2006. Since then, there have been important advances in breast surgical techniques, particularly in oncoplastic surgery and breast reconstruction techniques. This second edition of the *Atlas of Breast Surgery* includes many new illustrations with important updates on innovations in surgical techniques. Professors John Benson (Cambridge, UK) and Hani Sbitany (New York, USA) agreed to take on co-editorship of the atlas following the retirements of Professors Manfred Kaufmann and Jean-Yves Petit. In the second edition, many of the illustrations from the previous atlas have been preserved, with new illustrations to highlight important advances in surgical techniques since publication of the first edition. This atlas is intended as a guide for surgeons throughout the world who treat diseases of the breast, both benign and malignant.

The management of breast cancer has become increasingly complex over the past few years with sub-specialization in breast surgery being driven by a rising incidence of breast cancer, the development of oncoplastic techniques, and heightened patient expectations in terms of treatment and outcomes. The modern breast surgeon must acquire a spectrum of expertise covering oncology, radiology, and breast surgery as well as possessing an understanding of relevant surgical principles and practice of plastic surgery. Increasing utilization of neoadjuvant chemotherapy (NACT) to downstage locally advanced and phenotype appropriate disease has permitted more successful rates of breast conservation surgery although many women opt for "maximal surgery" and may request bilateral mastectomy for a unilateral cancer otherwise suited to breast conservation. The past two decades have witnessed increased demand for immediate or delayed whole breast reconstruction and the evolution of oncoplastic techniques that permit partial breast reconstruction using either volume replacement or displacement techniques. The challenge of oncoplastic surgery is to reconcile oncologic and aesthetic aims to optimize patient outcomes – patients should have access to a full repertoire of reconstructive techniques with choice of surgery based on patient need rather than surgeon preference. Skin-sparing mastectomy techniques have been widely adopted to improve cosmetic outcomes following reconstruction with nipple-sparing techniques, a further development in the conservative mastectomy approach. Nipple-sparing mastectomy can further enhance aesthetic outcomes but preservation of the nipple-areola complex (NAC) is of unproven safety and should be selectively applied for smaller unifocal cancers sited away from the NAC or as a prophylactic procedure. The introduction of acellular dermal matrices and synthetic meshes for implant-based reconstruction has significantly broadened indications for breast reconstruction and spurred a revival of pre-pectoral techniques in conjunction with nipple-sparing mastectomy. These new advancements in pre-pectoral breast reconstruction have allowed women to undergo less invasive techniques for whole breast reconstruction and improved patient satisfaction and quality of life.

With the advent of sentinel lymph node (SLN) biopsy there has been a significant de-escalation of axillary surgery both as a staging and therapeutic procedure. Not only is axillary lymph node dissection no longer indicated for SLN biopsy negative patients, but this procedure is increasingly omitted for selected SLN biopsy positive patients. Efforts are currently focused on which patients can avoid any form of axillary surgical staging and whether core biopsy-proven node positive patients who become clinically node negative after NACT can safely undergo SLN biopsy rather than being committed to a formal lymph node dissection.

Patients are increasingly well informed about treatment options and widespread use of social media, and existence of online blogs/communities has increased patients' knowledge and expectations of outcomes. Surgeons must engage more in shared decision-making processes and be prepared for further surgical intervention for late complications or aesthetic adjustments.

This atlas describes various surgical techniques and incorporates both science and art into a unique transatlantic perspective for treatment of breast disease; the authors are drawn from the United States and Europe and have extensive experience within this field. The management of both benign and malignant disease is outlined with a detailed account of the diagnostic pathway and methods for obtaining definitive pre-operative diagnosis. All sections contain illustrations to demonstrate and clarify surgical and other practical procedures. Particular emphasis is placed on those techniques that consistently provide good cosmetic outcomes.

The completion of this atlas has required the collaborative effort of many individuals. The authors are particularly indebted to the editorial staff of Springer-Verlag whose perseverance has enabled eventual publication of this atlas. We wish to especially thank Ms Aruna Sharma of the Springer-Verlag office in India for her support and patience in this endeavor.

We hope that qualified surgeons and trainees from general, plastic, and gynecology backgrounds will find this atlas a valuable aid in the management of patients with all types of breast disease.

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Contents

1 Historical Overview of Breast Surgery

Contemporary treatment of breast cancer is complex and involves multimodalities such as surgery, radiotherapy, and combinatorial systemic therapies. Despite a rising incidence, mortality rates from breast cancer have declined in many industrial countries with 10 year survival rates of 55% two decades ago compared to current rates exceeding 80%. These improvements are attributable to multidisciplinary management of the disease and introduction of screening programs. The earliest reference to the surgical treatment of breast cancer can perhaps be found in what is now known as the *Edwin Smith Surgical Papyrus*, a series of medical case presentations written in Egypt between 3000 and 2500 B.C. In those writings, it is clearly documented that physicians in ancient Egypt extirpated tumors of the breast. However, there was considerable controversy surrounding the surgical treatment of breast cancer throughout ancient times. Indeed, Hippocrates argued that breast cancer was a systemic disease and that extirpation of the primary tumor made matters worse. In about 400 B.C., he warned, "it is better not to excise hidden cancer, for those who are excised quickly perish; while they who are not excised live longer."

Similarly, Galen believed that breast cancer was a systemic disease and promulgated the "humoral theory" to account for its pathogenesis. Galen proposed that the breast tumor was a coagulum of black bile. He postulated that a woman's monthly menstrual flow relieved her of excess black bile and that this accounted for the increased incidence of breast cancer among postmenopausal women. Yet, Galen strongly advocated surgery for the treatment of breast cancer. He urged surgeons to "excise a pathologic tumor in a circle in the region where it borders on the healing tissue." However, Galen's disciples often resorted to nonsurgical treatments, including special diets, purgation, venesection, and leaching. All were considered effective in getting rid of excess bile and therefore acceptable options for the treatment of breast cancer.

In the eighteenth and nineteenth centuries, several surgeons promulgated a more aggressive surgical approach to the treatment of breast cancer (Fig. 1.1). Jean Louis Petit (1674–1750), Director of the French Surgical Academy, is credited with developing the first unified concept for the surgical treatment of breast cancer. In his writings, published 24 years after his death, Petit suggests that "…the roots of cancer were the enlarged lymphatic glands; that the glands should be looked for and removed and that the pectoral fascia and even some fibers of the muscle itself should be dissected away rather than leave any doubtful tissue. The mammary gland too should not be cut into during the operation."

About the same time, the French surgeon Le Dran challenged Galen's humoral theory. In 1757, he proposed that breast cancer was a local lesion that spread through the lymphatics. Thus, Le Dran argued that lymph node dissections should become an integral part of the surgical management of breast cancer. However, his views were not readily accepted. Indeed, Galen's humoral theory remained extremely popular throughout the eighteenth century, and many physicians were reluctant to discard it entirely, preferring instead to simply modify it. For example, the English surgeon John Hunter proposed that breast cancer made its appearance where lymph coagulated, a hypothesis with obvious parallels to Galen's black bile theory. Thus, Hunter and his disciples advocated the removal of enlarged lymph nodes in patients with primary breast cancer.

The modern surgical treatment of breast cancer has its origins in the mid-nineteenth century. During this period, the German pathologist Rudolf Virchow (Fig. 1.2) studied the morbid anatomy of breast cancer. He undertook careful postmortem dissections and postulated that breast cancer arose from epithelial cells and then spread along fascial planes and lymphatic channels. These studies laid the scientific foundation for the surgical treatment of breast cancer from the late nineteenth to the later part of the twentieth century. In contrast to Galen, Virchow did not regard breast cancer as systemic at onset but rather a local disease, amenable to cure with surgery.

I. Jatoi et al., *Atlas of Breast Surgery*, https://doi.org/10.1007/978-3-030-45951-2_1

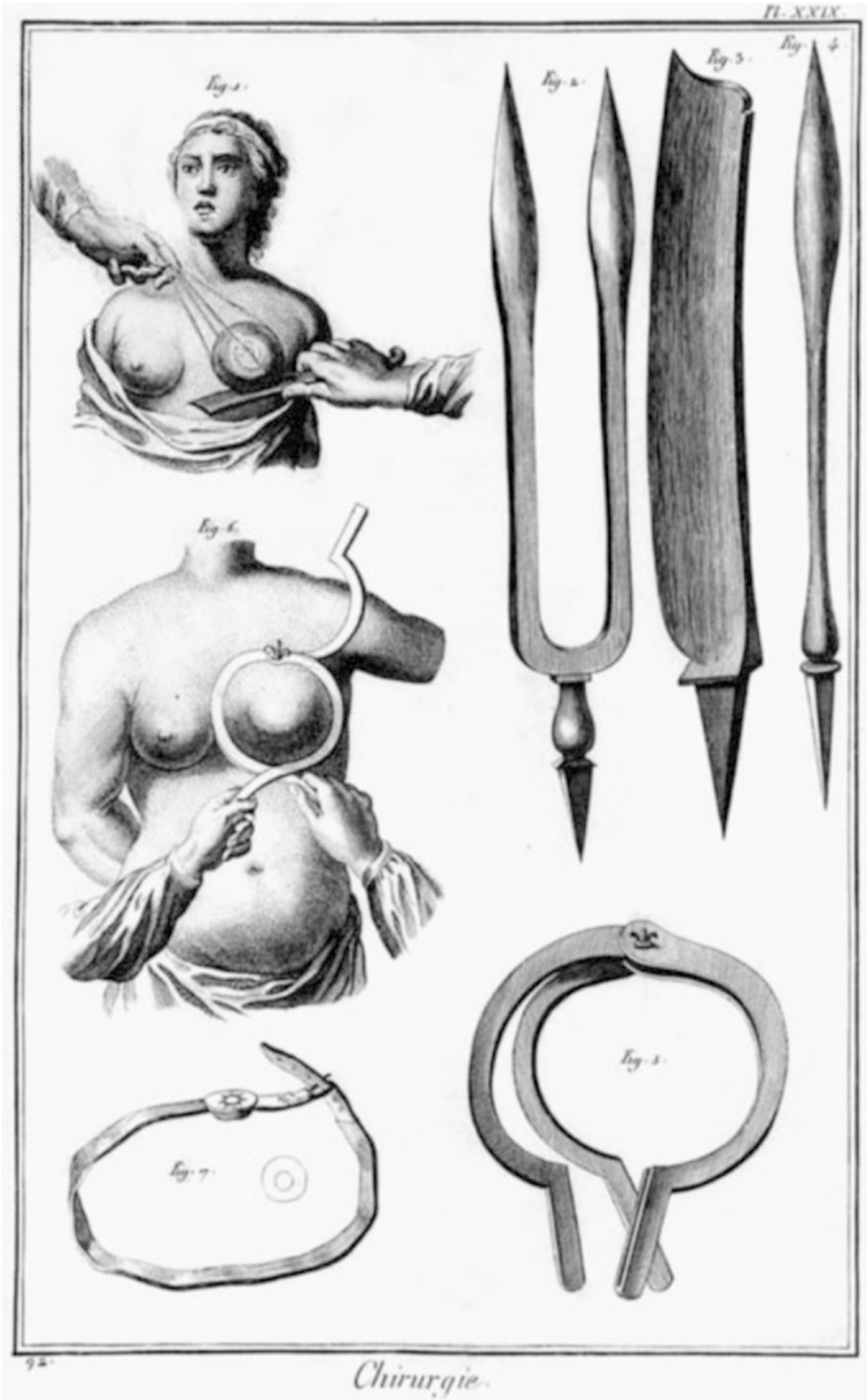


Fig. 1.1 Early instruments used for the removal of the breast and its tumors, as illustrated by Louis-Jacques Goussier, 1722–1792

Virchow's theory had a profound influence on the American surgeon William Halsted, who traveled through Europe in the late nineteenth century and studied with many of Virchow's pupils (Fig. 1.3). If we regard Virchow as the architect of the new cellular theory on breast cancer pathogenesis, then Halsted should be viewed as its engineer (Fig. 1.4). Shortly after returning to the United States, Halsted was appointed to the surgical faculty of the Johns Hopkins Hospital, where he described the radical mastectomy for the treatment of breast cancer. This operation incorporated the tenets of Virchow's hypothesis. Thus, the tumor-containing breast, underlying pectoral muscles, and ipsilateral axillary contents were removed en bloc. In this manner, the lymphatic channels connecting the breast and axillary contents were extirpated, a clear acceptance of the teachings of Virchow, who had argued that cancer spreads along fascial planes and lymphatic channels, and a repudiation of the systemic hypothesis concerning breast cancer pathogenesis.

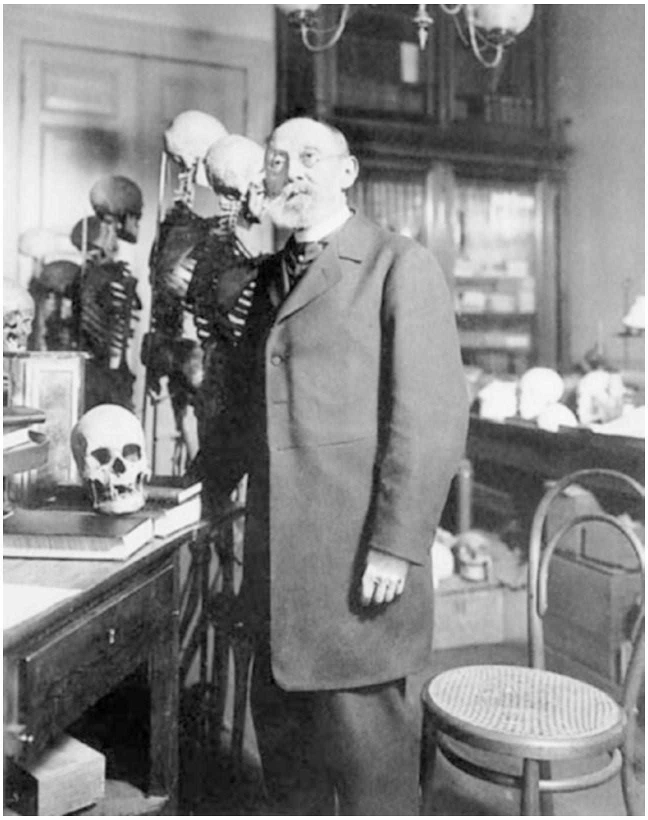
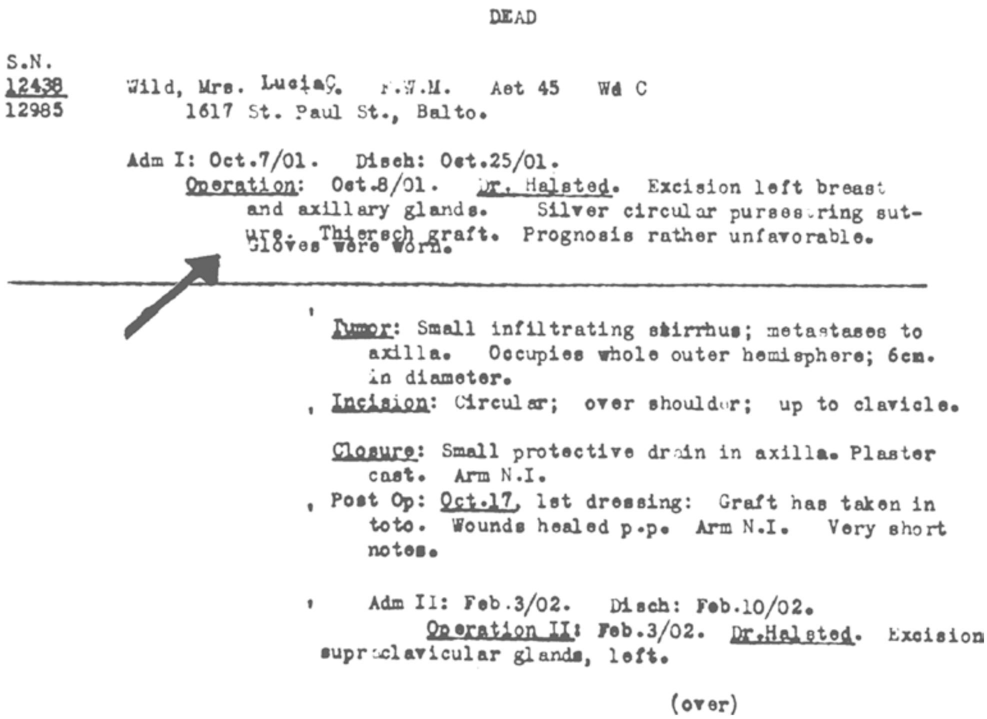


Fig. 1.2 The German pathologist Rudolf Virchow (1821–1902)

By the late nineteenth century, many surgeons throughout the United States and Europe had accepted the Virchow/Halsted paradigm and the operation that incorporated its tenets. The radical mastectomy was very effective in achieving local control of this disease, which, no doubt, contributed to its immense popularity. The transition from Galen's "systemic" paradigm to the Virchow/Halsted "local" paradigm was perhaps best summed up by Keen in a statement to the Cleveland Medical Society in 1894: "There is no question at all in the present day that [breast cancer] is of local origin. In my earlier professional life, it was one of the disputed points constantly coming up in medical society as to whether it was local or from the first a constitutional disease, and whether the latter it was said that no good could come from operating on the breast. But this question of local origin is no longer confronting us. It is a settled thing, a point won, and women must be taught that this brings hope to them".

Fig. 1.3 In this photograph, the American surgeon William Halsted (*center*) is seen with his colleagues in Berlin



DEAD

S.N.
12438 Wild, Mrs. LuciaC. F.W.M. Aet 45 Wd C
12985 1617 St. Paul St., Balto.

Adm I: Oct.7/01. Disch: Oct.25/01.
Operation: Oct.8/01. Dr. Halsted. Excision left breast and axillary glands. Silver circular pursestring suture. Thiersch graft. Prognosis rather unfavorable.
Gloves were worn.

Tumor: Small infiltrating scirrhus; metastases to axilla. Occupies whole outer hemisphere; 6cm. in diameter.
Incision: Circular; over shoulder; up to clavicle.
Closure: Small protective drain in axilla. Plaster cast. Arm N.I.
Post Op: Oct.17, 1st dressing: Graft has taken in toto. Wounds healed p.p. Arm N.I. Very short notes.

Adm II: Feb.3/02. Disch: Feb.10/02.
Operation II: Feb.3/02. Dr.Halsted. Excision supraclavicular glands, left.

(over)

Fig. 1.4 Patient record by Dr. Halsted in 1901 with excellent documentation of staging and surgical procedure. Rubber gloves were used (From Lewinson)

In 1948, Patey and Dyson of the Middlesex Hospital in London published a brief report describing a modification of the Halsted mastectomy. In this "modified radical mastectomy," the pectoralis major muscle was preserved. The operation was less disfiguring, and the authors reported that its results were as good as those of the standard radical procedure. Many surgeons in the United States and Europe soon adopted this procedure as an alternative to the more radical Halsted operation. Indeed, a modified radical mastectomy (with preservation of both the pectoralis major and minor muscles) is still widely used today in the treatment of early breast cancer.

After World War II, McWhirter in Edinburgh advocated simple mastectomy and high-voltage X-ray therapy in the treatment of primary breast cancer. In 1948, he published his classic paper entitled "The value of simple mastectomy and radiotherapy in the treatment of cancer of the breast" in the *British Journal of Radiology*. Although others had also suggested that radiotherapy be used in conjunction with surgery in the treatment of breast cancer, McWhirter was perhaps the most articulate spokesman for this treatment modality. He laid the foundations for the eventual use of radiotherapy in breast conserving surgery. During the Halsted era, surgeons generally assumed that the radical mastectomy reduced breast cancer mortality. This assumption was based on the observation that the radical mastectomy was very effective in achieving local control of the disease, and it was believed that local control influenced survival. By the latter half of the twentieth century, some investigators were questioning this assumption. In 1962, Bloom et al. reported on the outcome of 250 patients with primary breast cancer who received absolutely no treatment. These patients were diagnosed clinically between the years 1805 and 1933 at the Middlesex Hospital in London, and tissue diagnosis was established at autopsy. Henderson and Canellos compared the survival rate of these untreated patients from the Middlesex Hospital to those treated by radical mastectomy at the Johns Hopkins Hospital between the years 1889 and 1933. The survival curves of the two groups of patients were almost identical, suggesting that surgery contributed little to reducing breast cancer mortality. However, it is important to note that women in the late nineteenth and early twentieth centuries generally presented with locally advanced cancers, and many women had distant micrometastatic disease at the time of presentation. In such patients, one would not expect local therapy (surgery) to have much impact on mortality. Yet, this might not necessarily hold true for women diagnosed with breast cancer today, who present with earlier stage symptomatic and screen-detected breast cancer which may be confined to the breast and regional nodes without microscopic dissemination; it is these micrometastases at distant sites which ultimately determine a patient's clinical fate.

In recent years, several large randomized prospective trials have tested the tenets of the Halsted paradigm. Two trials, the National Surgical Adjuvant Breast Project-04 (NSABP-04) and the King's/Cambridge trials, randomized patients with clinically node-negative axilla to either early or delayed treatment of the axilla. The NSABP-04 trial was organized by Dr. Bernard Fisher of the National Surgical Adjuvant Breast and Bowel Project in Pittsburgh, in the

United States, and the King's/Cambridge trial was organized by the Cancer Research Campaign (CRC) in the United Kingdom. In these trials, axillary treatment consisted of either surgical lymph node clearance or radiotherapy and was performed either at the time of mastectomy or delayed until tumor recurrence in the axilla. Both trials showed that the delayed treatment of the axilla does not adversely affect survival. Thus, contrary to Halsted's hypothesis, the axillary lymph nodes do not seem to serve as a nidus for the spread of cancer (Table 1.1).

Halsted had also postulated that breast cancer is a locally progressive disease and that metastases occur by centrifugal and contiguous spread of the primary tumor in the breast. If this is indeed the case, then the extent of the mastectomy should influence survival. Over the last 30 years, this hypothesis has been tested in six randomized prospective trials. These trials randomized patients with primary breast cancer to either a breast conserving procedure (variously referred to as a lumpectomy, tylectomy, wide local excision, or quadrantectomy) or total mastectomy. The first of these six trials was conducted under the direction of Dr. Umberto Veronesi (1925–2016) (Fig. 1.5) at the Tumor Institute of Milan, in Italy, and the largest trial (NSABP-06) was conducted by Dr. Bernard Fisher (1918–2019) (Fig. 1.6) of the National Surgical Adjuvant Breast and Bowel Project in Pittsburgh, in the United States. These trials showed that the risk of local recurrence increases following breast conserving procedures, but the extent of the mastectomy does not influence survival, results that were inconsistent with the Halsted hypothesis.

These randomized trials collectively suggest that permutations in the surgical treatment of breast cancer have no impact on mortality. Ironically, these trials have led many investigators to once again conclude that breast cancer is a systemic disease at the time of diagnosis, a belief held by Galen and his disciples. Thus, over the last 2500 years, we seem to have come full circle in our thinking about the natural history of breast cancer!

There has been increased emphasis on maintaining quality of life in addition to maximizing length of life in recent years for those afflicted with breast cancer. Surgeons have played a very important role in this endeavor. The surgeon is often the first to discuss the diagnosis and treatment options with the patient, and effective communication skills can do much to allay anxiety and fear. Also, there is now a wider acceptance of breast reconstructive surgery as an important component in the overall management of breast cancer. Breast reconstruction can reduce the psychological trauma

Table 1.1 Comparison of Halstedian and Fisher hypotheses of tumor biology

Halstedian hypothesis	Fisher hypothesis
Tumors spread quickly in an orderly defined manner based upon mechanical considerations	There is no orderly pattern of tumor cell dissemination
Tumor cells traverse lymphatics to lymph nodes by direct extension supporting en bloc dissection	Tumor cells traverse lymphatics by embolization challenging the merit of en bloc dissection
The positive lymph node is an indicator of tumor spread and is the instigator of disease	The positive lymph node is an indicator of a host–tumor relationship which permits development of metastases rather than the instigator of distant disease
RLNs are barriers to the passage of tumor cells	RLNs are ineffective as barriers to tumor cell spread
RLNs are of anatomical importance	RLNs are of biological importance
The bloodstream is of little significance as a route of tumor dissemination	The bloodstream is of considerable importance in tumor dissemination
A tumor is autonomous of its host	Complex tumor–host interrelationships affect every facet of the disease
Operable breast cancer is a local–regional disease	Operable breast cancer is a systemic disease
The extent and nuances of operation are the dominant factors influencing patient outcome	Variations in local–regional therapy are unlikely to substantially affect survival

The Fisher theory now is basis for all our treatment concepts, where adjuvant (postoperative) or neoadjuvant (preoperative) systemic treatment is standard of care (from Fisher)

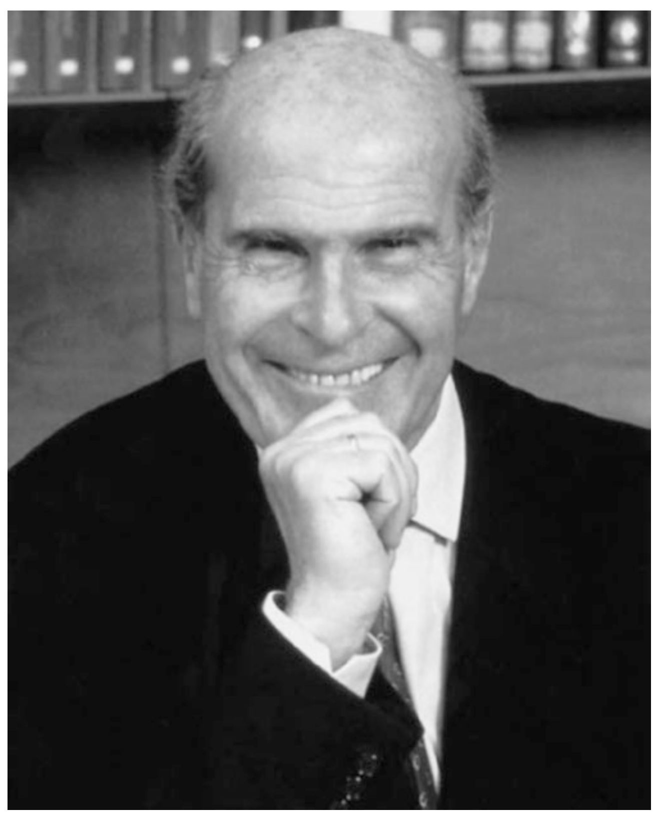


Fig. 1.5 Professor Umberto Veronesi (1925–2016) of Milan, Italy

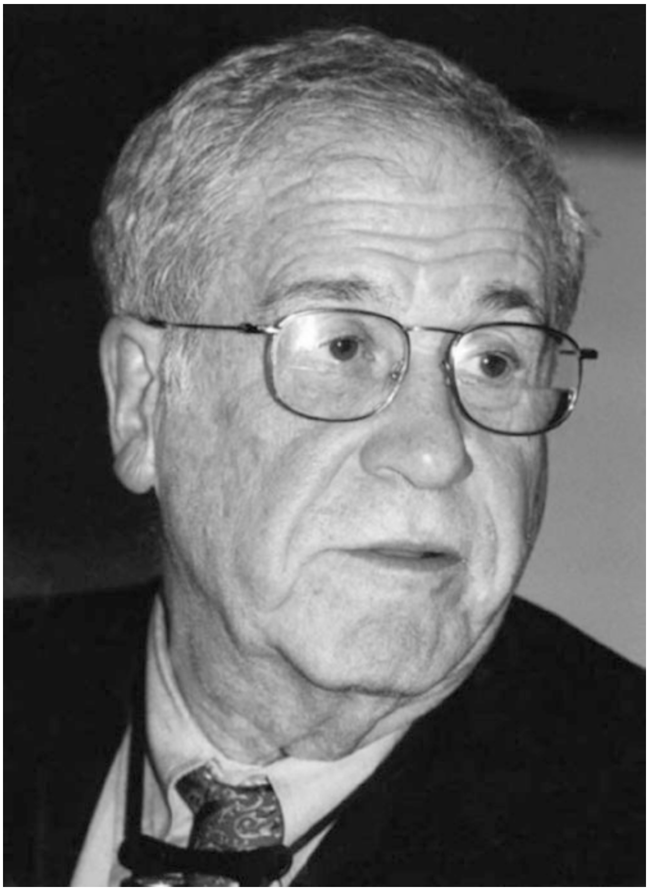


Fig. 1.6 Professor Bernard Fisher (1918–2019) of Pittsburgh, in the United States

associated with mastectomy, particularly the sense of mutilation, depression, and misgivings concerning femininity. Surgeons throughout the world have described a wide array of reconstructive techniques, including the use of expanders, implants, and tissue flaps. The modern specialized breast surgeon must acquire a spectrum of expertise covering oncology, radiology, breast surgery, and an understanding of relevant principles and practice of breast surgery. Increasing utilization of neoadjuvant therapy to downstage locally advanced disease has permitted more successful rates of breast conserving surgery. A progressive decrease in proportion of patients requiring mastectomy in favor of breast conserving surgery has coincided with increased demand for either immediate or delayed breast reconstruction together with evolution of oncoplastic procedures. The latter involves utilization of surgical techniques developed by plastic surgeons for cosmetic reshaping of the breast, subsequently being applied by breast surgeons for more extensive breast resections. Surgical treatment must on the one hand maximize the chance of negative resection margins but on the other achieve good cosmetic results. There is an innate conflict between the basic aims of oncologic and plastic surgery, and the challenge of oncoplastic breast surgery is to reconcile oncological and aesthetic aims to optimize outcomes for patients. Oncoplastic surgery aims to retain or enhance the natural appearance of the breast following excision of cancer. Techniques such as fat transfer can be employed to correct minor defects consequent to surgery and/or radiotherapy, but there is growing recognition that prevention of breast deformity is preferable to treatment. Early concerns were raised that oncologic outcomes might be compromised in attempts to minimize the volume of tissue resected for cosmetic purposes. However, there is no evidence that oncoplastic breast conservation techniques are less likely to achieve negative resection margins nor be associated with increased rates of re-excision. On the contrary, due to the greater volume of tissue removed with oncoplastic procedures, tumors can be excised with a high chance of clear resection margins at first surgery.

Patients are increasingly well-informed about treatment options and social media with online blogs that have fueled heightened patient expectations regarding outcomes, and the modern breast surgeon must engage more in shared decision-making processes. In particular, surgeons must be aware of unrealistic expectations and direct their patients to authorized websites in order to gain accurate and balanced information. Patients will reach a final decision on treatments based on synthesis of multiple factors relating to risk of breast cancer recurrence, perceived mortality, body image, femininity, self-confidence, and lifestyle. There has been a shift medicolegally in recent years from informed consent to informed choice.

Improved survivorship has implications for health-related quality of life, and healthcare workers must strive to ensure optimal oncologic, cosmetic, functional, and psychosocial outcomes. Surgeons must balance the needs of patients in each of these domains and be prepared to constantly face new challenges. The number of elderly patients is increasing, and oncoplastic surgery should be available to those who are otherwise fit despite their chronological age. Women who have undergone breast conservation or whole breast reconstruction may require further surgical intervention for late complications or to enhance breast aesthetics.

For centuries, the management of breast cancer was predicated on anecdotal experience and the results of retrospective studies. Today, it is largely based on the results of randomized, prospective clinical trials. These trials have shown that screening, adjuvant systemic therapy, and adjuvant radiotherapy can reduce breast cancer mortality. Surgeons have played a pivotal role in the design of many of these trials and will undoubtedly continue to influence the design of future trials. The results of these clinical trials have clearly had a very favorable effect in improving the outcome for women with breast cancer. Progress is being made in the treatment of breast cancer, and molecular profiling of tumors may permit greater proportional cell kill and herald the "individual biology century". Nonetheless, the development of personalized medicine is proving to be more challenging than anticipated, and precision medicine is probably a more realistic goal. Future progress may necessitate "academic industrial collaboration" in order to perform efficient candidate gene analysis which can identify mutations which are biologically plausible, actionable, and of clinical consequence. At the same time, future progress with also depend on the thoughtful planning of new clinical trials with an imperative of sharing data among the world's trialists for reliable assessment of moderate survival differences and avoidance of bias and small random errors.

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2 Anatomy

2.1 Development and Embryology

The breasts are skin appendages that phylogenetically represent modified sweat glands on the anterior thoracic wall. The detailed anatomy and development of the breast have relevance to the operating breast surgeon when performing procedures such as skin-sparing mastectomy when relatively long skin flaps are created. Surgical dissection must be confined to the "oncological plane" between subcutaneous and fibroglandular breast tissue in order to ensure resection of all breast tissue and maintain viability of the mastectomy skin flaps. Each breast is formed from a single bud that arises from primitive ectodermal streaks at approximately the 5th to 6th week of fetal life. Thickening of ectodermal tissue results in formation of mammary ridges that develop into paired mammary glands along the milk line or "galactic band" extending from axillary to inguinal regions of the embryonic trunk. By the 9th week of gestation, these mammary ridges have atrophied along much of their length leaving a single section in the pectoral region. By a coordinated process of invagination into chest wall mesoderm coupled with proliferation of basal cells, a nipple bud is formed. Sequential stages of budding and branching lead to formation of the secretory alveoli of the breast parenchyma with mesenchymal elements differentiating into the smooth muscle of nipple and areola. Accessory nipples sometimes with underlying breast tissue can be found along this milk line due to incomplete regression, but otherwise a single breast develops on each side in the pectoral region. Early growth and differentiation of breast tissue occurs in both sexes during the second trimester with development of sebaceous glands and rudimentary Montgomery tubercles together with circular smooth muscle fibers. In the third trimester, placental hormones enter the fetal circulation, and this promotes canalization of branched epithelial structures with formation of lobuloalveolar structures containing colostrum. Postnatal development is confined to females with the breast being a vestigial structure in the adult male. The secondary embryological status of the breast as an organ accounts for the absence of a true capsule surrounding the gland that essentially represents a large dermal and subcutaneous organ with lack of a specialized vasculature and innervation. Instead, the blood vessels, nerves, and lymphatics of the breast are commandeered from existing structures supplying the anterior thoracic wall.

Failure of these developmental stages leads to a variety of congenital anomalies ranging from complete absence of the breast to accessory (2–6%) and ectopic breast tissue (1–6%). These can involve one or both breasts and also be associated with abnormalities of the ipsilateral upper limb.

(a) *Accessory tissue* – this may involve the nipple only (polythelia) or the entire mammary gland (polymastia) and is consequent to incomplete regression of the mammary ridges. Accessory breast tissue most commonly occurs in the axillary region and can respond to pregnancy with lactational activity postpartum when a nipple is present.

(b) *Hypoplasia* – this is underdevelopment of the breast and contrasts with amastia which is complete absence of any breast (including nipple). The condition is usually of moderate severity and can be unilateral or bilateral with degrees of breast asymmetry. Poland's syndrome is a more severe form of hypoplasia associated with abnormalities of the pectoral muscle (sternal head usually absent but clavicular head often present) together with potential anomalies of the upper limb. Etiology of the syndrome is unknown but may relate to subclavian artery disruption in utero. Inclusion of hand abnormalities (symbrachydactyly with malformation of the middle phalanges and central skin webbing) as part of Poland's spectrum is debated with emphasis primarily on abnormalities affecting shoulder girdle musculature. In his original description published in 1841, Alfred Poland referred to neither hypoplasia nor complete absence of the breast/nipple and noted that the condition commonly

I. Jatoi et al., *Atlas of Breast Surgery*, https://doi.org/10.1007/978-3-030-45951-2_2

occurs in men also. In more extreme cases of Poland's syndrome, there may be absent costal cartilages or segments of the anterior ribs.

(c) *Hyperplasia* – overdevelopment of the breast may be unilateral or bilateral with variable degrees of asymmetry.

(d) *Amazia* – this contrasts with amastia and is characterized by the presence of a nipple–areola complex but no underlying breast tissue.

(e) *Acquired abnormalities* – precocious development of the breast can lead to diagnostic confusion and prompt surgical excision biopsy. This can lead to inadvertent removal of much of the breast bud in an attempt to excise a clinically indeterminate lesion. The prepubescent breast bud can also be damaged by irradiation administered for intrathoracic disease or even breast hemangioma. Similarly, acquired abnormalities may result from severe burns to the anterior chest area with scarring adversely affecting breast development.

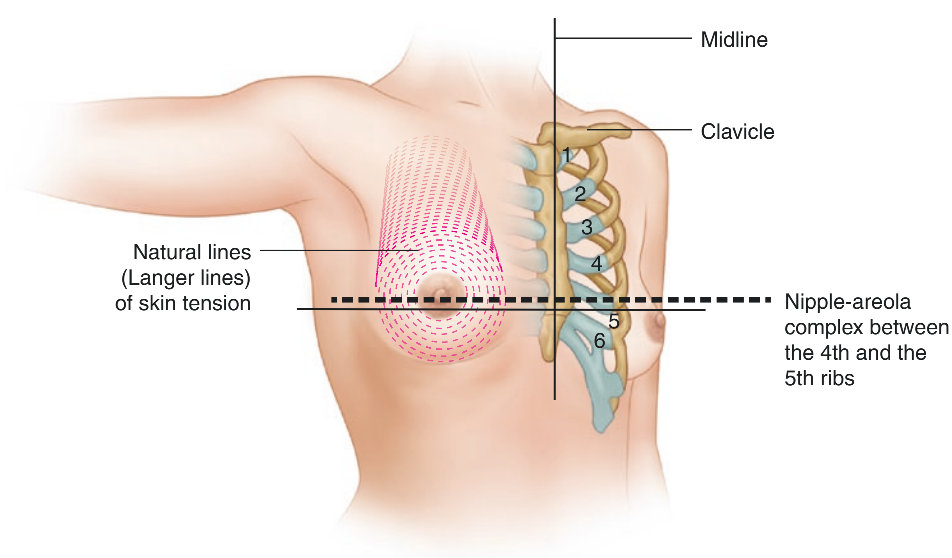
2.2 Anatomy of the Breast

In humans the breast is a domed structure on the anterior chest wall with a conical lens shape that contrasts with a rather flatter structure in other mammals. Breasts vary greatly in size and shape, tending to become more pendulous after lactation and a shallow disc of tissue in the atrophic breasts of old age or states of malnutrition. The human breast is typically between 10 and 12 cm in diameter and 5–7 cm in thickness with an average volume of approximately 400 mls. The adult breast extends from the 2nd or 3rd to the 6th or 7th rib in the vertical axis and from the lateral border of the sternum to the midaxillary line in the horizontal axis (Fig. 2.1). The lateral and inferior borders are well defined, but superiorly the breast merges with the subcutaneous tissue of the anterior chest wall. It is located on the anterolateral aspect of the chest wall and overlies predominantly the pectoralis major muscle, extending partially over the serratus anterior laterally, the external oblique inferolaterally, the rectus sheath inferomedially, and the costal cartilages medially and superiorly. Most of the glandular tissue is located in the central and upper outer quadrants of the breast, but there is an extension of breast tissue along the lateral border of the pectoralis major known as the tail of Spence that must be completely dissected at the time of mastectomy (especially now that routine axillary dissection "in continuity" is no longer performed for staging of breast cancer). Breast tissue can extend beyond these conventional boundaries, and ectopic tissue is particularly common in the axilla. It is important that this is differentiated from nodal tissue in cases of breast malignancy in order to avoid inappropriate upstaging of patients to from N0 to N1.

2.2.1 Glandular Structure

The breast is a glandular structure lying within the superficial fascia of the anterior chest wall and is composed of skin, subcutaneous tissue, and fibroglandular tissue (Fig. 2.2). The latter is formed of epithelial parenchyma together with supporting connective tissue (containing blood vessels, nerves, and lymphatics). These are pathologically reminiscent of both sweat and mammary glands and can secrete milk. The breast is essentially a conglomerate gland consisting of

Fig. 2.1 Surface anatomy of the breast



15–20 lobes arranged in a radial disposition. Each lobe represents a pyramid of glandular tissue with an apex pointing towards the nipple and a base peripherally. Secretions drain centripetally towards the nipple, and each lobe drains via a system of branching ducts into a lactiferous sinus and in turn into a collecting duct which is 2 mm in diameter and opens at the tip of the nipple. Each lobe drains separately and there is no communication between the ducts of adjacent lobes. Individual lobes are composed of between 20 and 40 lobules which in turn are made up of between 10 and 100 acini or alveoli which open into a common duct – the terminal duct (Fig. 2.2). This combination of glandular acini together with their draining duct is termed the *terminal duct lobular unit* (TDLU) and represents the basic functional unit of the breast. The terminal ducts drain into subsegmental and in turn larger segmental ducts that are interwoven within any single lobe. The epithelial structures are supported by connective tissue elements that surround the gland and condense into collagenous and inelastic septa between the lobes and lobules. This superficial fascia was formerly known as the "fascia mammae" and is derived from fibrous tissue in the subcutaneous layer of the chest wall and does not constitute a true capsule. This fascia has anterior and posterior layers between which the breast parenchyma lies. The anterior layer lies between the glandular and subcutaneous tissue while the posterior layer between the glandular tissue and the pectoralis major fascia. This fascia is a key component of the suspensory mechanism of the breast by virtue of its posterior and anterior attachments. The deeper layer of the superficial fascia covers the posterior surface of the breast and forms the anterior wall of the retromammary bursa, and this helps maintain mobility of the breast on the chest wall. The more superficial layer extends over the anterior surface of the gland and penetrates the substance of the organ to provide support for both glandular and ductal elements. This superficial fascia enveloping the breast is continuous with the superficial abdominal fascia of Camper, and condensation of this fascia creates the inframammary fold that must not be breached during skin-sparing mastectomy with immediate breast reconstruction. Fibrous thickenings formed of collagenous

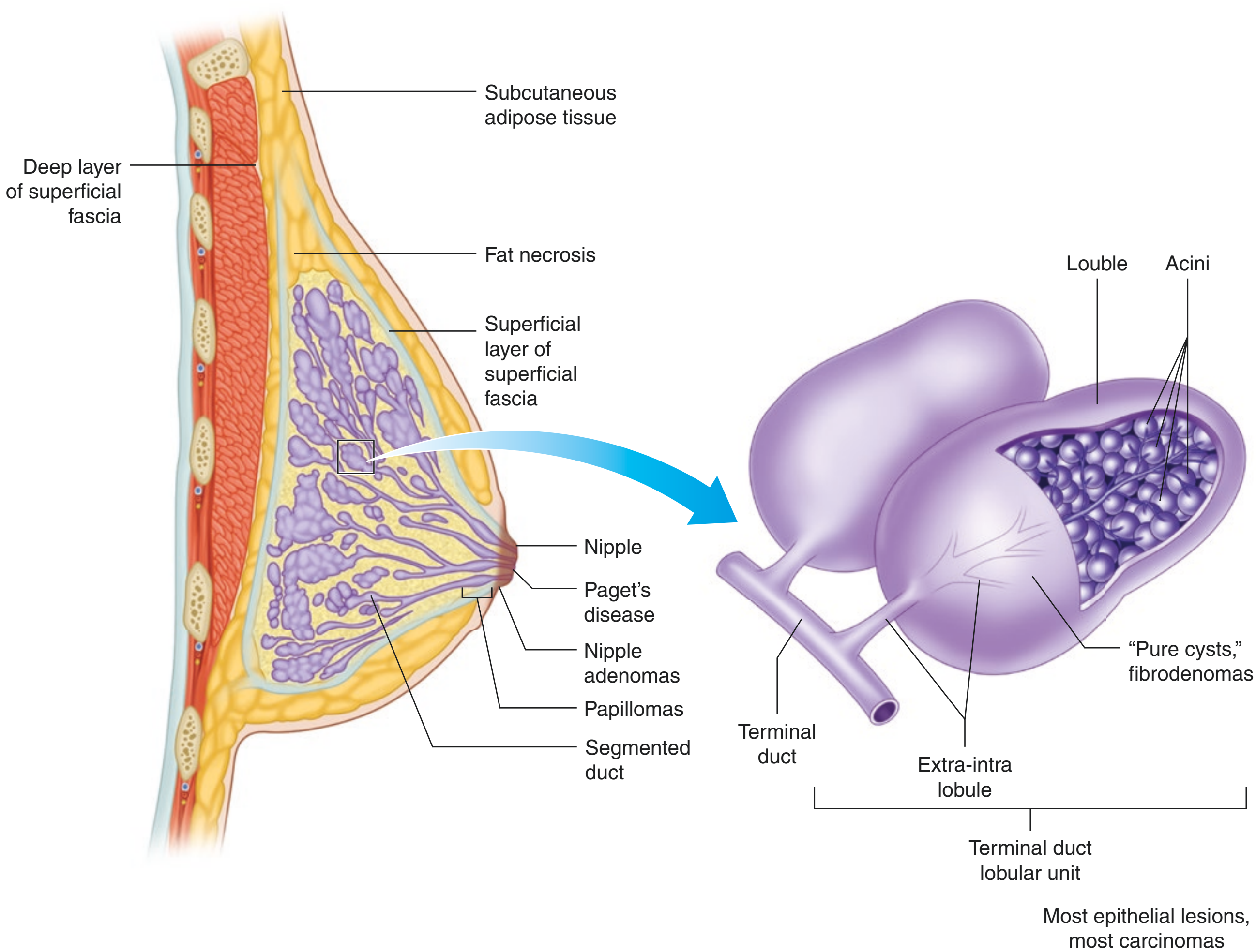


Fig. 2.2 Organization of the ductal-lobular system and its diseases

bundles pass from the superficial mammary fascia to the dermis of the skin. These suspensory ligaments of Cooper form projections which spread out to form a white, firm irregular surface of folds between the skin and the glandular tissue. They permit considerable mobility of the breasts in addition to a supportive function.

The "panniculus adiposus" forms a fatty envelope around the breast and is responsible for the smooth contour of the organ. Arteries, veins, nerves, and lymphatic vessels lie within this layer and are distributed throughout the structure. It is crucial that this layer is not partially excised during mastectomy as this will disrupt vital subcutaneous vessels maintaining viability of the flaps following extirpation of underlying breast parenchyma.

2.2.2 Nipple–Areola Complex

The nipple is the most prominent part of the breast and protrudes forward and outwards to a variable degree. It is a cylindrical structure, receives the connecting ducts from individual lobes of the breast, and contains blood vessels and nerves united by fibrous and cellular tissue. The nipple surmounts a pigmented zone of skin termed the areola to form the nipple–areola complex. The latter is circular with a diameter of between 15 and 60 mm and usually lies over the 4th intercostal space in a non-pendulous breast. It is covered with keratinizing stratified squamous epithelium with a basal layer of melanin-rich cells that imparts a dark coloration to the nipple–areola complex. The skin of the nipple–areola complex is generally pigmented but in fair-skinned women tends to be pinkish in color due to long dermal papillae reaching close to the surface. A system of mainly circumferential smooth muscle fibers exists deep to the areola with a few radial fibers along the lactiferous ducts. Contraction of these circular muscle fibers upon stimulation leads to hardening and erection of the nipple. Moreover, these smooth muscle fibers contract in response to sensations of touch or cold and render the nipple more protuberant for ease of suckling. They also facilitate emptying of the lactiferous sinuses during breastfeeding. The skin of the areola possesses dermal papillae in addition to hair follicles, sweat glands, and sebaceous glands whose secretions may be protective. A particular feature of the nipple–areola complex is the presence of accessory areola glands or "Montgomery tubercles" that from an embryological perspective have a structure intermediate between mammary glands proper and sweat glands.

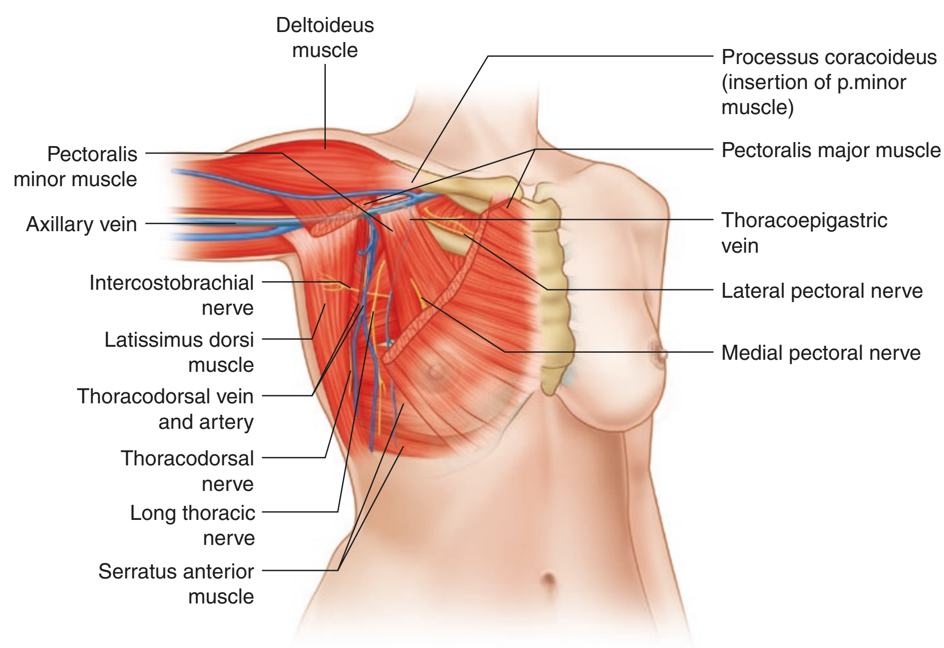
2.2.3 Applied Anatomy

The structure and form of breasts vary greatly with age, hormonal status, pregnancy, and lactation. The nulliparous breast tends to be hemispheric in shape, while those of multiparous women are larger and more pendulous. Breasts involute with advancing age with flattening and loss of firmness. The bases of the pyramids for individual lobes of the breast extend outwards to unequal lengths. The medial aspect of the breast has an irregular outline, and, superolaterally in the region of the axillary tail, the edge of the breast is turned up like a hem. These features should be borne in mind with skin-sparing forms of mastectomy that preserve much of the skin envelope of the breast. Although it was previously standard practice to always remove the nipple–areola complex for invasive malignancy, this is no longer the case, and increasingly nipple-sparing forms of mastectomy are being undertaken (for unifocal tumors smaller than 3 cm and located at least 1 cm away from the edge of the areola). Though breast conserving techniques are widely practiced and there is much emphasis on oncoplastic surgery, there is no natural plane of dissection within the glandular tissue of the breast; the arrangement of parenchymal and stromal components admixed into a conglomerate organ precludes definition of any surgical plane when undertaking a lumpectomy or wide excision of breast tissue.

2.3 Chest Wall Musculature

The breast is a superficial structure lying on the surface of the anterior and lateral chest wall. The relevant underlying muscles include pectoralis major and minor, serratus anterior, latissimus dorsi, and the aponeurosis of the external oblique and rectus abdominis muscles.

(a) *Pectoralis major* – this fan-shaped muscle takes origin from the medial half of the clavicle, lateral sternal border, and 6th and 7th ribs to insert onto the greater tuberosity of the humerus (the muscle forms the anterior axillary fold). The muscle has a natural cleavage between the larger sternocostal and smaller clavicular portions and serves to flex, adduct, and medially rotate the upper arm. The pectoralis minor muscle lies deep to its larger counterpart and takes origin from the 3rd, 4th, and 5th ribs with a tendinous insertion onto the coracoid process of the scapula. This muscle helps depress the shoulder, but its loss does not lead to any major functional impairment; it was previously sacrificed during a radical or modified radical mastectomy to permit access to level III axillary nodes (some surgeons divided the muscle at its insertion and reflected it downwards rather than removing the muscle). Nowadays, access to the apical region of the axilla can be achieved during surgery by wrapping the patient's arm and adjusting the on-table position of the limb to relax the pectoral muscles (Fig. 2.3a, b).



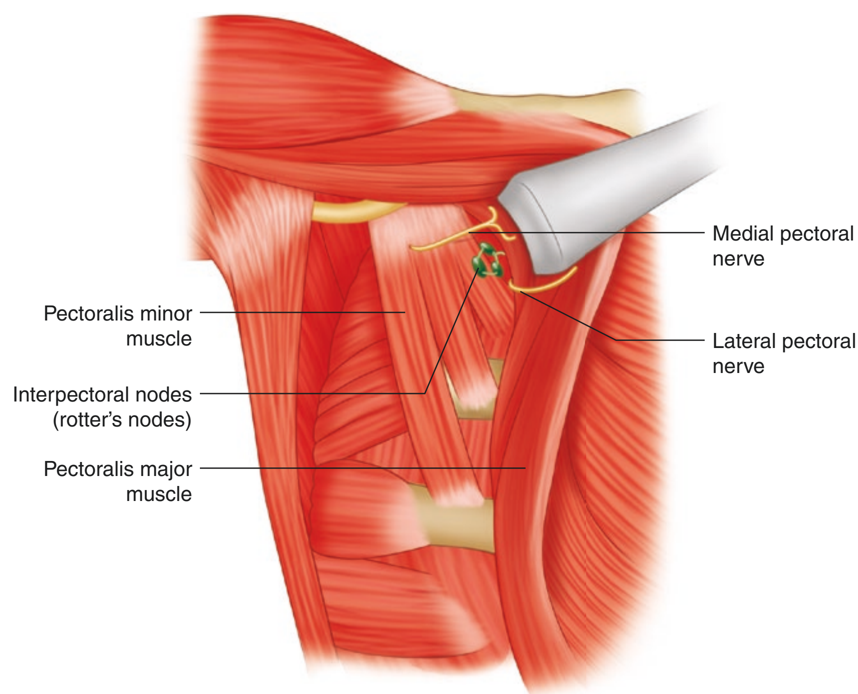


Fig. 2.3 (**a, b**) Anatomy of the axilla

(b) *Serratus anterior* – the serratus anterior muscle arises from a series of digitations from the upper eight ribs and inserts into the vertebral border of the scapula, thus stabilizing and holding the scapula against the posterior chest wall. Loss of function results in a "winged scapula" and inability to elevate the arm above the level of the shoulder.

(c) *Latissimus dorsi* – this is a large muscle taking origin from the upper thoracic vertebrae (T7–T12), the iliac crest, lumbar and sacral spines (by way of the thoraco-lumbar fascia), and the lowermost three or four ribs. The latissimus dorsi muscle converges to a narrow tendon which inserts into the floor of the intertubercular groove and forms the posterior axillary fold. The

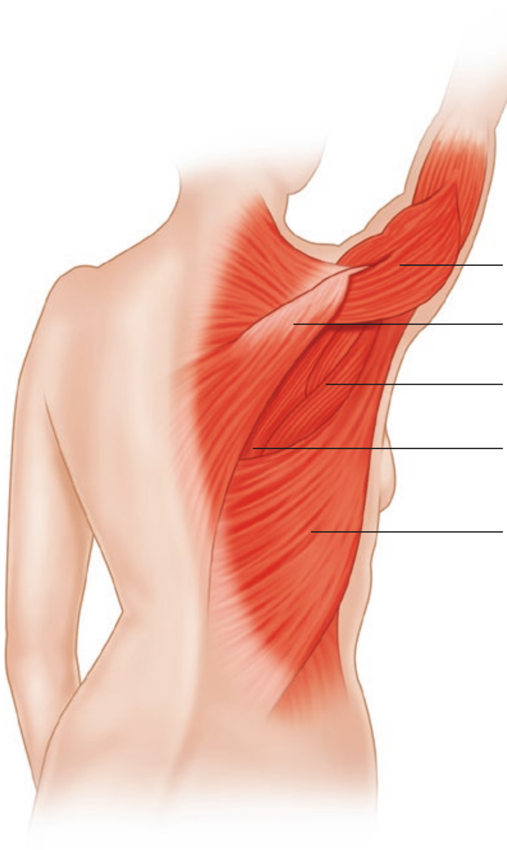


Fig. 2.4 Latissimus dorsi muscle and related muscles

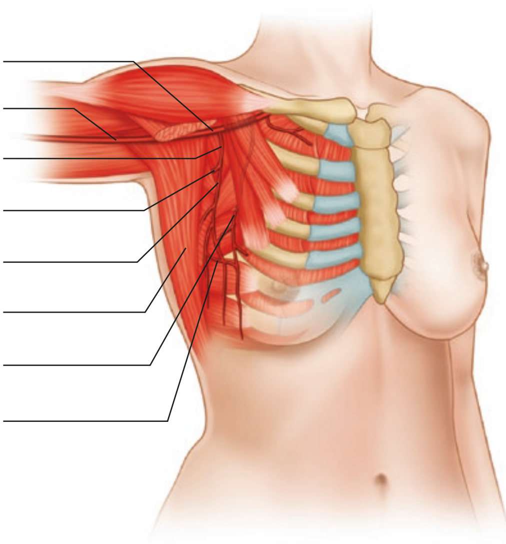


Fig. 2.5 Anterior view of latissimus dorsi muscle and blood supply (pectoralis major muscle removed)

muscle serves to medially rotate, adduct, and extend the arm (Fig. 2.4).

An interesting anomaly is Langer's axillary arch representing a remnant band of latissimus dorsi that crosses the base of the axilla and passes deep to the pectoralis major muscle to insert into the coracoid process. The presence of this band can cause confusion with clarification of anatomical structures during an axillary dissection. The latissimus dorsi muscle is used as a pedicled myocutaneous flap for breast reconstruction. The axial vessels are the thoracodorsal artery and vein; the former is a branch of the subscapular artery that originates as a branch from the axillary artery. The subscapular artery branches early on into the circumflex scapular and thoracodorsal arteries. The thoracodorsal artery is joined by one or two veins and the thoracodorsal nerve to form a neurovascular bundle and enters the latissimus dorsi muscle on its medial surface, approximately 6–12 cm from the subscapular artery. Damage to the thoracodorsal artery can be compensated for by increased flow within the dorsal scapular artery (Fig. 2.5).

(d) *Subclavius* – this muscle represents an important anatomical landmark in the apical zone of the axilla and helps define the clavipectoral fascia through which vital structures pass from the axilla to thorax. The muscle arises from the costochondral junction of the first rib from where the two layers of the clavipectoral fascia form a band stretching from the coracoid process to the first costochondral junction.

This musculature of the chest wall is important for certain types of breast reconstruction; when performing an implant-only based reconstruction, a pocket is dissected deep to both the pectoralis major and minor muscles with access through the central portion of the muscle or laterally between the pectoralis major and serratus anterior. A disadvantage of the latter approach is failure to maintain continuity of fascia between the two muscles that aid creation of a subpectoral pocket extending deep to the serratus anterior muscle. However, there is now a trend for use of acellular dermal matrices (ADM), and this permits detachment of the pectoralis major muscle inferolaterally and placement of a crescentic piece of ADM. Pre-pectoral placement of implants with avoidance of any subpectoral dissection and concomitant morbidity is currently being explored as an alternative surgical option. Likewise the latissimus dorsi muscle has been used extensively for breast reconstruction as part of an implant-assisted flap-based procedure. The latissimus dorsi muscle is freed from its attachments along its medial and inferior borders and transposed anteriorly with sandwiching of an implant between this myocutaneous flap and the pectoralis major muscle. Although a latissimus dorsi flap is very robust and unlikely to fail, it incurs some donor site morbidity and functional impairment. The advent of ADM as a surgical adjunct has resulted in a significant decrease in implant-assisted latissimus dorsi breast reconstruction.

2.4 Anatomy of the Axilla

The axilla is a pyramidal space bound anteriorly by the pectoralis major and minor muscles, medially by the serratus anterior of the lateral chest wall, laterally by a portion of the humerus between the groove and greater trochanter, superiorly by the axillary vein, and posteriorly by the subscapularis muscle (and part of the latissimus dorsi and teres major muscles). The base of this pyramid is the skin and axillary fascia, while the apex is an aperture extending into the posterior triangle of the neck through which most of the important vessels and nerves of the upper limb pass (Fig. 2.6).

The motor nerves supplying pectoralis major, serratus anterior, and latissimus dorsi have important relationships to the axilla and are potentially at risk from damage during axillary surgery. The pectoralis major muscle is innervated by the medial and lateral pectoral nerves, with the latter supplying the main sternoclavicular portion of the muscle. These nerves are readily identified during axillary surgery

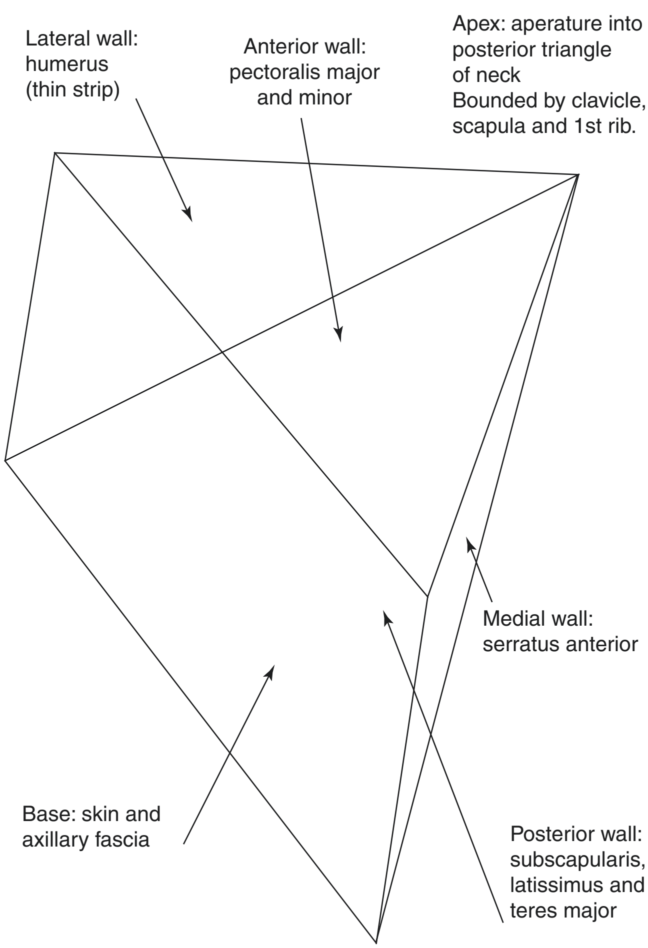


Fig. 2.6 The axillary pyramid (Reproduced with permission from Sabel MS: *Essentials of Breast Surgery*. Mosby/Elsevier, 2009)

as they pass around the lateral border of pectoralis minor and should be preserved. Damage to one or other pectoral nerves leads to muscle atrophy, and this may be of consequence to any subpectoral implant placement. The serratus anterior is supplied by the long thoracic or Bell's nerve (C5, C6, and C7 nerve roots of brachial plexus). The nerve is closely applied to the medial aspect of the axilla from where it gives off branches to serratus anterior. The nerve lies relatively posterior and is superficial to the fascia of serratus anterior. This means that the nerve can be readily drawn laterally into the specimen during surgery and inadvertently damaged (giving rise to a winged scapula). The thoracodorsal nerve supplies the latissimus dorsi muscle and arises from the posterior cord of the brachial plexus (C6, C7, and C8 roots). The nerve passes posterior to the axillary vein and along the posterior wall of the axilla in close relationship to the thoracodorsal vessels. This nerve may be injured during routine axillary dissection, especially if there is malignant nodal tissue adherent to the thoracodorsal pedicle. Although the functional consequence of damage is not great for a patient of average activity levels, the nerve should be preserved to prevent atrophy of the muscle lest this be used subsequently for reconstruction. The intercostobrachial nerve is purely sensory (T1, T2) and crosses the axilla to innervate the skin of the axilla and the upper arm (medial and posterior aspects). The nerve lies anterior to the long thoracic nerve and marks the limits of a level I axillary dissection. Some surgeons attempt to preserve this nerve, but it tends to divide and peter out laterally; there is no evidence of any subjective patient benefit from nerve preservation. It is sometimes sensible to deliberately sacrifice the intercostobrachial nerve to facilitate removal of an axillary mass and thorough clearance of malignant nodal tissue (Fig. 2.3).

2.5 Blood Supply

2.5.1 Arterial Supply

Despite its importance as an organ of lactation, the breast does not have a blood supply from a single defined source but instead relies on multiple sources of perfusion. Nonetheless, most of the blood supply to the breast comes from the internal mammary (60%) and lateral thoracic arteries (30%). Perforating branches of the internal mammary artery penetrate the 2nd, 3rd, and 4th (and occasionally 5th) intercostal spaces and traverse the pectoralis major muscle to supply the medial and deep parts of the gland. These vessels can produce troublesome bleeding at operation should they retract into the chest wall once divided. These branches of the internal mammary artery anastomose with vessels entering from the superolateral aspect of the breast which arise from the axillary artery; the lateral thoracic artery provides branches which sweep around the lateral border of the pectoralis major to reach the gland. There are minor contributions from branches of the thoracoacromial trunk together with 3rd, 4th, and 5th intercostal vessels supplying the deeper aspects of the gland. There is a rich anastomotic network between these different sources of blood supply, and during pregnancy the medial perforators increase considerably in diameter. Collateral branches supply both the parenchymal tissue and overlying skin and subcutaneous tissues (Fig. 2.7).

2.5.2 Venous Drainage

The venous drainage of the breast generally corresponds to the arterial supply but not completely. Veins beneath the areola form an anastomotic circle (circulus venosus) that receives blood from the breast tissue. This plexus drains into deeper veins with centrifugal carriage of blood to the periphery of the gland where venous outflow is via the internal thoracic, lateral thoracic, and upper intercostal veins. Breast cancer can spread hematogenously via these venous routes and also by way of the vertebral venous plexus that is linked to veins of the chest wall by valveless

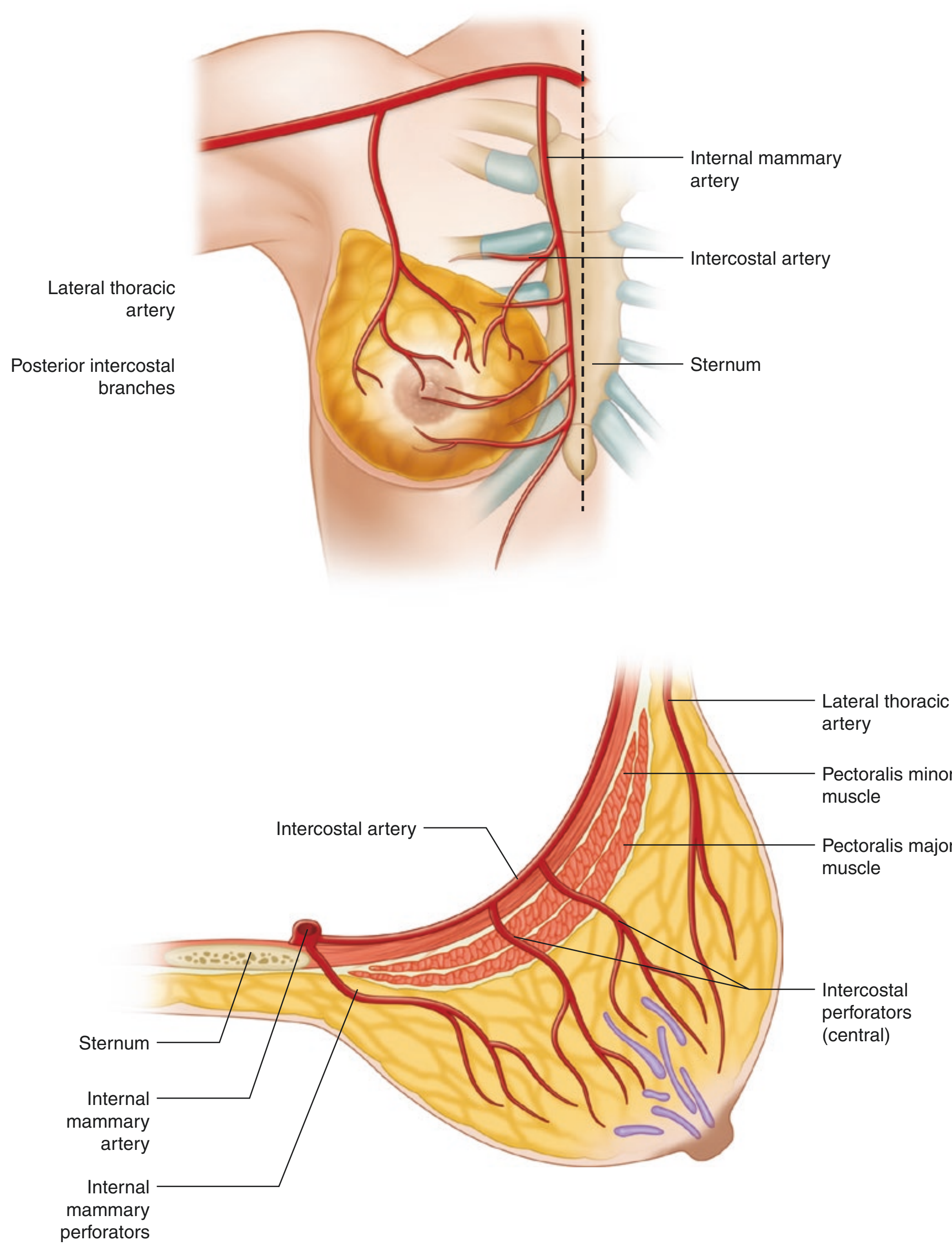


Fig. 2.7 Blood supply of the breast

conduits. These capacitance vessels become very prominent during pregnancy when venous flow increases enormously.

2.6 Lymphatic Anatomy

2.6.1 Axillary Nodes

Metastasis to regional nodes is a common pattern of dissemination for solid epithelial tumors. These typically invade local structures and spread in a *progressive* and *sequential* manner from a primary tumor focus. Locoregional pathways of spread lie in anatomical continuity with lymphatic vessels providing a link between index tumor and regional nodes. The majority of invasive breast cancers have potential to metastasize via the lymphatic system, and axillary lymph nodes are a principle route for regional spread of primary breast malignancy. Dissemination via the lymphatic system is in accordance with the Halstedian paradigm, although early hematogenous spread occurs in breast cancer with access to the circulation via lymphaticovenous communications in regional nodes and the leaky endothelium of tumor neovasculature.

There is some confusion in designation of nodal groupings, but an understanding of nodal anatomy is important in the surgical management of breast cancer. Classification systems can be based on clinical, anatomical, or surgical criteria:

1. Clinical groupings – medial, lateral, anterior, posterior, and apical
2. Anatomical groupings – lateral, anterior (pectoral), posterior (subscapular), central, subclavicular (apical), and interpectoral (Rotter's)

The lateral group is composed of four to six nodes lying posterior to the axillary vein which drains most of the lymph from the upper limb. The anterior (pectoral) group consists of four to five nodes along the inferior border of the pectoralis minor muscle closely linked to the lateral thoracic vessels. These nodes receive the majority of drainage from the breast. The posterior (subscapular) group is six or seven nodes on the posterior wall of the axilla and drains the posterior neck and trunk. The central group (three to four nodes) lies deep in the pectoralis minor muscle and secondarily receives lymph from lateral, anterior, and posterior groups. The subclavicular (apical) nodes lie at the apex of the axilla alongside the medial aspect of the axillary vein and number between 6 and 12 nodes. These receive drainage from all other nodal groups. Finally, the interpectoral nodes lie between the pectoralis major and minor and are otherwise known as Rotter's nodes. These drain into the central and apical nodes in the upper part of the axilla.

The axillary lymph nodes are also defined in terms of their relationship to the pectoralis minor muscle (Fig. 2.8):

- Level I – nodes below and lateral to lateral border of muscle
- Level II – nodes deep to muscle
- Level III – nodes above and medial to muscle

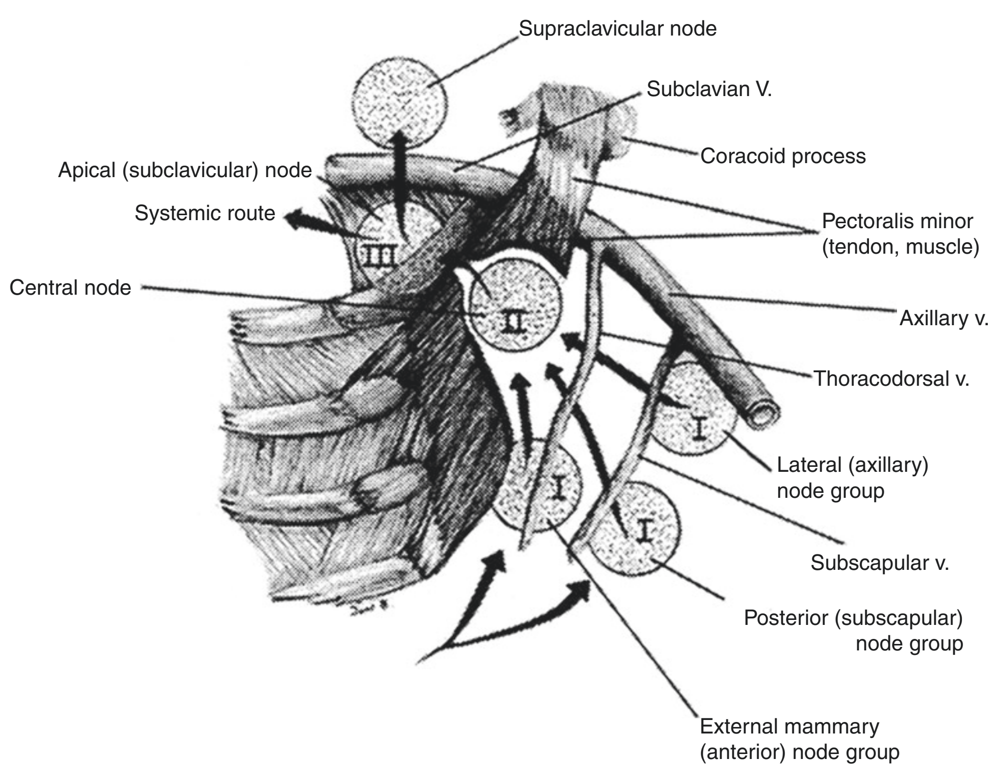


Fig. 2.8 Schematic diagram showing surgical levels of axillary nodes defined in terms of their relationship with the pectoralis minor muscle; level I nodes lie below and lateral to the muscle, level II nodes are deep to the muscle, and level III nodes are located above and medial to the muscle (Reproduced with permission from Copeland EM III, Bland KI. *The Breast* (Section II, Chapter 2). Philadelphia. WB Saunders, 1987)

There is a sequential and orderly passage of lymph from nodes at level I through level II to level III with infrequent involvement of level III nodes when those at levels I and II are tumor free. These "skip" metastases occur with an incidence of only 2–3%, and, for this reason, surgical clearance of lymph nodes is normally restricted to level II in the absence of overtly malignant nodes at these lower levels. This is particularly relevant in the so-called post-Z0011 era when patients with a low burden of axillary metastases can be safely managed without further regional intervention (be this dissection or irradiation of the axilla). The benefits of axillary surgery in terms of disease recurrence must be balanced with morbidities such as lymphedema and shoulder stiffness. Before the advent of sentinel lymph node biopsy, most patients with invasive breast cancer underwent formal axillary clearance with surgical excision of all nodes at levels I (4–8 nodes), level II (10–15 nodes), and occasionally level III (30 nodes). Patients now present with smaller tumors for which there is less likelihood of nodal involvement (20–25%). Sentinel lymph node biopsy is a staging procedure that can accurately determine the pathological status of axillary nodes but for some patients constitutes a therapeutic procedure when the only positive node(s) are contained within the sentinel nodes. Clearance of nodal tissue is confined to clinically node-positive patients and selected clinically node-negative patients found to have nodal disease on sentinel node biopsy.

