The procedures used to diagnose, stage, and treat breast disease are rapidly becoming less invasive and more cosmetically satisfying while remaining oncologically sound. In particular, percutaneous core biopsy has largely replaced excisional breast biopsy for both palpable and nonpalpable breast lesions and has proved to be an equally accurate, less invasive, and less costly means of pathologic diagnosis. Moreover, in clinically appropriate patients, sentinel lymph node biopsy (SLNB) has proved to be an accurate method of staging the axilla that reduces the incidence of many of the complications associated with traditional axillary node dissection. Furthermore, breast conservation has largely supplanted mastectomy for definitive surgical treatment of breast cancer; randomized trials continue to demonstrate equivalent survival rates for the two therapies. Even in those cases where mastectomy is either required or preferred, advances in reconstructive techniques have been made that yield significantly improved outcomes after breast reconstruction. Finally, in an effort to eliminate the need for open surgical treatment of breast cancer, various percutaneous extirpative and ablative local therapies have been developed and are being evaluated for potential use in managing breast cancer in carefully selected patients.

A more minimally invasive approach to breast disease will depend to a substantial extent on the availability of accurate and efficient imaging modalities. Adeptness with such modalities is rapidly becoming an essential part of the general surgeon’s skill set. In this chapter, we describe selected standard, novel, and investigational procedures employed in the diagnosis and management of breast disease. The application of these procedures is a dynamic process that is shaped both by technological advances and by physicians’ evolving understanding of the biology of breast diseases.

**Breast Ultrasonography**

Breast ultrasonography can be useful for evaluating palpable breast masses or mammographically indeterminate lesions; for carrying out postoperative and oncologic follow-up; for guiding aspiration and biopsy of lesions; and for facilitating intraoperative tumor localization, margin assessment, placement of catheters for partial-breast irradiation, and investigational tumor-ablating techniques.

In the office, breast ultrasonography has become a useful adjunct to the clinical breast examination, particularly in patients with radiographically dense mamograms: it defines breast lesions more clearly than physical examination does and thus can potentially reduce the number of unnecessary biopsies done for simple cysts or fibroglandular tissue presenting as a palpable nodularity. Whole-breast ultrasonography is not an effective screening tool and therefore should not be a substitute for annual mammography. The American College of Surgeons (ACS) and various surgical subspecialty organizations offer a multitude of courses, at varying skill levels, geared toward training general surgeons in the use of breast ultrasonography.

**Ductal Lavage**

The majority of breast cancers originate from the epithelium of the mammary ducts. Ductal lavage is a method of recovering breast duct epithelial cells for cytologic analysis via a microcatheter that is inserted into the duct. Potential applications include identifying high-risk women, predicting risk with molecular markers, monitoring the effectiveness of chemopreventive agents, and delivering drugs directly into the ducts. At present, however, ductal lavage remains investigational, and its predictive value and clinical utility await further definition.

**TECHNIQUE**

Most real-time ultrasound imaging is performed with handheld probes generating frequencies between 7.5 and 12 MHz. The procedure is conducted with the patient supine, a pillow behind the shoulder, and the ipsilateral arm extended over the head for maximal spreading of the breast. Sonographic transmission gel is applied between the transducer and the skin to reduce air artifacts, and the transducer is pressed slightly against the skin to improve image quality. The selected breast area is imaged from the nipple outward in a radial pattern.

All lesions should be sonographically characterized with respect to margins, effect on adjacent tissue, internal echo pattern, compressibility, height-width ratio, and presence of shadowing versus posterior enhancement. Classically, simple cysts tend to be oval or lobulated, anechoic, and sharply demargined; they typically demonstrate posterior enhancement. Benign solid lesions tend to be well circumscribed, hypoechoic, and wider than they are tall; they show homogeneous internal echoes and edge shadowing. Carcinomas are also hypoechoic masses, but they cross tissue planes and therefore tend to be taller than they are wide, with irregular borders; in addition, they can demonstrate heterogeneous interior patterns and broad acoustic shadowing [see Figure 1]. A lesion that has a single indeterminate characteristic on ultrasonography or that is clinically suspicious despite appearing benign on ultrasonography is an indication for core or open biopsy. Lesions should be characterized in at least two orthogonal planes, and the image should be saved for future reference.

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Ductoscopy

Advances in endoscopic technology have made visualization and biopsy of the mammary ducts possible. Mammary ductoscopy is a procedure in which a 0.9 mm microendoscope is employed to visualize the lining of the ductal system directly. It is currently being evaluated for use in three main areas: (1) evaluation of patients with pathologic nipple discharge, (2) evaluation of high-risk patients, and (3) evaluation of breast cancer patients to determine the extent of intraductal disease and perhaps reduce the rate of positive margins. At present, this investigational technology is available at only a few centers, and further study will be required to determine its precise role in the evaluation and management of breast disease.

TECHNIQUE

Ductoscopy can be performed either in the office or in the operating room with minimal discomfort. Before the procedure, a nipple block is usually performed with topical lidocaine cream, supplemented (if necessary) by intradermal injection of 1% lidocaine around the nipple-areola complex or intraductal instillation of lidocaine (or both). The breast is massaged to promote expression of nipple aspirate fluid, which facilitates identification of a ductal orifice. The duct is then gently dilated, and the ductoscope is advanced with the help of insufflation under direct visualization. Most ducts with pathologic discharge can readily be identified and dilated sufficiently to allow passage of the ductoscope.

An outer air channel on the fiberscope permits instillation and collection of saline solution so that cells can be retrieved for ductal lavage. Intraductal lesions can be percutaneously localized under direct endoscopic visualization for subsequent biopsy; alternatively, they may be amenable to endoscopic cytologic brushing or to the newly described technique of intraductal breast biopsy.

The procedure is usually well tolerated. It should be noted that duct excision is still regarded as standard practice for pathologic discharge, regardless of endoscopic findings.

Breast Biopsy

Cytologic or tissue diagnosis of a palpable breast mass may be obtained by means of fine-needle aspiration (FNA) biopsy, core-needle biopsy (CNB), or open incisional or excisional biopsy. Currently, most solid lesions are initially diagnosed by means of CNB, which is less invasive, less costly, and more expeditious than open biopsy while achieving comparable accuracy. In select circumstances, however, FNA biopsy and open biopsy may remain suitable options. All minimally invasive biopsy techniques are facilitated when guided by imaging modalities; such guidance enables the physician to perform a more directed biopsy that targets the lesion precisely while avoiding benign-appearing tissue, necrotic tissue, and adjacent structures (e.g., the chest wall, skin, and axillary vessels). Therefore, even when a lesion is palpable, ultrasound-directed biopsy is preferable to blind biopsy (though not absolutely necessary) and is recommended if the surgeon has a suitable ultrasound device in the office.

The choice of a specific biopsy technique should be individualized on the basis of the clinical and radiographic features of the lesion, the experience of the clinician, and the patient’s condition and preference.

FINE-NEEDLE ASPIRATION BIOPSY

FNA biopsy permits the sampling of cells from the breast or the axillary region for cytologic analysis. It is particularly useful for sampling a clinically or sonographically suspicious axillary node and for evaluating cyst fluid that is bloody or that comes from an incompletely collapsed or recurrent cyst. In patients receiving anticoagulants, FNA biopsy is a reasonable alternative to CNB for evaluation of a solid lesion, in that there is less potential for hemorrhage if anticoagulation cannot be discontinued. Discrete masses discovered on physical examination may be either cystic or solid. A lesion that is shown by ultrasonography to be a simple cyst need not undergo FNA biopsy unless it is symptomatic.

