Evidence-Based Medicine: Breast Reconstruction

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Learning Objectives: After studying this article, the participant should be able to: 1. Differentiate among the various techniques available to reconstructive breast surgeons. 2. Perform a comprehensive assessment of the breast reconstruction candidate. 3. Gain knowledge about the indications and contraindications for different breast reconstructive procedures. 4. Understand the complications inherent in different reconstructive breast procedures. 5. Summarize the long-term objective and subjective implications of surgery.

Summary: This article was prepared to accompany practice-based assessment with ongoing surgical education for the Maintenance of Certification for the American Board of Plastic Surgery. It is structured to outline the care of the patient with the postmastectomy breast deformity. (Plast. Reconstr. Surg. 132: 1658, 2013.)

As the treatment of breast cancer has evolved in the past decade, so have the art and science of breast reconstruction. Advancements in autogenous tissue techniques, refinements in implant technologies, and the development of acellular dermal matrix and immediate breast reconstructive techniques performed in concert with skin- or nipple-sparing mastectomies have resulted in superior aesthetic outcomes, with minimal disruption to the patient’s lifestyle (Level of Evidence: Therapeutic, IV). The purpose of this Maintenance of Certification in Plastic Surgery CME article is to provide an overview of the most clinically important areas of breast reconstruction in the recent decade, presented in a balanced and evidence-based fashion.

Timing of Reconstruction

Immediate Breast Reconstruction

Immediate breast reconstruction is usually reserved for patients with early stage breast cancer (clinical stage I and some patients with stage II breast cancer) who do not require postmastectomy radiotherapy. Several studies have demonstrated the benefits of reconstruction for the breast cancer patient’s body image and quality of life, and immediate reconstruction offers these benefits with little interruption. Technically, reconstruction is facilitated by the natural laxity of the native skin and preservation of the inframammary fold and the three-dimensional breast skin envelope. Lastly, adequate perfusion of the mastectomy flap is crucial to obtain a successful reconstruction, especially in implant reconstruction.

Delayed Breast Reconstruction

Compared with the aesthetic results obtained from immediate reconstructions, delayed reconstructions yield modest results at best. Delayed breast reconstruction is usually reserved for patients who will require postmastectomy radiotherapy, although this remains controversial. Because the fibrotic and contracted irradiated breast skin located between the mastectomy scar and the inframammary fold is usually resected and replaced with a large volume of flap tissue, delayed reconstruction generally requires the use of autogenous tissue.

Delayed-Immediate Breast Reconstruction

Although many centers advocate delayed reconstruction in patients who may require

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postmastectomy radiotherapy, some argue that this practice effectively denies a select group of patients ultimately not requiring postmastectomy radiotherapy the aesthetic and psychological benefits of immediate reconstruction.\textsuperscript{13} As a possible solution to this dilemma, the M. D. Anderson Cancer Center has developed a delayed-immediate breast reconstruction approach for individuals with intermediate disease whose postmastectomy radiotherapy status is undetermined preoperatively.\textsuperscript{10} The first stage involves mastectomy and placement of a subpectoral tissue expander. The need for postmastectomy radiotherapy is then determined based on final pathologic findings. In the event that postmastectomy radiotherapy is not indicated, the surgeon can proceed with the second stage: definitive breast reconstruction with either an implant or autogenous tissue. Conversely, if postmastectomy radiotherapy is indicated after review of the final pathologic findings, radiotherapy will occur with a partially inflated tissue expander, which is ultimately replaced with autogenous tissue.

**ONCOLOGIC CONSIDERATIONS**

**Skin-Sparing and Nipple-Sparing Mastectomies**

The primary driving force behind the movement toward more structure-sparing mastectomies is a higher demand for (1) prophylactic risk-reducing mastectomies and (2) immediate reconstruction. The main advantage of skin-sparing mastectomy is preservation of the three-dimensional breast skin envelope so that immediate reconstruction can more precisely restore the patient’s preoperative breast shape. Nipple-sparing mastectomy deviates from the historic viewpoint that removal of the nipple-areola complex is oncologically necessary to eliminate the ductal epithelium within the nipple.\textsuperscript{11} Opponents of nipple-sparing mastectomy argue that the nipples left behind are insensitive, may lose pigmentation and projection, or may become displaced or necrotic. Despite the controversies, there is a trend toward more nipple-sparing mastectomies performed for both prophylactic and therapeutic reasons for small tumors that are relatively far from the nipple.\textsuperscript{12}