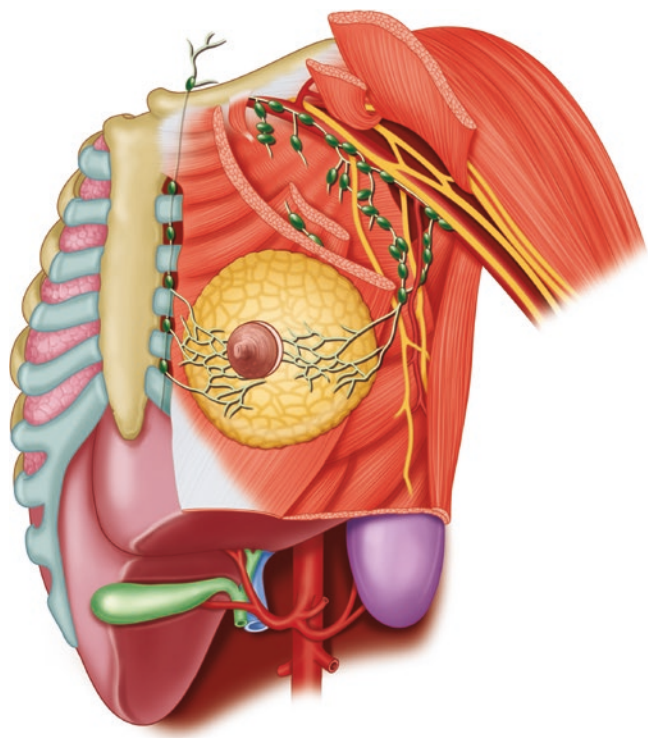


Fig. 2.9 Lymphatic drainage of the breast showing nodal groupings in the axilla and internal mammary chain. Roman numerals illustrate surgical levels of the axillary nodes (I, II, III) (Reproduced with permission from Copeland EM III, Bland KI. *The Breast* (Section II, Chapter 2). Philadelphia. WB Saunders, 1987)

2.6.2 Lymphatic Vessels

The lymphatics of the breast form an extensive and complex network of *peri-ductal* and *perilobular* vessels that drain principally to the axillary nodes**.** The mammary gland is derived from ectoderm and develops from anterior thoracic wall structures. The complex network of arborizing vessels which constitute the lymphatic system of the breast reflect its embryological origin from primitive tissues of the anterior thoracic wall, and subepithelial vessels represent part of the superficial system of the neck, thorax, and abdomen. The lymphatic vessels are confluent over the surface of the body with the subepithelial plexus of lymphatics communicating directly with subdermal vessels. The lymphatics of the breast skin and parenchyma are interconnected, and flow is passive within valveless vessels (Fig. 2.9).

This results in a degree of plasticity that is relevant to malignant infiltration whereby direction of lymph flow may be diverted due to blockage at proximal sites by tumor emboli. These features of the lymphatic system of the breast lead to preferential drainage of cutaneous malignancies to axillary nodes with the lymphatic vessels of the breast functioning as a single biological unit. Interestingly, this has clinical implications in terms of site of injection for sentinel lymph node biopsy (intradermal/subareolar and not peritumoral). In the region of the nipple–areola complex, a cutaneous plexus is linked to a sub-areolar plexus that receives lymphatics from the glandular tissue of the breast. From this subareolar and a related circumareolar plexus, lymph flows principally to the axillary nodes via a lateral lymphatic trunk. The latter together with minor inferior and medial lymphatic trunks drain along the surface of the breast to penetrate the cribriform fascia and reach the various groups of axillary nodes. Anatomical studies suggest that lymphatics of the breast initially drain to a group of between three and five "sentinel" nodes usually located at level I. Lymphatic channels exist which bypass the lower axillary nodes and probably account for "skip" metastases and the finite false-negative rate of sentinel lymph node biopsy. Lymph drains medially from the circumareolar plexus into lymphatics accompanying the internal mammary vessels to enter the internal mammary nodes. Approximately 75% of lymph flow passes to the axillary nodes and 25% to the internal mammary nodes. The internal mammary chain of nodes was recognized by Samson Handley in 1949 as a primary route for lymphatic drainage from *medial* and *central* zones of the breast. Internal mammary nodes can be identified on routine lymphoscintigraphy in about 15% of sentinel lymph node biopsy cases. Fewer than 10% of node-positive tumors *exclusively* involve internal mammary nodes [N1 = micrometastases; N2 = macrometastases], and substantial morbidity ensues from removal of internal mammary nodes with no gains in overall survival from aggressive resections. Furthermore, the necessity for internal mammary node biopsy remains controversial with clinical manifestation of internal mammary node recurrence being rare (0.1%). Accessory pathways of lymphatic drainage assume greater importance in more advanced states of disease when the main drainage route to the axilla becomes obstructed. Several pathways are recognized with substernal crossover to the contralateral internal mammary chain and presternal crossover to the contralateral breast. Mediastinal and rectus abdominis sheath pathways also exist with the latter connected to the subdiaphragmatic and subperitoneal plexus (liver and peritoneal nodes).

2.6.3 Lymphedema

Lymphedema continues to be a common clinical problem despite recent advances in treatments for breast cancer. Perhaps ironically, with improved survival rates, patients are now living sufficiently long to develop lymphedema, with rates reaching 50% after 20 years of follow-up. Following breast cancer surgery, many patients will develop transient swelling of the upper extremity, but chronic lymphedema can lead to profound physical and psychological sequelae, and the condition has aptly been described as a "*permanent disability requiring daily attention.*" Moreover, development of lymphedema constitutes the greatest fear of breast cancer-related treatments after risk of recurrent disease. In addition to physical disability, lymphedema negatively impacts upon other quality-of-life domains such as psychosocial and sexual functioning with increased levels of anxiety, frustration, depression, and impaired social interaction and body image. The incidence of lymphedema is generally related to the extent of surgical dissection and number of lymph nodes removed. Thus for a level I/II axillary dissection whereby all nodal tissue inferior to axillary vein is removed, rates of lymphedema are typically between 10% and 15%. By contrast, a level III axillary dissection that involves dissection medial to pectoralis minor with or without division of muscle and skeletonization of the axillary vein is associated with slightly higher rates of about 25%. Sentinel lymph node biopsy alone can be associated with significant rates of lymphedema that are reported to be as high as 5–8% at 5 years with rates independent of number of sentinel nodes excised. A combination of axillary dissection and irradiation of the axilla increases the chance of lymphedema (about 40%). Both axillary dissection and axillary radiotherapy are treatment options that provide good locoregional control for node-positive patients, but radiotherapy is associated with approximately half the rate of lymphedema (21.7% versus 40%; $p < 0.001$). Results of recent trials suggest that axillary radiotherapy can substitute for completion axillary dissection, especially in those patients with *low-volume disease* only. Surgeons often *loosely* refer to level II and III axillary dissection, but a contemporaneous dissection should be restricted to level II (unless there is evidence of gross nodal disease at this level) (Fig. 2.10).

2.7 Anatomy of the Abdominal Wall

The anterior abdominal wall provides both strength and stability to the patient's core. This area consists of both muscle and fascia. In the central abdomen, the two paired rectus abdominis muscles run longitudinally, one on each side of the abdomen. These are enveloped by two layers of fascia: the anterior rectus sheath and the posterior rectus sheath. The two paired muscles are separated in the midline by the linea alba, a fascial thickening. The rectus abdominis is a paired set of muscles that is vertically orientated either side of the midline, from the xiphisternum to the pubis. These muscles originate from the cartilage of the 5th, 6th, and 7th ribs and the xiphoid process and insert in front of the symphysis and body of the pubic bone (Fig. 2.11a, b).

The external oblique muscle ends in an aponeurosis that runs anterior to the rectus abdominis muscle; by contrast, the internal oblique muscle terminates in an aponeurosis that splits into anterior and posterior layers. The anterior layer passes in front of the rectus abdominis muscle and fuses with the aponeurosis of the external oblique muscle. The posterior layer passes behind the rectus abdominis muscle above the arcuate line. Below the arcuate line, this layer also passes in front of the rectus abdominis muscle. Finally, above the arcuate line, the transverse abdominis muscle ends in an aponeurosis that runs behind the rectus abdominis muscle. Below the arcuate line, the aponeurosis of the transverse abdominis muscle passes in front of the rectus abdominis muscle. Thus above the arcuate line, the posterior layer of the rectus sheath is formed by the aponeurosis of the transversus abdominis and internal oblique muscles. Below the arcuate line, the posterior layer of the rectus sheath is formed by the fascia transversalis alone. In the lateral hemi abdomen, there are three paired muscles stacked on top of each other, providing significant core strength. From superficial to deep, these are the external oblique, the internal oblique, and the transversus abdominis muscles. This layer of muscles is separated from the more central rectus abdominis muscle on each side by the linea semilunaris, another fascia thickening.

Abdominal pedicled and free flaps are based on blood vessels that supply the transverse rectus abdominis muscles (TRAM) and the overlying adipocutaneous tissue. In addition to this, the lower abdominal skin and fat also receives a blood supply from the superficial inferior epigastric system that derives from the external iliac vessels. The rectus

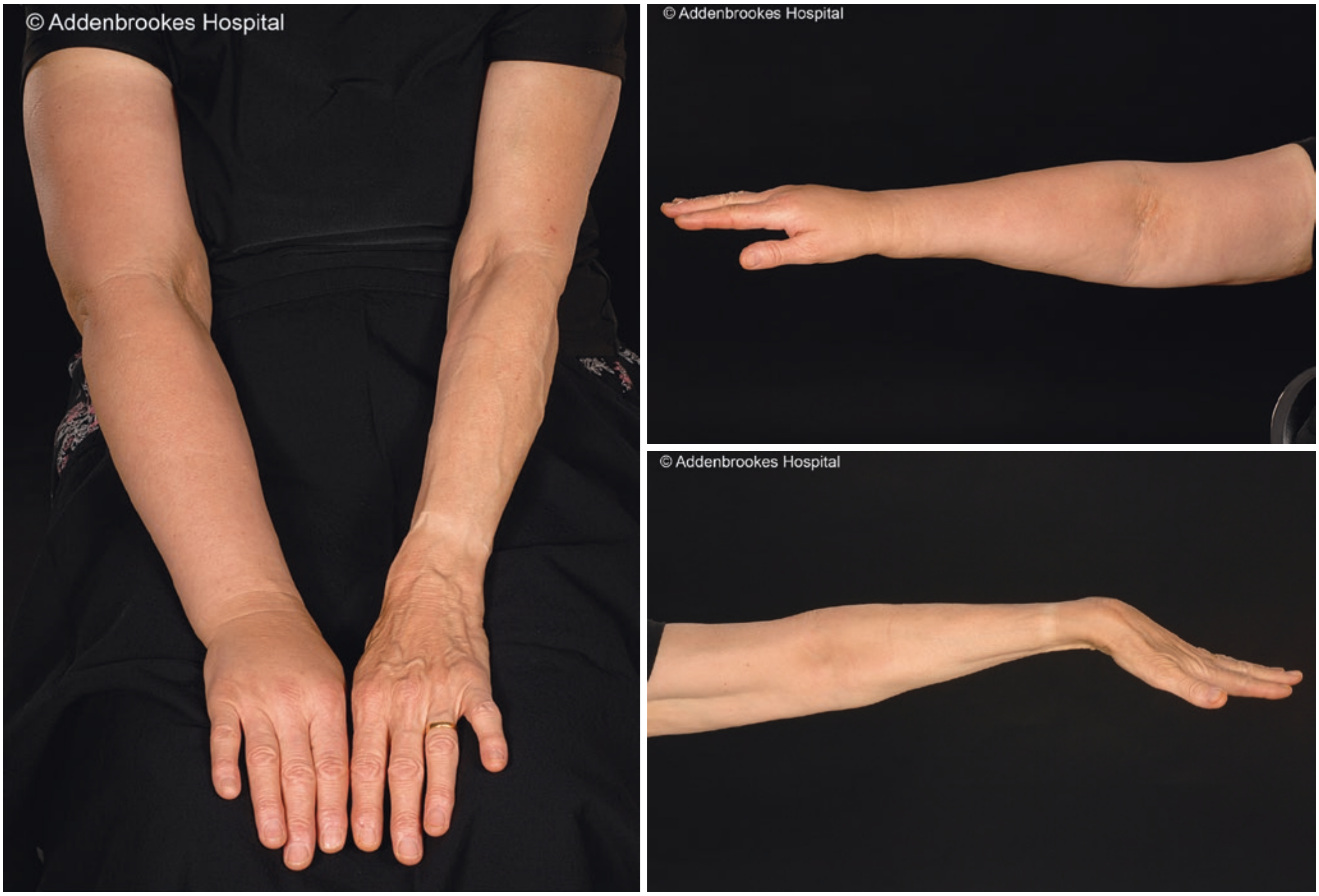


Fig. 2.10 Patient with moderate lymphedema affecting the right upper limb following a radical modified mastectomy

abdominis muscle has a dual blood supply; superiorly this is from the superior epigastric artery (a continuation of the internal thoracic artery) and inferiorly from the deep inferior epigastric artery (a branch of the external iliac artery). The superior epigastric artery is a so-called choke vessel, and its diameter progressively narrows as it passes through the tendinous intersections of the rectus abdominis muscle. In consequence, the dominant blood supply to the lower abdominal wall comes from the inferior epigastric artery which is used for a free TRAM flap reconstruction. Within the rectus sheath, these epigastric vessels enter the deep surface of the muscle and terminal branches of the superior epigastric artery and inferior epigastric artery anastomosis with each other (Fig. 2.11b). The inferior epigastric vessels enter the rectus sheath at the arcuate line. From these deeper vessels within the belly of the muscle, small perforating blood vessels traverse the rectus abdominis muscle and enter the overlying skin and adipose tissue, creating a network of vessels that connect across the anterior abdominal wall. This system forms the basis for the deep inferior epigastric perforator (DIEP) flap that harvests skin and adipose tissue of the lower abdominal wall while preserving much of the rectus abdominis muscle and rectus sheath. The blood supply to the anterior abdominal wall consists of three distinct zones. Zone 1 consists of the epigastric artery and vein. Zone 2 consists of the superficial pudendal vessels. Zone 3 consists of the lateral intercostal vessels. Knowledge of these blood vessels is important in understanding the blood supply to postsurgical abdominal incisions. Following harvest of an abdominally based free flap for breast reconstruction, the upper abdominal skin flaps are perfused by the intercostal vessels of Zone 3. Thus, limited undermining of these skin flaps from the underlying fascia will allow for greater maintenance of blood supply to this area and thus greater healing potential.

The advent of the DIEP flap was a significant advance in refining abdominal flap breast reconstruction and permits skin and fat of the lower abdomen to be harvested as a free flap based solely on the perforating vessels from the deep inferior epigastric system. Total muscle and fascia preservation combines the advantages of autologous abdominal tissue for breast reconstruction while minimizing the risks of morbidity from disrupting the integrity of the anterior abdominal wall. Moreover, in the lateral abdomen, the intercostal nerves run in the layer between the internal oblique muscles and the transversus abdominis muscles. Thus, dissection superficial to the internal oblique muscles will not risk deneurotization of the abdomen.

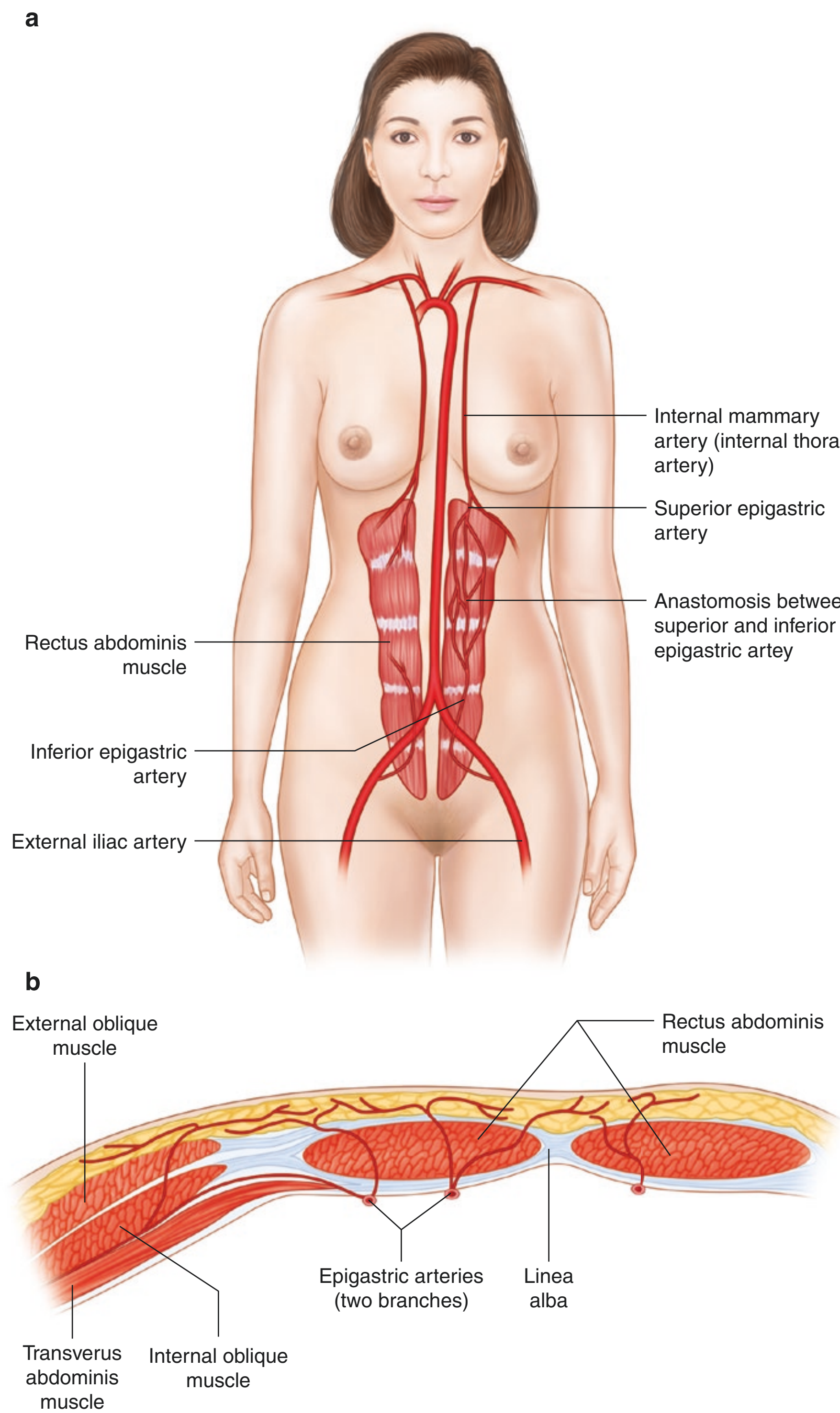


Fig. 2.11 (**a, b**) Anterior abdominal wall and blood supply

2.8 Physiology

2.8.1 Development and Function

Breasts are functionally dynamic organs whose activity is controlled by a variety of hormones and chemical modulators. These collectively ensure that the primary function of the breasts is fulfilled and sufficient milk is produced to sustain the newborn infant. Some of these directly influence physiological processes, while others act in a permissive capacity, but collectively they are important for breast development, secretion (lactogenesis), and milk production (galactopoiesis). Estrogen promotes duct elongation and branching as well as fat deposition; progesterone governs lobule development and establishes the secretory state. The two hormones act synergistically to coordinate breast development, and although estrogen stimulates development of the breast, it cannot act alone and is dependent during development on several hormones including hydrocortisone, insulin, and growth hormone. During pregnancy, the secretory units of the breast (alveoli) further develop under the influence of prolactin that not only stimulates mammary growth and differentiation but also triggers milk production and release after parturition. Prolactin is produced both centrally in the pituitary gland and locally in the breast where it acts as a paracrine or autocrine growth factor under the influence of progesterone. Suckling results in release of the pituitary peptide oxytocin that binds to receptors on the myoepithelial cells leading to contraction and release of milk.

Towards the end of the first trimester, gender differentiation occurs under the influence of estrogen and testosterone. The primitive duct system of the breast starts peripherally and grows towards the center with between 6 and 10 ducts converging upon the nipple at birth. Maternal progesterone stimulates lobular development with end-vesicle formation, but there is much variation in the degree of morphological differentiation in the neonate with some having a relatively advanced epithelial phenotype with secretory function. After birth, the abrupt withdrawal of female sex hormones allows endogenous neonatal prolactin to act directly upon alveolar epithelium to stimulate newborn breast secretion. This results in production of colostrum (or witches' milk) that can be expressed from the breasts of both sexes in about 90% of newborn infants (declining over a period of 3–4 weeks). There may be a transient hyperplasia of the breast epithelium in the immediate postnatal period, but subsequently the breast tissue regresses and involutes with loss of end vesicles. These changes occur in response to withdrawal of placental hormones, but during childhood the end vesicles become further canalized with minimal branching of the ducts and no alveolar formation. Puberty heralds the end of this period of dormancy.

Puberty in girls occurs around the age of 10–12 years in response to activation of the hypothalamo-pituitary-gonadal axis. Gonadotropin-releasing hormone from the hypothalamus causes secretion of follicle-stimulating (FSH) and luteinizing (LH) hormones from the anterior pituitary, and these stimulate the ovarian follicles to produce estrogen (17-estradiol). Breast epithelium is initially stimulated by estrogen only (estradiol), and this results in longitudinal growth of ducts with formation of buds from terminal ducts. Development of lobules containing the functional unit of the breast occurs after ovulation when progesterone is released from the corpus luteum. This together with an increase in the supporting peri-ductal connective tissue leads to lobular development and attainment of the mature breast in size, form, and shape. Thus estrogen and progesterone together are essential for complete development of ducts, lobules, and alveoli, but their relative roles remain unclear (Fig. 2.12a–d).

2.8.2 Menstrual Cycle

The period between menarche and menopause is termed the estrogen window and is characterized by repetitive cyclical changes reflecting hormonal fluctuations during the menstrual cycle. Defined histological changes occur within breast tissue, and these correlate with stages of the cycle. The follicular phase represents the period from onset of menstruation until ovulation. During this proliferative phase, FSH levels are high and encourage the maturing Graafian follicle to produce estrogen. This stimulates mitotic activity and RNA synthesis within epithelial cells together with proliferation and budding of ducts. Estrogen exerts a negative feedback effect with inhibition of FSH secretion as levels of estrogen peak towards the end of the follicular phase. There is a concomitant surge in LH secretion immediately prior to ovulation that causes swelling and rupture of the follicles and oocyte release. Expression of connective tissue and progesterone secretion in the luteal phase results in increased blood flow, lobular edema, and thickening of the basement membrane. This together with enlargement of alveolar diameter and appearance of secretions in response to elevated prolactin causes a cyclical increase in breast size of 15–30 mls. At the end of each menstrual cycle, there are regressive changes with shrinkage of lobules and alveoli accompanied by narrowing of lumina. There is a reduction in tissue edema, and breast volume returns to normal 1 week after menstruation (Fig. 2.13).

2.8.3 Menopause

The menopause occurs in most women around the age of 50 years with cessation of ovarian function and resultant climacteric symptoms such as hot flushes, night sweats, mood/sleep disturbance, and vaginal dryness. Involutional changes result from loss of hormonal stimulation (estrogen and progesterone) and involve absolute reduction in numbers of both ducts and lobules with loss of approximately three-quarters of terminal duct lobular units. Within the remaining lobules, there is thinning of epithelial and myoepithelial layers, thickening of the basal lamina, and obliteration of the lumina. This process may culminate in a scattering of atrophic ducts and acini within a hyalinized stroma with much of the breast parenchyma being replaced with fatty tissue. This increases the sensitivity of mammography in postmenopausal women, and this represents the group targeted in national screening programs.

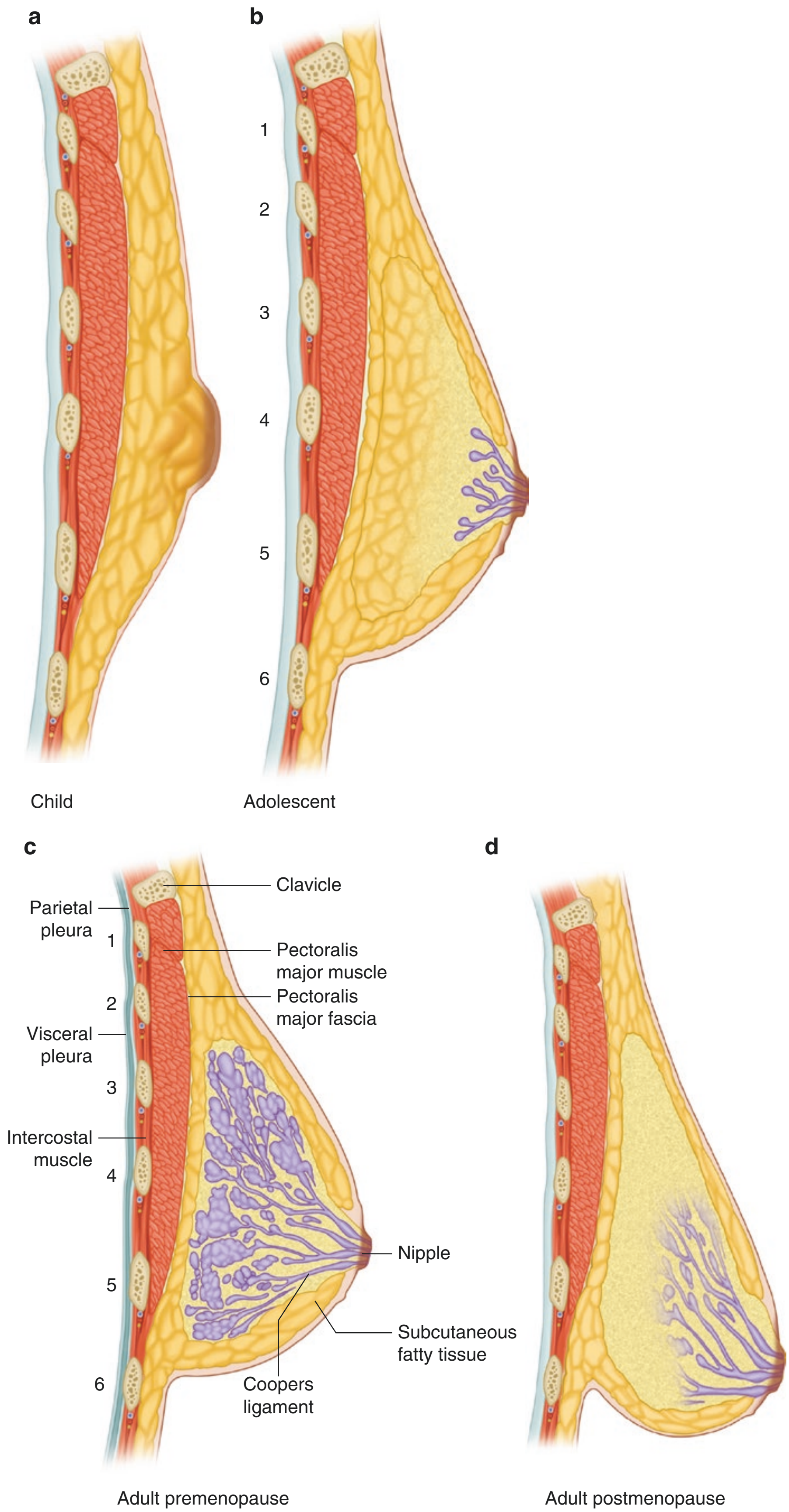


Fig. 2.12 (**a–d**) Breast development. (**a**) In a prepubertal girl, the mammary glands grow and branch slowly. (**b**) In adolescence, the mammary glands develop rapidly, with the growth of the duct system influenced by estrogen and progesterone. (**c**) The adult premenopausal breast. (**d**) The adult postmenopausal breast. Ribs are numbered in (**b**) and (**c**)

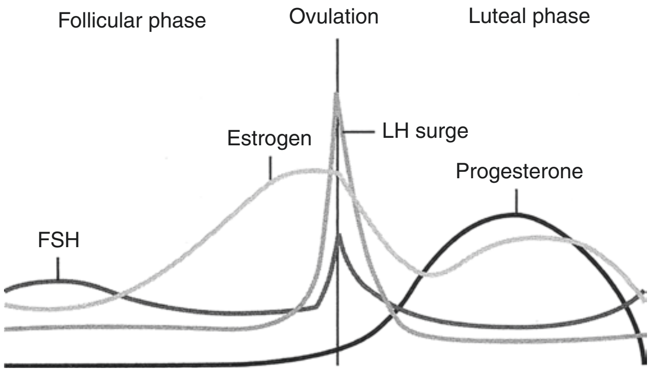


Fig. 2.13 Changes in hormonal levels in relation to the menstrual cycle

2.8.4 Pregnancy

During pregnancy there is intense stimulation of breast tissue in response to alterations in hormonal balance, and this leads to maximal breast development in preparation for lactation. These changes are driven by a surge of sex steroids from the placental unit (human placental lactogen and human chorionic gonadotropin) together with prolactin and growth hormone from the anterior pituitary gland.

Phase of Proliferation In the early stages of pregnancy, there is proliferation of ducts, lobules, and alveoli with a tenfold increase in the number of alveoli per lobule. More lobules are formed, and the degree of ductal sprouting and elongation far exceeds that seen in the menstrual cycle. A more differentiated form of lobule characterizes the end of the first trimester when there is noticeable breast enlargement and patients often report a sensation of breast heaviness and fullness. There is often venous engorgement in the overlying skin with the nipple and areola becoming more pigmented as the areola enlarges.

Phase of Differentiation Lobular-alveolar development is completed during the second trimester of pregnancy when rising progesterone levels promote differentiation of lobules into secretory units lined by a single layer of epithelium. Progesterone also inhibits ductule growth and stimulates mesenchymal elements with a massive increase in blood supply. During the third trimester, there is some loss of stroma to permit expansion of hypertrophic lobules that gradually fill with colostrum. Increased vascularity coupled with distension of colostrum-laden alveoli leads to a net increase in breast size with an average weight gain for each breast of 350 g (Fig. 2.14).

2.8.5 Lactation

Synthesis and secretion of milk occurs during the second half of pregnancy with prolactin production continuing from the 8th week of pregnancy until birth. The action of prolactin is partially antagonized during pregnancy by placental hormones, but this influence is abruptly removed at parturition together with suppression of prolactin inhibitory factor from the hypothalamus. Prolactin is primarily responsible for milk production, but the secondary actions of cortisol, insulin, and growth hormone are permissive. High circulating levels of estrogen and progesterone during pregnancy suppress development of prolactin receptors on alveolar cells and thus prevent manifestation of the full secretory phenotype until after parturition. Secretion of mature milk begins approximately 30–40 hours after birth, and although prolactin levels return to near normal, suckling induces periodic surges of prolactin release from the anterior pituitary via a neuroendocrine reflex which relays signals from sensory nerve endings in the breast to the hypothalamus. Suckling can maintain lactation indefinitely and averages 1–2 mls/g of breast tissue per day. During the first few days, postpartum colostrum is secreted which is a thick yellowish immature milk product rich in immunoglobulins. Immunoglobulin G provides passive immunity to protect the newborn infant from infection and possibly future atopic disposition.

Oxytocin is produced in the hypothalamus and stored in the pituitary from where it is released by the suckling stimulus. This is the second hormone involved in milk production and additionally is responsible for the milk letdown reflex. Myoepithelial cells contract with expulsion of milk into the lactiferous sinuses. Oxytocin causes contraction of smooth muscle around major lactiferous ducts, encouraging expression of milk. Secretion of oxytocin can be modulated by physiological factors; anticipation of breastfeeding increases while pain and anxiety inhibit secretion. When suckling stops, prolactin levels are no longer stimulated, and the breast involutes to its prepartum state.

2.9 Clinical Features

There is much variation in the physical characteristics of individual breasts; some patients have lumpy (or nodular) breasts that render palpation of a discrete or separate lump more difficult. Superimposed on this physical spectrum are the changes influenced by age and hormonal status. The breast undergoes reversible proliferative changes during each menstrual cycle, and this can exacerbate any preexisting lumpiness. At puberty, the breast texture is dense, compact, smooth, and homogeneous. During lactation, the glands separate into smaller bodies with indentations around them, i.e., become lobulated. A similar change occurs in the nulliparous breast towards the menopause. This lobulation must be distinguished from a discrete lump, particularly malignancy. The formal assessment of a breast lump or lumpiness now involves a combination of clinical examination with breast imaging (mammography, ultrasound) and possible percutaneous biopsy. Beyond the

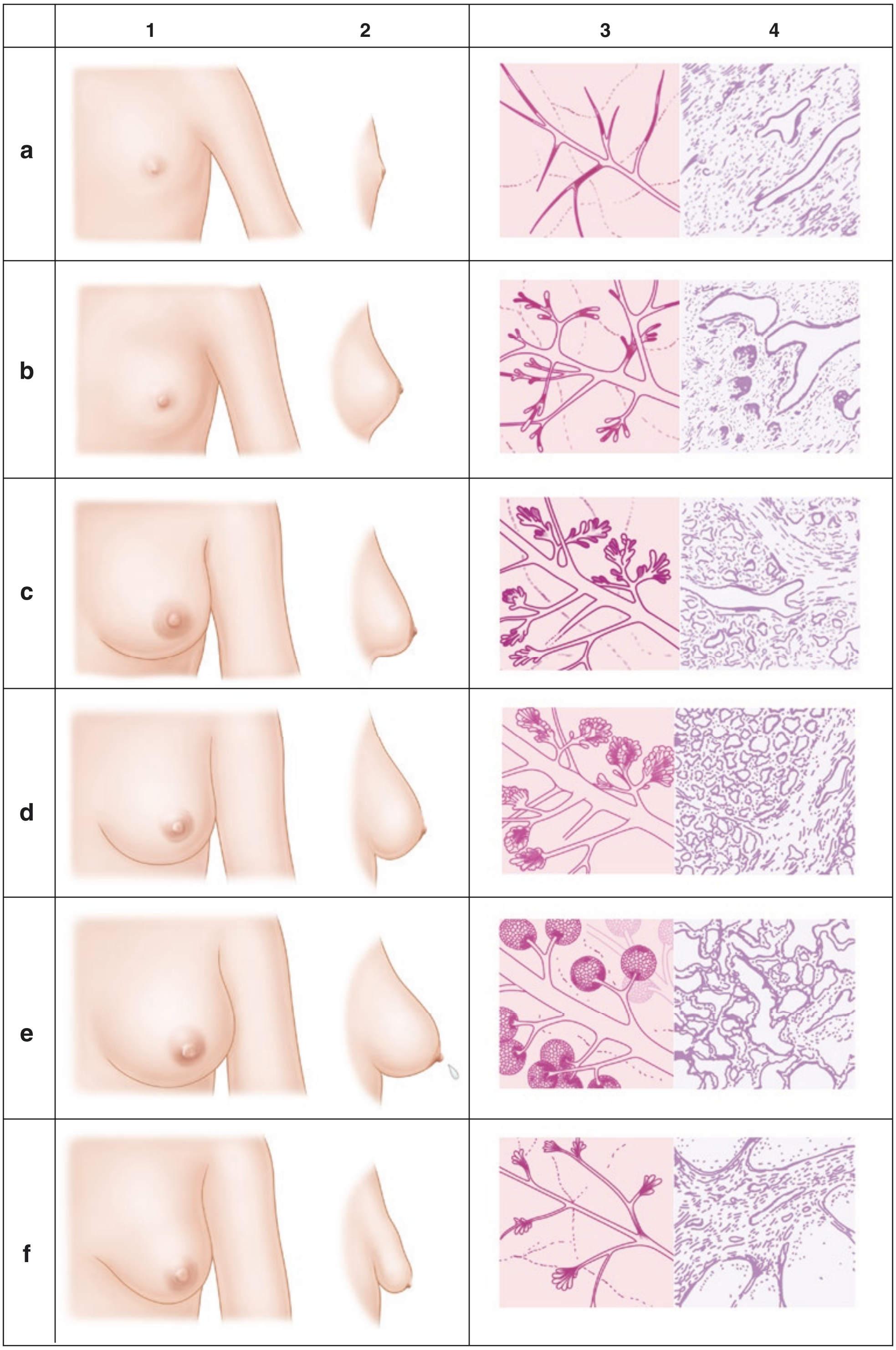


Fig. 2.14 Schematic representation of mammary gland developments showing anterior and lateral views of the breast together with corresponding microscopic appearances of ducts and lobules at the following time points (**a**) prepubertal (childhood), (**b**) puberty, (**c**) mature (reproductive), (**d**) pregnancy, (**e**) lactation, and (**f**) postmenopausal (senescent) state (Reproduced with permission from Copeland EM III, Bland KI: *The Breast* (Section II, Chapter 2). Philadelphia. WB Saunders, 1987)

menopause, lobulation becomes less apparent due to atrophy of glandular parenchyma and deposition of adipose tissue. By contrast, the glandular tissue undergoes marked proliferation and hypertrophy during pregnancy with an increase in blood supply. The breasts become full, heavy, tense, and often painful.

3 Diagnostic Pathways

3.1 Clinical Examination

Evaluation of breast cases is based on the principle of "triple assessment" involving a combination of clinical examination, imaging, and tissue biopsy. This yields an overall accuracy of almost 100% and permits the majority of patients attending "one-stop" clinics to be reassured and discharged without further follow up. There is much overlap in the clinical features of benign and malignant breast conditions, and physical examination alone has limited accuracy. This underscores the principle of triple assessment in which clinical examination is complemented by radiological imaging with or without some form of tissue biopsy. A review of almost 7000 patients undergoing "triple assessment" within one of the author's unit revealed an accuracy of 99.6% with only 0.4% of cases representing a "missed diagnosis" on retrospective review. Patients present to breast clinics with a range of symptoms but two-thirds will have either a lump or an area of lumpiness (nodularity). Many breast complaints such as pain, lumpiness, and nipple discharge may be sequelae of normal physiological changes taking place at different stages of reproductive life and in response to cyclical hormonal changes. Benign conditions such as fibroadenosis and fibroadenomas may present with lumps that fluctuate with the menstrual cycle or have decreased in size since first noticed by the patient. They are also more likely to be associated with pain and tenderness than a malignant breast lesion.

A previous history of benign breast conditions, particularly cysts or fibrocystic change, can be important indicators of the likely nature of any current breast problem. A proportion of those complaining of a breast lump will not actually have a discrete or dominant mass but rather an area of focal nodularity that represents a prominent area of normal glandular tissue or an abnormality of normal development and involution (ANDI). The latter is a spectrum of changes in breast parenchyma (epithelial elements, and stroma). Distinction may be evident on clinical examination, but often further evaluation with ultrasound is necessary to confirm the presence of a discrete mass (Fig. 3.1a–c). Ultrasound examination has a high sensitivity for detection of focal mass lesions and can usually distinguish between benign, malignant, and suspicious lesions (Fig. 3.2a–c).

A mammogram would not normally be performed on a patient under 35 years of age due to reduced sensitivity in young women and risk of unnecessary radiation exposure (Fig. 3.3a, b).

However, once a suspicious lesion is identified on ultrasound in a younger patient, this should be further evaluated with mammography as this is likely to provide additional information, particularly changes of calcification. Clinical classification is based on a scoring system as follows:

- E(P)1 = normal
- E(P)2 = benign
- E(P)3 = suspicious probably benign
- E(P)4 = suspicious probably malignant
- E(P)5 = malignant

Although this is a pragmatic system, the designation of a lesion as E3 can present challenges to the assessment process. The important question is whether further evaluation with needle biopsy is indicated following discussion between the clinician and radiologist. Some breast units have a policy that patients examined by a "non-consultant" grade/resident with an E3 lump, and normal/benign imaging (without needle biopsy) should be reexamined by another clinician. There is published evidence that performance in clinical breast examination is highly variable depending on clinical grade and experience (range 44.6–65.9%). More senior clinicians were significantly less likely to designate a lump as E3 compared with more junior colleagues. There was a strong downward trend in the percentage classified as E5 as sensitivity for breast cancer detection decreased. When patients are discharged after "triple assessment," it is mandatory to inform patients that if they remain worried or changes persist, they should return to their doctor for reassessment. Patients do not require routine follow-up with clinical review and/or repeat ultrasound examination for benign and non-suspicious find-

I. Jatoi et al., *Atlas of Breast Surgery*, https://doi.org/10.1007/978-3-030-45951-2_3

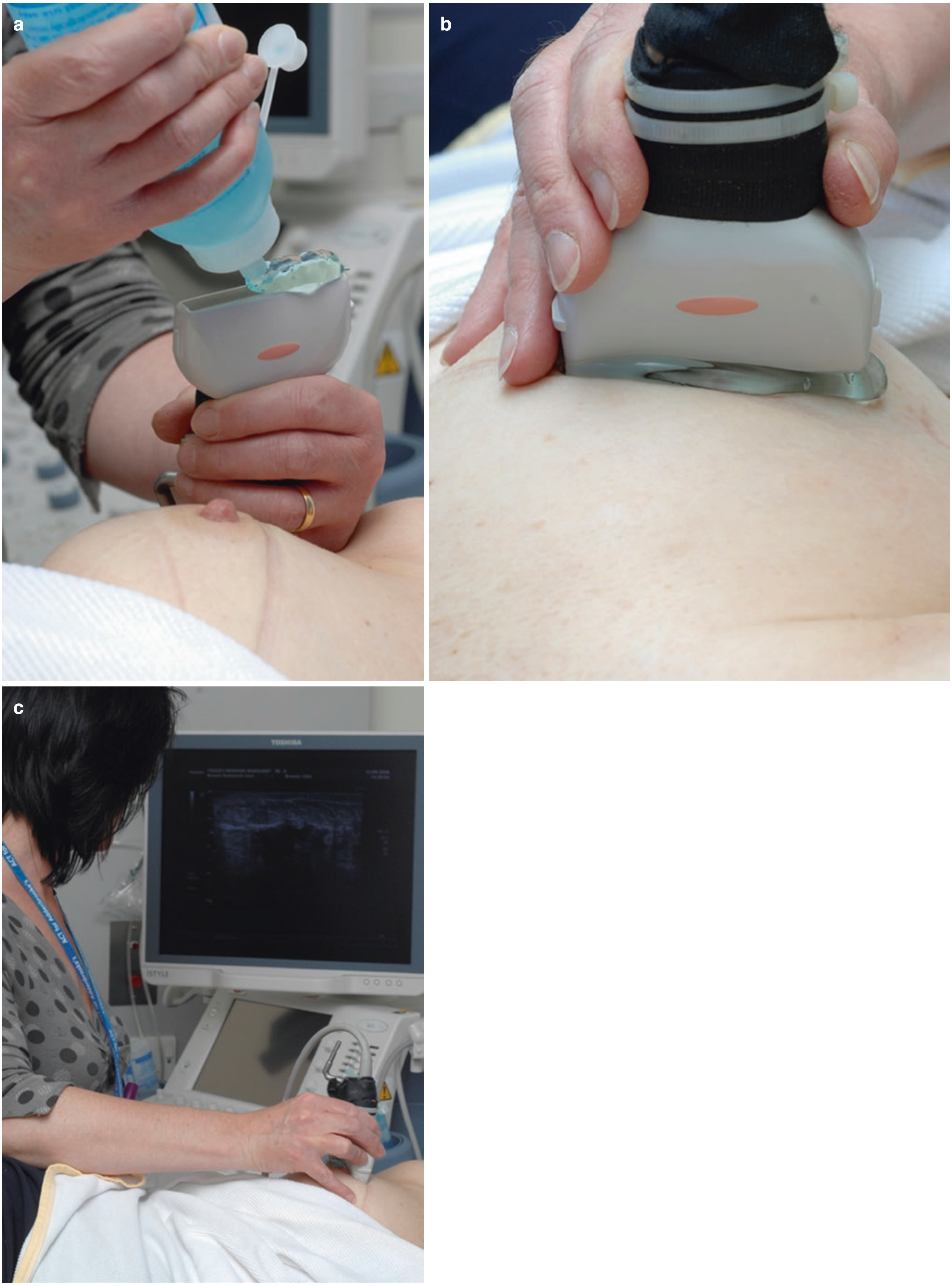


Fig. 3.1 (**a**–**c**) Modern B-mode breast ultrasound machine with handheld probe

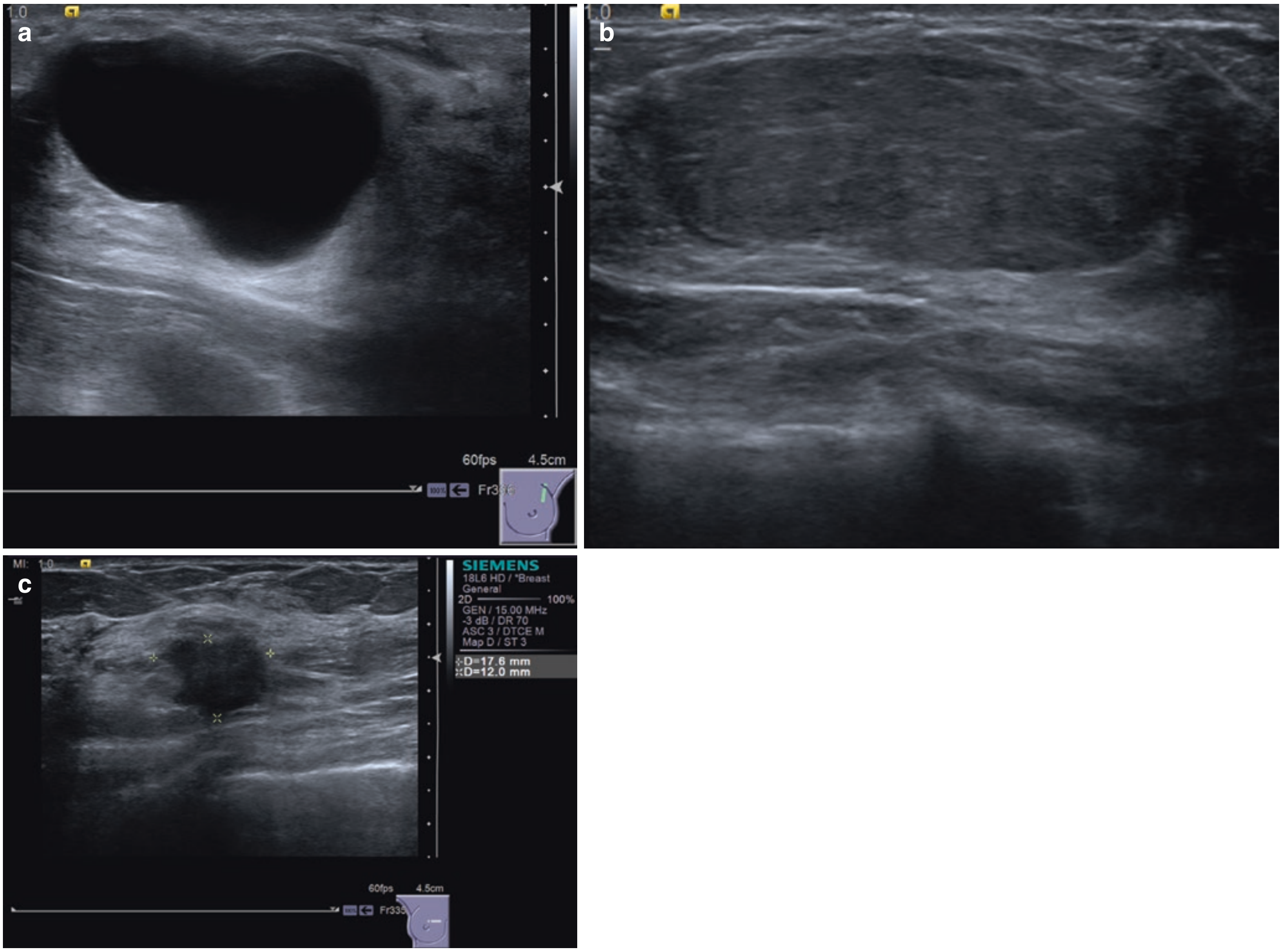


Fig. 3.2 Breast ultrasound can readily distinguish between breast cysts (**a**), benign solid (**b**), and malignant solid lesions (**c**). There is through transmission of ultrasound waves in cysts with a posterior enhancement. Solid lesions have internal echoes that are typically hypoechoic for malignant lesions (**c**) that are taller than wide in comparison with benign lesions

ings on triple assessment. Sometimes patients are falsely reassured after attending a one-stop clinic and being informed that there are no suspicious findings (despite persistence and even enlargement of a lump).

The principle of "triple assessment" implies that patients are considered for some form of percutaneous biopsy, but this is not mandatory and does not indicate inadequate evaluation (Fig. 3.4a, b). Usually needle biopsy is prompted when there is a clearly palpable, discrete mass and there is suspicion on clinical or radiological assessment. However, it is important to be selective with needle biopsy in order to maintain a favorable benign to malignant biopsy ratio – this is an important quality control parameter, particularly for screen-detected lesions. Sometimes a patient will have an area of focal nodularity with the impression of a dominant lesion within, but no overtly dominant mass. A localized area of focal nodularity attributable to fibrocystic changes can appear clinically suspicious but quite innocent on ultrasound with no focal abnormality that can be readily targeted for biopsy. Some cancers are mammographically or sonographically occult, but this represents no more than 10% of cases (more tumors fail to be visualized on mammography then ultrasound examination). An innocent ultrasound assessment performed by an experienced operator can usually exclude more sinister pathology, but ultimately there is a judgment call in terms of the clinical examination component – there is much variation in the sensitivity of clinical breast examination (CBE) between clinicians, and what is considered E3 by one may be rated as E2 another. A study from North America found that 43% of doctors considered themselves to have poor clinical breast examination skills, and only 50% were moderately confident. The clinical classification necessarily has a subjective element in these indeterminate cases, and this presents a challenge for "triple assessment"; an excessive proportion of "B2 cores" should be avoided, but missed cancers minimized. Therefore a balance must be reached based on clinical and radiological features and discussion between clinician and radiologist. Less experienced practitioners may be tempted to "biopsy everything," while others attempt to be as selective as possible and biopsy only

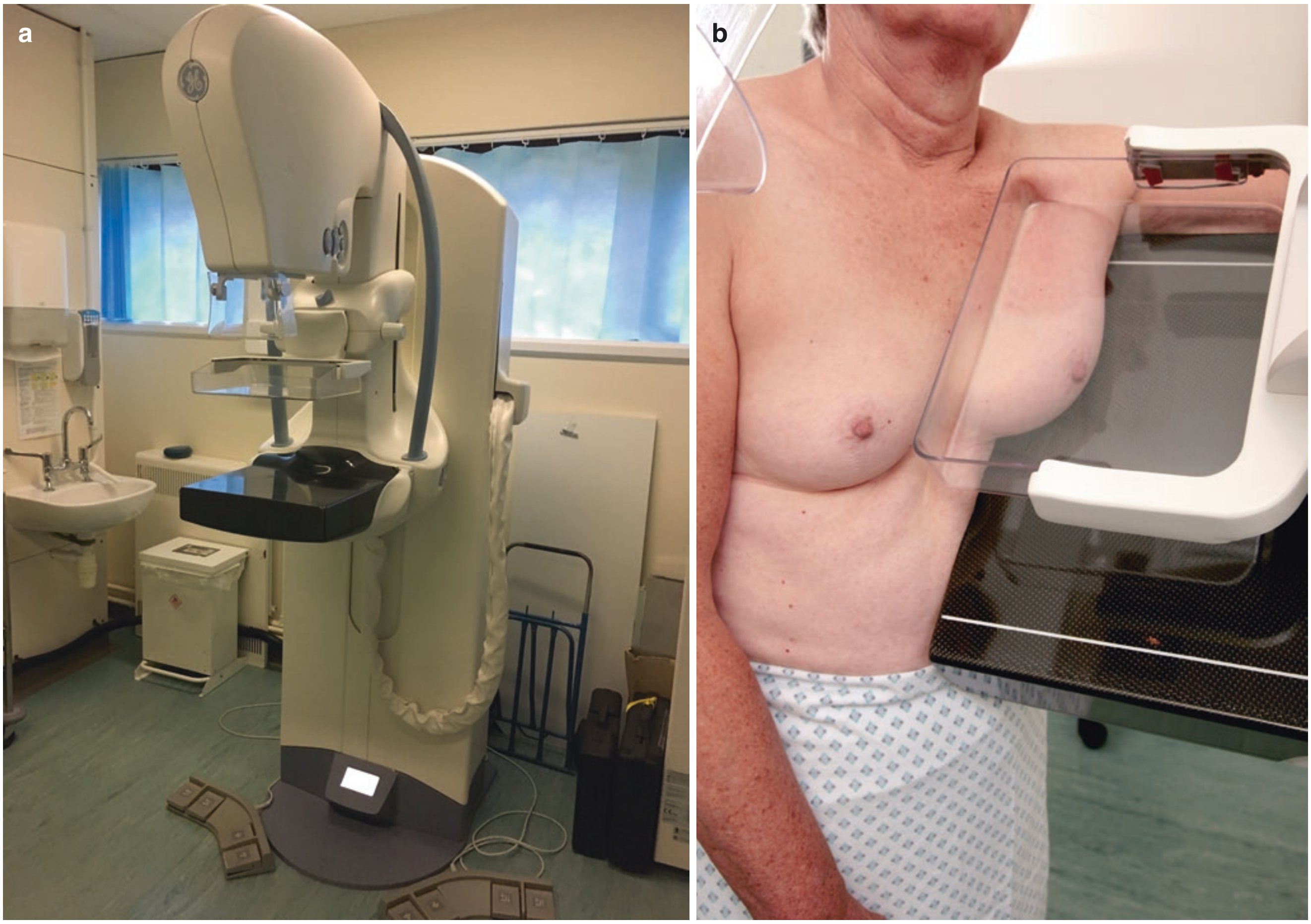


Fig. 3.3 (**a**, **b**) Mammography has reduced sensitivity in younger women due to higher breast density which masks underlying lesions and is not routinely employed for symptomatic investigation of women aged <35 years

those lesions which have a significant probability of malignancy. Every unit should carefully audit their results periodically to ascertain whether too many or too few core biopsies are being undertaken.

In the absence of core biopsy, it is a sensible suggestion to arrange a follow-up examination to determine whether the area of clinical concern has regressed (particularly in response to the menstrual cycle). Faced with an unchanged situation, a core biopsy could then be undertaken (a cancer is unlikely to have enlarged significantly in a 6-week period) or further radiological interrogation undertaken with MRI imaging.

3.2 Imaging Studies

Mammography – mammography is normally undertaken for all women aged ≥35 years presenting with a breast mass. Some units in the United States will routinely perform mammography over the age of 30 years but are increasingly recognizing that breast density in the age group 30–35 reduces sensitivity with limitations on the accuracy and interpretation of imaging. An initial distinction must be made between a circumscribed mass on mammography and an asymmetric density; the former is a localized lesion of homogeneous density that is round in shape with convex margins (Fig. 3.5).

By contrast, an asymmetric density has mixed density and concave margins (Fig. 3.6).

Benign lesions typically have well-defined margins, while malignant lesions are characterized by ill-defined, spiculate margins that represent a desmoplastic reaction within surrounding stromal elements (Fig. 3.7a, b).

Radiological assessment of a lesion on mammography will take account of the patient's age together with features such as number, size morphology, and density of lesions in addition to calcifications (Figs. 3.8, 3.9, and 3.10).

Tomosynthesis can help to spread out the breast tissue and prevent a lesion being obscured against the background of normal breast parenchyma. When a lesion is identified on conventional mammography in a patient with relatively dense breast tissue or is manifest as a subtle opacity, tomosynthesis is a useful supplemental investigation (Fig. 3.11).

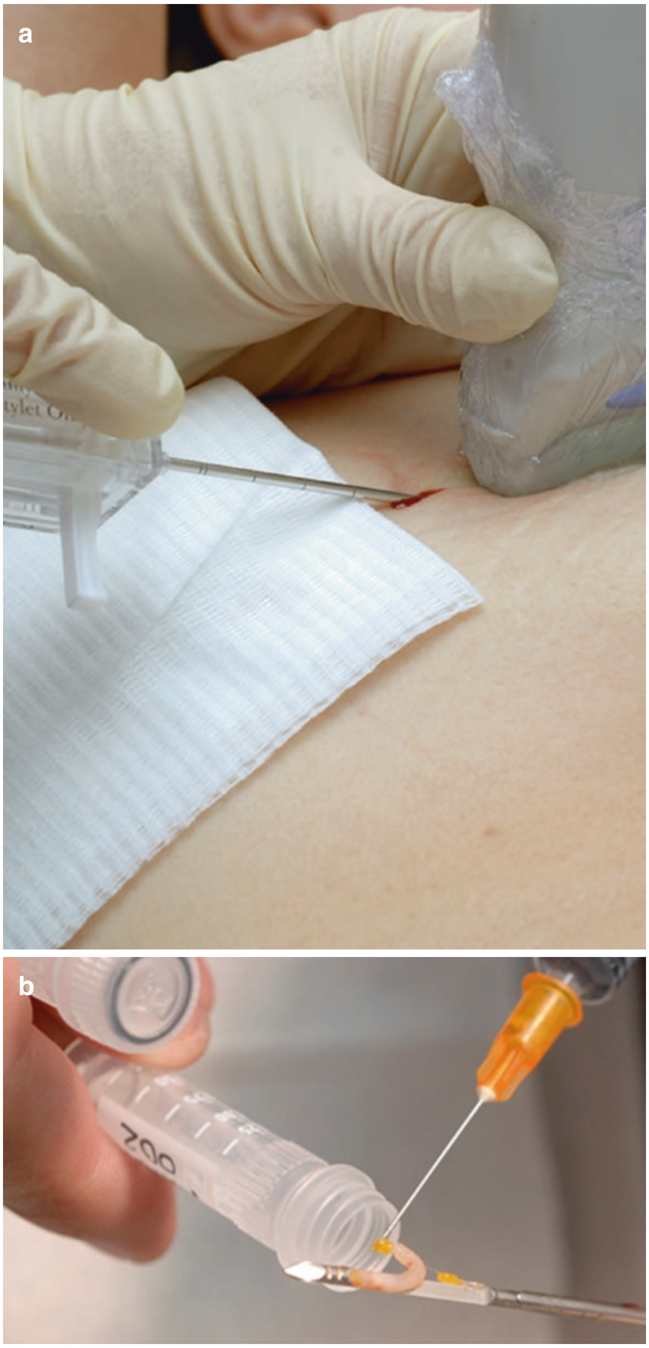


Fig. 3.4 (**a**, **b**) A patient undergoing ultrasound-guided breast biopsy employing a spring-loaded biopsy device (Bard Magnum)

Ultrasound – this is complementary to mammography for assessment of a mass lesion and helps differentiate between benign and malignant lesions. Benign lesions are wider than tall and have an absent or homogeneously reduced internal echo pattern and a bright distal acoustic shadow (Fig. 3.2a). This contrasts with malignant lesions which are taller than wide and have a heterogeneously reduced internal echo pattern and distal acoustic shadowing (Fig. 3.2b). Ultrasound examination is very helpful for evaluation of breast lesions in women <35 years and is the

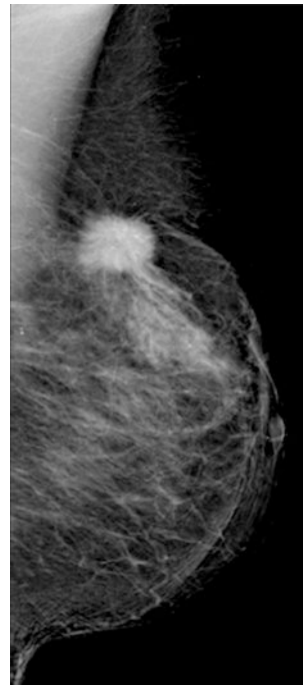


Fig. 3.5 Rounded, well-defined opacity on mammography with an irregular border typical of a malignant neoplasm of the left breast (confirmed on core biopsy)

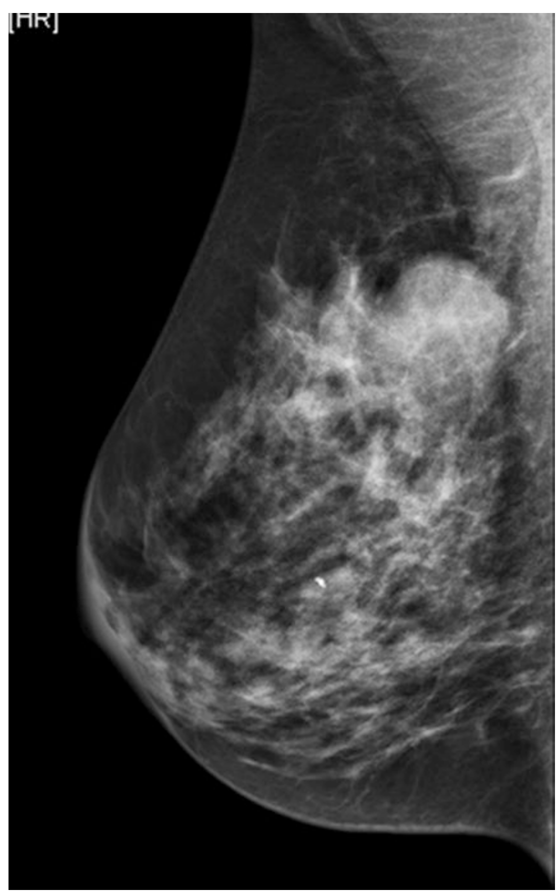


Fig. 3.6 An asymmetric density in the upper outer quadrant of the right breast measuring 38 mm; core biopsy revealed an invasive carcinoma

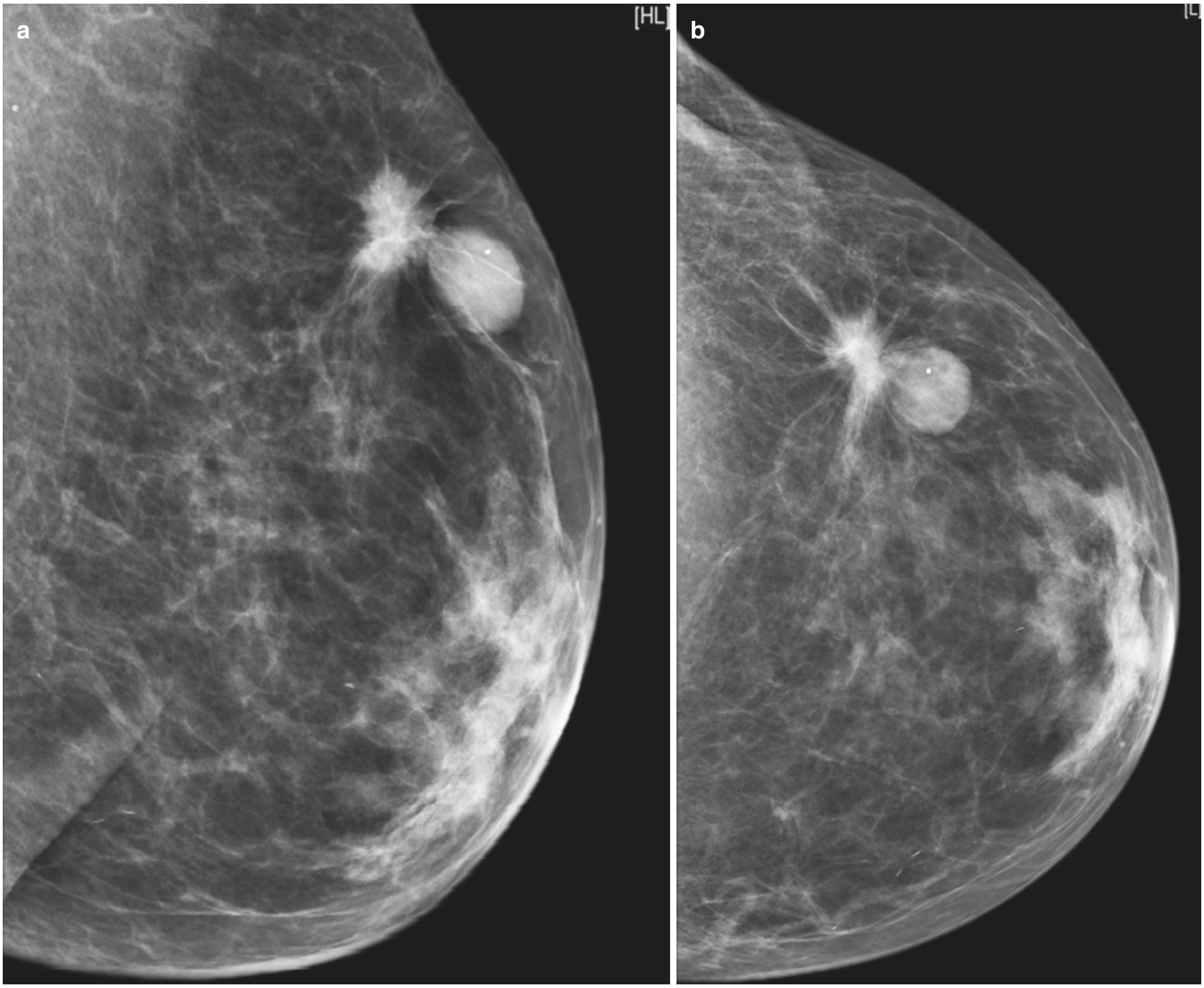


Fig. 3.7 (**a**, **b**) Elderly patient with two discrete contiguous mass lesions in left breast; a smooth round fibroadenoma and spiculate mass lesion characteristic of an invasive carcinoma are evident on both mediolateral (**a**) and craniocaudal views (**b**)

primary modality for image-guided biopsy of breast masses. Once malignancy is suspected on ultrasound or confirmed on biopsy, mammography should be undertaken to determine the presence of calcification and ascertain extent of disease (MRI may also be necessary). Modern forms of ultrasound examination are very accurate with a high negative predictive value – if the ultrasound is innocuous (U2), there is a low probability of malignancy. However, it should be borne in mind that ultrasound is very operator dependent, and interpretation will vary depending on experience.

MRI – magnetic resonance imaging is increasingly being employed in a diagnostic context for clarification of tumor extent and exclusion of multifocal lesions prior to surgery (Fig. 3.12a–c). In an era of complex oncoplastic surgery, it is important to undertake thorough local staging of disease and determine whether any contralateral lesion is present at the time of diagnosis (particularly for lobular cancers) (Fig. 3.13).

Multifocal carcinoma of the left breast involving several different quadrants (multicentric).

Increasing numbers of patients present with breast problems and a history of breast augmentation that can render mammography difficult (Fig. 3.14a, b).

Posterior displacement techniques can be used for implants placed in the subpectoral plane, but for subglandu-

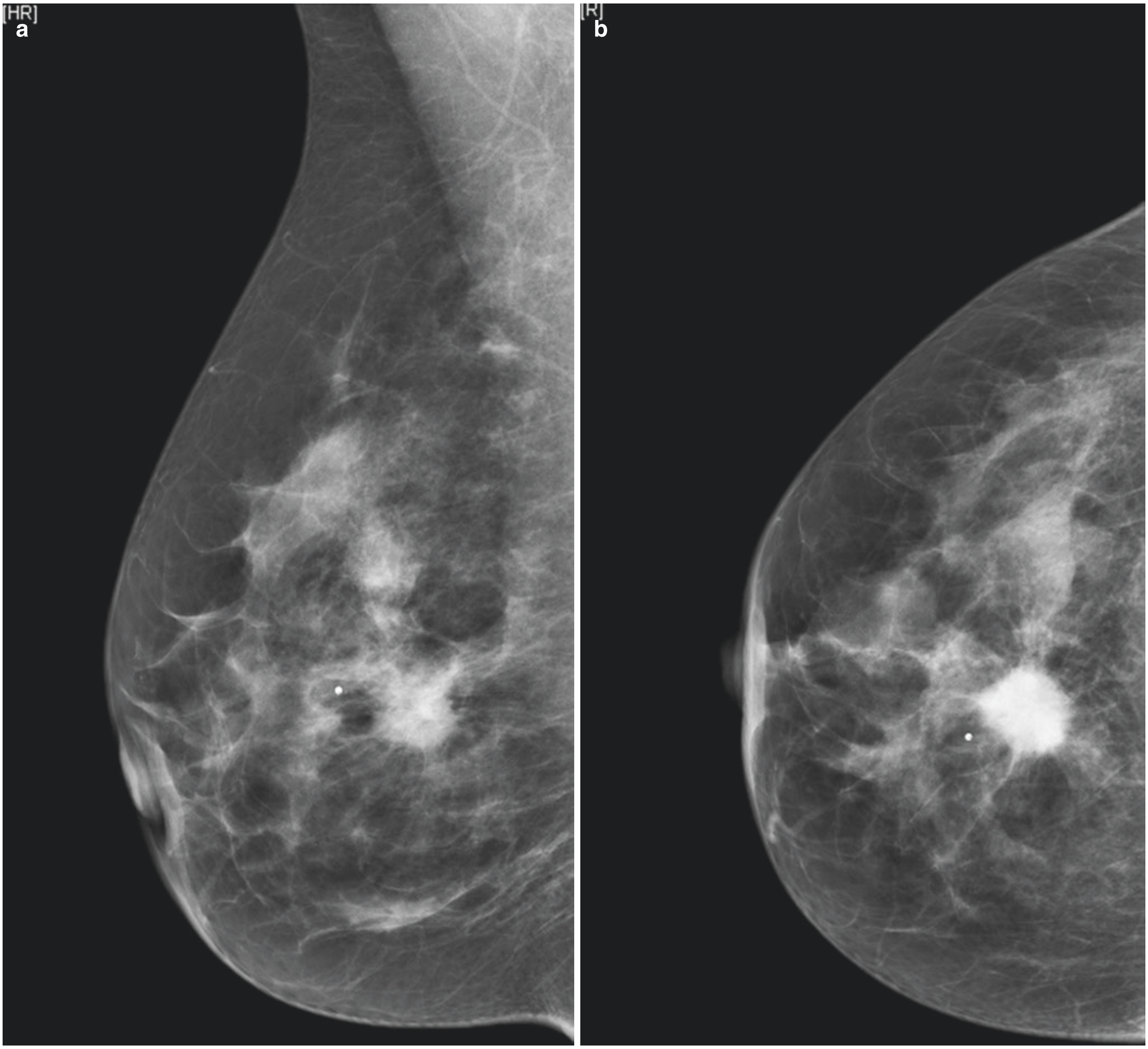


Fig. 3.8 (**a**, **b**) Mediolateral (**a**) and craniocaudal (**b**) views of a malignant spiculate mass lesion in the upper outer quadrant of the right breast presenting as a palpable mass (25 mm)

lar implants, there might still be significant shadowing which can obscure some breast parenchyma. A principle disadvantage of MRI examination (apart from cost) relates to false-positive results; benign lesions have active blood flow and can enhance on MRI that may render distinction from malignant lesions difficult (Fig. 3.15).

MRI relies on dynamic contrast enhancement for distinction between benign and malignant lesions. The former demonstrate slow uptake (type 1 curve), while the latter have a rapid uptake and washout (type 3 curve). Indeterminate lesions have a type 2 curve with moderate early enhancement. If such indeterminate lesions are not evident on second look ultrasound, then MRI-guided biopsy may be necessary (Fig. 3.16).