Technique

The skin of the breast or axilla is prepared, and a local anesthetic is injected superficially via a 25-gauge needle. Although smaller needles may be used, a 21-gauge needle is optimal for FNA biopsy because it can be effectively used both for aspiration of potentially viscous fluid and for procurement of sufficient cellular material from solid masses. To generate adequate suction, a 10 ml or larger syringe should be used. As noted (see above), FNA biopsy ideally is performed under ultrasonographic guidance. If such guidance is unavailable, the lesion is held steady between the thumb and the index finger of the nondominant hand. Before the needle enters the skin, 1 ml of air is introduced into the biopsy needle. 

Figure 1 Breast ultrasonography. Shown are (a) a simple cyst that has smooth margins, is anechoic, and shows posterior enhancement; (b) a fibroadenoma that has smooth margins, is hypoechoic, and shows posterior shadowing; and (c) a mammary carcinoma that has irregular borders, is hypoechoic, and shows irregular posterior shadowing.
syringe. Then, without the application of suction, the needle is advanced into the lesion. Once the needle is in place, strong suction is applied. If the lesion is cystic, all fluid is aspirated, at which point the mass should disappear. Ultrasonography can confirm the complete collapse of a cyst or help direct the needle to an undrained portion of the cyst. The fluid need not be sent for analysis unless it is bloody or is associated with a residual palpable mass or an incompletely collapsed cyst as seen on ultrasonography. If the fluid is to be sent for analysis, it is injected directly into the pathologic preservative. The patient is reexamined 4 to 8 weeks after successful aspiration. If the same cyst has recurred, aspiration should be repeated and the new aspirate sent for cytologic analysis.

If the lesion is solid, the needle is moved back and forth within the lesion along a 5 to 10 mm tract until tissue is visualized in the hub of the needle. (This oscillation of the needle along the same tract is the most effective way of obtaining a cellular, diagnostic specimen). Suction is released while the needle is still within the lesion, and the needle is then withdrawn. The contents of the needle are expelled onto prepared glass slides, spread into a thin smear, and fixed according to the preferences of the cytology laboratory. The syringe may be rinsed so that a cellblock can be prepared for further analysis. The lesion should be sampled twice to ensure that a sufficiently cellular sample has been obtained.

**Interpretation of Results**

Accurate interpretation of FNA requires substantial experience on the part of both the operator and the cytopathologist; only in a few select centers with expert breast cytopathologists has it remained the diagnostic procedure of choice for solid breast masses. Consequently, one must exercise considerable caution about using FNA biopsy rather than CNB as the sole means of confirming a cancer diagnosis before the initiation of definitive operative management or neoadjuvant therapy. FNA biopsy is unable to discriminate carcinoma in situ from invasive carcinoma and therefore incapable of establishing whether axillary node staging is needed. Furthermore, because of the smaller quantity of tissue extracted, FNA biopsy is a less reliable means of assessing receptor status than CNB is. Finally, in 1% to 2% of cases, FNA biopsy may yield false positive results,12 potentially leading to an unnecessary cancer operation. For these reasons, it is recommended that malignancies identified by FNA biopsy be confirmed by means of CNB or open biopsy (preferably the former) before definitive therapy is provided.

Cytologic analysis that is diagnostic of a specific benign lesion (e.g., a fibroadenoma) may generally be relied on if it is in concordance with the clinical features of the lesion. However, a negative result from FNA biopsy does not exclude cancer: this procedure fails to diagnose as many as 40% of breast malignancies.12 Cellular atypia, pathologic discordance, or a nondiagnostic FNA is an indication for tissue diagnosis.

**CORE-NEEDLE BIOPSY**

As noted (see above), CNB is the diagnostic procedure of choice for breast lesions. Like FNA biopsy, it is easily performed in an outpatient setting. Unlike FNA biopsy, CNB removes a narrow cylinder of tissue that is submitted for pathologic rather than cytologic analysis. Whenever feasible, CNB of both palpable and nonpalpable lesions is performed under ultrasonographic guidance, which permits real-time documentation of the needle’s position within the lesion. For lesions not visualized on ultrasonography or for suspicious microcalcifications, stereotactic guidance may be employed instead. A preoperative diagnosis of malignancy obtained via CNB enables the surgeon to perform a single-stage operative procedure. It may also help lower the positive margin rate for patients undergoing breast-conserving therapy, thereby reducing the need for reexcision and improving the cosmetic outcome.13 Various automatic, rotational, and vacuum-assisted devices may be employed to perform CNB; in what follows, we briefly discuss these devices (see Technique, below). When CNB is performed with a 14-gauge needle, as is the case with Tru-Cut (Cardinal Health, Dublin, Ohio) devices and spring-loaded guns, up to 30% pathologic upgrading may be seen on subsequent surgical excision.1 When CNB is done with a larger needle (8 to 11 gauge), as is the case with image-guided vacuum-assisted and rotational devices, a greater volume of tissue is delivered, and consequently, less pathologic upgrading is seen.14 With the vacuum-assisted core biopsy (VACB) devices currently available, it is possible to remove all radiographic evidence of the lesion. It is therefore common practice with all core biopsies to place a titanium clip or another surrogate marker at the biopsy site to facilitate future localization procedures. In addition, a clip should be placed at the biopsy site if the patient has a larger cancer for which neoadjuvant chemotherapy is required; some such lesions exhibit a complete clinical response to chemotherapy and thus are no longer radiographically visible at the time of definitive operative treatment. Two-view postbiopsy mammography should be performed to confirm accurate placement of the clip and adequate sampling of the lesion at the time of biopsy.

**Technique**

**Palpation-guided biopsy** In this setting, a manual Tru-Cut–type device or, more commonly, a spring-loaded semiautomatic biopsy gun is used to obtain the specimen. The skin is prepared, and a local anesthetic is infiltrated superficially via a 25-gauge needle. A nick is made in the skin with a No. 11 blade to permit easy entry of the biopsy needle (usually a 14-gauge needle). As with FNA biopsy (see above), the lesion is held steady in the nondominant hand while the biopsy needle is advanced into the periphery of the lesion. Next, the needle is manually advanced through the center of the lesion (if a manual device is used), or the gun is fired (if a spring-loaded device is used). Finally, the needle is withdrawn to retrieve the core. Four to five cores, each from a separate pass, should be obtained to ensure that the lesion is not undersampled. Pressure is applied over the lesion and the biopsy tract for 10 to 15 minutes to ensure adequate hemostasis. The nick in the skin is closed with an adhesive strip (e.g., Steri-Strip; 3M, St. Paul, Minnesota).

