State of the Art and Science in Postmastectomy Breast Reconstruction

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Learning Objectives: After reading this article, the participant should be able to: 1. Examine clinicopathologic factors to determine the best timing for breast reconstruction. 2. Develop treatment plans for all patients for breast preserving reconstruction. 3. Determine the best approaches for partial and whole breast reconstruction. 4. Be familiar with advanced techniques in breast reconstruction.

Background: Often, the decision to perform a partial or total mastectomy hinges on reconstructive issues, not oncology-related considerations.

Methods: Innovative timing and reconstruction approaches are being implemented after partial mastectomy and breast reconstruction after mastectomy.

Results: Among patients undergoing repair of a partial mastectomy defect, immediate or delayed repair before radiation allows for use of remaining breast tissue for repair. Innovative approaches include breast remodeling, local rotation advancement, and concentric mastopexy and breast reduction techniques to recontour remaining breast tissue. Delayed repair after whole-breast radiation usually is not preferred and is performed with autologous fat grafting or a flap. However, partial breast radiation allows for safe delayed repair after irradiation using the same techniques used for preradiation repair. The optimal timing for breast reconstruction after mastectomy remains a topic of controversy. Adjunct techniques for implant-based postmastectomy reconstruction include the use of acellular dermal matrix and autologous fat grafting, especially in the setting of radiation therapy. Techniques also include a more focused use of flaps only in the setting of radiation therapy with increasing use of new perforator-based autologous tissue flap options.

Conclusion: Innovative approaches to breast reconstruction have evolved to provide restorative healing for patients and hasten return to their modern, active lifestyles. (Plast. Reconstr. Surg. 135: 755e, 2015.)

The decision to repair a partial mastectomy defect or perform total breast reconstruction after mastectomy is among the most critical decisions in breast reconstruction. Often, the decision to perform a partial or total mastectomy hinges upon reconstructive issues, not oncology-related considerations. Certainly, cancer stage and the ability to obtain negative tumor margins are important factors, as are breast size and tumor location. Referring breast surgeons should frequently address the question of whether to perform a partial or total mastectomy. This question can serve as a good starting point at which to determine the best personalized extirpative and reconstructive approach for each patient.

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APPROACH TO REPAIR OF PARTIAL MASTECTOMY DEFECTS

Patient Selection for Partial Mastectomy

In general, repair of partial mastectomy defects is best suited for patients with large breasts.\(^1\) Adequate volume of remaining breast tissue after tumor extirpation allows for rearrangement of the tissue to reshape the breast.\(^2\) Patients with ptotic-shaped breasts also are good candidates for partial mastectomy because certain reparative techniques use a mastopexy or breast reduction, which repositions the nipple-areola complex higher on the breast mound (Level of Evidence: Therapeutic, IV).\(^3\) Breast ptosis also allows for repositioning of the lower-pole breast tissue to the upper pole of the breast, which results in a more youthful-appearing breast.

Large-breasted patients with advanced stages of breast cancer who desire reconstruction also can benefit from partial mastectomy.\(^4\) Neoadjuvant chemotherapy can enable patients with large tumors that favorably respond to neoadjuvant chemotherapy to become eligible for breast-conserving surgery which entails partial mastectomy followed by radiation therapy.\(^5\) Patients with advanced disease usually require radiation therapy regardless of whether they undergo partial or total mastectomy. Large-breasted patients tend to be obese, and obesity is associated with higher reconstruction complication rates after mastectomy, especially in the setting of radiation therapy.\(^6\) To reduce the potential for complications, partial mastectomy can be a good option for these patients. The reduction in breast size also makes the technical delivery of radiation therapy less cumbersome.\(^7\)

Timing of Repair of Partial Mastectomy Defects

The timing of oncoplastic repair influences both the outcome and the reconstructive technique used to perform the repair. Waiting to repair a partial mastectomy defect until after radiation therapy often leads to a contracted deformity for which a flap to replace breast skin is required. Most patients who undergo breast-conserving surgery do not desire this treatment approach. However, when a repair is performed before radiation therapy, this allows for the use of remaining local breast tissue, which results in the most natural outcome because breast texture and color are maintained.\(^8\)

The optimal time at which to repair a partial mastectomy defect often depends on when a patient presents for consultation (Fig. 1).\(^1\) Patients who present after radiation therapy by default undergo delayed repair, and those who present after partial mastectomy but before radiation therapy benefit from repair before radiation therapy. Repair before radiation therapy allows for the use of local-tissue techniques without the need to address high rates of complications associated with use of these techniques on an irradiated breast. However, patients who present before partial mastectomy and radiation therapy require an assessment of the extent of local disease, and a negative tumor margin must be obtained. Patients with multifocal disease as identified by preoperative ultrasonography or extensive microcalcifications seen on preoperative mammography (for which a negative tumor margin may be more difficult to obtain) usually benefit from delayed repair before radiation therapy. Immediate repair at the time of partial mastectomy is best employed in patients with localized disease when reliable intraoperative tumor margin assessment is available. If concerns arise regarding the status of the intraoperative tumor margin, delayed repair before radiation therapy to allow for permanent tumor sections before repair may be the best option. However, immediate repair of partial mastectomy defects tends to result in the best aesthetic outcomes.