The latter procedure requires special equipment and highly skilled personnel and can lead to significant delays in surgery for what may ultimately prove to be a unifocal cancer when additional foci of disease are not confirmed.

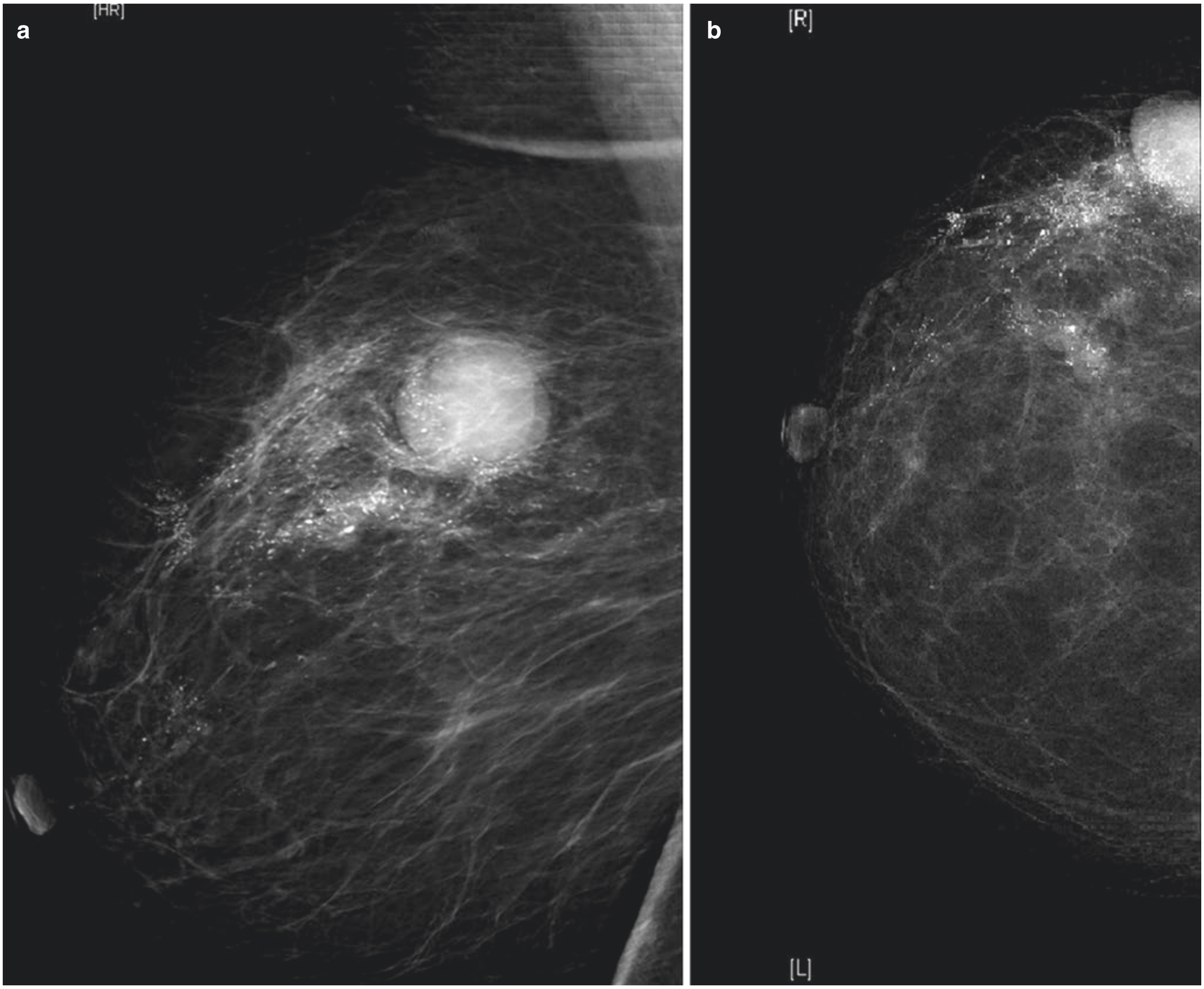


Fig. 3.9 (**a**, **b**) Extensive pleomorphic microcalcification (120 mm) detected incidentally in a patient presenting with a palpable mass. The latter is seen as a smooth well-defined mass on mammography (medio-lateral (**a**) and craniocaudal (**b**) views, measuring 27 mm. Core biopsies revealed high nuclear grade DCIS associated with microcalcification and a papillary neoplasm

3.3 Percutaneous Needle Biopsy Techniques

Percutaneous needle biopsy techniques can now provide a definitive diagnosis for the majority of benign and malignant lesions. The "triple assessment" approach to evaluation of breast masses has dramatically reduced the need for open surgical biopsy, and in particular a definitive preoperative diagnosis can be provided in >95% of cancer cases which allows planning of treatment and fully informed consent from the patient about surgical options. Moreover, it is unacceptable nowadays to perform a diagnostic excision biopsy without any prior image-guided needle biopsy of a breast mass. Use of ultrasound to guide needle biopsy allows accurate direction and placement of needles for either FNAC or core biopsy with real-time visualization of the needle within the lesion (Fig. 3.17).

Linear ultrasound transducers of 7.5 MHz or 10 Mhz allow clear identification of both the needle and the lesion during the biopsy procedure. Wide bore core needle biopsy is preferred to fine needle aspiration and yields cores of tissue that maintain tissue architecture and permit distinction between invasive and noninvasive carcinoma (Fig. 3.18a, b).

The standard core biopsy needle is either 14-gauge or 16-gauge, but larger volumes of tissue can be obtained from vacuum-assisted core biopsy devices – most often 11-gauge (Fig. 3.19).

These larger needles reduce "underdiagnosis" and increase the chance of obtaining a definitive preoperative cancer diagnosis. Nowadays, core biopsy is very much pre-

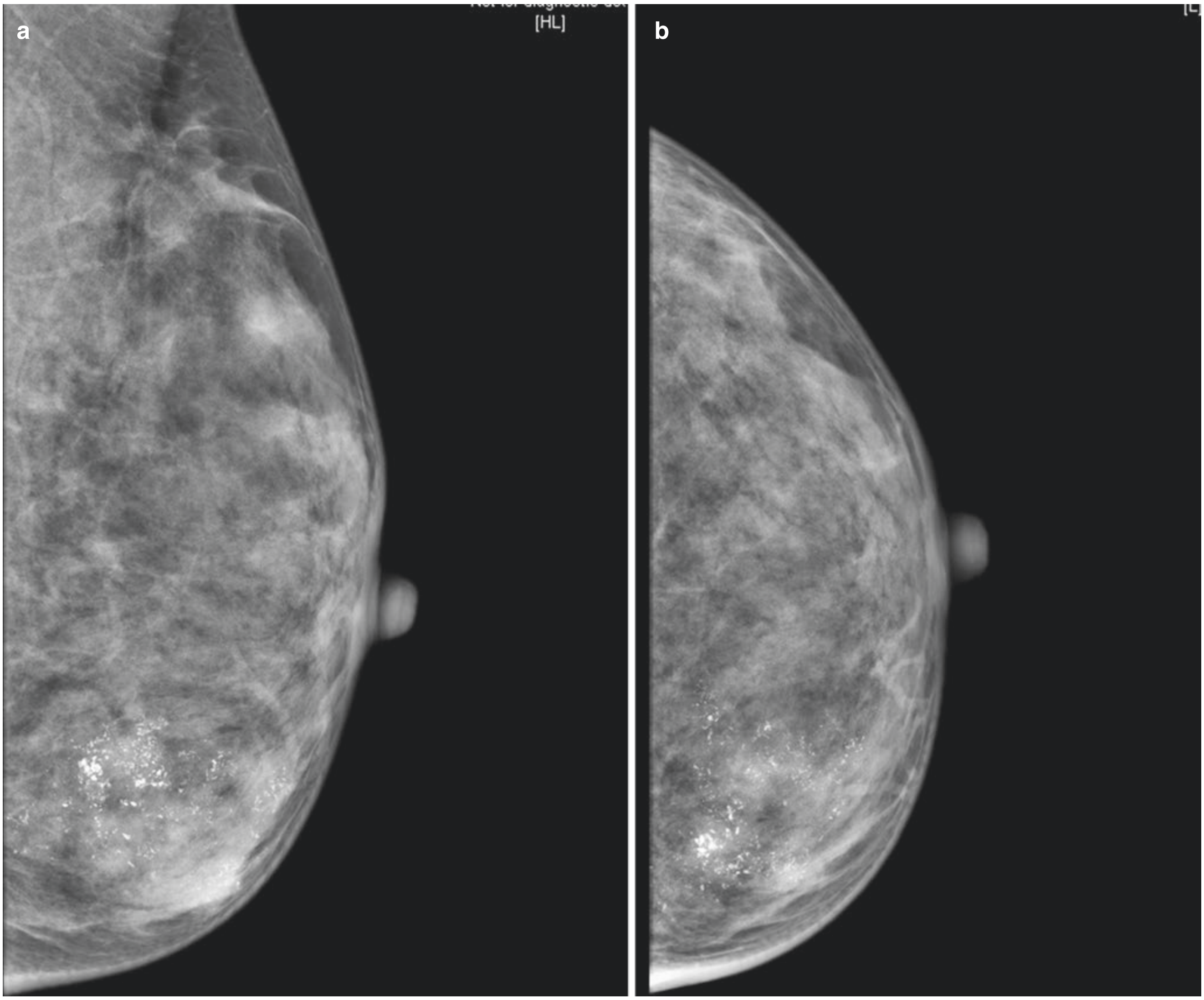


Fig. 3.10 (**a**, **b**) Screen-detected suspicious area of microcalcification in the inferior aspect of the left breast on mediolateral (**a**) and craniocaudal (**b**) views (50 mm). Core needle biopsy confirmed high nuclear grade DCIS with comedo necrosis

ferred over FNAC and does not require the services of a skilled cytopathologist. There are generally fewer equivocal results which usually then lead to core biopsy (rather than diagnostic excision biopsy). There are some units that continue to employ and have good results from FNAC of breast lesions performed either freehand (Fig. 3.20) or under ultrasound guidance, and indeed many radiologists prefer the ease and safety of FNAC for biopsy of axillary nodes.

Fine needle aspiration cytology – this is a simple and relatively quick procedure that can be carried out in less than 1 minute. It can readily distinguish a solid from a cystic lesion, and material from a cellular smear can be interpreted within a few minutes. Historically, this technique underpinned the concept of a "one-stop" clinic in which a patient could attend for assessment and receive a definitive diagnosis during the clinic on the same day. This setup requires the services of an experienced cytopathologist who can provide high levels of accuracy with sensitivity of about 95% and specificity approaching 100%. Although false-positive rates are very low, FNAC cannot distinguish between invasive and noninvasive disease, and this has relevance in the era of neoadjuvant chemotherapy. Moreover, confirmation of malignancy with a C5 designation usually requires a subsequent core needle biopsy to ascertain receptor profiles (estrogen receptor, progesterone receptor, HER2, and Ki-67) (Fig. 3.21a, b).

The designation of C3 and C4 is especially problematic as there are insufficient cytological features to declare malignancy, and yet these lesions cannot be accepted as benign. Further tissue acquisition is mandatory in these circumstances and essential for distinction between atypical ductal proliferation and low-grade DCIS. False-negative rates for FNAC are 2–3% which are relatively high and attributable to

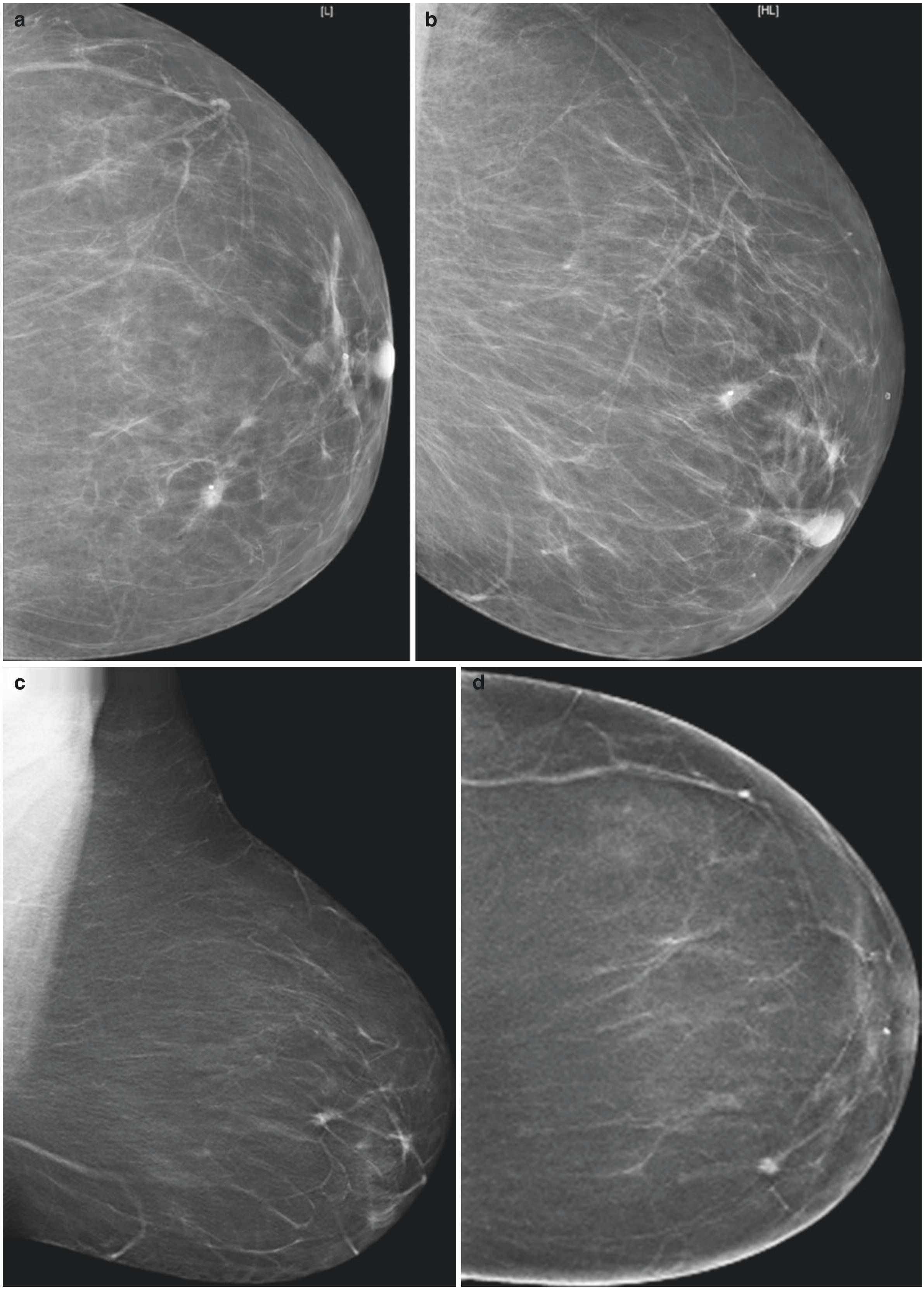


Fig. 3.11 Small screen-detected cancer (7 mm) in the upper inner quadrant of the left breast seen on mediolateral oblique (**a**) and craniocaudal views (**b**). The lesion is seen more clearly on tomosynthesis views (**c**) and (**d**). Core biopsy confirmed a grade *II* invasive ductal carcinoma

sampling error; in the event of a C2 diagnosis and lack of concordance between clinical, radiological, and cytological findings, either core biopsy or diagnostic excision biopsy must be undertaken (sometimes an MRI may be requested as the next investigation prior to any further biopsy). The procedure of FNAC is usually performed with a 21-gauge needle mounted on either a 10 ml or 20 ml syringe after initial cleansing of the skin with an alcohol wipe. Local anesthesia is unnecessary and may be more uncomfortable than the FNAC procedure itself! The operator fixes the tumor with his or her hand using either the thumb and index finger or index and middle finger (syringe holders are available allowing suction to be applied more easily). The needle (with attached syringe) is then placed into the center of breast mass ensuring that the tip of the needle does not advance beyond the mass into the adjacent breast tissue. The needle is passed through the breast mass in various directions taking especially care *not* to withdraw the syringe from the breast mass while continuing to maintain suction on the syringe. Suction is then released and the needle brought out of the breast mass. The tissue debris on the needle and tip of the syringe is sprayed onto glass slides using air pressure from the syringe plunger. It is important that the tip of the needle does not touch the surface of the glass slide. The material on the slide is smeared using a second glass slide and slides air-dried and subsequently stained and processed by the pathologist to determine the presence of malignant cells (Fig. 3.22).

Alternatively, cytology material can be emptied into a special solution/medium and then collected using a filtration system. Although FNAC is a technically simple procedure, it can be associated with complications such as hematoma, pneumothorax, and infection. It is important to introduce the needle at a tangent to the chest wall to avoid penetration into the pleural cavity.

Core needle biopsy – inadequacy of sampling, particularly for lesions with a paucity of cells coupled with inability

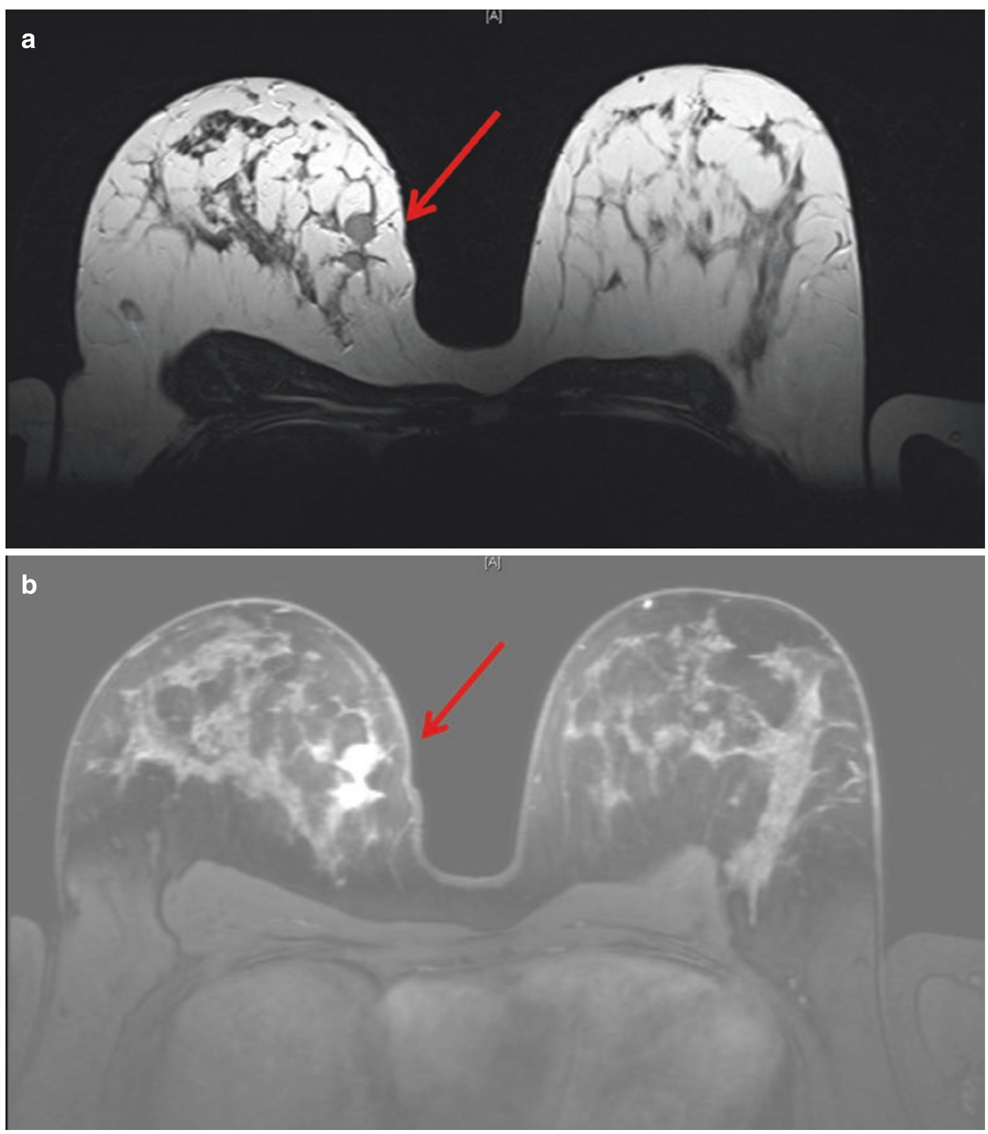


Fig. 3.12 (**a**) T2-weighted imaging. As seen on the US two nodules medial right breast. (**b**) T1 non subtracted post-contrast imaging. Two enhancing nodules medial right breast. (**c**) T1 post-contrast imaging. Two enhancing nodules medial right breast demonstrating washout (type 1 enhancement)

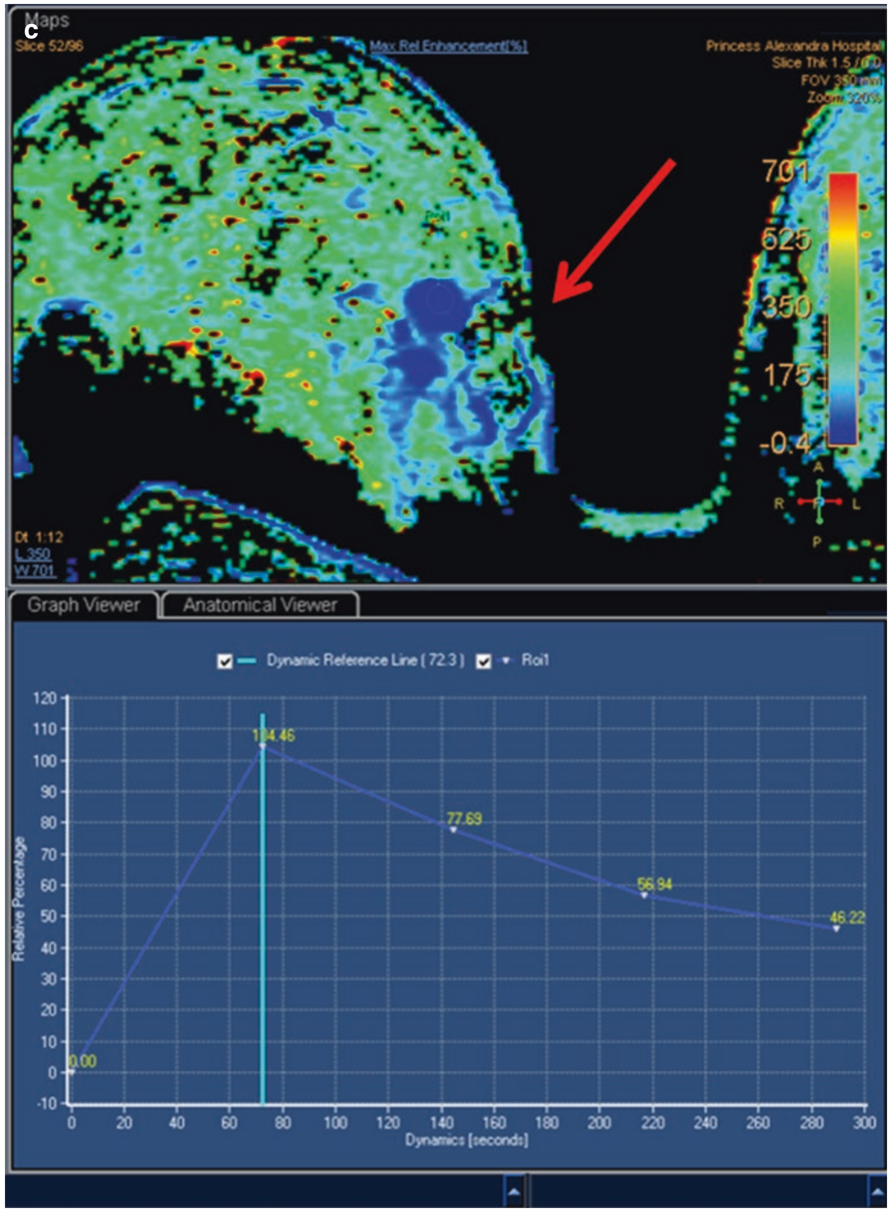


Fig. 3.12 (continued)

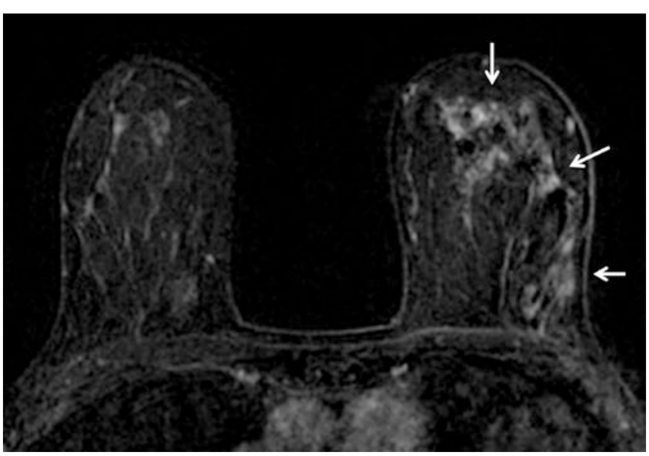


Fig. 3.13 Axial T1 post dynamic contrast image identifying extensive enhancement in the left upper central and lateral breast. This infiltrative multicenter multifocal appearance is typical for a lobular cancer

to diagnose invasive cancer, has led to a shift towards core needle biopsy in recent years. Core needle biopsy yields solid pieces of breast tissue (20–25 g) that can be examined histologically as fresh or paraffin-embedded material allowing assessment of both breast architecture and cellular morphology (Fig. 3.23).

Specimen cores are up to 2 cm in length corresponding to the throw of the needle. Techniques for core needle biopsy can be applied to either palpable or impalpable lesions with image-guided practices now preferred over manually guided methods to ensure optimal sampling at first attempt. Standard techniques for core biopsy employ 14-gauge or 16-gauge needles attached to disposable, automated spring-loaded devices that provide accurate sampling and good quality cores for routine histology and immunohistochemical analysis (Fig. 3.17). These techniques are especially amenable to

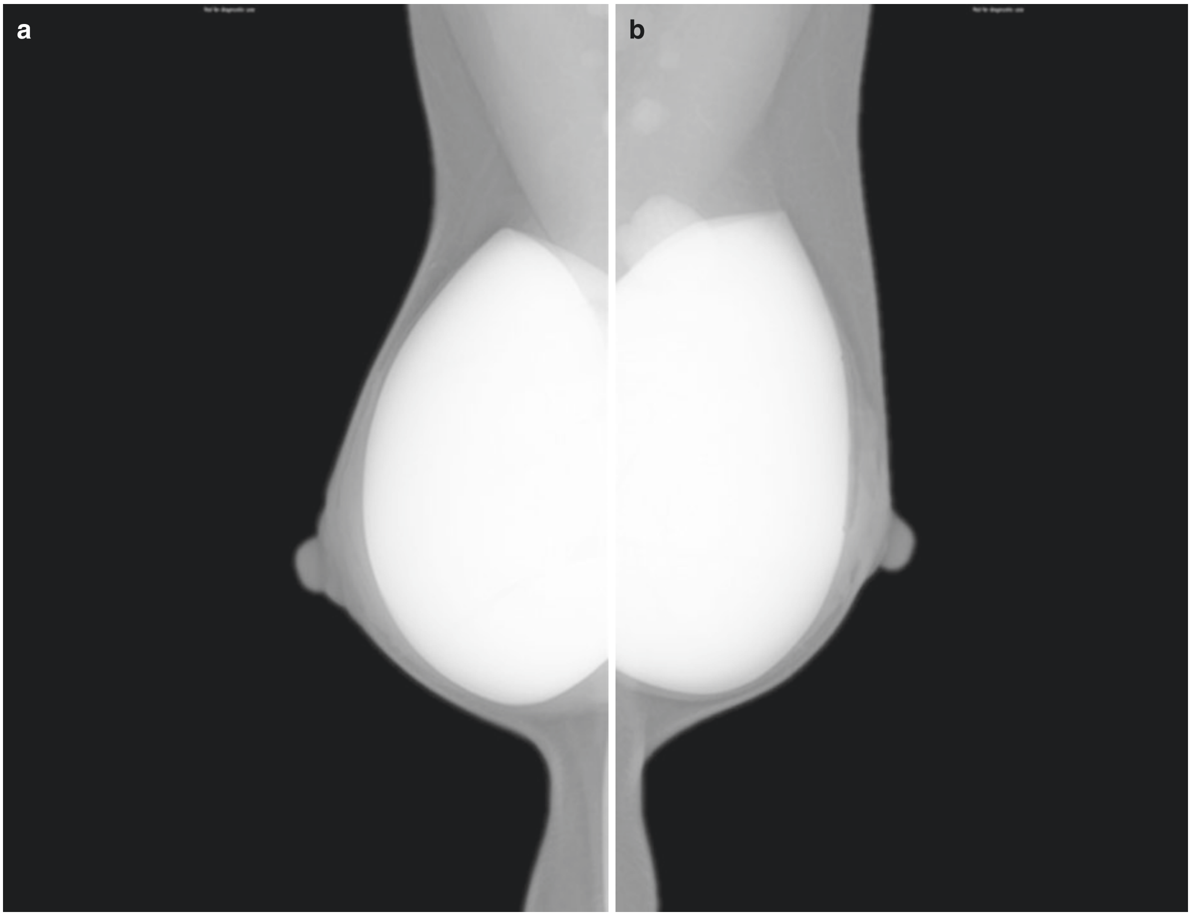


Fig. 3.14 (**a**, **b**) Mammography can be difficult to perform in patients with implants following cosmetic breast augmentation

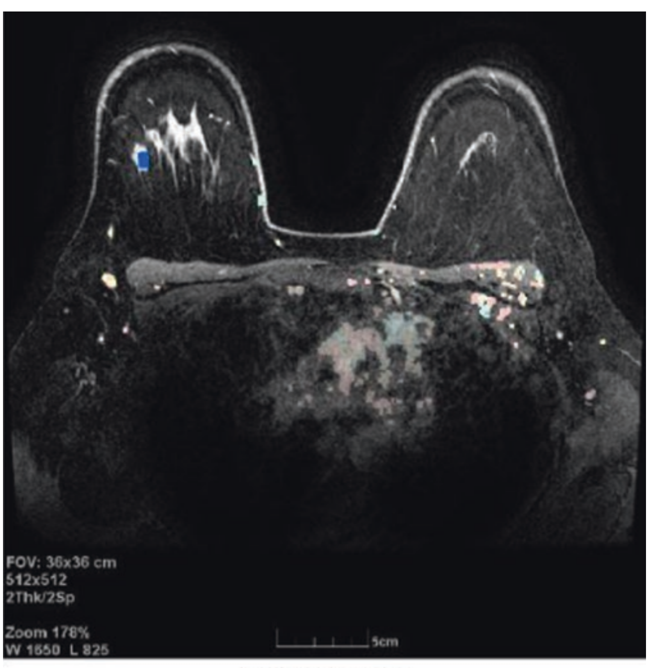


Fig. 3.15 Fibroadenoma detected incidentally on MRI examination performed for local staging of breast cancer

sampling of palpable and sonographically visible but impalpable lesions, and smaller 18-gauge needles can assist biopsy of lesions within dense breast tissue and more confined areas such as the axilla. When performing an ultrasound-guided core biopsy, local anesthetic (1% lignocaine or long-acting derivative) is injected around the intended biopsy site. A small incision measuring no more than 2–3 mm is made with an 11-blade scalpel to allow entry of the biopsy needle into the breast. This entry point should be pre-marked with a pen and made 1–2 cm away from the ultrasound transducer probe, thus allowing the operator to visualize the breast lesion. It is useful if the surgeon test-fires the biopsy gun and becomes familiar with its firing mechanism before placing the spring-loaded needle into the breast tissue. It is usually possible to hold the ultrasound probe with the non-dominant hand and manipulate the spring-loaded needle with the other hand (Fig. 3.4c). However, it is often sensible to enlist the assistance of a technician to stabilize the ultrasound probe thereby providing the operator with greater flexibility to manoeuver the biopsy instrument. The needle should be directed to the edge of the area of concern and photo documentation of the image completed. The patient should then be warned that the instrument is about to be fired to avoid audio stress. The instrument is then fired, and 2–3 accurately placed needle passes will usually ensure an adequate sample of the breast lesion is obtained. Core biopsy has both higher sensitivity and specificity compared with FNAC (sensitivity 84.5% versus 81.5%, respectively, and specificity 81.2% versus 58.4%, respectively, based on results from the NHS breast screening program).

Vacuum-assisted biopsy – the majority of breast lesions can be sampled using standard techniques of core biopsy with needles ranging from 14-gauge to 18-gauge in size. However, sometimes these needle sizes cannot adequately sample a lesion, and a more invasive procedure using an 11-gauge vacuum-assisted biopsy (VAB) device can be used to obtain more robust sampling and larger volumes of tissue (the vacuum aids retrieval of these larger samples) (Fig. 3.24a–c).

This may be used at the outset or following an inadequate standard gauge core biopsy where a surgical diagnostic exci-

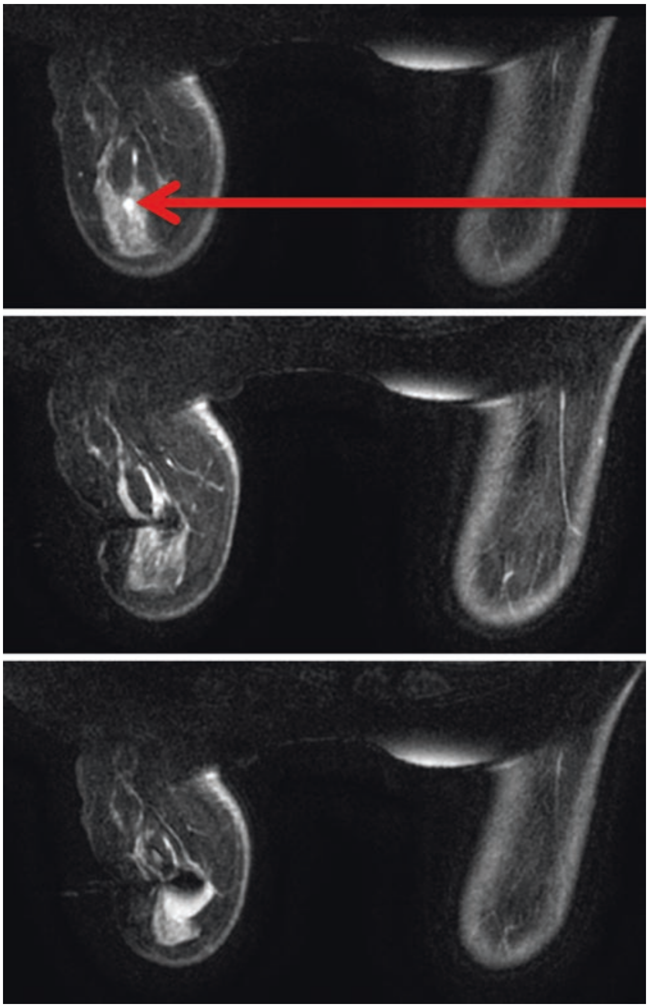


Fig. 3.16 MRI-guided breast biopsy in patient with lesion detected on MRI but not seen on second look ultrasound

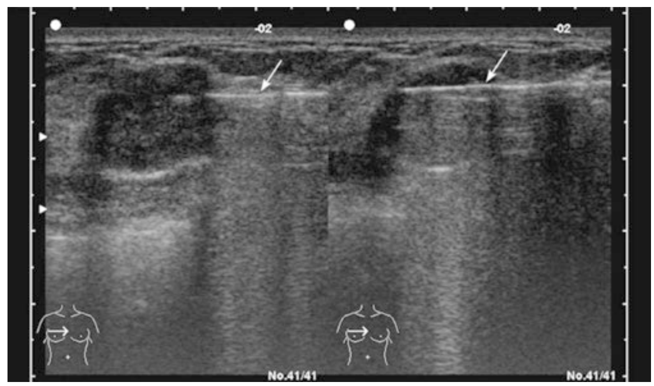


Fig. 3.17 When taking high-speed core-cut biopsy samples of non-palpable and palpable breast masses, visualization and documentation of the needle traversing the lesion is recommended

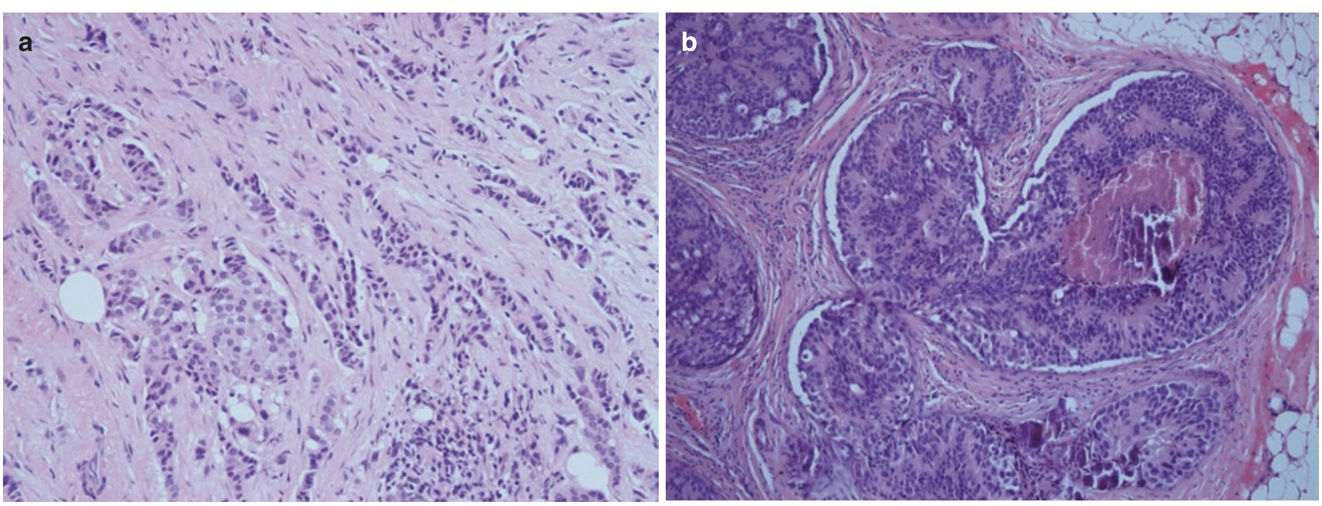


Fig. 3.18 Core biopsy of breast lesions preserves tissue architecture and can differentiate between invasive carcinoma (**a**) and ductal carcinoma in situ (**b**)

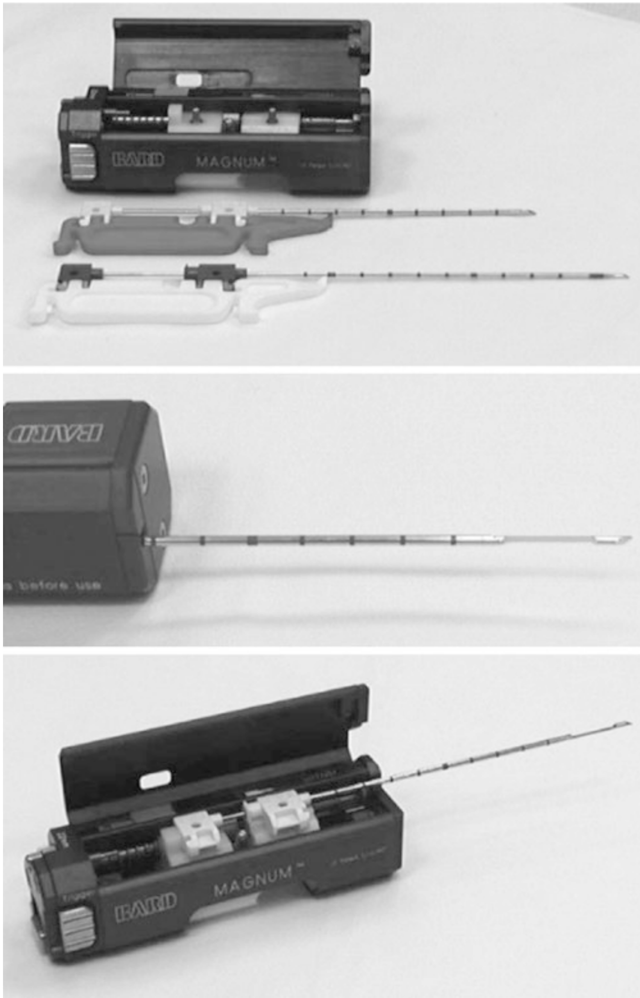


Fig. 3.19 High-speed core-cut biopsy instrument. The example shown is an Angiomed Bard Magnum with size 12-, 14-, or 16-gauge needles (100 mm in length and 1.9 mm diameter)

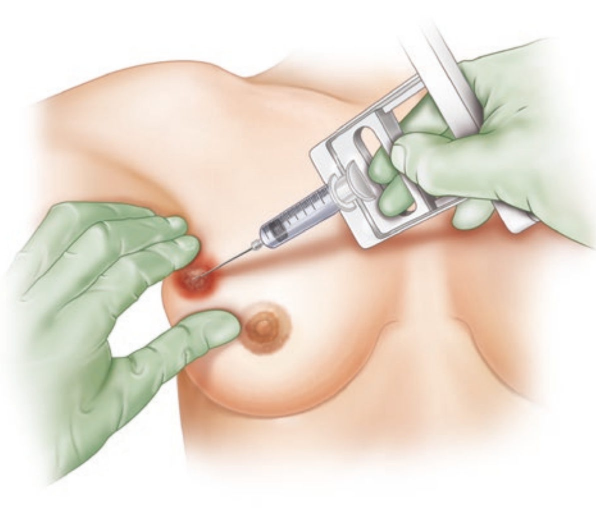


Fig. 3.20 Fine needle aspiration of a palpable breast mass

sion biopsy would otherwise be indicated. Thus these vacuum-assisted biopsy devices reduce the frequency of histological underestimation associated with conventional core biopsy. In the recent past, large-bore (7-gauge or 8-gauge) vacuum devices have been employed to completely remove a lesion – the so-called vacuum-assisted excision biopsy (VAE) (see below).

Stereotactic-guided biopsy – the term stereotactic biopsy refers to a method of sampling breast lesions that are visible mammographically but not seen on ultrasound examination. These techniques are designed specifically to biopsy areas of microcalcification detected on screening or incidentally during investigation of symptomatic disease (Fig. 3.25a–d).

Stereotactic equipment calculates the position of a target lesion within the breast by localizing coordinates in the horizontal, vertical, and depth axes from the surface of the breast. The mammograms are carefully reviewed on a dedicated workstation to determine the optimal directional approach to the lesion (the needle should remain parallel to the chest wall to avoid a pneumothorax). Routine imaging at the start of the procedure permits calculation of the horizontal and vertical axes, and two-angled images (15° from the center) then allow calculation of the depth of the lesion within the breast based on the principle of parallax. These coordinates will then guide the core needle device to the targeted lesion on the breast. The patient is positioned prone on the procedure table, with the breast in the dependent position through an aperture on the stereotactic table. The skin overlying the breast is cleansed with an appropriate solution (povidone iodine, chlorhexidine, or alcohol) and the needle entry site infiltrated with local anesthetic prior to making a small incision with an 11-blade (slightly larger than for standard core biopsy techniques) (Fig. 3.4c). The needle is then manually advanced to the appropriate depth as calibrated by the computer, and stereotactic images are taken to ensure correct position of the needle tip in relation to the breast lesion. The spring-loaded needle is then fired into the breast lesion and the location of the core biopsy checked with repeated stereotactic images. Multiple cores should be obtained when sampling microcalcifications and a specimen X-ray taken to confirm adequate sampling of the cluster (Fig. 3.26).

Both core biopsy samples and corresponding radiographic images are submitted to the pathologist. Note that VAB techniques are preferred to standard core biopsy when sampling microcalcifications under stereotactic guidance. Use of large-gauge needles has increased the overall success rate of these stereotactic procedures (false-negative rate of about 2%) and reduced the number of open (wire-guided) diagnostic excision biopsies. However, when microcalcifications are readily visible on ultrasound, then ultrasound-guided biopsy constitutes an easier and less time-consuming biopsy method than stereotactic techniques that are also more expensive.

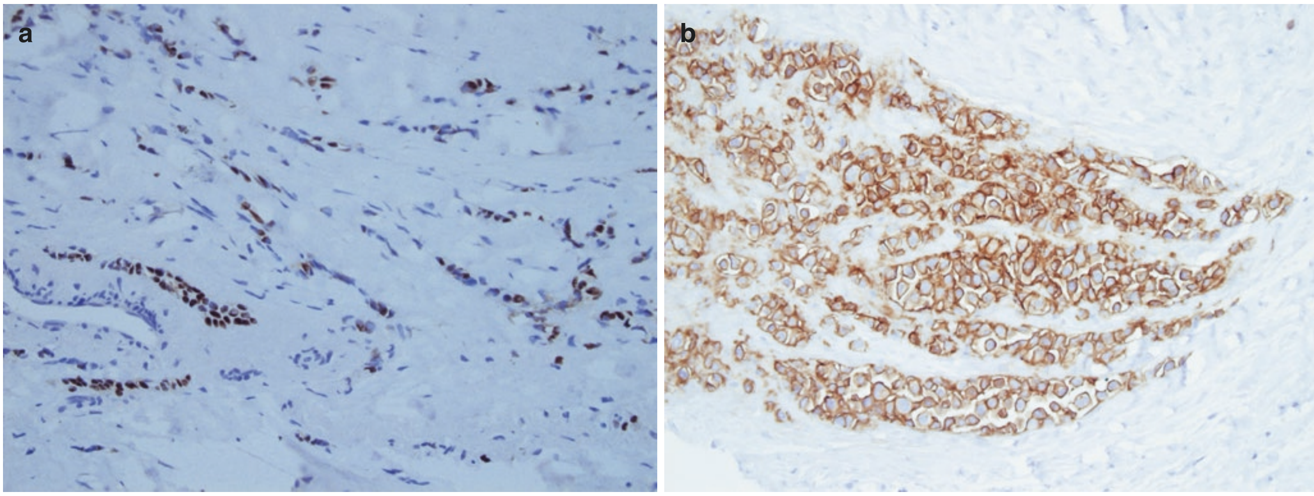


Fig. 3.21 (**a**, **b**) Core biopsy specimens can be stained for estrogen receptor (**a**) and HER2 (**b**) and thus provide important information for planning patient management

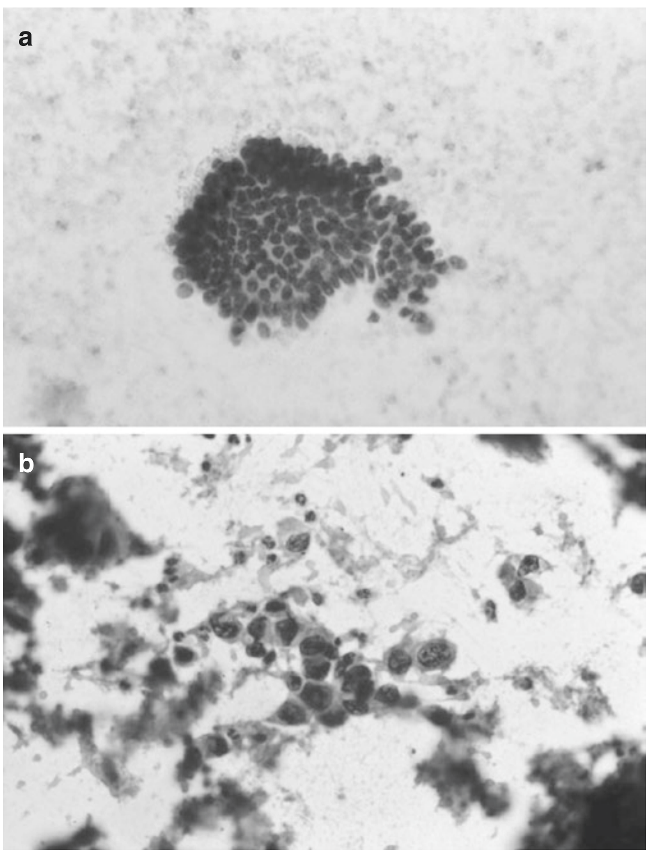


Fig. 3.22 (**a**) Fine needle puncture: normal breast epithelial complex (×400). (**b**) Fine needle puncture: tumor cells from solid breast cancer (×400)

Vacuum-assisted excision biopsy – the majority of lesions classified on core biopsy as B3 have until recently always prompted a diagnostic excision biopsy with or without wire localization. These B3 lesions are of uncertain malignant potential and include the following:

1. Atypical ductal hyperplasia with moderate degrees of atypia
2. Lobular neoplasia (atypical lobular hyperplasia, lobular carcinoma in situ (LCIS))
3. Papillary lesions
4. Columnar cell change with atypia
5. Phyllodes tumor

In addition to the above histological diagnoses, surgical excision is also warranted for a radial scar or when there is lack of concordance between the clinical, radiological, and core biopsy findings. A radial scar (complex sclerosing lesion) can be associated with a tubular carcinoma in up to 20% of cases (Fig. 3.27).

A radial scar is not a premalignant lesion, but when atypical hyperplasia coexists, the relative risk for developing cancer is increased sixfold. As radial scars can be difficult to distinguish from a carcinoma on radiological grounds, all must be excised. LCIS is usually an incidental pathological finding, and it does not itself present symptomatically. There is an increasing trend towards second line VAB or vacuum-assisted excision of selected B3 lesions rather than subjecting patients to a surgical excision biopsy for purely diagnostic purposes (Figs. 3.28 and 3.29).

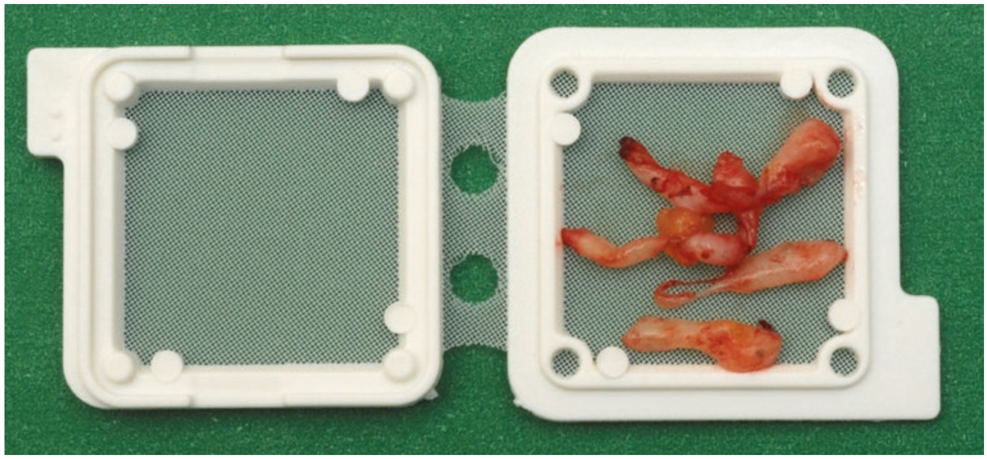


Fig. 3.23 Cores of tissue retrieved from ultrasound-guided core biopsy placed in a cassette prior to formal histopathological assessment

Thus several of the above B3 lesions are potentially suitable for VAE that may avoid the need for surgery. There is consensus that the following B3 lesions can be managed with VAE rather than diagnostic excision following either standard core biopsy or VAB:

1. Atypical ductal hyperplasia with moderate degrees of atypia
2. Lobular neoplasia (atypical lobular hyperplasia, lobular carcinoma in situ (LCIS))
3. Papillary lesions without atypia
4. Columnar cell change with atypia

However, it should be noted that certain B3 lesions always require surgical excision biopsy including cellular fibroepithelial lesions, papillary lesions with atypia, and mucocele-like lesions which all have a higher upgrade rate to malignancy than the aforementioned lesions.

MRI-guided biopsy – with increased usage of MRI as part of preoperative workup of patients and screening of higher risk patients, the number of MRI abnormalities has increased significantly. These reflect greater sensitivity of MRI and are often suspicious areas of enhanced uptake that may represent multifocal, contralateral, or incidental disease and warrant further investigation. Some of these lesions will be visualized on a directed ("second look") ultrasound thereby permitting conventional image-guided biopsy. However, often this is not the case, and MRI-guided biopsy is necessary for tissue acquisition in these circumstances. A standard 14-gauge needle can be used, but a larger bore 11-gauge needle is preferred, and these MRI-guided techniques can be challenging and demand special training and equipment (high strength field magnet, breast biopsy coil, and MRI compatible titanium needles) (Fig. 3.16). Ideally, these biopsies should be undertaken within the breast facility where the original MRI scans have been carried out in order to ensure consistency in protocols and image interpretation. Of note, the biopsy needle must be placed within the breast, while the patient is outside the magnet and then MRI images taken to confirm the position of the needle. Biopsies are then taken with multiple passes to guarantee adequate sampling and a clip deployed to permit subsequent mammographic identification of the biopsy site (Fig. 3.30).

3.4 Surgical Diagnostic Excision Biopsy

Several methods are available for procuring biopsy material including percutaneous needle biopsy techniques discussed previously and open surgical biopsy procedures. The optimal method depends on the amount of tissue required and the objective of the biopsy (whether to completely excise a breast lesion or to simply sample). The greatest amount of tissue is obtained with open biopsy techniques (excision biopsy or wire-localized biopsy), and progressively decreasing amounts of tissue are yielded from large-bore needle biopsy (VAE, VAB) and standard core biopsy (Fig. 3.31).

The size of the skin incision corresponds to the amount of tissue required from the procedure. Thus a very small incision is required for stereotactic VAB, but a slightly larger incision is necessary for standard core biopsy in which the needle must be maneuvered within the tissue to obtain satisfactory samples. The largest incisions pertain to open biopsy procedures, but these incisions should be kept as small as possible for these diagnostic biopsies (as opposed to lumpectomy for cancer) (Fig. 3.32).

A wire-localized biopsy is performed to assess abnormalities of the breast that are impalpable but seen on mammography (Fig. 3.33).

The process of acquiring tissue for histological examination under these circumstances demands a coordinated effort and cooperation between the surgeon and radiologist to ensure the appropriate area of breast tissue is excised corresponding to the radiological lesion. The crucial step is placement of the wire under image guidance within the radiology suite, although some surgeons with ultrasound competency

Fig. 3.24 Vacuum-assisted biopsy permits larger volumes of tissue to be retrieved and reduces the chance of underdiagnosis of invasive (as non-invasive) carcinoma and ductal carcinoma in situ (as atypical ductal hyperplasia)

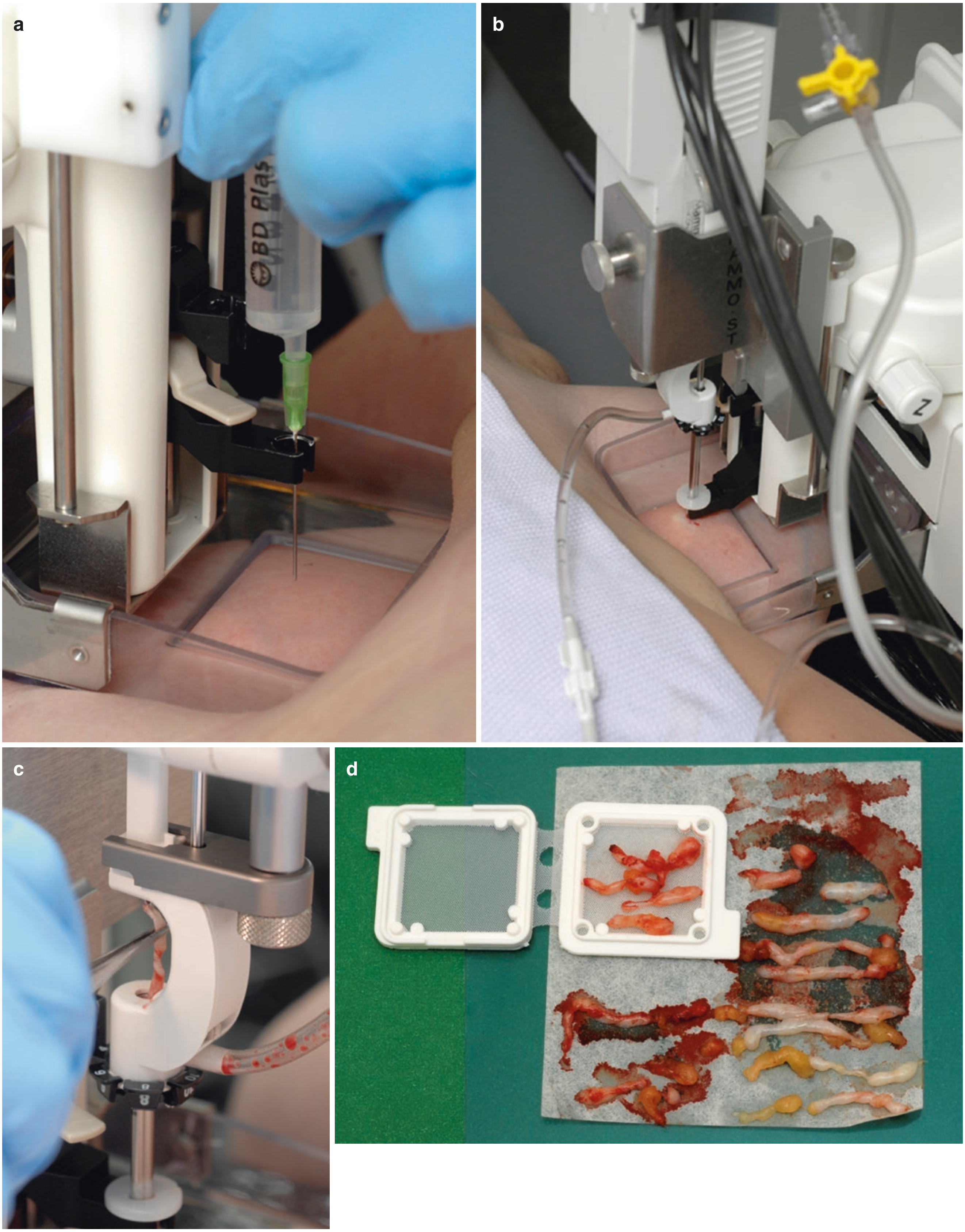


Fig. 3.25 (**a**–**d**) Stereotactic biopsy using either standard gauge core or vacuum-assisted techniques permits accurate sampling of areas of microcalcification that are unlikely to be seen on ultrasound

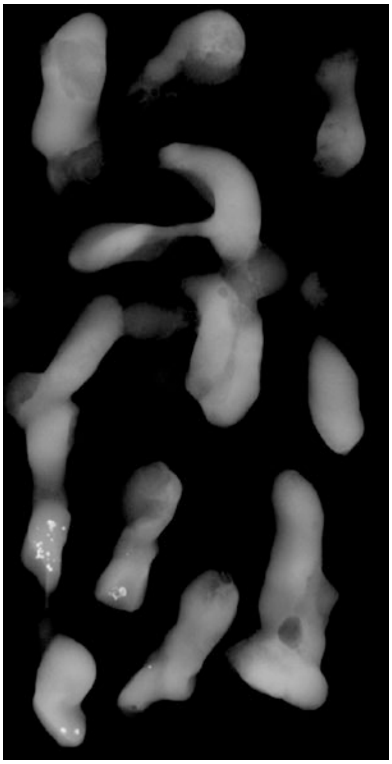


Fig. 3.26 Cores of tissue with calcification on specimen radiology confirm that adequate sampling has been undertaken after stereotactic biopsy of screen-detected microcalcification

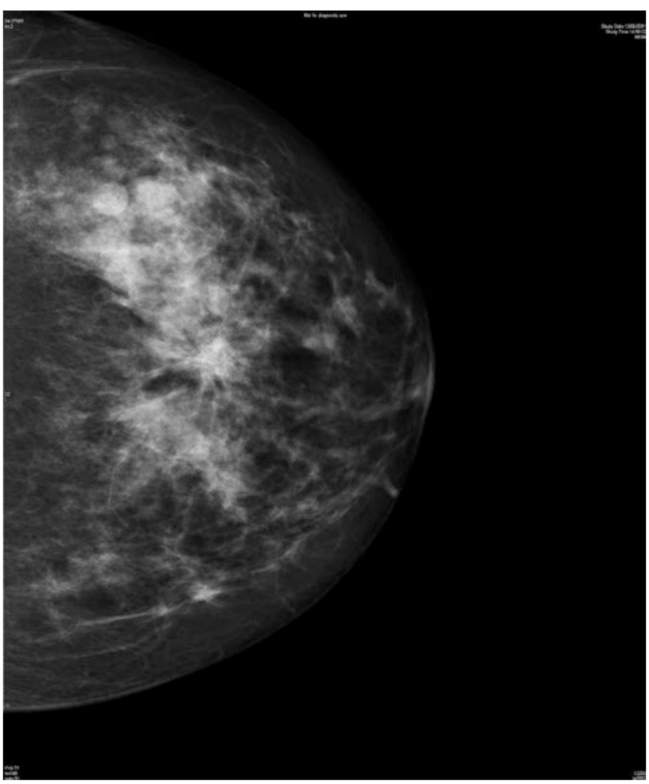


Fig. 3.27 A radial scar with radiating spicules can be difficult to distinguish from a carcinoma radiologically and should be surgically excised

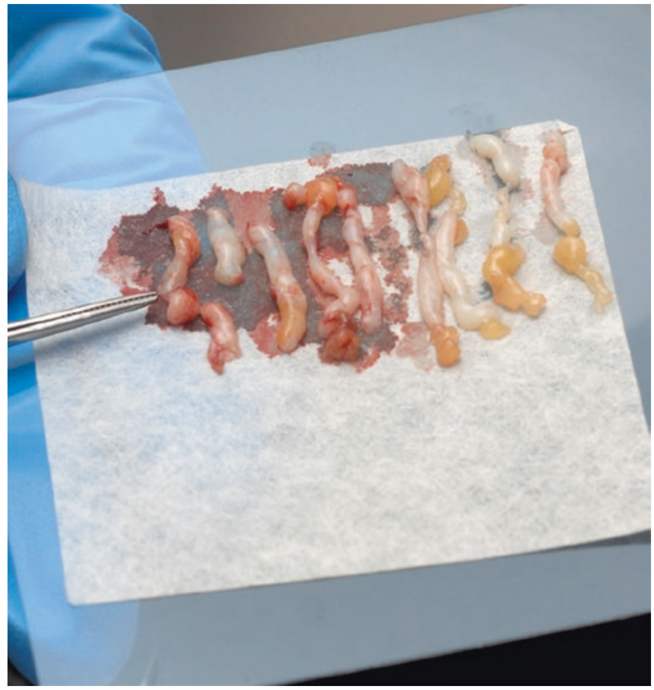


Fig. 3.28 Specimens taken during vacuum-assisted excision using an 8-gauge needle. These cores of tissue can be X-rayed to confirm excision of calcification seen on mammography or the presence of a clip from previous vacuum-assisted biopsy (first line VAB)

perform their own localizations in the operating room. A variety of flexible hooked wires are available which are placed in the breast tissue via a rigid introducer needle under the guidance of bi-planar mammography or ultrasound. Mammograms with two views (antero-posterior and medio-lateral) should be obtained showing the position of the wire and its relationship to the lesion or deployed clip (from previous core biopsy) (Fig. 3.34a, b).

The tip of the wire should lie within 2 cm of the lesion, and the latter should ideally be transfixed by the wire. These localization films should be carefully scrutinized and a three-dimensional image created that guides the surgical dissection. The surgeon may feel confident to proceed with excision biopsy when the wire transfixes the lesion, but the tip lies more than 2 cm from the lesion (although beware this may lie within muscle and be difficult to retrieve) (Fig. 3.35a, b).

When the lesion has been localized with ultrasound only, it is helpful to place a clip within the lesion to confirm its removal on specimen radiography. Following wire localization, the patient is either transported back to the ward or directly to the operating room with the wire in situ; it is important to securely tape the outer part of the wire to the surface of the breast to minimize the chance of dislodgement. The procedure is performed under either local or general anesthesia depending on the preference of the patient and surgeon; intravenous sedation can be used in conjunction with local anesthesia. The tape is carefully removed

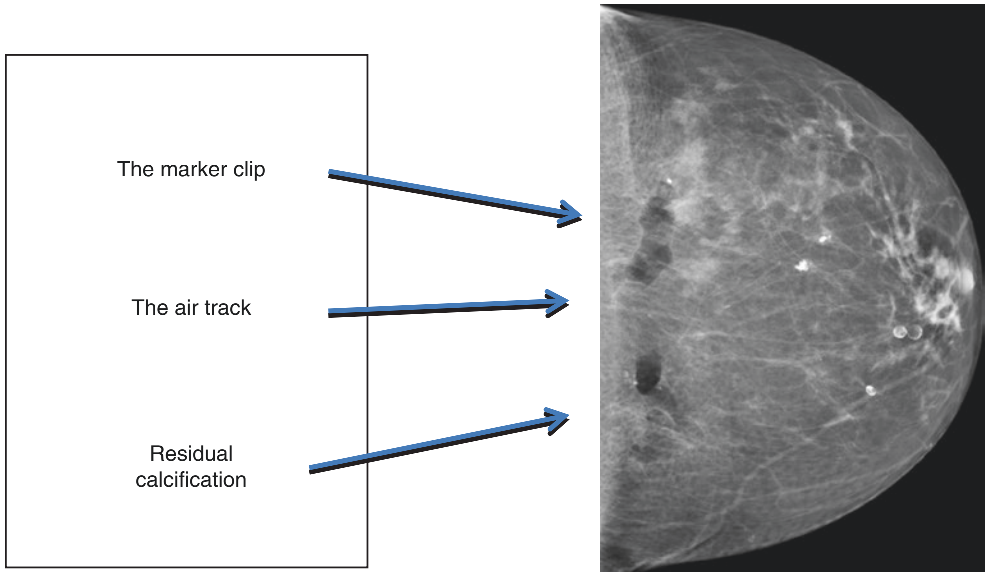


Fig. 3.29 Following vacuum-assisted excision, a cavity containing air and a needle tract is visible on post-procedure imaging of the breast. Post-procedure mammogram following vacuum-assisted excision of "B3" lesion of uncertain malignant potential. Upper arrow points to clip from initial vacuum-assisted biopsy; the middle arrow shows an air tract and the lower arrow some residual calcifications

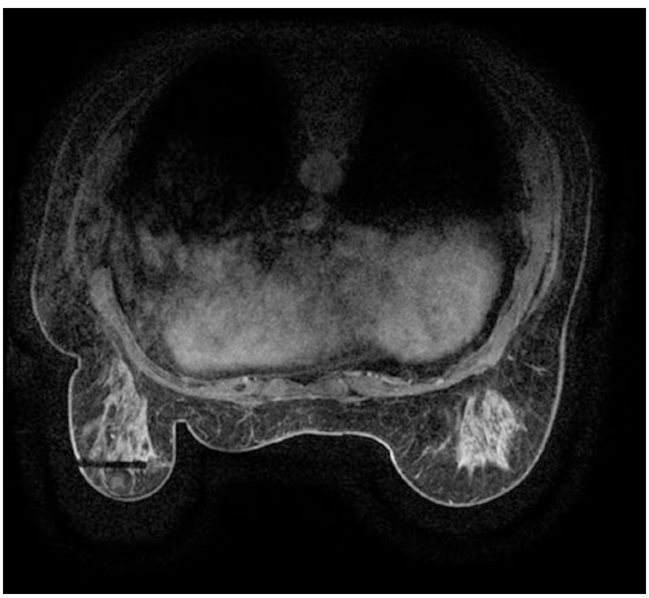


Fig. 3.30 MRI-guided biopsy of breast lesion with deployment of clip post-biopsy to permit subsequently localization in the event of surgical diagnostic excision biopsy

from the surface of the breast and may be adherent to the wire that is sometimes wrapped in a coil when there is excess external wire. The latter can be trimmed with a wire cutter or heavy scissors but must not be too short as otherwise it may retract into the breast tissue when manipulating the breast during surgery. This maneuver is carried out under non-sterile conditions before cleansing the skin with sterilizing solution (double gloves may be worn by the surgeons with the outer pair discarded).

Placement of the incision depends upon how the lesion was approached during wire localization; if the entry point of the wire is close to the skin projection of the lesion (this can be marked with ultrasound by the radiologist at the time of wire placement), then a curvilinear incision is made immediately adjacent to the wire. However, if the entry point of the wire is some distance from the lesion, then a more direct incision overlying the lesion should be made to avoid tunneling along the length of the wire (Figs. 3.36 and 3.37).

