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BREAST CANCER SURGERY AND BREAST RECONSTRUCTION:

WHAT THE OPTIONS ARE, WHAT YOUR PATIENTS NEED TO KNOW

SUPPLEMENT EDITOR:
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CLEVELAND CLINIC

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Breast Cancer Surgery and Breast Reconstruction:

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Supplement 1 to Volume 75, March 2008

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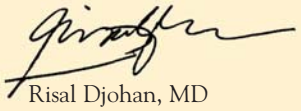
From the editor

With advances in breast cancer screening and awareness, breast cancers are now detected at earlier stages and in younger women. These trends, together with recent advances in surgical treatments for breast cancer and reconstructive procedures, make breast reconstruction an option clearly worth considering for many women with breast cancer.

This supplement was conceived to make primary care physicians, general surgeons, and other physicians not directly involved in breast reconstruction aware of the many reconstructive options available to women with breast cancer today. Our aim is to help these physicians better counsel their patients with breast cancer about these options early in treatment planning so that patients can make informed and individualized choices in the interest of both their long-term health and their quality of life.

We begin with an overview of breast cancer screening and diagnosis and proceed to a review of current surgical options for treatment of breast cancer. We then survey key issues to consider in breast reconstruction following mastectomy and following breast conservation therapy, as well as special considerations surrounding the timing of reconstruction.

Our approach is nontechnical, as our aim is to help physicians who are not breast surgeons better counsel their patients about what breast reconstruction involves and its associated benefits and risks.



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Trends in breast cancer screening and diagnosis

ABSTRACT

Screening mammography is the single most effective method of early breast cancer detection and is recommended on an annual basis beginning at age 40 for women at average risk of breast cancer. In addition to traditional film-screen mammograms, digital mammograms now offer digital enhancement to aid interpretation, which is especially helpful in women with dense breast tissue. Useful emerging adjuncts to mammography include ultrasonography, which is particularly helpful for further assessment of known areas of interest, and magnetic resonance imaging, which shows promise for use in high-risk populations. Image-guided biopsy—directed by ultrasonograpy or stereotactic mammography views—plays a critical role in histologic confirmation of suspected breast cancer.

Early detection of breast cancer is vital to reducing the morbidity and mortality associated with this disease. After a brief overview of breast cancer epidemiology and risk assessment, this article describes screening and diagnostic imaging techniques as they are currently practiced to promote early breast cancer detection. We conclude with a review of image-guided needle biopsy techniques and a recommended approach to breast cancer screening in the general population.

EPIDEMIOLOGY OF BREAST CANCER: DAUNTING BUT SLOWLY IMPROVING

After nonmelanoma skin cancers, breast cancer is the most common form of cancer in women today, accounting for more than 1 in 4 cancers diagnosed in US women.[1] If the current incidence of breast cancer remains constant, US females born today have an average risk of 12.7% of being diagnosed with breast cancer during their lifetime (ie, 1-in-8 lifetime risk), based on National Cancer Institute statistics.[2,3] The American Cancer Society estimated that 178,480 new cases of invasive breast cancer and 62,030 new cases of in situ breast cancer would be diagnosed in the United States in 2007, and that 40,460 US women would die from breast cancer that year.[1] Only lung cancer accounts for more cancer deaths in women.

The role of race and ethnicity

Breast cancer risk varies by race and ethnicity in the United States. After age 40 years, white women have a higher incidence of breast cancer compared with African American women; conversely, before age 40, African American women have a higher incidence compared with white women. African American women are more likely than their white counterparts to die from their breast cancer at any age. Incidence and death rates from breast cancer are lower among Asian American, American Indian, and Hispanic women compared with both white and African American women.[1]

Recent hopeful trends

Despite the daunting incidence numbers reviewed above, recent years have seen encouraging trends in US breast cancer epidemiology.

For invasive breast cancer, the growth in incidence rates slowed during the 1990s, and rates actually declined by 3.5% per year during the period 2001–2004.[1] These changes are likely attributable to multiple factors, including variations in rates of mammography screening and decreased use of hormone replacement therapy after the 2002 publication of results from the Women's Health Initiative trial. Still, the trend is encouraging.

Incidence rates of in situ breast cancer rose rapidly during the 1980s and 1990s, largely due to increased diagnosis by mammography, but have plateaued since 2000 among women aged 50 years or older while continuing to rise modestly in younger women.[1]

Meanwhile, the overall death rate from breast cancer in women declined by 2.2% annually from 1990 to 2004.[1]

RISK FACTORS AND RISK MODELING

Risk factors for breast cancer have been well described and include the following:

- Age (≥ 65 years vs < 65 years, although risk increases across all ages up to 80 years)
- Family history of breast cancer

Both authors reported that they have no commercial affiliations or financial interests that pose a potential conflict of interest with this article.

- Late age at first full-term pregnancy (> 30 years)
- Never having a full-term pregnancy
- Early menarche and/or late menopause
- Certain genetic mutations for breast cancer (eg, in the *BRCA1*, *BRCA2*, *ATM*, and *CHEK2* genes)
- Certain breast disorders, such as atypical hyperplasia or lobular carcinoma in situ
- High breast tissue density
- High bone density (postmenopausal)
- High-dose radiation to the chest.

The above risk factors are, in general, fixed. More elusive risk factors, in that they are variable and modifiable, include obesity, use of exogenous hormones (recent and long-term hormone replacement therapy; recent oral contraceptive use), alcohol use, tobacco use, diet, and a low level of physical activity. Breast implants are *not* a risk factor for breast cancer, though their presence does obscure breast tissue on imaging, limiting the detectability of a tumor when it does develop (see "Screening the Surgically Altered Breast" below).

Women with a genetic predisposition to breast cancer merit special consideration. Hereditary breast cancers account for about 5% to 10% of breast cancer cases, and the *BRCA1* and *BRCA2* mutations are responsible for 80% to 90% of these cases, while other gene mutations (noted above) or genetic syndromes account for the rest. Clinical options for managing women with a genetic predisposition include surveillance, chemoprevention, and prophylactic surgery.[4] Detailed discussion of the management of these women is beyond the scope of this article, but readers are referred to **http://www.nccn.org/professionals/physician_gls/PDF/genetics_screening.pdf** for practice guidelines from the National Comprehensive Cancer Network.[5]

Tools for risk assessment

Several tools are available to predict a woman's risk of developing breast cancer. Probably the most widely used is the Gail model,[6] which was published in 1989 and forms the statistical basis for the National Cancer Institute's Breast Cancer Risk Assessment Tool, which is available for downloading at **http://www.cancer.gov/bcrisktool/**.[7] The model uses a woman's personal medical and reproductive histories and her family history of breast cancer to predict her 5-year and lifetime risk of developing invasive breast cancer. Factors included in the risk calculation are age, race, number of first-degree relatives with a history of breast cancer, age at first live birth (or nulliparity), age at menarche, number of breast biopsies, and presence or absence of a history of atypical hyperplasia. The relative risk for each of these factors is multiplied to generate a composite risk. The Gail model has been validated for white women but has been shown to underestimate breast cancer risk in African American women; it remains to be validated for Hispanic women, Asian women, and other subgroups of women.[7]

The commonly taught "triple test" for palpable breast lesions is another risk model that incorporates clinical findings. It consists of a physical examination, mammography, and fine-needle aspiration[8] (in the "modified triple test," ultrasonography replaces mammography[9]). When all three elements of the test are concordant (either all benign or all malignant), the triple test has been reported to have 100% diagnostic accuracy.[8,9]

TABLE 1
American Cancer Society guidelines for early breast cancer detection, 2003

Women at average risk

Begin mammography at age 40.

For women in their 20s and 30s, it is recommended that clinical breast examination be part of a periodic health examination, preferably at least every 3 years. Asymptomatic women aged 40 and over should continue to receive a clinical breast examination as part of a periodic health examination, preferably annually.

Beginning in their 20s, women should be told about the benefits and limitations of breast self-examination (BSE). The importance of prompt reporting of any new breast symptoms to a health professional should be emphasized. Women who choose to do BSE should receive instruction and have their technique reviewed on the occasion of a periodic health examination. It is acceptable for women to choose not to do BSE or to do BSE irregularly.

Women should have an opportunity to become informed about the benefits, limitations, and potential harms associated with regular screening.

Older women

Screening decisions in older women should be individualized by considering the potential benefits and risks of mammography in the context of current health status and estimated life expectancy. As long as a woman is in reasonably good health and would be a candidate for treatment, she should continue to be screened with mammography.

Women at increased risk

Women at increased risk of breast cancer might benefit from additional screening strategies beyond those offered to women of average risk, such as earlier initiation of screening, shorter screening intervals, or the addition of screening modalities other than mammography and physical examination, such as ultrasound or magnetic resonance imaging. However, the evidence currently available is insufficient to justify recommendations for any of these screening approaches.

Reprinted, with permission, from Smith RA, et al. American Cancer Society guidelines for breast cancer. CA Cancer J Clin 2003; 53:141–169.

A WORD ABOUT BREAST EXAMINATION

Breast self-examination

The role of breast self-examination is controversial in the literature. There are currently no data to support the contention that it increases detection of breast

TABLE 2
Screening versus diagnostic mammography

Screening mammogram

- Annual examination
- Patient is asymptomatic
- Two standard views (mediolateral oblique and craniocaudal) obtained of each breast
- Batch-read later by radiologist

Diagnostic mammogram

- Performed as a follow-up to an abnormal screening mammogram *or* when patient is symptomatic (lump, pain, or nipple discharge)
- Examination is tailored to the patient's issue and directed by an on-site radiologist
- Ultrasonography may be added, if necessary

TABLE 3
BI-RADS categories for mammography reporting

	Assessment	Follow-up
0	Incomplete	Further diagnostic imaging and/or review of prior studies needed
1	Negative	Routine yearly screening
2	Benign findings	Routine yearly screening
3	Probably benign findings	Short-term imaging follow-up at 6 months
4	Suspicious abnormality	Recommend biopsy
5	Highly suspicious of malignancy	Biopsy and treatment, as necessary
6	Known biopsy-proven malignancy	Continue ongoing treatment

BI-RADS = Breast Imaging Reporting and Data System

cancer. As a result, the American Cancer Society no longer recommends that all women perform monthly breast self-exams, although it advises that all women be told about the potential benefits and limitations of breast self-examination **(Table 1)**.[10] Research suggests that structured breast self-examination is less important than self-awareness. Women who detect breast tumors themselves typically find them outside of a structured examination, such as when bathing or getting dressed.[1]

Clinical breast examination

As noted in **Table 1**, regular clinical breast examinations are recommended by the American Cancer Society for asymptomatic women at average risk for breast cancer, with the recommended frequency depending on the woman's age.[10] The US Preventive Services Task Force takes the stance that there is insufficient evidence to recommend for or against breast cancer screening with clinical breast examination alone.[11] While it is unclear precisely what contribution clinical breast exams make to the detection of breast cancer, they certainly provide clinicians an opportunity to raise awareness about breast cancer and educate patients about breast symptoms, risk factors, and new detection technologies.[10]

SCREENING MAMMOGRAPHY

Screening mammography is the single most effective method of early breast cancer detection,[1] and the American Cancer Society recommends that women at average risk for breast cancer have annual screening mammograms beginning at age 40 years **(Table 1)**.[10]

The evidence base

The primary evidence supporting the recommendation for screening mammography comes from eight randomized trials that studied the effectiveness of screening mammography for cancer detection in Sweden,[12,13] the United States,[14] Canada,[15,16] and the United Kingdom.[17] Overall, breast cancers detected by screening mammography are smaller and have a more favorable history and tumor biology than those detected clinically without the use of imaging. A pooled analysis of the most recent data from all randomized trials of screening mammography in women aged 39 to 74 years showed a 24% reduction in mortality (95% CI, 18% to 30%) in women undergoing screening mammography, although not all individual trials showed a statistically significant mortality reduction.[10]

The screening procedure at a glance

A screening mammogram, as distinguished from a diagnostic mammogram **(Table 2)**, consists of two standard radiographic views of each breast (mediolateral oblique and craniocaudal).[18] The woman being screened is advised to wear no powders or deodorants and should be asymptomatic. Women with symptoms (eg, breast lump, focal tenderness, nipple discharge) should be scheduled for a diagnostic mammogram **(Table 2)**, not a screening mammogram.

The mammography technologist obtains the standard radiographs of each breast, and computer-assisted detection software can be applied to the mammogram films to aid in the identification of abnormalities as a computer-generated second opinion. Although com-

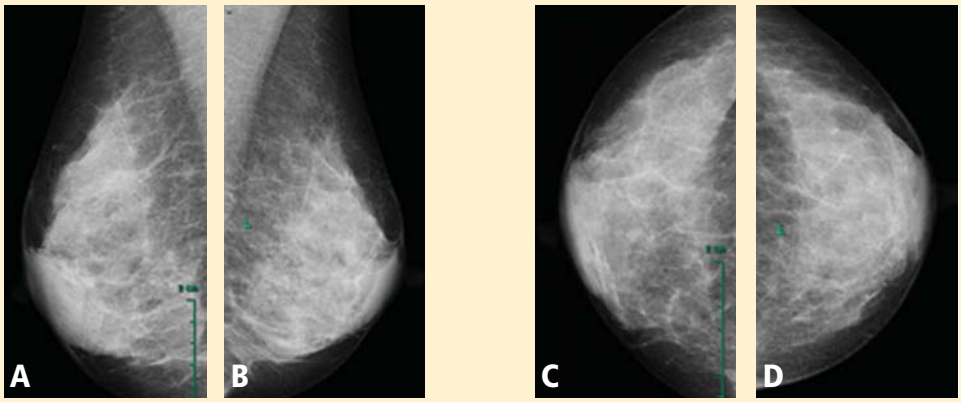

FIGURE 1. Normal dense digital mammogram images showing right and left mediolateral oblique views (panels A and B, respectively) and right and left craniocaudal views (panels C and D, respectively).

puter-assisted detection is not currently standard of care, it is available at most institutions. The films are read later by a radiologist who will interpret them according to the American College of Radiology's standard system of describing mammogram findings, called the Breast Imaging Reporting and Data System (BI-RADS). In this system, results are assigned a category rating on a scale from 0 to 6 **(Table 3)**. This standardization allows physicians to use consistent language, ensures better follow-up of suspicious findings, and reduces interobserver variability.