**Ultrasound-guided biopsy** This technique may be employed for both palpable and nonpalpable lesions. The lesion that is to undergo biopsy is centered on the screen of the ultrasound device. A local anesthetic is injected superficially, first along the anticipated biopsy tract and then both anterior and posterior to the lesion; this latter maneuver helps ensure that there is a safe distance between the lesion and the skin or the chest wall. A nick is made in the skin with a No. 11 blade. The biopsy needle is then inserted through the skin, with care taken to keep it in a plane parallel to the footplate of the ultrasound probe as it passes through the breast tissue. The biopsy itself can be either performed in a freehand manner or directed with a needle guide attached to the probe. The ideal final positions of the tip and shaft vary, depending on the particular biopsy device selected for the procedure [see Figure 2]. Regardless of which device is used, the tip and shaft of the needle should be visualized throughout the entire approach to
Semiautomated gun biopsy. When a spring-loaded semiautomated biopsy gun is used, the tip of the needle should abut the lesion in such a way that the biopsy trough will be in the lesion after the device is fired. Ideally, the repeat passes should sample different portions of the lesion and avoid any necrotic areas that have been visualized.

Vacuum-assisted core biopsy. Vacuum-assisted rotational cutting devices employ a 7- to 11-gauge probe with a distal sampling trough and an inner rotating cutter. The sampling trough can be placed either in the center of the lesion or directly under it. The probe is attached to a vacuum system, which draws the target tissue into the trough. Once the tissue has been drawn into the trough, the inner rotating cutter is advanced and cuts a core from it. The tissue core is then delivered by the vacuum system through the barrel of the probe and into a proximal collection chamber. The probe can be rotated up to 360° and can retrieve multiple samples through a single insertion in the skin. The larger tissue volumes obtained with these rotational VACB devices have reduced the incidence of atypical ductal hyperplasia or ductal carcinoma in situ (DCIS) upgrades on subsequent excisional biopsies.³

Cryobiopsy. In a cryobiopsy, a thin (19-gauge) solid needle is placed in the middle of the targeted tissue. The tip is then cooled to approximately −10°C, a temperature that freezes the tissue to the needle but does not cause tissue necrosis. An outer rotating cutting cannula (10 gauge) is then advanced over the inner localizing needle. The device is removed from the breast, and the single specimen is removed. As with the semiautomatic biopsy gun, multiple passes into the breast are still required. However, the local anesthetic effect of the cooling process, the ability of the device to stir the tissue, and the absence of a firing gun–type action make cryobiopsy advantageous, particularly for a mobile lesion that lies close to the skin or the chest wall.

Stereotactic-guided biopsy. Lesions that are visible only on mammography—including small solid lesions, asymmetric densities, and suspicious groups of microcalcifications—can often be targeted and subjected to core biopsy under stereotactic guidance.¹³ This outpatient procedure commonly makes use of a mounted VACB gun, similar to the handheld VACB device previously described (see above). Stereotactic biopsy is appropriate for lesions that are clearly visible on digital images and identifiable on stereotactic projections. Lesions that lie close to the chest wall or in the subareolar region may not be amenable to stereotactic biopsy and are often best approached via open biopsy with needle localization (see below). Likewise, lesions in thinly compressible breasts may not be amenable to stereotactic biopsy, because firing of the needle may result in a through-and-through injury to the breast. Certain stereotactic systems may not be suitable for patients who are unable to lie prone or are morbidly obese. It should be kept in mind that stereotactic biopsy is a diagnostic procedure and is not intended for therapeutic purposes. On the whole, it is safe, and the complication rate is acceptably low.

Depending on the system being employed, the patient either lies prone on the stereotactic table or sits upright. With the breast compressed craniocaudally or mediolaterally, stereotactic digital imaging is then performed to visualize the targeted lesion and calculate its location in three dimensions, and a suitable probe insertion site is identified. The skin is prepared, and a small amount of buffered 1% lidocaine with epinephrine is administered. The skin at the insertion site is punctured with a No. 11 blade, the probe is manually advanced to the prefire site, and the position of the probe is

Figure 2  Core-needle biopsy. The positioning of the needle shaft and tip varies with the particular biopsy device being used. (a) For manual or semiautomatic guns that fire through the lesion, the position of the tip before firing should be at the edge of the lesion. Keeping the needle shaft parallel to the chest wall or the skin keeps these structures from being injured when the gun is fired or the core is manually obtained. (b) For most vacuum-assisted devices, multiple cores can be obtained through a single placement of the device within the breast. For diagnostic biopsies performed under ultrasonographic or stereotactic guidance, the needle may be placed in the center of the lesion and rotated up to 360° in specified intervals. (c) For cryobiopsy, the tip of the needle should be advanced through the center of the lesion toward the skin. Brisk bleeding may occur during and immediately after the procedure, but it usually can be controlled by the application of direct pressure. Patients are restricted from engaging in strenuous activity for 24 hours after biopsy. Bruising may result, but it typically resolves within days. Other potential complications include hematoma, fat necrosis, a palpable lump, and infection; however, such events are uncommon. Most patients receiving oral anticoagulants can be switched to a subcutaneous alternative that can be stopped on the morning of the procedure.
confirmed by means of stereotactic imaging. The device is then fired, repeatedly cutting, rotating, and retrieving samples until the desired amount has been removed. Targeted removal of suspicious microcalcifications is confirmed with specimen mammography.

Once the biopsy is complete, an inert metallic clip is deployed into the biopsy site through the probe for future localization; deployment and positioning are initially confirmed by stereotactic imaging. The biopsy device is then removed, the edges of the skin incision are approximated with Steri-Strips, and a compressive bandage is applied. Typically, 1 g of tissue (equivalent to approximately 10 to 12 samples with an 11-gauge probe) is sufficient for diagnosis. Once the procedure is over and the breast has been released from compression, a two-view mammography should be obtained to verify that the clip was accurately placed and to document that the targeted lesion was adequately sampled.

**Interpretation of Results**

CNB is a highly accurate diagnostic tool: the false-negative rate is only 1% to 2%, which is comparable to that of open wire-localized biopsy. When pathologic evaluation reveals fibroadenoma, microcalcifications within benign fibrocystic tissue, or other comparably benign pathologic conditions, there is no need for any special follow-up, and routine screening mammography may be resumed. However, when biopsy of the targeted mass lesion fails to yield a mass diagnosis or a biopsy specimen from group of clustered calcifications is devoid of microcalcifications on pathologic review, the discordant result should be viewed with some suspicion and should be considered an indication for open biopsy. Subsequent excisional biopsy is also indicated when CNB reveals atypical hyperplasia, radial scar, lobular carcinoma in situ (LCIS), or papilloma. The rationale is that the excisional biopsy may result in a pathologic upgrade to cancer. For example, open biopsy after a CNB indicative of atypical ductal hyperplasia may reveal DCIS in approximately 40% of patients when CNB was performed with a 14-gauge automated gun. The use of larger (e.g., 11-gauge) core biopsy devices has reduced the frequency of this finding to approximately 20%, but it has not eliminated the need for excision. False positive results are rare with CNB; therefore, a diagnosis of malignancy may be believed, and a one-stage definitive surgical procedure may then be planned without further biopsy.

**Touch Preparation of Cores**

For an immediate but preliminary diagnosis, cytologic touch preparation of fresh cores may be performed in the office. The tissue is blotted to remove any gross blood, the core is gently smeared along a glass slide, and the slide is then immediately fixed in 70% ethanol. A layer of cells is left on the surface of the slide for cytologic evaluation, while the core is preserved for permanent preparation. This procedure has a diagnostic accuracy of nearly 90%. Although the false-negative rate is approximately 25%, an immediate diagnosis is obtained in 75% of patients. Like all preliminary diagnoses, touch preparation diagnoses should be treated with caution until the final results of histopathologic evaluation are available.