These curvilinear incisions should be made along the direction of one of the natural skin crease lines (of Kreissel) and take account of the need for further surgery. In the event of subsequent lumpectomy (wide local excision), this can be extended and should be encompassed by a conventional mastectomy incision. However, this initial incision is likely to be left undisturbed if a periareolar incision is employed for a skin-sparing mastectomy (with immediate breast reconstruction). Skin hooks or Allis tissue-holding clamps are used to elevate the skin and subcutaneous tissue. The strategy for dissection depends on the size and site of the lesion in relation to the wire, but essentially this is a diagnostic procedure and should aim to remove about 1 cm of tissue around the tip of the wire. The distal end of the wire should be delivered into the wound early on in the procedure to facilitate dissection of the specimen. The latter can be grasped with an Allis clamp close to the tip of the wire but taking care not to use excessive traction which might dislodge the wire. Electrocautery should be avoided during dissection as this can create artifacts that obscure pathological assessment of the specimen. However, once the wire and breast tissue around it are removed, meticulous attention is paid to achieving hemostasis. Sometimes it is useful to place a clip on a cavity margin that is macroscopically "close" pending specimen radiology. The excised specimen should be orientated with sutures and radiopaque clips while maintaining its anatomical position. Standard protocols for marking exist in

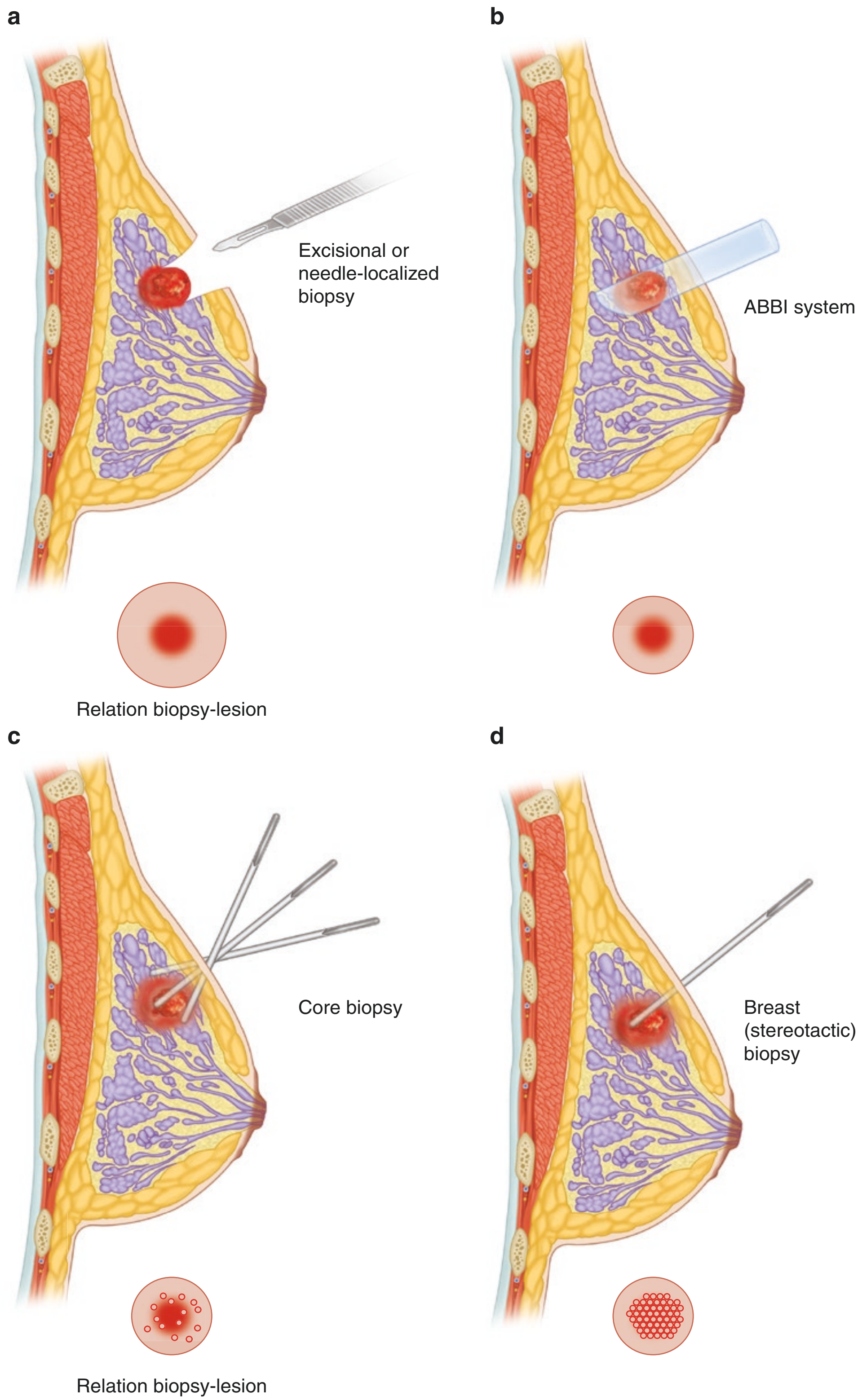


Fig. 3.31 (**a**–**d**) Comparison of different biopsy techniques, their invasiveness, and the amount of tissue sampled. (**a**) Excisional or needle-localized biopsy; (**b**) the advanced breast biopsy instrument (*ABBI*) system; (**c**) core biopsy; (**d**) the stereotactic vacuum-assisted biopsy device

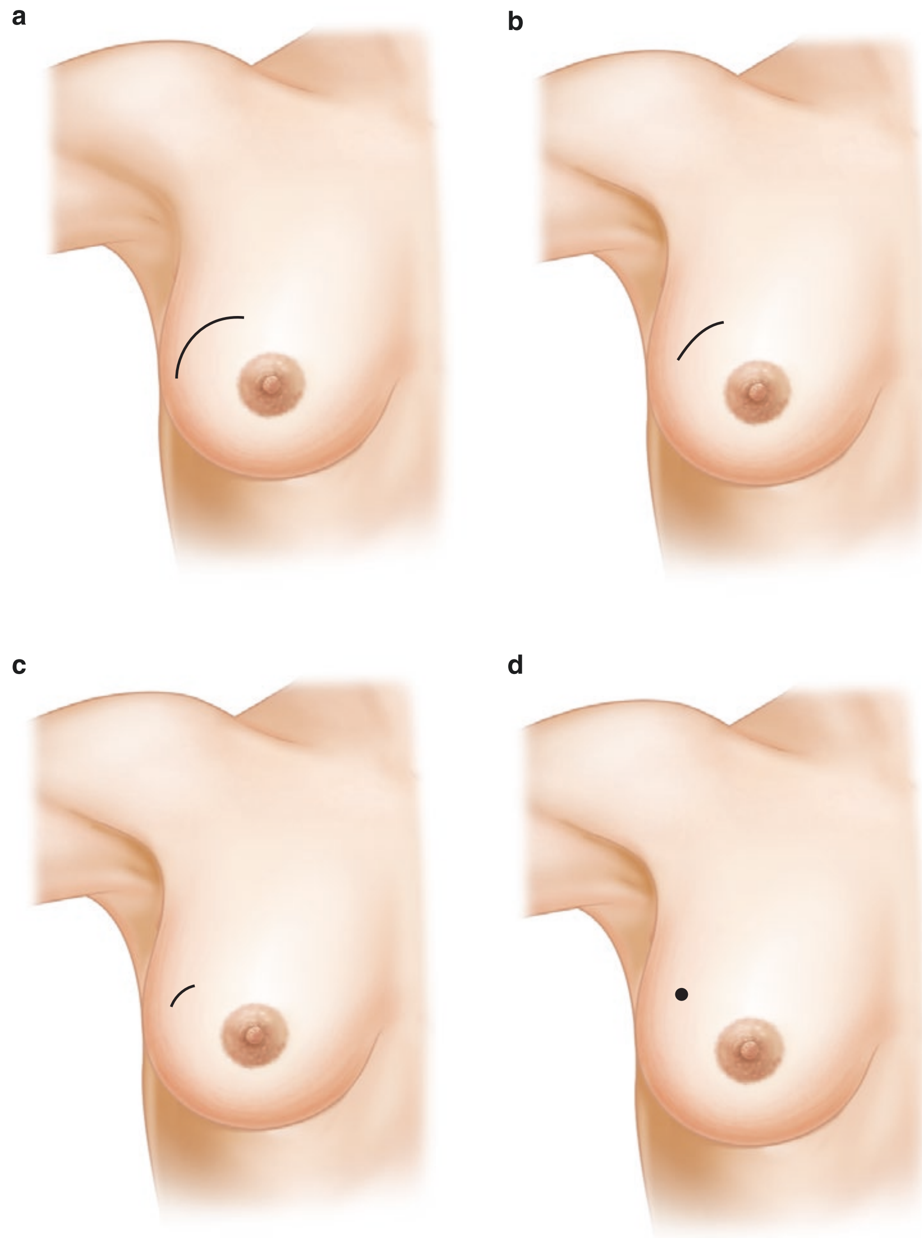


Fig. 3.32 (**a**–**d**) Comparison of different biopsy techniques, their invasiveness, and the amount of tissue sampled. (**a**) Excisional or needle-localized biopsy; (**b**) the advanced breast biopsy instrument (*ABBI*) system; (**c**) core biopsy; (**d**) the stereotactic vacuum-assisted biopsy device

each institution (e.g., double long superior, single long anterior, etc.). The specimen is imaged either within the radiology suite or using a dedicated intraoperative X-ray device (Fig. 3.38a, b).

Many surgeons perform intraoperative radiological assessment of impalpable (and sometimes palpable) lesions using portable X-ray devices such as the Faxitron (MX20) that can halve rates of positive margins after wide excision for malignant lesions. Specimen radiology should confirm excision of the lesion and clip if present with no attempt to obtain wide margins of clearance for a diagnostic procedure. The breast wound is irrigated and the skin edges reapproximated using a running absorbable subcuticular suture. A subcutaneous suture can be used in addition to the skin suture, but no formal remodeling of the breast tissue is necessary (the amount of tissue for a diagnostic excision should not exceed 20–30 g) (see Figs. 3.33, 3.34, 3.35, 3.36, and 3.37).

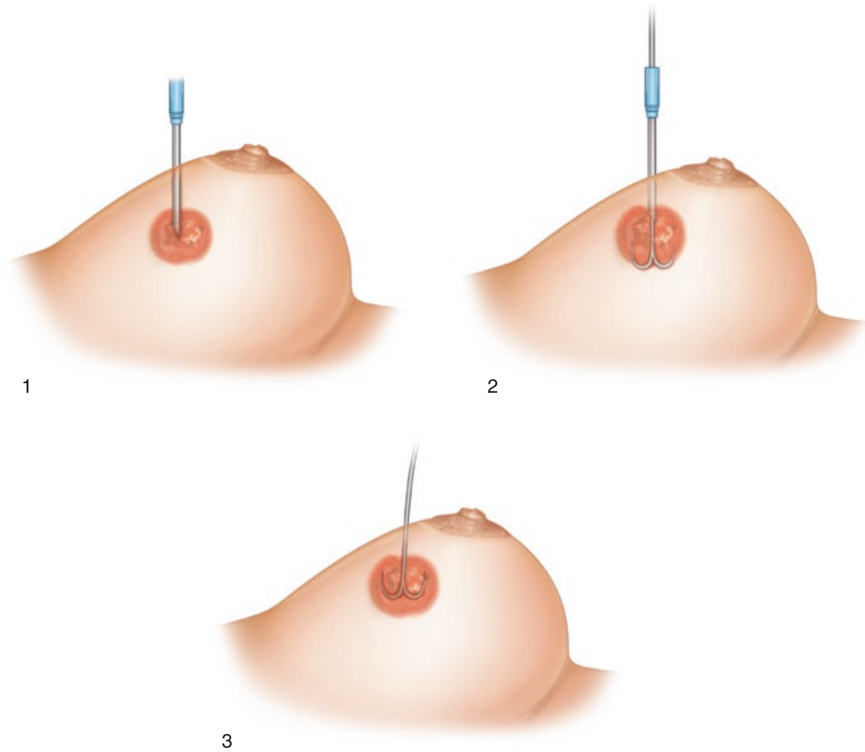


Fig. 3.33 Needle-localized biopsy

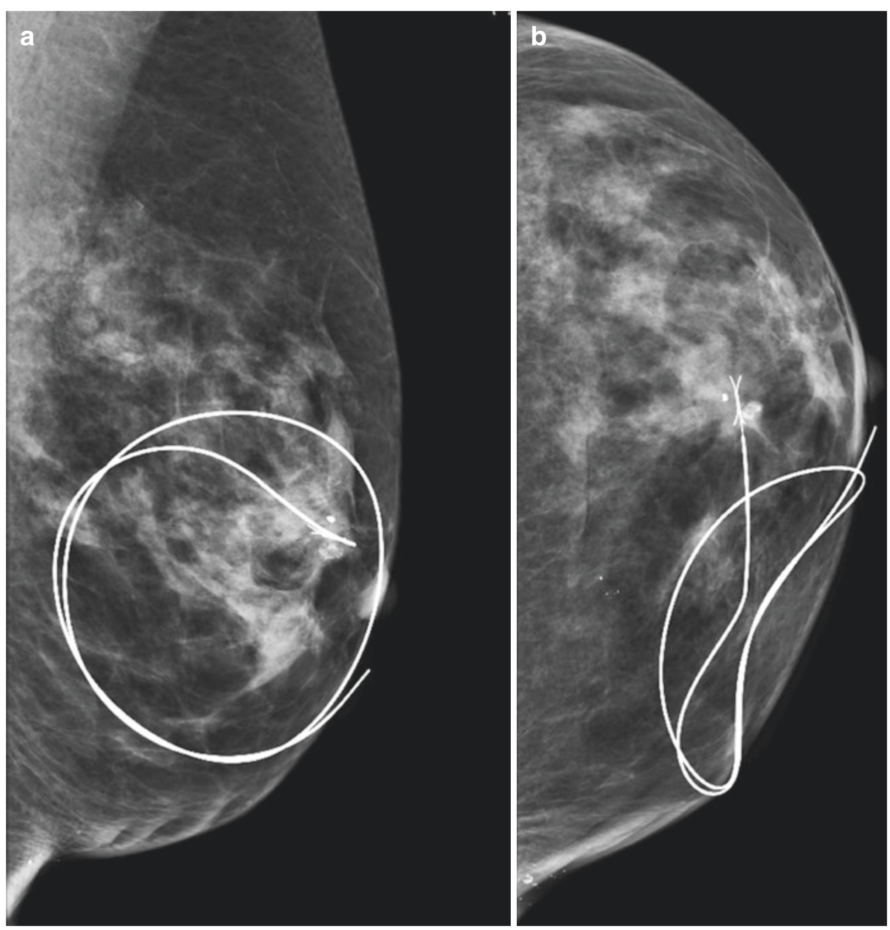


Fig. 3.34 (**a**, **b**) Needle localization of impalpable, screen-detected lesion within the upper outer quadrant of the left breast. The tip of the wire lies close to the lesion and the post-biopsy clip in two-view mammography (mediolateral (**a**) and craniocaudal (**b**))

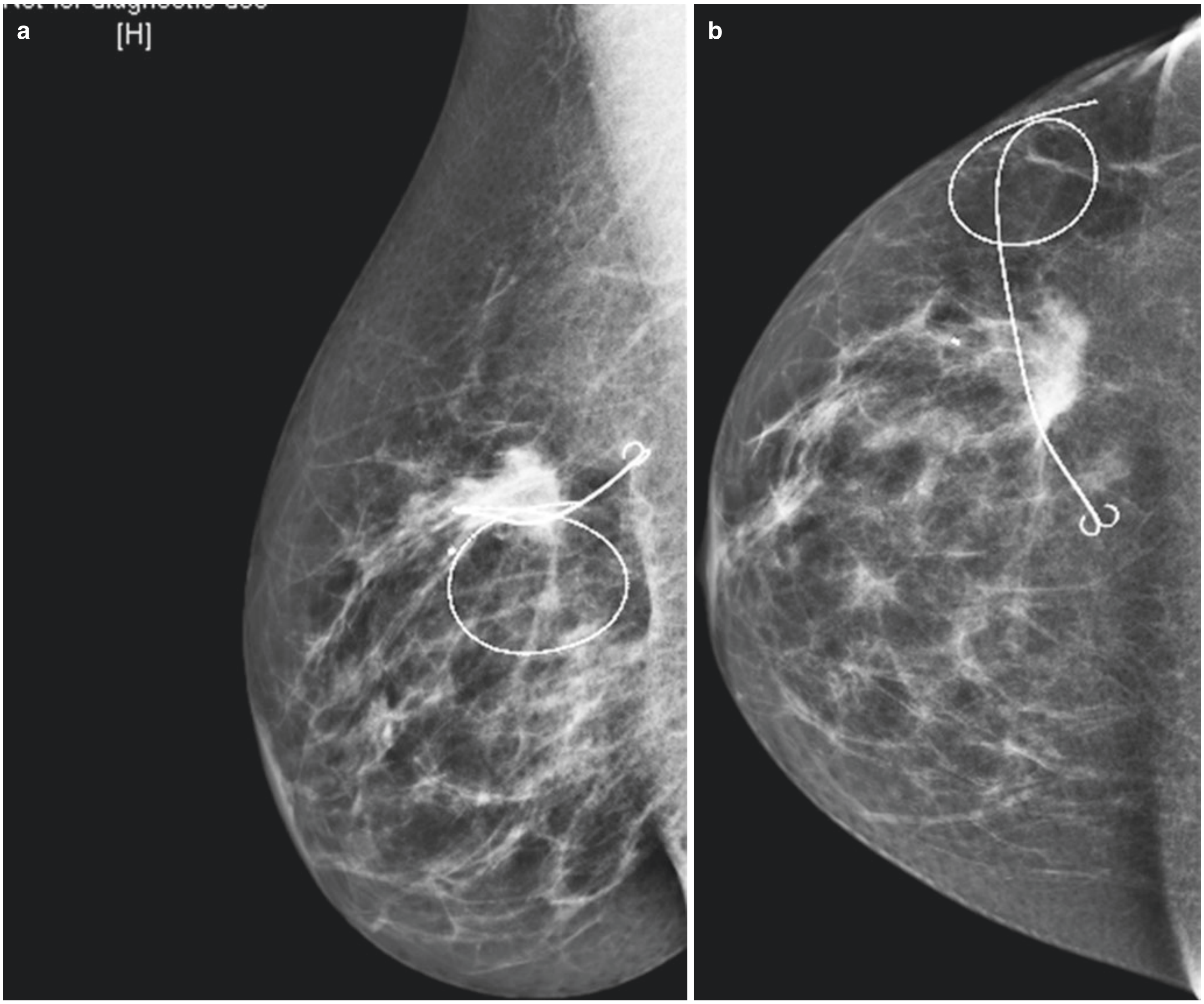


Fig. 3.35 (**a**, **b**) Needle localization of screen-detected lesion showing tip of wire almost 3 cm beyond lesion. The tip of the wire should lie within 2 cm of the lesion for accurate wire-guided surgical excision

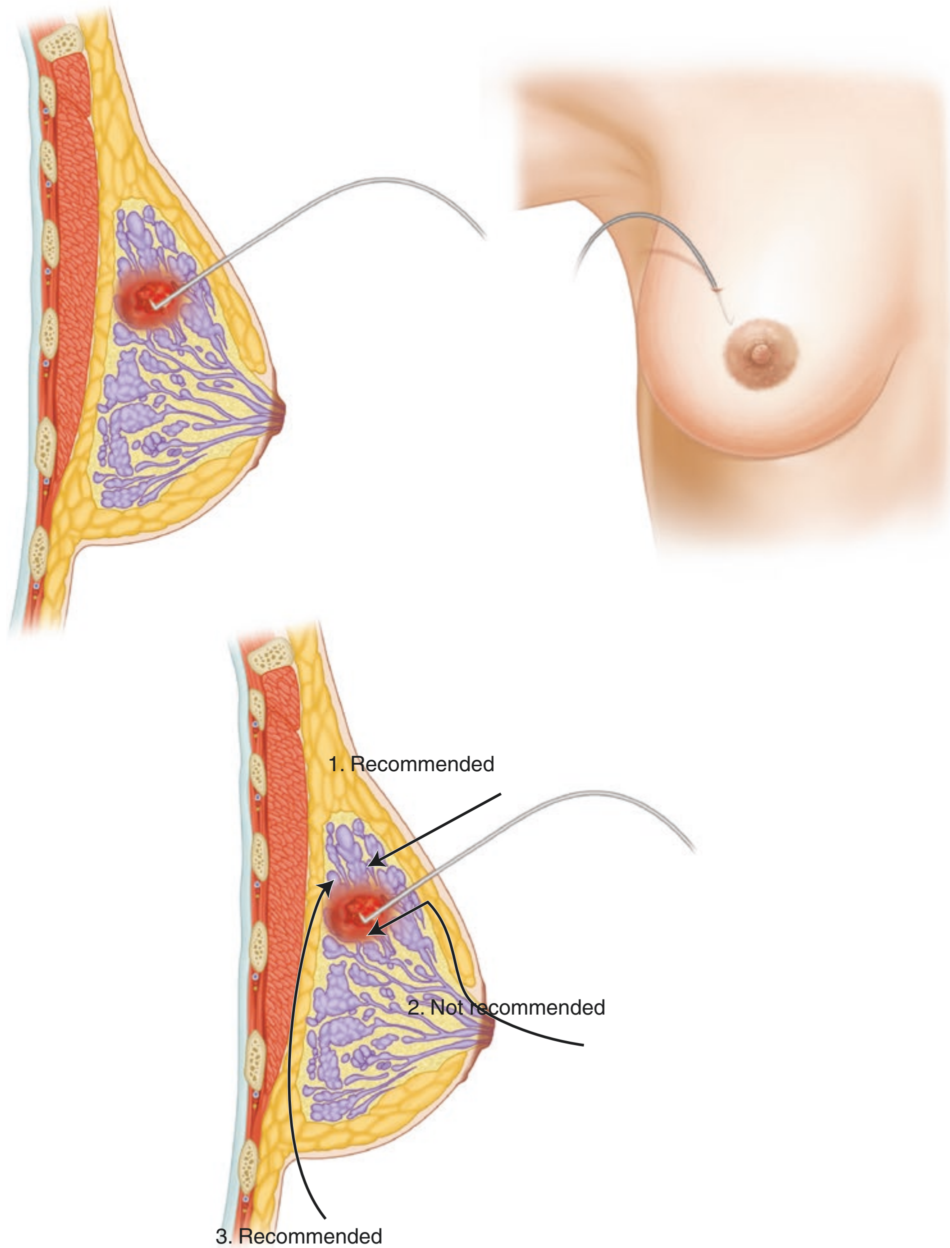


Fig. 3.36 Guidance for correct approach during needle-localized biopsy. The posterior glandular approach (*1* on *right*) is recommended, whereas periareolar (*2* on *right*) is not recommended. Inframammary approach (*3 on right*) is only recommended if the tumor is deeply located

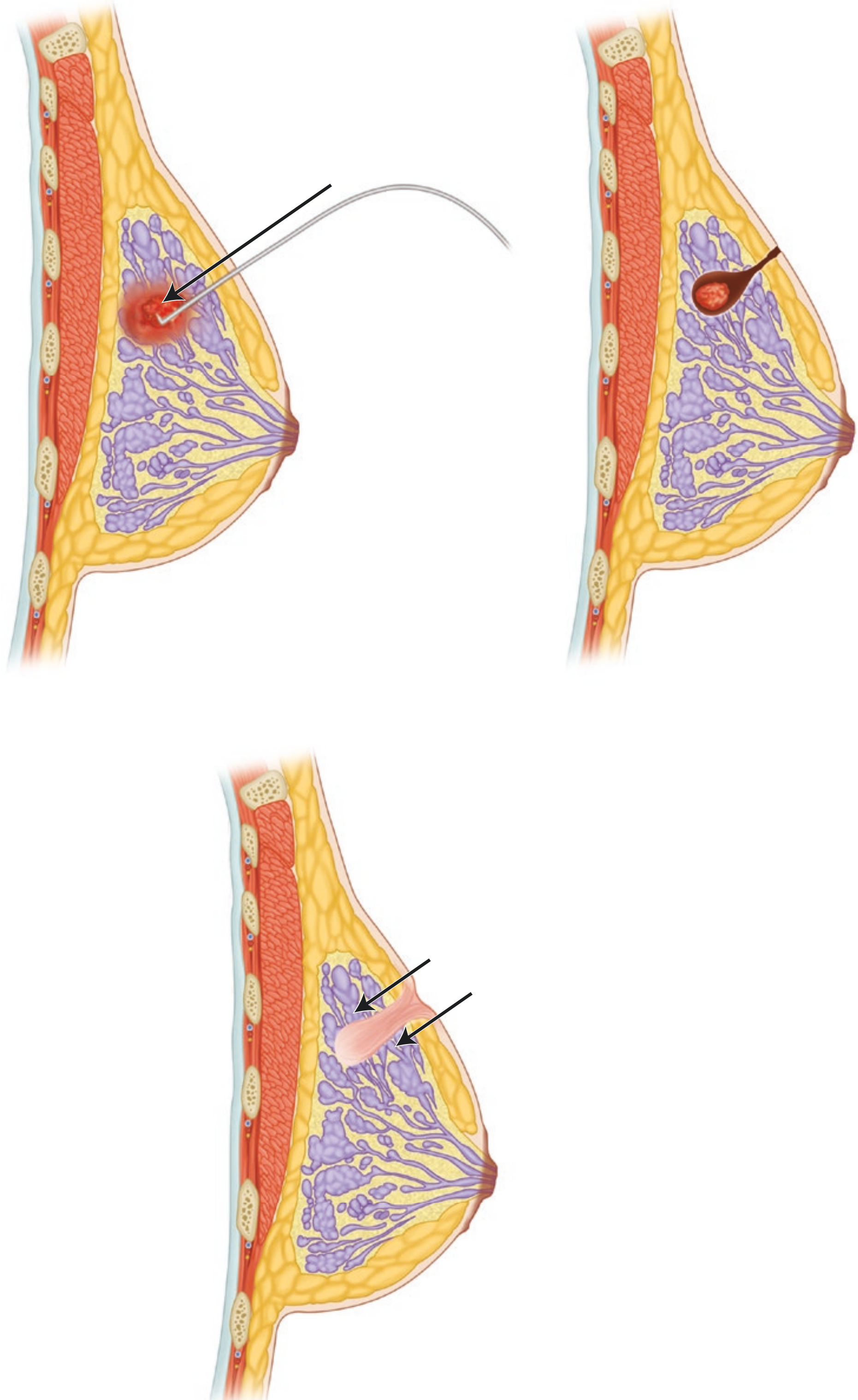


Fig. 3.37 Needle-localized biopsy

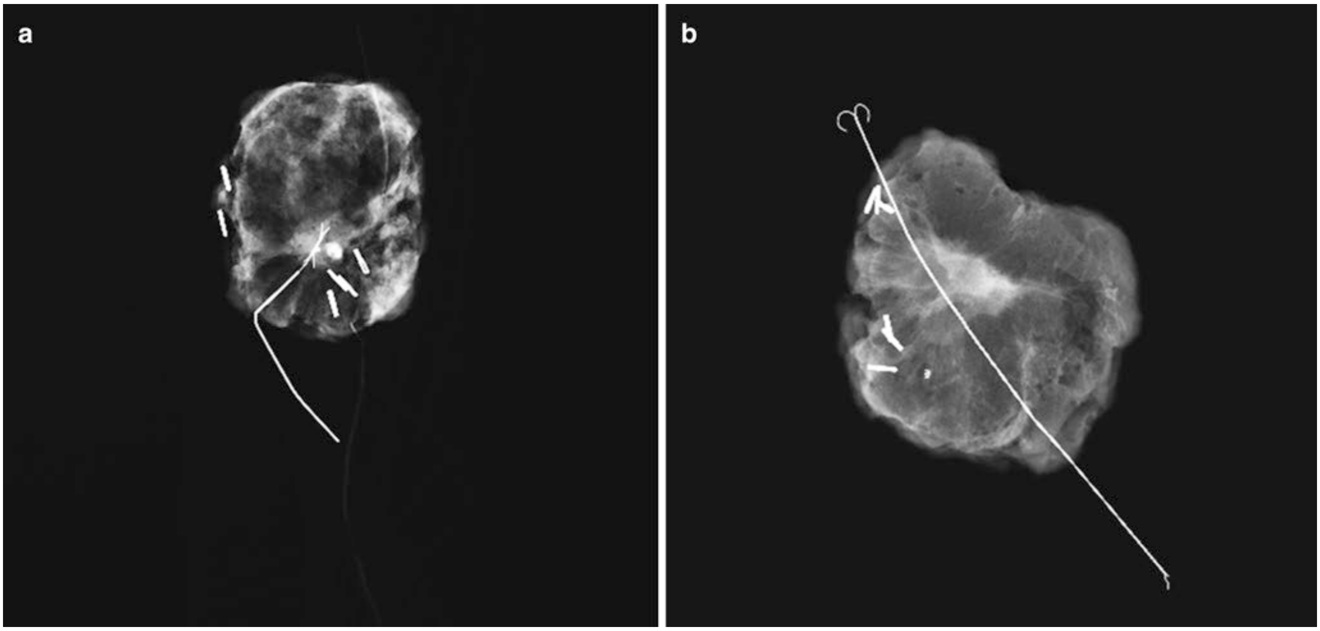


Fig. 3.38 (**a**, **b**) Specimen X-rays following surgical excision of needle-localized lesions; (**a**) accurately localized small screen-detected cancer lying centrally within specimen and good margin of surrounding tissue; (**b**) successful excision of poorly localized carcinoma in which the tip of the wire lies well beyond the center of the lesion

Further Reading

1. Britton P, Duffy SW, Sinnatamby R, et al. One-stop diagnostic clinics: how often are breast cancers missed? Br J Cancer. 2009;100:1873–8.
2. Wishart GC, Warwick J, Pitsinis V, et al. Measuring performance in clinical breast examination. Br J Surg. 2010;97:1246. https://doi.org/10.1002/bjs.7108.

Surgery for Benign Breast Disorders

4

4.1 Overview of Benign Disorders

Benign non-neoplastic conditions of the breast show a wide variety of proliferative and regressive changes in the breast parenchyma, epithelial elements, and stroma. Some of these form distinct entities, but the majority has been grouped together, and various terms used to collectively describe these changes. Terminology includes chronic mastitis, benign mammary dysplasia, cystic mastopathy, fibroadenosis, and most commonly fibrocystic disease. The latter refers clinically to a condition characterized by painful breasts with tender nodularity that may be localized or generalized. Pathologically fibrocystic disease is associated with fibrosis, adenosis, apocrine metaplasia, epithelial hyperplasia, and cyst formation. Cyclical pain and nodularity is very common in women of reproductive age and is considered to be physiological rather than pathological. Focal nodularity is seen in women of all ages and is the most common cause of a breast lump. Historically many of these lumps were excised, but when examined histologically a normal evolutionary process in the form of fibrosis and sclerosis is seen with no evidence of any pathological abnormality. Similar changes have been observed in autopsy studies of women with symptomatic breast disease. For these reasons, the term fibrocystic changes rather than "disease" is more appropriate and refers to the above pathological changes, with cyst formation being more prominent in the run up to the menopause. The term fibroadenosis is often used when describing symptoms of pain and lumpiness in younger women for whom macrocyst formation is a less frequent component of this pathological spectrum. To encompass all of these clinico-pathological manifestations, the concept of "aberrations of normal development and involution" (ANDI) has been proposed as a framework to classify these benign disorders and apply rational management (which rarely involves surgical intervention).

4.2 Cysts

Cysts are round or spherical structures derived from lobules and are defined by the presence of a walled space with fluid. Cysts are often multifocal and bilateral and are usually found in clusters. Small cysts seen in breast biopsies represent a process of involution, but several microcysts may expand and coalesce to form a large cyst. Cysts are lined by epithelium that may be flattened, attenuated, or even absent, and myoepithelial cells can be demonstrated. Macrocysts commonly present as smooth, discrete palpable and sometimes tender lumps that may reduce in size spontaneously. Cysts are common in pre- and peri-menopausal women with a median age of 40–60 years. They are uncommon over the age of 60 unless patients are taking hormone replacement therapy, but an associated intracystic papilloma can occur in this age group. Cysts vary in size and can measure up to several centimeters, but those under 1 cm in size are usually impalpable and asymptomatic. Cysts are readily diagnosed on mammography and have typical ultrasound features of an anechoic mass with well-defined margins and posterior acoustic enhancement due to through transmission of sound waves (B-mode ultrasound) (Fig. 4.1).

The diagnosis of a simple cyst is confirmed by aspiration of cyst contents with no residual sonographic abnormality. The technique used to aspirate a palpable breast cyst is similar to fine needle aspiration cytology. The skin surface is cleansed with alcohol and aspiration performed under ultrasound guidance with a 21-gauge needle attached to a 20 ml syringe (Fig. 4.2a, b).

Cysts are aspirated until no longer palpable and incidental non-palpable cysts are usually left alone but can be aspirated when substantial in size. The contents of a cyst generally contain brown, yellow, or greenish fluid. If such fluid is obtained on aspiration, there is no need to send this off for cytological examination. However, if the aspirate is

I. Jatoi et al., *Atlas of Breast Surgery*, https://doi.org/10.1007/978-3-030-45951-2_4

Fig. 4.1 A simple cyst showing through transmission and posterior acoustic enhancement

uniformly bloodstained (non-traumatic), then the fluid should be examined to exclude the possibility of an intracystic papilloma or intracystic carcinoma. Rupture of a cyst results in an inflammatory response with collection of lymphocytes, plasma cells, and macrophages in the adjacent stroma with associated fibrosis. These changes may have a suspicious appearance on sonographic assessment and prompt core needle biopsy to exclude carcinoma. Elastography is an emerging technique for evaluation of breast lesions and can distinguish between complex cysts and simple cysts such that core biopsy may be unnecessary when there is a solid component attributable to septae and internal debris (Fig. 4.3).

4.3 Fibroadenoma

Fibroadenomas are benign circumscribed lesions of the breast composed of varying amounts of epithelial and stromal components (Fig. 4.4a, b).

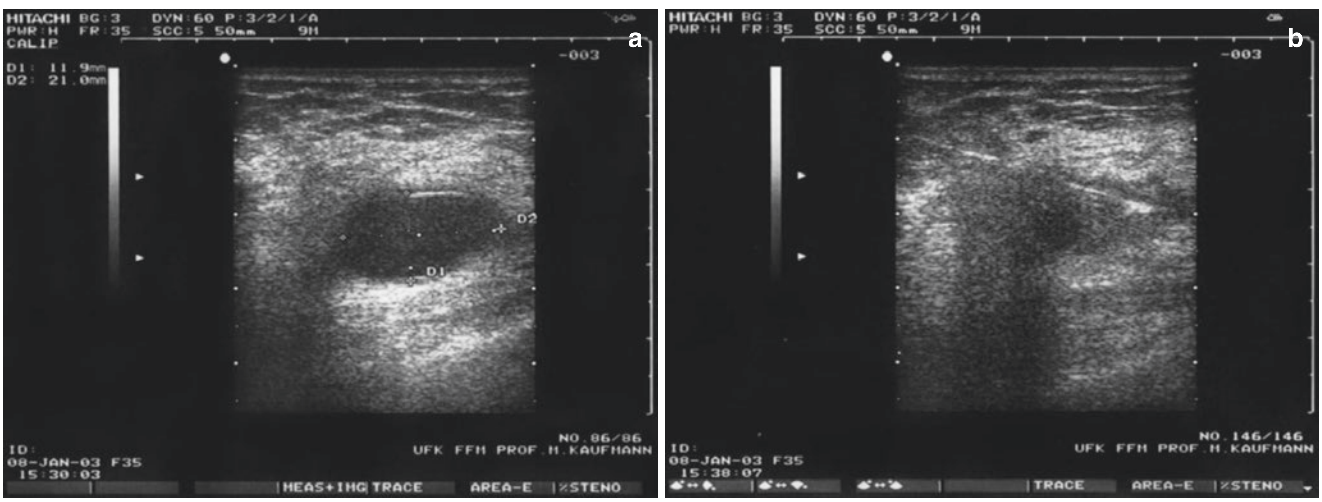


Fig. 4.2 (**a**, **b**) Cyst aspiration under ultrasound guidance

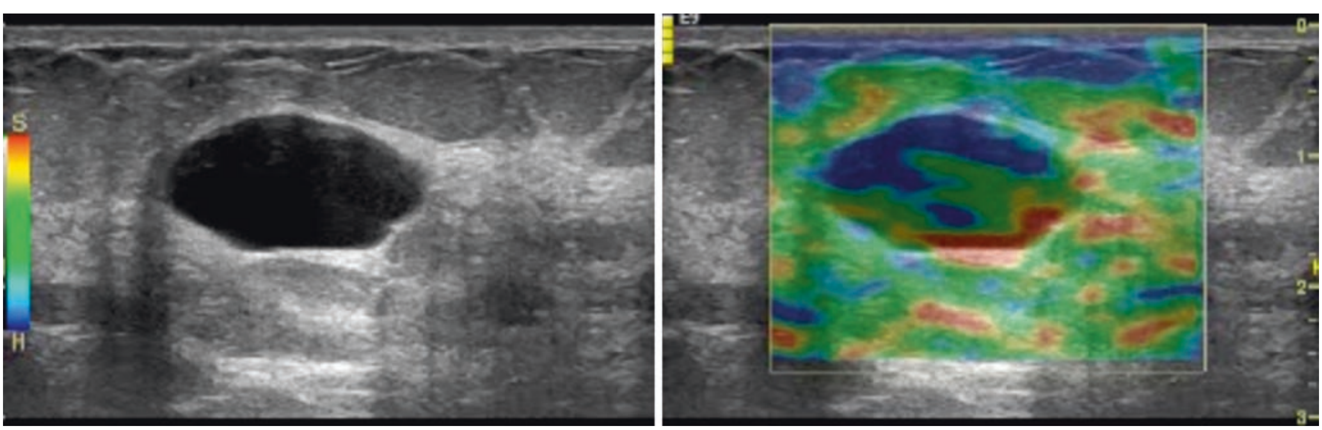


Fig. 4.3 Elastography can identify internal septae and debris and aid distinction between simple and complex cysts

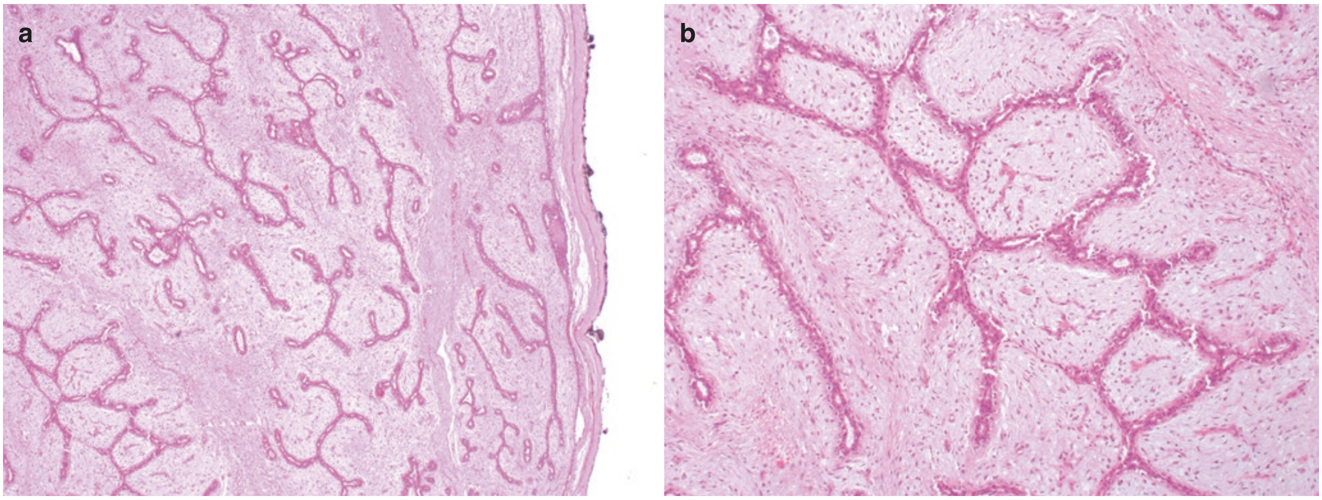


Fig. 4.4 (**a**, **b**) – Intracanalicular fibroadenoma at ×5 (**a**) and ×10 (**b**) magnification

Although often described as a benign tumor, these lesions more accurately represent a localized malformation or aberration of normal development and involution. They arise from a single lobule as opposed to a single cell and respond to the cyclical hormonal changes in the same way as normal breast tissue. Fibroadenomas present clinically as smooth, firm well-defined masses that are mobile within the breast ("breast mouse") and generally occur in younger women (12–30 years). Their natural history is to regress spontaneously, but a minority (<5%) will increase in size and may require surgical excision. The majority of lesions measure between 1 and 3 cm but can grow much larger (giant fibroadenoma). Some fibroadenomas undergo involution in the peri-menopausal phase and become calcified. Fibroadenomas have a characteristic ultrasound appearance of a circumscribed mass wider than tall with homogeneous internal echogenicity. Some units perform needle biopsy of all fibroadenomas, but others confine biopsy to patients over the age of 25–30 years. Any suggestion of a phyllodes tumor on needle biopsy (B3) should prompt excision biopsy, but otherwise these lesions can be observed and only removed if there is sonographic evidence of an increase in size. Excision is performed whenever possible through a peri-areolar incision (or possibly an inframammary fold incision) for cosmetic reasons. The fibroadenoma can be manipulated to the site of the nipple-areola complex with the surgeon's nondominant hand. Then, with the dominant hand, the surgeon makes a peri-areolar or inframammary incision or incises directly over the lesion that is shelled out (Fig. 4.5).

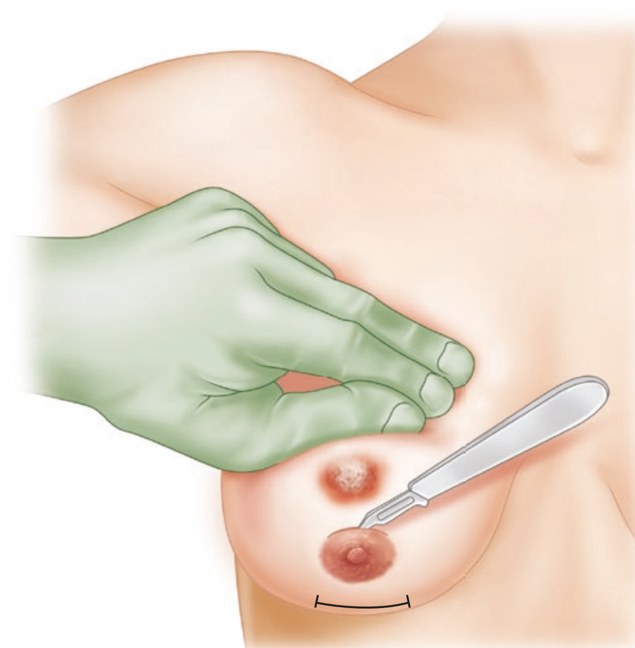


Fig. 4.5 Excision of fibroadenoma (periareolar or alternative inframammary incision)

It is important to initially dissect down onto (but not into) the fibroadenoma and establish the plane of dissection. The glistening surface of a fibroadenoma is readily identified at operation, but sometimes the lesion can be partially fused with dense breast tissue, and a plane must be created with sharp dissection, staying close to the edge of the lesion. When there is a suggestion of a benign phyllodes tumor on core biopsy, then a narrow rim of breast tissue should be excised around the fibroadenoma. This will capture any small pseudopodia that protrude from a phyllodes tumor and avoid the need for cavity re-excision if this diagnosis is confirmed on definitive histology. After removal of the fibroadenoma, meticulous attention should be paid to hemostasis with electrocautery, especially if parenchymal tissue has been incised. The surrounding breast tissue will re-expand to fill the space previously occupied by the fibroadenoma, and there is no indication for any local tissue rearrangement – even for large fibroadenomas.

4.4 Papillary Lesions

Papillomas are a common cause of bloodstained nipple discharge, and surgery is usually warranted for persistent symptoms. Solitary papillomas occur centrally within the breast most frequently in the large collecting ducts deep to the nipple-areola complex. They occur most commonly in middle age but can be found in teenagers and elderly women. More than 80% of women with papillomas present with nipple discharge that is either bloodstained or watery in nature. A mass is sometimes palpable and papillomas have previously been detected as a filling defect on ductography (galactography). The majority of papillomas are small (few millimeters) and seen only on microscopic examination as an elongated structure extending along the duct. Nonetheless, they can be larger (up to 3 cm) and appear as soft, friable masses that can lead to dilatation and distension of a duct. A papilloma typically has a fibrovascular stromal core covered by a double layer of epithelium with a distinct villous structure arising as a branching and arborescent configuration (Fig. 4.6a–d).

The stalk is often attached to the duct wall, and benign papillomas invariably show both an inner epithelial layer and an outer myoepithelial cell layer. The epithelial layer may have foci of hyperplasia that demonstrate atypia, and this feature influences management.

When bloodstained discharge arises from a single duct, a microdochectomy can be undertaken that aims to excise a single duct. In order to identify the relevant duct, a narrow lacrimal probe can be introduced into the duct, or blue dye can be instilled into the duct using a catheter attached to a thin butterfly syringe (Fig. 4.7).

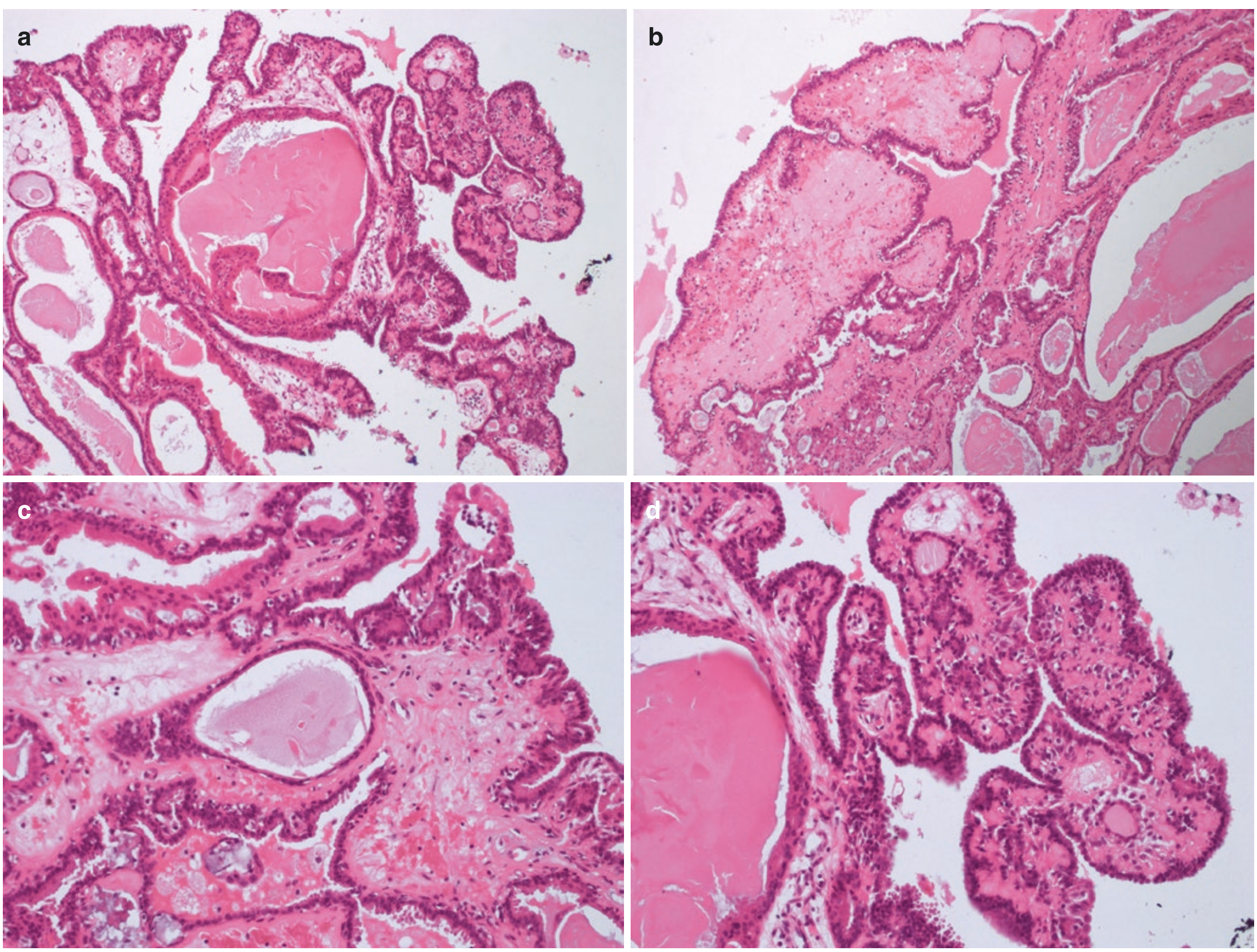


Fig 4.6 (**a**–**d**) Benign papilloma of the breast presenting with nipple discharge at ×10 magnification (**a**, **b**) and ×20 magnification (**c**, **d**)

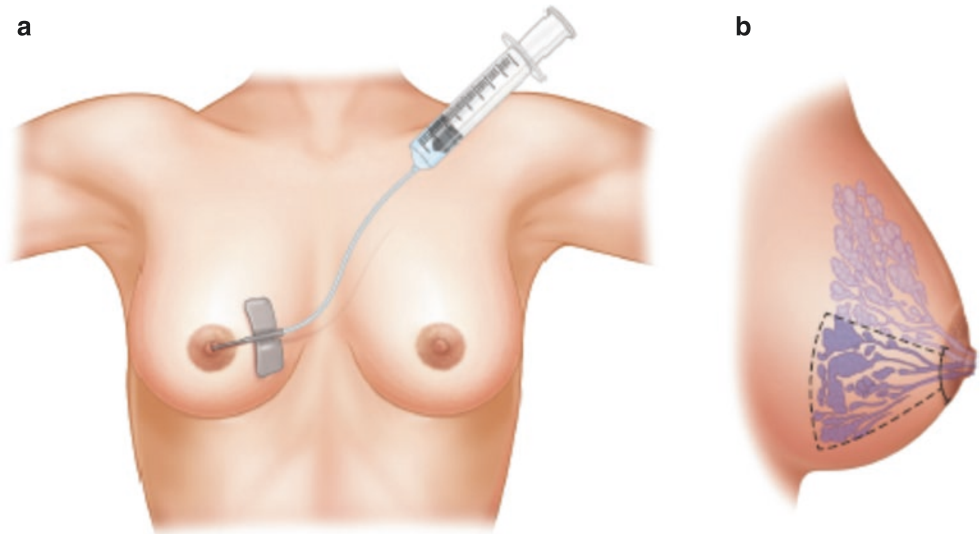


Fig. 4.7 (**a**, **b**) Microductectomy. (**a**) Blue dye is injected into the lactiferous duct and sinus using a thin butterfly syringe. (**b**) Tissue stained by the blue dye is removed (*dotted line*)

The catheter is removed and a periareolar incision made (a lacrimal probe is left in place to guide dissection). Tissues are dissected down to the duct containing either blue dye or probe. The duct is excised and submitted for pathological evaluation. It is important to dissect the duct up to the under-surface of the nipple-areola complex to minimize the chance of leaving behind a small papilloma in the proximal end of the duct. Meticulous attention is paid to hemostasis and the wound irrigated. The wound edges are approximated with a continuous subcuticular absorbable suture. An alternative approach is to make a periareolar incision and then lift up the areola with skin hooks or Allis forceps. The area of breast tissue that includes the involved duct (or ducts) is broadly excised, extending the zone of excision posteriorly. The involved duct is likely to be dilated and contains darkish-colored material that aids identification. A wedge excision of several ducts can be performed if a single culpable duct cannot be identified (Fig. 4.8).

A more peripherally located papilloma that is away from the nipple can be managed with vacuum excision biopsy when there is no evidence of atypia on core biopsy. However, these percutaneous techniques are not suitable for lesions lying superficially immediately deep to the nipple-areola complex or skin of the breast.

4.5 Duct Ectasia

The term "duct ectasia" was introduced by Haagensen in 1951 to describe a benign condition associated with dilatation of the terminal ducts deep to the nipple-areola complex. The condition is associated with the presence of desquamated cellular debris within the lumina of ducts together with variable degrees of peri-ductal fibrosis and inflammation. The disease process is considered to be evolutionary with duct obstruction being the primary initiating event. This then leads to duct dilatation and distension from accumulation of cellular debris and lipids. Subsequent atrophy and discontinuity of epithelium lining the ducts permits egress of contents into the surrounding stroma with induction of an inflammatory response and accumulation of polymorphonuclear leukocytes, histiocytes, and plasma cells. This process provides an ideal milieu for bacterial growth. Breast tissue and parenchyma are normally colonized by a range of aerobic and anaerobic organisms that can lead to secondary infection. This disease process can affect multiple ducts, and the precise clinical manifestation is dependent on the stage of this disease process. In the later stages, there is peri-ductal fibrosis which can produce distortion and obliteration of ducts.

Patients with troublesome non-bloodstained discharge from multiple ducts that causes soiling of undergarments and nightclothes are suitable for a sub-areolar duct excision. This procedure aims to extirpate the major ducts immediately below their opening at the nipple for diagnostic or therapeutic purposes (Fig. 4.9).

In many cases, discharge from multiple ducts is attributable to duct ectasia, but other causes of profuse nipple discharge should be considered, especially if the discharge is bilateral. When a prolactin-secreting tumor of the anterior pituitary gland (microadenoma) is suspected, patients must undergo thorough preoperative workup to exclude any sinister pathology. Sub-areolar duct clearance is usually performed under general anesthesia. After applying a cleansing agent over the entire field, an infra-areolar incision in made that should not exceed one-third of the

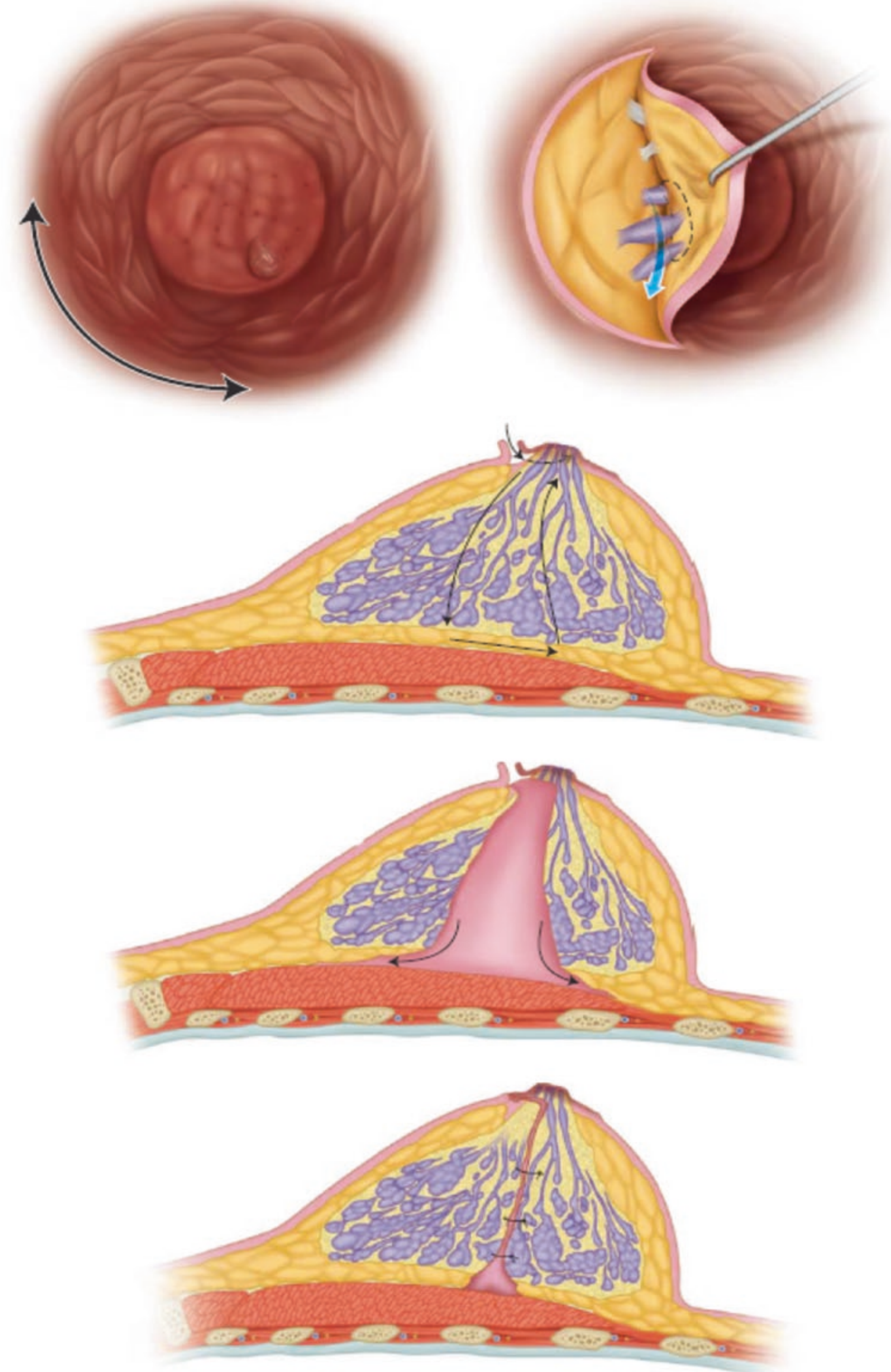


Fig. 4.8 Ductectomy through a periareolar incision

circumference of the areola. Dilated ducts containing secretions are usually readily identified at operation, and all ductal tissue is excised. Gentle finger pressure on the undersurface of the nipple is a useful manoeuver to check whether there are any residual ducts producing discharge. Distal severed ducts should not be ligated, and meticulous hemostasis is carried out before irrigating the cavity with copious amounts of saline or saponification solution. The skin edges are approximated with a continuous absorbable subcuticular suture.

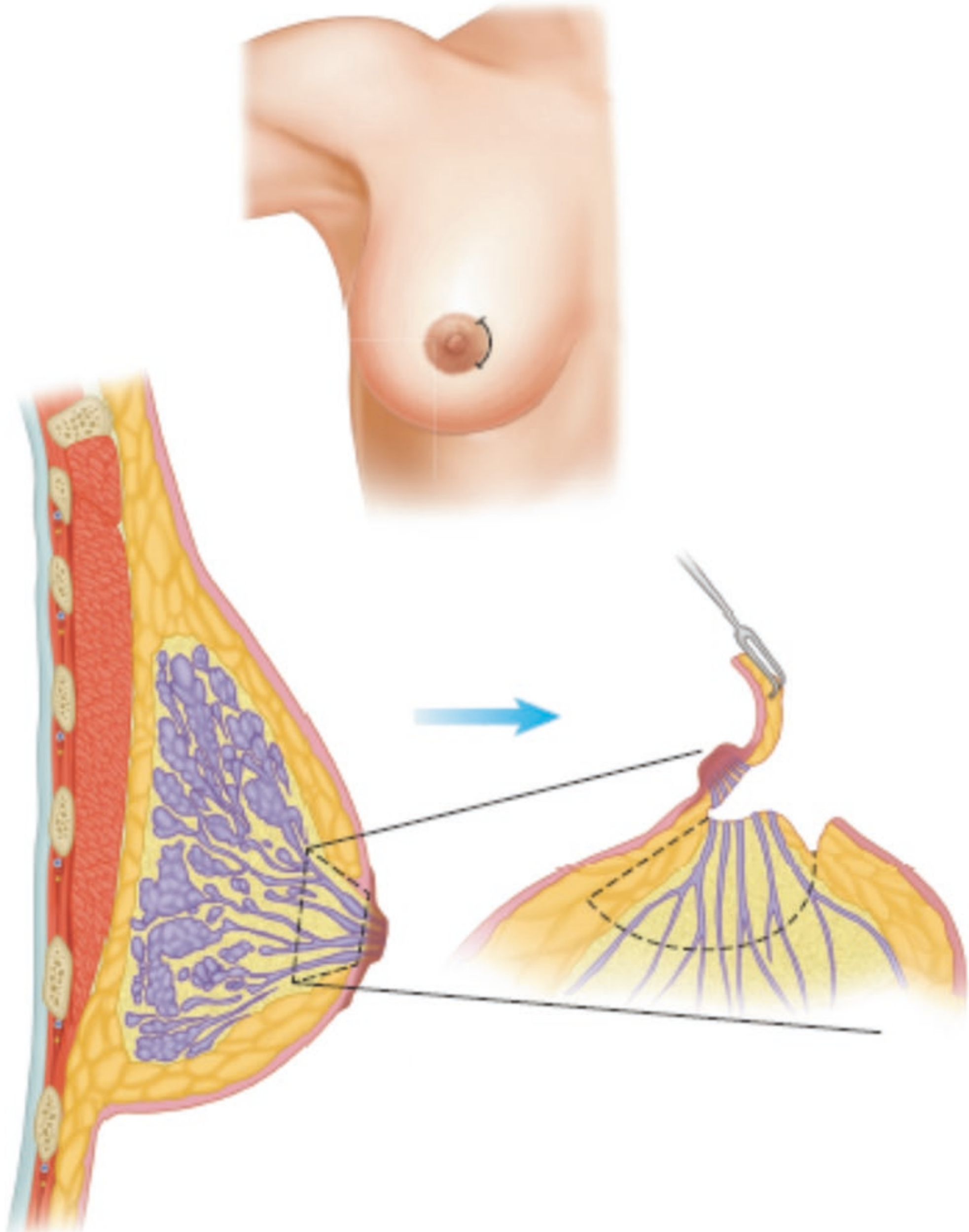


Fig. 4.9 Sub-areolar dissection, required to extirpate the major ducts immediately below the nipple

4.6 Breast Infection and Abscess

Mammary duct associated inflammatory disease sequence is an umbrella term encompassing a spectrum of benign disease processes. These range from mammary duct ectasia and peri-ductal inflammation/mastitis to sub-areolar breast abscess and the sequelae of mammary duct fistula. Mammary duct associated inflammatory disease sequence presents with a broad spectrum of symptoms, and it is important for surgeons to recognize the symptomatology and appreciate the underlying pathophysiological processes. Unnecessary surgical intervention should be avoided and appropriate nonsurgical treatments offered that aim to ameliorate acute symptoms and minimize the chance of progression to abscess and fistula formation.

Peri-ductal mastitis – younger women tend to have more severe forms of peri-ductal inflammation in areas adjacent to non-dilated ducts, and it has been proposed that for some younger women duct dilatation may occur secondary to peri-ductal inflammation that is the primary event. Peri-ductal mastitis is a cause of nipple retraction and inversion but not a consequence of any congenital anomaly of the nipple-areola complex. Furthermore, smoking is a major etiological factor for peri-ductal mastitis, and any coexistent duct ectasia may be an unrelated phenomenon.

Sub-areolar abscess – epidermalization results in production of excess amounts of keratin leading to obstruction of ducts by formation of keratin plugs. Keratin is a highly irritating material and evokes an inflammatory response. Thus the initial obstruction by keratin plugs causes secondary inflammation surrounding ducts. Colonization of inflamed peri-ductal tissue occurs from either endogenous breast bacteria or skin commensals leading to sub-areolar abscess formation. The latter represents one stage further on from peri-ductal inflammation with bacterial colonization and eventually abscess formation. It should be noted that non-puerperal abscesses are often difficult to manage compared to puerperal abscesses that completely resolve after incision and drainage. During the early stages of progression from peri-ductal mastitis to a sub-areolar abscess, there are focal inflammatory changes with an indurated mass without pus formation. At this stage, symptoms may settle with a 2 weeks course of a broader spectrum antibiotic and metronidazole (to cover anaerobic organisms). However, if a patient presents with an area on the breast that is erythematous, warm, and fluctuant, this generally indicates the presence of an underlying abscess. An abscess of the breast should be drained emergently with release of debris and tenacious pus. In most instances, a breast abscess is drained in a manner identical to drainage of abscesses elsewhere. Thus an incision is made directly over the abscess cavity, pus drained out, and the wound packed open. However, there are some techniques that can be applied specifically to the drainage of a breast abscess. Thus smaller collections that are less evident clinically can initially be managed with percutaneous ultrasound-guided fine needle aspiration with possible repeat aspiration after 3–4 days. When there is clinical or sonographic evidence of a mature abscess, then formal incision and drainage should be performed and is the preferred option for larger lesions pointing on the skin surface.

As indicated in Fig. 4.10, some large abscesses can be drained through an incision along the areola border without excision of skin unless this is necrotic or non-viable. The size of this incision should allow introduction of a digit to permit breakdown of internal loculations. The cavity is irrigated with dilute hydrogen peroxide followed by dilute iodine-based solution. The wound is closed around a narrow corrugated (or Penrose) drain that is left in place for 4–5 days to permit establishment of a tract and prevent premature closure of the wound. Alternatively the drain can be brought out through the inframammary fold, but this involves disturbing unaffected breast tissue (Fig. 4.11).

Closure of the wound is preferable to packing; the latter necessitates daily dressing changes until the wound granulates and closes secondarily. Large abscess cavities on the posterior aspect of the breast are sometimes amenable to drainage through an incision in the inframammary fold with placement of a drainage catheter into the abscess cavity (it may be helpful to undertake this with intraoperative ultrasound guidance) (Fig. 4.12).

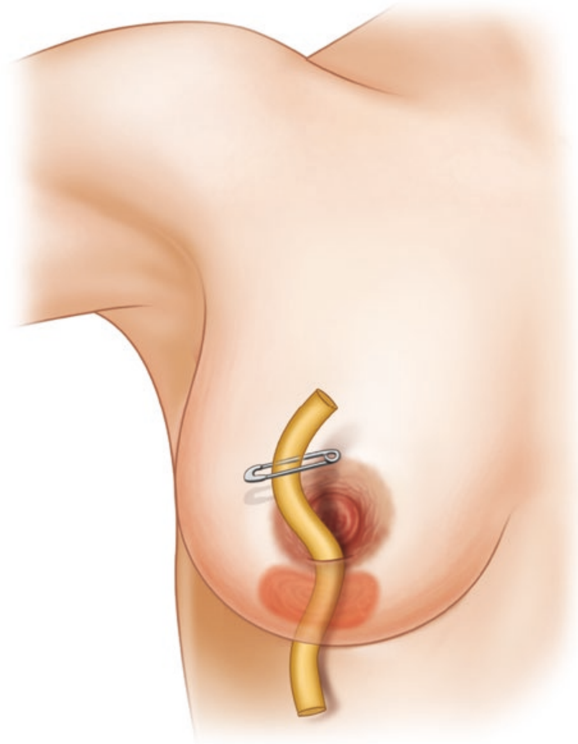


Fig. 4.10 Drainage of a larger breast abscess

Mammary duct fistula – a sub-areolar abscess can discharge at the edge of the areolar and subsequently heal temporarily. Recurrent episodes produce a tract lined by granulation tissue and formation of a frank mammary duct fistula that communicates with a major mammary duct. Smoking is associated with an increased incidence of squamous metaplasia, although only one-quarter of smokers have gross mammary duct ectasia. However, almost 90% of patients with severe inflammatory conditions affecting the nipple-areola complex are smokers, and virtually all patients with a peri-ductal fistula are smokers. A mammary duct fistula usually develops after failure to satisfactorily treat a sub-areolar abscess and is the final stage in the mammary duct associated inflammatory disease sequence. It is associated with chronic inflammatory changes and produces a discharging lesion either at the areolar border or base of the nipple. The cutaneous lesion represents the site of discharge of a sub-areolar abscess along the most direct route of least resistance. Multiple episodes of sinus healing followed by recurrent abscess formation produce a fistulous tract lined by granulation tissue. Direct communication between the fistula and a major lactiferous duct may not be demonstrable in up to 10% of cases, but often a probe can be passed along the fistulous tract to emerge at the nipple (Fig. 4.13).

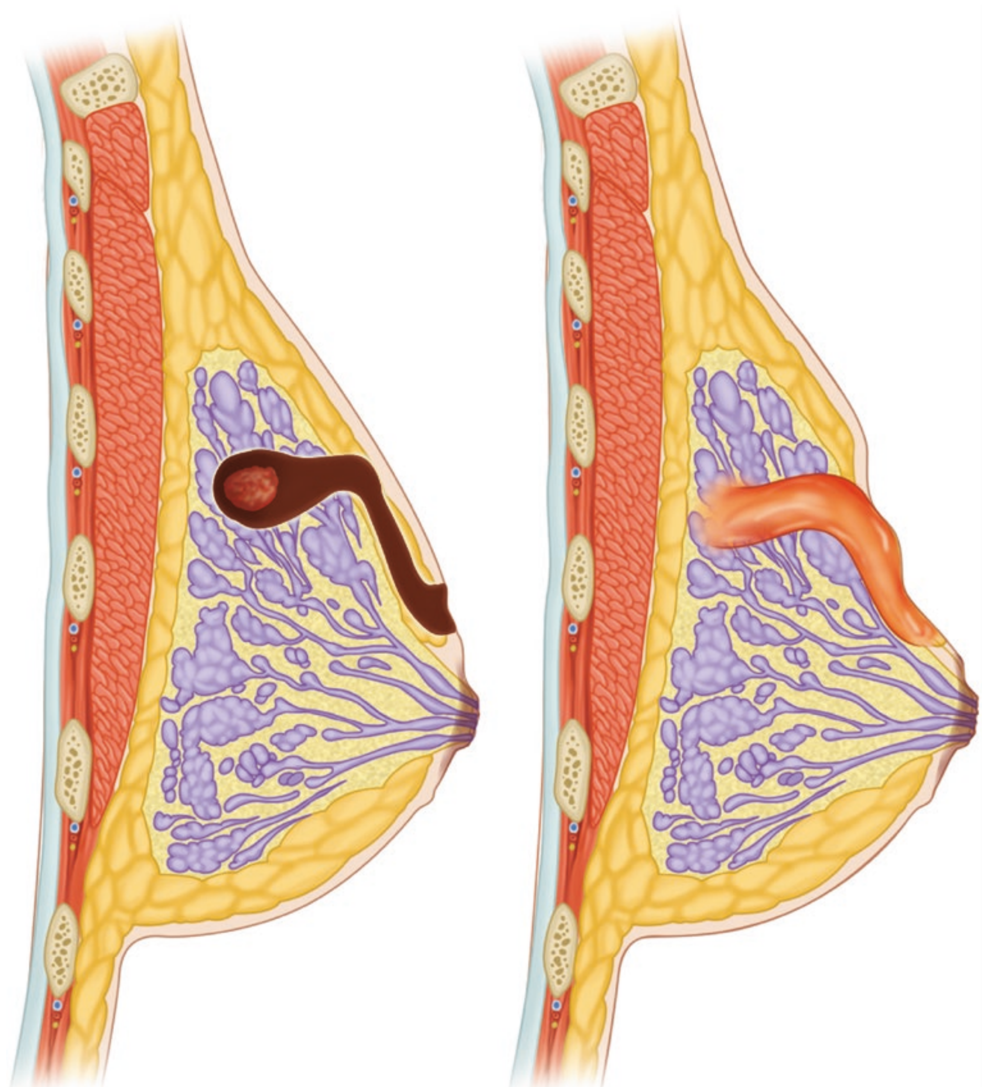


Fig. 4.11 Drainage of a large abscess through a periareolar incision

Simple incision and drainage of a mammary duct fistula frequently leads to recurrence. Successful management of chronic mammary fistulas mandates excision of the fistula tract together with diseased sub-areolar ducts. It is crucial that the terminal portion of duct within the nipple is excised with the main specimen and the wound packed with healing by secondary intention.

4.7 Gynaecomastia

There is a remnant of breast tissue in all males, and hypertrophy of this leads to the condition of gynecomastia that literally means "female breast." Most cases are idiopathic without any identifiable underlying cause and are usually unilateral. The condition is probably more common than generally appreciated due to many men denying the presence of a mass or admitting to other symptoms. Enlargement of breast parenchymal tissue should be distinguished from pseudogynecomastia that is attributable to excessive subcutaneous fatty tissue. An imbalance of sex hormones during adolescence results from an early surge of plasma estradiol before increased production of testosterone. This can stimulate the breast tissue of young boys and is responsible for pubescent gynecomastia that can be a source of pain, tenderness, and psychological distress. This form of gynecomastia usually resolves spontaneously by the late teenage years, and pressure from the patient (and parents) for surgical intervention should be resisted. It is particularly important to exclude testicular tumors, liver disease, and medication as a cause for gynecomastia before designation as idiopathic; testicular tumors as associated with elevated levels of estrogen can present clinically with gynecomastia. External genitalia examination should always be undertaken in male patients, and any suspicious testicular mass should prompt ultrasound examination and urological referral (tumor markers such as beta-HCG and alpha-fetoprotein should be requested). A relative excess of estrogen occurs in patients with liver

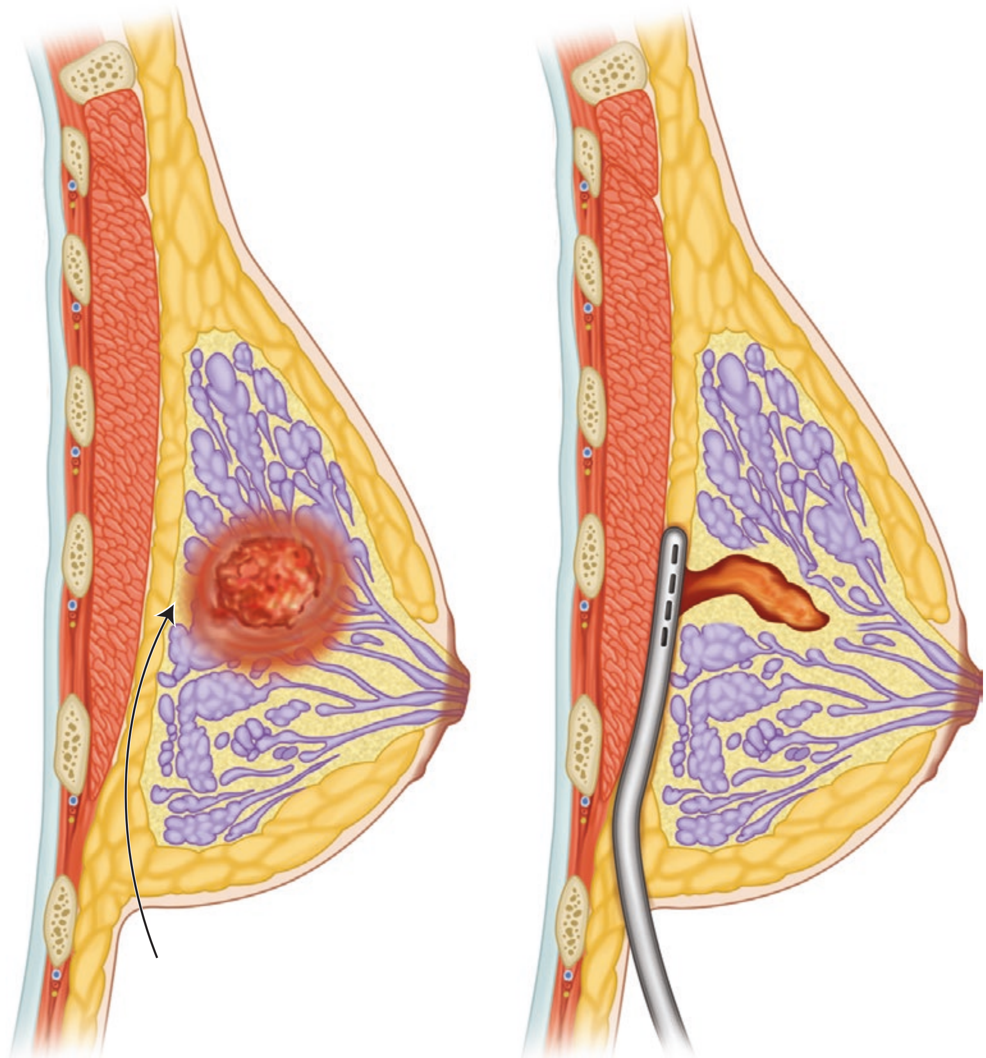


Fig. 4.12 Drainage of an abscess through an incision located in the sulcus. Sometimes it is necessary to exclude the possibility of an inflammatory breast cancer with a punch biopsy of the skin or core needle biopsy of the parenchyma. All patients presenting with erythema should undergo full evaluation with comprehensive imaging and biopsy if indicated

disease due to impaired metabolism and reduced clearance of hormones. Hyperestrogenic states lead to feminization with gynecomastia, hypogonadism, and loss of body hair. Several drugs reduce production of testosterone or inhibit action of the hormone including H2 antagonists (cimetidine), spironolactone, flutamide, and phenytoin. Historically, digoxin and isoniazid were other examples of commonly used drugs causing gynecomastia, and contemporary agents include recreational drug use (heroin, marijuana (tetrahydrocannabinol). These specific causes of gynecomastia often affect both breasts; surgical correction is inappropriate, and management should focus on treatment of the underlying condition or withdrawal of any causative exogenous agent. Often gynecomastia will regress within weeks of discontinuation of medication.

Clinical examination reveals concentric enlargement of the breast disc without nipple distortion or axillary lymphadenopathy. There may be an element of pseudogynecomastia in obese individuals, and bilateral changes may be present. Investigations include mammography which demonstrates high specificity for gynecomastia in men aged ≥40 years and can exclude more sinister pathology. There is no indication for core needle biopsy when mammography shows a typical flame-shaped opacity and clinical assessment is non-suspicious for malignancy (relatively soft, concentric retroareolar mass without fixation or skin changes).