**Radiation Therapy and Reconstruction**

The oncologic benefits of postmastectomy radiotherapy are firmly established only for patients with T4 cancer or four or more positive axillary lymph nodes\textsuperscript{9,16} (Table 1); however, there is a trend for offering postmastectomy radiotherapy to patients with T1/T2 tumors with fewer than four positive axillary lymph nodes.\textsuperscript{9,16} The implications of performing postmastectomy breast reconstruction in the setting of radiotherapy are both profound and controversial. Distinction between prior versus future radiotherapy must be made because the approach to breast reconstruction is different. Lack of consensus guidelines on the optimal technique and timing of breast reconstruction in patients suspected of requiring breast reconstruction\textsuperscript{9} necessitates a clear understanding of the pros and cons of each option to provide a thoughtful and individualized treatment approach. To help guide the complex decision-making process for patients, we have proposed a practical reconstructive algorithm as outlined in Figure 1. For a patient who both desires and meets the requirements for tissue expander/implant reconstruction, immediate reconstruction using the Memorial Sloan-Kettering Cancer Center protocol is our preferred method of reconstruction in the setting of anticipated postmastectomy radiotherapy. If the opportunity for immediate tissue expander/implant reconstruction is lost before postmastectomy radiotherapy takes place, reconstruction of a delayed irradiated mastectomy defect will necessitate the use of autogenous tissue.\textsuperscript{17}

**Systemic Therapies**

The most recent guidelines endorsed by the National Comprehensive Cancer Network advocate treatment tailored to the individual’s estimated risk combined with her tumor hormone status.\textsuperscript{18} Systemic treatment can be broadly divided into three categories: endocrine, cytotoxic, and biological therapies. Hormone-responsive tumors are treated with endocrine therapy, including ovarian suppressors that reduce estrogen production, block estrogen receptors (tamoxifen), and prevent estrogen production (aromatase inhibitor). Hormone-nonresponsive tumors or patients at intermediate/high risk are treated with cytotoxic chemotherapy. Biological therapy using trastuzumab (a monoclonal antibody) that

**Table 1. Absolute and Relative Indications for Postmastectomy Radiotherapy**

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<thead>
<tr>
<th>Indications for PMRT: Recommended</th>
<th>Indications for PMRT: Suggested</th>
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<tr>
<td>T4 cancer</td>
<td>Four or more positive axillary lymph nodes</td>
</tr>
<tr>
<td>Operable stage III disease</td>
<td>T3 tumors with positive axillary lymph nodes</td>
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targets the human epidermal growth factor receptor 2 to modulate the immune system significantly improves survival in human epidermal growth factor receptor 2–positive patients. Studies have shown that although immediate reconstruction is associated with a modest increase in time to chemotherapy, this is not considered a clinically significant delay (Reference 23, Level of Evidence: Therapeutic, III). 22–24

RECONSTRUCTION OPTIONS

The key to achieving the optimal aesthetic outcome is an individualized patient-to-procedure approach. Factors affecting this decision-making process include the following: location/type of cancer and extent of resection; patient’s risk factors; need for adjuvant radiotherapy; availability of local and distant donor tissue; desired size and shape of the reconstructed breast; and, most important, patient preference.

Implant-Based Options

Single-Stage Reconstruction

This type of reconstruction is generally reserved for patients undergoing immediate reconstruction using a skin-sparing mastectomy or nipple-sparing mastectomy approach who have relatively small, nonptotic breasts and do not wish for a significant change in volume of the reconstructed breast. Using an adjustable implant provides more flexibility to this procedure, especially in a patient who may have some skin shortage with the mastectomy, or a patient who may wish to have a modest volume augmentation. 25,26 The use of acellular dermal matrix in direct-to-implant immediate reconstruction has been found to have low complication rates (3.9 percent) in a single-surgeon clinical series of 260 patients. 27

Two-Stage Tissue Expander/Implant Reconstruction

Two-stage tissue expander/implant reconstruction with or without acellular dermal matrix is the most commonly used mode of implant-based reconstruction. 28 In the setting of immediate reconstruction where the skin envelope has questionable perfusion, placement of a partially filled tissue expander ensures that no tension is placed on the vulnerable skin envelope. Nonetheless, tissue expander/implant complication rates are reported to range from 8 to 60 percent. 6,7,29 The following disadvantages have been observed with total tissue expander muscle coverage: (1) attenuation of pectoralis major; (2) underexpansion of the lower pole; and (3) pain associated with elevation of the serratus muscle/fascia. 30–33 The debate regarding saline versus silicone was settled by the unequivocally higher reported patient satisfaction rate for those in whom silicone implants were used for breast reconstruction (Reference 34, Level of Evidence: Therapeutic, III). 34,35