**PERCUTANEOUS EXCISIONAL BIOPSY**

In some instances, patient preference may dictate complete removal of a mass regardless of its benign appearance. As an alternative to open biopsy (see below), percutaneous excision of small masses may be performed. This procedure can be performed in an outpatient setting with the patient under local anesthesia. Some of the devices used for percutaneous excision are vacuum assisted and remove the mass as multiple cores, whereas others deliver large intact samples in a single pass [see Figure 3]. Although such approaches clearly show promise for future surgical treatment of breast cancer, these percutaneous devices are currently approved by the U.S. Food and Drug Administration (FDA) only for excision of benign masses. Lesions found to be harboring cancer should undergo subsequent open surgical reexcision. Excision of lesions that are close to the skin or the chest wall or are larger than 2 to 3 cm in diameter may prove technically challenging with percutaneous techniques; open excisional biopsy [see Open Biopsy, below] may be preferable for such lesions.

**CRYOABLATION**

Patients with a biopsy-proven fibroadenoma who want their mass removed but desire an alternative to open or percutaneous surgical excision may be candidates for cryoablation, which destroys targeted tissue by alternately freezing and thawing it. Intracellular ice formation, osmotic injury, and ischemic injury are all believed to contribute to the mechanism of tissue destruction.

![Figure 3](image-url) **Percutaneous excisional biopsy.** This procedure may be performed by means of several different methods. (a) One approach is to employ a vacuum-assisted device, which is placed with the trough under the lesion and the shaft parallel to the posterior aspect of the lesion. The needle is then lifted anteriorly as it is rotated first 45° degrees clockwise, then back to the center position (0°), and finally 45° counterclockwise to remove the entire lesion in multiple cores. (b) Another option is to employ an electro-surgical device such as the Ovation (Rubicon Medical, Inc., Redwood City, California), which circumscribes the mass with a cutting wire loop while concurrently deploying a retractable plastic bag that encapsulates the lesion and retracts it through the skin en bloc. (c) A third option is to employ a device such as the Intact Breast Lesion Excision System (Intact Medical Corp., Natick, Massachusetts), which circumscribes the mass with radiofrequency wand and delivers it en bloc.
lines of skin tension [see Figure 5a, 5b]. Currently, however, some surgeons are advocating the use of radial incisions, particularly for medial, lateral, and inferior lesions. If a previous CNB proved the lesion to be benign (e.g., fibroadenoma) but the patient still favors excision, it is acceptable to move the incision to a circumareolar position or another less visible site.

For diagnostic biopsies, the surgeon should orient the specimen, and the pathologist should ink all margins. Meticulous hemostasis should be achieved before closure to prevent the formation of hematomas that could complicate subsequent definitive oncologic resection. A cosmetic subcuticular skin closure is preferred.

**NEEDLE (WIRE)-LOCALIZATION BREAST BIOPSY**

Lesions that are not amenable to stereotactic core biopsy may be excised by means of needle (wire)-localization breast biopsy (NLBB). Such lesions include those that are close to the chest wall or under the nipple, as well as those occurring in a thin breast, where firing the needle may cause it to pass through the opposite side of the breast. Radiographic evidence of a radial scar is also an indication for NLBB: a core pathologic diagnosis of such a scar would ultimately necessitate open excision. Finally, reexcision is required when stereotactic or ultrasound-guided CNB reveals lesions determined to be high risk on pathologic evaluation (e.g., atypical hyperplasia, LCIS, papilloma, carcinoma, or lesion whose pathologic status is discordant with radiographic findings). In these circumstances, wire localization may be performed on the residual lesion, a clip placed at the time of CNB, or another surrogate marker (see below). To bracket a more extensive area of calcifications, multiple wires may be placed, especially if previous CNB revealed atypia or malignancy in the area.

**Technique**

The lesion to be excised is localized by inserting a thin needle and a fine wire under mammographic or ultrasonographic guidance immediately before operation. To facilitate incision placement, images should be sent to the OR with the wire entry site indicated on them. The incision is placed as directly as possible over the mass to minimize tunneling through breast tissue. With superficial lesions, the wire entry site is usually close to the lesion and thus may be included in the incision. With some deeper lesions, the wire entry site is on the shortest path to the lesion and so may still be included in the incision. Once the incision is made, a block of tissue is excised around and along the wire in such a way as to include the lesion [see Figure 6a, b]. This process is easier and involves less excision of tissue if the localizing wire has a thickened segment several centimeters in length that is placed adjacent to or within the lesion. The wire itself can then be followed into breast tissue until the thick segment is reached, at which point the excision can be extended away from the wire to include the lesion in a fairly small tissue fragment.

With many lesions, the wire entry site is in a fairly peripheral location relative to the position of the lesion, which means that including the wire entry site in the incision would result in excessive tunneling through breast tissue. In such cases, the incision is placed over the expected position of the lesion [see Figure 6c], the dissection is extended into breast tissue to identify the wire a few centimeters away from the lesion itself, and the free end of the wire is pulled up into the incision. A generous block of tissue is then excised around the wire. Intraoperative ultrasonography may be useful for identifying the tip of the needle and facilitating excision, particularly in the case of a deep lesion or biopsy site in a large breast.

Radiography should be performed intraoperatively on all wire-localized biopsy specimens to confirm excision of the lesion. If the
lesion was missed, another tissue sample may be excised if the surgeon has some idea of the likely location of the missed lesion. If, however, the surgeon suspects that the wire was dislodged before or during the procedure, then the incision should be closed, and repeat localization and biopsy should be performed later. In addition to wire dislocation or transection, wire localization is occasionally associated with vasovagal reactions. Alternatives to wire localization include hematoma ultrasound-guided (HUG) excision (see below), carbon marking, use of methylene blue dye, and placement of radioactive seeds.

Hematoma ultrasound-guided excision In patients who have undergone CNB, particularly those who have undergone VACB, the hematoma at the biopsy site can often serve as a physiologic marker that accurately guides intraoperative localization [see Figure 7]. This procedure, referred to as HUG excision, renders wire placement unnecessary and can facilitate operative scheduling. The hematoma is localized in two planes, and 1 cm margins are marked off around the lesion; dissection is then continued down toward the chest wall in a block fashion. Excision of the hematoma can be confirmed by ultrasonography of the specimen ex vivo, as well as direct visualization of the hematoma in the gross specimen.

Terminal Duct Excision

Terminal duct excision is the procedure of choice in the surgical treatment of pathologic nipple discharge. The goal is to excise the discharging duct with as little additional tissue as possible. To this end, the surgeon should carefully note the precise position of the offending duct at the time of the initial examination.

OPERATIVE TECHNIQUE

The patient is instructed to refrain from manually expressing her discharge for several days before operation. After local anes-
in the pathologic discharge, the entire subareolar duct complex must be excised from immediately beneath the nipple dermis to a depth of 4 to 5 cm within the breast tissue. The breast tissue should be reapproximated beneath the nipple to prevent retraction of the nipple or indentation of the areola.