Reparative Techniques for Partial Mastectomy Defects

The technique for repair is often influenced by the timing of the repair and radiation therapy.\(^1\) Delayed repair after whole-breast radiation therapy frequently necessitates the transfer of a flap to assist with healing within the irradiated breast. Delayed repair also usually necessitates skin replacement that results from the contracted deformity. In many cases, breast skin is not resected as part of the extirpative procedure. Autologous fat grafting, along with percutaneous needle release of scar bands, also is a common approach for delayed repair; however, multiple surgical procedures usually are required. The options for repair after partial-breast radiation therapy are different; with partial-breast radiation therapy, the remaining breast tissue has not been irradiated and can be used to repair the defect without encountering the high complication rates associated with local-tissue techniques after whole-breast radiation therapy. Repair of partial-mastectomy defects must be performed after partial-breast radiation therapy so the tumor bed can be targeted (external beam radiation therapy) or after removal of the brachytherapy applicator.
Fig. 1. Management algorithm for repair of partial mastectomy defects. TAP, thoracodorsal artery perforator; XRT, radiation therapy.
In small-breasted patients (A or B cup), repair before radiation therapy can be more challenging because there is a paucity of remaining breast tissue with which to rearrange and reshape the breast. In small-breasted patients, especially those who can avoid radiation therapy if they have a mastectomy, nipple-sparing mastectomy with total breast reconstruction may be a better option. These patients tend to be thin and have a paucity of autologous tissue options, so avoiding radiation therapy preserves the option for implant-based breast reconstruction. Among patients who present for delayed repair after radiation therapy, percutaneous needle release of scar bands along with fat grafting can be used to repair a small breast.1

Immediate repair of partial-mastectomy defects before radiation therapy can be an ideal option for patients with C- and D-cup breasts; however, the reconstructive surgeon must consider the extent of breast skin resection, breast size, tumor size and location, and the degree of breast ptosis.1 In these situations (immediate or delayed before radiation therapy), the breast has not been irradiated and use of the remaining breast tissue can result in excellent outcomes.

In patients with C-cup breasts without substantial breast ptosis, options include local tissue rearrangement, concentric mastopexy, and the use of rotation advancement flaps. Lower-quadrant defects tend to be more difficult to repair in C-cup patients, especially those without breast ptosis, and the option of nipple-sparing mastectomy with immediate reconstruction should be discussed with these patients.

Although there are many local tissue arrangement methods, the breast remodeling technique that entails complete separation of the breast skin envelope from the underlying parenchyma allows for plication of the breast parenchymal defect without tethering of the overlying skin. The second stage of this reparative technique involves autologous fat grafting to replace the diffuse volume loss that can occur as a result of radiation therapy. Fat grafting is very effective in this scenario; contracted contour deformities and fibrotic radiated breast skin are not considerations because the defect is repaired prior to radiation therapy.

Concentric mastopexy for the C-cup breast can be very effective for patients with defects in the upper quadrants of the breast (Fig. 2). The resultant superior advancement of the breast tissue fills defects in the upper quadrants and allows for access to perform the extirpation. With this technique, the contralateral concentric mastopexy with direct liposuction for volume reduction to maintain symmetry is performed at the time of the ipsilateral repair.

Rotation advancement from the lower outer breast can be useful in patients with upper outer and upper central defects. Because scarring can be extensive, many of these patients may be better served with a deepithelialized thoracodorsal flaps.

![Fig. 2. Concentric mastopexy technique to repair partial mastectomy defects. (Above, left) Preoperative views of a 37-year-old with C-cup, nonptotic breasts who has a 2-cm invasive breast cancer in the 10-o’clock position in the right breast. (Above, right) Intraoperative view of access incision the breast surgeon used to perform the partial mastectomy. Defect after partial mastectomy. (Below, left) After direct repair of the defect and deepithelialization of the concentric region. (Below, center) After purse-string closure of the concentric region using permanent suture. (Below, right) Postoperative views 6 weeks after an immediate repair of the right breast using the concentric mastopexy technique and left concentric mastopexy for symmetry.](image-url)
artery perforator flap. Local deepithelialized flaps (thoracodorsal artery perforator, latissimus dorsi, intercostal perforator) for repair of partial mastectomy are now commonly transferred before radiation after confirmation of a negative postoperative tumor margin. Transfer of the flap before radiation therapy avoids the need for the skin island because skin replacement is not usually required. Skin replacement after partial mastectomy is usually required because of the contracted deformity that results when a defect is not repaired before radiation therapy. Direct skin excision as part of the extirpative procedure has become less common in recent years.