Fig. 1. Decision algorithm for breast reconstruction in patient faced with mastectomy and postmastectomy radiotherapy. MSKCC, Memorial Sloan-Kettering Cancer Center; LD, latissimus dorsi; TE, tissue expander. DIEP, deep inferior epigastric perforator. (Reprinted with permission from Memorial Sloan-Kettering Cancer Center.)
Acellular Dermal Matrix
Since the feasibility of using acellular dermal matrix in both one- and two-stage prosthetic breast reconstruction was described in the literature, its use has rapidly gained popularity (Reference 39, Level of Evidence: Therapeutic, III). When used as an inferolateral hammock, acellular dermal matrix is hypothesized to enhance the breast aesthetic by better defining the inframammary fold, allowing more lower pole fullness, and reducing the severity of capsular contracture. However, a recent retrospective review of 337 two-stage tissue expander/implant reconstructions with and without acellular dermal matrix found no significant difference between the two groups in terms of capsular contracture in the multivariate analysis. Because using acellular dermal matrix allows for significantly higher initial tissue expander fill volume, some feel that the most important application of acellular dermal matrix is in the setting of one-stage direct-to-implant reconstruction or inadequate local muscle coverage of the implant.

Autogenous Tissue-Based Options
The longevity of results obtained with autogenous tissue reconstruction may be especially appropriate for younger patients. In addition, complete breast mound restoration in a single stage is possible in most patients. Lastly, the versatility in size and shape afforded by autogenous reconstruction may permit matching a woman’s opposite, native breast with little or no surgical modification.

Abdomen-Based Reconstructions
There are a number of advantages to using donor tissue from the abdomen. First, because of a characteristic infraumbilical fat deposit in females, the transverse rectus abdominis myocutaneous (TRAM) flap almost always provides enough soft-tissue bulk for reconstruction of the breast mound. Second, in patients without complications, the vascular supply is reliable. Finally, the resultant scar and abdominal contour are similar to those following an abdominoplasty.

Pedicled TRAM Flap
The blood supply of the pedicled TRAM flap is derived from the superior epigastric artery by means of a series of choke vessels within the rectus abdominis muscle. After harvest of the flap, a subcutaneous tunnel from the abdominal donor site to the mastectomy defect is created to accommodate the flap. Either the ipsilateral, contralateral, or bilateral rectus muscles may be used. In patients with risk factors such as obesity, smoking, and prior irradiation, a “delay procedure” may be performed at least 2 weeks before the pedicle procedure.

Free TRAM Flap
The free TRAM flap is based on the more dominant inferior epigastric vascular pedicle, permitting transfer of larger volumes of tissue with minimal risk of fat necrosis. As opposed to Hartrampf’s description of the zones of perfusion in a pedicled TRAM flap, the best perfused areas of a free TRAM flap lie within the hemiabdomen that is ipsilateral to the pedicle. Because of the robust blood supply to a free TRAM flap, the procedure can be used with a greater degree of safety in patients with risk factors such as tobacco use, diabetes, and obesity. Microvascular anastomoses are generally performed to the thoracodorsal or internal mammary vessels. Insetting of the free tissue transfer is facilitated because the flap is not tethered by a pedicle. In addition, the potential upper abdominal contour deformity arising from the bulk of the transposed pedicled flap is eliminated.

Muscle-Sparing TRAM Flap
The muscle-sparing TRAM flap, which is limited to the portion of muscle and anterior rectus sheath that encompasses the lateral and medial rows of perforating vessels, is a modification of the TRAM flap that theoretically minimizes violation of the abdominal wall and the risk of donor-site morbidity. A more comprehensive understanding of the evolution of the muscle-sparing TRAM flap to the deep inferior epigastric perforator (DIEP) flap is reflected in the classification system described by Nahabedian et al. (Table 2). The muscle-sparing TRAM flap can be performed as a pedicled flap, although it is more commonly used as a free tissue transfer.