Surgical intervention is appropriate for patients with idiopathic forms of gynecomastia who are concerned about the cosmetic appearance of the breast and wish to avoid medication for treatment of this condition. It is important for patients to understand that this is a cosmetic procedure, and surgery can be associated with complications and scarring. In particular, an ugly "saucer" deformity can result from inadequate removal of all peripheral breast tissue or an aggressive local excision that leaves the nipple unsupported by deeper tissue. There are several surgical approaches to treatment of gynecomastia (Fig. 4.14), and options should be discussed with the patient.

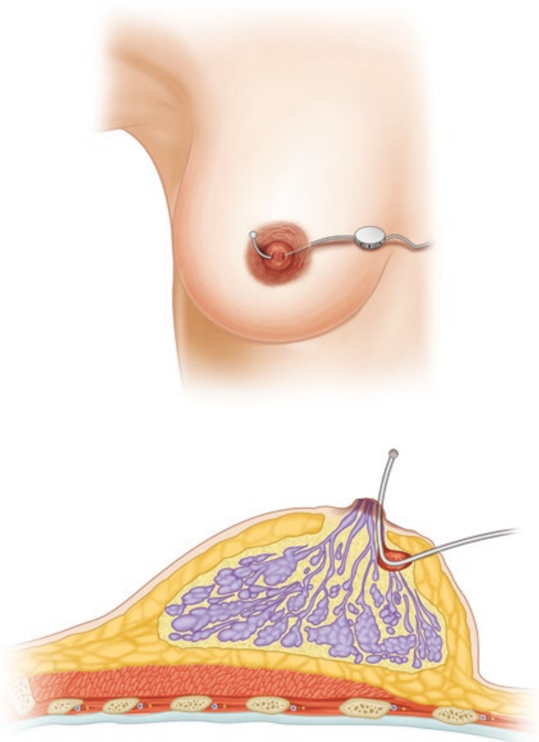


Fig. 4.13 Drainage of a sub-areolar abscess using a lacrimal duct probe

Sometimes a combination of surgery and liposuction will yield the best results and maximize chest wall symmetry (Fig. 4.15).

For patients with modest degrees of gynecomastia, a periareolar incision is preferred and can be extended with small wings medially and laterally. The nipple-areola complex is retracted anteriorly and the underlying breast tissue extirpated by sharp dissection or possibly liposuction depending on consistency of the tissue. It is crucial to ensure that dissection is carried out to the peripheral limits of the breast tissue, and a small disc of breast tissue should be retained underneath the nipple to avoid a sunken deformity. Note that any residual breast tissue in this context is not associated with elevated risk for breast cancer in contrast to risk-reducing nipple-sparing forms of mastectomy in women. Hemostasis is achieved using electrocautery and the wound closed in layers with a continuous subcuticular dissolvable monofilament suture (3-0 or 4-0). The surgical cavity should be irrigated copiously prior to closure and the skin suture supported with robust closure of the subcutaneous tissues to minimize adherence of the nipple to the chest wall musculature. An alternative choice of incision is one sited along the inframammary fold. However, this may hinder access to the superior limits of the breast and be cosmetically less acceptable to non-hirsute individuals (Fig. 4.16).

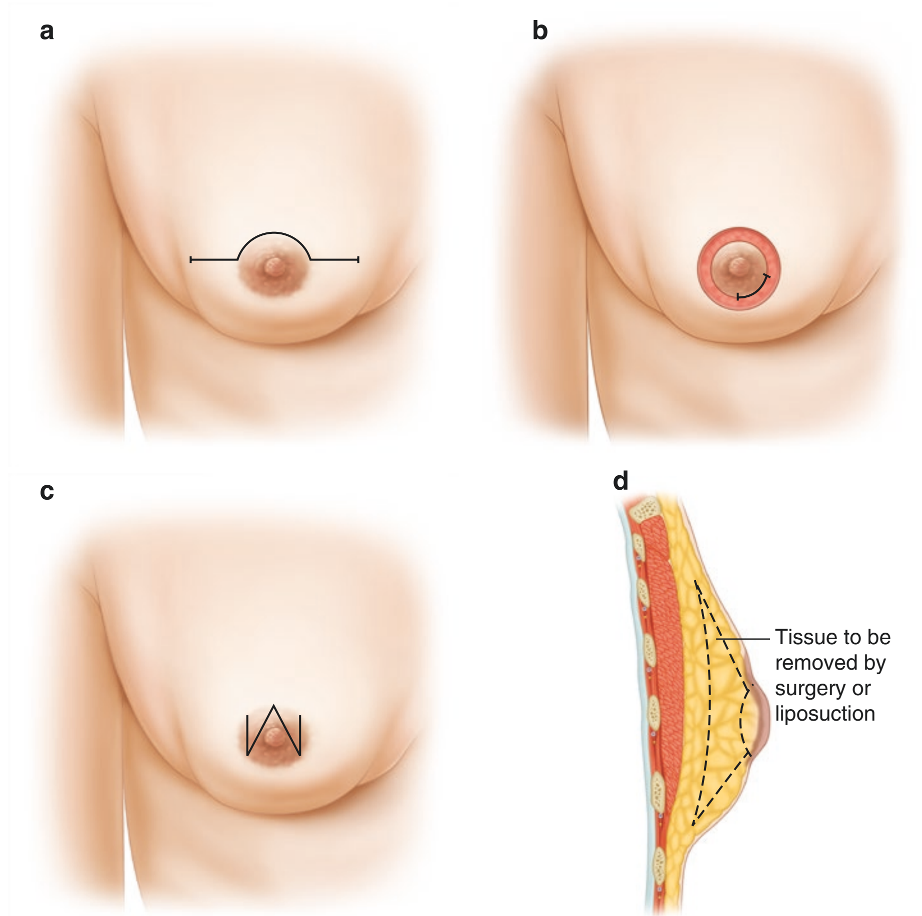


Fig. 4.14 (**a**–**d**) Surgical management of gynecomastia. (**a**) Nipple–areola complex incision. (**b**) Round block incision and de-epithelialization periareolar. (**c**) “W” incision. (**d**) The area of breast tissue excised beneath the nipple-areola complex

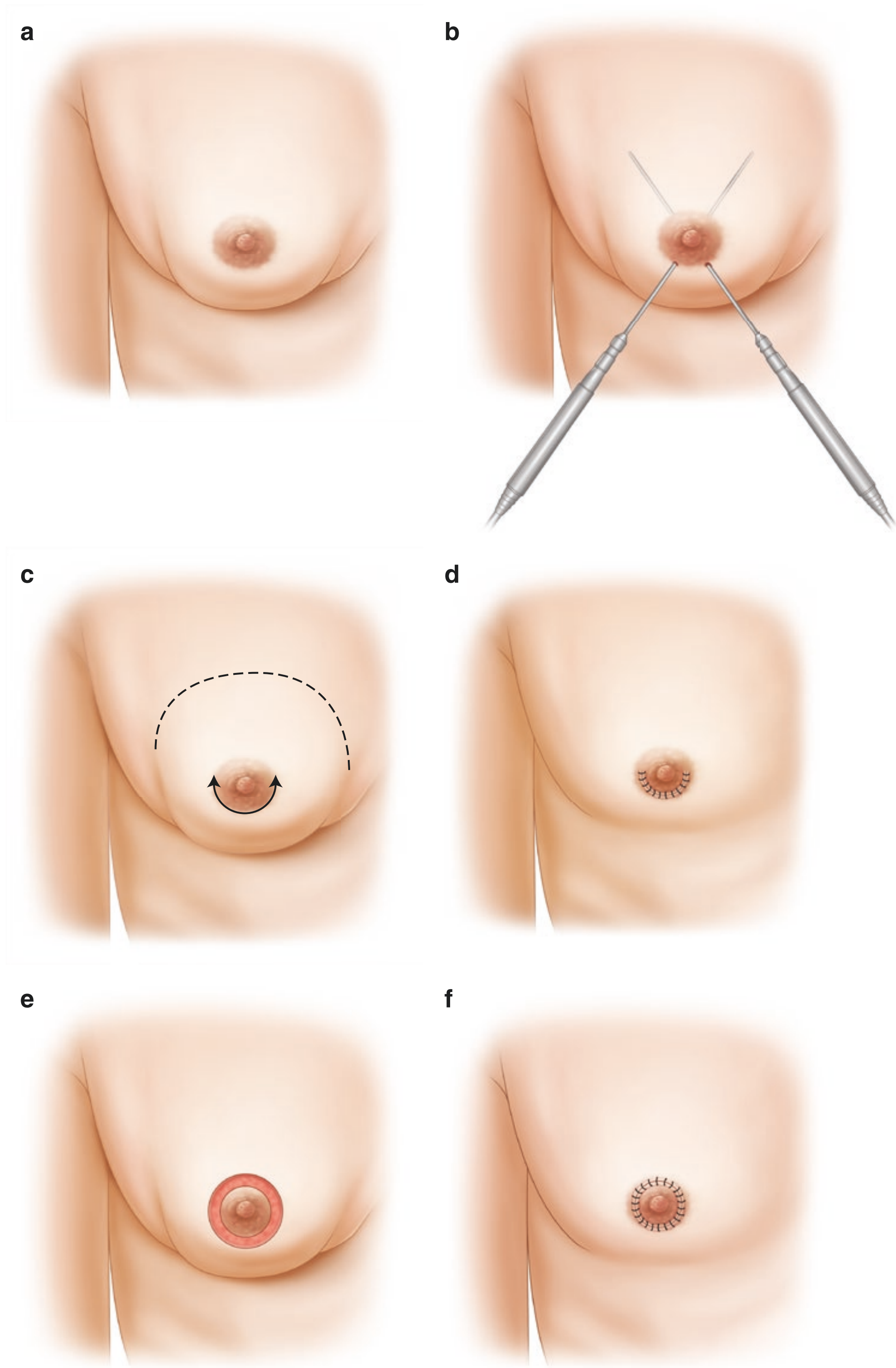


Fig. 4.15 (**a**–**f**) Treatment of gynecomastia with liposuction. (Indication for liposuction only in cases of fatty tissue or in addition for body contouring)

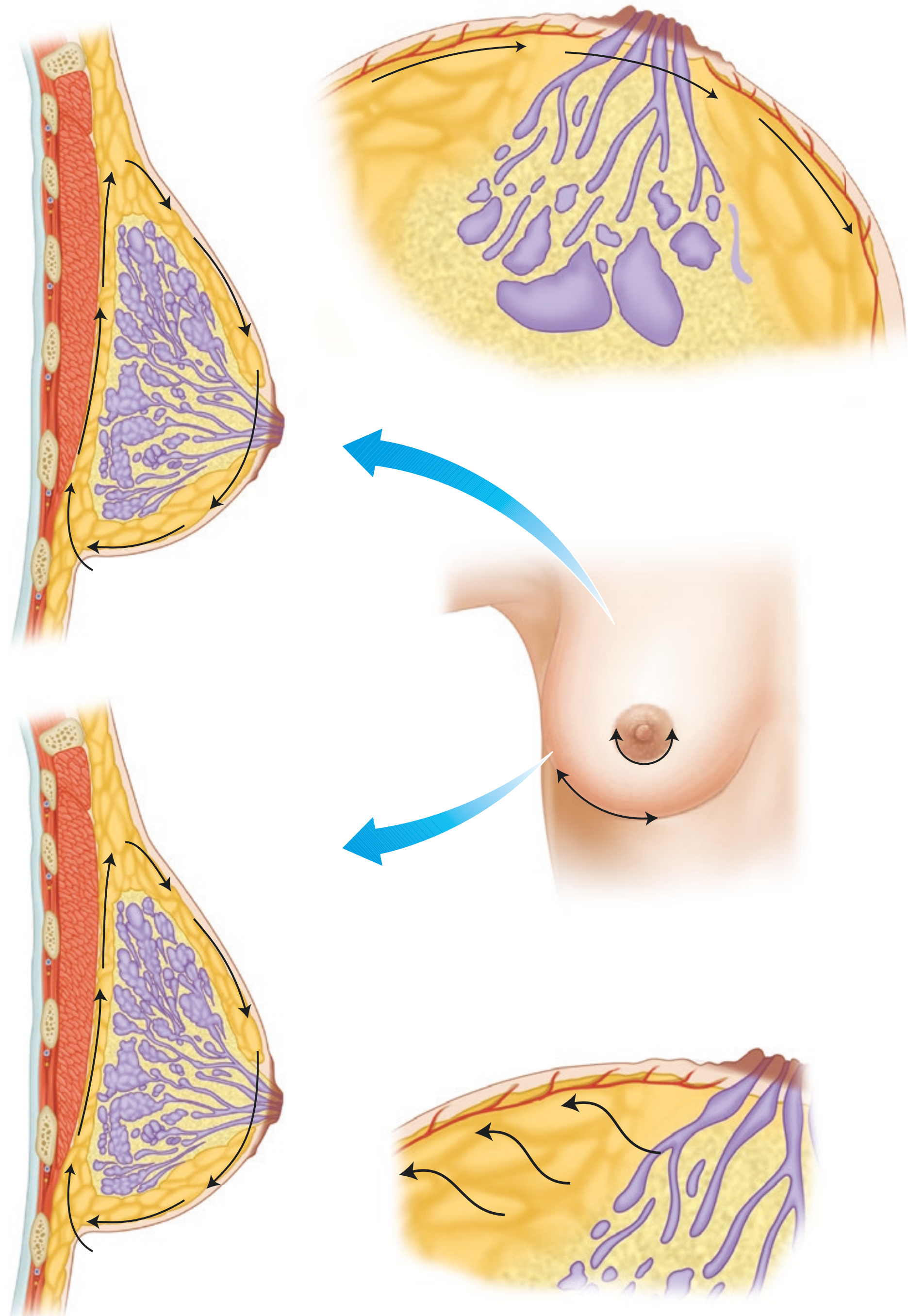


Fig. 4.16 Treatment of gynecomastia with subcutaneous mastectomy

5 Surgery for Breast Cancer

5.1 Mastectomy

The term mastectomy refers to surgical extirpation of all breast parenchymal tissue, and any procedure that intentionally aims to preserve a proportion of breast tissue is otherwise known as breast conserving surgery. Until the latter quarter of the twentieth century, breast cancer surgery involved mastectomy only and was dominated by two surgical procedures – the radical and modified radical mastectomy. The operation of radical mastectomy is attributed to William Stewart Halsted and was presaged on the assumption that breast cancer arose from a single focus within the breast and spread contiguously and centrifugally over time with progressive involvement of adjacent tissue and the lymphatic system. A fundamental principle of the so-called Halstedian hypothesis was that maximal efforts at local control would prolong survival. The Patey modified radical mastectomy removed breast and axillary tissue in continuity but preserved the pectoralis major muscle and much reduced the morbidity of the traditional radical operation. With the rapid development of breast reconstructive techniques over the past three decades, the modified radical mastectomy has evolved into the skin-sparing and nipple-sparing forms of mastectomy that are now being applied to both prophylactic and therapeutic breast surgical procedures. Skin-sparing mastectomy was introduced in the early 1990s, and initial concerns that greater skin preservation might lead to higher rates of local recurrence have not been justified. Several studies have now confirmed low rates of local recurrence (<5%) for skin-sparing procedures that are not significantly higher than for conventional forms of mastectomy when patients are matched for stage of disease. Ongoing studies are attempting to define those breast cancer patients for whom nipple-sparing mastectomy can be safely performed in the ipsilateral breast without compromising oncologic outcomes. Axillary surgery is an integral component of breast cancer surgery and has undergone dramatic change with a trend towards de-escalation of nodal resection. The operations of both radical and modified radical mastectomies implied concomitant axillary dissection, but with the advent of sentinel lymph node biopsy, formal axillary dissection is now much less commonly performed (as either a primary or secondary procedure). A notable change has been omission of completion axillary dissection in selected node-positive cases with reliance on adjuvant nonsurgical modalities for eradication of low burden axillary disease. The majority of patients nowadays undergo initial sentinel lymph node biopsy, be this in the context of conventional mastectomy without reconstruction, skin-/nipple-sparing mastectomy with reconstruction, or breast conserving surgery. Thus, patients are more likely to undergo simple mastectomy and sentinel lymph node biopsy rather than mastectomy and axillary lymph node dissection – the modified radical mastectomy. Decisions for mastectomy versus breast conserving surgery are based on both surgical considerations and patient choice. The tumor-to-breast-size ratio, proximity to the nipple–areola complex, and multifocality are key factors in determining suitability for breast conserving surgery and recommendation for mastectomy. In recent years, there has been a trend for maximal surgery whereby patients request both ipsilateral and contralateral prophylactic mastectomies for smaller unilateral tumors that are otherwise amenable to breast conserving surgery (usually in conjunction with bilateral breast reconstruction). Prophylactic mastectomy might be considered for women who harbor high-penetrance mutations (i.e., BRCA-1, BRCA-2, CDH1, PTEN, STK11, p53, and PALB2) that substantially increase the risk of developing breast cancer or for those who have previously been treated with mantle irradiation for Hodgkin's lymphoma who likewise have significantly increased risk of breast cancer. Generally, women who are candidates for prophylactic mastectomy have a lifetime risk of developing breast cancer that exceeds 40%. Yet, there are no randomized controlled trials assessing the efficacy of prophylactic mastectomy in reducing breast cancer risk. Thus, the true effect of prophylactic mastectomy in reducing breast cancer risk and impact on mortality are poorly understood. Nonetheless, nonrandomized studies suggest that prophylactic mastectomy may

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reduce the risk of developing breast cancer by about 90–95% with a corresponding reduction in breast cancer mortality. It is important that women considering prophylactic mastectomy are fully informed and understand that the procedure will not entirely eliminate the risk of developing breast cancer.

When considering prophylactic mastectomy, there are four options: total mastectomy, skin-sparing mastectomy, nipple-sparing mastectomy, and subcutaneous mastectomy. Total mastectomy has been discussed above and involves resection of the nipple–areola complex together with a significant proportion of the breast skin envelope and all breast parenchyma. However, this is not the optimal strategy for most patients nowadays who undergo therapeutic or prophylactic mastectomy in conjunction with immediate breast reconstruction. For this group of patients, preservation of the breast skin envelope is paramount, and options include subcutaneous mastectomy, skin-sparing mastectomy, and nipple-sparing mastectomy. Subcutaneous mastectomy loosely refers to a form of mastectomy in which much of the breast parenchyma is excised but the skin envelope including the nipple–areola complex is preserved. The breast is approached through an inframammary fold incision, and accessing more peripheral areas of the breast can be challenging. Furthermore, subcutaneous mastectomy traditionally leaves a sliver of breast tissue deep to the nipple–areola complex to maintain vascularity, and this remnant may constitute up to 15% of breast parenchymal tissue. This contrasts with a formal nipple-sparing mastectomy where dissection is continued up to the undersurface of the nipple–areola complex with "coring out" of the nipple in efforts to remove all breast tissue. Skin-sparing mastectomy refers to removal of the nipple–areola complex and preservation of the remainder of the native breast skin envelope. The nipple–areola complex is removed as part of the mastectomy specimen, and there is minimal chance of any residual breast tissue on the mastectomy flaps. A variety of incisions can be used for skin-sparing approaches, but a standard peri-areolar incision is most common (Fig. 5.1). The peri-areolar incision can be extended to include a zone of skin overlying a tumor lying close to the nipple–areola complex (Fig. 5.2). Furthermore, a modification of the skin-sparing mastectomy is the "skin-reducing mastectomy" that employs a Wise pattern to remove redundant skin (Fig. 5.3). The defect resulting from removal of the nipple–areola complex (± adjacent skin) is either closed primarily with a linear scar or filled with a transposed island of skin from an autogenous graft (Fig. 5.4). It is now appreciated that preservation of the nipple–areola complex can reduce psychological stress, enhance body image, and improve overall satisfaction with results of breast surgery (without any benefits being offset by fear of recurrence due to retention of the nipple–areola complex).

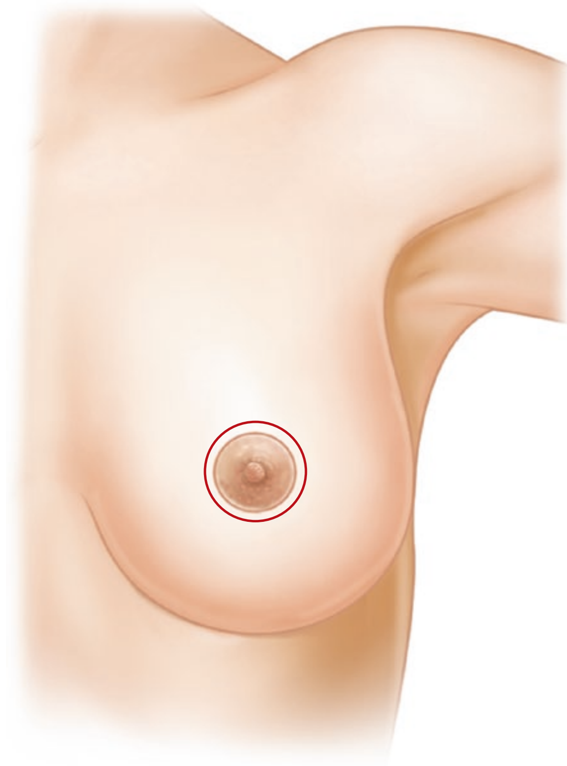

Fig. 5.1 Peri-areolar incision for skin-sparing mastectomy

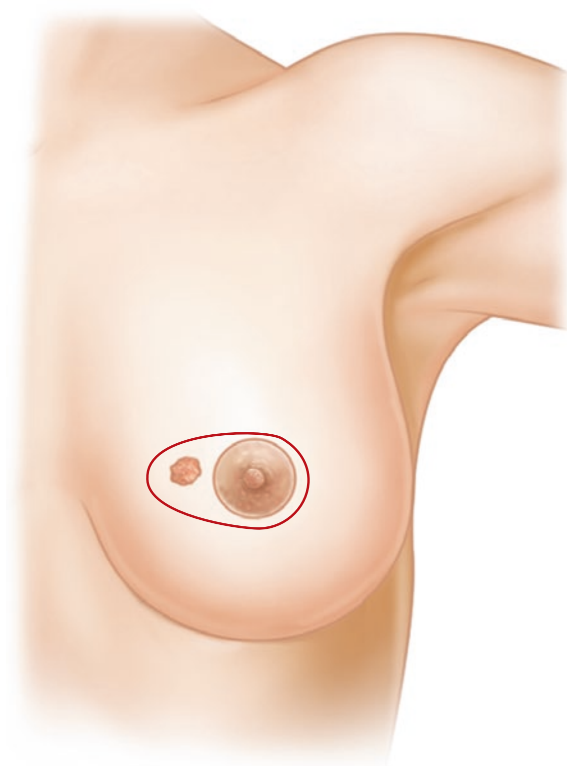

Fig. 5.2 Extended peri-areolar incision with removal of skin overlying tumor

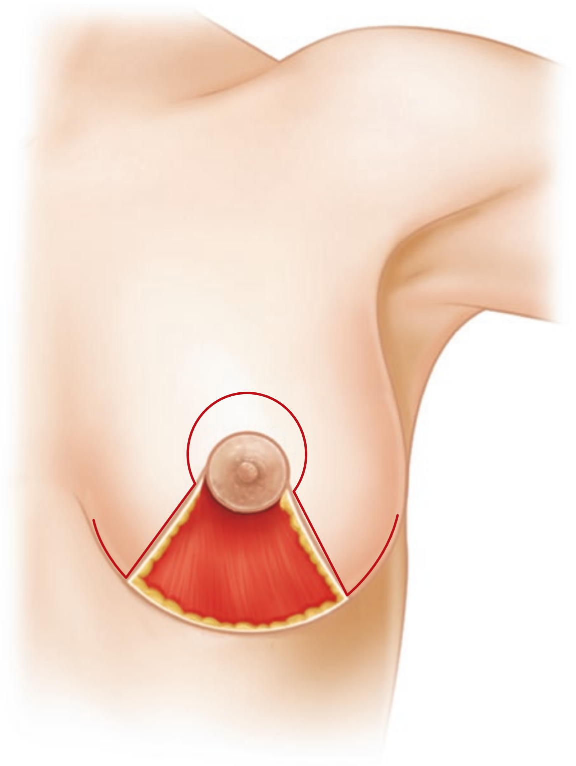

Fig. 5.3 Wise pattern incision for skin-reducing mastectomy (this can involve either preservation or sacrifice of the nipple–areola complex [this can be reattached as a free graft to a disc of de-epithelialized skin])

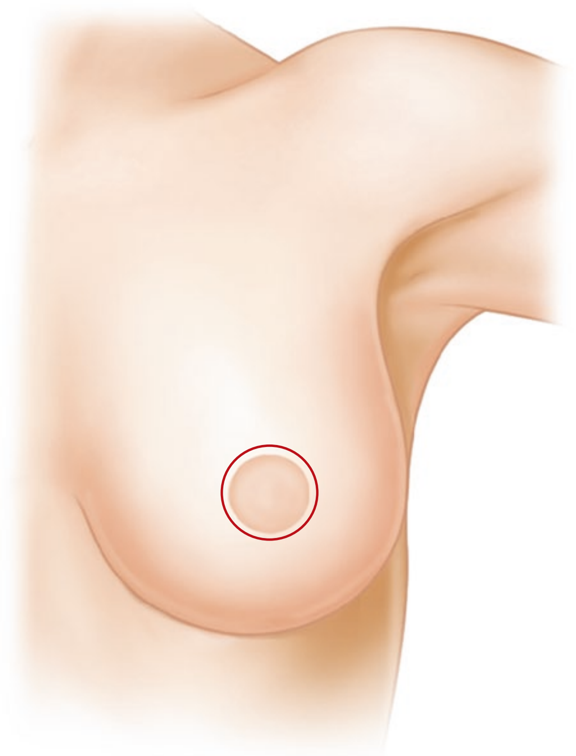

Fig. 5.4 The defect in the breast skin envelope resulting from removal of the nipple–areola complex can be replaced with a disc of skin from an autogenous graft. This maintains the total surface area of the breast skin envelope and avoids a degree of flattening at the dome of the breast

5.2 Conventional Forms of Mastectomy

When evaluating patients for any form of mastectomy, the location of the tumor is of critical importance. In general, a wide elliptical incision is made which incorporates the nipple–areola complex and extends towards the axilla – once again, it should be emphasized that the term "modified radical mastectomy" refers to removal of the entire breast and extirpation of adjacent lymph nodes in the axilla. For this reason, an obliquely placed incision is convenient for access to the axillary contents (Fig. 5.5).

Furthermore, depending on the exact location of the tumor in the breast, the incision might be placed eccentrically in relation to the nipple–areola complex to ensure removal of any involved skin overlying the tumor (namely, infiltration of skin rather than clinical tethering that can be surgically released to obtain anterior clearance histologically). For tumors in the upper outer quadrant of the breast, the incision should extend around the nipple–areola complex and the tumor and into the axilla as illustrated in the accompanying diagram (Fig. 5.6).

Upper outer quadrant tumors are most common, and this diagram (Fig. 5.6a) illustrates the typical incision for mastectomy passing obliquely from the lower parasternal region towards the axilla. For tumors in the lower outer quadrant, a low incision may be appropriate with the inferior part of the ellipse placed at the level of the inframammary fold (Fig. 5.7). This type of approach can similarly be used for tumors located in the lower inner quadrant of the breast (Fig. 5.8). An important aspect of contemporary forms of modified radical mastectomy is preservation of the pectoralis major and minor muscles; access to the apex of the axilla can be facilitated by wrapping the arm in order to allow manipulation and relaxation of the pectoral muscles during surgery; it is unnecessary to either divide or remove the pectoralis minor muscle to perform a level III dissection of the axillary contents. A simple mastectomy refers to removal of the breast alone without any axillary surgical procedure.

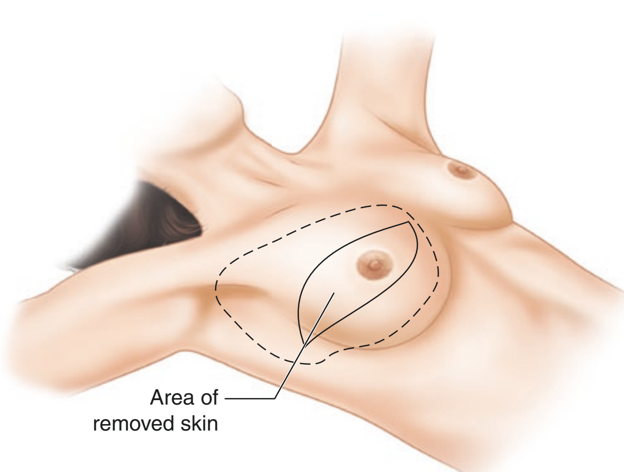

Fig. 5.5 Incision for modified radical (Patey) mastectomy

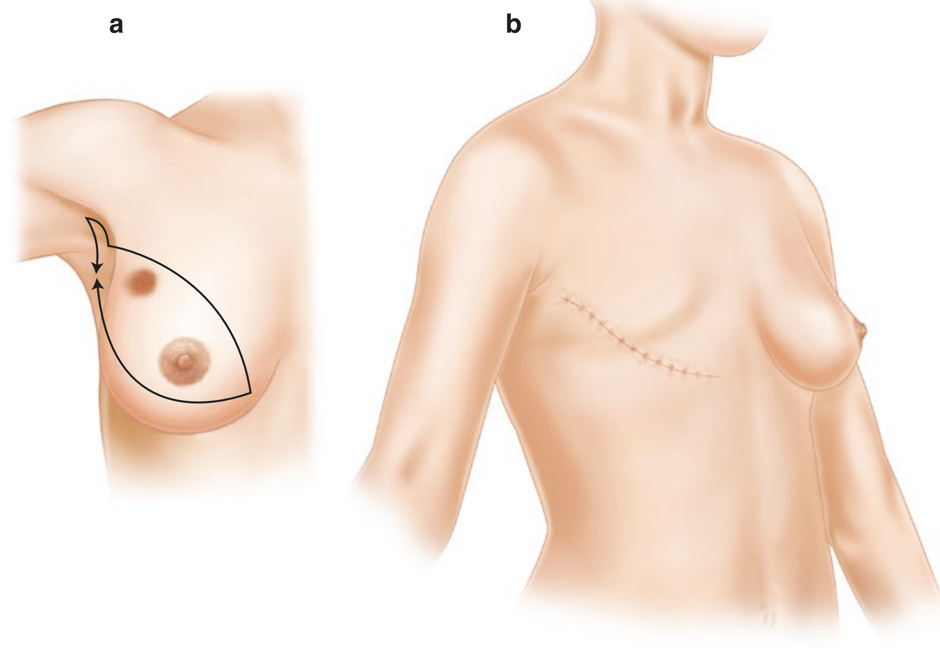

Fig. 5.6 (**a**, **b**) Mastectomy: type of incision for a tumor in the upper outer quadrant

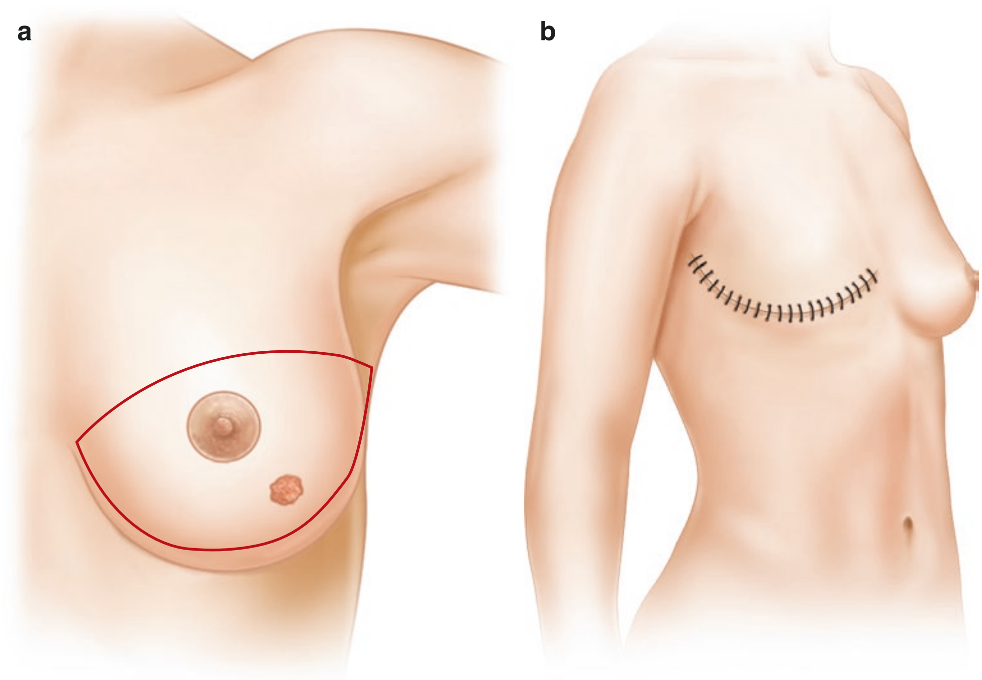

Fig. 5.7 Low sited mastectomy incision for lower outer quadrant tumors

However, unless this is being done for palliation, a simple mastectomy is likely to be combined with sentinel lymph node biopsy or some form of axillary sampling in the absence of formal axillary lymph node dissection. When mastectomy is combined with an axillary sampling procedure rather than lymph node dissection, the incision does not need to extend laterally beyond the limit of the breast tissue (and certainly no higher than the hair line). The incision for a simple mastectomy is depicted in the accompanying illustration (Fig. 5.9).

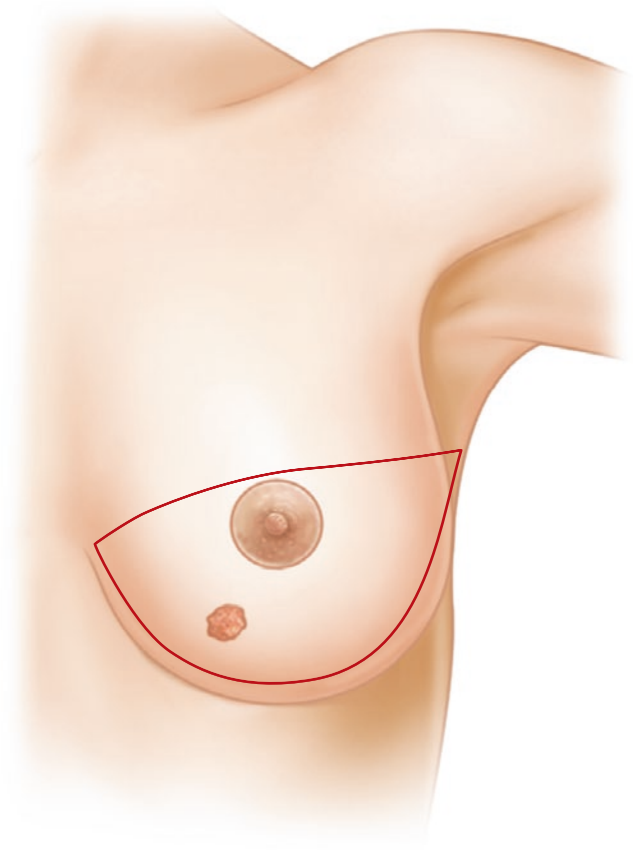

Fig. 5.8 Low sited mastectomy incision for lower inner quadrant tumors

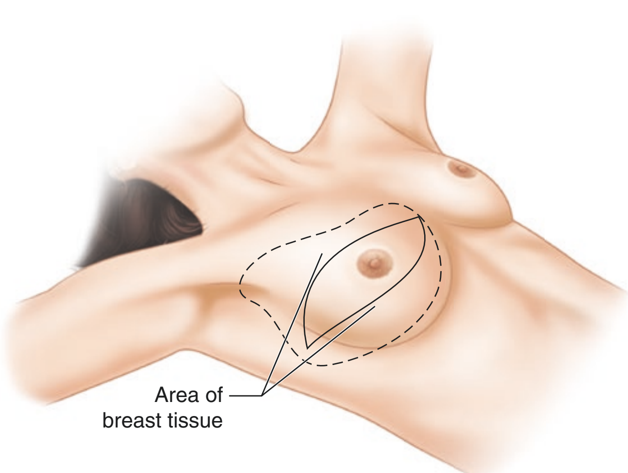

Fig. 5.9 Incision for simple mastectomy

When performing mastectomy, the surgeon should pay careful attention to the thickness of the skin flaps. The dissection should be contained within the "oncologic plane" that lies between the surface of the breast parenchyma and the subcutaneous layer (see Chap. 2). The latter contains blood vessels that should be preserved and protected to avoid compromising viability of the mastectomy skin flaps. This applies especially when the mastectomy flaps are relatively long (e.g., the superior flap with an eccentrically placed inframammary fold incision). This oncological plane is relatively bloodless, and bleeding tends to occur when dissection drifts more deeply into the breast tissue or superficially encroaches upon subcutaneous vessels. The suspensory ligaments of the breast periodically need to be released and care taken not to incur any thermal damage to the skin when freeing these structures from their more superficial attachments. Careful division of these ligaments will facilitate removal of all parenchymal tissue and minimize the chance of retained tissue on the undersurface of the mastectomy flaps. The technique of distracting the tissues is crucial, and the assistant should retract the flaps in an upward and forward direction using either skin hooks or gentle tissue holding instruments (e.g., Allis). The surgeon applies countertraction with a small swab placed over the breast tissue, and fingers should be kept close to the zone of dissection. The oncological plane is identified early on with care taken to avoid inadvertent dissection within the subcutaneous layer after making the initial skin incision. One advantage of tissue holding instruments is the ability to grasp both the skin and subcutaneous tissue that minimizes the chance of the dermis being sheared off the underlying fatty tissue. However, some surgeons prefer to grasp only the dermis and avoid any temporary marks on the epidermis from use of tissue holding instruments. Some surgeons employ sharp flap dissection with a knife, while others prefer electrocautery using a diathermy "pencil." Diathermy scissors or a tissue-cutting device ("LigaSure") is preferred by some surgeons who may also choose to infiltrate the flaps prior to dissection. Small vessels should be picked up and cauterized using either diathermy forceps or toothed tissue forceps to which electrocautery is applied. Larger perforating vessels from the internal mammary artery should be divided between ligatures (or clips) with care taken to ensure these vessels do not retract back into the chest wall before ligation is secured. The dissection should proceed superiorly to about the level of the clavicle, inferiorly to the level of the rectus abdominis muscle, medially to the sternum, and laterally to the latissimus dorsi muscle. Once the anterior surface of the breast is dissected free from the overlying subcutaneous tissue, then its posterior surface should be dissected free from the underlying pectoralis major muscle using electrocautery. Diathermy forceps at a low machine setting can facilitate dissection of breast tissue off the pectoralis major fascia and is less traumatic than the diathermy pencil that can readily cut into the fascia and muscle. From an oncologic perspective, the pectoralis major fascia can either be removed or preserved; when tumor is attached deeply or locally invades the pectoralis muscle, then a sliver of muscle tissue should be removed to ensure histological clearance of the tumor on its deep surface (these patients with locally advanced breast cancers are likely to receive postmastectomy radiotherapy).

Once the mastectomy is completed, the surgeon proceeds with an axillary dissection or sentinel lymph node biopsy, although the latter procedure can be undertaken before mastectomy using the lateral one-third of the incision. This reduces the chance of higher echelon nodes being stained blue from a prolonged period between dye injection and node harvesting. When performing axillary dissection, the breast and axillary contents are generally extirpated as a single specimen.

There is a current trend to employ quilting of the mastectomy flaps to reduce the chance of seroma formation. Some surgeons also extend the quilting process to include the axilla, although this can restrict arm movements postoperatively and may lead to impaired shoulder function for some time after surgery. Quilting can be performed using two or three rows of continuous or interrupted sutures (2-0 Monocryl or Vicryl). It is standard practice to place one or two closed suction drains after mastectomy, especially in the context of axillary lymph node dissection. These can be a soft silastic material or a harder noncompressible tubing that contains perforations. Drains are tied securely with a 2-0 silk suture as some patients are nowadays discharged home with drains. Some surgeons prefer to omit drains when a comprehensive quilting process has been undertaken. There is no clear evidence supporting one practice over another in terms of quilting and placement of drains!

The wound is closed by placing an interrupted 3-0 braided or monofilament suture subcutaneously (Vicryl, Dexon, or Monocryl) with a running 3-0 Monocryl subcuticular stitch to re-approximate the skin edges. Steri-Strips can be applied to the wound prior to a nonadherent dressing or surgical glue can be used. However, some patients prefer to have their mastectomy wound initially covered with a dressing and will examine the surgical site more closely in their own time postoperatively.

5.3 Simple Mastectomy

Simple mastectomy refers to removal of the breast only without any axillary surgery. There are several possible reasons why a surgeon may elect to perform simple mastectomy. In the prophylactic setting, simple mastectomy may be undertaken as a bilateral procedure in a genetically predisposed patient or as a contralateral risk-reducing procedure for a unilateral cancer. Alternatively, a patient who develops a local recurrence in the breast after breast conserving surgery for invasive cancer may elect to undergo simple (or salvage) mastectomy. Additionally, patients with evidence of diffuse, multicentric ductal carcinoma in situ of the breast may elect to undergo simple mastectomy with reconstruction rather than a complex oncoplastic procedure (this would usually be combined with sentinel lymph node biopsy as either a concomitant or upfront procedure).

An elliptical incision is made that incorporates the nipple–areola complex as illustrated in Fig. 5.9. A more horizontal incision can be used, and a relatively modest skin resection will facilitate any delayed breast reconstruction (see below for skin- and nipple-sparing approaches). The surgical technique for flap dissection is similar to that described above for modified radical mastectomy, but in the context of a prophylactic procedure, the pectoralis major fascia should be preserved. Otherwise, the wound is closed as previously discussed with placement of quilting sutures being optional.

5.4 Skin-Sparing Mastectomy

A circular incision is made around the nipple–areola complex or some variant incision employed as shown in Fig. 5.1. Care should be taken to resect only the nipple–areola complex and leave the remainder of the breast skin envelope intact and healthy. Skin flaps are raised in a circumferential fashion through this “keyhole” incision using electrocautery. Distraction of the tissues and judicious dissection are critical for skin-sparing mastectomy where quality of the mastectomy flaps determines aesthetic outcomes. The assistant lifts the skin and subcutaneous tissues with skin hooks or tissue holding instruments while the surgeon applies countertraction on the breast tissue. The dissection usually becomes easier as the operation progresses and the tissue planes open up. The oncologic plane can be difficult to define at the outset, especially when the breast tissues are stained with blue dye used for localization of the sentinel lymph node. A useful manoeuver in these circumstances is to spend a few moments mopping up excess blue dye after making the initial incision in the skin and subcutaneous tissue. It is often preferable to commence creation of skin flaps in the lower inner quadrant away from the blue stained tissues in the upper outer quadrant. As the periphery of the breast is approached, care must be taken not to breach the borders that can be defined with needle ink marks and seen from within the breast cavity. In particular, the medial border and inframammary fold must be preserved to maintain optimal definition in the reconstructed breast. Once the dissection is underway and flaps have been partially dissected, retraction is best undertaken with fingers rather than instruments to minimize flap trauma. The surgeon's own fingers are a useful adjunct to distracting the tissues at the point of dissection and ensure boundaries are not breached. The breast should be dissected off the anterior chest wall in a direction from inferomedial to superolateral and care taken to remove the axillary tail (of Spence). Depending upon the size of the aperture in the breast skin envelope, it may be possible to carry out axillary surgery through the central breast incision; otherwise, a counter-incision in the axilla may be necessary to access the nodal tissue – especially when axillary dissection rather sentinel lymph node is being performed. When an axillary incision is deemed necessary, it is preferable to excise nodal tissue as a separate specimen, not in continuity with the breast tissue. The mastectomy specimen should be orientated according to local policy and submitted for full histological evaluation.

5.5 Nipple-Sparing Mastectomy

It is feasible to dissect the skin and subcutaneous tissues from the breast parenchyma without risk of leaving residual breast tissue, but the nipple–areola complex is different. The main lactiferous ducts converge upon the nipple and breast tissue and are inextricably linked with tissues of the nipple itself. A subcutaneous mastectomy aims to retain a sliver of breast tissue deep to the nipple–areola complex, but a more radical resection of retro-areolar tissue is possible. Thus microanatomical studies indicate that tissues within the nipple contain no terminal duct lobular units from where cancer usually arises. There is now better appreciation of how tissue can be excised from the central core of the nipple without risk to its blood supply and increasing confidence of nipple-sparing mastectomy as a safe oncologic procedure – particularly as a therapeutic procedure. Thus nipple-sparing mastectomy was initially employed for treatment of smaller peripheral tumors located more than 2 cm from the edge of the areola. More recently, indications have broadened to include tumors closer to the nipple and selected cases of multifocal lesions. Usually a sample is taken from the retro-areolar tissue at the time of surgery and sent separately for histological examination. If this is positive for malignancy, then the nipple–areola complex is removed as a secondary procedure. An alternative approach is to carry out frozen section examination during surgery, but this can be associated with a false-negative result and can present logistical problems in some breast units.

There are technical challenges associated with nipple-sparing mastectomy, and a primary goal is to avoid necrosis of skin or the nipple–areola complex and achieve optimum positioning of the nipple–areola complex in large and ptotic breasts post-reconstruction. The surgical approach and type of incision must be individually selected to optimize aesthetic results and maximize levels of patient satisfaction. Several types of incision have been described for nipple-sparing mastectomy, and each has relative merit in terms of permitting access to peripheral zones of breast tissue and maintaining blood supply to the nipple–areola complex. Placement of the correct incision is critical for success of nipple-sparing approaches, and various types of incision are illustrated in Fig. 5.10a–g.

Peri-areolar with lateral or medial extension – this incision can be placed along the superior or inferior border of the areolar margin and provides optimum access to breast tissue in the retro-areolar region and upper outer or upper inner quadrants. The vascularity of the areolar skin can be compromised in patients with larger ptotic breasts and smokers (Fig. 5.10a, b).

Inframammary fold – an incision (8–10 cm) placed inferiorly along the inframammary fold or slightly laterally provides an excellent aesthetic outcome with an inconspicuous scar. However, this approach is only suitable for small- or moderate-sized breasts as access to the superior and medial limits of the breast tissue can be awkward and may risk incomplete resection. There is also a risk of nipple necrosis in larger breasted women and a counter-incision may be required for axillary surgery in cases of a therapeutic procedure (Fig. 5.10e, f).

Lazy –S – this incision commences about 1 cm lateral to the areola margin and extends outwards in a radial fashion (Fig. 5.10g). Although this incision is much less likely to be associated with ischemic complications of the nipple–areola complex, the scar lies directly over the breast skin mound and is cosmetically less acceptable to many women – and even surgeons!

Incisions must be adjusted accordingly when the nipple–areola complex is preserved in order to retain a vascular supply from the adjacent mastectomy skin flaps via dermal vessels. Skin incisions can be placed around part of the nipple–areola complex circumference with a lateral extension, but incisions placed away from the nipple–areola complex are preferred such as the inframammary fold or a radial incision in the upper outer quadrant which can facilitate axillary surgery (although arguably these particular incisions are less advantageous with de-escalation of axillary surgery in the era following publication of the ACOSOG Z0011 trial). Nonetheless, peri-areolar incisions are more likely to be associated with nipple necrosis, and another alternative is the

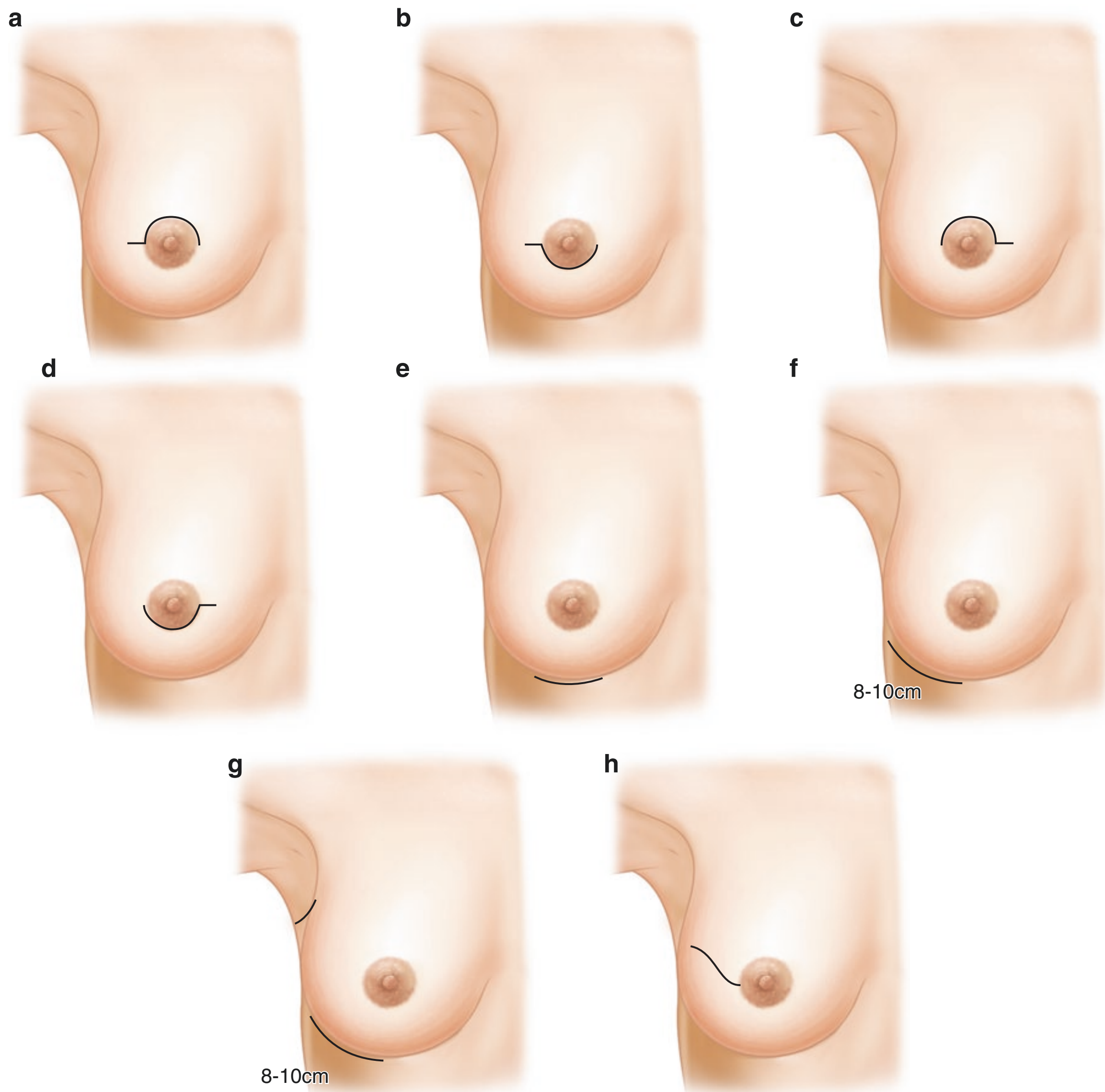

Fig. 5.10 Various incisions can be employed for nipple-sparing mastectomy, but an inframammary fold incision placed either centrally or more laterally and measuring 8–10 cm is popular for both prophylactic and therapeutic procedures in moderate-sized breasts (sentinel lymph node biopsy can be performed through a lateral inframammary fold incision) (**e** and **f**) but otherwise a separate axillary incision is made (**g**). A lateral incision from the edge of the areola (**h**) is less likely to interfere with blood supply to the nipple compared to periareolar incisions (superior or inferior (**a**–**d**)) that can be associated with nipple necrosis

omega pexy incision. An interesting surgical manoeuver is to dissect the retro-areolar tissue under local anesthesia in advance of definitive surgery in order to "precondition" the blood supply of the nipple–areola complex by stimulating inflow of blood from the adjacent peripheral skin.

Nipple-sparing mastectomy techniques are continuing to evolve in the context of therapeutic surgery but are widely accepted as a prophylactic procedure. Surgeons must learn how to select breast cancer patients for whom nipple preservation is oncologically safe and recognize the importance of meticulous surgical technique to minimize risks of local recurrence and ischemic changes within the retained nipple–areola complex.

5.6 Breast Conserving Surgery

Breast conserving surgery is now established as the preferred standard of care for management of women with early-stage breast cancer and was endorsed by the National Institutes of

Health consensus conference in 1991. Longer-term follow data from several prospective randomized clinical trials undertaken in the latter quarter of the last century have demonstrated equivalent survival outcomes for breast conserving surgery compared with either radical mastectomy or modified radical mastectomy. Widespread adoption of conservative forms of breast surgery have coincided with introduction of mammographic screening programs and heightened awareness of breast cancer among women in general, leading to earlier symptomatic presentation. Breast conserving surgery involves removal of the tumor and a variable amount of surrounding normal breast tissue such that negative surgical margins are achieved together with an acceptable cosmetic result (most of these patients will receive breast irradiation). A variety of techniques can be used for extirpation of the primary tumor but share the common aim of removing a column of breast tissue from the subcutaneous layer to the chest wall. There are several terms referring to tumor excision in the context of breast conserving surgery including lumpectomy, wide local excision, segmental excision, and quadrantectomy. These latter two procedures have become subsumed into oncoplastic surgery that often involves wide resection of breast tissue with some form of partial breast reconstruction. The development of oncoplastic surgery is a natural evolution in the application of breast conserving surgery to management of breast cancer. With conventional forms of breast conserving surgery, the surgeon aims to resect 1–2 cm of macroscopically normal tissue around a tumor that may be palpable or wire-localized. It is essential that the radial margins of resection abutting against remaining breast parenchyma are microscopically negative. Breast conservation surgery must satisfy the oncological mandate of excising a tumor with *negative* margins while maintaining acceptable cosmesis. Despite recent improvements in rates of local control following breast conserving surgery, up to one-quarter of patients with either invasive or noninvasive disease typically require reoperation following initial lumpectomy (be this cavity re-excision or mastectomy). Re-excision is often prompted by a component of ductal carcinoma in situ that may be underestimated in radiological extent. Historically, there has been much controversy as to what constitutes an adequate or "negative" surgical margin after breast conserving surgery. The closer ink is to tumor, the narrower are margins with a positive margin associated with ink on cancer cells. Surgical margin status is considered a major predictor of ipsilateral breast tumor recurrence, and therefore an *adequate* width of surgical margin is important. There appears to be no correlation between the width of surgical margin and rates of ipsilateral breast tumor recurrence, but margins must be negative; a large meta-analysis has confirmed that the odds ratio for local recurrence is >2 for positive margins (i.e., tumor at ink). There was no statistical evidence that increasing margin width from "no tumor at ink" to 1 mm, 2 mm, or 5 mm influenced odds of local recurrence with adjustment for follow-up time. Nonetheless, this meta-analysis contained few cases permitting direct comparison of a 1 mm margin versus "no tumor at ink," and some surgeons have therefore adopted 1 mm as the minimum margin mandate for invasive disease (with or without admixed DCIS). Following publication of a consensus statement from the Society of Surgical Oncology/American Society of Radiation Oncology, there has been increasing acceptance of a minimal margin mandate of "no tumor at ink" for invasive cancer with or without admixed DCIS (a minimum margin of 2 mm is recommended for pure "DCIS"). Volumes of excision need to be minimized except for mammoplasty procedures, and rates of re-excision have decreased with adoption of these consensus recommendations. Nonetheless, rates of re-excision and reoperation following routine breast conserving surgery for both palpable and impalpable lesions remain relatively high, and this has spurred efforts to develop reliable intraoperative assessment tools which can provide a timely indication of whether re-excision of a cavity margin is indicated at the time of primary surgery.

Within a screened population, between two-thirds and three-quarters of patients should be suitable for breast conserving surgery, although rates of conservation are variable at both institutional and geographical levels. These variations likely reflect differences in philosophy and training among surgeons coupled with concerns about local recurrence among patients. Careful selection of patients for breast conserving surgery is essential with an inverse relationship between oncological demands for surgical radicality on the one hand and cosmesis on the other. There is a balance between the risk of local recurrence and good cosmetic results – new techniques of oncoplastic surgery are advancing the limits of conservative surgical resections (towards "extreme oncoplasty").

Most patients deemed eligible for breast conserving surgery will have a favorable tumor-to-breast-size ratio and be suitable for conventional forms of wide local excision (lumpectomy) in which the tumor is excised with a narrow margin of surrounding breast tissue and no formal remodeling of the breast. Despite the need for re-excision in some cases, the majority of patients should attain an optimal cosmetic outcome in the longer term following breast irradiation. Surgical lore has emphasized the importance of placing incisions directly over a tumor without tunneling through normal breast tissue to excise a malignant lesion. However, many surgeons are electing to use peri-areolar incisions to access tumors in any quadrant and avoid scars in exposed areas of the breast mound. This technique involves creation of a flap of tissue by dissecting in the plane between the breast parenchyma and subcutaneous tissues and then deepening the dissection once beyond the outer boundary of the tumor. This approach can be challenging when cavity identification and margin re-excision are necessary to achieve negative surgical margins. The distance between nipple and tumor should not be excessive when a peri-areolar incision is planned and more peripheral wire-localized lesions are best excised with an incision corresponding to the skin projection of the tumor (marked with ultrasound). When an incision is placed directly over the tumor, this should lie within the natural skin crease lines and be curvilinear. Skin should not routinely be excised with conventional breast conserving surgery, but any zones of tethering (dimpling) can be incorporated into a limited crescent-shaped ellipse of the skin. Once the skin incision is made, sharp dissection is used to remove the tumor with a margin of healthy tissue around it. Two fingers are used to identify the tumor, and normal breast tissue around it is sharply dissected using scissors or a knife (Fig. 5.11).

Although diathermy dissection is popular nowadays, this may create diathermy artefacts that can interfere with accurate pathological evaluation of margins. However, once the tumor is removed, meticulous hemostasis must be achieved with diathermy, and the wound subsequently irrigated. Hematoma is the most common complication following lumpectomy, and transected parenchyma of younger patients with dense breast tissue is particularly prone to postoperative bleeding when hemostasis is inadequate. Conventional forms of breast conserving surgery usually do not require any formal glandular rearrangement, but many surgeons undermine and mobilize the parenchymal tissue around the cavity to permit closure of the latter, especially for medially and inferiorly placed tumors. However, this is not essential for small-to-moderate-sized defects, and closure is otherwise confined to the subcutaneous tissues and skin (running subcuticular monofilament such as 4-0 Monocryl).

Mastectomy will be indicated for some patients based on tumor size, location, multifocality, or patient choice and is increasingly undertaken using skin-sparing and nipple-sparing procedures in conjunction with immediate breast reconstruction. It becomes progressively more difficult to achieve a good cosmetic outcome as the proportion of breast tissue removed increases, with results dependent upon both volume and weight of the resected specimen. Generally, a greater percentage breast volume excision is associated with larger tumors with a risk of an unsatisfactory cosmetic result when more than 10–20% of breast tissue is removed (and only 5–10% in cosmetically sensitive zones medially and inferiorly). Oncoplastic procedures often permit wide resection of breast tissue that increases the chance of negative margins while at the same time ensuring a satisfactory cosmetic outcome that improves patient well-being and quality of life. However, it should be noted that longer-term data on rates of local recurrence following excision of larger tumors (albeit with negative margins) are sparse, and wider margins of surgical clearance do not necessarily reduce rates of ipsilateral breast tumor recurrence. Selection of patients for either oncoplastic surgery with a high percentage volume excision or mastectomy with whole breast reconstruction will be influenced by host factors such as age and family history. Surgical planning can be aided by magnetic resonance imaging that can clarify local disease extent and confirm uni-focality or reveal additional foci of disease in the same or different quadrants. Where imaging is equivocal and tumor parame-

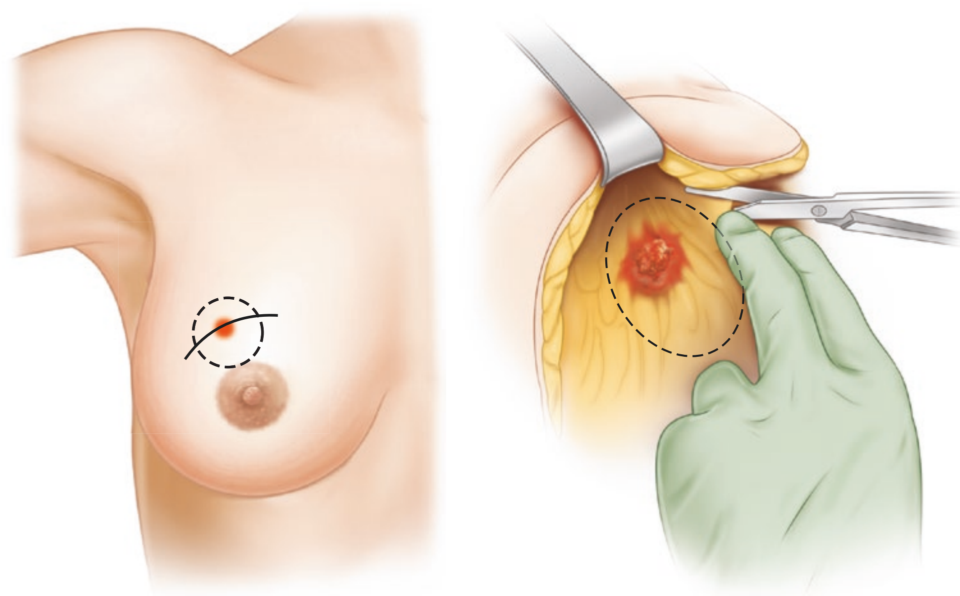

Fig. 5.11 Lumpectomy (wide local excision). Retraction of the tumor with fingers of the nondominant hand facilitates resection of the tumor with an adequate margin of normal surrounding breast tissue

ters borderline for breast conserving surgery, it is preferable to undertake a two-stage procedure – initial wide local excision of the tumor permits full histopathological evaluation with assessment of margins. A definitive oncoplastic procedure can subsequently be carried out either 2–3 weeks later (with cavity margin re-excision if necessary) or following completion of breast radiotherapy. A one-stage procedure is optimal and avoids any technical difficulties relating to sequelae of previous surgery and radiotherapy (scarring, fibrosis). There are less likely to be problems with skin viability when completion mastectomy is undertaken after simple tumor excision compared with a more complex oncoplastic procedure with parenchymal undermining and transposition. There is a higher chance of wound infection and fat necrosis in patients who are obese (body mass index >30), smokers, or diabetic. These potential complications and their effect on further oncological treatment should be fully discussed with the patient.

Oncoplastic surgery in the context of partial breast reconstruction encompasses both volume replacement and volume displacement techniques. The former imports additional tissue with a flap to compensate for loss of volume from surgical ablation. By contrast, the latter rearranges the remaining breast tissue using methods of glandular advancement that serve to redistribute parenchyma and minimize the impact of wide local excision. In effect, the volume loss is absorbed over a wider area with concomitant reshaping of the breast. Volume displacement surgery is less complex than autologous tissue transfer methods without associated donor site morbidity. Nonetheless, the reconstructed breast is of smaller overall volume, and surgery on the contralateral side is often required for symmetrization. This applies especially to therapeutic mammoplasty where tumor excision is incorporated into a standard or modified reduction procedure. Volume displacement represents the simplest option for partial breast reconstruction and is usually preferred over techniques for volume replacement that involve more extensive surgery with harvesting of a myocutaneous or subcutaneous perforator flap (these cannot subsequently be used for whole breast reconstruction in the event of local recurrence and mastectomy). Volume displacement techniques are only possible in patients with medium to large breasts, while volume replacement techniques are suited to small-breasted women. The choice of method is determined by both the breast volume and size of the surgical cavity for infill.

5.7 Volume Replacement Techniques

These techniques have previously been reliant on use of the latissimus dorsi flap harvested as either a myocutaneous or myosubcutaneous flap but are increasingly based on chest wall perforator flaps. These aim to reduce muscle disruption and hence donor site morbidity.

Latissimus dorsi myocutaneous flap – this was previously suited to partial breast reconstruction following quadrantic resection of a tumor in the upper outer quadrant. The flap can be mobilized through the quadrantectomy incision. The method for transposing the flap onto the anterior chest wall was adapted for medial and central defects by tunneling the flap deep to the pectoralis major muscle and delivering this at the base of the surgical cavity (Figs. 6.11 and 6.12 in Chap. 6).

Latissimus dorsi myosubcutaneous flap – this is a modified version of the latissimus dorsi flap commonly known as the “LD mini-flap.” The latissimus dorsi muscle is harvested with a laterally placed lazy-S incision through which resection of breast and axillary tissue is simultaneously performed. No skin overlying the muscle is removed although subcutaneous fat can be used to enhance tissue bulk if necessary. This flap is particularly suitable for tumors in the superior and central aspects of the breast, and adequate mobilization ensures there is sufficient reach (Fig. 6.14a–c in Chap. 6).

Tumor bed biopsies have been employed by proponents of this technique to reduce the chance of positive margins and permit immediate mastectomy if further biopsies after routine cavity re-excision are also positive. Alternatively, a two-stage procedure can be carried out with delayed partial breast reconstruction (± cavity re-excision) between 5 and 10 days after initial tumor excision using an extended axillary incision. There is no evidence for any significant atrophy of the muscle, and this does not interfere with subsequent radiological surveillance (muscle is lucent).

Chest wall perforator flaps are becoming popular as a method for partial breast reconstruction when larger volumes of tissue are resected in the inferior and lateral aspects of the breast. These highly specialized volume replacement techniques include the thoracodorsal artery perforator flap (TDAP) and the lateral intercostal artery perforator flap (LICAP) that are discussed in more detail in Chap. 6.

5.8 Volume Displacement Techniques

Several options are available for volume displacement that constitutes a spectrum of techniques of varying complexity. The common aim of volume displacement is to utilize the remaining tissue to fill the defect resulting from extirpation of the tumor. Displacement techniques reshape the breast through advancement, rotation, or transposition of existing parenchyma and skin with a resultant decrease in overall breast volume.

Simple breast tissue mobilization – the cosmetic outcome after removal of a relatively small volume of tissue can be enhanced by simple mobilization of breast tissue adjacent to the surgical cavity. The extent of this mobilization depends on the size of the defect and may involve undermining the whole breast plate. Extensive mobilization of breast tissue can sometimes threaten the blood supply to both glandular tissue and skin, leading to postoperative necrosis and secondary sepsis, or can compromise flap viability in the event of future mastectomy.

Local tissue flaps – larger defects such as those resulting from central resections that include the nipple–areola complex cannot be adequately filled by simple mobilization and require creation of a formal flap of local breast tissue. An example is the advancement rotation flap described by Grisotti for filling a central defect after removal of the nipple–areola complex (Fig. 5.12).

This is a dermato-glandular flap based on an inferior pedicle and has a skin paddle that replaces the nipple–areola complex and can be used to fashion a new areola immediately. The tumor is excised together with the nipple–areola complex as a column of tissue from the subcutaneous layer to the pectoral fascia. A skin island is mobilized which will form the new nipple–areola complex and viability of the skin maintained by creation of a dermato-glandular bridge based inferiorly and corresponding in width to the diameter of the disc. The new areola is formed from the skin island, and the breast parenchyma fills the defect (nipple reconstruction is done as a delayed procedure). An interesting approach for parenchymal redistribution following removal of peri-areolar tumors not located in the retro-areolar region is the round block technique. This involves mobilization of the nipple–areola complex with formation of a zone of de-epithelialization or "corona" around the nipple–areola complex. Dissection is continued into the relevant quadrant with wide excision of the tumor. Glandular tissue around the defect is undermined to allow closure of the defect. The skin edges are sutured to the areola and the de-epithelialized zone is buried. This is a good example of how volume displacement techniques can "absorb" the local defect over a wider area of breast substance (Fig. 6.36 in Chap. 6).

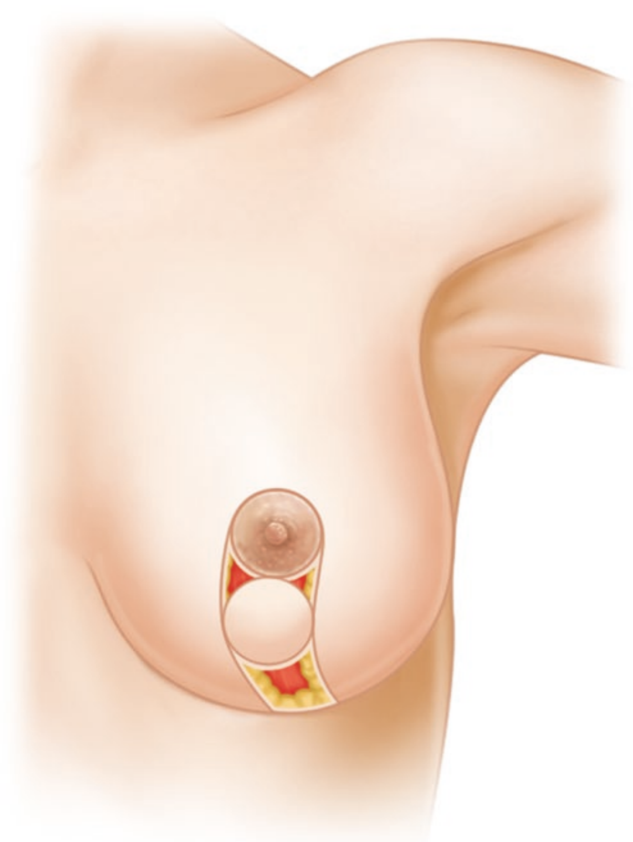

Fig. 5.12 Preoperative markings for a Grisotti flap showing an inferiorly based glandular–cutaneous flap with the outline of the new nipple–areola complex lying adjacent to the native structure. Reconstruction is based on creation of this dermoglandular pedicle with a disc of overlying skin that will form the new nipple–areola complex. The pedicle extends from the medial and lateral margins of the areola down to the inframammary fold. Distally, these two lines converge to produce a characteristic comma-shaped appearance

Therapeutic mammoplasty – this has emerged over the past two decades as a popular method for integrating local tumor excision with a classical reduction mammoplasty procedure. Most of these cases involve patients with relatively large breasts and/or who desire smaller breasts and have a tumor located in the zone of resection for a conventional Wise pattern reduction mammoplasty (Fig. 6.29 in Chap. 6).

This includes inferior pole tumors from the 3 o'clock to 9 o'clock positions together with tumors immediately above the nipple–areola complex in medium to large breasts. With appropriate patient selection, this epitome of oncoplastic breast surgery permits wide tumor excision and yields excellent cosmetic results with maintenance of skin and nipple sensation. Although there are few rigorous studies evaluating either oncological or cosmetic outcomes, local recurrence rates are less than 10%, and more than 80% of patients report fair to excellent results at 5 years. Most patients undergo a superior pedicle technique and require a reduction of the contralateral breast to achieve symmetry. An inferior pedicle technique requires preservation of a pyramid of tissue in the inferior portion of the breast to maintain perfusion of the nipple. This can potentially compromise the resection volume for a tumor located in the inferior portion of the breast, and therefore a superior pedicle is usually more appropriate (Fig. 6.30a–d in Chap. 6).

Reduction mammoplasty can also be used for removal of small inferior quadrant tumors when a patient has large breasts but requests a smaller breast size. This reduction in breast size can improve dose homogeneity when planning subsequent external beam whole breast radiotherapy. Therapeutic mammoplasty techniques have extended the boundaries of conventional breast conserving surgery and can improve cosmetic outcomes and quality of life when tumor size and location would otherwise mandate mastectomy (with or without immediate breast reconstruction). However, it is essential to apply strict oncological selection criteria and proceed with mastectomy when the estimated risk for ipsilateral breast tumor recurrence is high despite clear resection margins and good cosmetic results. There is accumulating evidence that cosmetic outcomes and patient reported outcome measures are superior for patients undergoing breast conserving surgery with partial breast reconstruction compared with mastectomy and whole breast reconstruction. Furthermore, therapeutic mammoplasty techniques are being developed to encompass treatment of tumors that lie outside the excision zone of a standard therapeutic mammoplasty including excision of multiple ipsilateral breast cancers (Fig. 5.13).

Under these circumstances, the local defect following tumor excision lies within the area of conserved breast tissue. Modifications of the standard therapeutic mammoplasty based on superior or inferior primary pedicles have evolved to permit closure of these more remote defects. Thus, a primary pedicle can be extended or a secondary pedicle created. Careful planning of skin incisions and appropriate orientation of the nipple–areola complex pedicle is essential for these mammoplasty techniques that demand understanding and experience of plastic surgery principles. Tumors that lie in zones inferior to the mammoplasty pillars can be excised with a classical Wise pattern reduction procedure. Those in the central and central/inferior zones are amenable to either a Wise pattern or a vertical type mammoplasty. Results of these more complex therapeutic mammoplasty procedures are reported to be good or excellent in two-thirds of cases. The majority of cases with positive surgical margins require completion mastectomy rather than re-excision of margins. A contralateral breast reduction is always required for therapeutic mammoplasty procedures and whenever there is uncertainty about completeness of tumor excision, it is preferable to carry out a staged procedure with initial tumor excision pending full histopathological evaluation. A subsequent therapeutic mammoplasty and contralateral procedure or mastectomy and immediate breast reconstruction can be undertaken. It should be noted that some loss of volume will occur after breast irradiation and this should be taken account of when planning the contralateral symmetrizing procedure.