**Surgical Options for Breast Cancer**

There are several surgical options for primary treatment of breast cancer; indications for selecting among them are reviewed elsewhere [see 3.1 Breast Complaints]. It should be emphasized that for most patients, partial mastectomy (lumpectomy) to microscopically clear margins coupled with axillary staging and radiation therapy yields long-term survival equivalent to that associated with mastectomy and axillary staging. Currently, indications for mastectomy include patient preference, the inability to achieve clean margins without unacceptable deformation of the breast, the presence of disease in multiple quadrants (multicentric disease), previous chest wall irradiation, pregnancy, the presence of severe collagen vascular disease (e.g., scleroderma), and the lack of access to a radiation therapy facility.

**Partial Mastectomy**

Partial mastectomy—also referred to as wide local excision or lumpectomy—involves excision of all cancerous tissue to microscopically clear margins. Although 1 cm margins are the goal, many surgeons consider 2 mm margins to be adequate for reducing the risk of local recurrence.30 Hence, reexcision is indicated whenever margins are either positive or too close (< 2 mm). Partial mastectomy is commonly performed with the patient under local anesthesia, with or without sedation. The addition of an axillary staging procedure (a common event) usually necessitates general anesthesia, but in select circumstances, local or epidural anesthesia may suffice.

**OPERATIVE TECHNIQUE**

An incision is placed directly over the lesion to minimize tunneling through breast tissue; it should be oriented so as to be included within a subsequent mastectomy incision if margins prove positive. As with open biopsy (see above), curvilinear incisions have been the standard, but radial incisions are now being advocated by some surgeons, particularly for upper outer, medial, lateral, and inferior lesions. A radial incision facilitates excision of tumors that extend in a ductal distribution, preserves the contour of the breast, and permits easier reexcision if margins prove positive [see Figure 5b]. With current oncoplastic techniques,31,32 lesions in the central, medial, or superior portions of the breast can be resected with minimal cosmetic deformity [see Figure 5c, d, e, f]. Resection of a portion of the overlying skin is not necessary unless the lesion is extremely superficial.

To obtain clear margins, a 1 to 1.5 cm margin of normal-appearing tissue should be removed beyond the edge of the palpable tumor or, if excisional biopsy has already been performed, around the biopsy cavity. In the case of nonpalpable lesions diagnosed by means of CNB, wire localization has already been performed, and 2 to 3 cm of tissue should be excised around the wire to obtain an adequate margin. Intraoperative ultrasonography may reduce the rate of positive margins by allowing visualization of the tumor edge or the previous biopsy site.33

The specimen should be oriented by the surgeon and the margins inked by the pathologist; this orientation is useful if reexcision is required to achieve clean margins. Reexcision of any close (< 2
mm) margins may be performed during the same surgical procedure if the specimen margins are assessed immediately by the pathologist. If the specimen was not oriented, the entire biopsy cavity should be reexcised. Surgical clips may be left in the lumpectomy site to help the radiation oncologist plan the radiation boost to the tumor bed or to direct partial-breast irradiation. In the closure of the incision, hemostasis should be meticulous: a hematoma may delay adjuvant therapy. Deep breast tissue should be approximated only if such closure does not result in significant deformity of breast contours. A cosmetic subcuticular closure is preferred. Wearing a support bra worn during the day and the night can reduce shearing of fragile vessels.

ACCELERATED PARTIAL-BREAST IRRADIATION WITH BALLOON CATHETER

Historically, whole-breast irradiation has been the standard treatment to reduce the risk of local recurrence after breast-conserving therapy (BCT). Long-term follow-up of patients who have received BCT demonstrates, however, that only 1% to 3% of recurrences within the breast arise at a significant distance from the primary cancer site (i.e., in other breast quadrants); the remainder develop near the original biopsy site. This approach provides the rationale for the approach known as accelerated partial-breast irradiation (APBI), in which a shortened course of high-dose radiation is delivered to the tissue surrounding the lumpectomy cavity (the region theoretically at greatest risk). Several different APBI techniques have been developed, including placement of interstitial catheters, use of a localized external beam, single-dose intraoperative treatment, implantation of radioactive beads or seeds, and insertion of a balloon catheter into the lumpectomy site. Although long-term follow-up has not been carried out, the short-term results reported for some APBI techniques indicate that in most centers, recurrence rates have been low, with good cosmesis and only mild chronic toxicity.

The technique of APBI can be illustrated by considering the MammoSite Radiation Therapy System (Cytec Corp., Palo Alto, California), in which a balloon catheter is inserted into the surgical cavity after lumpectomy to provide partial-breast irradiation (see below). Although the catheter may also be inserted at the time of the original operation, it is preferable to wait for final pathologic evaluation to confirm clear margins; if the catheter is inserted and margins are found to be positive, it will have to be replaced (a costly process). Postoperative insertion may be done either percutaneously under ultrasonographic guidance or by means of an open technique. Once the catheter is in place, a radiation source (iridium 192) is delivered into the balloon via a high-dose rate remote afterloader.
Cryotherapy is inconsistent.

In the treatment of breast cancer, the degree of tumor destruction achieved with either heat or cold. Unfortunately, early study results reveal that in the treatment of nonresectable liver tumors. It kills tumor cells by disrupting the cellular membrane during multiple freeze (−40°C)/thaw cycles.

Cryotherapy, laser ablation, radiofrequency ablation (RFA), and focused ultrasound ablation have all been studied as means of eradicating small breast cancers.36 In most of these techniques, a unicentric) disease.44 The vital blue dye is then injected, commonly in the subareolar plexus, and the breast is massaged for 5 minutes to stimulate lymphatic flow. Lymph nodes that are “hot” (i.e., radioactive), blue, or both, as well as palpable nodes, are removed.

The most common method of identifying the SLN involves injection of both a vital blue dye and a radionuclide.41-44 The radionuclide is first injected into the subareolar lymphatic plexus, either preoperatively or, in some centers, intraoperatively.41 Because the breast and its overlying skin drain to the same few lymph nodes,45 peritumoral, intradermal, and subareolar injection are all acceptable approaches; subareolar injection has the advantage of being expeditious and accurate in cases of multicentric (as well as unicentric) disease.44 The vital dye is then injected, commonly in the subareolar plexus, and the breast is massaged for 5 minutes to stimulate lymphatic flow. Lymph nodes that are “hot” (i.e., radioactive), blue, or both, as well as palpable nodes, are removed.
for evaluation by frozen-section analysis or touch-print cytology. The technique of SLNB is described in greater detail elsewhere [see 3:6 Lymphatic Mapping and Sentinel Lymph Node Biopsy].

SLNB has also been employed in DCIS patients, but in general, its use should be limited to patients with extensive DCIS who are undergoing mastectomy (in the event of occult invasive disease). Some investigators recommend SLNB for patients with extensive DCIS who are undergoing BCT (in whom CNB may have missed an area of invasion), though others caution against this practice. Results from the National Surgical Adjuvant Breast and Bowel Project (NSABP) B-27 trial suggest that in patients undergoing neoadjuvant therapy, SLNB may be performed either before or after therapy, with no significant differences in identification and false-negative rates; however, this suggestion is not universally accepted. Contraindications to SLNB include the presence of clinically positive axillary nodes, previous axillary surgery, and pregnancy or lactation. Large or locally advanced breast cancers commonly give rise to a positive SLN but are not a contraindication to the procedure, in that some patients may still be spared the morbidity of a full axillary dissection.