Table 2. Classification of Muscle-Sparing Free TRAM Flaps*

<table>
<thead>
<tr>
<th>Muscle-Sparing Technique</th>
<th>Definition (Rectus Abdominis)</th>
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<tr>
<td>MS 0</td>
<td>Full width, partial length harvested</td>
</tr>
<tr>
<td>MS 1</td>
<td>Preservation of lateral segment</td>
</tr>
<tr>
<td>MS 2</td>
<td>Preservation of medial and lateral segments</td>
</tr>
<tr>
<td>MS 3 (DIEP)</td>
<td>Preservation of entire muscle</td>
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*MS, muscle-sparing; DIEP, deep inferior epigastric perforator.

breast mound, the gluteal perforator flap is still
region provides ample volume for creating a
mary reasons for using an alternate flap.
out a high-risk abdominal scar is one of the pri
a patient with a slender body habitus with or with
lifestyle must allow for the potential diminution
have adequate tissues in the lower abdomen to be
considered a candidate. In addition, a patient’s
adequate tissues in the lower abdomen to be
considered by most to be a second-line choice for
autogenous breast reconstruction. This is because
surgical dissection can be complex, intraoperative
repositioning of the patient necessitates increased
operative time, and failure rates are higher. Com-
pared with the superior gluteal flap, the scar from
the inferior gluteal arterial perforator flap can be
concealed in the inferior gluteal crease, and
its vascular pedicle is relatively longer. However,
a disadvantage of the inferior gluteal arterial per-
forator donor site is the potential for sciatic nerve
irritation.55

Transverse Upper Gracilis Flap
The transverse upper gracilis flap uses a trans-
verse skin island that overlies the gracilis muscle
and is transferred on the medial circumflex femo-
ral artery. Complications include widened scars,
lower limb lymphedema, and higher rates of sec-
ondary surgery needed to augment its volume.56–60
We consider transverse upper gracilis a second-
line choice and reserve it exclusively for immedi-
ate reconstruction of small breasts.

Combined Autogenous Tissue/Implant
Reconstruction

Pedicled Latissimus Dorsi Flap
Although the latissimus dorsi myocutane-
ous flap is extremely reliable, the tissue bulk is
usually inadequate and necessitates insertion of
a prosthesis.61,62 Because of its robust blood sup-
ply from the thoracodorsal vessels, the latissimus
dorsi flap may also be used in women at high
risk of wound complications following either
implant-based reconstruction or pedicled TRAM
flap reconstruction. Significant compromise of
the thoracodorsal vessels can reduce the bulk of
the proposed flap, warranting consideration of
alternative reconstruction options. In patients
who have undergone a previous axillary lymph
node dissection, preoperative imaging may be
considered to delineate the patency of the tho-
racodorsal vessels; otherwise, care must be taken
to avoid ligating the serratus branch until the
thoracodorsal vessels are examined intraopera-
tively. The skin island can be designed at the bra
line, along the lateral margin of the muscle in
an oblique or vertical fashion (Fig. 2). Durkin et
al. provided an algorithm to guide the selection
process for the different latissimus dorsi skin
paddles (Fig. 3).63

Balancing Procedures and Ancillary Procedures
Alterations in shape and size of the recon-
structed breast may be required following
primary mound creation. Following autogenous tissue reconstruction, secondary adjustments include liposuction of the flap for improved contour and fat necrosis excision. After implant-based reconstruction, autologous fat grafting may be used to improve superior-pole hollowing.\textsuperscript{64,65} Despite promising reports, the biological mechanism responsible for the regenerative and filling effects of autologous fat grafting remains unclear.\textsuperscript{63,64} This is particularly troubling when lipoaspirates are deposited in a potential tumor bed to correct a lumpectomy defect in a patient who is faced with a risk of cancer recurrence in the first decade as high as 20 percent.\textsuperscript{66} In patients undergoing unilateral reconstruction who have large and/or ptotic breasts, a contralateral reduction and/or mastopexy may be appropriate (Fig. 4). Conversely, patients with small-volume breasts undergoing implant-based reconstruction may require a contralateral augmentation (Fig. 5). We prefer to perform the augmentation in either the subpectoral or dual plane, as it has been shown that implants placed behind the muscle do not interfere with mammography to the same extent as subglandular implants.\textsuperscript{67}

**Nipple-Areola Complex Reconstruction**

Although the creation of a breast mound restores the contour of the native breast, reconstruction of the nipple-areola complex represents the finishing touch on the reconstructed breast, and this is particularly challenging on an implant-reconstructed mound. Multiple techniques have been described for reconstruction of the nipple, including local flaps, composite...
grafts, and nipple-sharing techniques where the opposite nipple is used as a donor site (Fig. 6). Nipple-areola complex reconstruction is ideally performed a minimum of 2 months after the final breast mound procedure, once the reconstructed breast has achieved its final shape. Determining the ultimate position of the nipple-areola complex is a critical step, as secondary corrections for nipple asymmetry are difficult. In cases of secondary treatment of failed nipple reconstructions, various treatment options are available, including inserting autogenous grafts, rolled dermal tissue, or acellular dermal matrix under a new skin flap, or injecting semipermanent soft-tissue fillers such as calcium hydroxylapatite.