Analog vs digital

Breast radiographs can be obtained by the traditional film-screen (analog) method or obtained digitally **(Figure 1)**.

Digital mammograms are radiographs that are acquired digitally and allow digital enhancement to aid in interpretation. When receiving a digital mammogram, the woman being screened still undergoes compression and positioning as for a conventional film-screen mammogram, and the images are still produced with x-rays. However, digitization allows manipulation of the images as they are being interpreted, enabling the radiologist to focus on areas of interest or to "window" and "level" the image, similar to adjusting the tint and contrast on a television set.

Research trials comparing digital and film mammography, such as the Digital Mammographic Imaging Screening Trial (DMIST),[19] have found digital mammography to be especially helpful in women with extremely dense breasts, who have an elevated risk for breast cancer. For women with fatty breasts the differences between the types of mammogram are less significant.

The type of mammogram a woman receives generally depends on the equipment available at the site she visits. Digital mammography units currently cost approximately 3 times as much as corresponding film-screen units, yet digital mammograms command reimbursement rates only about 1.6 times higher than those for film mammograms **(Table 4)**. A hard copy of the digitized image can be printed, although the hope is that eventually fewer mammogram images will be printed and space-saving electronic storage will supplant storage of printed films.

For further detail on digital mammography, readers are referred to the recent review by D'Orsi and Newell.[20]

SCREENING THE SURGICALLY ALTERED BREAST

Following surgical cancer treatment or reconstructive surgery, screening of remaining breast tissue for cancer is still performed and is just as essential to patient care as presurgery screening. The first line of defense for any patient with a surgically altered breast is mammography.

When a patient has had breast reconstruction following mastectomy, it is presumed that very little breast tissue remains. There is no standard of care for screening the nonbreast tissue introduced by the reconstructive procedure. Nonetheless, at our institution we perform a single mediolateral oblique projection on any flap-reconstructed breast in light of rare anecdotal accounts of cancer found in and around the reconstructed breast. When problem-solving is needed to evaluate a new palpable abnormality, special angled views (tangential) and directed ultrasonography can be used. We do not routinely perform screening mammography on mastectomy patients who have had reconstruction with implants, but we can investigate areas of clinical concern (eg, due to palpable masses) with directed ultrasonography.[21]

The cosmetically altered breast presents its own issues in cancer detection. Both silicone-gel and saline implants obscure breast tissue that could contain cancer. For this reason, special implant-displaced views are performed that allow visualization of a larger por-

TABLE 4
Screening options for breast cancer

Screening option	Approved by FDA?	HCPCS code	Medicare reimbursement*
Analog screening mammography	Yes	77057	$78.13
Digital screening mammography	Yes	G0202	$124.50
Magnetic resonance imaging	No	77059	$933.77
Computer-aided detection	Yes	77051	$16.07
Clinical breast exam	N/A	G0101	$33.94
Breast self-exam	N/A	N/A	N/A

*2007 Medicare reimbursement for Cleveland, Ohio.
FDA = US Food and Drug Administration; HCPCS = Healthcare Common Procedure Coding System; N/A = not applicable

tion of breast tissue beyond that allowed by standard mammograms. Therefore, an asymptomatic patient with implants who presents for screening mammography will have eight mammography views obtained instead of the routine four views.[22]

Patients who have had breast reduction, excisional biopsy, or prior breast conservation surgery (lumpectomy and radiation) are screened in a routine manner with mammography.[23] Patients who have had prior surgical procedures often have architectural distortion at the surgical site, which is generally stable over time. Any prior surgical procedure can predispose the patient to the development of fat necrosis, which is a benign entity but can mimic cancer in its early phases through the development of calcifications and, occasionally, a new palpable lump. We most commonly confront this issue in the period 2 to 4 years after the operation.[24] Occasionally the findings are such that a biopsy is needed to determine whether fat necrosis is the cause. In this population, magnetic resonance imaging (MRI) can also be used as an adjunctive tool, and can sometimes clarify the presence of fat necrosis and other postoperative findings, such as seroma, hematoma, or inflammation. In other instances, only a biopsy can determine what a particular finding represents.

DIAGNOSTIC MAMMOGRAPHY

Any mammography performed for a problem-solving purpose is considered diagnostic mammography **(Table 2)**; the exam is tailored to the patient's individual issue.[25] Diagnostic mammography requires the presence of a qualified radiologist at the time of imaging. The goal is to come to a final conclusion about the mammographic or clinical finding at the time of the patient's visit. Special views are usually performed that include, but are not limited to, spot-compression or spot-magnification views, depending on the finding.[26] The patient is then given a same-day written account of the results at the conclusion of the study.

Examples of problems that may prompt diagnostic mammography include patient-reported palpable findings, screening mammography findings that are recalled for further investigation, or physician-detected findings. Often, ultrasonography is also used at the same visit and its results are integrated with the mammography findings to arrive at the final impression.

BREAST ULTRASONOGRAPHY AND BREAST MRI

Ultrasonography and MRI are two very useful adjunctive tools for breast lesion detection and analysis. At this time, however, neither is a replacement for screening mammography as a primary screening modality; rather, each is used in a complementary fashion for lesion analysis and biopsy guidance.[10,27]

Ultrasonography: Best for further study of areas of interest

Ultrasonography uses high-frequency sound waves to create a picture using a probe directed to an area of interest in the breast. The optimal probe for breast imaging is one typically operating in a frequency of 12 to 18 MHz and 4 cm in scanning width.

Because ultrasonography provides views of only a small area of breast tissue at a time, it is operator and patient dependent. It is best used when a known area of interest needs further evaluation, such as when a patient reports a palpable abnormality or when a mass is detected on mammography.

Ultrasonography uses no ionizing radiation, so it is especially helpful in young or pregnant women who present with a palpable abnormality. It is also useful for patients who have recently undergone a surgical procedure. As ultrasonography is currently used, no compression is needed and it can be performed easily in patients with limited mobility. Needle biopsies are most easily performed using ultrasonographic guidance.

MRI: An emerging adjunct under study in high-risk patients

Breast MRI is an emerging modality under active research that shows promise for adjunctive breast imaging. It is commonly being used as a tool for local staging in women with newly diagnosed breast cancer.[28,29] Current research is focused on its suitability as a screening modality, in conjunction with mammography, in high-risk populations based on family his-

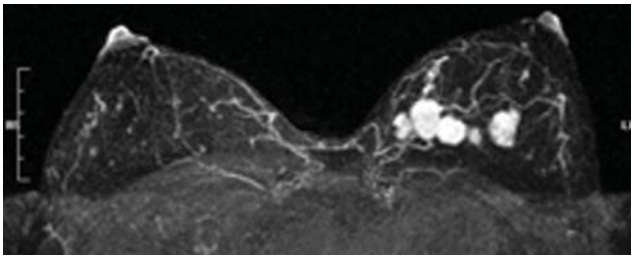

FIGURE 2. Contrast-enhanced breast MRI in the axial projection demonstrating multiple malignant masses in the left breast.

tory and other factors addressed in the Gail model[6] and similar risk models.

The limitations of breast MRI include its high cost, unsuitability for some patients (eg, the obese [due to table weight constraints], patients with pacemakers, patients with renal failure), the potential for unnecessary biopsies due to decreased specificity, lack of portability, and the length of time required for imaging.

Breast MRI is a four-dimensional study, with time as the fourth dimension (in addition to length, width, and depth). The patient receives an intravenous line and is given gadolinium for contrast enhancement. Imaging time depends on the protocol used and is specific to the imaging center, but it typically involves approximately 20 minutes of motionless scan time for the patient.[30] Lesions are detectable by their level of vascularity, and diagnostic images are dependent on adequate contrast enhancement **(Figure 2)**. Several software packages are commercially available that perform post-processing of breast MRI data. Although cancer on MRI has a characteristic enhancement curve, there is much overlap with benign entities; as a result, morphologic characteristics of the lesion—such as size, shape, and borders—are paramount.[31]

When a lesion is initially detected with MRI, an attempt is usually made to identify it with ultrasonography as well, owing to the ease of ultrasonography-guided biopsy.[32] It is important, however, for an imaging center that performs breast MRI to be able to perform biopsies using MRI guidance since not all lesions are identifiable by other modalities.[33] Breast MRI studies are not easily portable between imaging facilities since a typical study contains a thousand or more images that are best viewed on a site-specific workstation monitor.

HISTOLOGIC CONFIRMATION

Once an abnormality is detected on imaging, a confirmatory histologic diagnosis is needed before embarking on medical or surgical treatments. Image-guided biopsy plays a critical role in this regard. In our breast imaging section, we perform ultrasonography-guided core needle biopsy and aspiration, stereotactic needle biopsy, and MRI-guided needle biopsy, as well as wire localizations on the day of surgery. All procedures performed are considered minimally invasive and are suitable for a vast majority of patients for whom they are recommended.[34]

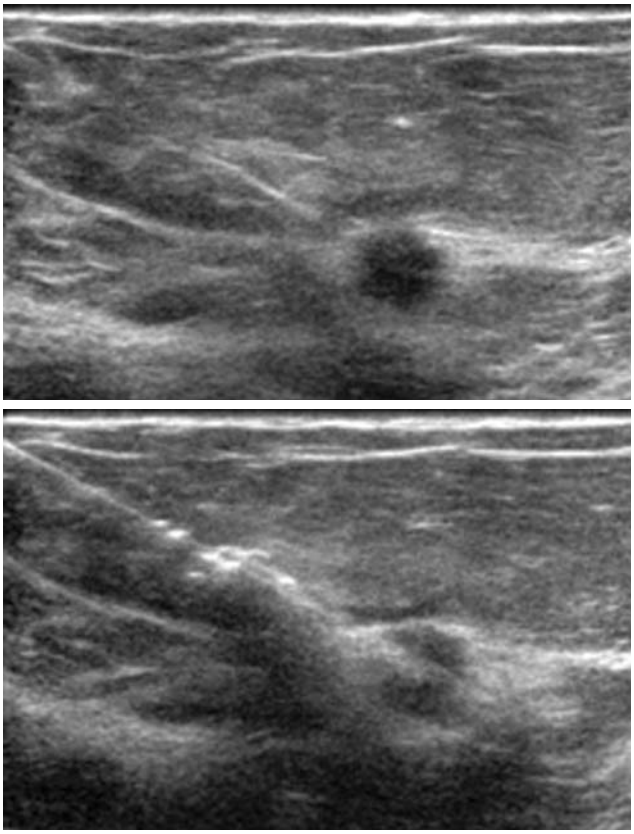

FIGURE 3. "Pre-fire" (top) and "post-fire" (bottom) ultrasonographic views of an 18-gauge percutaneous needle core biopsy of a suspicious breast mass.

Ultrasonography-guided procedures

Ultrasonography-guided core needle biopsy is the modality of choice for most patients when a suspicious abnormality is visible on ultrasonography.[35] Generally, the patient is placed in an angled supine position, with her arm elevated for optimal lesion accessibility. Following administration of a local anesthetic, a small nick is made in the skin and a specialized 14- or 18-gauge spring-loaded core biopsy needle is inserted during real-time imaging with the ultrasonographic probe **(Figure 3)**. Several samples are obtained, and the pathologic diagnosis is generally available within a few working days. Breast core biopsy needles are also commercially available as handheld vacuum-assisted devices, which can sample larger amounts of tissue in a short time but are more expensive and often accompanied by a noisy vacuum device.

TABLE 5
Recommendations for breast MRI screening as an adjunct to mammography

Recommend annual MRI screening (based on evidence*)
BRCA mutation
First-degree relative of *BRCA* carrier, but untested
Lifetime risk ~20%–25% or greater, as defined by BRCAPRO† or other models that are largely dependent on family history
Recommend annual MRI screening (based on expert consensus opinion‡)
Radiation to chest between age 10 and 30 years
Li-Fraumeni syndrome§ (patient or first-degree relatives)
Cowden and Bannayan-Riley-Ruvalcaba syndromes¶ (patient or first-degree relatives)
Insufficient evidence to recommend for/against MRI screening#
Lifetime risk 15%–20%, as defined by BRCAPRO or other models that are largely dependent on family history
Lobular carcinoma in situ or atypical lobular hyperplasia
Atypical ductal hyperplasia
Heterogeneously or extremely dense breast on mammography
Personal history of breast cancer, including ductal carcinoma in situ
Recommend against MRI screening (based on expert consensus opinion)
Lifetime risk < 15%

* Evidence from nonrandomized screening trials and observational studies.

† A statistical model and software package for genetic counseling of women at high risk of hereditary breast or ovarian cancer.

‡ Based on evidence of lifetime risk for breast cancer.

§ A rare disorder that greatly increases the risk of developing several types of cancer, including breast cancer, particularly in children and young adults.

¶ Hamartoma syndromes associated with increased incidence of several malignancies, especially a marked increase in the incidence of breast carcinoma in women.

Payment should not be a barrier. Screening decisions should be made on a case-by-case basis, as there may be particular factors to support MRI. More data on these groups is expected to be published soon.

Ultrasonography-guided fine-needle aspiration is an additional option for patients when core biopsy cannot be performed because the lesion is located adjacent to sensitive structures, such as implants or the pectoralis muscle. Fine-needle aspiration is also used to evaluate complicated breast cysts and, occasionally, lymph nodes. Drawbacks of fine-needle aspiration (relative to larger core needle biopsy) are that it is limited to cytologic, not histologic, examination and that it yields a higher false-negative rate.