Axillary Dissection

Before the advent of SLNB, axillary dissection was routinely performed in breast cancer patients: it provided prognostic information that guided subsequent adjuvant therapy, it afforded excellent local control, and it may have contributed a small overall survival benefit.

Axillary dissection includes resection of level I and level II lymph nodes [see Figure 10a]. The superior border of the dissection is formed by the axillary vein; the lateral border of the dissection is formed by the latissimus dorsi; the medial border is formed by the pectoral muscles and the anterior serratus muscle; and the inferior border is formed by the tail of the breast. Level II nodes are easily removed by retracting the pectoralis major and the pectoralis minor medially; it is not necessary to divide or remove the pectoralis minor. Level III nodes are not removed unless palpable disease is present.

Axillary dissection, either alone or in conjunction with lumpectomy or mastectomy, usually calls for general anesthesia, but it may be performed with thoracic epidural anesthesia. To facilitate identification and preservation of motor nerves within the axilla, the anesthesiologist should refrain from using neuromuscular blocking agents. In the absence of neuromuscular blockade, any clamping of a motor nerve or too-close approach to a motor nerve with the electrocautery will be signaled by a visible muscle twitch.

Structures to be Preserved

There are a number of vascular structures and nerves passing through the axilla that must be preserved during axillary dissection [see Figure 10b]. These structures include the axillary vein and artery; the brachial plexus; the long thoracic nerve, which innervates the anterior serratus muscle; the thoracodorsal nerve, artery, and vein, which supply the latissimus dorsi; and the medial pectoral nerve, which innervates the lateral portion of the pectoralis major.

The axillary artery and the brachial plexus should not be exposed during axillary dissection. If they are, the dissection has been carried too far superiorly, and proper orientation at a more inferior position should be established. In some patients, there...
may be sensory branches of the brachial plexus superficial (and, rarely, inferior) to the axillary vein laterally near the latissimus dorsi; injury to these nerves results in numbness extending to the wrist. To prevent this complication, the axillary vein should initially be identified medially, under the pectoralis major. Medial to the thoracodorsal nerve and adherent to the chest wall is the long thoracic nerve of Bell. The medial pectoral nerve runs from superior to the axillary vein to the undersurface of the pectoralis major, passing through the axillary fat pad and across the level II nodes; it has an accompanying vein whose blue color may be used to identify the nerve. If a submuscular implant reconstruction [see Breast Reconstruction after Mastectomy, below] is planned, preservation of the medial pectoral nerve is especially important to prevent atrophy of the muscle.

The intercostobrachial nerve provides sensation to the posterior portion of the upper arm. Sacrificing this nerve generally leads to numbness over the triceps region. In many women, the intercostobrachial nerve measures 2 mm in diameter and takes a fairly cephalad course near the axillary vein; when this is the case, preservation of the nerve will not interfere with node dissection. Sometimes, however, the nerve is tiny, has multiple branches, and is intermingled with nodal tissue that should be removed; when this is the case, one should not expend a great deal of time on attempting to preserve the nerve. If the intercostobrachial nerve is sacrificed, it should be transected with a knife or scissors rather than with the electrocautery, and the ends should be buried to reduce the likelihood of postoperative causalgia.

**OPERATIVE TECHNIQUE**

The incision for axillary dissection should be a transverse or curvilinear one made in the lower third of the hair-bearing skin of the axilla. For cosmetic reasons, it should not extend anteriorly onto the pectoralis major; however, it may be extended posteriorly onto the latissimus dorsi as necessary for exposure. Skin flaps are raised to the level of the axillary vein and to a point below the lowest extension of hair-bearing skin, either as an initial maneuver or after the initial identification of key structures.

The key to axillary dissection is obtaining and maintaining proper orientation with respect to the axillary vein, the thoracodorsal bundle, and the long thoracic nerve. After the incision has been made, the dissection is extended down into the true axillary fat pad through the overlying fascial layer. The fat of the axillary fat pad may be distinguished from subcutaneous fat on the basis of its smoother, lipomalike texture. There may be aberrant muscle slips from the latissimus dorsi or the pectoralis major; in addition, there may be an extremely dense fascial encasement around the axillary fat pad. It is important to divide these layers early in the dissection. The borders of the pectoralis major and the latissimus dorsi are then exposed, which clears the medial and lateral borders of the dissection.

The axillary vein and the thoracodorsal bundle are identified next. As discussed (see above), the initial identification of the axillary vein should be made medially, under the pectoralis major, to prevent injury to low-lying branches of the brachial plexus. Sometimes, the axillary vein takes the form of several small branches rather than a single large vessel. If this is the case, all of the small branches should be preserved.

The thoracodorsal bundle may be identified either distally at its junction with the latissimus dorsi or at its junction with the axillary vein. The junction with the latissimus dorsi is within the axillary fat pad at a point two thirds of the way down the hair-bearing skin of the axilla, or approximately 4 cm below the inferior border of the axillary vein. Occasionally, the thoracodorsal bundle is bifurcated, with separate superior and inferior branches entering the latis-
simus dorsi; this is particularly likely if the entry point appears very high. If the bundle is bifurcated, both branches should be preserved. The thoracodorsal bundle may be identified at its junction with the latissimus dorsi by spreading within axillary fat parallel to the border of the muscle and looking for the blue of the thoracodorsal vein. Identification is also facilitated by lateral retraction of the latissimus dorsi. The long thoracic nerve lies just medial to the thoracodorsal bundle on the chest wall at this point and at approximately the same anterior-posterior position. It may be identified by spreading tissue just medial to the thoracodorsal bundle, then running the index finger perpendicular to the course of the long thoracic nerve on the chest wall to identify the cordlike nerve as it moves under the finger. Once the nerve is identified, axillary tissue may be swept anteriorly away from the nerve by blunt dissection along the anterior serratus muscle; there are no significant vessels in this area.

The junction of the thoracodorsal bundle with the axillary vein is 1.5 to 2.0 cm medial to the point at which the axillary vein crosses the latissimus dorsi. The thoracodorsal bundle enters the posterior surface of the axillary vein, and the nerve and the artery pass posterior to the axillary vein. There are generally one or two scapular veins that branch off the axillary vein medial to the junction with the thoracodorsal bundle. These are divided during the dissection and should not be confused with the thoracodorsal bundle.

The axillary vein and the thoracodorsal bundle having been identified, the pectoralis major is retracted medially at the level of the axillary vein, and the latissimus dorsi is retracted laterally to place tension on the thoracodorsal bundle. Once this exposure is achieved, the axillary fat and the nodes are cleared away superficial and medial to the thoracodorsal bundle to the level of the axillary vein. Superiorly, dissection proceeds medially along the axillary vein to the point where the fat containing level II nodes crosses the axillary vein. To improve exposure, the fascia overlying the level II extension of the axillary fat pad should be incised to release tension and expose the lipomalarike level II fat. As noted [see Structures to Be Preserved, above], the medial pectoral nerve passes onto the underside of the pectoralis major in this area and should be preserved. One or more small venous branches may pass inferiorly from the medial pectoral bundle; particular attention should be paid to preserving the nerve when ligating these venous branches.