**OUTCOMES**

**Complications**

**Implant Reconstruction**

Early complications associated with tissue expander/implant reconstruction include infection, hematoma, seroma, and mastectomy skin flap necrosis. Infection, malposition, deflation, and exposure of the device secondary to skin flap necrosis are among the conditions that may necessitate tissue expander or implant removal. Although acute extrusion and implant loss are rare, late reoperation rates are reported as high as 30 percent. However, reported reoperation rates are difficult to compare, as different definitions and follow-up times are used in different studies. Capsular contractures,
Implant dislocation, visible wrinkling, and deflation are among the late complications that may require surgical intervention. In addition to structural complications, a possible link between T-cell anaplastic large-cell lymphoma of the breast and implants is under investigation.\textsuperscript{79} Anaplastic large-cell lymphoma is rare, representing 0.9 percent of all cases of non-Hodgkin’s lymphoma diagnosed in the United States in 2010. Although we have accumulated valuable experience with the use of acellular dermal matrix in the past 8 years, its purported advantages remain untested in clinical trials.\textsuperscript{80,81}

**Autogenous Reconstruction**

Acute complications associated with autogenous tissue include wound-related and ischemic complications at the donor and/or recipient site: infection, seroma, hematoma, delayed healing, wound dehiscence, and fat and skin flap necrosis. The incidence of fat necrosis and partial flap loss approaches 5 percent in most free TRAM flaps compared with 15 to 20 percent in pedicled TRAM flaps.\textsuperscript{82,83} The rate of total flap loss is 1 to 2 percent in most pedicled and free TRAM flap series.\textsuperscript{84} Smoking, chest wall irradiation, significant abdominal scarring, and obesity are associated with increased complication rates.\textsuperscript{82,83} Long-term complications of autogenous reconstruction are related primarily to donor-site morbidity. Data accumulated over the past decade show that muscle- and fascia-sparing techniques (e.g., DIEP flaps) result in measurably better postoperative truncal strength.\textsuperscript{51,52} Postoperative abdominal hernia or, more commonly, abdominal wall laxity remains a persistent issue for some patients choosing TRAM flap reconstruction. Interestingly, muscle-sparing techniques do not appear to decrease the risk of abdominal bulging or hernia formation (Level of Evidence: Therapeutic, III).\textsuperscript{85}

**Patient-Reported Outcomes**

Outcomes research in breast reconstruction evaluates both clinician and patient perspectives. From the patient perspective, we consider the impact of breast reconstruction on
Fig. 5. Right immediate reconstruction using tissue expander/implant and left dual-plane augmentation for balancing. (Above) Preoperative views demonstrating right lumpectomy defect in small breasts with grade I ptosis. (Below) Postoperative views.

Fig. 6. Different techniques for nipple reconstruction. (Above) CV flap. (Center) Star flap. (Below) Skate flap. (Reprinted with permission from Memorial Sloan-Kettering Cancer Center.)
health-related quality of life and patient satisfaction. The BREAST-Q is a patient-reported outcome questionnaire that facilitates quantification of patient satisfaction; body image; and important health-related quality-of-life domains such as physical, psychosocial, and sexual well-being. The BREAST-Q is a breast surgery–specific instrument with a breast reconstruction module designed to address unique issues of importance to reconstruction patients. In a prospective study of autogenous reconstruction patients, the BREAST-Q documented improvement in body image, psychosocial well-being, and sexual well-being as early as 3 weeks after reconstruction. In contrast, self-reported abdominal well-being scores remained below preoperative baseline at 3 months (Level of Evidence: Therapeutic IV). Other key BREAST-Q research includes a cross-sectional survey performed by Hu et al. that reported decreased satisfaction with implant-based reconstruction among patients greater than 5 years postoperatively, whereas patient satisfaction with TRAM flap reconstruction remained comparatively stable.

CONCLUSIONS

The decision-making process for breast reconstruction that alone does not confer survival benefit can be complex and will largely rest on the patient’s personal values and beliefs and guidance from the surgeon. Therefore, competency of a plastic surgeon lies not only in his or her technical skills to carry out the reconstruction but also in his or her knowledge of the advantages and disadvantages of each procedure, the different oncologic aspects, and the long-term objective and subjective implications of surgery.

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