The batwing and hemi-batwing mammoplasty and crescentic resections are employed for excision of tumors in the upper outer quadrants of the breast between 10 o'clock and 2 o'clock that lie relatively close to the nipple–areola complex and usually below the bra line. Although the degree of breast

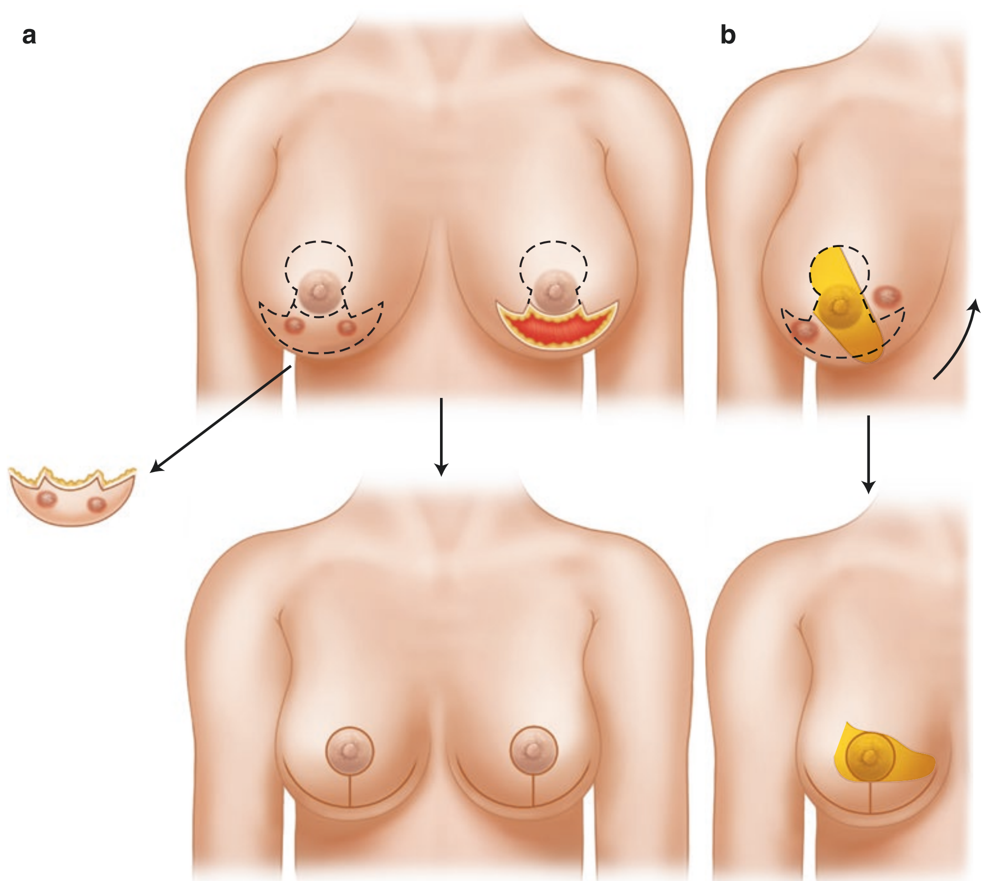

Fig. 5.13 The standard therapeutic mammoplasty procedure (inferior or superior pedicle) can be adapted with creation of extended primary or secondary pedicles to permit excision of multiple ipsilateral cancers in patients with relatively large breasts (**a**) and (**b**)

mobilization and reduction is less than for a conventional Wise pattern mammoplasty, tumors can nonetheless be excised with an adequate margin and good cosmetic results. By contrast, tumors lying above the bra line are not suitable for any formal mammoplasty procedures and should be managed with local tissue mobilization and simple skin closure. These more specialized volume displacement techniques are discussed in more detail in the next chapter.

5.9 Axillary Surgery

Irrespective of whether a patient undergoes breast conserving surgery or mastectomy, the management of the axilla is the same. Prior to either of these operations, the surgeon should first determine whether the patient is "clinically node-positive" or "clinically node-negative." A patient is considered clinically node-positive if there is palpable axillary adenopathy, evidence of axillary node metastases on breast imaging (mammography, ultrasound, or MRI), or histological confirmation of axillary lymph node metastases. If one or more of these conditions is met and the patient is deemed clinically node-positive, then the patient is generally not a suitable candidate for sentinel node biopsy and should undergo a formal axillary lymph node dissection (ALND). Alternatively, in the absence of any clinical evidence of axillary lymph node metastases, the patient is considered to be "clinically node-negative" and should undergo sentinel biopsy at the time of the operation for the primary breast cancer. If the sentinel node biopsy suggests a significant burden of axillary nodal metastases (i.e., more than 2 sentinel nodes with tumor deposits that exceed 2 mm in size), then the patient will generally require further axillary treatment (i.e., either completion ALND or axillary radiotherapy). However, if the sentinel node biopsy indicates no axillary involvement or a low burden of axillary disease, then further axillary treatment might be avoided.

5.10 Axillary Lymph Node Dissection

Surgical execution of a formal ALND requires detailed knowledge of axillary anatomy. When undertaking an axillary dissection, it is important to consider that the pectoralis minor muscle serves as the landmark that divides the axilla into three levels (i.e., Berg levels I, II, and III). Level I refers to the axillary contents lateral to the lateral border of pectoralis minor muscle, level II refers to the axillary contents posterior to the muscle (between its medial and lateral borders), and level III refers to the axillary tissue medial to the medial border of the pectoralis minor muscle. A formal axillary dissection (i.e., complete ALND) generally requires dissection of levels I and II. However, if there is palpable adenopathy medial to the pectoralis muscle, then retraction or division of the muscle might be required to include level III in the axillary dissection (Fig. 5.14).

To undertake an axillary dissection, a curvilinear incision is made along the inferior aspect of the axillary hairline. For maximal exposure, the incision should be extended anteriorly to the pectoralis major muscle and posteriorly to the anterior border of the latissimus dorsi muscle. Alternatively, a radial incision along the lateral border of pectoralis major can be used to maximize access to the axillary contents in cephalad and caudal directions (Fig. 5.15).

The dissection is extended deeper, using electrocautery to divide the Scarpa's fascia. Care should be taken to identify the latissimus dorsi muscle along its lateral aspect. The thoracodorsal nerve penetrates the medial aspect of the latissimus dorsi muscle, and therefore identification of this muscle along its lateral aspect will reduce risk of injury to this nerve.

Once the latissimus dorsi muscle is identified along its lateral aspect, blunt dissection should be used to identify the anterior border of the muscle. With great care, using fine scissors, a small opening should be created in the clavipectoral fascia, which invests the axillary contents, and then blunt dissection used to extend that opening (Fig. 5.16).

The thoracodorsal nerve should be identified near where it penetrates the medial aspect of the latissimus dorsi muscle. The nerve is immediately adjacent to the thoracodorsal artery and thoracodorsal vein (which together comprise the thoracodorsal bundle), and care should be taken to avoid injury to the nerve and these vessels. Once the thoracodorsal nerve is identified, blunt dissection should be used (with a Kittner dissector) to free off the axillary contents anterior to the nerve, with dissection continued carefully superiorly to about the level of the axillary vein.

The Kittner dissector should be carefully used to identify the entire axillary vein from its medial to lateral extent within the axilla. The pectoralis minor muscle should be identified medially and then retracted medially (Fig. 5.16). The tail of the axillary contents will be inferior to the axillary vein and extend posterior to the pectoralis minor muscle (Berg level II). The index finger should be used to gently create a plane inferior to the axillary vein and around the tail of the axillary contents that extends posterior to the pectoralis minor muscle. This comprises level II of the axillary dissection, and ligaclips should be used to detach the axillary contents medially at this level. A combination of blunt, sharp, or diathermy dissection can be used in the axilla depending on individual surgeon preference.

Careful blunt dissection should continue along the lateral aspect of the chest wall, taking care not to injure the long thoracic nerve, which runs along the posterior aspect of the serratus anterior muscle and innervates it (Fig. 5.16). This nerve can often be gently palpated on the serratus anterior muscle, along its posterior aspect, and may have the feel of a

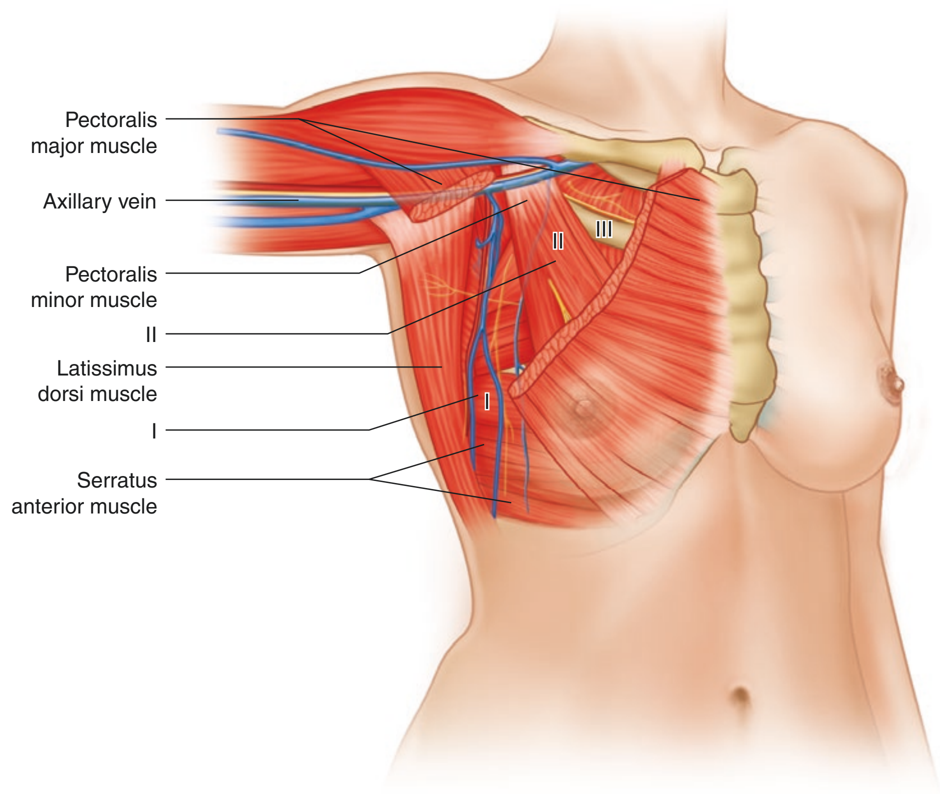

Fig. 5.14 Surgical levels of axillary lymph nodes defined in relation to the pectoralis major muscle. A standard axillary lymph node dissection is usually confined to nodes at levels 1 and II

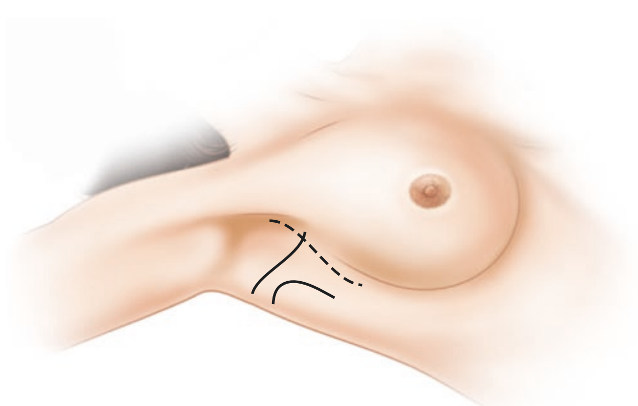

Fig. 5.15 When axillary lymph node dissection follows sentinel lymph node biopsy, a transverse axillary incision can be extended cranially and caudally to yield a lazy-S incision that permits adequate access to axillary contents

"violin string." Careful blunt dissection about 1 cm lateral to the chest wall will often allow for visual identification of the nerve.

In summary, axillary dissection should extend superiorly to the axillary vein (and include resection of tissue immediately posterior to the pectoralis minor muscle, at level II), laterally to the medial border of the latissimus dorsi muscle, medially to the chest wall (serratus anterior muscle), inferiorly to the inter-digitation of the latissimus dorsi and serratus anterior muscles, and posteriorly to the subscapularis muscle. All axillary contents within these anatomical borders should be resected and submitted en bloc to the pathologist for histological evaluation. This encompasses a level I and level II axillary dissection. The long thoracic nerve and the thoracodorsal nerves should always be identified and preserved during this dissection. At the end of this procedure, we generally place a 10-flat Jackson–Pratt drain through a separate skin stab wound just inferior to the axillary incision line. The stab wound is created lateral to the latissimus dorsi muscle, and the perforated segment of the drain is placed within the axilla, while the external tubing (with no perforations) is sewed to the skin with a 3-0 nylon. The axillary wound is then closed by placing a few interrupted 3-0 vicryl stitches in the subcutaneous tissues, with a running 3-0 Monocryl subcuticular stitch to approximate the skin edges. Dermabond or some other glue can be applied over the wound. Some surgeons routinely employ quilting sutures to approximate the mastectomy flaps to the chest wall. These can be inserted as individual rows of dissolvable sutures or as a continuous "locking" suture and extended into the axilla if appropriate. This tech-

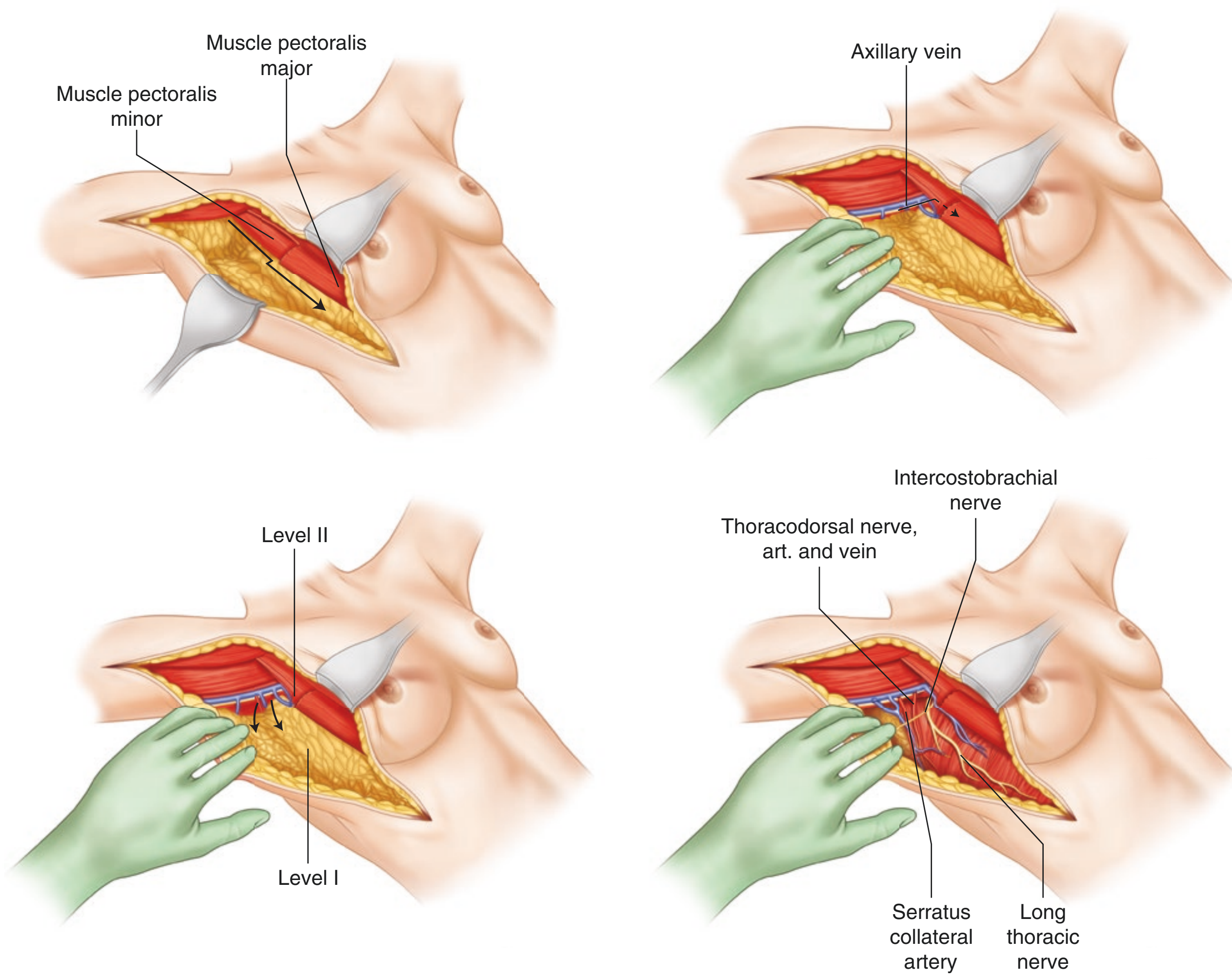

Fig. 5.16 A standard level II axillary lymph node dissection clears all tissue below the level of the axillary vein and preserves nerves, the long thoracic and thoracodorsal nerves. The intercostobrachial nerve crosses the axilla and is usually sacrificed with significant sensory detriment

nique appears to reduce the incidence of seroma formation and may allow drains to be dispensed with.

5.11 Sentinel Node Biopsy

The sentinel lymph nodes are the first lymph nodes in the axillary basin to receive lymphatic drainage from the breast (Fig. 5.17).

The number of sentinel lymph nodes can vary but generally range between 1 and 4 nodes with an average of 2–3 nodes retrieved in routine surgical practice. If the sentinel nodes are free of metastatic disease, then the remaining lymph nodes in the axillary basin are unlikely to harbor metastases. Alternatively, if the sentinel nodes contain deposits of metastases (greater than 2 mm in size), then additional lymph nodes in the axillary basin might be involved as well.

The sentinel nodes can be identified using several methods including radioactive tracers, blue dyes, fluorescent indocyanine green (ICG) dye, or ferromagnetic particles. Generally, for better accuracy in identifying the sentinel

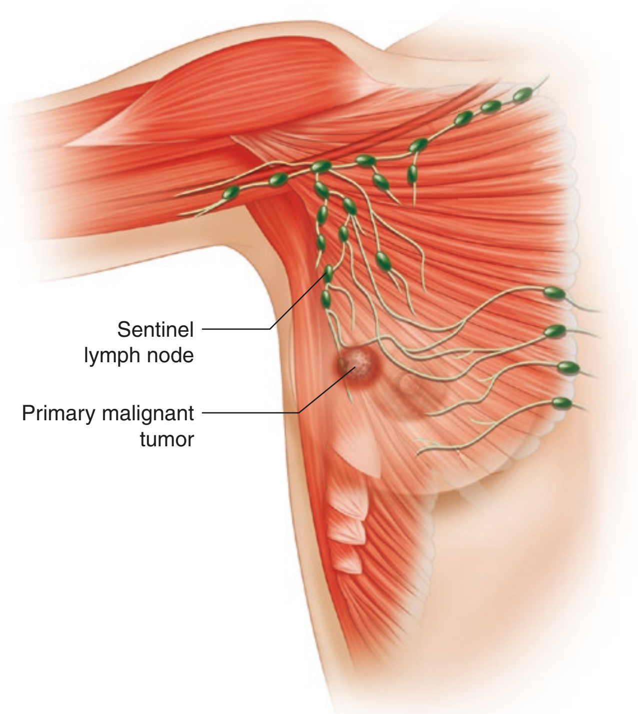

Fig. 5.17 The sentinel lymph node is the first node to receive drainage from a tumor and is located at level *I* in more than three-quarters of cases

nodes, it is recommended that two tracers be used (i.e., radiotracer and dye). There is international consensus that a combination of blue dye and radioisotope is optimal in terms of performance parameters (including identification rates and false-negative rates) with evidence that dual techniques shorten the learning curve for beginners. In recent years, some surgeons have chosen to omit blue dye when there is a good percutaneous signal from the radioisotope in order to avoid problems with staining of tissues and anaphylactic reactions associated with blue dye; ICG may help minimize these disadvantages and could potentially be used as a sole tracer agent with avoidance of radioactivity.

The radioactive tracer is injected on the morning of surgery beneath the nipple–areola complex. Blue dye (Patent Blue, lymphazurin, or methylene blue) is generally used to identify the sentinel node as a co-localizer. Blue dye should be injected immediately posterior to the nipple–areola complex, approximately 10 minutes prior to making the incision in the axilla. However, the methylene blue dye may result in skin necrosis, so it should never be injected directly beneath the nipple–areola complex. Rather, some surgeons prefer to inject methylene blue dye around the tumor (peri-tumoral) approximately 10 minutes before making an incision in the axilla. For all practical purposes, these tracers can be injected anywhere in the breast, as lymphatic uptake from any location in the breast will effectively localize the sentinel nodes.

Approximately 10 minutes after injection of the dye, a curvilinear incision is made in the axilla, along the inferior aspect of the hairline. Electrocautery is used to divide Scarpa's fascia. A Kittner (or similar) dissector is then used to dissect off the fatty tissue to identify the blue lymphatic ducts (containing blue dye). The blue ducts will lead to the blue sentinel nodes, and this can be confirmed with a gamma probe, which should indicate high uptake of radiotracer in the sentinel nodes. Alternatively, the gamma probe can be used to first identify the area of maximum radiotracer uptake, and the Kittner dissector is then used to dissect away the fatty tissue and identify the blue sentinel nodes. A node is defined as sentinel if blue, hot, blue and hot, or palpably suspicious. Some surgeons remove all blue stained nodes, not just those containing a blue afferent lymphatic. Likewise, some surgeons consider any radioactive node to be "hot" and aim to remove these rather than confining resection to those nodes defined as hot based on having an ex vivo count at least 10% of the hottest node. Interestingly, techniques that remove more than 2 or 3 nodes may be relevant to recent trends for omission of completion ALND in selected sentinel lymph node biopsy-positive patients. Thus when there is a low metastatic ratio, it may be more acceptable to avoid further axillary surgery due to a lower probability of non-sentinel lymph node involvement.

It should be noted that the gamma probe used to detect radioactive nodes has a narrow collimated beam and a high signal may indicate a node lying in the line of this beam but still some distance from the probe. Hence further dissection may be required to extract the hot node. Blue dye and ICG offer a visual dimension that is complementary to the probe signal and can aid more direct identification of the sentinel nodes (Fig. 5.18a, b).

Once the sentinel nodes are identified, ligaclips are used to clip and divide the lymphatic ducts leading to the sentinel nodes. In this manner, the sentinel nodes are resected and then submitted to pathology for histological assessment.

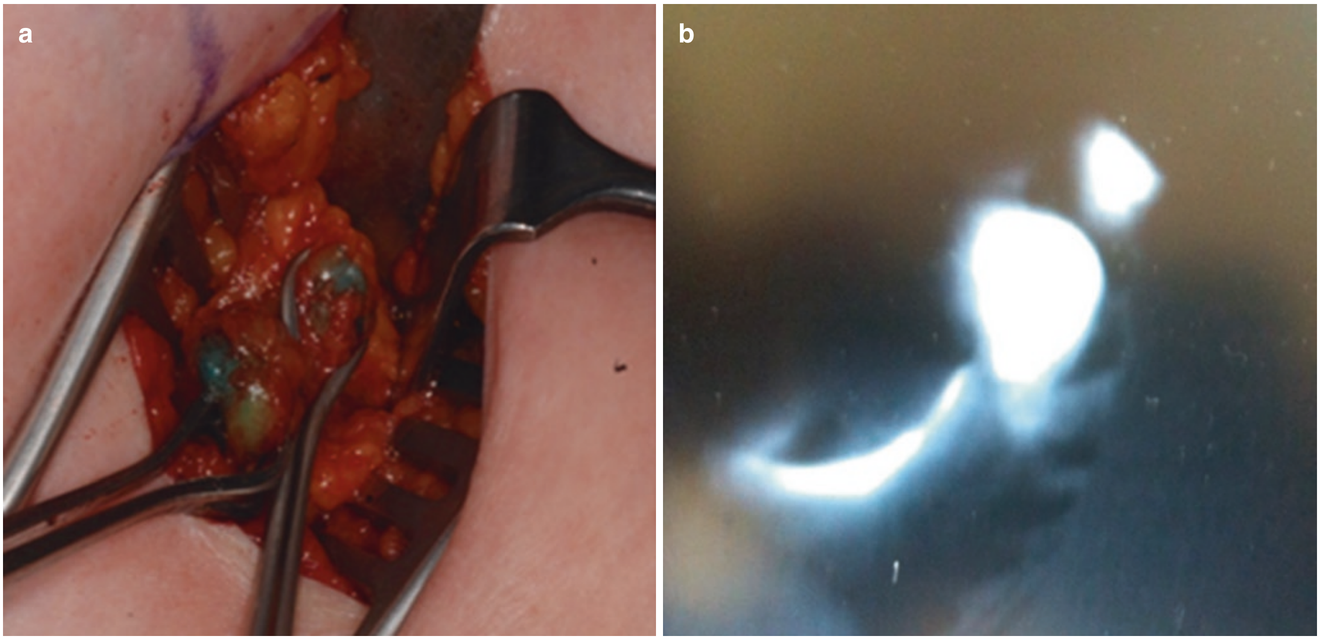

Fig. 5.18 (**a**, **b**) Use of dyes for localization of the sentinel lymph node provides a visual dimension which can facilitate retrieval of sentinel nodes and is complementary to techniques for radiocolloid localization

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6 Plastic and Reconstructive Breast Surgery

An estimated 1.7 million women worldwide will be diagnosed with invasive breast cancer in 2018. Alongside these new diagnoses, there will be a corresponding increase in annual rates of breast reconstruction. The latter offers well-documented benefits in terms of body image, quality of life, and high patient satisfaction, irrespective of whether this follows mastectomy or breast conservation. This is attributable to advances in surgical techniques and a multitude of surgical options for women seeking breast reconstruction after either mastectomy or lumpectomy.

6.1 Surgical Planning and Incisions for Mastectomy

When planning a mastectomy, one of the most important initial decisions to be made is whether nipple-areola complex (NAC) preservation will be undertaken (nipple-sparing mastectomy). In general, this decision is made both on grounds of oncologic safety and aesthetic benefit. If preoperative imaging reveals no direct involvement of the nipple with tumor, there is a high probability that nipple-areola preservation is feasible. Once this is confirmed by the surgical oncologist, and the plan is to remove nipple parenchyma but preserve nipple skin, then the incision location must be planned for a nipple-sparing mastectomy (NSM).

Multiple incisional approaches are possible for NSM (Fig. 6.1). The most commonly used incisions are inframammary and radial. The inframammary incision is generally used for smaller breasts with no evidence of preoperative ptosis. Conversely, a radial incision can also be used in these situations, should there be a need for more central access to the breast parenchyma.

For those cases in which there is grade 2 preoperative ptosis of the breasts and there is a desire to correct this by incorporating a mastopexy into the incision for the NSM, then a crescent mastopexy-type pattern can be used. This can excise superior areolar skin and elevate the NAC, correcting up to 2 cm of ptosis. When this design of incision is employed, it is important that the portion of the incision along the superior areolar border be less than 25% of the overall areolar circumference, in order to preserve perfusion of the NAC.

It is particularly important that the correct location for the incision be planned to allow for comprehensive access to all areas of glandular tissue and thereby perform a thorough mastectomy. However, positioning of the incision also has important implications for aesthetic outcomes of the reconstructed breast. To this end, the location of the incision should be planned jointly by the surgical oncologist and plastic surgeon.

6.2 Breast Reconstruction Options

Following mastectomy, breast reconstruction can be done at the time of mastectomy (immediate breast reconstruction), or at any time after mastectomy (delayed breast reconstruction). In recent years, immediate breast reconstruction has gained wider acceptance. Breast reconstruction can be performed using either prostheses or autogenous tissue in the immediate or delayed setting.

There are several options available for those patients choosing prostheses. A permanent prosthesis can be placed at the time of mastectomy, if there is sufficient viable skin to support coverage of the desired size of implant. Alternatively, a tissue expander can be placed surgically and inflated gradually over a period of several weeks in the outpatient setting by injecting saline through a port. This results in creation of a breast skin mound with ptosis, and a typical teardrop shape comes from temporary overexpansion. At a second operation, the tissue expander is then removed and replaced with a permanent prosthesis.

For those patients choosing breast reconstruction with autologous tissue, the three most common options are the latissimus dorsi flap, the transverse rectus abdominus myo-

I. Jatoi et al., *Atlas of Breast Surgery*, https://doi.org/10.1007/978-3-030-45951-2_6

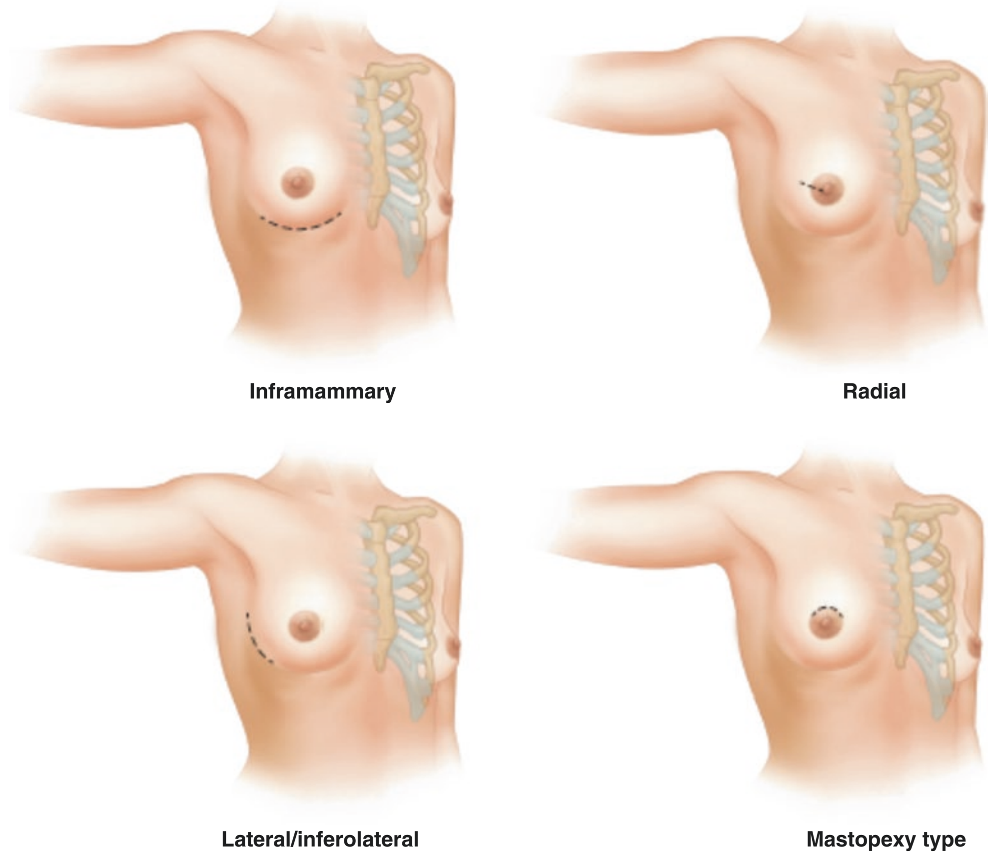


Fig. 6.1 Examples of the various incisional approaches most commonly used for nipple-sparing mastectomy

cutaneous (TRAM) flap, or the deep inferior epigastric perforator (DIEP) flap. The latissimus dorsi muscle flap alone usually does not provide enough tissue bulk, and therefore a permanent prosthesis is often placed beneath the flap – an implant-assisted latissimus dorsi flap reconstruction. However, a totally autologous technique for latissimus dorsi flap reconstruction promoted by Emmanuel Delay in France provides satisfactory results in selected patients without the need for placement of an implant.

In contrast, the TRAM flap provides considerable tissue bulk in appropriate patients; a prosthesis is not required in most cases. The TRAM flap is technically a more difficult surgical procedure and carries a greater risk of complications. Several different TRAM flap techniques have been developed, including pedicled and free flap variants that require the use of microvascular procedures. The main drawback of a standard TRAM flap is harvesting the full width of rectus abdominis muscle together with the overlying subcutaneous tissue. This is necessary to carry the blood supply (inferior epigastric vessels) and maintain viability of the tissue. For this reason, the deep inferior epigastric perforator (DIEP) flap was developed in the submuscular pocket. With this technique, the same area of infraumbilical abdominal tissue is harvested, but with careful dissection and isolation of vascular perforators that pass from the inferior epigastric vessels through the muscle fibers. These vascular perforators can then be taken and used for anastomosis without the need to sacrifice the rectus abdominis muscle. The DIEP flap is taken as a microvascular free flap with the perforator vessels anastomosed to blood vessels in the chest (usually internal mammary vessels). This revascularizes the flap prior to use in reconstruction of the breast.

6.3 Prosthetic Breast Reconstruction

Following mastectomy, implant-based procedures are the most commonly performed reconstructive option. Either with a traditional two-stage approach using tissue expansion or via a single-stage (direct to implant) approach, these techniques produce highly aesthetic outcomes with a multitude of breast sizes.

Immediate placement of a tissue expander or permanent implant at the time of mastectomy is preferable and takes advantage of the natural shape of the breast skin envelope to achieve an improved aesthetic outcome. However, delayed breast reconstruction following previous mastectomy is another option and frequently performed. Tissue expanders and implants, when used for postmastectomy reconstruction, can be placed in different anatomic planes: fully submuscular (underneath pectoralis major muscle and serratus anterior muscle or fascia), dual-plane (under a combination of pectoralis major muscle and acellular dermal matrix (ADM)), or pre-pectoral (completely covered with acellular dermal matrix).

With submuscular reconstruction a pocket is created for coverage of a definitive prosthesis comprising the pectoralis major and serratus anterior muscles. The tissue expander is placed in the muscular pocket, and the catheter and port are tunneled subcutaneously to a position deep to the skin in the axilla or inframammary region (Fig. 6.2). In cases of staged reconstruction, there is placement of an expander with the fill port located on the surface of the expander (Fig. 6.3). Postoperatively, a magnetic device can be employed to help localize the port and thereby facilitate inflation.

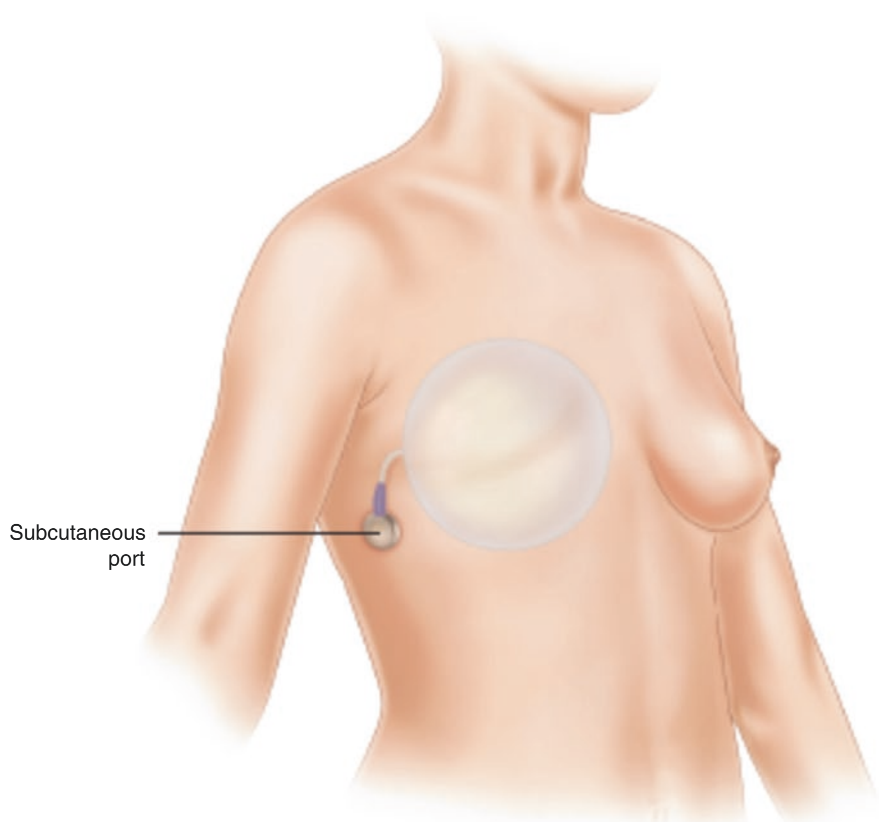
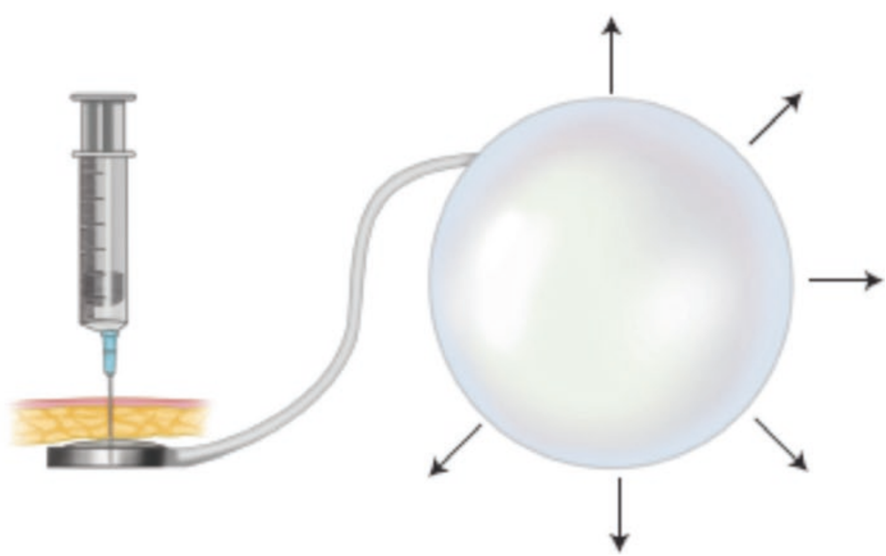


Fig. 6.2 Breast reconstruction with expander



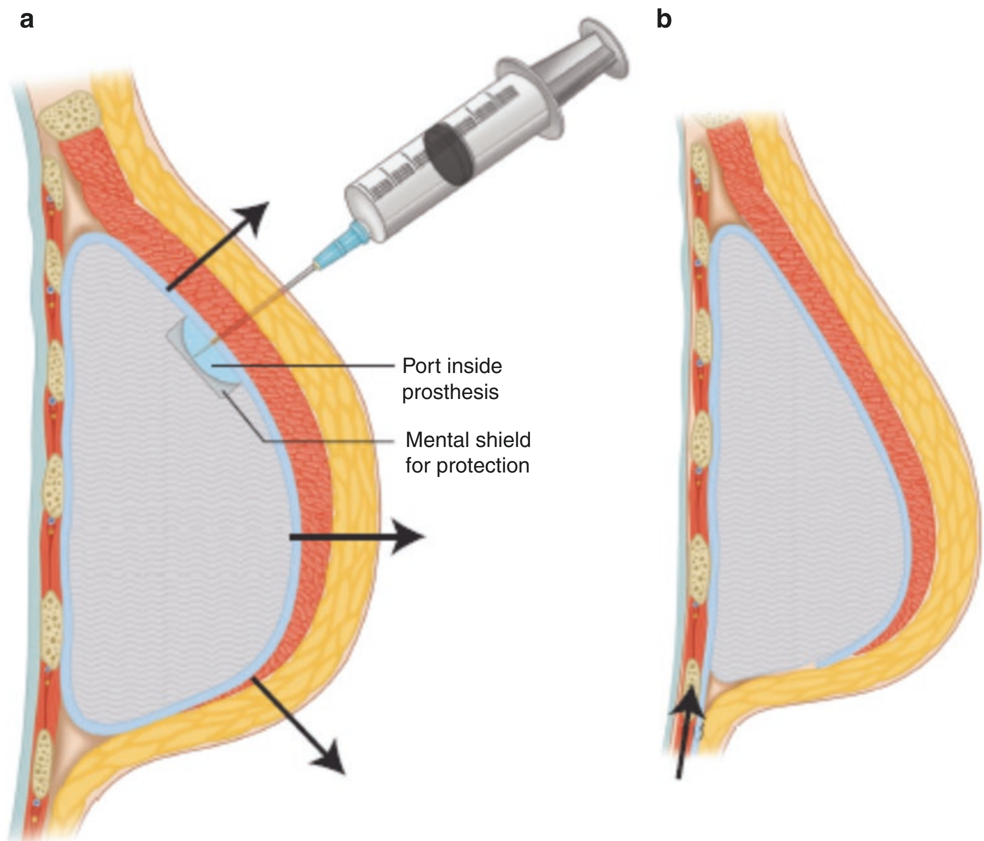


Fig. 6.3 (**a**) Cutaneous expander. (**b**) Position of the definitive prosthesis. After definitive substitution with a definitive prosthesis, the same stitches in the sulcus improve the natural ptosis

The expander is inflated by passing a 22 gauge needle into the port and injecting saline solution through it. This is done once or twice per week until the expander is inflated sufficiently such that the nipple projection lies at the same level bilaterally and the correct size of breast has been achieved. This will provide a degree of ptosis. After a suitable period of expansion, the tissue expander is replaced by a permanent prosthesis at a second operation.

Figures 6.2 and 6.3a, b illustrate the principle of cutaneous expansion, which is necessary to obtain a degree of ptosis. The latter is achieved by gradual inflation of the prosthesis by injecting saline solution through the port once or twice each week over a period of several weeks.

Traditional submuscular techniques have been employed most frequently to obtain soft tissue coverage of both tissue expanders and implants and are reliant on the pectoralis major and serratus anterior muscles and fascia. In recent years, there has been a shift in technique with utilization of ADM as an adjunctive material for soft tissue coverage, thus avoiding the need for muscle elevation to the same degree. ADMs represent a special type of biologic mesh, consisting of a sheet of collagen scaffold that can integrate and revascularize from the patient's own surrounding tissue after surgery. They most commonly are derived from either human or porcine tissue.

Initial applications of ADM involved elevating and inferiorly disinserting the pectoralis major muscle effectively using ADM as an inferior extension of the pectoralis major. In this manner, the ADM covers the lower portion of the prosthesis and is sewn onto the chest wall along the lower border of the prosthesis, at the site of the desired inframammary fold (Fig. 6.4). This allows for a greater in-fill volume to the pocket, and thus a greater intraoperative volume is possible (whether tissue expander or implant). This also improves appearance of the reconstructed breast due to precise placement of the inframammary fold by suturing of the ADM directly to the chest wall (Fig. 6.5).

More recently, ADM has been used to a greater extent in pre-pectoral breast reconstruction. With this technique, no muscle elevation is performed to create a pocket for the prosthesis. Instead, ADM is used to cover the entire prosthesis (Fig. 6.6), and this represents a fully muscle-preserving prosthetic breast reconstruction. This technique is restricted to those patients with well-vascularized mastectomy skin flaps as this is required to revascularize the relatively large sheet of ADM and thereby permit successful breast reconstruction.

Both of these techniques utilizing ADM can be performed for either single-stage permanent implant coverage, or tissue expander coverage at the time of mastectomy. The technique is selected based on preoperative breast size, desired reconstructed breast size, size and dimensions of the native breasts, as well as clinical vascularity of the skin flaps following completion of mastectomy.

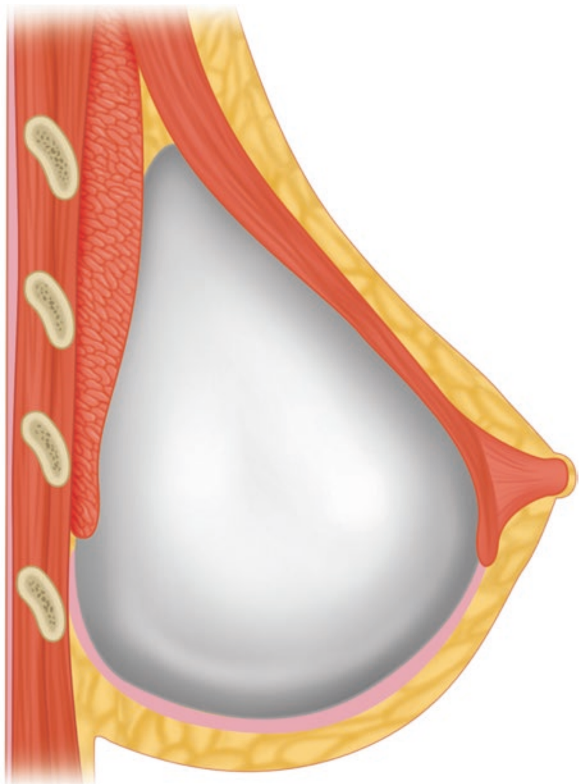


Fig. 6.4 Partial subpectoral/partial ADM coverage of an implant on cross-section, showing the combination of tissue coverage used for the prosthesis

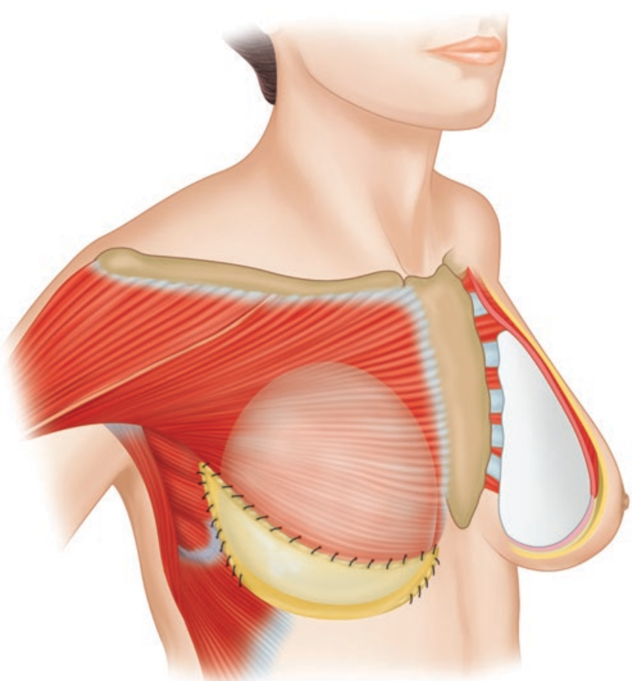


Fig. 6.5 Partial subpectoral/partial ADM coverage of an implant on frontal view, showing the ability of the ADM to act as an inferior extension of the dis-inserted pectoralis major muscle

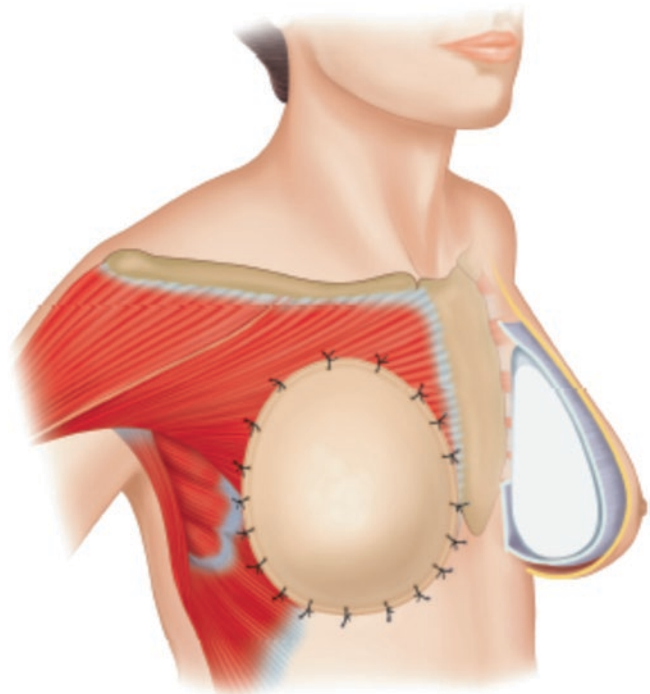


Fig. 6.6 Pre-pectoral breast reconstruction, showing complete soft tissue coverage of the prosthesis with ADM; thus, there is no need for muscle elevation, and this reconstruction is fully muscle preserving

The major benefits of prosthetic breast reconstruction are a patient's ability to choose the size of their reconstructed breasts, rapid postoperative recovery, and prompt return to normal activities from avoidance of transposing tissues from other parts of the body and concomitant donor site morbidity.

6.4 Pre-pectoral Breast Reconstruction

Traditionally, prosthetic breast reconstruction following mastectomy involves placing a tissue expander or permanent implant beneath not only the breast skin envelope but also the pectoralis major muscle. Coverage can be assisted by incorporating the serratus anterior muscle or fascia or more recently by use of ADM as additional material. Submuscular placement of prosthetic devices is based on the premise that this is associated with lower rates of capsular contracture compared to subcutaneous placement.

For many years, this submuscular approach has been the dominant technique for postmastectomy breast reconstruction. However in recent years and following the advent of ADM, there has been a dramatic increase in the numbers of pre-pectoral breast reconstruction being performed. This method avoids any dissection or elevation of the pectoralis or serratus muscles and instead uses ADM exclusively for soft tissue coverage of expander or implant which is placed anterior to the pectoralis major muscle.

This pre-pectoral approach has led to several important benefits for patients, including reduced levels of pain and elimination of animation deformity. Furthermore, absence of the pectoralis major muscle in the reconstructive process has allowed women to experience enhanced aesthetic definition of the reconstructed breast (implant positioning is no longer inhibited by pectoralis muscle anatomy). Moreover, they do not suffer any loss of upper body strength as a consequence of full muscle preservation.

The outcomes of pre-pectoral breast reconstruction using ADM for soft tissue coverage and support have been shown to be equivalent to those of subpectoral reconstruction. These observations also apply in the setting of postmastectomy radiation therapy. Many of the initial concerns surrounding this procedure were due to the increased risk of rippling and upper pole aesthetic deformities due to absence of the pectoralis major muscle covering the upper pole of the implant. However, use of cohesive gel implants together with autologous fat grafting for volume restoration has lessened such concerns. These advances in breast reconstruction have eliminated the need to sacrifice the pectoralis major muscle for purposes of improving upper pole aesthetic outcome. As a consequence, the frequency of pre-pectoral reconstruction techniques is rapidly growing in popularity in the United States. When planning a pre-pectoral implant-based breast reconstruction, the surgeon must bear in mind certain contraindications. This technique should be reserved for patients with viable and well-perfused mastectomy skin flaps. Thin skin flaps can be suitable for these tissue expander-based pre-pectoral breast reconstructions provided they are healthy and well perfused. Furthermore, these techniques should not be promoted in patients with uncontrolled diabetes and active smoking habits or in patients who are morbidly obese. From the oncologic perspective, contraindications to pre-pectoral reconstruction include those patients with deeply situated breast tumors that reach within 0.5 cm of the chest wall and cases of inflammatory breast cancer. All the aforementioned factors should be considered when planning this type of breast reconstruction.

6.5 Hypothesis to Explain Capsular Contracture

Fibroblasts within the tissue in contact with the prosthesis will migrate to the zone immediately around breast implants and expanders following surgical placement. These special fibroblasts, known as myofibroblasts, are responsible for depositing an envelope of scar tissue around the device (otherwise known as a capsule) and are directly responsible for any subsequent capsular contracture. After healing of the surgical wound, myofibroblasts generally disappear in the majority of patients. However, these cells may persist within capsules that have formed around breast prostheses, and this might offer an explanation for the mechanism of capsular contracture

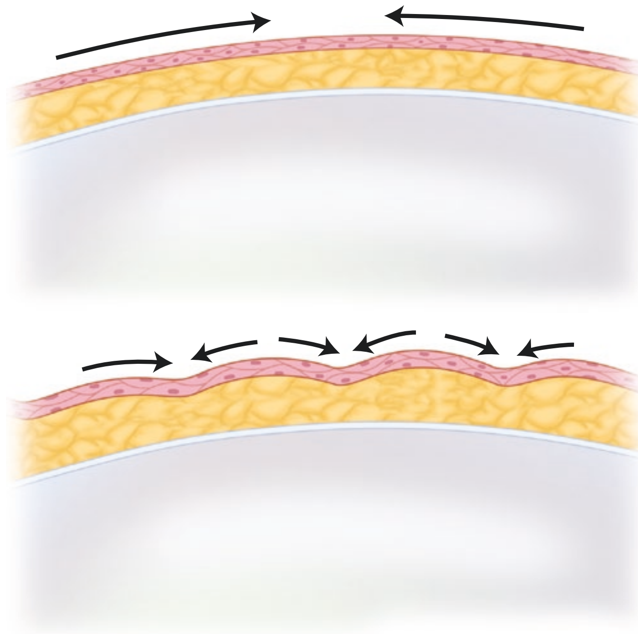


Fig. 6.7 A hypothesis to explain capsular contracture

As shown in the accompanying illustrations, when an implant is placed on the chest wall in breast reconstruction, it becomes lined with contractile fibroblasts (Fig. 6.7) and the implant can thus be viewed as a three-dimensional wound. These contractile fibroblasts are responsible for an initial phase of contracture, but counter pressure from the implant tends to prevent further contracture. Firmer implants should therefore be less prone to capsular contracture than softer implants.

Any process that results in increased inflammation within the breast pocket can lead to hyperactivity of fibroblasts and resultant capsular contracture. Thus, infection (biofilm) and hematoma have been implicated in higher rates of capsular contracture.

Capsular contracture is graded on clinical criteria, based on examination findings, and is defined using the Baker classification scale (Fig. 6.8).

6.6 Suspension Technique (Advancement Abdominal Flap)

When a permanent prosthesis is to be inserted following mastectomy and definition of the previous inframammary fold has been lost, the cosmetic appearance can potentially be improved using the "suspension technique." First, a wide area of abdominal tissue is undermined inferiorly, along the anterior surface of the rectus abdominis muscle (Fig. 6.9a). In this manner, the skin and subcutaneous tissue along the inferior aspect of the mastectomy wound are mobilized. The head of the operating table should then be raised, placing the patient in a semi-upright position. The abdominal flap that has been mobilized is then pulled up and maintained with a triangular nonabsorbable mesh that is fixed at the level of the future inframammary fold. The mesh is brought up superiorly, posterior to the pectoralis major muscle (Figs. 6.9b and 6.10), and the superior aspect of the mesh is attached to the costal cartilage with two nonabsorbable stitches (3–0 Prolene) as illustrated (Fig. 6.9b). The prosthesis is then placed anterior to the mesh and posterior to the pectoralis muscle as shown (Fig. 6.10). This "suspension technique" is a form of abdominal flap advancement and was first described by Rietjens in 1977.

Grade I	No palpable capsule	The augmented breast feels as soft as an unoperated one.
Grade II	Minimal firmness	The breast is less soft and the implant can be palpated, but is not visible.
Grade III	Moderate firmness	The breast is harder, the implant can be palpated easily, and it (or distortion from it) can be seen.
Grade IV	Severe contracture	The breast is harder, tender, painful and cold. Distortion is often marked.

Fig. 6.8 Baker classification system for grading capsular contracture

6.7 Breast Reconstruction in the Setting of Post-mastectomy Radiation

Breast reconstruction in the setting of post-mastectomy radiotherapy (PMRT) presents a particular challenge and is associated with higher rates of incisional dehiscence, infection, and capsular contracture. Reported rates of overall complications in this setting range from 15% to 40% with some centers not infrequently experiencing complication rates of 30–40% following irradiation of a reconstructed breast.

When planning prosthetic reconstruction in the context of PMRT, the surgeon must first decide whether radiation will be delivered to a tissue expander or permanent implant. Reported rates of infection are lower with irradiation of permanent implants, since all operations on the breast have to be undertaken prior to radiation. However, rates of capsular contracture are higher for this option with the irradiated

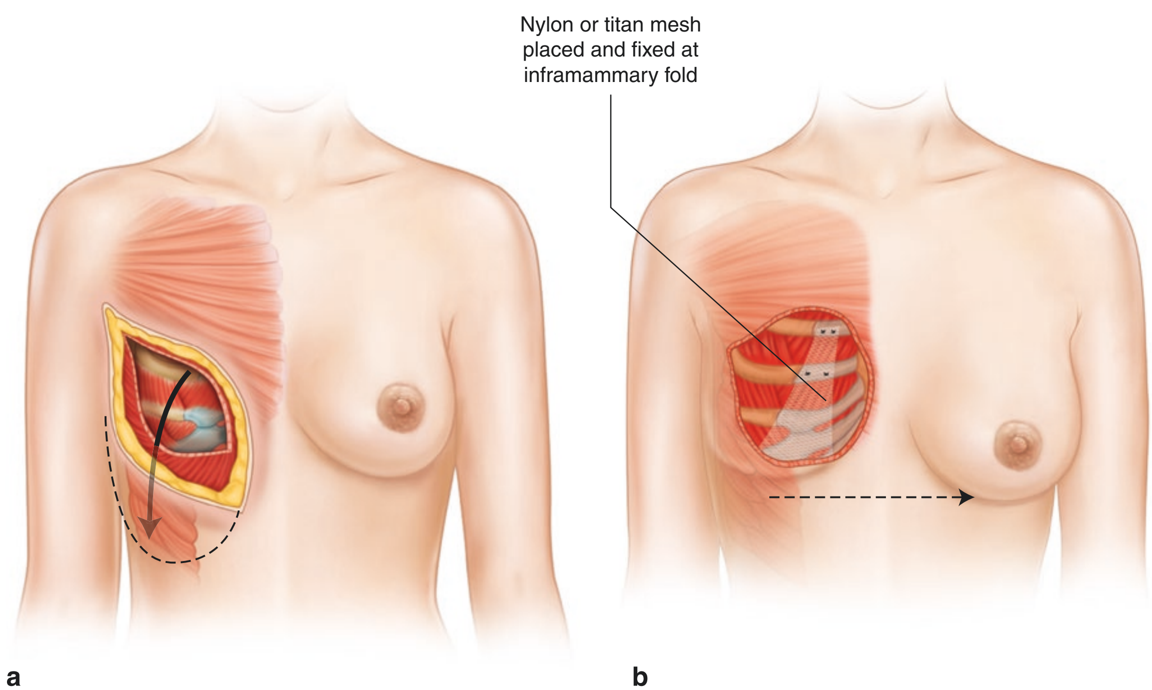


Fig. 6.9 (**a**, **b**) Immediate breast reconstruction, using the "suspension technique II"

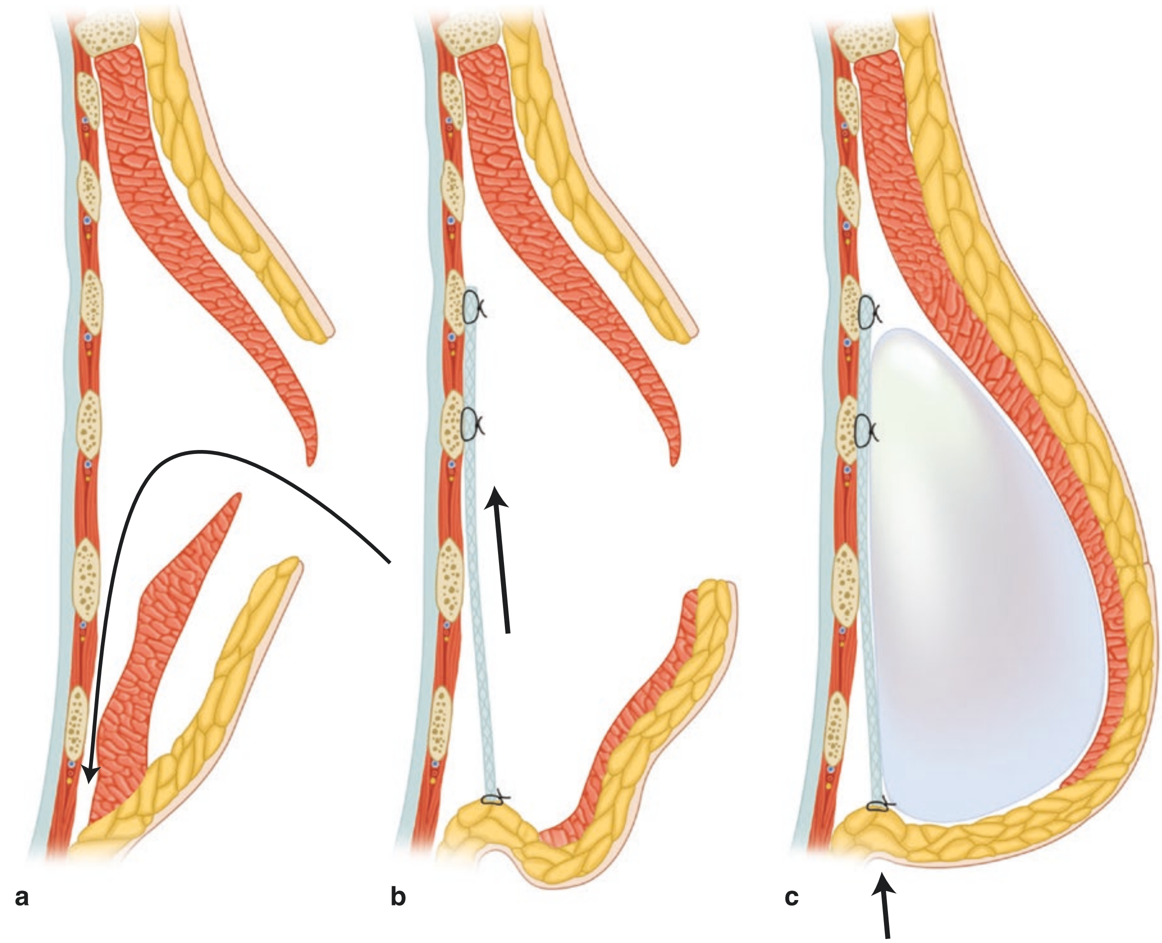


Fig. 6.10 (**a**) Immediate breast reconstruction using the "suspension technique" (profile view). (**b**) With mesh. (**c**) Suspension technique with mesh and subpectoral prosthesis

implant remaining in situ permanently, without the option for capsulectomy after completion of radiation. Delivery of radiation to tissue expanders allows the opportunity for capsulectomy and contracture reduction with correction of any displacement or deformity that has occurred during radiation. For this reason, irradiation of tissue expanders is the most common approach in the setting of PMRT.

Even when radiation delivery to a permanent implant is preferred, many patients undergoing two-stage reconstruction will not be suitable candidates as radiation therapy begins around 4 weeks after mastectomy. This timeline will not allow for the second-stage expander to implant exchange to be performed prior to radiation delivery.

Given these risks and constraints, many strategies have been developed to reduce complication rates following mastectomy and prosthetic reconstruction in the setting of PMRT. This is especially relevant with increasing frequency of NSM. In this group of patients, radiation increases rates of skin necrosis and infection, but not necessarily rates of nipple necrosis relative to non-irradiated breasts. Therefore NSM can be safely performed when PMRT is anticipated.

Location of the incision has been shown to be critical in terms of complication rates in the setting of PMRT. A periareolar, radial, or any other incision on the anterior aspect of the breast is associated with lower complication rates compared with an inframammary fold incision when radiation follows surgery. Regardless of incision type used for NSM and immediate tissue expander placement, the second-stage exchange operation for a permanent implant after radiation treatment should always be performed through a different incision. The original incision consists of scar tissue that has been significantly devascularized by irradiation. Instead, a new incision should be planned in an area without scars from previous surgery. This strategy will significantly reduce wound dehiscence rates following PMRT.

Another important consideration is the time interval between completing radiation and the second-stage expander to implant exchange operation. While there remains no absolute consensus on this, there is data to suggest that waiting at least 6 months after radiation completion will significantly reduce complication rates from the second operation. This will allow the acute effects of radiation fibrosis to dissipate, including the acute inflammatory changes in the skin envelope that allows for improved healing. During this time period, many surgeons will perform autologous fat grafting on the acutely irradiated breast skin as this procedure has been shown to reduce some of the damaging effects of radiation fibrosis.

The widespread use of ADM in breast reconstruction has helped reduce complication rates in the setting of PMRT. Multiple centers have published similar findings confirming that prosthetic implants with ADM coverage are associated with significantly lower rates of complications overall (including implant extrusion) relative to full submuscular coverage. Thus, the use of ADM to support and cover prosthetic implants when radiation treatment is indicated or anticipated should be encouraged. Other benefits of ADM include greater control over the aesthetic boundaries of the reconstructed breast, less implant movement, and reduced rates of capsular contracture.

The use of autologous tissue for breast reconstruction in the setting of radiation results in lower rates of infection due to the vascularized nature of these tissue-based reconstructions. However, certain considerations are of paramount importance in these patients, and radiation of autologous flaps results in higher rates of fat necrosis and partial flap loss. For these reasons, many centers delay autologous flap reconstruction until after completion of radiation and instead proceed with placement of a temporary tissue expander at time of mastectomy which serves to maintain the shape of the skin envelope (so-called delayed-immediate reconstruction).

Nonetheless, some specialized breast reconstruction centers have performed immediate autologous reconstruction followed by radiation of flaps with consistently high levels of success. In their experience, rates of revisional surgery to manage PMRT-induced complications are the same as for non-irradiated flaps. These outcomes give merit to performing definitive reconstruction as a single operation prior to radiation treatment. It has also been found that those flaps with enhanced perforator blood supply, namely, muscle-sparing TRAM (msTRAM), have lower complications and better outcomes when irradiated compared with relatively poorly perfused single or double perforator (DIEP) flaps. Thus, msTRAM flaps are preferred when radiation is anticipated in this reconstructive setting.

For those patients undergoing microsurgical autologous tissue reconstruction following radiation, the more common scenario of waiting longer periods of time after completion of radiation will improve free flap outcomes. This allows for recovery over time of the internal mammary or thoracodorsal vessels from the damaging effects of radiation which in turn will lead to improved anastomotic patency and vascularity. Studies suggest that waiting 1 year after completion of radiation before undertaking microvascular breast reconstruction results in significantly reduced rates of total flap loss compared to proceeding with surgery within 1 year.

Regardless of the exact procedure planned, both pedicled and autologous flap-based reconstructions have excellent outcomes in the setting of radiation treatment. The vascularized autologous nature of these flaps renders them well-suited to resisting the damaging effects of radiation and specifically to minimize infection rates.

6.8 Latissimus Dorsi Flap

In recent years, there has been a decline in the use of latissimus dorsi flaps for breast reconstruction with the advent of ADM. However, this remains an acceptable choice for autologous reconstruction either as a totally autologous technique or in combination with a tissue expander or implant.

When a latissimus dorsi flap is selected as the method for breast reconstruction, preoperative planning is critical in terms of marking of the shape and extent of the donor site skin to be taken with the muscle as part of a myocutaneous flap. The surgeon should outline the site of the planned mastectomy skin incision or estimate the amount of skin to be imported onto the chest wall to replace thin, devascularized, or radiation-damaged skin. This incision pattern is outlined on paper, which is then used as a template to outline the skin over the latissimus dorsi muscle. The accompanying illustration depicts possible locations of the skin paddle overlying the muscle that might be used in a latissimus dorsi flap reconstruction (Fig. 6.11). The more elliptical the skin

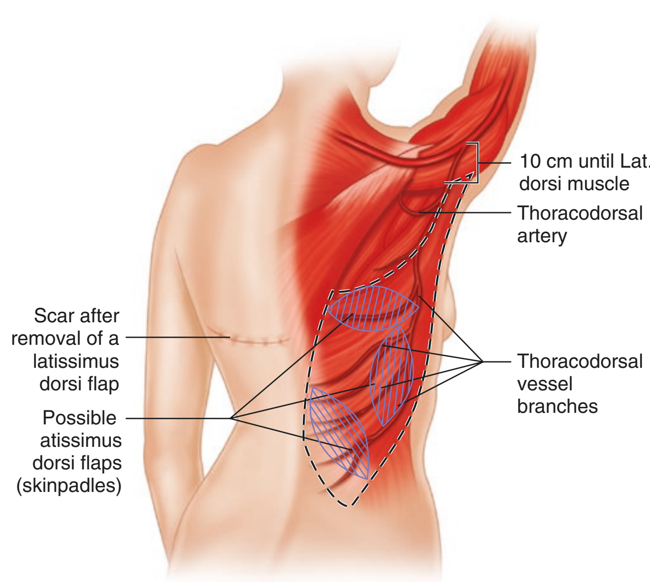


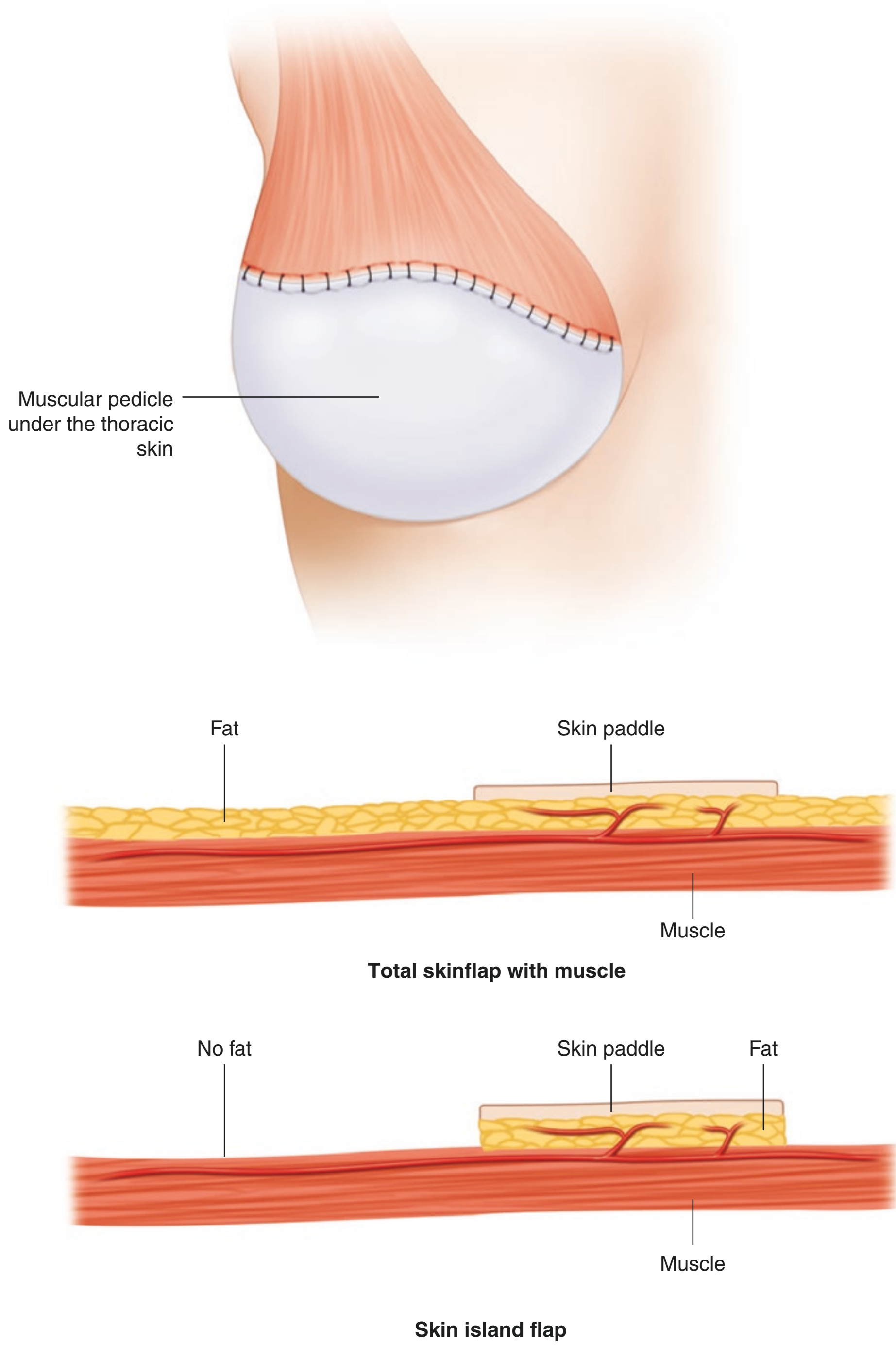
Fig. 6.11 Breast reconstruction with latissimus dorsi flap, blood supply, and possible skin paddles

incision, the easier it is to close (maximum width should not exceed 10 cm).

The latissimus dorsi flap is comprised of a skin paddle and underlying fat and muscle (Fig. 6.12). When the flap is used for immediate breast reconstruction, the mastectomy component must be completed before beginning the reconstruction. The mastectomy wound is packed with moist laparotomy pads and isolated with an Ioban drape. The patient is then turned on her side and placed in the lateral decubitus position, providing the surgeon with easy access to the latissimus dorsi muscle and surrounding tissues. The patient's position on the operating room table is secured with a beanbag, and an arm/shoulder support is essential to prevent traction on the brachial plexus.

An elliptical or small circular incision is made (corresponding to the mastectomy incision) for skin replacement.

Fig. 6.12 Latissimus dorsi flap



This incision is made on the previously marked skin surface overlying the latissimus dorsi muscle. The incision is deepened down to the muscle, and an area of adjacent skin and subcutaneous tissue is undermined. The latissimus dorsi flap is mobilized by initially incising muscle along its anterior margin and continuing the dissection posteriorly, using fingers to bluntly dissect the muscle off the underlying rib cage. When the posterior attachments of the flap are freed, its peripheral attachments are severed by sharp dissection, beginning inferiorly and continuing the dissection superiorly. Along the superior aspect of the dissection, care should be taken to identify and preserve the thoracodorsal pedicle, which may have been previously exposed during an axillary dissection. Preservation of the thoracodorsal pedicle is critical, as it provides the blood supply to the latissimus dorsi flap. With blunt dissection, a subcutaneous tunnel is created from the mastectomy defect into the axilla and the tunnel enlarged sufficiently to allow the latissimus dorsi flap, with its pedicle to be rotated anteriorly into the mastectomy defect.