The next step in the dissection is to reflect the axillary fat pad inferiorly by dividing the medial attachments of the axillary fat pad along the anterior serratus muscle. Care must be taken to preserve the long thoracic nerve. Because there are no significant vessels or structures in the tissue anterior to the long thoracic nerve, this tissue may be divided sharply, with small perforating vessels either tied or cauterized. Finally, the axillary fat is freed from the tail of the breast with the electrocautery or a knife.

There is no need to orient the axillary specimen for the pathologist, because treatment is not affected by the anatomic level of node involvement. A closed suction drain is placed through a separate stab wound. (Some practitioners prefer not to place a drain and simply aspirate postoperative seromas as necessary.) A long-acting local anesthetic may be instilled into the axilla—a particularly helpful practice if the dissection was done as an outpatient procedure.

**Mastectomy**

The goal of a mastectomy is to remove all breast tissue—including the nipple, the areola, and the pectoral fascia—while leaving viable skin flaps and a smooth chest wall for application of prosthesis. This should be the objective whether the mastectomy is performed for cancer treatment or for prophylaxis. Skin-sparing mastectomy (SSM) performed in conjunction with immediate reconstruction is discussed elsewhere [see Breast Reconstruction after Mastectomy, below]. Proper skin incisions and good exposure are the key components of a well-performed mastectomy. Mastectomy usually calls for general anesthesia, but it may be performed with thoracic epidural anesthesia or local anesthesia in select circumstances.

**OPERATIVE TECHNIQUE**

The traditional mastectomy incision is an elliptical one that is placed either transversely across the chest wall or at an upward angle toward the axilla. It should be fashioned in such a way as to include the nipple-areola complex and any incision from a previous biopsy [see Figure 11a]. Ideally, the upper and lower skin flaps should be of similar length so that there is no redundant skin on either flap. The outline of the incision may be established by using the following five steps.

1. The lateral and medial end points are marked.
2. The breast is pulled firmly downward.
3. To define the path of the upper incision, a straight line is drawn from one end point to the other across the upper surface of the breast.
4. The breast is pulled firmly upward.
5. To define the path of the lower incision, a straight line is drawn from one end point to the other across the lower surface of the breast.

The outlined incision is then checked to confirm that it can be closed without either undue tension or redundant skin. Dog-ears or lateral skin folds can be prevented by extending the incision medially or laterally to remove all the skin that contributes to the forward projection of the breast. The closure should be fairly snug intraoperatively while the arm is extended; significant slack will be created when the arm is returned to the patient’s side. The medial and lateral end points of the incision may be adjusted upward or downward to include any previous biopsy incisions.

As noted [see Partial Mastectomy, above], there is increasing acceptance of the use of radial and oncoplastic incisions for BCT. In a small percentage of women, persistently positive margins may dictate conversion from BCT to mastectomy. In large-breasted women with excess breast skin, traditional elliptical incisions can easily incorporate any previous radial or superior-pole oncoplastic incisions that may have been performed [see Figure 11b]. In smaller-breasted women, however, sigmoid, modified Wise, or other oncoplastic mastectomy incisions may be needed to incorporate previous lumpectomy incisions [see Figure 11c].

Once the incision is made, the next step is to create even and viable flaps. In most patients, there is a fairly well defined avascular plane between subcutaneous fat and breast tissue. This plane is identified by pulling the edges of the incision upward with skin hooks and beginning a flap that is 8 to 10 mm thick. After an initial release of the skin edge, the desired plane is developed by applying firm tension downward on the breast tissue and away from the skin at a 45° angle. The fine fibrous attachments between breast tissue and subcutaneous fat (Cooper’s ligaments) are then divided with the electrocautery or a blade, and crossing vessels are coagulated or ligated as they appear. To protect both arterial supply to and venous drainage from the skin flap, one must refrain from excessive ligation or cautereization of vessels on the flap. For most women, flap viability is not an issue. For diabetics, smokers, and other patients with diffuse small vessel disease, however, it is a serious consideration. In such patients, flaps should be no longer than necessary with no...
excess tension, and extra care should be taken to preserve flap vessels. Patients should be warned that even with these measures, there may be some skin necrosis along the incision. Such necrosis is best treated with gradual debridement of the eschar.

Flaps are raised superiorly to the clavicle, medially to the sternum, inferiorly to the inframammary fold, and laterally to the border of the latissimus dorsi. The pectoral fascia is incised both superiorly and medially. Inferiorly, the fascia of the abdominal muscles is not divided. The pectoralis major, the abdominal muscles, and the anterior serratus muscle form the deep border of the dissection. The pectoral fascia is removed with the breast specimen and may be separated from the muscle with either the electrocautery or a blade.

In a simple mastectomy, the dissection proceeds around the lateral edge of the pectoralis major but stops before entering the axillary fat pad (unless the procedure is being done in conjunction with SLNB). A single closed suction drain is placed through a separate lateral stab wound in such a way that it extends under the lower flap and a short distance upward along the sternal border of the dissection.

A modified radical mastectomy essentially consists of an axillary node dissection added to a simple mastectomy. At the lateral edge of the dissection, the border of the latissimus dorsi is exposed, as is the lateral border of the pectoral muscle. Retraction of these two muscles provides excellent exposure for the axillary dissection [see Axillary Dissection, above]. Some surgeons prefer to remove the breast from the chest wall first, whereas others leave the breast attached to provide tension for the axillary dissection. Upon completion of the procedure, two closed suction drains are placed, one in the axilla and another under the lower flap and extending to the midline.

After either a simple or a modified radical mastectomy, the skin is closed and a dressing applied according to the surgeon’s preference. Early arm mobilization is encouraged.

Breast Reconstruction after Mastectomy

The vast majority of women undergoing mastectomy are candidates for breast reconstruction and should be offered a plastic surgery consultation before undergoing definitive surgical treatment. Reconstruction is covered by insurance and may be done either at the time of the mastectomy (immediate reconstruction) or as a delayed procedure (delayed reconstruction). Regardless of when it is done, reconstruction does not interfere with detection of recurrent disease. Immediate breast reconstruction does not significantly delay subsequent adjuvant therapy, and if it is done through a skin-sparing incision (see below), it may contribute to a more natural cosmetic outcome. Options for reconstruction include implants with tissue expansion, the transverse rectus abdominis myocutaneous (TRAM) flap, the latissimus dorsi myocutaneous flap, and various free flaps. Patient preference and lifestyle, the availability of suitable autologous tissue, and the demands imposed by additional cancer therapies are variables that can influence the timing and choice of the optimal reconstructive technique [see Figure 12].

Patients who definitely need radiation therapy after mastectomy are at higher risk for complications after reconstruction. Whereas most physicians recommend delayed reconstruction in such cases, a small percentage of these patients undergo immediate reconstruction in the event that the need for postmastectomy radiation therapy is unclear at the time of mastectomy (i.e., final pathology results are not available), a delayed-immediate reconstruction may be performed. An expander is placed at the time of SSM to preserve the breast skin envelope, and the definitive reconstructive plan is formulated once the final pathologic results have become available and the need for radiation therapy has been determined.

SKIN-SPARING MASTECTOMY

SSM, which consists of resection of the nipple-areola complex, any existing biopsy scar, and the breast parenchyma, followed immediately by breast reconstruction, has become an increasingly popular approach for women requiring mastectomy. With this approach, the inframammary fold is preserved, and a generous skin envelope remains after reconstruction; cosmetic results are thereby optimized. In addition, SSM is oncologically safe and is...
not associated with an increased incidence of local recurrence.\textsuperscript{53} The recurrences that do occur typically develop below the skin flaps and thus are easily detectable; deep recurrences beneath the reconstruction are comparatively uncommon.