Stereotactically guided procedures

Stereotactic core biopsy is performed when lesions—usually calcifications, but sometimes masses—are visible only on mammography.[36,37] "Stereotactic" refers to the means by which the target is localized, ie, with a "stereo pair" of digital mammogram pictures with a small field of view. The patient is placed in a prone position with the breast of interest placed through a hole at the undersurface of the table in a light compression. The biopsy unit is attached to a dedicated computer that calculates coordinates. The needle is then brought to the coordinate position for sampling to take place.

The biopsy needle used for this procedure is vacuum-assisted, which means the needle is placed only one time, and samples in the vicinity of the target are vacuumed into a reservoir for retrieval. If the target is calcifications, a specimen radiograph is routinely performed to verify adequate sample acquisition before the patient leaves the biopsy table.[38] When the original target is no longer visible, a titanium marker clip is often placed. This facilitates localization of the biopsied area should surgery be needed.

Stereotactic biopsy has several limitations that ultrasonography-guided biopsy does not. The patient must be cooperative and mobile enough to get on the table and hold a prone position for the duration of the procedure (about 45 minutes). If the patient is taking warfarin or has a bleeding diathesis, preprocedure steps such as clinical evaluation to check the international normalized ratio and prothrombin time, or even stopping the warfarin temporarily, may be needed to minimize bleeding during the procedure, as a 9- or 12-gauge needle is used. Stereotactic biopsy is also limited by lesion position. A far posterior lesion may not be accessible if it does not reach through the hole in the table. Also, there is a limit to the compressed thinness of breast tissue that can be biopsied. Finally, most tables used for stereotactic biopsy have a functioning weight limit of 300 pounds.

Open surgical biopsy

A final option is open surgical biopsy, which is used when the more minimally invasive techniques are equivocal, discordant, or impossible due to the limitations noted above, or when atypical cells are found.

HOW SHOULD WE SCREEN OUR PATIENTS?

The various screening options for breast cancer are listed in **Table 4**, along with their market approval status and Medicare reimbursement levels.

For women at average risk for breast cancer, the American Cancer Society recommends an annual mammogram and clinical breast examination by a

physician beginning at age 40 **(Table 1)**.[10]

For women at high risk for developing breast cancer (> 20% to 25% lifetime risk, based on the Gail model[6] or similar risk models), breast MRI should be considered as an adjunct to annual screening mammography **(Table 5)**.[39] Evidence is currently insufficient, however, to support the adjunctive use of breast MRI for women with other risk factors **(Table 5)**, although studies are ongoing.[39]

In conclusion, the process of finding breast cancer includes regular screening with mammography and clinical breast examination (plus MRI in high-risk women) and the diagnostic modalities of ultrasonography, MRI, and diagnostic mammography. Our ultimate goal is to find cancer at the earliest time possible by all means necessary for the individual patient.

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Overview of breast cancer staging and surgical treatment options

ABSTRACT

Following diagnosis of breast cancer, patients undergo assessment for local and systemic treatment. Establishing a relationship and communication with the patient is critical to this assessment, as are history-taking, clinical breast examination, review of imaging studies, and interactive discussion with the patient of treatment options and possible breast reconstruction. Some type of surgical therapy is indicated in virtually all women with breast cancer, generally as the first part of a multicomponent treatment plan. The main goal of surgical therapy is to remove the cancer and accurately define the stage of disease. Surgical options broadly consist of breast conservation therapy, generally followed by radiation therapy, or mastectomy. The surgical procedure also includes assessment of regionl lymph nodes for metastasis, either by axillary lymph node dissection or by the less-invasive sentinel lymph node biopsy, for the purpose of cancer staging and guiding adjuvant therapy.

In the late 19th century, breast cancer was considered a fatal disease. That began to change in the 1880s when W.S. Halsted described the radical mastectomy as the way to treat patients with breast cancer.[1] This aggressive surgical treatment—in which the breast, axillary lymph nodes, and chest muscles are all removed—remained the standard of care throughout much of the 20th century; as late as the early 1970s, nearly half (48%) of breast cancer patients were treated with radical mastectomy. During the 1970s, however, the Halsted radical mastectomy was largely abandoned for a less-disfiguring muscle-sparing technique called the modified radical mastectomy; by 1981, only 3% of patients underwent the Halsted mastectomy.[2]

The 1980s heralded even more minimally invasive techniques with the advent of breast conservation therapy, in which an incision is made over the tumor and the tumor is completely removed with negative margins, leaving behind normal breast tissue. (This procedure has been referred to by many different names, including definitive excision, lumpectomy, quadrantectomy, and partial mastectomy; since they all mean the same thing, for clarity and consistency this article will use "breast conservation therapy" throughout.) During the 1990s, surgical invasiveness was further minimized with the emergence of sentinel lymph node excision.

An important contributor to this evolution in the standard of breast cancer therapy since the 1970s has been the National Surgical Adjuvant Breast and Bowel Project (NSABP), a National Cancer Institute–funded clinical trials cooperative group. NSABP studies have been the driving force to show that the extent of surgery could be reduced without compromising outcome.[3] These studies, along with several other trials, have resulted in a marked reduction in surgical aggressiveness and a multitude of adjuvant therapies for women with breast cancer. This article will briefly explore where this evolution has brought us in terms of the surgical options available for treatment of breast cancer today. We also discuss other key components in the management of women with newly diagnosed breast cancer, including cancer staging, patient counseling, and assessment of axillary lymph nodes.

BREAST CANCER CLASSIFICATION AND STAGING

Pathologic classification

Breast cancer is an adenocarcinoma that occurs primarily in two forms: ductal or lobular carcinoma, in which malignancy develops in the breasts ducts or lobules, respectively. The majority of breast cancers are ductal in origin. Another key pathologic distinction is between in situ versus invasive carcinoma, which depends on whether the cancer cell remains within the duct or lobule (stage 0, or in situ) or has spread on a microscopic level to the adjacent breast

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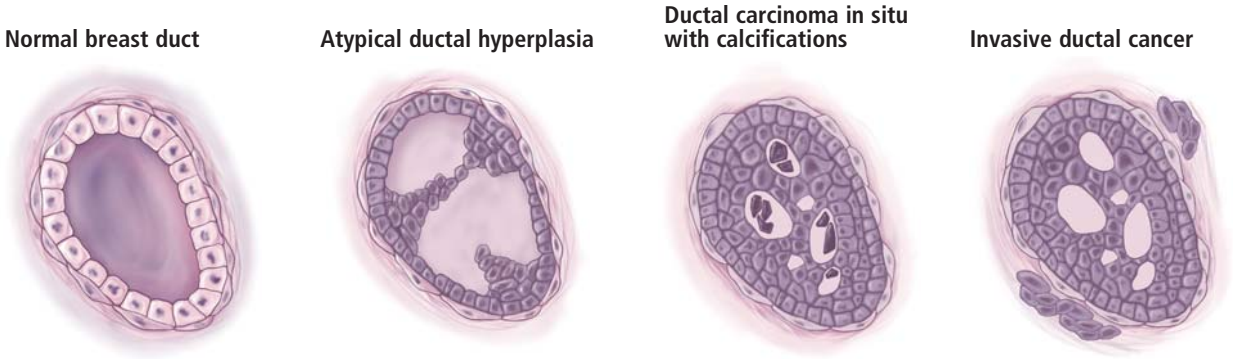

FIGURE 1. Histology progression model of ductal breast cancer.

parenchyma (invasive or infiltrating) **(Figure 1)**. Despite its nomenclature, lobular carcinoma in situ is not a cancer; it is merely a marker of increased risk for developing invasive cancer (either ductal or lobular) that may appear on either side (right or left breast), not just the side of the original biopsy.

Cancer staging

"What stage am I?" is a question every patient asks upon receiving a new diagnosis of breast cancer. Breast cancer staging is based on the TNM system, defined by the American Joint Committee on Cancer, which takes into account tumor (T) size, the extent of regional lymph node (N) involvement, and the presence or absence of metastasis (M) beyond the regional lymph nodes.[4] Using this system, whose criteria and details are outlined in **Table 1**, breast cancer is staged from 0 to IV. Stage 0 implies in situ cancer, while stages I to IV indicate invasive cancer, with IV implying metastatic spread to distant organs.

A simpler method relies on the National Cancer Institute's SEER (Surveillance, Epidemiology, and End Results) summary staging system.[5] This system classifies tumors as "localized" (contained in the breast, either in situ or invasive), "regional" (identified in regional lymph nodes), or "metastatic" (spread to distant organ systems).

Of course, patients cannot be told their stage until after surgery, when a final pathologic report detailing tumor size and nodal status is available. Some patients will never be definitively staged—for instance, those who undergo neoadjuvant chemotherapy for locally advanced disease prior to lymph node dissection, or those who do not have a metastatic work-up. The metastatic work-up involves ordering of additional tests to assess for metastasis, but only when prompted by specific patient symptoms. Thus, if the patient has shortness of breath, a chest radiograph or a chest computed tomograph (CT) needs to be ordered; for elevated liver enzymes, CTs of the abdomen and pelvis are ordered; for central nervous system symptoms, brain magnetic resonance imaging (MRI) is ordered; and for back pain or bone pain, a bone scan is ordered to rule out metastatic disease of bone.

INITIAL PATIENT ASSESSMENT AND COUNSELING

Relationship-building is fundamental

Following an initial diagnosis of breast cancer, the patient must undergo an assessment for local and systemic disease. The surgeon, as a member of a multidisciplinary breast cancer treatment team, often spearheads this initial assessment. This first visit must go beyond mere clinical evaluation, however, and include thorough discussion and relationship-building with the patient, as this early meeting establishes a relationship with the patient that will carry through her entire process of cancer care. For a true understanding between patient and surgeon to occur, it is critical for patients to be comfortable in sharing their fears, expectations, and lifestyle needs. Following a diagnosis of breast cancer, the initial reactions women go through include both fear and realization of one's own mortality. Although these responses may no longer be justified by the reality of patient outcomes in most cases, they are normal and fully understandable reactions. For this reason, clinicians must be sensitive to these reactions while being supportive about the efficacy of the treatment options available.

History, breast exam, and review of imaging studies

In addition to the establishment of communication and understanding, the vital components of this first meeting include a detailed medical history, a clinical breast examination, a review of imaging studies, and a discussion of treatment options.

TABLE 1
Criteria for staging breast tumors according to the American Joint Committee on Cancer's TNM classification[4]

	Primary tumor (T)*	Regional lymph node status (N)	Distant metastasis (M)
Stage 0	Carcinoma in situ	No evidence of cancer in nearby nodes	No
Stage I	Tumor ≤ 2 cm†	No evidence of cancer in nearby nodes	No
Stage IIA	No evidence of primary tumor	Metastasis to 1–3 nodes	No
	Tumor ≤ 2 cm†	Metastasis to 1–3 nodes	No
	Tumor > 2 cm but ≤ 5 cm	No evidence of cancer in nearby nodes	No
Stage IIB	Tumor > 2 cm but ≤ 5 cm	Metastasis to 1–3 nodes	No
	Tumor > 5 cm	No evidence of cancer in nearby nodes	No
Stage IIIA	No evidence of primary tumor	Metastasis to 4–10 nodes	No
	Tumor ≤ 2 cm†	Metastasis to 4–10 nodes	No
	Tumor > 2 cm but ≤ 5 cm	Metastasis to 4–10 nodes	No
	Tumor > 5 cm	Metastasis to 1–3 nodes	No
	Tumor > 5 cm	Metastasis to 4–10 nodes	No
Stage IIIB	Tumor of any size with direct extension to chest wall or skin	No evidence of cancer in nearby nodes	No
	Tumor of any size with direct extension to chest wall or skin	Metastasis to 1–3 nodes	No
	Tumor of any size with direct extension to chest wall or skin	Metastasis to 4–10 nodes	No
Stage IIIC	Any tumor designation	Metastasis to > 10 nodes	No
Stage IV	Any tumor designation	Any lymph node designation	Yes

* Size measurements are for the tumor's greatest dimension.
† Includes microinvasion of 0.1 cm or less in greatest dimension.

The history should include all aspects of the patient's reproductive history, her family history of breast cancer, and any comorbidities and medications being taken.

The clinical breast examination should give special attention to the shape (asymmetry), appearance (eg, dimpling, erythema, nipple inversion), and overall feel of the breasts. A palpable mass must be recorded in terms of its location in relation to the skin, the nipple-areola complex, and the chest wall, as well as the quadrant of the breast in which it lies. The regional lymph node basins need to be examined closely, including the axilla and supraclavicular nodes.

Imaging studies also need to be reviewed closely. Patients today frequently present with multiple types of imaging studies, including mammography, ultrasonography, and MRI. Occasionally patients also may present with nuclear medicine exam results, CTs, thermographic images, positron emission tomography studies, and bone scans. All radiology studies need to be reviewed closely and examined in the context of what they were ordered for and what utility they potentially provide.

Treatment options: Surgery is first step in most cases

Once the above components are addressed, the patient should be engaged in a discussion of treatment options. Most women with breast cancer will undergo some type of surgery in conjunction with radiation therapy, chemotherapy, or both. Generally, surgery takes place as the first part of a multiple-component therapy plan. The main goal of surgery is to remove the cancer and accurately define the stage of the disease.

Consider plastic surgery consultation

When indicated and available, consultation with a plastic surgery team may be appropriate at this stage to provide support and comfort to the patient so that she better understands her options for breast reconstruction along with those for breast cancer surgery. Recent data show that most general surgeons do not discuss reconstruction with their breast cancer patients before surgical breast cancer therapy, but that when such discussions do occur, they significantly influence patients' treatment choices.[6] Giving patients the chance to learn about reconstructive options through discussion with a plastic surgeon represents a good opportunity to provide complete patient care in a multidisciplinary way.

OVERVIEW OF SURGICAL OPTIONS

Two general approaches, no difference in survival

The two mainstays of surgical treatment today are (1) breast conservation therapy, generally followed by total or partial breast irradiation, and (2) mastectomy.