The back wound (from which the latissimus dorsi flap was taken) is closed primarily with a closed suction drain brought out inferior to the wound. The wound is generally closed in two layers with interrupted 3–0 vicryl sutures for the deep dermal layer followed by a running 3–0 subcuticular monocryl stitch. Once the back wound is closed, the bean bag is deflated and removed, and the patient is again rotated to the supine position to complete the reconstruction on the anterior chest wall. The Ioban drape overlying the mastectomy wound is removed, the patient is re-prepped and redraped, and the surgeon is now ready to secure the flap onto the anterior chest wall.

The superior and medial aspects of the latissimus muscle are then sutured to the pectoralis major muscle and fascia. The inferior aspect of the latissimus dorsi muscle is sutured into the rectus abdominis muscle, and the lateral aspect of the latissimus dorsi is sutured to the serratus anterior muscle and fascia. In this manner, a submuscular pocket is created underneath the latissimus. A few of these sutures are left untied, and prostheses of various sizes are placed into this pocket until one of suitable size is found. The appropriately sized prosthesis is left in place, and the sutures are tied down around it. The skin edges of the wound are then re-approximated.

6.9 Whole Breast Reconstruction with a De-epithelialized Latissimus Dorsi Muscle and Skin Flap

The accompanying illustration depicts whole breast reconstruction with a de-epithelialized latissimus dorsi flap (Fig. 6.13).

The latissimus dorsi flap (with its de-epithelialized skin paddle) is mobilized and brought into the mastectomy wound as previously described. The de-epithelialized skin paddle is buried under the mastectomy skin flap and folded on itself.

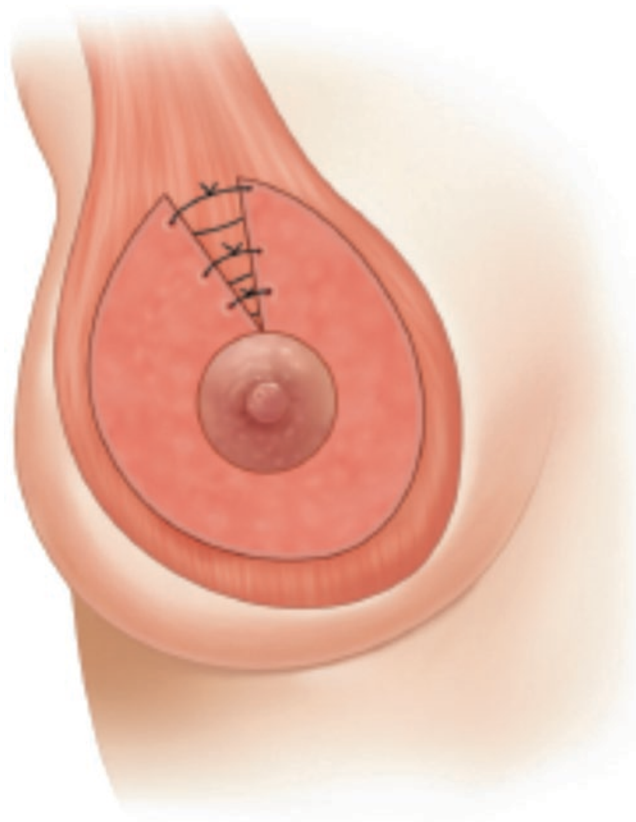


Fig. 6.13 Breast reconstruction with a totally de-epithelialized latissimus dorsi flap. The de-epithelialized skin paddle is buried under the thoracic skin and folded on itself

The skin from the anterior surface of the chest wall is then re-approximated, with the latissimus dorsi flap and its de-epithelialized skin paddle buried underneath. This flap provides a mound of tissue beneath the mastectomy skin flap, simulating the breast.

In many cases, the latissimus flap can be used in this way to reconstruct the entire breast without a permanent prosthesis. However in some cases, the latissimus can be combined with an underlying prosthetic implant to restore the necessary breast volume and projection in a single operation. When this technique is used after radiation, the latissimus flap is commonly combined with an underlying tissue expander to allow for safe expansion of a breast mound, protected by the non-irradiated LD flap.

6.10 Latissimus Dorsi Flap to Repair Glandular Defects Following Quadrantectomy

Following breast-conserving surgery, a large glandular defect in the upper outer quadrant can be repaired with a latissimus dorsi flap tunneled into the wound as depicted in

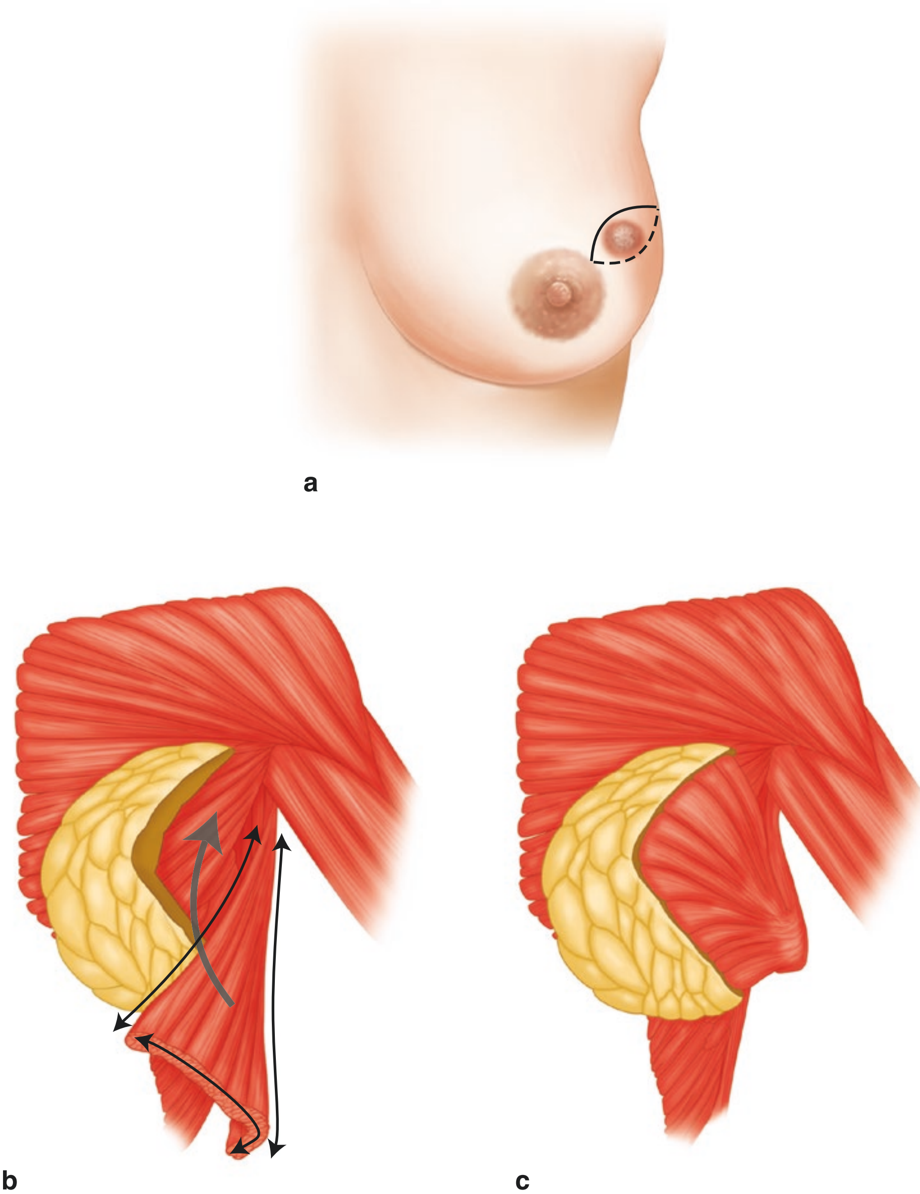


Fig. 6.14 (**a–c**) Quadrantectomy. Glandular defect in the upper outer quadrant; plasty with muscular latissimus dorsi flap

these illustrations. The tissue bulk provided by the latissimus flap improves the cosmetic outcome following breast-conserving surgery (Fig. 6.14a–c).

6.11 Autologous Fat Grafting

Another technique for autologous breast reconstruction that has gained popularity in recent years is autologous fat grafting. This process is especially useful as an adjunctive technique for enhancing mastectomy skin flap thickness around implants and restoring volume following breast conservation. Fat injection can also help to increase the size of autologous tissue flaps used in breast reconstruction such as the latissimus dorsi flap or DIEP flap.

Autologous fat grafting has emerged as a critical component of breast reconstruction due to its powerful ability to restore volume to the soft tissue envelope of the breast and improve its quality. Unlike other fillers, fat has the ability to revascularize from surrounding tissue and live permanently in the injected region, surviving on its new blood supply. In addition to adding thickness and volume to the soft tissue envelope, fat also improves the quality of this tissue through rejuvenation and softening. The latter is attributed to the high concentration of stem cells in human adipocytes.

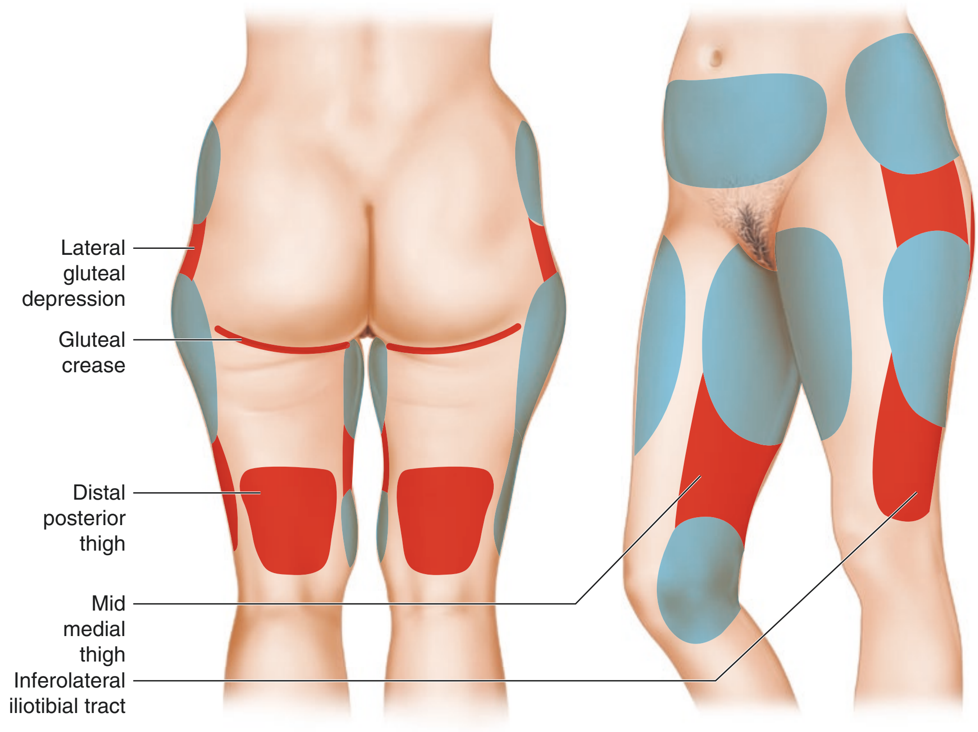


Fig. 6.15 Zones of fascial attachment, on the lower extremities, depicted in red. These areas should be avoided with liposuction, when harvesting fat for grafting, as they are at high risk for contour deformities

The benefits of fat grafting are numerous and relate to its biocompatibility, availability, versatility, and ability to integrate into host tissues and survive. It has become essential in correcting intractable aesthetic deformities and minor asymmetries that were previously difficult to address. Furthermore, fat grafting has demonstrated low infection rates and has been shown to be oncologically safe in breast cancer patients.

Surgical technique is the key element determining successful outcomes in autologous fat grafting. It ensures that viable cells are being injected and that all cells are given a vascularized environment in which they can survive at the highest rates. The infraumbilical abdomen and thighs are the most commonly chosen donor sites for fat harvest due to both their accessibility with a patient in the supine position and the high concentration of viable adipocytes in these areas.

The surgeon must carefully mark the zones of planned liposuction preoperatively, with the patient standing to ensure that all donor site areas are used equally and symmetrically to avoid a donor site defect. Zones of fascial attachment on the lower extremities should be avoided with liposuction to prevent contour deformities (Fig. 6.15).

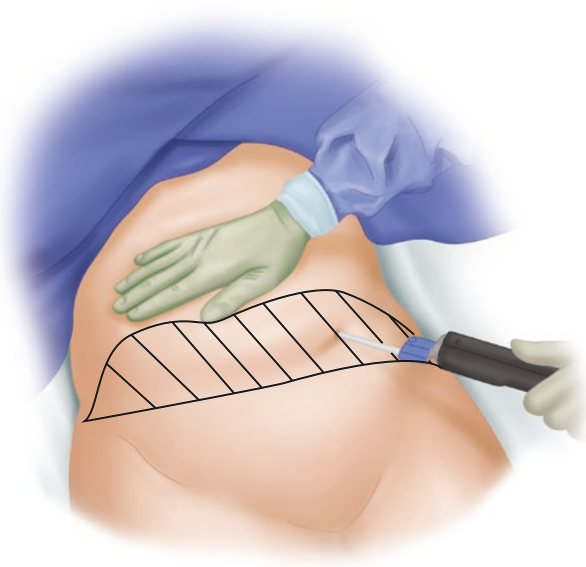


Fig. 6.16 The use of conventional liposuction techniques to harvest autologous fat for grafting

Fat can be harvested using a variety of techniques, depending on surgeon preference. Methods which have been shown to be safe and effective include conventional liposuction, power-assisted liposuction, and handheld syringe liposuction (Fig. 6.16). With all of these recommended techniques, a blunt tip liposuction cannula should be used for

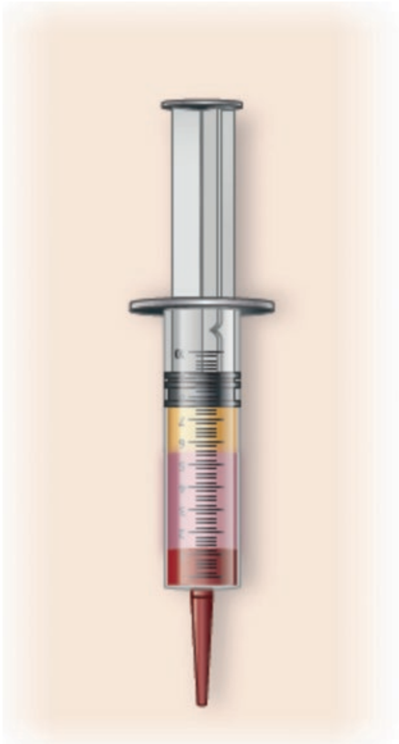


Fig. 6.17 Example of processed fat, showing separation of oil (top layer), adipocytes (middle layer), and blood (bottom layer); the oil and blood layers will be decanted, leaving only healthy fat for reinjection

safe harvest. Additionally, it has been shown that larger diameter harvest cannulas produce higher concentrations of viable adipocytes than smaller cannulas.

The lipoaspirate is processed after harvesting to remove the majority of oil, blood, tumescent fluid, collagen strands, and lysed cells in the graft. Removal of these components is necessary to more accurately predict the volume correction achievable with grafting; if not removed, they will rapidly resorb after injection resulting in lower volume restoration than anticipated. Many techniques have traditionally been utilized for fat washing and processing including decanting, filtration, and centrifugation (Fig. 6.17).

Following completion of processing, the fat is then loaded into syringes for injection (Fig. 6.18). The key to increasing fat survival is to maximize contact of each injected string of adipocytes with the surrounding host vascularized tissue. To achieve this, the approach during injection is to infiltrate many thin strands of fat, dispersed equally throughout the soft tissue envelope (Fig. 6.19).

When performed in this manner, fat grafting is highly effective in soft tissue augmentation. As such, it has become a preferred adjunctive technique for augmentation of all types of breast reconstruction discussed in this chapter.

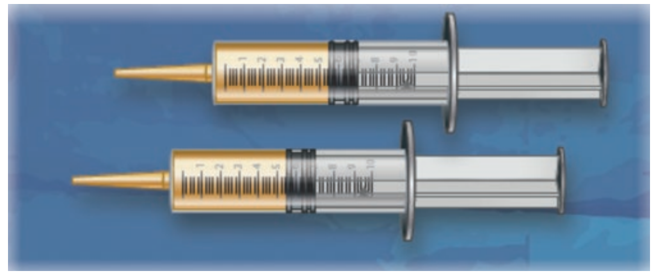


Fig. 6.18 Following processing, the adipocytes are loaded into injection syringes for grafting

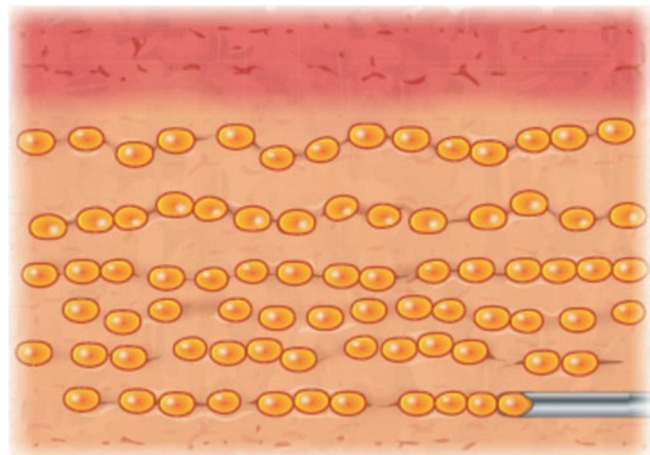


Fig. 6.19 Proper injection of fat in a "string-of-pearls" fashion is done with thin strands of fat, such that all injected fat is in contact with surrounding vascularized tissue

6.11.1 Pedicled TRAM Flap Reconstruction

The pedicled TRAM was the original abdominal-based autologous option for breast reconstruction described in the late 1970s by Hartrampf. Over recent years, with the advent of microsurgical breast reconstruction, the number of pedicle TRAMs performed has decreased. This is due to excessive harvest of abdominal wall fascia with a pedicled TRAM and the need to leave an aperture in the upper abdominal fascia when tunneling the flap. This increases the risk of abdominal bulging postoperatively and can be unsightly. Thus, whenever possible, surgeons should aim to carry out either a free TRAM or DIEP flap that minimizes disruption of the anterior abdominal wall. However, the pedicled TRAM flap remains a good option in centers where microsurgical techniques are not available.

When performing a pedicled TRAM flap for breast reconstruction, preoperative markings are critical. Prior to surgery, the breast mound is outlined using indelible ink with the patient standing. The perimeter of the flap to be taken from the abdominal wall is also outlined. This is done

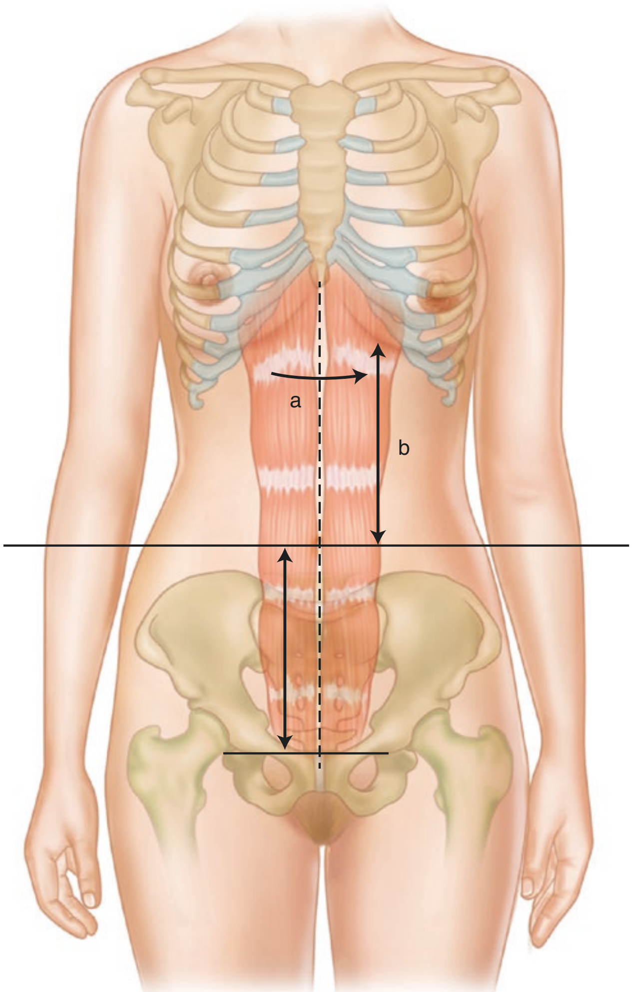


Fig. 6.20 Pedicled TRAM flap reconstruction. The opening of the costoxiphoid angle facilitates the rotation of the superior portion of the pedicle (*a*). The distance between the umbilicus and the costal border corresponds to the real length of the pedicle and helps to predict whether the pedicle will be tense or not after transfer of the flap (*b*)

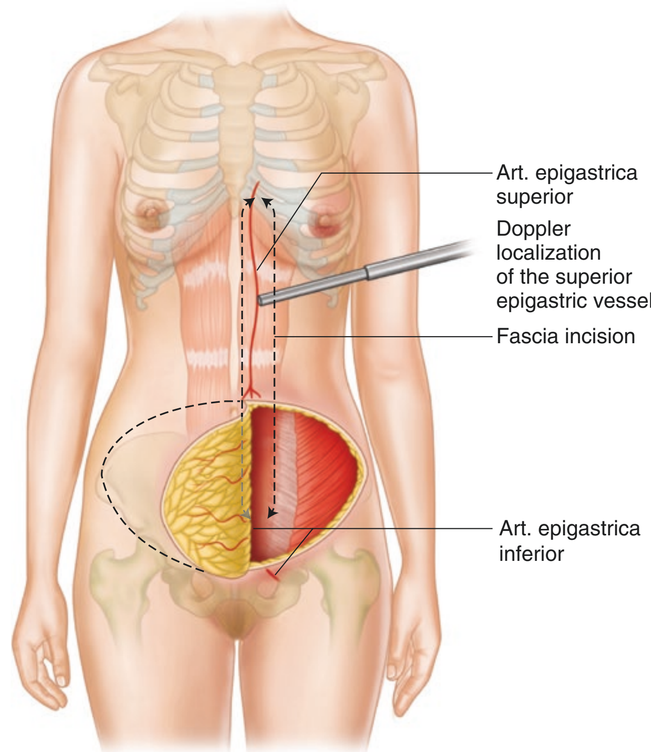


Fig. 6.21 Pedicled TRAM flap reconstruction

by grasping tissue approximately two fingerbreadths above and below the umbilicus and pulling up on the anterior abdominal wall as much as possible. The surgeon should make certain, by gently pinching the superior and inferior aspects of this tissue, that the edges will easily re-approximate once the flap is taken and the patient is in a sitting position (Fig. 6.20).

The key anatomical structure within the TRAM flap is the rectus abdominis muscle. The rectus abdominis is situated within longitudinal fascial sheaths on the anterior abdominal wall and is readily visible once the skin and subcutaneous tissues of the anterior abdominal wall are retracted anteriorly. The blood supply of the rectus is derived from the superior epigastric artery (a continuation of the internal mammary artery) and the inferior epigastric artery (from the external iliac artery). These vessels enter the posterior aspect of the rectus abdominis muscles. Additional blood supply is derived from the intercostal vessels, which enter the rectus abdominis muscles laterally. The blood supply to the overlying skin is largely derived from perforating branches of the underlying muscles. Thus, branches of the epigastric vessels perforate through the anterior rectus sheath and supply the skin.

The previously outlined skin on the abdominal wall is incised with sharp dissection down to the level of the fascia. Skin and subcutaneous tissues are then undermined superiorly up to the level of the xiphoid. During this dissection, a plane is developed between the subcutaneous tissues and underlying muscle fascia.

The portion of the flap (the random portion) that will not be attached to the underlying rectus muscle is elevated off the contralateral rectus fascia and brought to the midline (the medial aspect of the rectus sheath) (Fig. 6.21).

It is generally recommended that the random portion of the flap paddle is left attached to the rectus until harvesting of the main pedicle is completed. Thus, in the event that the superior epigastric vessels of the main pedicle are injured, there remains the option of using the contralateral pedicle.

The random portion of the flap is composed of skin and subcutaneous tissue, with no underlying muscle. Additionally, the ipsilateral random portion is dissected off the external oblique

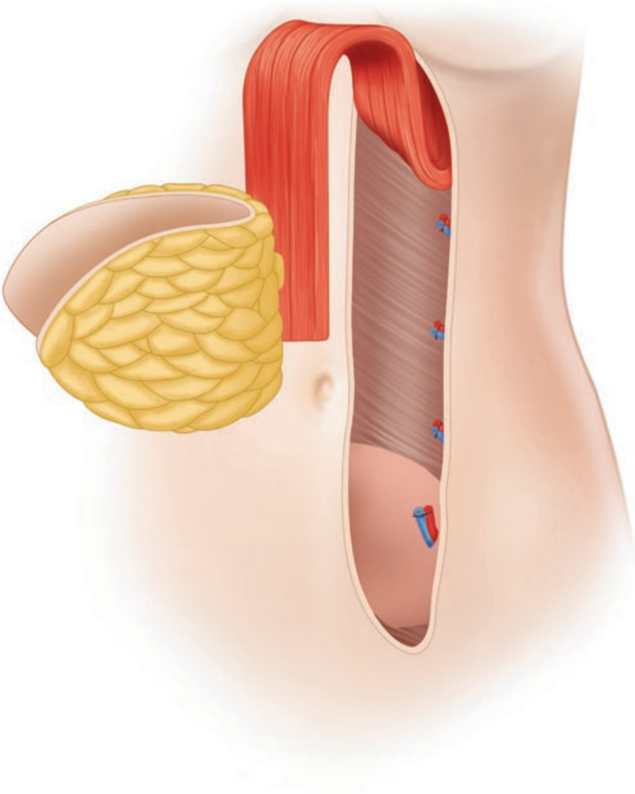


Fig. 6.22 Complete harvesting of one pedicle

fascia and brought to the lateral aspect of the rectus sheath. The skin overlying the rectus muscle (that will be included in the TRAM flap) is supplied by a row of medial and lateral perforating vessels which should be carefully preserved.

At this point, the surgeon divides the inferior rectus fascia (below the TRAM flap) and identifies the muscle. The surgeon places two fingers underneath the rectus muscle and lifts it anteriorly, thereby placing it under tension. The inferior epigastric pedicle should now be palpable. The muscle is then divided, and the inferior epigastric pedicle is doubly ligated with 3–0 silk and divided. The rectus muscle is dissected free posteriorly, and the lateral aspect of the rectus sheath is divided with a scalpel up to the superior border of the flap. The medial border of the rectus sheath is divided to the level of the umbilicus which is then dissected free from the flap (Fig. 6.22).

The fascia overlying the rectus muscle is then incised up to the level of the xiphoid (Fig. 6.23). The rectus muscle is completely mobilized by sharp and blunt dissection and a tunnel created through the inframammary fold that communicates with the mastectomy wound. The flap is then rotated into the wound (Figs. 6.24 and 6.25). The muscle layer of the flap is sutured to the surrounding pectoralis major muscle, and skin edges are approximated. Jackson–Pratt (or similar) drains are placed in the axilla and the upper abdomen.

Closure of the abdominal wounds is depicted in the accompanying illustrations (Figs. 6.26 and 6.27).

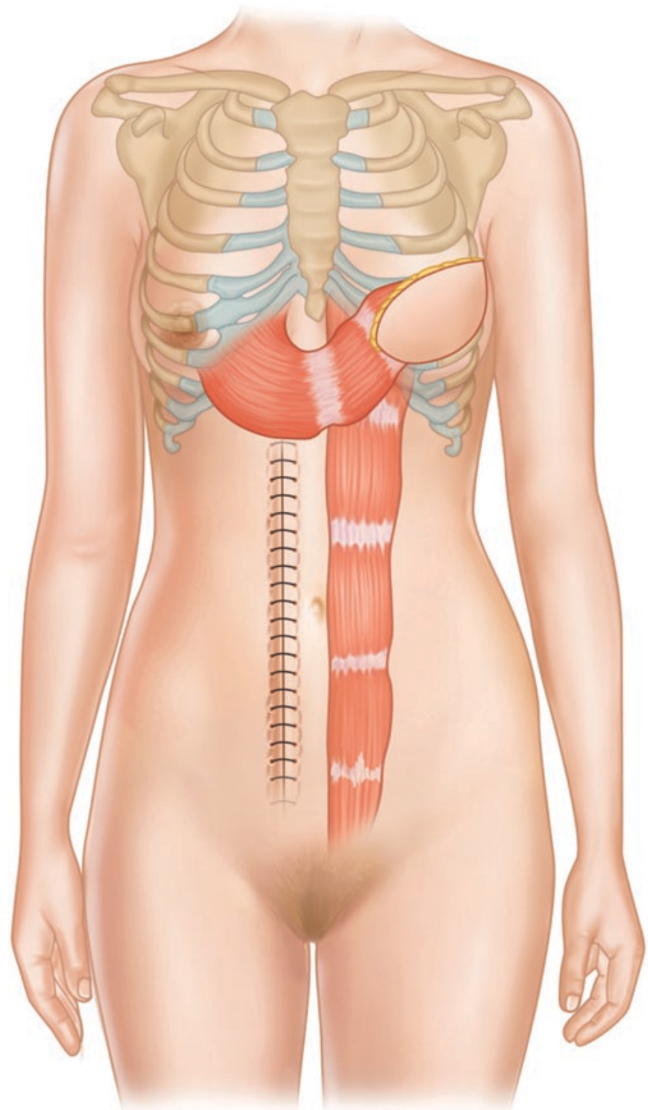


Fig. 6.23 To avoid lateralization of the umbilicus in the case of a single pedicle TRAM, a small local flap is used

An imbricating running suture is placed in the opposite anterior rectus sheath to help bring the umbilicus to the midline and thereby provide symmetry (Fig. 6.28a–c). In most cases of bipedicle flap reconstruction, a mesh closure is generally necessary (Fig. 6.26a–c).

6.11.2 Abdominal Closure

Closure of the abdomen is an important step in the operation and should be done meticulously to avoid complications such as skin necrosis, hernia, and unsightly scars. The suture of the fascia should be done with the patient in the lying position, while the closure of the cutaneous flaps will be done at the end in a sitting position.

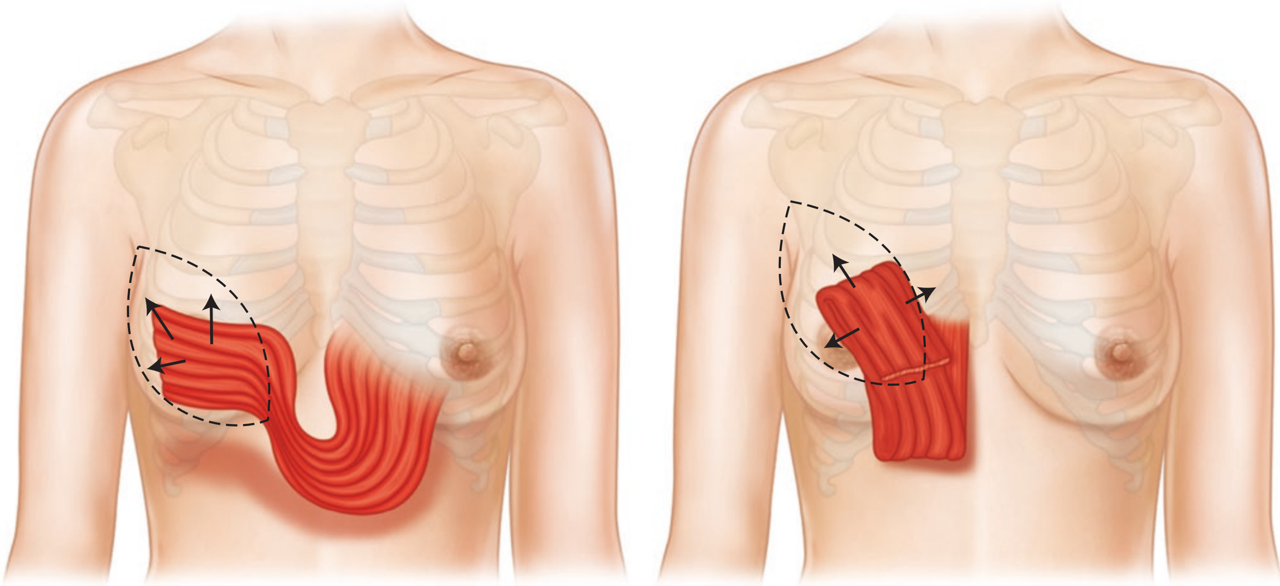


Fig. 6.24 Rotation of the pedicle

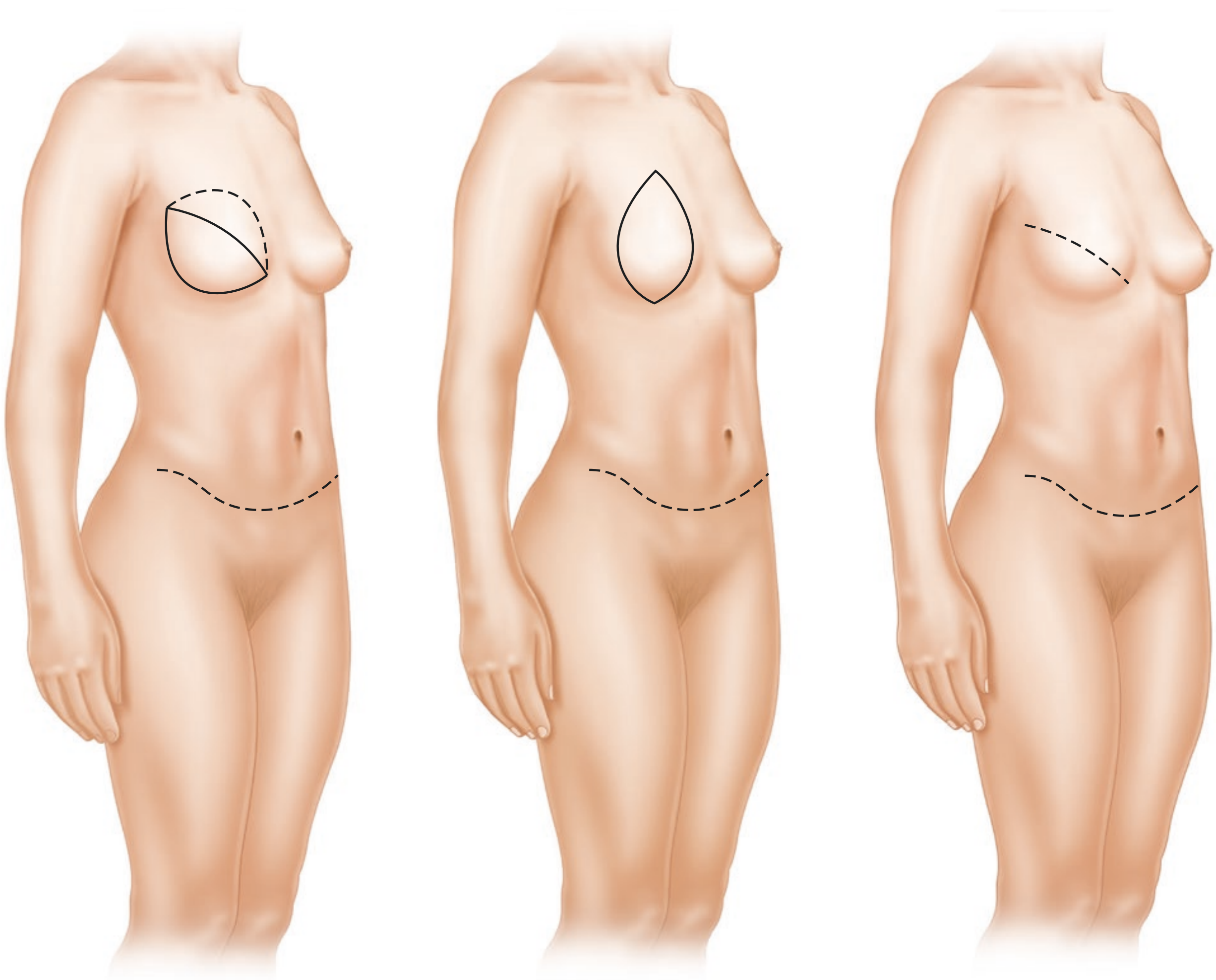


Fig. 6.25 Positions of the paddle according to the previous positions

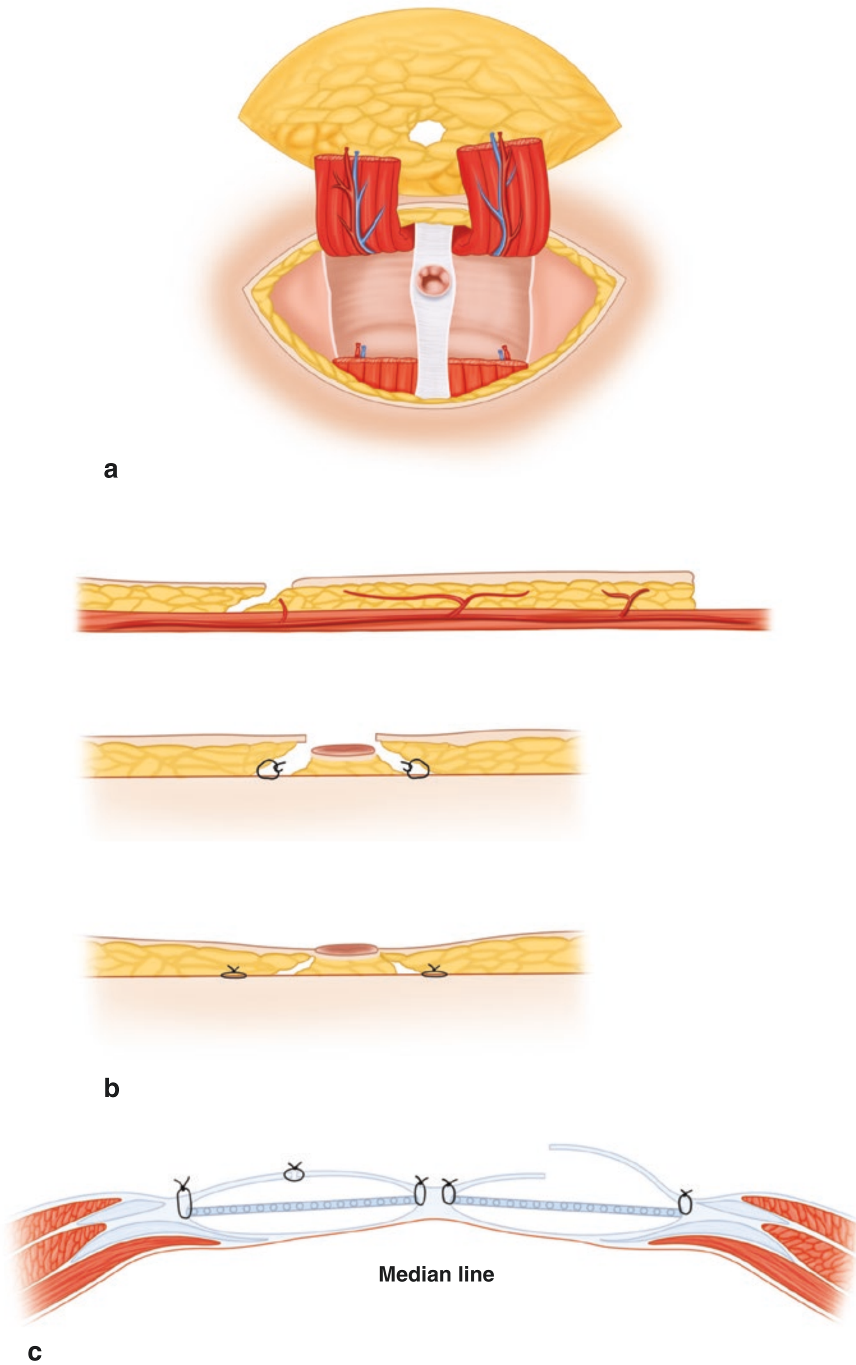


Fig. 6.26 (**a**) Bipedicle flap. (**b**) Umbilical closure. (**c**) Abdominal closure

The fascia can be closed directly with nonabsorbable stitches under moderate tension and without mesh in the case of a single pedicle. When the fascia seems fragile and the tension therein is questionable, insertion of a mesh is recommended (Fig. 6.27). A nonabsorbable mesh is more secure and can be totally covered by the superficial layer of the rectus fascia. In the case of a double pedicle use of a mesh is essential to prevent herniation. Closure of the fascia with a single pedicle can create excessive tension on the umbilicus that deviates from the midline of the abdomen.

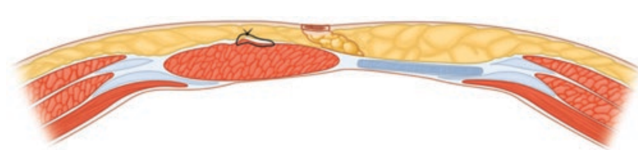


Fig. 6.27 Abdominal closure TRAM. Centralization of the umbilicus in the case of a single pedicle TRAM

Centralization of the umbilicus can be achieved through plication of the contralateral fascia as shown in Fig. 6.28a–c.

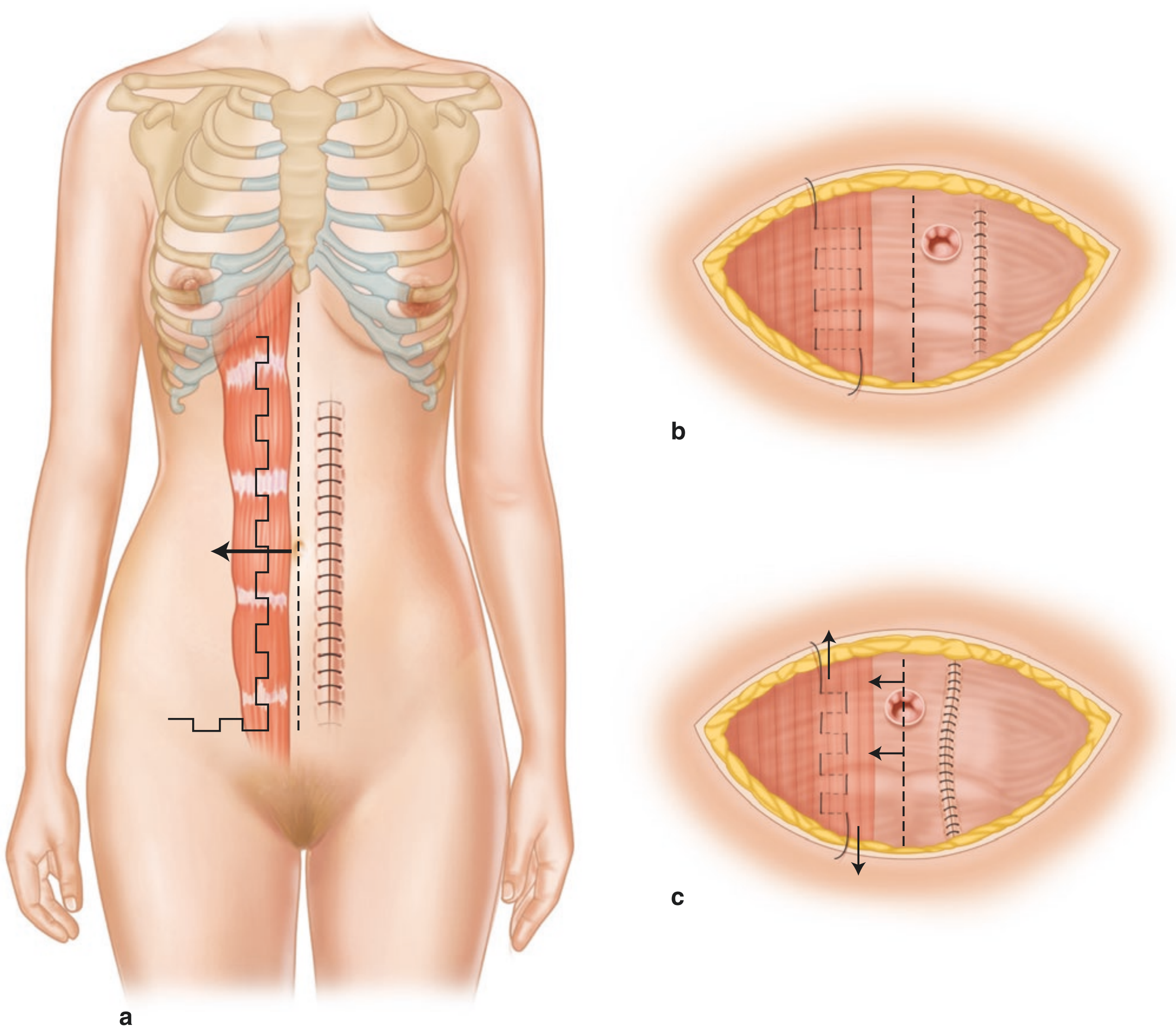


Fig. 6.28 (**a–c**) Left pedicled TRAM with suture on the right rectus sheath in order to centralize the umbilicus

It is possible to create the future opening for the neo-umbilicus along the median line and to use the reach of the umbilicus to assist accurate positioning.

The cutaneous flaps are closed under tension after raising the patient to the sitting position. Double drain placement is recommended. Upon completion of closure, the color of the flap should be checked to verify the quality of blood supply. If there is any doubt, it is necessary to sit the patient up a little more and remove the area.

Healing of the skin and subcutaneous tissues in the lower abdomen is enhanced with a knowledge of the vascular perforators supplying this area and ensuring their maintenance after surgery. Preoperatively, the abdominal subcutaneous tissue is perfused by perforators in Zone 1 (epigastric perforators from the rectus abdominis), Zone 2 (suprapubic perforators), and Zone 3 (lateral intercostal perforators) (Fig. 6.29). After a TRAM flap reconstruction, the area at greatest risk for vascular depletion is the skin and subcutaneous tissue above the incision. Postoperatively, this area is perfused by Zone 3. Thus, during abdominal closure, this area should undergo minimal undermining in order to maintain these perforators and maximize healing potential.

6.11.3 Free Flaps for Autologous Breast Reconstruction

(a) Transverse Rectus Abdominis Myocutaneous (TRAM) Free flap

TRAM free flaps require the use of microsurgical procedures. In the classic TRAM free flap, a full width of rectus muscle together with the subcutaneous tissue

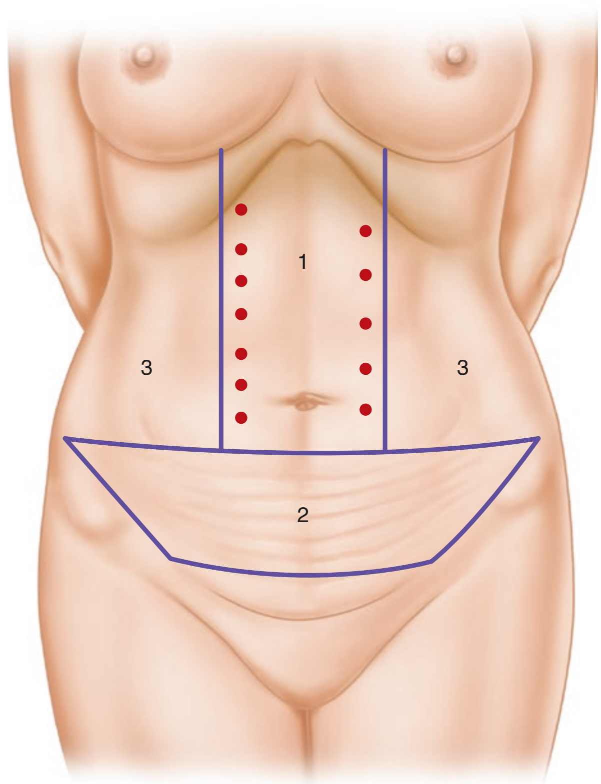


Fig. 6.29 The zones of abdominal subcutaneous tissue and skin perfusion

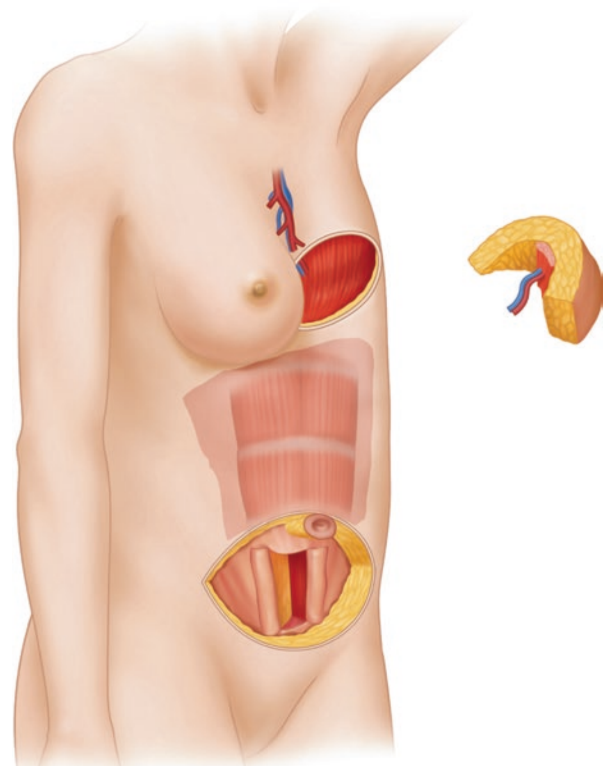


Fig. 6.30 A free TRAM flap, after harvest, prior to vascular anastomosis in the chest. The abdominal donor site shows the skin and muscle that are removed as part of the flap

and skin paddle is removed at the level of the inferior epigastric vessels. The inferior epigastric vessels are freed of surrounding tissue and prepared for microvascular anastomosis (Fig. 6.30). It is the anastomosis in the chest between the inferior epigastric vessels and either the internal mammary or thoracodorsal vessels that allows the TRAM flap to survive. After harvesting of the flap, the abdominal donor site on the side of vessel harvest lacks a full width of rectus muscle (Fig. 6.31).

(b) Deep Inferior Epigastric Perforator (DIEP) Flap

The DIEP flap removes the same skin and subcutaneous abdominal tissue island as a TRAM flap. However, the DIEP flap spares the entire donor site rectus abdominis muscle. This is made possible by dissecting the specific perforators from the epigastric vessels, as they pass through the muscle, and leaving the muscle itself intact within the anterior abdominal wall (Fig. 6.32). In this way, the flap remains well perfused but is supplied by individual perforators that have been dissected free from the muscle (Figs. 6.33 and 6.34). This allows the patient to maintain intact abdominal core anatomy and strength without functional compromise (Fig. 6.35).

(c) Transverse Upper Gracilis (TUG) Flap

A secondary option for the flap donor site in autologous breast reconstruction is the medial thigh fat. This fat can be

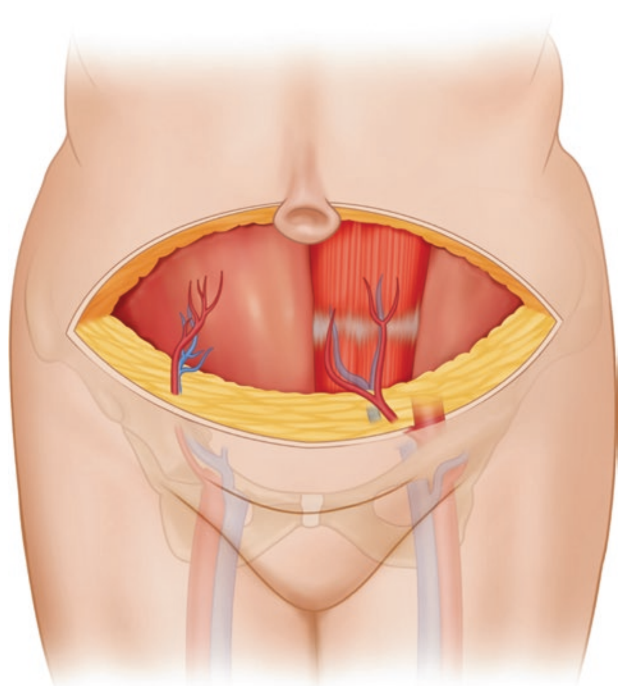


Fig. 6.31 Abdominal donor site after harvest of a right TRAM flap. On the right hemi-abdomen, the side of the inferior epigastric vessel harvest, there is a full width removal of a strip of rectus abdominis muscle

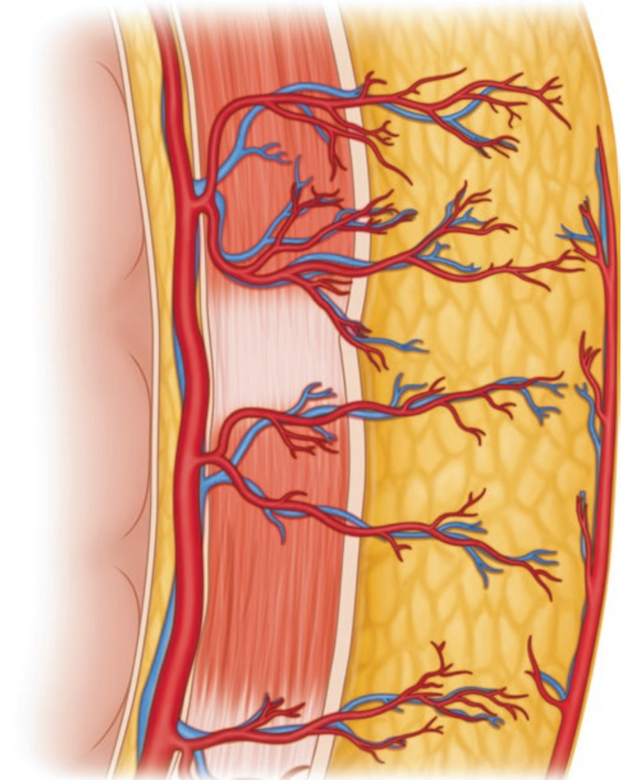


Fig. 6.32 Cross-sectional view of vascular perforators coming from the deep inferior epigastric vessels, through the rectus abdominis muscle, to the overlying lower abdominal skin and fat of the DIEP flap. With DIEP dissection, these individual perforators are dissected free from the muscle, thus preserving all the muscle on the abdominal wall, and not harvesting it with the flap

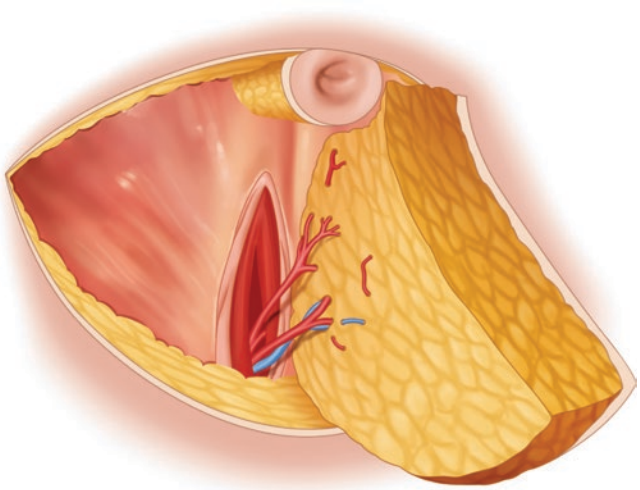


Fig. 6.33 Completed dissection of DIEP flap on the abdomen. Vascular perforators have been dissected through the preserved rectus muscle

harvested together with the underlying gracilis muscle and its blood supply (medial circumflex femoral artery and vein) as a free flap for breast reconstruction (Fig. 6.36).

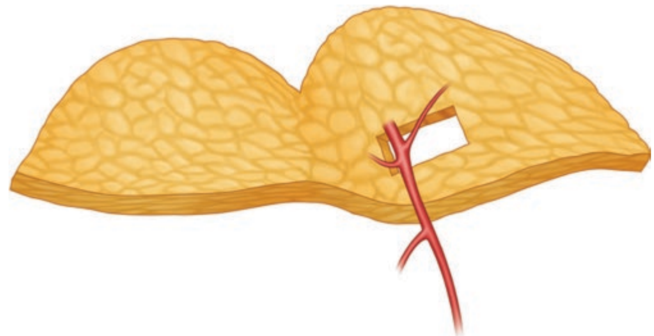


Fig. 6.34 Completely dissected DIEP flap, following removal from the abdomen, prior to microvascular anastomosis on the chest. Note that no abdominal muscle has been taken as part of this flap

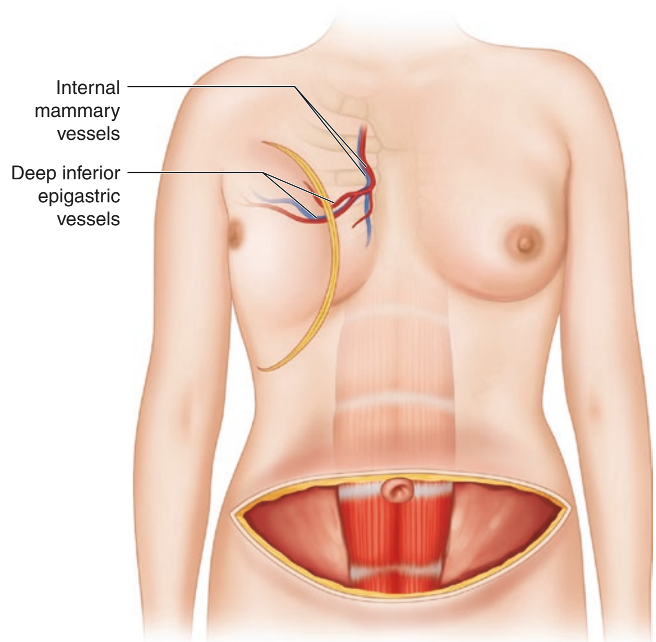


Fig. 6.35 Completed anastomosis of DIEP flap, showing revascularized flap on chest, and condition of abdominal donor site, with full muscle preservation

(d) Supper Gluteal Artery Perforator (SGAP) and Inferior Gluteal Artery Perforator (IGAP) Flap

Another option for the flap donor site is the gluteal subcutaneous tissue and skin. This autologous tissue can be harvested on vascular perforators from either the superior gluteal artery and vein (SGAP free flap) or inferior gluteal artery and vein (IGAP free flap) (Fig. 6.37).

6.12 Nipple Reconstruction

The creation of a nipple–areola complex following breast reconstruction improves cosmetic outcome and many patients request such a procedure. The most popular tech-

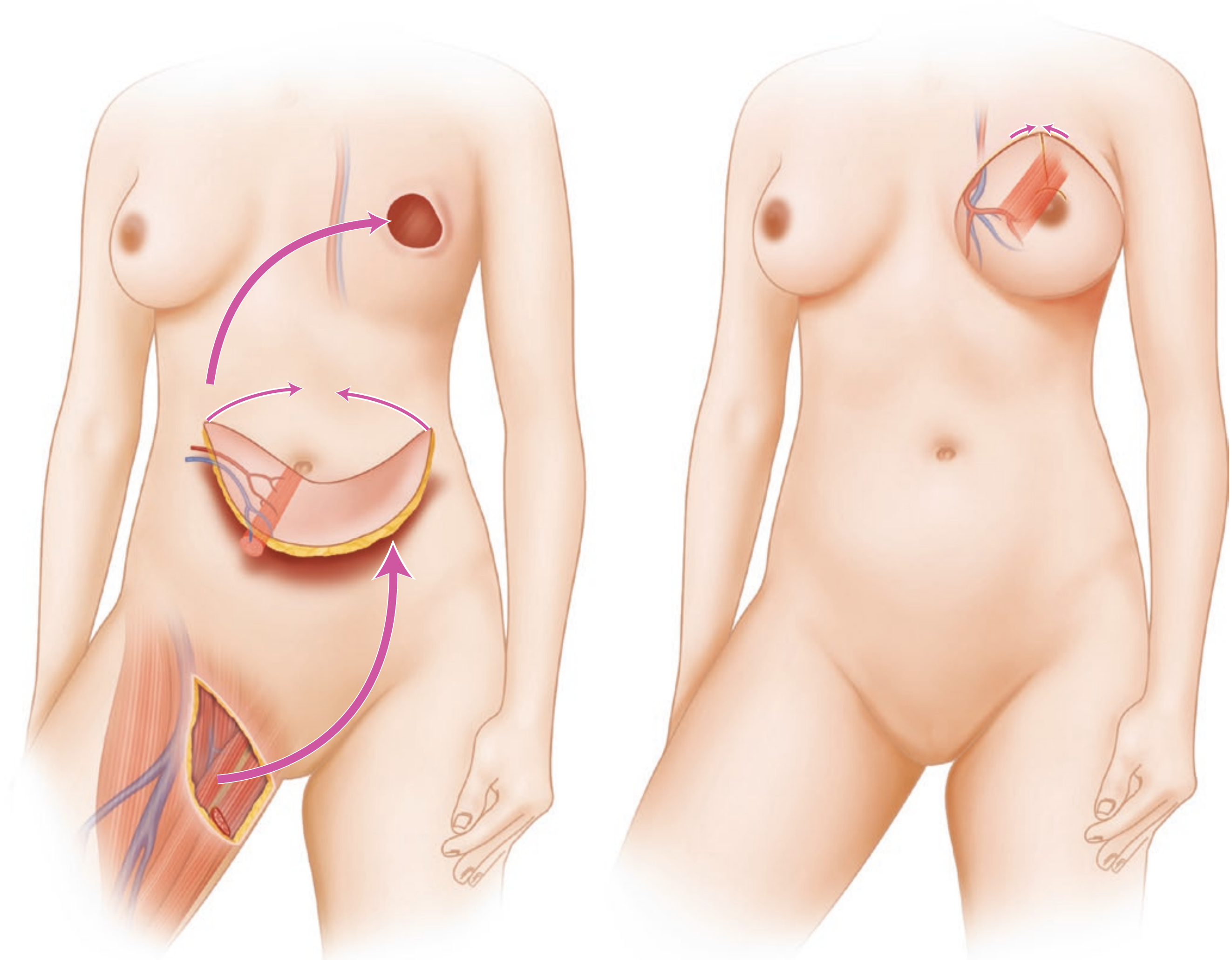


Fig. 6.36 Harvest of a right TUG free flap for left breast reconstruction after mastectomy

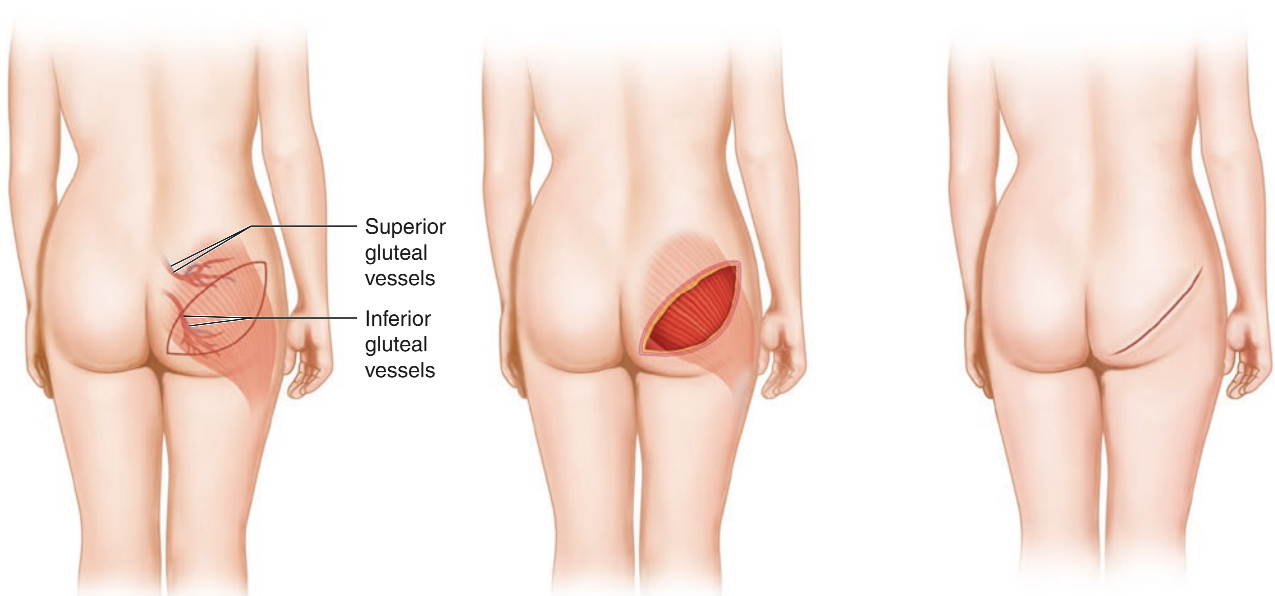


Fig. 6.37 Harvest of a right SGAP free flap for breast reconstruction after mastectomy

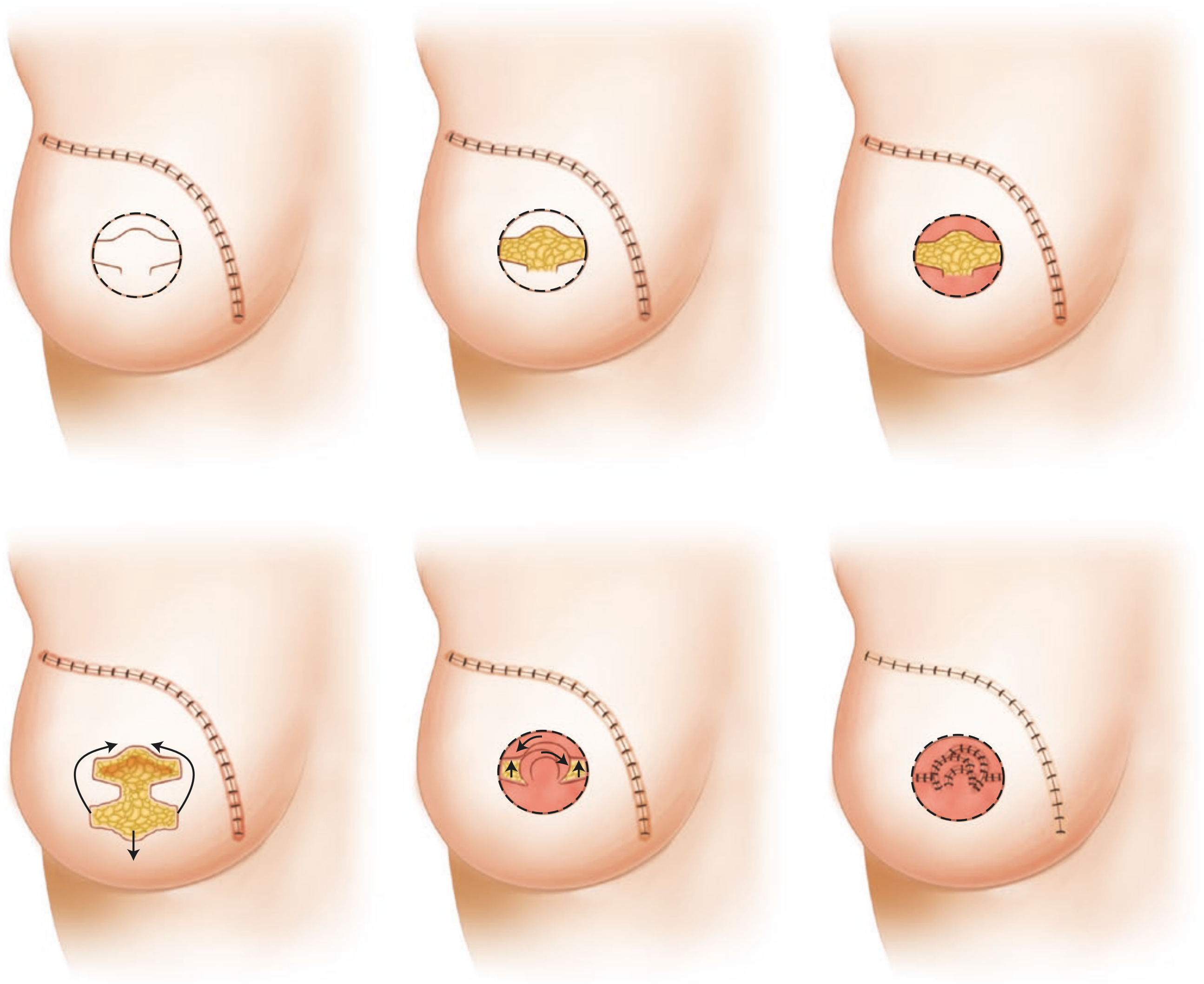


Fig. 6.38 Nipple–areola reconstruction (color of the areola and the nipple is obtained by tattooing the surface of the circle)

nique for nipple reconstruction combines a tattoo procedure with a small triangular skin flap that is often referred to as a skate flap, illustrated in Fig. 6.38. The location of the areolar should be drawn preoperatively with the patient in the standing position to check for bilateral symmetry of the nipple–areola complex. The nipple–areola reconstruction is generally performed as a second-stage procedure under local anesthesia. The tattooing should be done prior to reconstructing the nipple. A skin flap is then developed and folded on itself and sutured with 4–0 absorbable sutures, as shown in the accompanying illustrations. The angle of the skin flap should be oriented appropriately if it is in the vicinity of the previous mastectomy scar (Fig. 6.39).

For those patients who require enhanced projection of the reconstructed nipple, there is the potential for placement of inserts within these reconstructions. The most commonly used nipple inserts consist of silicone blocks or small pieces of ADM. This can be useful to obtain long-term projection but is accompanied by risk of extrusion and subsequent skin breakdown.

There is an option of three-dimensional (3D) tattooing for those women undergoing skin-sparing mastectomy who do not wish to undergo a separate surgical procedure for nipple reconstruction. This can be performed on an outpatient basis as a non-surgical procedure and can yield long-lasting results with a realistic appearance of the nipple and areola (matched for color before mastectomy).

6.13 Oncoplastic (Post-lumpectomy) Breast Reconstruction

While post-mastectomy whole breast reconstruction remains the most commonly performed oncologic reconstruction, increasing use of oncoplastic techniques alongside partial mastectomy (breast conservation surgery) procedures has

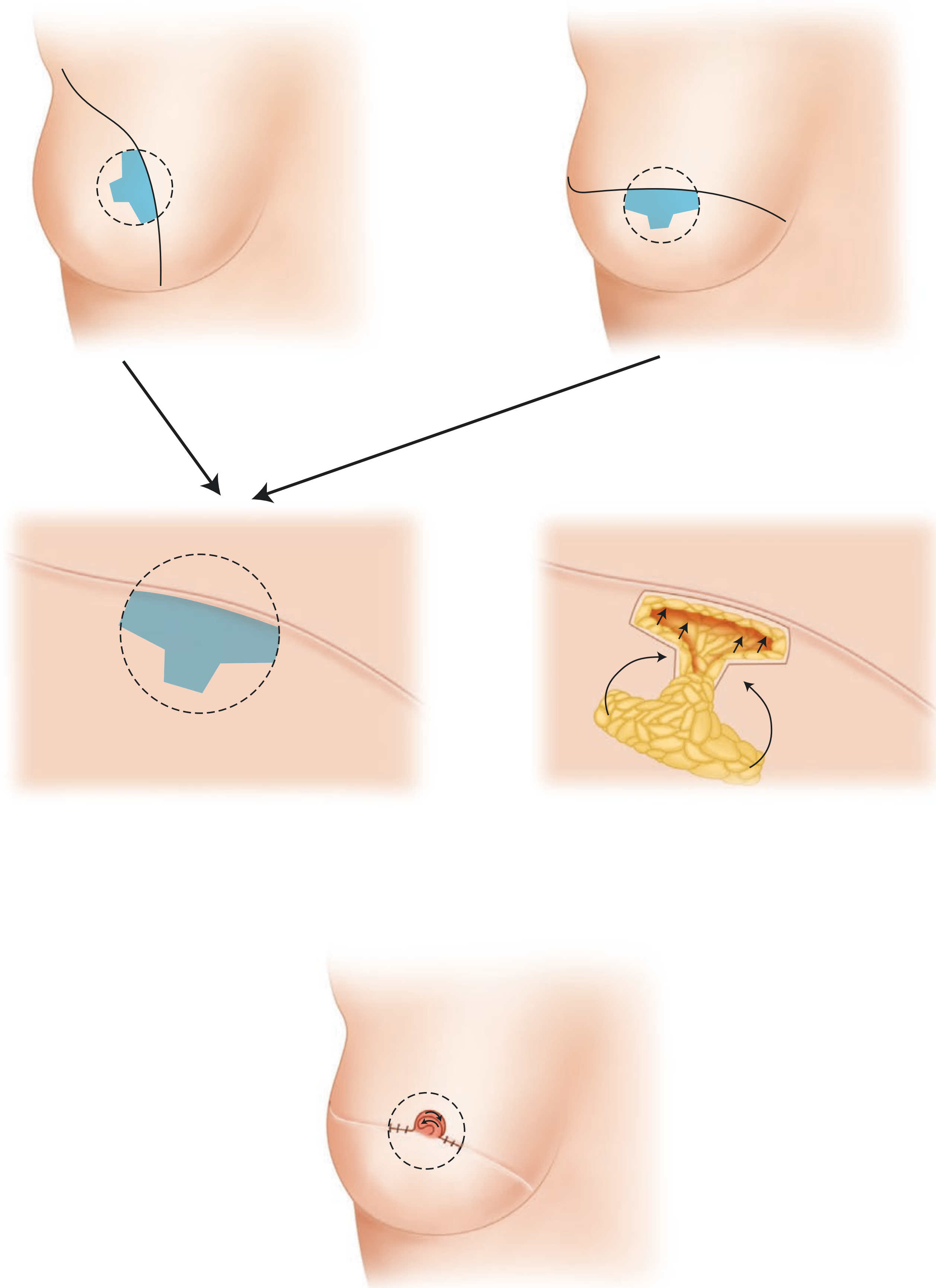


Fig. 6.39 Nipple–areola reconstruction in the vicinity of the previous mastectomy scar

been notable in recent years. This is due to the severity of lumpectomy breast defects and a desire to avoid them by undertaking partial breast reconstruction. As such, two oncoplastic techniques are now commonly employed at the time of partial mastectomy: local tissue rearrangement and oncoplastic reduction mammoplasty.