The incision for SSM with immediate reconstruction should be planned in collaboration with the plastic surgeon [see Figure 13], and the inframammary fold should be marked preoperatively with the patient in a sitting position. Several options are available for SSM. For CNB-diagnosed tumors that are not superficial, a circumareolar incision may be employed, with a lateral extension for exposure if necessary. Different incisions may be used if it proves necessary to incorporate previous incisions or to remove skin anterior to superficial tumors. A separate axillary incision may be useful when axillary dissection or SLNB is being performed. Select patients may be candidates for newer techniques that spare the nipple, the areola, or both; however, these techniques are still under investigation, and long-term follow-up is required to determine their utility and applicability. CNB sites generally are not included in the excised skin segment, the surgeon may opt to excise them through a separate skin ellipse. Intraoperatively, flaps are created in a circular fashion to optimize exposure. Although optimal cosmesis is part of the rationale for SSM, cosmetic considerations should never be allowed to compromise the extent of the dissection in any way.

**RECONSTRUCTION OPTIONS**

**Prosthetic Implants**

The simplest method of reconstruction is to place a saline- or silicone-filled implant beneath the pectoralis major. Even after SSM, the pectoralis major is usually so tight that expansion of this muscle and the skin is necessary before an implant that matches the opposite breast can be inserted. Serial expansions are performed on an outpatient basis until an appropriate size has been attained. A second operative procedure is then required to exchange the expander for a permanent implant. A nipple and an areola are constructed at

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**Figure 12** Algorithm outlines the major steps in breast reconstruction after mastectomy.
a later date. AlloDerm (LifeCell Corp., Branchburg, New Jersey), an acellular dermal matrix derived from human cadaver skin, may be sewn to the pectoralis muscle and the inframammary fold to reinforce the lower pole of the breast. This measure may reduce postoperative pain and improve cosmesis, as well as facilitate immediate implant placement in smaller-breasted women.

The major advantages of implant reconstruction are reduced operating time, faster recuperation, and a reasonably good cosmetic outcome. The cosmetic result may deteriorate over time as a consequence of capsule formation or implant migration, and the implant may have to be replaced after each decade of use.

**Autologous Tissue**

An alternative approach to reconstruction is to transfer vascularized muscle, skin, and fat from a donor site to the mastectomy defect. The most commonly used myocutaneous flaps are the TRAM flap [see Figure 14] and the latissimus dorsi flap [see Figure 15]. Use of the free TRAM flap is advocated by certain centers and may be a preferred option for patients who smoke or are diabetic or obese.

The major advantage of autologous tissue reconstruction is that it generally yields a superior cosmetic result that remains stable over time; in addition, the reconstructed breast has a softer, more natural texture than a breast that has undergone implant reconstruc-

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**Figure 13**  Skin-sparing mastectomy. Shown is the recommended placement of a circumareolar incision for SSM. A lateral extension can provide further exposure for flap development or axillary staging. Separate incisions may be used to excise previous lumpectomy incisions or to gain access to the axilla.

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**Figure 14**  Breast reconstruction after mastectomy: TRAM flap. (a) The infraumbilical flap is designed. The TRAM flap is tunneled subcutaneously into the chest wall cavity. Blood supply to the flap is maintained from the superior epigastric vessels of the rectus abdominis. (b) Subcutaneous fat and deepithelialized skin are positioned under the mastectomy flaps as needed to reconstruct the breast mound. (c) The fascia of the anterior rectus sheath is approximated to achieve a tight closure of the abdominal wall defect and to prevent hernia formation. The umbilicus is sutured into its new position.
tion. The main drawbacks are the magnitude of the surgical procedure (involving both a prolonged operating time and longer inpatient hospitalization), the potential need for blood transfusion, and the pain and loss of muscle function that arise at the donor site. Smokers and patients with significant vascular disease may not be ideal candidates for autologous tissue reconstruction. Partial necrosis of the transferred flap may create firm areas; on rare occasions, complete necrosis and consequent loss of the flap can occur.

A number of factors are considered in choosing between the TRAM flap and the latissimus dorsi flap. In a TRAM flap reconstruction, the contralateral rectus abdominis is transferred along with overlying skin and fat to create a breast mound. This procedure yields a flatter abdominal contour but calls for a long transverse abdominal incision and necessitates repositioning of the umbilicus. The major advantages of TRAM flap reconstruction are that it provides enough tissue to match most contralateral breasts and that it offers the option of performing bilateral TRAM flap procedures in healthy candidates who want bilateral reconstruction. Patients who have undergone abdominal procedures that compromise the TRAM flap’s vascular supply are not ideal candidates for TRAM reconstruction. Patients who have undergone abdominal procedures that compromise the TRAM flap’s vascular supply are not ideal candidates for TRAM reconstruction. Postoperative discomfort is greater with TRAM flap reconstruction than with other flap reconstructions because of the extent of the abdominal portion of the procedure.

In a latissimus dorsi myocutaneous flap reconstruction, the ipsilateral latissimus dorsi is transferred along with overlying skin and fat to create a breast mound. The operative technique for the latissimus dorsi flap reconstruction is complex, requiring intraoperative changes in patient position (unless the oncologic surgeon is willing to perform the mastectomy with the patient in a lateral decubitus position). Patients who have undergone irradiation of the breast, the chest wall, or the axilla (including irradiation of the thoracodorsal vessels) may not be eligible for this procedure. A major advantage of the latissimus dorsi flap is that its donor site is associated with less postoperative discomfort than the abdominal donor site of the TRAM flap. In addition, transfer of the latissimus dorsi results in substantially less functional impairment than transfer of the rectus abdominis. One major drawback is that in many women, the latissimus dorsi is not bulky enough to provide symmetry with the contralateral breast; consequently, to match the size of the opposite breast, the flap must be supplemented with an implant. Thus, the drawback of the implant’s limited lifespan is added to the drawbacks associated with autologous tissue reconstruction.

Free-flap reconstruction options are used primarily when other autologous and implant reconstruction options are not available, do not provide sufficient tissue volume, or have failed. They are more complex procedures, requiring microvascular anastomoses and carrying a higher risk of total flap loss. The two most commonly employed free-flap options are the free TRAM flap and the free gluteus flap.

Donor-site morbidity—including postoperative pain, wound-healing complications, decreased abdominal muscle strength, and hernia formation—is a prime disadvantage of either pedicled or free TRAM flap reconstruction. As a result, muscle-sparing alternatives to autogenous breast reconstruction have been developed, such as the deep inferior epigastric perforator (DIEP) flap. In this approach, free flaps are used that comprise skin and fat alone, without the rectus abdominis. Avoidance of muscle sacrifice in the abdomen ultimately translates into greater patient satisfaction, but careful patient selection is essential to optimize outcomes. The disadvantages of the DIEP flap include the considerable technical expertise and long operating time required, as well as the greater potential for flap loss (because this flap has a more tenuous blood supply than the standard TRAM flap).
References


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Figures 2,3, 5-11, and 13-15 Alice Y. Chen.