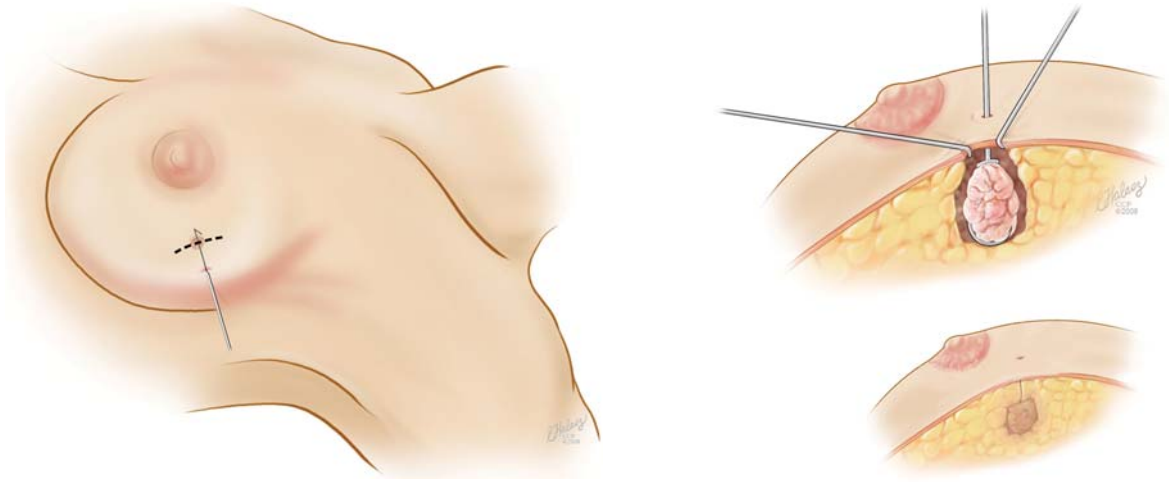

FIGURE 2. Needle localization for partial mastectomy (breast conservation therapy). The left panel shows an operative approach to a mammographically evident breast cancer that has been localized (ie, a wire placed preoperatively). An incision is made over the breast cancer and the wire is followed down to the cancer (right panel), which is then excised and sent for specimen radiography to confirm that the correct area has been removed. Clips (not shown) are then left along the border of the cavity to help the radiation oncologist plan radiation therapy.

The prospective randomized trial data obtained from the NSABP trials have demonstrated no survival differences between patients with early-stage breast cancer based on whether they were treated with breast conservation therapy or mastectomy.[2] Beyond this fundamental issue of survival, there are a number of nuances, many of them logistical, related to the success of either operation that the clinician must keep in mind when presenting these surgical choices to patients. These considerations are reviewed below.

Breast conservation therapy

For breast conservation therapy, the ratio of tumor size to breast size must be small enough to ensure complete tumor removal with an acceptable cosmetic outcome. In general, it is estimated that up to 25% of the breast can be removed while still ensuring a "good" cosmetic outcome. Advances in closure techniques allowing for more tissue to be removed with even better cosmetic outcomes are known as oncoplastic closure. These techniques are mostly performed by breast oncologic surgeons, often in consultation or conjunction with plastic surgeons. (Reconstructive options following breast conservation therapy are reviewed in a subsequent article in this supplement.) Additionally, the patient must agree and be deemed a candidate for postoperative radiation therapy. The patient must be able to be followed clinically to enable early detection of a potential local recurrence.

Figure 2 depicts needle localization and tumor excision in breast conservation therapy. The mainstay of breast conservation therapy is removal of the tumor with adequate normal breast tissue surrounding the cancer. Much debate surrounds "margin status," or the width of normal breast tissue surrounding a gross tumor that has been removed. While it is understood that the goal of breast conservation therapy is to reduce tumor burden and obtain negative margins, a negative tumor margin does not guarantee complete absence of tumor. However, a negative margin is assurance that the tumor burden is reduced to microscopic levels that can be controlled by radiation therapy. Often the margin status is not known until the final pathologic specimen is serially sectioned and examined microscopically. A positive margin after initial breast conservation therapy generally requires a return to the operating room for further resection and clearance.

Mastectomy

A second surgical option for patients is mastectomy. Today "mastectomy" can refer to any of several subtypes of surgical procedures, which are outlined below and should be considered on a patient-by-patient basis. Mastectomy is appropriate when breast conservation therapy is not possible (due to large or multicentric tumor) or would result in poor cosmetic outcome, or when the patient specifically chooses it.

Modified radical mastectomy (Figure 3, left) involves complete removal of the breast with preservation of the pectoral major and minor muscles (unlike radical mastectomy) and dissection of level I and II axillary lymph nodes. Level I lymph nodes are the lowest-lying nodes in the axilla, inferior to the lower edge of the pectoralis minor muscle; level II nodes lie under-

FIGURE 3. Incisions for three common types of mastectomy.

neath the pectoralis minor muscle. (Level III axillary lymph nodes, which are not dissected in this procedure, lie above the pectoralis minor muscle.)

Simple mastectomy involves removal of the breast only, without removal of lymph nodes. Either of the incisions depicted in the left and center panels of **Figure 3** can be used. Both modified radical mastectomy and simple mastectomy involve removal of the nipple and areola (nipple-areola complex).

Skin-sparing mastectomy (Figure 3, center) is performed when a patient is undergoing immediate breast reconstruction (using either a silicone or saline implant or autologous tissue). The goal is to remove all breast tissue, along with the nipple-areola complex, while preserving as much viable skin as possible to optimize the cosmetic outcome.[7,8]

Nipple-areola–sparing mastectomy. There is increasing experience with attempts to preserve the nipple-areola complex. These procedures attempt to preserve either the whole complex, termed nipple-areola–sparing mastectomy (sometimes called simply nipple-sparing mastectomy) **(Figure 3, right)**, or just the areola, with removal of the nipple (areola-sparing mastectomy). These procedures are also performed in a skin-sparing fashion.

There is some controversy surrounding these techniques to spare the nipple and/or areola, including debate over which technique—nipple-areola–sparing mastectomy or areola-sparing mastectomy—may be more oncologically safe. Currently the literature shows that both are probably safe oncologic alternatives for remote tumors that do not have an extensive intraductal component. Generally, frozen sections are performed intraoperatively on the retroareola tissue to document that there is no evidence of tumor.[9]

The main driving force behind all of these types of skin-sparing techniques is aesthetic outcome; **Figure 4** depicts the comparative outcomes in a patient who underwent skin-sparing mastectomy in the right breast and nipple-sparing mastectomy in the left. Ongoing randomized controlled studies are being conducted to further validate these procedures.

SURGICAL COMPLICATIONS

Breast procedures are fairly safe operations, but every operation has a risk of complications. Reported complications of breast surgery include the following:

- Bleeding
- Infection (including both cellulitis and abscess)
- Seroma
- Arm morbidity (including lymphedema)
- Phantom breast syndrome
- Injury to the motor nerves.

Seromas often occur in patients after mastectomy or lymph node surgery. Prolonged lymphatic drainage is usually exacerbated by extensive axillary node involvement and obesity.

Arm morbidity can present in different ways. Lymphedema is the most common manifestation, with reported incidences of approximately 15% to 20% when axillary lymph node dissection is performed versus 7% when sentinel lymph node biopsy is done.[10] The risk of lymphedema can be reduced by avoiding blood pressure measurements, venipunctures, and intravenous insertions in the arm on the side of the surgery, as well as by wearing a compression sleeve on the affected arm during airplane flights.

Phantom breast syndrome is rare but may manifest as pain that may also involve itching, nipple sensation, erotic sensations, or premenstrual-type soreness.

Many surgeons have historically removed the intercostobrachial nerves but are now trying to preserve

FIGURE 4. Photos of a patient before (left) and after (right) bilateral mastectomy and breast reconstruction using silicone implants. The patient underwent skin-sparing mastectomy for cancer in the right breast and prophylactic nipple-areola–sparing mastectomy in the left breast.

these nerves, which when removed cause loss of sensation in the upper inner arm. Although rare, nerve injury during an axillary procedure has been reported. It may involve the long thoracic nerve (denervating the serratus anterior muscle and causing a winged scapula) or the thoracodorsal bundle (denervating the latissimus dorsi muscle and causing difficulty with arm/shoulder adduction).

LOCAL CANCER RECURRENCE

Among women undergoing mastectomy for breast cancer, 10% to 15% will have a recurrence of cancer in the chest wall or axillary lymph nodes within 10 years.[11] Similarly, among women undergoing breast conservation therapy plus radiation therapy, 10% to 15% will have in-breast cancer recurrence or recurrence in axillary lymph nodes within 10 years, although women who undergo breast conservation therapy without radiation have a much higher recurrence rate.[11] Considerations for screening the surgically altered breast are discussed in the previous article in this supplement (see page S5).

ASSESSMENT OF AXILLARY LYMPH NODES FOR METASTASIS

Even when patients have a known histologic diagnosis of breast cancer and have made a firm decision regarding the surgical option for removal of their cancer, the status of their axillary lymph nodes remains a great unanswered question until after the surgical procedure is completed. Lymph node status—ie, determining whether the cancer has spread to the axillary lymph nodes—still serves as the critical determinant for guiding adjuvant treatment, predicting survival, and assessing the risk of recurrence.

Axillary lymph node dissection

The standard approach for evaluating lymph node status has been a complete dissection of the axillary space, or axillary lymph node dissection. As briefly noted above, the axillary lymph nodes are anatomically classified into three levels as defined by their location relative to the pectoralis minor muscle. The extent of a nodal dissection can be defined by the number of nodes removed.

Sentinel node biopsy: A less-invasive alternative

Axillary lymph node dissection has been called into question over the last 15 years due to its invasiveness and the potential morbidity associated with it (including lymphedema and paresthesias). As a result, sentinel lymph node biopsy, a minimally invasive technique for identifying axillary metastasis, was developed to avoid the need for (and risk of complications from) axillary lymph node dissection in patients who have a low probability of axillary metastasis.

The concept of the sentinel node is based on two basic principles: (1) there is an orderly and predictable pattern of lymphatic drainage to a respective nodal basin, and (2) the first lymph node functions as an effective filter for tumor cells.[12] The technique of mapping the sentinel node in breast cancer patients was developed in the early 1990s and has since been studied, refined, and validated. The technique is performed intraoperatively with periareolar injection of vital blue dye, technetium-labeled sulfur colloid, or a combination of the two **(Figure 5)**. The axillary lymph nodes are then inspected for staining and/or the radioactive tracer, and any node that has taken up the dye or tracer is designated as a sentinel lymph node and removed **(Figure 6)**. Generally, the sentinel node is sent for intraoperative frozen section examination to determine the presence or absence of metastasis. If the sentinel lymph node biopsy is positive for metastasis, then axillary lymph node dissection is warranted; if it is negative, no additional axillary surgery is needed.

If this mapping procedure fails to clearly identify a sentinel node, then a complete axillary lymph node dissection is performed. Reasons for failed mapping include technical issues as well as anatomic ones.[13]

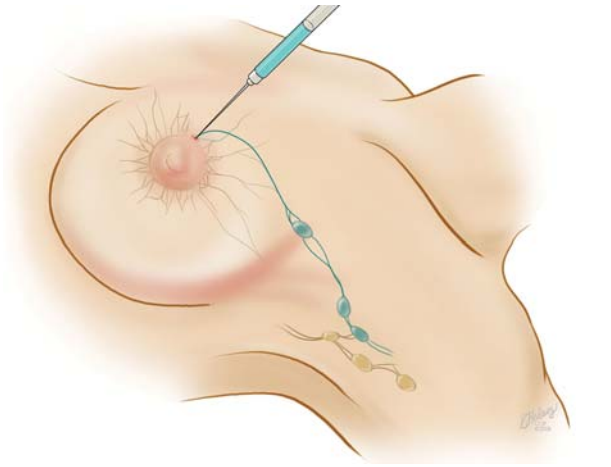

FIGURE 5. Sentinel lymph node biopsy involves intraoperative injection of vital blue dye and/or radionuclide near the areola, after which the axillary nodes are inspected for uptake of the dye or radionuclide to identify the sentinel node.

Performing sentinel lymph node biopsies clearly involves a learning curve, and the sensitivity and specificity of these biopsies do vary among surgeons, correlating with the surgeons' technical experience.[14] Disruption of the breast lymphatics from prior breast surgery can reduce the sensitivity of a sentinel lymph node biopsy. Similarly, the presence of a hematoma or seroma from a prior biopsy can impede sentinel node detection. Tumor location can also be a factor in detecting a sentinel node, especially for tumors located in the inner quadrants of the breast, as they may drain to the internal mammary nodes.

Overall, however, it is now accepted that intraoperative lymph node mapping with sentinel lymphadenectomy is an effective and minimally invasive alternative to axillary lymph node dissection for identifying nodes containing metastases.

CONCLUSIONS

Decisions surrounding the choice of breast surgery procedure must be individualized to the patient and her desires and based on comprehensive patient evaluation and thorough patient counseling. Optimal results for the patient—oncologically, psychologically, and in terms of cosmetic outcomes—require consultation and collaboration among general surgeons, medical oncologists, genetic counselors, radiation oncologists, radiologists, and plastic surgeons to clarify the risks and benefits of various intervention options. Striving for this multidisciplinary collaboration will promote optimal patient management and the most favorable clinical outcomes.

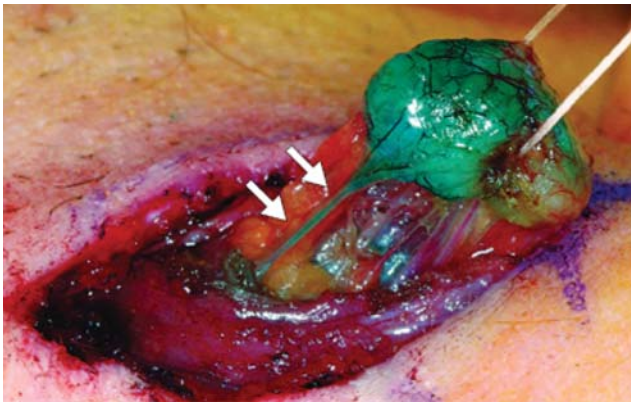

FIGURE 6. Removal of a sentinel lymph node after uptake of vital blue dye. Arrows point to the afferent lymphatic vessel that drains to the lymph node.