The aim is to perform these reconstructive techniques at the time of oncologic tissue resection as a preventative technique; once these defects have become apparent in the breast, they are very challenging to repair and reconstruct secondarily (especially when patients proceed to radiation therapy). When techniques for oncoplastic reconstruction are compared in terms of morbidity, those performed prior to radiation therapy are associated with significantly fewer complications compared to post-irradiation procedures.

Local tissue rearrangement tends to be performed in those patients with smaller breasts and tumor size with minimal preoperative ptosis. Following excision of breast tissue, the remaining healthy surrounding breast parenchyma is mobilized as vascularized flaps and advanced for insetting into the lumpectomy cavity. This obliterates any potential dead space and reduces the likelihood of long-term contour deformities as well as seroma formation and infection.

Oncoplastic breast reduction (mammoplasty) is performed on patients with larger preoperative breast size (C to D cup) who have grade 2 or 3 ptosis. This procedure necessitates a large skin resection and is performed on both breasts (including the non-cancerous contralateral breast) to maintain postoperative symmetry. This operation involves a standard breast reduction using either a wise or vertical pattern technique. The nipple pedicle can be placed at any site (depending on tumor location) such that this tissue is safely preserved. This technique has great versatility and allows for planning a lumpectomy as part of a standard breast reduction with removal of the affected breast quadrant. The final result is an aesthetically favorable breast mound with correction of ptosis and avoidance of any contour deformities.

For many patients, preoperative tumor size may be excessively large for breast conservation. However, neoadjuvant chemotherapy can be employed to shrink the tumor and convert patients from requiring mastectomy to being candidates for oncologically safe breast conservation. Furthermore, even when postoperative adjuvant radiation therapy is required, this option can result in lower complication rates compared to mastectomy with whole breast reconstruction followed by PMRT.

Thus, oncoplastic reduction mammoplasty allows for conservation of the breasts with improved aesthetic outcome together with potential reduction in postoperative complication rates. Similarly, this option can be advantageous in the setting of axillary lymph node dissection where mastectomy and whole breast reconstruction is reported to be associated with higher complication rates, especially infection.

6.14 Thoracoepigastric Cutaneous Flap for Partial Breast Reconstruction

In some cases of quadrantectomy and breast conservation, the size of the breast resection defect is unsuitable for either local tissue rearrangement or oncoplastic breast reduction which would otherwise leave an unacceptable result. In such cases, a volume replacement technique must be used which will restore the excised breast tissue and offer a similar breast size and shape as the preoperative state (rather than a complete reshaping of the breast).

As previously discussed in this chapter, a common option for partial breast reconstruction remains the latissimus dorsi (LD) myocutaneous flap. This flap allows for large amounts of subcutaneous tissue and skin to be harvested from the back, and this makes it ideal for inferior (lower pole) and inferolateral defects following breast conservation.

Two other options which are gaining in popularity for partial breast reconstruction are the thoracodorsal artery perforator (TDAP) flap and the lateral intercostal artery perforator (LICAP) flap. These chest wall perforator flaps have the advantage of a more acceptable donor site defects compared with the LD flap but can be associated with relatively long scars.

The TDAP flap involves harvest of a skin and subcutaneous tissue island similar to the LD flap but without the latissimus muscle. This fasciocutaneous island is perfused by the descending branch of the thoracodorsal artery, and the transverse area of soft tissue can reliably cover an area of 20×10 cm based on the vascular pedicle.

The LICAP flap is often used in women who lack availability of abdominal or latissimus donor sites for autologous tissue. In this case, excess lateral chest wall tissue which creates a subcutaneous fold in many women can be used as a vascularized fasciocutaneous flap for partial breast reconstruction. Anatomic studies have shown that there are typically between 2 and 5 lateral intercostal perforators present within 6–8 cm of the mid-axillary line. A single perforator with a diameter of at least 5 mm can supply the entire lateral skin and subcutaneous tissue island. This tissue can then be rotated 180 degrees from the back to the anterior chest and thereby used to reconstruct partial breast defects.

6.15 Reduction Mammoplasty

Breast which are heavy and pendulous are a source of chronic pain and discomfort for many women. Although some may request reduction mammoplasty to relieve pain and discomfort, many women also have an expectation that the procedure will improve their appearance.

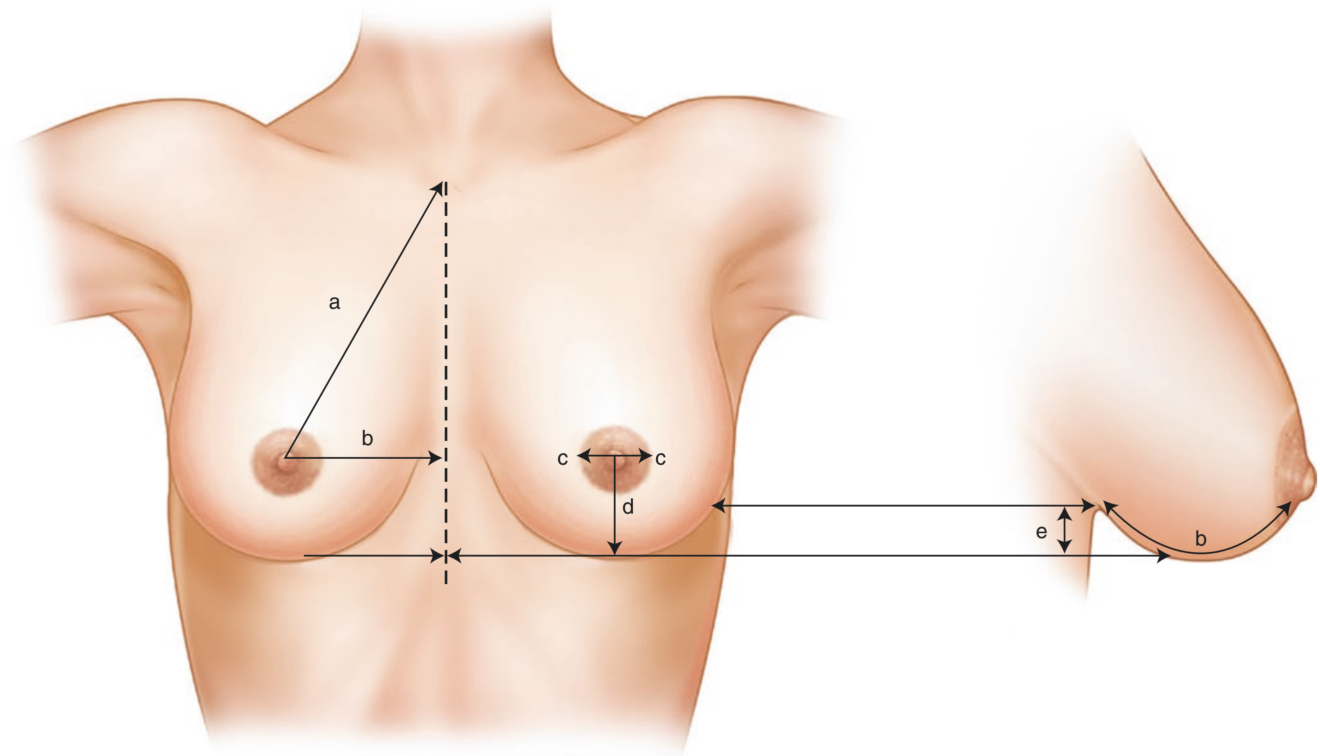


Fig. 6.40 Measurements required prior to reduction mammoplasty. a = 19–21 cm; b = 9–11 cm; c = 4–5 cm; d = 5–8 cm; e = 0–2 cm

Prior to undertaking breast reduction mammoplasty the surgeon should document several useful measurements that are indicated in Fig. 6.40.

Additionally, the breasts should be marked with the patient in the standing position and clearly indicate the planned incision pattern as depicted in the accompanying illustration (Fig. 6.41).

Reduction mammoplasty can be performed using a vertical technique where a superior pedicle is left intact to provide a blood supply to the nipple–areola complex (Fig. 6.42a). Alternatively, the procedure can be performed with an inferior pedicle which provides sufficient blood supply to the nipple–areola complex (Fig. 6.42b).

Both the superior pedicle technique and the inferior pedicle technique are illustrated in Fig. 6.42. Specifically, these drawings depict the contours of the breast tissue specimen that is obtained after using the superior pedicle and inferior pedicle techniques respectively for reduction mammoplasty (Fig. 6.42c, d).

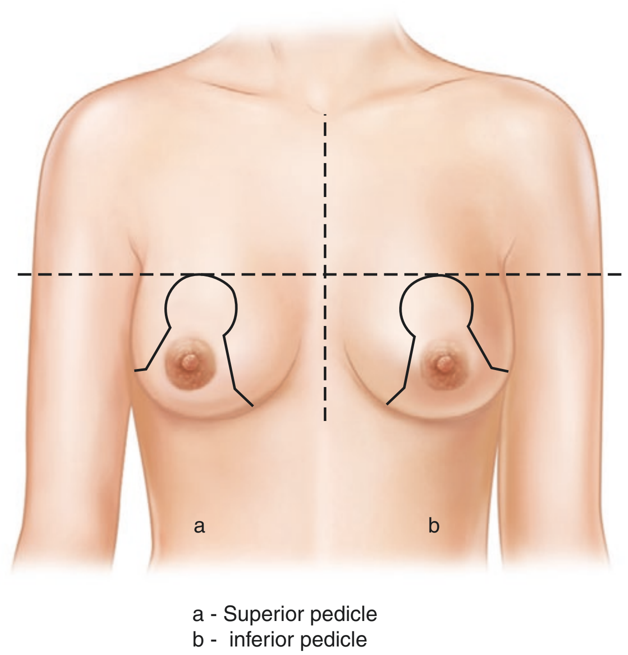


Fig. 6.41 Reduction mammoplasty

6.16 Reduction Mammoplasty: Vertical Technique (Lejour)

Figure 6.43 depicts a surgeon's preoperative markup for a reduction mammoplasty utilizing the vertical scar technique (Lejour). The drawing shows the limit of the supra-areolar de-epithelialization (1, in Fig. 6.43a), the medial limit of infra-areolar de-epithelialization (2, in Fig. 6.43a), the lateral

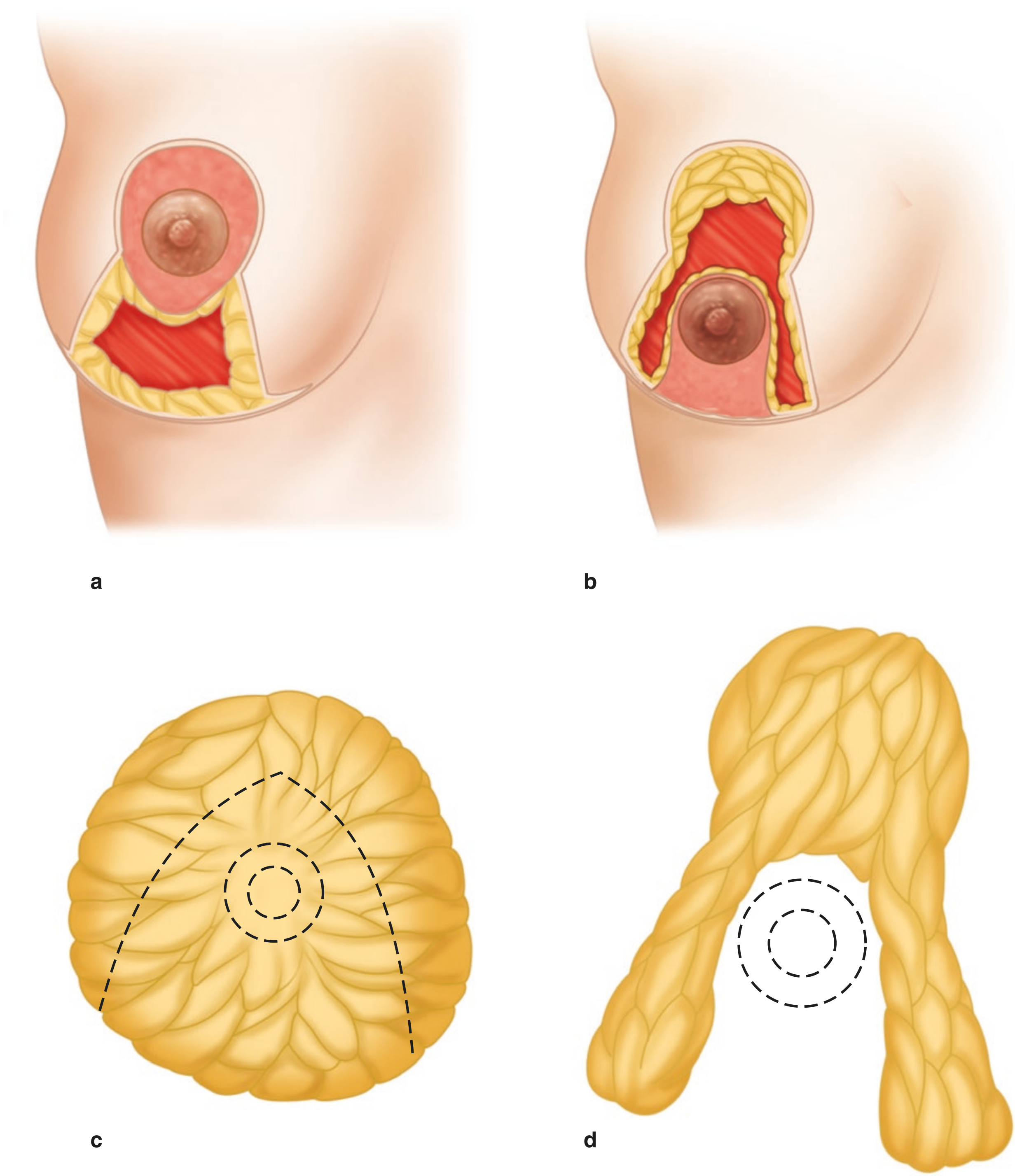


Fig. 6.42 (**a-d**) Reduction mammoplasty

limit of infra-areolar de-epithelialization (3, in Fig. 6.43b), and the inferior aspect of the resection (4, in Fig. 6.43c).

The accompanying illustrations briefly summarize the key features of the reduction mammoplasty utilizing the vertical technique (Lejour). A margin of tissue around the nipple–areola complex is de-epithelialized (1, in Fig. 6.43a). The surgeon then undermines a wide area of tissue anterior to the serratus anterior and pectoralis major muscles. Breast tissue in the inferior quadrant is then resected (Fig. 6.44) followed by re-apposition of glandular tissue with absorbable

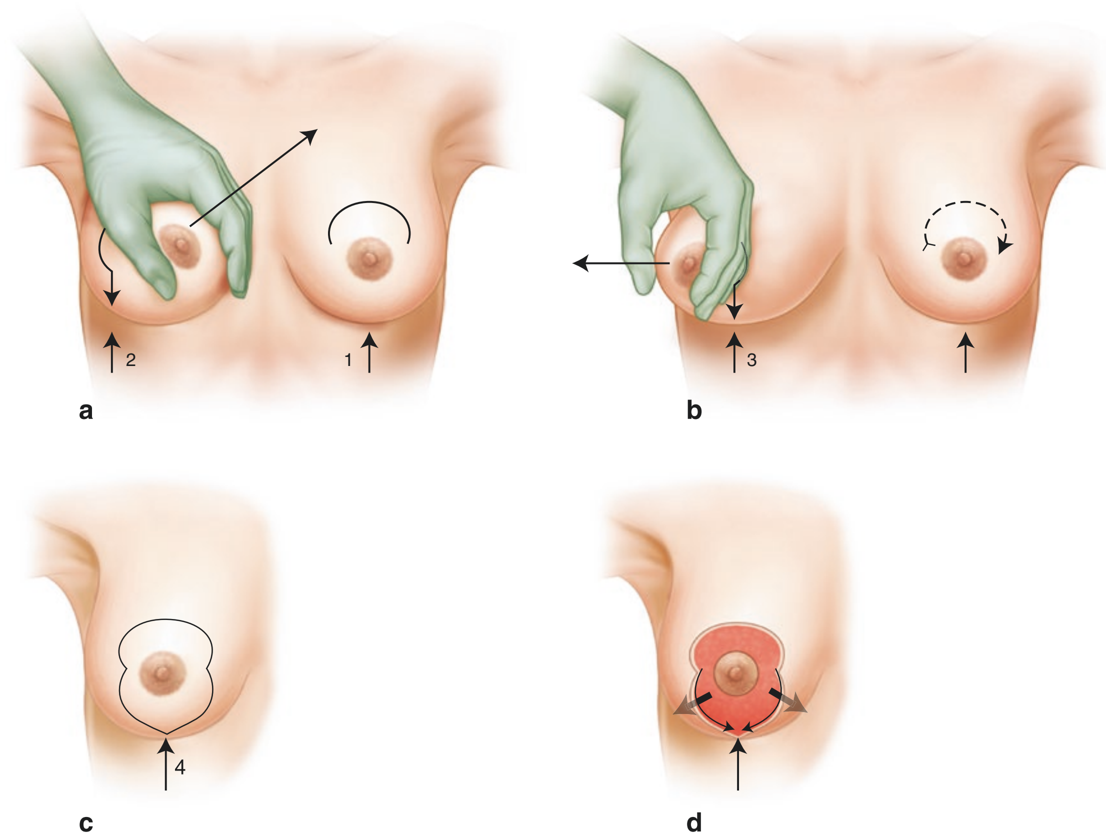


Fig. 6.43 (**a–d**) Reduction mammoplasty; vertical scar technique (Lejour)

stitches (Fig. 6.45). The skin edges are re-approximated with interrupted 3–0 monocryl stitches (Fig. 6.45) which includes the de-epithelialized tissue around the nipple–areola complex and closure of the inferior vertical incision.

Further key aspects of the reduction mammoplasty using the vertical technique (Lejour) are depicted in Fig. 6.43. Seen here is the appearance of the breast after de-epithelialization with a section of the glandular tissue shown inferiorly. The illustration above (Fig. 6.42 a, b) depicts the appearance of the breast tissue after glandular resection. The illustration below (Fig. 6.42c, d) depicts the appearance of the glandular tissue that has been resected and sent to the pathologist.

This illustration (Fig. 6.42a–d) further demonstrates the technique of wide retroglandular undermining anterior to the pectoralis major muscle. This undermining allows the surgeon to eventually restore the continuity of the gland after resection and also to bimanually palpate the breast to check for the presence of any tumors.

Seen in this illustration (Fig. 6.42a–d) is the appearance of the breast after peri-areolar and inferior de-epithelialization, with undermining of the lower glandular tissue.

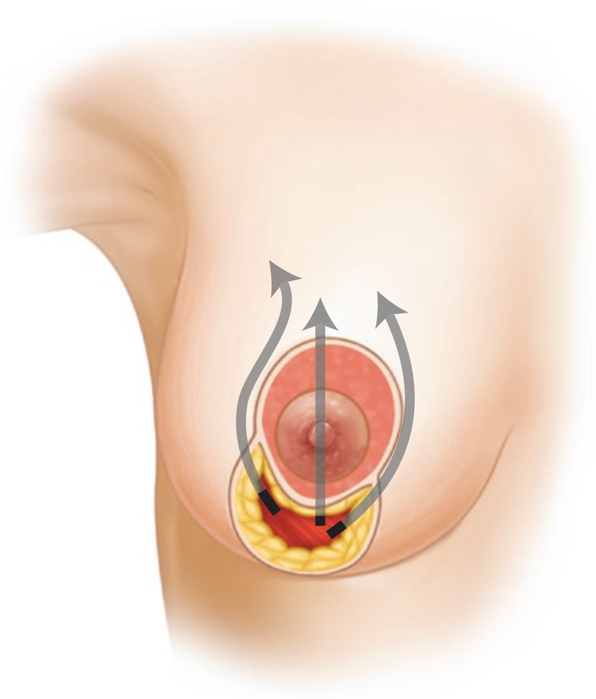


Fig. 6.44 Reduction mammoplasty; vertical scar technique (Lejour)

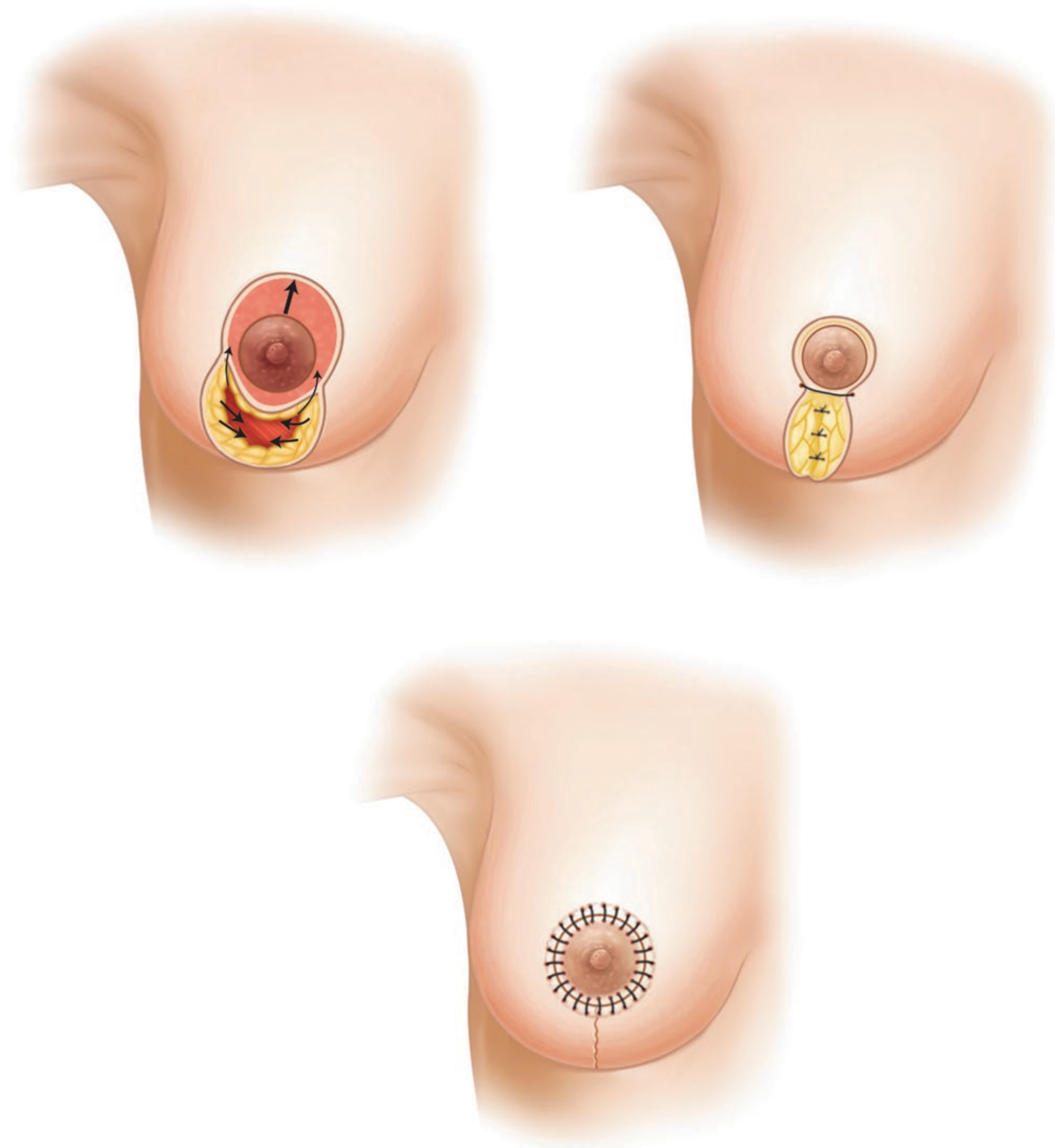


Fig. 6.45 Reduction mammoplasty; vertical scar technique (Lejour)

6.17 Reduction Mammoplasty: Inferior Pedicle Technique

If the inferior pedicle technique of reduction mammoplasty is utilized, then the blood supply to the nipple–areola complex is derived from a pyramid of tissue along the inferior aspect of the breast.

The accompanying illustrations provide an overview of the technique. An inferior pedicle is de-epithelialized from the nipple–areola complex down to the inframammary fold (Fig. 6.46a). The surgeon then sharply divides tissue along the medial and lateral borders of this inferior pedicle and resects tissue medial and lateral to the pedicle (away from the pedicle), as shown in Fig. 6.46b, c. The glandular tissue

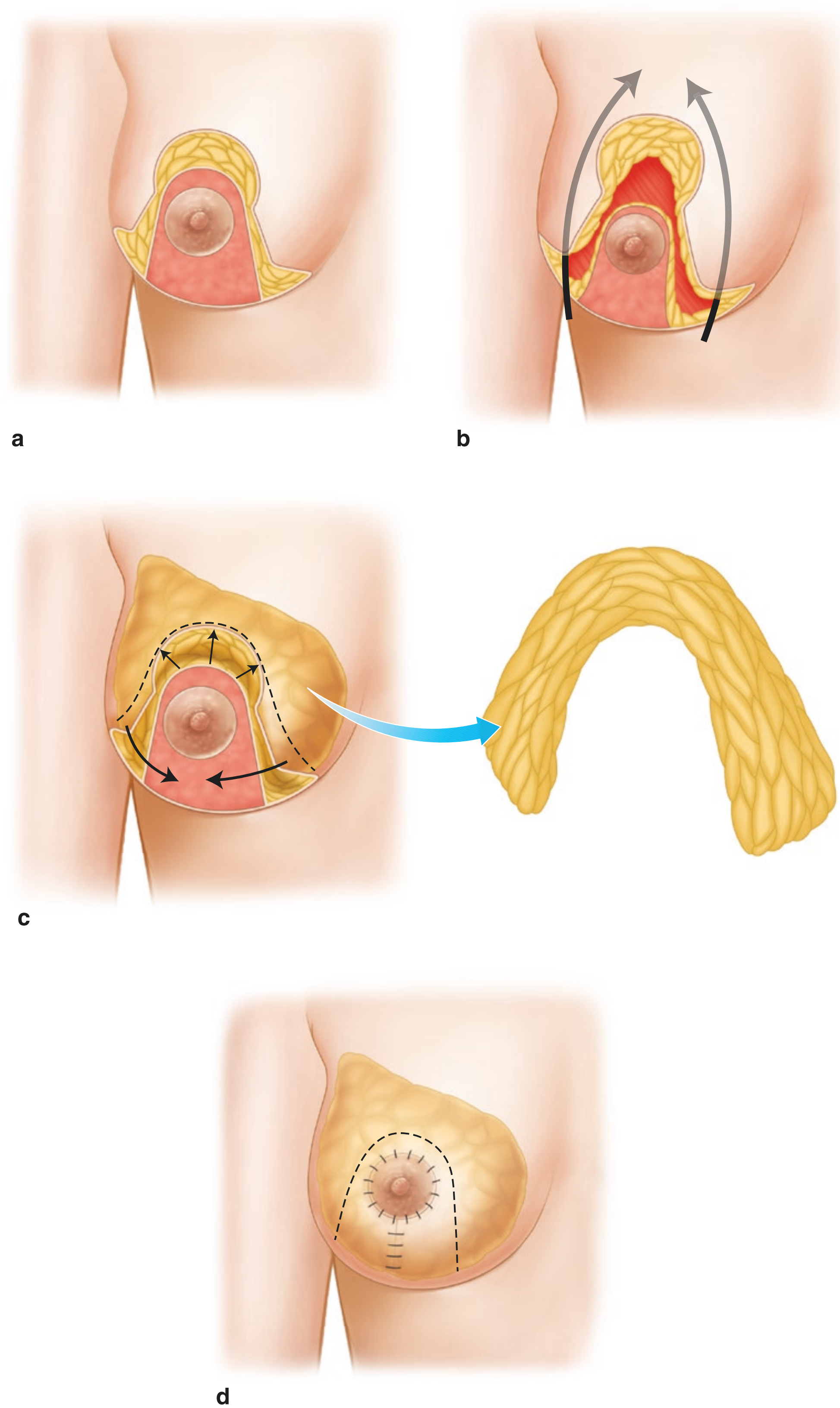


Fig. 6.46 (**a–d**) Reduction mammoplasty; inferior pedicle technique

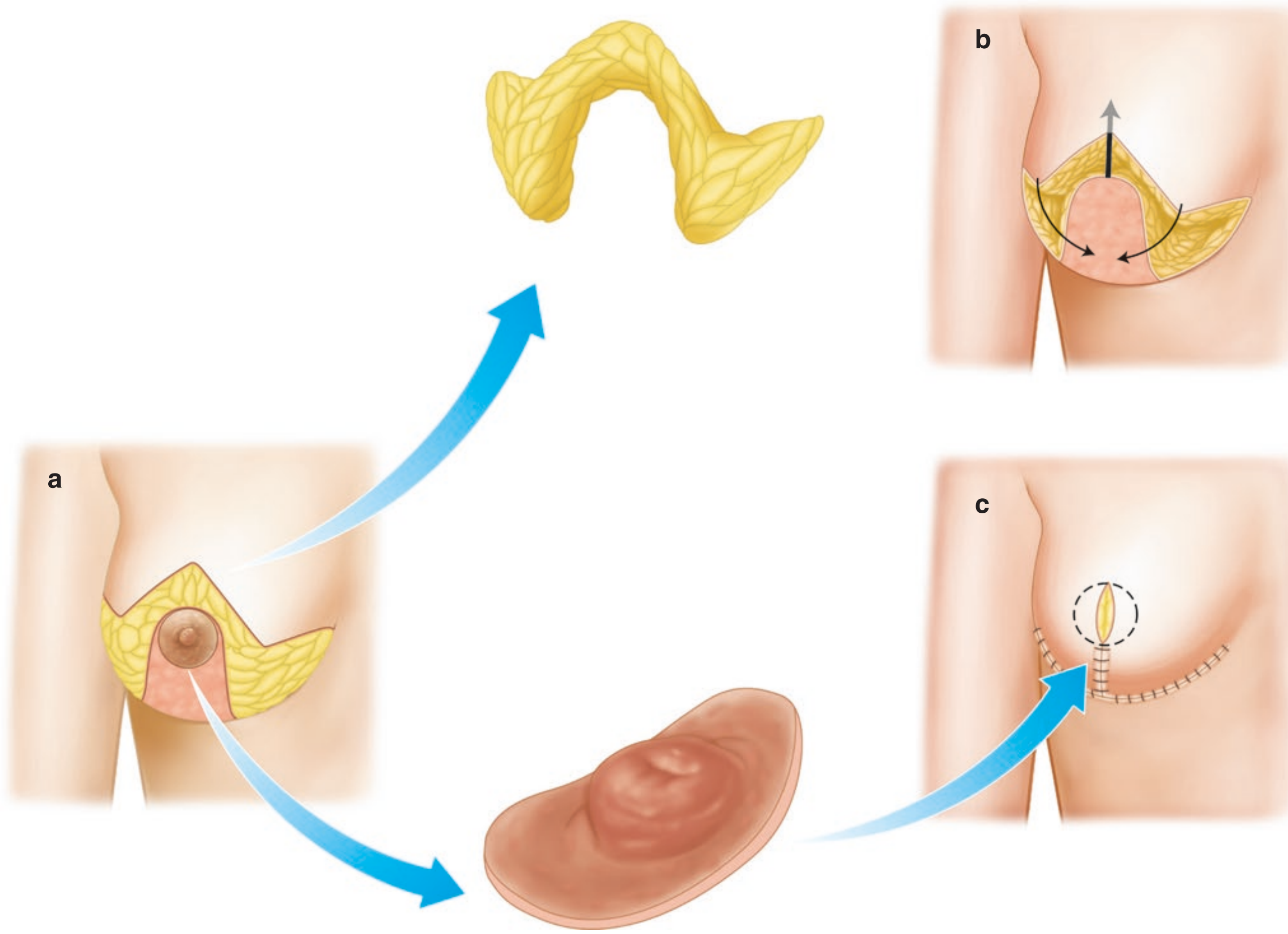


Fig. 6.47 (**a**–**c**) Reduction mammoplasty inferior pedicle technique with vertical and horizontal scar (Thorek)

is then re-approximated with absorbable sutures, and the medical and lateral flaps are advanced and closed along the inframammary fold (Fig. 6.46d).

The appearance of the resected breast specimen is also shown in the accompanying illustration (Fig. 6.46c).

Reduction mammoplasty utilizing the inferior pedicle technique is further illustrated in Fig. 6.47a–c, utilizing the Thorek technique. These illustrations depict the appearance of the vertical and horizontal scars utilized for the operation and again show the appearance of the accompanying breast specimen that is obtained following the resection (Fig. 6.47b). Also seen is the technique for amputation of the nipple–areola complex and subsequent grafting onto the glandular tissue after complete skin closure (Fig. 6.47c) (Thorek).

6.18 Round Block Technique of Reduction Mammoplasty

Figure 6.48 depicts the round block technique for reduction mammoplasty. As shown, a rim of tissue around the nipple–areola complex is de-epithelialized and tissue from the inferior quadrant of the breast is resected. The defect in the inferior quadrant of the breast is then re-approximated with absorbable interrupted sutures.

The de-epithelialized skin around the nipple–areola complex is re-approximated with a running 2–0 monocryl or a nonabsorbable subcuticular stitch. A second purse string suture is done with 4–0 monocryl to close the skin.

The appearance of the resected breast tissue is as shown (Fig. 6.48).

6.19 Breast Ptosis Classification

Breast ptosis is defined by the position of the nipple–areola complex relative to the inframammary crease. This classification scheme, developed by Regnault, is illustrated in the accompanying diagrams.

Under normal circumstances the entire breast, including the nipple–areola complex, lies above the level of the inframammary crease (Fig. 6.49a).

In a patient with minor ptosis, the nipple lies at the level of the inframammary crease (Fig. 6.49b).

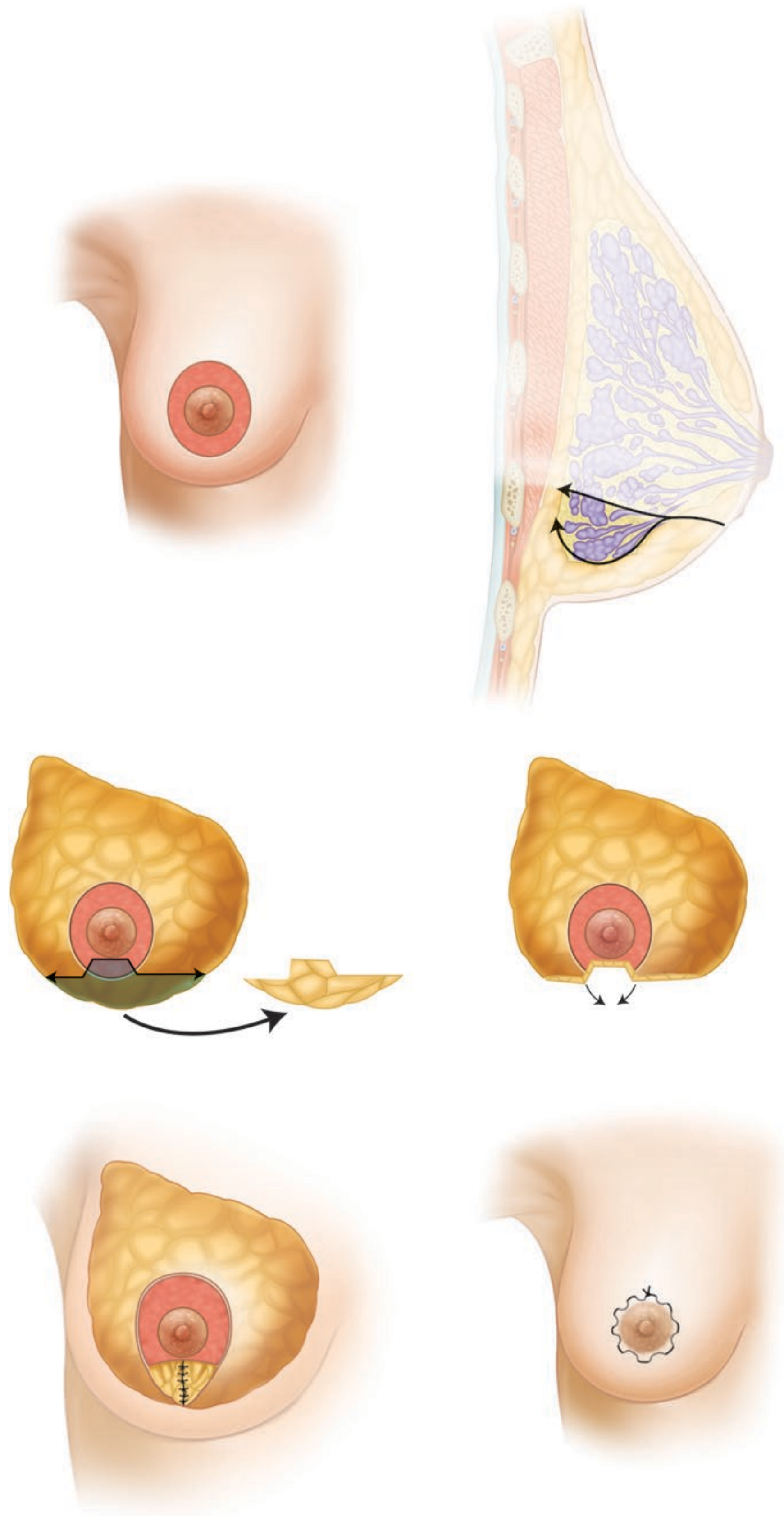


Fig. 6.48 Round block technique for reduction mammoplasty

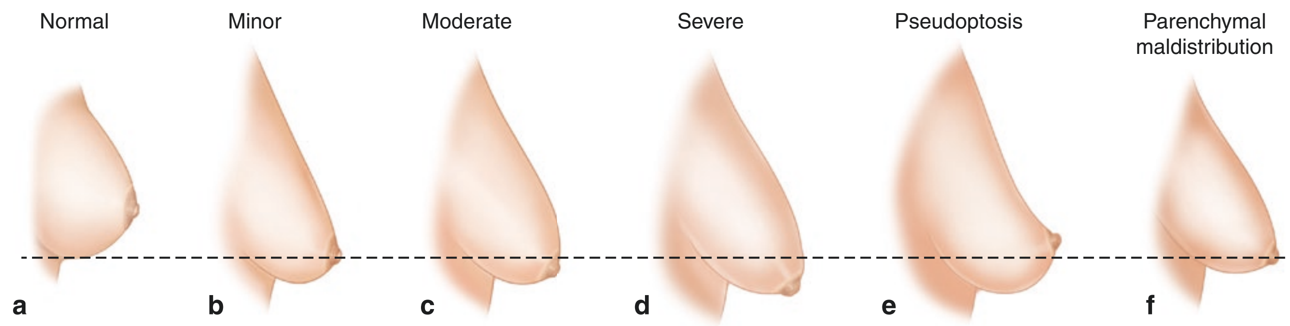


Fig. 6.49 (**a–f**) Breast ptosis classification

When the nipple lies below the level of the inframammary crease but remains above the lower contour of the breast gland, this is referred to as moderate ptosis (Fig. 6.49c). Finally, in a patient with severe ptosis, the nipple lies below the inframammary crease and along the lower contour of the breast (Fig. 6.49d).

When the nipple lies above the level of the inframammary crease but loose skin droops below the level of the crease, this is referred to as pseudoptosis (Fig. 6.49e).

The term parenchymal maldistribution refers to a situation where the nipple and the lower aspect of the breast droop below the inframammary crease as shown in the accompanying diagram (Fig. 6.49f).

6.20 Mastopexy

A mastopexy, otherwise known as a "breast lift," is indicated for correction of more severe forms of ptosis and is described later. When a patient presents with minor ptosis or pseudoptosis, an area cephalad to the nipple–areola complex is de-epithelialized thereby permitting advancement of the latter structure.

Patients who benefit most from mastopexy are generally those with moderate or severe ptosis. Several techniques are available that can correct these degrees of ptosis and are illustrated in the accompanying section.

Mastopexy sometimes involves deep fixation of the breast tissue to the underlying pectoralis major muscle. In this technique, planes of dissection are created both inferiorly and superiorly between the breast and skin. The superior dissection is extended posteriorly for a short distance to create a plane between the breast and pectoralis major muscle. A few stitches are then placed along the superior aspect to fix the breast to the underlying pectoralis major muscle. This serves to lift the breast and improves its projection.

This technique often produces a very good result in the immediate term, but the mastopexy is generally not stable, and long-term results tend not to be maintained.

In the following pages, other techniques for mastopexy are described and illustrated.

6.21 Round Block Technique for Mastopexy

Figures 6.50 and 6.51 illustrate the round block technique for mastopexy. Patients presenting with a significant degree of ptosis undergoes periareolar de-epithelialization (Fig. 6.50a). Following this initial maneuver, two options are available. Firstly, a single purse string suture can be inserted thereby bringing the edges of the de-epithelialized zone together (Fig. 6.50b, c). The surface of the breast adjacent to the nipple–areola complex will now appear flattened, giving the appearance of a "tomato shape breast" (Fig. 6.50d). This particular technique is useful for making small corrections to the breast.

Alternatively, the surgeon may elect to transpose a flap of glandular tissue from the lower quadrant to beneath the de-epithelialized periareolar area (Fig. 6.50e, f). The gland is essentially transected to obtain two glandular flaps that cross each other and be fixed to the pectoral fascia in order to reduce the diameter of the base and increase projection of the breast (Fig. 6.50g). The skin edges of the de-epithelialized area are approximated resulting in optimal projection of the breast as illustrated (Fig. 6.50h).

Figure 6.51 demonstrates use of dermal flaps (de-epithelialized skin) to fix the breast to the pectoralis major muscle in a manner somewhat like an internal bra that result in improved projection of the breast. As illustrated, the dermis is undermined, thereby creating a dermal flap which is brought down to the pectoralis major muscle with suturing of the dermal flap to the muscle (Fig. 6.51a, b).

Alternatively, when the dermal flap is relatively short, a semi-absorbable mesh can be used as championed by Goes. One end of the Vicryl mesh is sutured anteriorly to the dermal flap and the other end posteriorly to the pectoralis

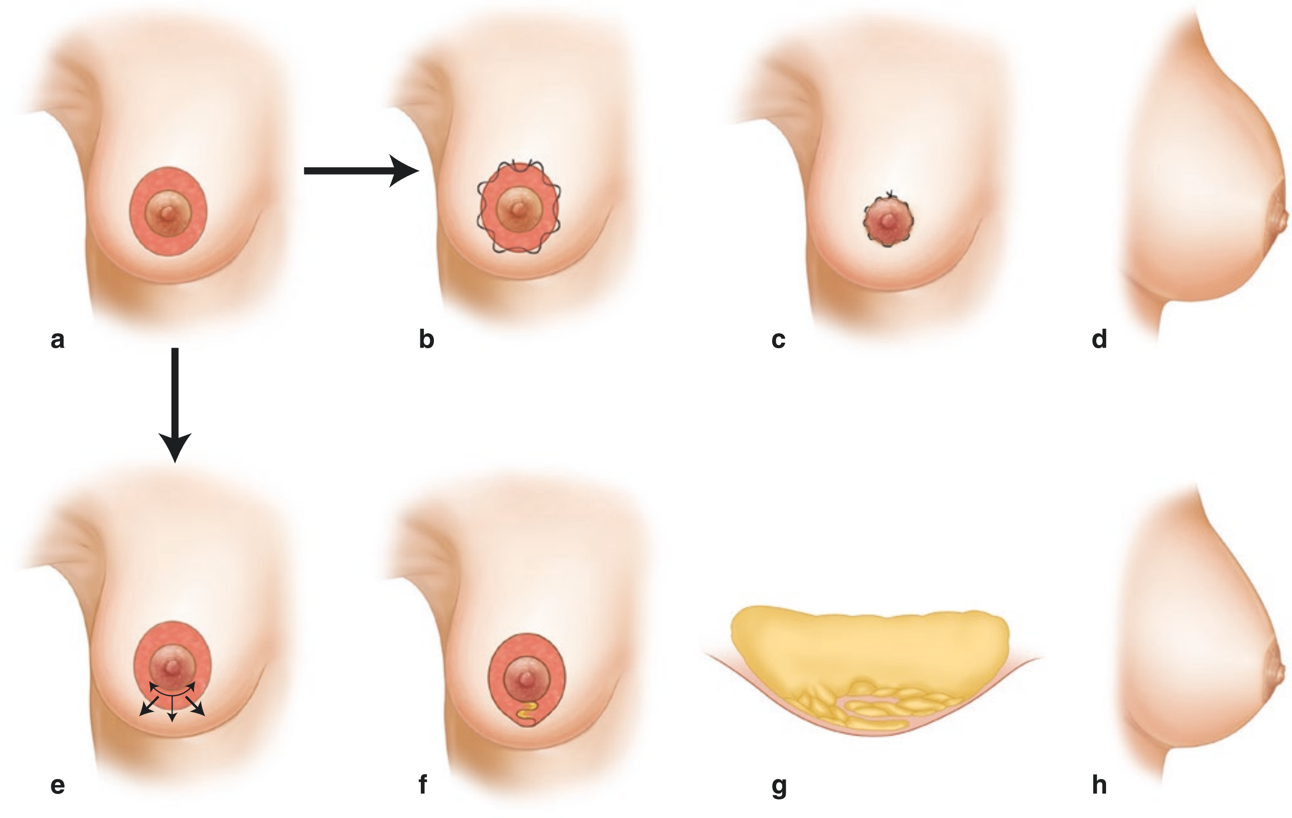


Fig. 6.50 (**a–h**) Round block technique for mastopexy

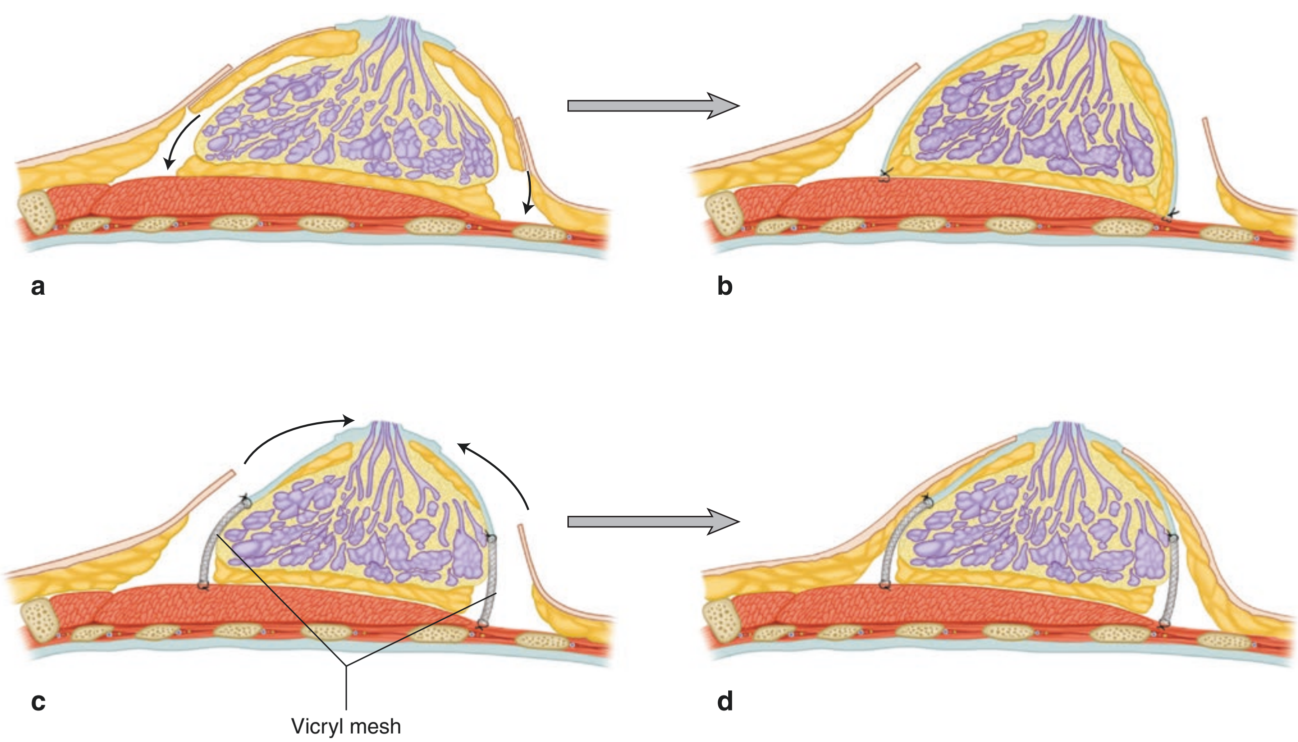


Fig. 6.51 Round block technique for mastopexy

major muscle (Fig. 6.51c, d). The skin edges are approximated with a 3–0 monocryl subcuticular stitch. The final suture lines are depicted in the accompanying illustration (Fig. 6.51c, d).

6.22 Mastopexy: Oblique Technique (DuFourmentel)

This technique involves de-epithelialization of a rim of tissue around the nipple–areola complex (Fig. 6.52). After de-epithelialization, a section of breast tissue is resected inferiorly, and the adjacent breast tissue is undermined. The defect in the breast is then closed with absorbable sutures, and the skin edges are approximated with a 3–0 monocryl subcuticular stitch. In addition, the de-epithelialized area around the nipple–areola complex is approximated with a running absorbable stitch.

6.23 Augmentation Mammoplasty

Augmentation mammoplasty is one of the most common cosmetic procedures performed by plastic surgeons. The procedure is popular among women of all ages, and the following illustrations provide a brief overview of the various procedures.

There are basically three surgical approaches to augmentation mammoplasty axillary, periareolar, and inframammary fold (Fig. 6.53a–c). As shown, these each allow the surgeon to create a plane between the breast and the anterior aspect of the pectoralis major muscle or, alternatively, between the posterior aspect of the muscle and the chest wall.

Figure 6.54 shows how the prosthesis for augmentation mammoplasty can be placed in either a submammary or subpectoral location. Varying degrees of subpectoral dissection can be performed within this range of anatomic implant location, based on the desired amount of nipple-areola complex (NAC) elevation with the final outcome (Fig. 6.55). The most common type of subpectoral augmentation involves inferior dis-insertion of the muscle off the 6th–8th ribs, thus creating a larger submuscular pocket for the implant. This is termed a type 1 dual-plane augmentation. With a type 2 dual-plane placement, the muscle is similarly dis-inserted off the ribs but is also separated from the breast parenchyma on its anterior surface, up to the level of the NAC. This permits a degree of NAC elevation in those cases where there is mild preoperative ptosis. For augmentation of breasts with moderate preoperative ptosis, a type 3 dual-plane augmentation can be performed. This involves more extensive separation of the muscle from the breast parenchyma along its anterior surface following inferior dis-insertion. This facilitates more pronounced elevation of the NAC with augmentation.

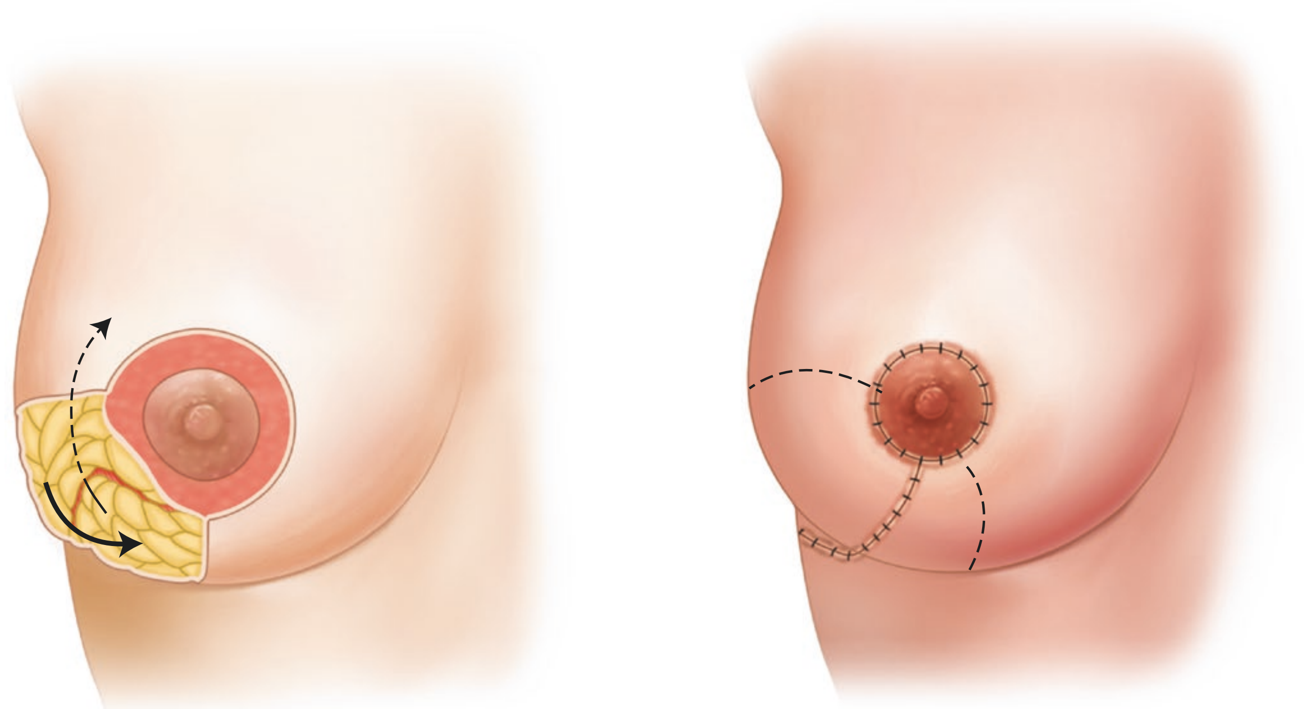


Fig. 6.52 Mastopexy; oblique technique (DuFourmentel)

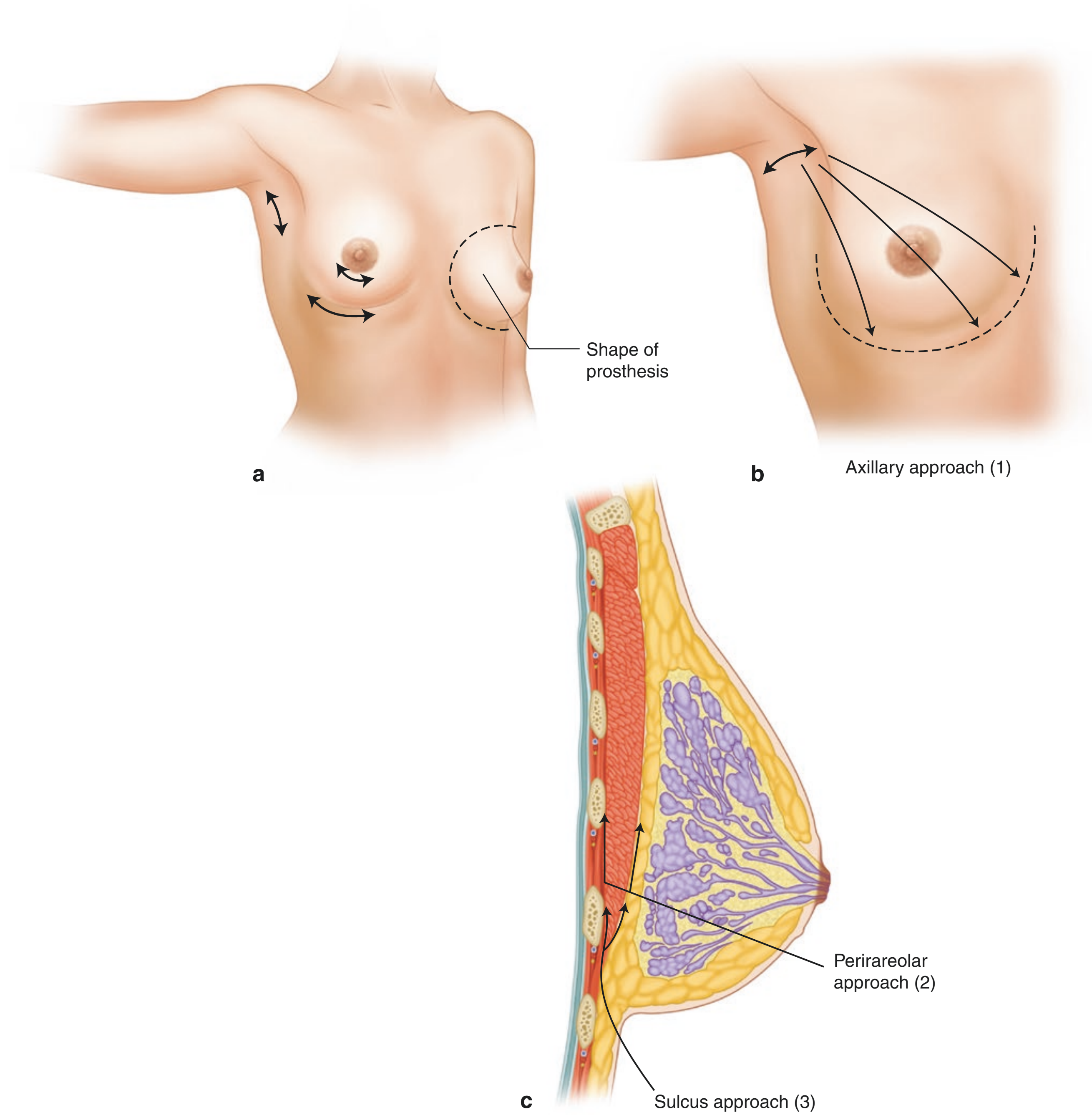
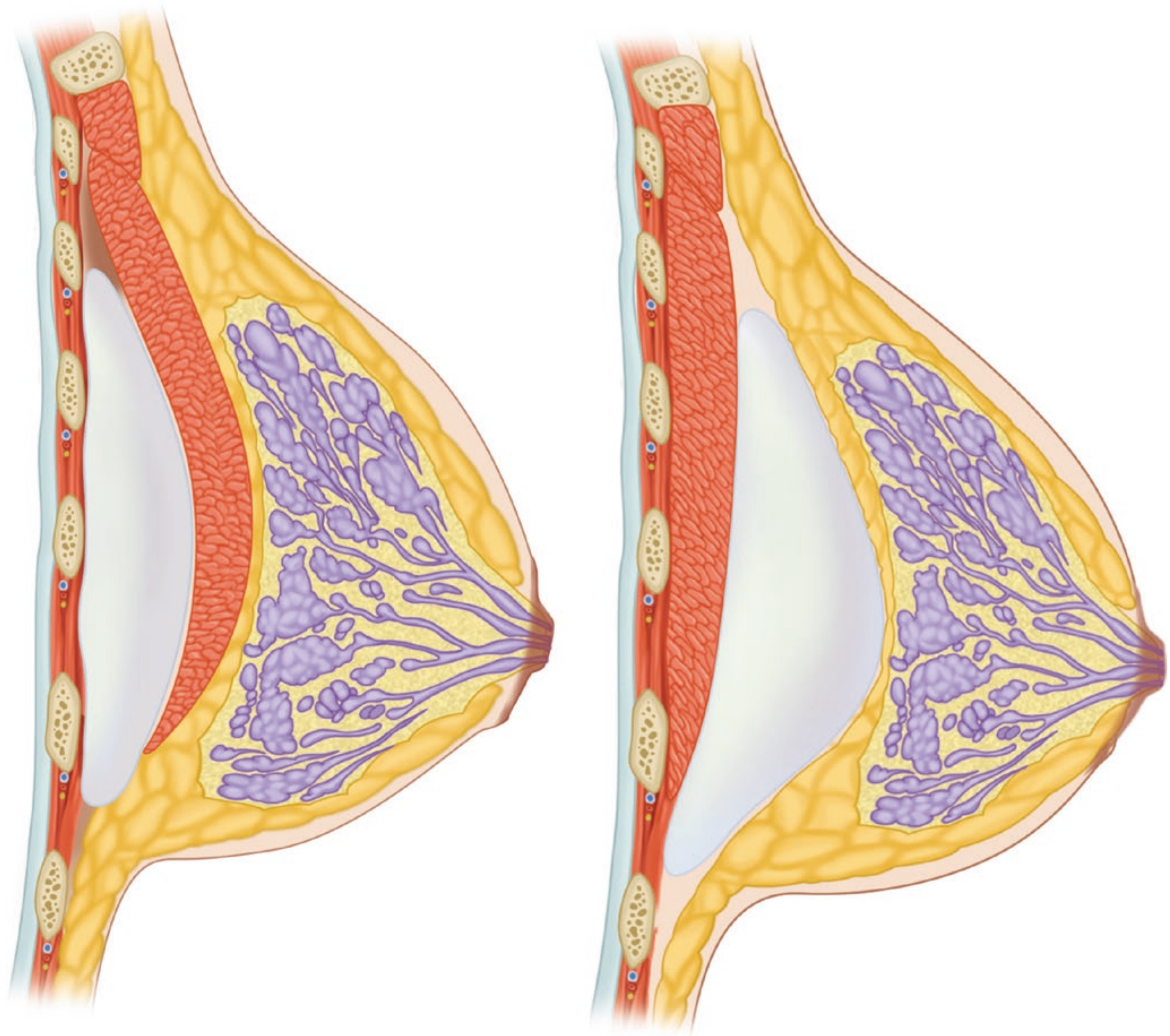


Fig. 6.53 (**a–c**) Surgical approaches for augmentation mammoplasty



Subpectoral implant

Prepectoral implant

Fig. 6.54 Augmentation mammoplasty

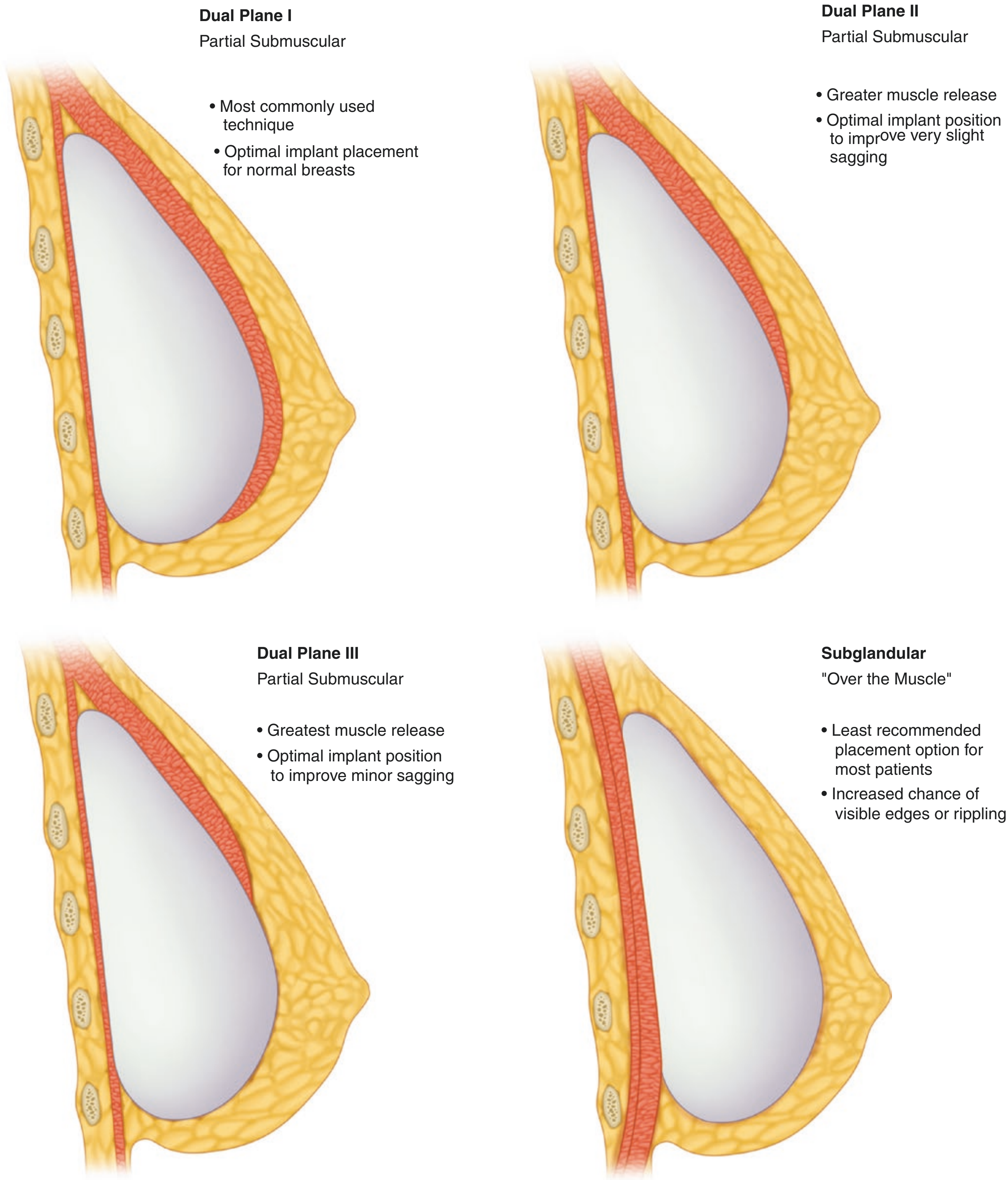


Fig. 6.55 Illustration of various degrees of dual-plane augmentation, based on ranges of separation of pectoralis major muscle from overlying breast parenchyma, at time of augmentation

As depicted in Fig. 6.56, patients with breast asymmetry may elect to undergo augmentation mammoplasty, whereby the prosthesis is usually placed in the submammary position (anterior to the pectoralis major muscle).

6.24 Nipple Plasty for Inverted Nipple

The technique of nipple plasty for inverted nipple is illustrated in Fig. 6.57. The procedure begins with a curvilinear incision adjacent to the inverted nipple (Fig. 6.57b). The dissection is then continued posteriorly as shown, so that the inverted nipple can be lifted up with a skin hook (Fig. 6.57c). An absorbable stitch is then placed around the nipple after elevation, and this is securely tied down (Fig. 6.57d).

A plastic syringe that has been cut is then placed over the nipple. As illustrated, a 3–0 Prolene stitch is then placed on each side of the cut syringe. These extend from the nipple, through the plastic syringe, and are then tied down onto the skin (Fig. 6.57e). In this way, the nipple that has been re-inverted is secured and maintained in this position for about 10 days until the wounds have healed.

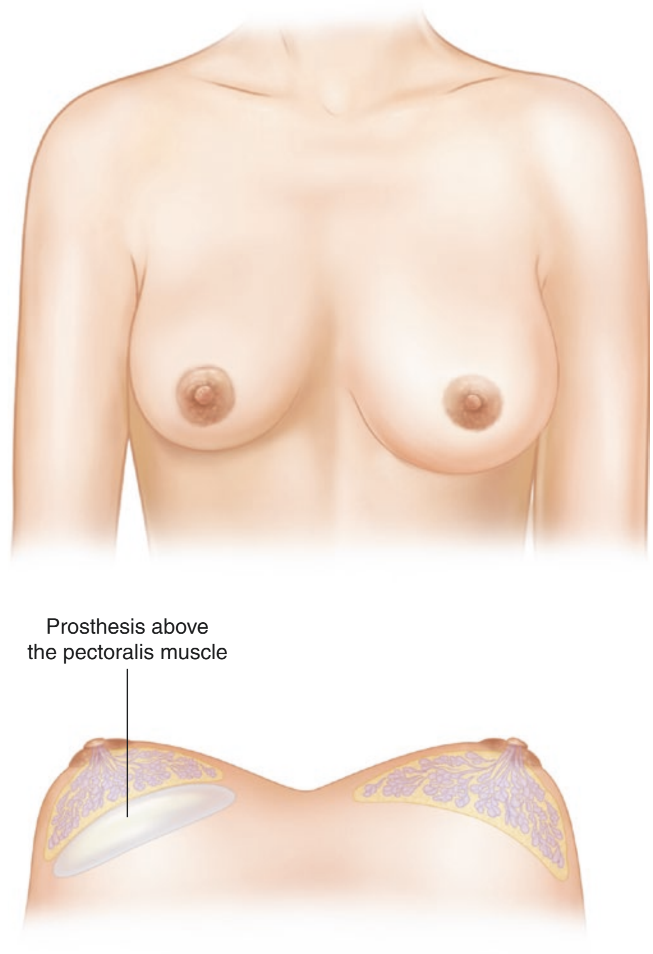


Fig. 6.56 Augmentation mammoplasty for breast asymmetry

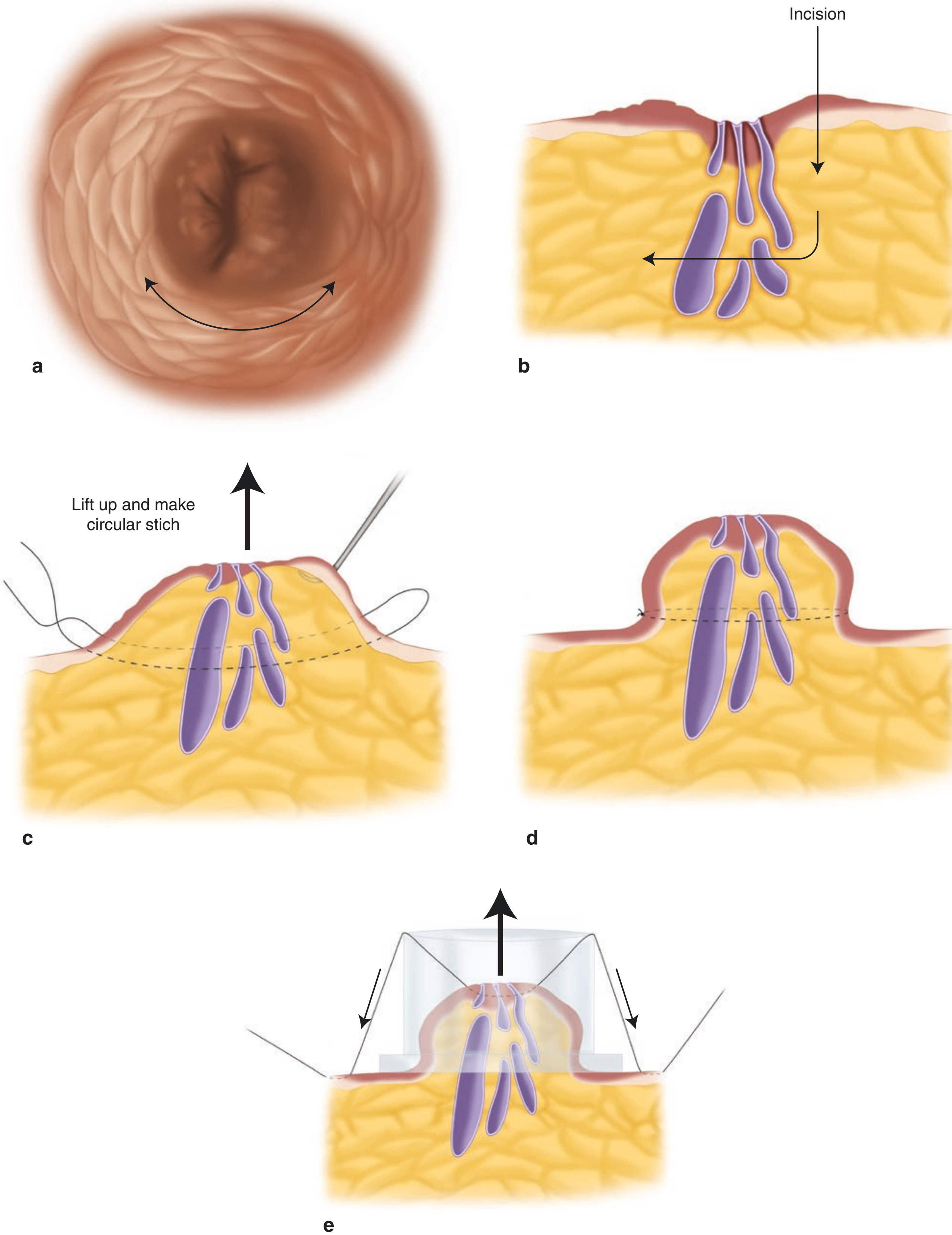


Fig. 6.57 Nipple plasty for inverted nipple

Further Reading

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Index

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