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Breast reconstruction options following mastectomy

ABSTRACT

Breast reconstruction can help to address the disfigurement and sense of loss that often follow mastectomy. The decision whether to pursue reconstruction and the choice of reconstructive strategy are individualized decisions that must take into account the patient's body characteristics, overall health, breast cancer treatment plan, and personal preferences. Options for reconstruction broadly include placement of breast implants or use of the patient's own tissue (autologous reconstruction). Both saline-filled and silicone gel-filled implants are safe and effective options for implant-based reconstruction. Autologous reconstruction usually involves transfer of tissue from the abdomen, with recent advances allowing preservation of the abdominal muscles. Both implant-based and autologous procedures have advantages and drawbacks, and both types of reconstruction may be compromised by subsequent radiation therapy. For this and other reasons, consultation with a plastic surgeon early in treatment planning is important for women considering postmastectomy reconstruction.

Patients recently diagnosed with breast cancer are distraught with concerns not only about surviving their disease but also about how its treatment will affect their body image and self-image. Although the risk of breast cancer increases with age, it is not a disease limited to the elderly. With advances in screening and awareness, breast cancers are now detected at earlier stages and in younger women. Approximately 5% of breast cancer patients are age 40 years or younger, which explains the recommendation that women be told about the benefits (and limits) of regular breast self-examinations beginning in their 20s.[1] Additionally, breast cancer is the most common cancer in pregnant and postpartum women, occurring in about 1 in 3,000 pregnant women.[2] Although breast conservation therapy is an attractive option, for many patients mastectomy is still the recommended surgical treatment. When mastectomy is required, it is understandable that many women are very concerned about losing their breast.

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REASONS FOR RECONSTRUCTION

Mastectomies are commonly performed for women with ductal carcinoma in situ or with early or locally advanced invasive breast cancer (infiltrating ductal carcinoma) and sometimes for recurrent disease or for prophylaxis in high-risk women such as those with *BRCA* gene mutations or lobular carcinoma in situ. As reviewed in the preceding article in this supplement, mastectomy can be performed in various ways, using modified radical, skin-sparing, or nipple-sparing mastectomy techniques.

An emotional 'double hit'

Following mastectomy, women are often left with what may be regarded as an emotional "double hit." First, of course, is the anxiety from having a cancer diagnosis. Second, and perhaps equally devastating for some, is the emotional impact of losing a breast and the accompanying perception of disfigurement or loss of femininity and sexuality. These latter feelings often lead women who have undergone or will undergo mastectomy to explore the possibility of breast reconstruction.[3–5]

Both a medical and an emotional decision

While the reasons that women may seek breast reconstruction are many and varied (eg, to restore their self-esteem and social functioning, to help put their cancer experience behind them), it is important for primary care providers and other referring physicians to recognize that this decision is both a medical and an emotional one. Most women healthy enough to undergo extirpative surgical procedures are, in fact, healthy enough to undergo breast reconstruction if

desired. Since choosing a reconstructive strategy is a complex process that takes into account many therapeutic and individual patient factors, plastic surgery consultation plays a major role in the comprehensive treatment of breast cancer.

TIMING AND TYPE OF RECONSTRUCTION

The timing of breast reconstruction can vary. In cases where the patient knows she will want reconstruction and the cancer surgery is performed at a site where a reconstructive surgery team is available, reconstruction can be performed immediately following mastectomy during a single trip to the operating room. When a reconstructive surgeon is not available locally or when systemic or local cancer therapies need to be completed first, reconstruction may need to be delayed.

Immediate reconstruction has the advantage of improved aesthetics while mitigating the sense of loss that can accompany mastectomy. Delayed reconstruction will give the patient more time for her decisions. An additional option, called "delayed-immediate" reconstruction, involves placing a tissue expander at the time of mastectomy (to preserve the breast skin envelope) and awaiting pathology results to determine whether radiation therapy is needed. If radiation is not needed, the patient undergoes reconstruction right away; if radiation is needed, the patient undergoes delayed reconstruction after radiation therapy is completed, with the breast skin envelope preserved for better aesthetic results. (The timing of reconstruction and these various timing options are discussed in detail in the final article in this supplement.) Selecting the correct timing and method of reconstruction requires good communication and coordination between the patient, her oncologist, and her multidisciplinary surgical team comprising both breast and plastic surgery specialists.

The patient and her surgeon will also discuss which reconstructive technique is best for her. Choosing a reconstructive strategy is a highly individualized process that takes into account the patient's body characteristics, overall health, breast cancer treatment plan, and personal preferences. Consequently, a strategy offered to one patient is not necessarily valid for another. In general, options for reconstruction include use of the patient's own tissue (autologous tissue), use of implant material (nonautologous), or a combination of an implant and autologous tissue.

IMPLANT-BASED RECONSTRUCTION

What the procedure involves

Nonautologous breast reconstruction usually involves a two-step procedure: placement of a tissue expander followed by later placement of a permanent implant.

At the time of mastectomy, a tissue expander type of implant is placed under the pectoralis major muscle, the main muscle under the breast. The tissue expander is then inflated at weekly intervals by percutaneous injection of saline solution, allowing expansion of the tissues over the expander, including the muscle and breast skin. These injections are administered in an outpatient clinic beginning about 2 to 3 weeks after expander placement. Once the expander is filled to the desired volume and the tissue has been expanded sufficiently, which typically takes 3 to 6 months, a second procedure is performed to remove the expander and place a permanent implant. This latter procedure is done through the previous scars and usually is much less involved than the first operation. **Figure 1** illustrates the various stages of expander placement and inflation.

Choice of permanent implant

Permanent implants vary by shape, texture of the implant shell, and filler material. They are typically filled with either silicone gel or saline.

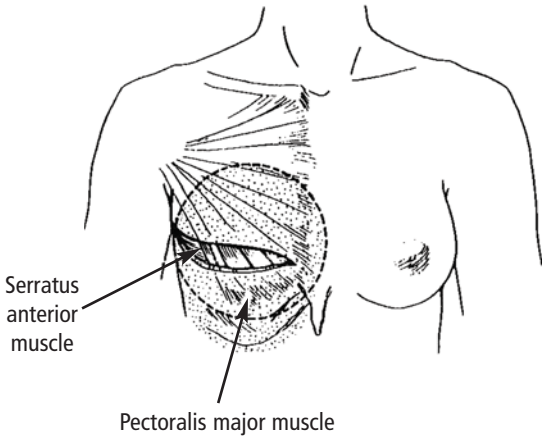
Breast implants have been available for many years for use in both reconstructive breast surgery and cosmetic augmentation. A great deal of bad press and misinformation had surrounded the use of silicone gel-filled implants, with the result that they ceased to be marketed in the United States beginning in the early 1990s while the US Food and Drug Administration (FDA) reviewed additional safety information on their use. During this period when the use of silicone implants was limited, saline-filled implants became the preferred choice until the FDA approved the reintroduction of silicone implants to the market in November 2006, after what the agency described as years of rigorous scientific review of multiple clinical studies and other data.[6] The FDA concluded that silicone implants are safe and effective for general use in breast reconstruction, correction of congenital breast anomalies, and breast augmentation.[6] There is no evidence that silicone implants pose a significant systemic risk to women undergoing breast reconstruction.

The silicone implant offers a softer, more natural feel to the reconstructed breast than the saline implant. As a result, increasing numbers of women are opting for silicone implants **(Figures 2, 3)**. However, saline implants remain a sound, proven alternative for women who are not comfortable with receiving a silicone implant.

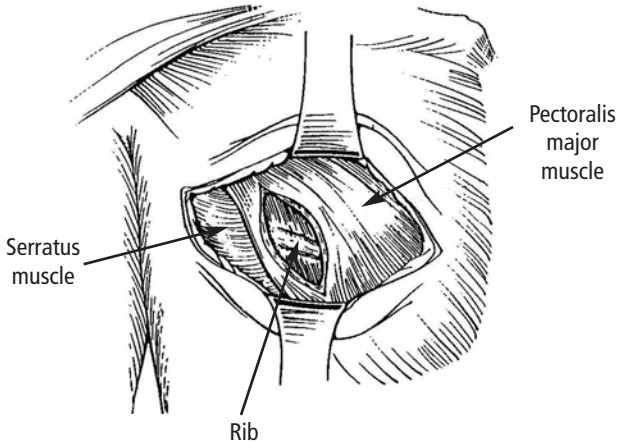
Potential complications

Implant extrusion. One of the potential complications of implant-based reconstruction is extrusion of the tissue expander or implant through the skin. If

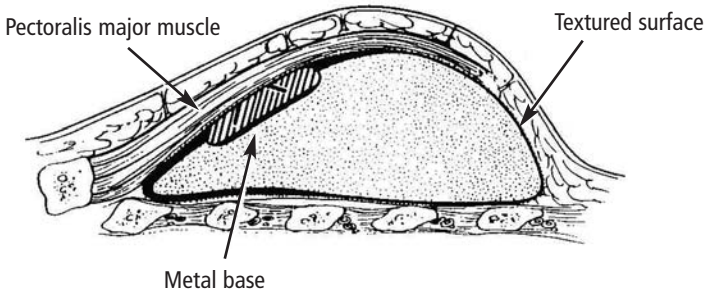
Preparation for expander placement



Pocket preparation for expander placement



Anatomic position of expander



Expansion of tissue with inflations over a period of 3 to 6 months

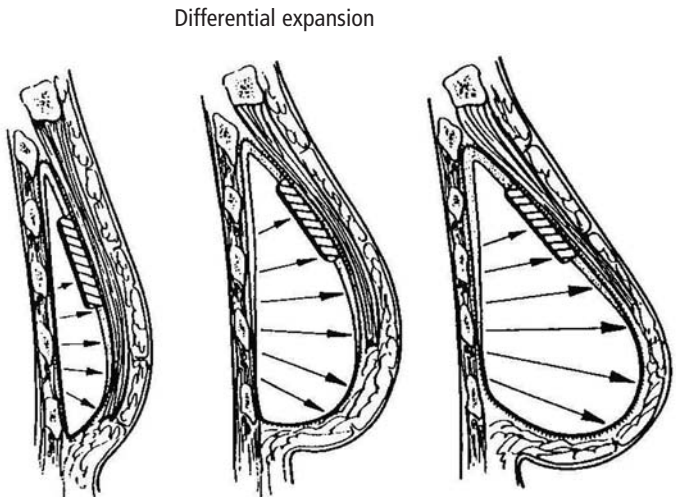


FIGURE 1. The process of expander placement and inflation in preparation for implant-based reconstruction.

FIGURE 2. Preoperative (left) and postoperative (right) photos of a patient who underwent mastectomy of the right breast followed by silicone implant placement and nipple reconstruction. She had matching vertical mastopexy of the left breast. The postoperative photo was taken 20 months after reconstruction.

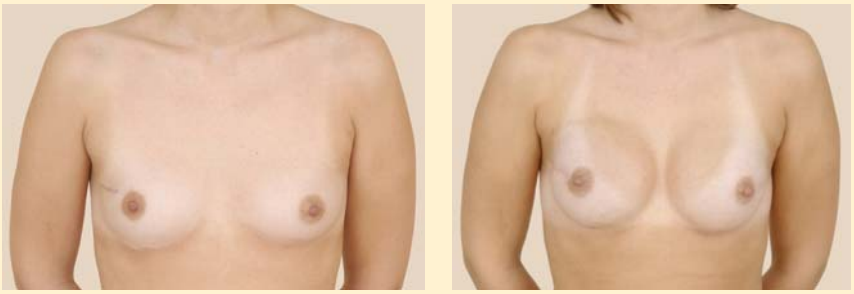


FIGURE 3. Preoperative (left) and postoperative (right) photos of a patient who underwent reconstruction with silicone implants after bilateral nipple-sparing mastectomy. The postoperative photo was taken at 9-month follow-up.

the implant becomes exposed, it will likely need to be removed. The risk of implant extrusion is, in part, why the implant is placed under the chest wall muscle, since the muscle provides protective cover. Because the breast skin often is very thin after mastectomy, placement of the implant directly under the skin alone does not provide adequate protective coverage and is therefore no longer an acceptable reconstructive technique.

Capsular contracture is another potential and more frequent complication of implant-based reconstruction. In all cases, the body forms a protective coverage, or fibrous capsule, around the implant. This process is called encapsulation. Most of the time, the capsule is relatively thin and pliable. Infrequently, however, the capsule can become thickened, hardened, and contracted, which constitutes capsular contracture. Although rare, severe contractures cause deformation of the reconstructed breast as well as pain. Severe contractures often require an operation to replace or remove the implant and treat the excessively thickened capsule. This can be done by exchanging the implant and either opening the capsule (capsulotomy) or removing the capsule (capsulectomy). If the contracture is significant enough or if the contracture recurs, then reconstruction using autologous tissue might be needed.

Advantages of implant reconstruction

Although nonautologous implant-based reconstruction can have some limitations, this procedure attracts many patients as a result of its advantages and good aesthetic results. The mastectomy procedure is prolonged by only about 1 hour, and most patients require only an overnight stay after the procedure. The recovery period is approximately 2 to 3 weeks, at which point tissue expansion is started.

What if radiation therapy is needed?

When treatment of the breast cancer is expected to involve radiation therapy right from the beginning, implant-based reconstruction is not an optimal choice. Radiation can affect the reconstruction in several negative ways. By design, radiation treats cancer by destroying dividing cells. Dividing cells are also required for wound healing and tissue remodeling. Without this remodeling ability, surgical scars are more susceptible to breakdown, which leads to tissue loss. In addition, because the effects of radiation are long-term, over time the thin tissue over the implant might respond poorly to the excessive stress of the implant, raising the possibility that tissue thinning could eventually lead to implant loss.[7]

Certainly there are instances when radiation therapy is not anticipated prior to the extirpative operation but

FIGURE 4. Preoperative (left) and postoperative (right) photos of a patient with left breast cancer who underwent mastectomy and immediate autologous reconstruction with the DIEP free flap technique. In a separate procedure, she had matching reduction mammaplasty of the right breast and nipple reconstruction on the reconstructed left breast. The postoperative photo was taken 17 months after initial reconstruction of the left breast.

then becomes necessary to complete the cancer treatment, based on final pathology results. Some patients in these circumstances may have had implants placed prior to the decision to give radiation. This does not doom the implant reconstruction to failure, however. Depending on the effect of the radiation and the patient's body, there might be only a limited impact on the implant and the overall reconstruction result. We recommended close follow-up in these patients to monitor for any long-term complications such as skin discoloration, implant extrusion, or capsular contracture, which can be addressed as they arise.

AUTOLOGOUS RECONSTRUCTION

Techniques using abdominal tissue

As noted above, autologous breast reconstruction uses the patient's own tissue. If the patient has adequate abdominal fat, the skin and fatty tissue of the lower abdomen may be used to reconstruct the missing breast. Historically, this type of reconstruction has included a portion of the abdominal muscles.

TRAM flap technique. The transverse rectus abdominis muscle (TRAM) flap technique takes advantage of the blood supply within the rectus abdominis muscle and its overlying skin and soft tissue. The muscle serves as the conduit for the blood supply of the skin and fatty tissue used in this method of reconstruction. The distal insertion of the muscle close to the pubic symphysis is cut, and the tissue receives its blood via the superior epigastric artery, which passes through the rectus muscle. This skin and soft tissue is then brought into the defect on the chest beneath the skin by tunneling it through the undermined skin flap between the abdomen and chest.

While the reconstructive results with the TRAM flap are good, this technique has been associated with increased risk of hernias or bulges in the abdominal wall. In sacrificing the rectus abdominis muscle, one of the major contributors to posture and the dynamic abdominal contour of the ventral abdomen is lost and the abdominal wall is weakened. This risk becomes even more significant when both rectus abdominis muscles are used to reconstruct both breasts.

DIEP free flap technique. Recent advances in breast reconstruction involve a variation of the TRAM flap operation that allows preservation of the rectus abdominis muscle. This procedure—called the deep inferior epigastric perforator (DIEP) free flap technique—involves meticulous dissection of the vessels within the rectus abdominis muscle from their distal perforation through the rectus fascia all the way down to their proximal pedicle off of the external iliac artery and vein. Once these vessels are identified and isolated, they are transected and reanastomosed to the internal mammary or thoracodorsal vessels of the chest. This anastomosis requires a microsurgical operation to reestablish blood perfusion to the flap. To complete the reconstruction, the flap is then secured and tailored to form a new reconstructed breast **(Figure 4)**. The main advantage of the DIEP technique is being able to use the patient's own tissue while minimizing morbidity to the patient.

Limitations of techniques using abdominal tissue. Although autologous reconstruction is most commonly performed using tissue from the lower abdomen, flaps from the lower abdomen can be used only when there is sufficient fatty tissue to provide bulk for reconstructing the breast. In thin patients, using flaps from the abdomen may not be a good option. Contraindications to autologous reconstruction using the abdomen include previous abdominal surgery such as abdominoplasty, liposuction, open cholecystectomy, or other major abdominal operations that would compromise circulation to the skin and tissue over the flap. Other relative contraindications to autologous tissue reconstruction using the

FIGURE 5. Preoperative (left) and postoperative (right) photos of a patient with left breast cancer who underwent mastectomy with immediate autologous reconstruction using the DIEP free flap procedure. This patient underwent radiation of the left breast following completion of her reconstruction. The postoperative photo was taken 20 months after surgery.

abdomen are obesity, smoking, a history of blood clots, and other major systemic medical conditions.

Options when abdominal tissue cannot be used

For patients who have insufficient tissue on the abdomen or have had previous abdominal surgery that compromises perfusion to the abdominal tissue, other options for autologous breast reconstruction are available. The gluteal tissue can be used, based on its superior or inferior blood supply, known as the superior gluteal artery perforator (SGAP) flap or the inferior gluteal artery perforator (IGAP) flap. Like the DIEP free flap technique, reconstruction using these flaps also requires a microsurgical procedure.

Another common option involves using skin and muscle from the back, or the latissimus dorsi myocutaneous flap. This flap does not require microsurgery; however, often the amount of tissue available to reconstruct the breast is inadequate to create a breast mound, requiring that the reconstruction be supplemented with an implant beneath the flap.[8]

Pros and cons of autologous reconstruction

Unlike implant-based reconstruction, autologous reconstruction obviously eliminates the need for implant replacement in the future. It also generally results in a more natural-feeling and natural-looking breast. Another advantage is that the breast reconstructed with autologous tissue will grow and decrease in size with weight fluctuations, just as a nonreconstructed breast would. Finally, in many cases the patient also essentially undergoes an abdominoplasty, or "tummy tuck" procedure, by virtue of how the tissue is harvested for reconstruction, which is likely to be welcomed by many patients.

At the same time, this need for an additional incision at the harvest site can constitute a drawback for other patients, given the additional scarring and a potential increased risk of complications. Additionally, radiation therapy also can affect wound healing and tissue remodeling in the autologously reconstructed breast, although its impact on the healing process and cosmetic outcome is usually less detrimental than is the case with implant-based reconstruction. Most of the time, the reconstructed breast will maintain its shape and volume **(Figure 5)**. However, some radiation changes can affect the final outcome of the reconstruction, and results vary by individual case.

COMPLETING THE RECONSTRUCTION

Nipple reconstruction

Reconstruction of the nipple and areola is important in that many patients feel that the nipple is what makes a breast. With the increased use of nipple-sparing mastectomy and improved reconstructive techniques, the aesthetic outcomes of reconstruction are often regarded as superior to many breast conservation procedures. A recent study by Cocquyt et al suggests that skin-sparing mastectomy with immediate DIEP flap reconstruction or TRAM flap reconstruction appears to yield a better cosmetic outcome than breast conservation therapy.[9]

Reconstruction of the nipple and areola restores the shape of the nipple, the shape of the areola, and the color of both with tattoos. Closing the autologous flap in a circular manner creates the shape of the areola, and the nipple is formed by local bilobed or trilobed skin flaps wrapped around each other to create a cone. Although nipple reconstruction can be performed at the time of immediate reconstruction, it is usually performed at a later time in the outpatient setting when the shape of the reconstructed breast is more definite after healing has occurred.

Revisional procedures

In many cases reconstructive breast surgery is not able to provide a breast that is shaped or sized exactly as

desired or that perfectly matches the contralateral breast. Revisional procedures are sometimes performed to improve breast appearance and symmetry. Most revisional breast surgeries are performed on an outpatient basis and at times can be completed at the time of nipple reconstruction.

Modifying the contralateral breast

Modification of the contralateral breast is often necessary, and either a mastopexy (breast lift), reduction, or augmentation of the contralateral side may be needed for symmetry.

Mastopexy and reduction mammaplasty. Mastopexy, a skin-tightening and nipple-repositioning procedure, is performed to correct soft tissue descent without removing much breast tissue (see **Figure 2**), while reduction mammaplasty involves removing 400 to 2,000 grams of breast tissue (see **Figure 4**). A patient who has had a unilateral mastectomy without reconstruction may be a candidate for reduction mammaplasty of the contralateral breast. A unilateral large breast can cause marked neck and back pain due to the asymmetry of the weight on the chest.

Augmentation. Patients with smaller breasts often will undergo a matching augmentation procedure on the contralateral breast following completion of mastectomy and reconstruction on the other side.

Prophylactic mastectomy. For some women with a very high lifetime risk of breast cancer, such as those with *BRCA1* or *BRCA2* gene mutations, prophylactic mastectomy of the contralateral breast or even bilateral prophylactic mastectomy may be recommended by the oncologic surgeon. In some of these selected patients with sufficient abdominal tissue, bilateral DIEP flaps may be suitable; otherwise, the reconstruction can be completed with tissue expanders and implants.

WHAT ABOUT INSURANCE COVERAGE?

As the result of a federal law enacted 10 years ago, insurance coverage should not be a concern for women who are considering breast reconstruction following mastectomy. The Women's Health and Cancer Rights Act of 1998 requires all medical insurers that provide coverage for mastectomy to also cover all stages of reconstruction of the affected breast as well as surgery and reconstruction of the contralateral breast to produce a symmetrical appearance.[10]

CONCLUSION

Although breast cancer remains a significant health risk to women and can result in significant disfigurement, breast reconstruction strategies continue to improve. These strategies offer women who have undergone mastectomy some excellent options for creating a near-normal-appearing breast. Women interested in pursuing reconstruction should meet with a plastic surgeon early in the course of their breast cancer treatment planning in order to better understand the options available and make an informed and individualized choice.

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Reconstruction options following breast conservation therapy

ABSTRACT

Women who have had breast conservation therapy for malignancy are candidates for various surgical techniques for immediate or delayed breast reconstruction. These include local tissue rearrangement, therapeutic reduction mammaplasty, and various flap reconstruction procedures. Each technique has advantages and disadvantages, and individual patient factors, particularly breast size and resection defect size, should drive the choice among procedures. Immediate reconstruction (at the time of breast conservation surgery) is preferred over delayed reconstruction, for multiple reasons. Patients tend to be satisfied with the cosmetic outcome of these procedures, but thorough patient counseling and preoperative planning is critical to a good result.

Oncoplastic surgery refers to immediate or delayed breast reconstruction following partial mastectomy, also known as breast conservation therapy. The term was coined by Audretsch et al in 1998[1] and is now often referred to as *oncoplasty*. It involves four integral components:[2]

- Oncologically sound techniques of tumor removal
- Partial reconstruction of the breast to correct small defects
- Immediate reconstruction for larger defects using various principles of plastic surgery
- Creation of symmetry with the contralateral breast.

This article provides a brief overview of various procedures used for reconstruction following breast conservation therapy and the factors that guide selection among these procedures for individual patients. It concludes with a discussion of complications of oncoplastic procedures, patient counseling, and other general considerations in patient management.

All authors reported that they have no commercial affiliations or financial interests that pose a potential conflict of interest with this article.

THE RATIONALE FOR RECONSTRUCTION

Breast conservation therapy may result in suboptimal appearance of the breast, including contour deformities and asymmetry, especially following adjuvant radiation therapy **(Figure 1)**.[3] Many patients who have had breast conservation therapy come to plastic surgeons to improve the aesthetic appearance of their breast, sometimes years after their initial treatment. It is becoming increasingly accepted that immediate reconstruction not only is oncologically sound in most patients but also yields aesthetically superior results.[4,5] Oncoplasty allows for the removal of large tumors with wider margins and better cosmetic results. Cosmetic failure with partial mastectomy is directly related to loss in breast volume.[6] Collaboration between the oncologic surgeon and the plastic surgeon, especially in cases of larger tumors requiring more tissue removal, can improve cosmetic outcomes. Ideally, partial breast reconstruction should result in a normal-appearing breast in terms of shape and symmetry when compared with the contralateral breast.[2]

Effects of radiation argue for immediate reconstruction

Although radiation therapy is integral to the comprehensive treatment of breast cancer after breast conservation therapy, radiation-induced changes to the breast are one of the greatest obstacles faced when delayed reconstruction is performed. Radiation results in deformation of the parenchyma, leading to retraction, fibrosis, vasculitis, and skin breakdown. The effects of radiation on breast tissue may possibly be a larger problem when reconstruction is delayed, as wound healing is inhibited and vascular supply is impaired. Therefore, immediate reconstruction should be undertaken whenever possible.[7] (The timing of reconstruction is discussed in greater detail in the final article in this supplement, although mainly in the context of mastectomy.)

OPTIONS FOR RECONSTRUCTION

Various techniques of partial breast reconstruction can be used to achieve an aesthetically acceptable result. They can be thought of as volume-displacement procedures, such as local tissue rearrangement and reduction

Outcomes of breast conservation therapy plus radiation therapy *without* reconstruction

FIGURE 1. Patients who had breast conservation therapy (partial mastectomies) followed by radiation therapy without oncoplastic reconstruction. These women clearly had poor aesthetic outcomes and would have benefited from options such as reduction mammaplasty or local tissue rearrangement.

mammaplasty, or as volume-replacement procedures using flap reconstruction.[8] Additionally, simple wound closure (primary closure) may be performed if small amounts of tissue can be removed without creating a noticeable defect, but simple closure is an option only for large breasts. The decision among techniques depends on a variety of factors, as delineated below.

Local tissue rearrangement

Local tissue rearrangement is defined as the use of local tissue (skin and subcutaneous and/or breast tissue) from either the breast or the axilla. This technique involves the transfer of adjacent breast parenchyma and skin to the area of the defect. It is dependent on a random blood supply and does not involve creating a parenchymal tissue pedicle.[4,5] It does rely, however, on a balance between the amount of tissue resected and the available residual breast size and volume. This procedure is not suitable for patients who require large-volume resection with a small breast or limited breast tissue.

When local tissue rearrangement is to be performed, the surgical incision needs to be planned by both the oncologic surgeon and the plastic surgeon to ensure an appropriate cosmetic outcome and prevent displacement or distortion of the nipple-areola complex. If such planning is not done, the cosmetic outcome may be compromised, thereby undermining one of the reasons for breast conservation in the first place. When full-thickness excisions of tissue are removed from a certain area of the breast—termed "no man's land" by Grisotti and Calabrese[7]—the nipple-areola complex shifts to an unnatural position. Therefore, resections in this area, located superiomedial to the nipple, should include little or no skin.

Other techniques of tissue transposition include circumareolar incisions for tumors located adjacent to the nipple-areola complex, radially designed resections for lateral tumors, and donut-shaped resections for superior or lateral tumors.[8]

Reconstruction using locally rotated tissue tends to have the lowest complication rate and best aesthetic outcome in terms of symmetry, texture, and color of the breast **(Figure 2)**. However, up to 40% of patients will need a contralateral breast reduction to achieve symmetry. In one study, immediate reconstruction with local tissue rearrangement resulted in fewer complications compared with latissimus dorsi flap reconstruction.[4]

Reduction mammaplasty

The use of therapeutic mammaplasty to reconstruct the breast after breast conservation therapy involves total breast remodeling and a contralateral breast reduction, resulting in a size reduction of both breasts **(Figure 3)**.[9] Breast reduction techniques rely on the creation of a parenchymal tissue pedicle, which involves using de-epithelialized breast tissue. There may or may not be an intact nipple-areola complex, depending on the location of the tumor.[2,4] It is important to note that standard breast reduction techniques cannot simply be applied to the affected breast and that the pattern of reduction depends on the location of the tumor. Centrally located tumors can be treated successfully with reduction techniques.[9] Nipple centralization may need to be performed as well.[5]

Standard breast reduction techniques are used on the contralateral (uninvolved) breast. This matching procedure can be performed at the same time as the initial cancer operation or as a delayed procedure. The matching procedure is usually performed at a later date for those who need to undergo radiation therapy, allowing time for healing and for final breast volume and shape to be achieved. Reduction of the contralateral breast does not increase its risk for cancer; in fact, reduction may improve body image and make breast

FIGURE 2. Preoperative (left) and postoperative (right) photos of a 58-year-old woman who underwent bilateral breast conservation therapy and reconstruction with local tissue rearrangement (note faint lateral scar on the right breast, to the right of the areola). The postoperative photos were taken 5 weeks after surgery.

self-examinations and follow-up mammography easier.

Therapeutic reduction mammaplasty is highly versatile and gives a better aesthetic result in the immediate setting when compared with flap reconstruction. However, it is usually limited to patients with a brassiere cup size of D or larger.[4]

An advantage of reduction mammaplasty is that reducing the size of the affected breast facilitates postoperative radiation therapy. Some radiation oncologists are reluctant to administer radiation to a large breast because of increased toxicity to the skin and the likelihood of a poor aesthetic outcome. With reduction mammaplasty, lower radiation doses are required and the delivery of radiation is more uniform.[4]

Reduction mammaplasty is ideal for women with moderate-sized or large breasts with ptosis (sagging), for whom a reduction in size would be considered a positive outcome.[10] Patients with symptomatic macromastia likewise benefit from reduction in breast volume. An additional advantage is that the reduction procedure on the contralateral breast affords the opportunity for tissue sampling from this presumedly uninvolved breast; occult carcinomas in the contralateral breast have been identified in a small percentage of patients.[11]

At the same time, the exposure of the contralateral breast to surgery also constitutes the main disadvantage of this procedure, as both breasts are placed at risk for wound or nipple complications and the discomfort of surgery.[9] Moreover, surgery time is also increased. Lastly, reduction mammaplasty can be offered only to patients who possess enough breast tissue to undergo reduction.[12]

Flap reconstruction

Flap reconstruction is indicated in patients who have significant breast volume deficit after resection and have insufficient adjacent tissue for local tissue recruitment and rearrangement. This method of reconstruction is based on an axial blood supply, which means that a specific vascular pedicle is responsible for a given distribution of tissue. For this purpose, flaps can be either myocutaneous (muscle-skin flaps), fasciocutaneous (fascia, subcutaneous tissue, and skin) or adipocutaneous (containing fat and skin). Examples include the latissimus dorsi myocutaneous flap, the transverse thoracoepigastric skin flap, and the lateral thoracic adipocutaneous flap.[4–6]

The latissimus dorsi myocutaneous flap is used most often, especially when more than 25% of the breast volume has been resected. Since a large volume of tissue is removed, either the tumor and a margin can be resected or a nipple-sparing subcutaneous mastectomy may be performed[10] (nipple-sparing mastectomy would not be breast-conserving and has been discussed earlier in this supplement). This myocutaneous flap is based on the thoracodorsal vessels and was first described for volume replacement after breast-conserving surgery by Noguchi et al.[13] A benefit of this flap is that most patients do not need reduction of the contralateral breast for symmetry, as the flap usually provides adequate tissue volume.[4] This is beneficial for the patient, as she is not exposed to the potential complications of an operation on the contralateral breast.

The lateral thoracic adipocutaneous flap is another option. This flap has the benefit of sparing the muscle while using skin and fat from the axillary region. It can be based on one of three vascular pedicles that have been shown to be reliable as a sole blood supply. The most common pedicle for this technique is the thoracodorsal artery, as the main blood supply for the thoracodorsal artery perforator flap. This flap provides a potentially large amount of tissue for use and affords patients the chance to have a redundant roll of axillary tissue removed. This tissue can be used alone for reconstruction or in conjunction with a breast implant.[6]

One drawback of the latissimus dorsi flap is the potential for mismatch of skin color and texture when there is a need to address a significant skin deficit on the breast. Replacing a whole aesthetic unit, as opposed to only a small skin paddle, can minimize this potential; thus, using a larger amount of skin may provide a better aesthetic result. Rarely, if there is no skin defect, the muscle alone can be used, with no skin component.[5] The lateral thoracic flap, on the other hand, may be more similar in skin color and texture to the native

FIGURE 3. Preoperative (left) and postoperative (right) photos of a 64-year-old woman who underwent right partial mastectomy and moderate reduction mammaplasty/mastopexy for symmetry. The postoperative photos were taken 1 month after surgery.

breast and may allow the scar to be better hidden in the axilla than is the case with the latissimus dorsi flap.[6] Any type of flap presents potential donor site problems as well as breast complications (discussed below).

Flap reconstruction broadens the application of breast conservation therapy to women who would not otherwise be candidates because of the large volume of tissue they need to have removed.[2] Oncoplasty reconstruction also allows the oncologic surgeon to be more aggressive with tissue removal without concerns about compromising the aesthetic outcome. Patients with small to moderate breasts are therefore candidates for flap reconstruction, as even modest resections in such patients result in a large volume of tissue loss and the need for additional tissue to reconstruct the breast.[14] Any of the aforementioned flaps are advantageous, as they are in close proximity to the breast and can readily be used for reconstruction.[6]

CHOICE OF TECHNIQUE

Many factors contribute to the choice among reconstructive methods for a particular patient after breast conservation therapy.

Tumor location plays a significant role. Kronowitz et al described using breast reduction as their primary reconstructive modality, particularly for tumors of the upper inner, upper outer, and lower inner quadrants of the breast.[4] They used flap reconstruction only for outer-quadrant tumors, and they found that tumors of the lower outer quadrant were the largest and lent themselves to local tissue rearrangement, often with axillary tissue.[4] Centrally located tumors usually require removal of the nipple-areola complex and can be challenging to reconstruct. The techniques include either (1) direct closure with some degree of local tissue remodeling, or (2) reduction mammaplasty. The majority of patients with centrally located tumors will need contralateral breast reduction for symmetry[14] and nipple-areola reconstruction at a later date.

The size of the defect created by the tumor resection also significantly affects the choice of technique, as does the patient's preoperative brassiere size. In the analysis by Kronowitz et al, defects smaller than 20% of the overall breast size were found to be amenable to breast reduction, whereas larger defects were reconstructed with flaps or local tissue rearrangement.[4] Also, women with a brassiere cup size of D or larger tended to undergo breast reduction, whereas those with a size smaller than D underwent local tissue rearrangement or flap reconstruction.[4]

One way to conceptualize the type of reconstruction needed is to consider the defect size in relation to the breast size, as delineated in **Table 1**. Small and medium-sized breasts with medium-sized defects not only need reshaping but also may need reallocation of tissue from the axilla to the breast. This will result in additional scars, but they should not be noticeable when the patient is clothed. Small or medium-sized breasts with large defects are generally not amenable to local tissue rearrangement, and latissimus dorsi flap reconstruction is preferred. The volume of tissue provided by the flap can correct the majority of these defects. Lastly, large breasts with large defects are most amenable to breast reshaping, with a contralateral operation to provide symmetry (ie, reduction mammaplasty).[5]

COMPLICATIONS

Complications of breast surgery include seromas (of the breast as well as the donor site when a flap is used), nipple necrosis, wound dehiscence, infection, hematoma, fat necrosis, and mastectomy flap necrosis. Postoperative hematomas and superficial wound infections tend to occur in the immediate postoperative period (usually within the first few days), whereas the other complications mentioned may take 1 to 2 weeks to develop. These complications are common to all breast operations and are not specific to reconstruction after breast conservation therapy.

Postoperative complications vary in frequency but are more common when reconstruction is delayed.[4,7]

TABLE 1
Algorithm for selecting a reconstructive technique following breast conservation therapy

Breast size	Defect size	Technique
Small	Small-medium	Local tissue rearrangement/ myocutaneous flap*
Medium	Small-medium	Local tissue rearrangement/ myocutaneous flap*
Small-medium	Large	Myocutaneous flap*
Large	Small-medium	Primary closure
Large	Medium-large	Reduction mammaplasty

*"Myocutaneous flap" refers to any flap reconstruction technique.

They also vary depending on the reconstructive technique. Donor-site seromas and fat necrosis are most common with immediate reconstruction using a flap; wound dehiscence is most common with delayed local tissue rearrangement; and breast seroma is most common with delayed reduction mammaplasty.[4]

Other issues to consider include the possible delay in adjuvant therapy in patients who experience wound healing problems, especially in those who are obese, who smoke, or who undergo therapeutic mammaplasty.[15,16] Moreover, operative time is increased with oncoplasty as compared with simple wide local excision, which increases patients' exposure to anesthesia and thereby raises the risk of complications, particularly in older patients with comorbidities.[16]

Risk factors for complications

Certain patient characteristics carry an increased risk for postoperative complications. These include tobacco smoking, previous breast surgeries, comorbidities that impair wound healing, and obesity.[4,15–17]

The vasoconstrictive, thrombotic, and hypoxic effects of tobacco place patients who smoke at an increased risk for necrosis of the nipple-areola complex, as well as for pulmonary complications, when breast reduction is performed. The standard recommendation is cessation of smoking for 6 to 8 weeks preoperatively to reduce pulmonary risks, although rigorous scientific validation is lacking.[17]

Breasts that have been previously operated on have scarring of the skin and subcutaneous tissues, which may affect the surgical incision and technique. Additionally, vascular compromise of the underlying breast tissue and nipple-areola complex is a possibility in patients who have had previous breast operations.[4] For these reasons, it is of utmost importance to obtain a full history of any previous breast procedures a patient has had.

Obesity is a risk factor for impaired wound healing, as delayed wound healing has been correlated with increased body mass index in patients undergoing breast reduction.[15]

What about positive margins?

Addressing positive margins can be problematic after breast conservation therapy with immediate reconstruction, as it is difficult to locate the resection margin after the breast tissue has been rearranged.[4,5,12,14] Patients who have positive margins will usually need to undergo completion mastectomy and opt for immediate reconstruction with a transverse rectus abdominis myocutaneous (TRAM) flap or a latissimus dorsi flap with an implant. Therefore, use of a TRAM flap for initial reconstruction after breast conservation therapy is discouraged.[4,14] If a TRAM flap is needed to restore the shape and contour of the breast after breast conservation, it is usually better to perform a mastectomy, as it provides a superior aesthetic result and reduces the risk of a subsequent malignancy since the breast tissue is removed.[5]

PATIENT COUNSELING, PREOPERATIVE PLANNING

The diagnosis of breast cancer is devastating for most women and is compounded by mental anguish associated with the anticipated changes in their appearance.[10] There is a psychological advantage to having reconstruction performed during the same operation as resection because the breast's preoperative form is immediately restored and little to no asymmetry is seen postoperatively.[12] One study showed that breast cancer patients who underwent reconstructive surgery had better body images and felt they had more control over their treatment compared with patients who simply had breast conservation therapy or mastectomy without reconstruction; these perceptions also conferred a psychological benefit among the patients who had reconstructive procedures.[18]

At the same time, all patients need to be counseled about the potential drawbacks of reconstruction, including the possibility of reoperation for positive margins, wound complications, or a disappointing or unacceptable aesthetic outcome.

Oncoplastic surgery is a multispecialty collaboration. Good communication and preoperative planning is imperative and must include the general surgeon, plastic surgeon, oncologist, and, most importantly, the patient. Considerations in how to approach diagnostic biopsies, lymph node sampling, timing of contralateral breast symmetrizing procedures, and the possibility of positive margins all need to be discussed preoperatively.[8,10]

ADDITIONAL CONSIDERATIONS

Timing of reconstruction

Immediate reconstruction is preferred for many reasons, including a reduced incidence of wound healing problems, facility in administering postoperative radiation therapy, and better aesthetic results.[3,4,11] A one-stage procedure also facilitates breast remodeling, as there is no scar tissue to deal with. Patients' psychological trauma of coping with a deformity is also reduced because better symmetry is achieved with immediate reconstruction.[10]

Additionally, some authors have reported lower rates of local recurrence in breast conservation therapy patients who received immediate reconstruction, likely owing to the larger amount of tissue resected and subsequent lower incidence of positive margins.[4,11,14] Local recurrence in patients undergoing breast conservation therapy and oncoplasty is between 2% and 9%, depending on the study.[11,12]

Postoperative surveillance

Postoperative surveillance can still be performed effectively despite the tissue transposition involved in any of the oncoplastic reconstruction techniques. A new baseline mammogram is obtained, to which future imaging studies are compared. Fat necrosis may appear to be new calcifications. Titanium clips may also be placed within the defect cavity so that it can be tracked to its new location. These clips also aid in localizing postoperative radiation therapy.[11]

Patient satisfaction

Several studies have assessed patient satisfaction with breast conservation therapy without and with reconstruction. Following breast conservation therapy without reconstruction, cosmetic results are rated as poor by 15% to 20% of patients.[10] Patients notice breast asymmetry and are generally dissatisfied to some degree after breast conservation with radiation therapy and no further reconstruction.[3] In contrast, a survey in a series of patients who had oncoplasty found that 95% reported good aesthetic results at short-term follow-up.[10] Another series found that 88% of patients undergoing oncoplastic techniques reported fair to excellent outcomes at 2 years, and 82% did so at 5 years.[12] When these patients were further analyzed, assessments of cosmetic outcomes were worse in those who received preoperative rather than postoperative radiation therapy.[12]

SUMMARY

Oncoplastic surgical approaches can be applied to the full spectrum of patients undergoing breast conservation therapy. They are particularly useful when a large defect is anticipated, when a symmetrizing procedure is desired for the contralateral breast, and when the tumor-to-breast volume ratio is unfavorable for simple closure.[14] Immediate reconstruction is clearly preferred over delayed reconstruction, as it is associated with fewer complications, easier administration of postoperative radiation therapy, better aesthetic results, and possibly lower rates of local recurrence. Patients are more satisfied with the cosmetic outcome of oncoplastic procedures compared with breast conservation therapy alone. Successful oncoplasty requires thorough patient counseling and comprehensive preoperative planning among patient, oncologist, and general and plastic surgeons.

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Options and considerations in the timing of breast reconstruction after mastectomy

ABSTRACT

Timing of breast reconstruction after mastectomy is determined primarily by patient factors and the need for postmastectomy radiation therapy. If the risk of needing postmastectomy radiation is low, then immediate reconstruction produces the optimal aesthetic result. If the risk of needing postmastectomy radiation is high, then delayed reconstruction is preferable to optimize both radiation delivery and aesthetic outcome. For patients with an increased risk of needing postmastectomy radiation, "delayed-immediate" reconstruction, which involves placing a tissue expander at the time of mastectomy and awaiting pathology results to determine the need for radiation and guide reconstruction scheduling, is a viable approach. Thorough and informed physician counseling about the pros and cons of these options is critical for all women undergoing mastectomy.

Timing of breast reconstruction after mastectomy involves many factors that are important in choosing between three options—immediate, delayed, or "delayed-immediate" reconstruction.

Immediate reconstruction is performed at the time of initial breast cancer surgery and allows for joint planning of incisions between the oncologic and plastic surgery teams. This produces the optimal aesthetic result since it allows for preservation of the breast skin envelope and sometimes for nipple preservation, and is oncologically safe for patients treated for cure of their cancers.

Delayed reconstruction involves initially performing a mastectomy and then determining the need for postmastectomy radiation, which cannot be assessed until review of permanent sections on pathology. Reconstruction is then performed after chemotherapy, radiation therapy, or both (if needed) are completed.

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Delayed-immediate reconstruction involves placing a tissue expander at the time of skin-sparing mastectomy to preserve the breast skin envelope. After the final pathology is reviewed following mastectomy, immediate reconstruction is performed if the patient does not require postmastectomy radiation therapy. If radiation therapy is required, then the patient undergoes standard delayed reconstruction after the radiation therapy is completed. This allows for skin conservation, thereby improving aesthetic outcome, while still allowing final reconstructive decisions to be made after it is determined whether radiation will be required.

IMMEDIATE RECONSTRUCTION: WHEN INDICATED, THE OPTION WITH THE BEST AESTHETIC RESULTS

Currently, the majority of breast reconstructions are performed as immediate reconstructions at the time of mastectomy. Immediate reconstruction is a routine consideration for patients suspected to have stage 0, I, or IIA breast cancers (see table on page S12 of this supplement, in the article on staging and surgical treatment by Hammer et al). These patients with early-stage cancer represent more than 70% of women who undergo mastectomy. Less-extensive resection of the breast skin by oncologic surgeons and the development of reconstructive options by plastic surgeons have improved quality of life for breast cancer patients.[1] Nipple-sparing mastectomy in selected patients is associated with high levels of patient satisfaction, improved aesthetic outcomes, and oncologic safety in the setting of early-stage tumors with no skin involvement.[2]

Oncologic safety is established

Numerous factors affect patient decision-making regarding reconstruction. The primary reason patients elect not to undergo immediate reconstruction is fear that reconstruction will hamper the ability to detect a cancer recurrence. In addition, patients as well as many physicians may have the unfounded fear that cancer cells can remain viable in the mastectomy bed and therefore that immediate reconstruction is ill-advised.

Multiple studies have shown that immediate recon-

struction is oncologically safe after mastectomy, even in patients with locally advanced breast cancer.

In a study of 540 patients who underwent immediate reconstruction following mastectomy, Newman et al identified 50 patients with locally advanced breast cancer; all of these patients received postoperative chemotherapy, and 40% received postoperative radiation therapy as determined by tumor characteristics.[3] At median follow-up of 58.5 months, there were no differences in either local or distant recurrence between these 50 patients and 72 matched patients with locally advanced breast cancer who did not undergo immediate reconstruction but received standard chemotherapy and radiation therapy for locally advanced disease.[3]

Similarly, a study by Langstein et al demonstrated that immediate reconstruction does not delay detection of cancer recurrence in the chest wall, in that the time to diagnosis of recurrence was similar whether patients underwent immediate reconstruction or not.[4] No differences in local recurrence rates were noted based on the type of reconstruction performed (autologous flaps or implants). In addition, most cases of chest wall recurrence were associated with distant metastatic disease.[4]

Importance of physician input, other factors

Physician input is of vital importance to the patient considering mastectomy with immediate reconstruction. Traditionally, many patients have been advised by their health care providers to wait until mastectomy and chemotherapy or radiation therapy are complete before considering reconstruction. After undergoing such physically and emotionally exhausting treatments, however, patients are often spent and have no interest in undergoing another surgical procedure. Proper counseling by physicians—including the explanation that immediate reconstruction is associated with no difference in recurrence or survival outcomes compared with delayed reconstruction or no reconstruction at all—is essential to allay the fear of recurrence or death that often guides patients' decision-making.

Indeed, a recent questionnaire-based study of factors influencing mastectomy patients' choices regarding reconstruction found that patients regarded their surgeon's advice as the most important factor.[1] Moreover, women in the study who chose to undergo reconstruction were more likely than women who chose mastectomy alone to identify their surgeon's advice as the most important influencing factor. These women who chose reconstruction also were more likely than those not choosing reconstruction to have discussed their decision with their partner and to express interest in meeting other women who had undergone mastectomy. The study's quality-of-life assessment demonstrated that women who chose reconstruction were in better physical health, placed more importance on body image and sexuality, and were less afraid of surgery compared with those not choosing reconstruction.[1]

The type of cancerous lesion also contributes to patient decision-making regarding immediate reconstruction. Patients with ductal carcinoma in situ are twice as likely to choose immediate reconstruction as those with invasive cancer.[5] Age plays an important role as well. Younger patients are more likely to elect to undergo reconstruction, with patients younger than age 50 having a 4.3-fold greater likelihood of choosing reconstruction than their older counterparts.[5]

Accounting for adjuvant medical therapy

Preoperative evaluation and postoperative histologic lymph node status determine the potential need for adjuvant therapy and facilitate optimal surgical decision-making. Chemotherapy usually begins within 30 to 40 days after surgery but can be delayed up to 12 weeks. Thus, a reconstruction that will be healed within this time frame is ideal. Reconstruction choices that involve well-vascularized tissue will optimize healing prior to chemotherapy. Chemotherapy cannot be started in the presence of seroma, infection, or necrotic tissue. In cases of breast conservation surgery and radiation therapy only, radiation can be delayed up to 8 weeks for complete healing prior to its commencement.

In a patient who will require radiation, autologous reconstruction (using the patient's own tissue) is preferable to tissue expander and implant reconstruction. Indications for radiation after mastectomy include tumor invasion of the chest wall, invasive cancers larger than 5 centimeters, and, in some cases, positive lymph nodes. Patients who undergo radiation of an autologous flap often have some shrinkage of the flap volume. Dense scar formation, capsular contraction, and implant extrusion may occur with radiation of implants, leading to a poor cosmetic outcome. Implant reconstructions that fail for these reasons are best corrected by autologous means.

Another consideration that should be addressed between the oncologic surgeon and the plastic surgeon is the possibility of an axillary lymph node dissection after reconstruction in the event of a positive sentinel node biopsy. If the oncologic surgeon must return to the axilla for removal of nodes after reconstruction, cooperation is needed between the two teams for incision planning and dissection. This is especially true in cases of microvascular free-tissue

Comparative outcomes of immediate and delayed postmastectomy reconstruction

FIGURE 1. Top panels: A patient who underwent immediate postmastectomy reconstruction of the left breast. **Bottom panels:** A patient who underwent delayed postmastectomy reconstruction of the left breast. In both patients the deep inferior epigastric perforator (DIEP) free flap technique was used. The postoperative photo of the patient at the top was taken 14 months after immediate reconstruction. The postoperative photo of the patient at the bottom was taken 17 months after mastectomy and 3 months after the DIEP reconstruction.

transfer reconstruction, in which vessels in the axilla are used for anastomosis. Recent data suggest that most microsurgery practitioners prefer to use the internal mammary vessels to avoid the need to return for another operation involving the axilla, which can jeopardize flap viability.[6]

DELAYED RECONSTRUCTION: A VIABLE OPTION REQUIRING REALISTIC EXPECTATIONS

Although reconstruction at the time of mastectomy is the preferred approach at present, delayed reconstruction in a patient who previously had a mastectomy is also a viable option. Since surgical therapy for breast cancer has been practiced long before reconstructive procedures were in widespread use, many patients were not offered any reconstructive options at the time of mastectomy. Other patients chose to delay reconstruction until after radiation therapy and/or chemotherapy were completed.

Why patients may choose to delay

Delayed reconstruction may be preferable for patients who are not ready to make a decision at the time of initial surgery as a result of the overwhelming news of their cancer diagnosis and the many treatment options they have to consider. These patients may benefit from first focusing on treatment of their cancer and reserving consideration of reconstruction for later. In other cases, patients with multiple medical comorbidities may benefit from a staged procedure to minimize the length of surgery. It should be recognized, however, that if reconstruction is not performed at the time of initial mastectomy, the likelihood that it ultimately will be performed may be significantly reduced.

What prompts the decision to eventually seek reconstruction?

The goals of patients seeking delayed reconstruction are numerous. Some express a desire to put the "cancer phase" of their life behind them, while others hope to escape the stigma of being different. Generally these women wish to think, feel, and carry on their lives as they did before their mastectomy. In addition, patients may desire a tangible, lasting result to symbolize that their treatment is finished. In the late phase of the recovery process, breast reconstruction may be viewed as a healthy route of return to the patient's "normal" life before cancer.

It is important for mastectomy patients to know that they are still candidates for breast reconstruction as a delayed procedure, even if their mastectomy was performed in the distant past.

Expectations must be tempered

It is of vital importance that patients have realistic expectations for the outcome of delayed reconstruction, particularly in fields that have been previously radiated **(Figure 1)**. Lengthy preoperative counseling is critical, as is clear communication among all physicians caring for the patient. Unrealistic expectations can lead to extreme patient dissatisfaction. Patients must also be aware of the potential for complications, some of which might require future surgery, as well as planned future procedures that require more surgery, including reconstruction of the nipple and/or areola and procedures to achieve symmetry in the contralateral breast.

DELAYED-IMMEDIATE RECONSTRUCTION

The goal of delayed-immediate reconstruction is to optimize reconstruction in patients who are at risk of needing postmastectomy radiation therapy, since it is not known until after review of permanent sections, several days following mastectomy, whether these patients will require radiation.

The rationale

If immediate reconstruction is performed and the patient is found to have pathologic lymph node involvement, postoperative radiation therapy may compromise aesthetic results. Additionally, the reconstructed breast may pose technical difficulties in terms of delivery of radiation to the internal mammary nodes. At the same time, if breast reconstruction is delayed and final pathology review shows that radiation is not indicated, the mastectomy skin and shape of the breast skin envelope will be lost (and the aesthetic outcome compromised) unless measures are taken to preserve them.[7]

The protocol at a glance

Those measures to preserve the breast skin envelope consist of placement of a tissue expander at the time of mastectomy, pending final pathology results. If no radiation therapy is needed, the optimal reconstructive procedure can be chosen and performed within the next 1 to 2 weeks. If radiation is necessary, the expander can be deflated in the clinic before initiation of radiation therapy, to optimize radiation delivery to the internal mammary nodes. The expander can then be serially expanded after radiation, and delayed reconstruction with an autologous flap can be performed at a later date. Delayed-immediate reconstruction also offers the opportunity to revise the inframammary crease and debride any nonviable mastectomy skin.

Insurance coverage is federally mandated

Patients should be aware that the Women's Health and Cancer Rights Act of 1998 (see article by Djohan et al earlier in this supplement) applies to delayed and delayed-immediate reconstruction as well as to immediate reconstruction, requiring that medical insurers that cover mastectomy cover these procedures as well.

CONCLUSIONS

The timing of breast reconstruction is determined primarily by patient factors and the necessity for postmastectomy radiation therapy. If the risk of needing postmastectomy radiation is low, then immediate reconstruction produces the optimal aesthetic outcome. The main advantage of immediate reconstruction is the availability of relatively supple nonscarred tissue that can be recruited for reconstruction. If the risk of needing postmastectomy radiation is high, then delayed reconstruction is preferable to optimize both radiation delivery and aesthetic outcome. Delayed reconstruction is somewhat more challenging, as it involves well-healed scar tissue that is already retracted and adherent to the chest. Nevertheless, reconstruction remains possible at this point and options depend on tissue quality and the plastic surgeon's expertise. For patients with an increased risk of needing postmastectomy radiation, delayed-immediate reconstruction represents a viable approach that optimizes oncologic as well as aesthetic outcomes regardless of whether the patient ultimately does or does not need radiation therapy.

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