The designation of seven zones within the breast that correspond to straightforward dermoglandular designs has simplified and organized the approach to the repair of partial mastectomy defects in patients with D-cup breasts (Fig. 3). The Wise skin resection pattern combined with inferiorly based dermoglandular pedicles tends to be the most versatile for the breast reduction technique. However, for lower-quadrant defects, the use of a vertical skin resection pattern and a superiorly based dermoglandular pedicle can be very effective. When the breast reduction technique is used for repair, some surgeons now perform contralateral breast reduction to achieve symmetry approximately 6 months after radiation therapy completion. This approach allows for volume stabilization in the ipsilateral repaired breast and better symmetry. The need to revise an already-reduced breast and the inherent risk of vascular compromise to the nipple-areola complex are eliminated, and the option to fat graft the ipsilateral breast to restore volume that may have been lost as a result of radiation therapy remains viable.

**BREAST RECONSTRUCTION FACTORS AFTER TOTAL MASTECTOMY**

**The Timing of Breast Reconstruction Is of Utmost Importance in the Decision-Making Process**

Currently, more centers in the United States recommend radiation therapy for patients with breast cancer, including patients with early-stage breast cancer. The expanding use of radiation therapy in patients with early-stage breast cancer.

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**Fig. 3.** Breast repair after a partial mastectomy in a 41-year-old woman with a 36DD bra size who presented with a T2N0 (stage IIA) invasive ductal carcinoma in the upper inner quadrant of the right breast (zone 1). **(Above, left)** Preoperative view. Wise skin pattern markings and the inferomedial dermoglandular pedicle in preparation for repair with the breast reduction technique. **(Above, right)** Intraoperative view showing the tumor resection, which was performed through an access incision along the superior limb of the Wise pattern. **(Below, left)** Intraoperative view showing the deepithelialized inferomedial dermoglandular pedicle and after creation of both the dermoglandular pedicle and the Wise skin flap, which in certain zones (zones 2 and 7) can serve as separate reconstructive components. **(Below, center)** Postoperative view 10 months after repair showing how the retained medial wedge of breast tissue filled the defect in zone 1. The surgeon can plan for contralateral breast reduction using the same inferomedial dermoglandular design. **(Below, right)** Postoperative view 1 month after contralateral breast reduction for symmetry.
has increased the complexity of planning for breast reconstruction.\textsuperscript{10} If radiation therapy is required or a patient is at moderate or high risk for requiring radiation therapy, delaying the definitive (implant placement or flap transfer) reconstruction with initial placement of a tissue expander to preserve the breast skin envelope for a skin-preserving delayed reconstruction after postmastectomy radiation therapy is usually the best course, but if radiation therapy is not required or the patient is at low risk for requiring radiation therapy, immediate reconstruction is appropriate and permits better
aesthetic outcomes. However, because nodal metastases may not be detected until mastectomy and because micrometastases may not be detected until the final pathology review, it is often not known until several days after mastectomy whether radiation therapy will be required. If breast reconstruction is performed at the time of mastectomy and a patient is found postoperatively to have lymph node involvement, radiation therapy may adversely affect the aesthetic outcome and the reconstructed breast may present technical difficulties associated with radiation delivery to the internal mammary nodes, resulting in either increased lung dose or inadequate radiation doses to these nodes. In contrast, if breast reconstruction is delayed because physicians suspect that a patient may require radiation therapy, but the review of permanent sections reveals that radiation therapy is not needed, the mastectomy skin and shape of the breast skin envelope will be lost, along with the chance for the best possible aesthetic outcome.

In 2002, the author implemented a two-stage approach, delayed-immediate breast reconstruction (Fig. 4), to maximize the chance for the best aesthetic outcome. Figure 4 shows the procedure for patients with unilateral breast cancer not treated with prophylactic contralateral mastectomy and for patients with bilateral breast cancer. In patients with unilateral breast cancer who elect to undergo prophylactic contralateral mastectomy, contralateral mastectomy and immediate reconstruction are performed at the time of definitive reconstruction of the breast with cancer. With delayed-immediate reconstruction, patients who do not require radiation therapy can achieve aesthetic outcomes similar to those realized with immediate reconstruction, and patients who require radiation therapy can avoid the aesthetic problems associated with delivery of radiation after an immediate breast reconstruction (Fig. 5). Patients who are at increased risk for conditions necessitating

In 5. (Above, left) Preoperative view of delayed-immediate reconstruction in a 32-year-old woman who presented after neoadjuvant chemotherapy for a T2N1 right breast cancer who was thin and had a D-cup breast with minimal abdominal and buttock tissue. She had a skin-preserving modified radical mastectomy with placement of a subpectoral 600-cc tissue expander with an intraoperative saline fill volume of 600 cc. (Above, right) Postoperative view 6 weeks after surgery, with no additional expansion performed since surgery. (Below, left) The current approach to expander deflation is shown in this patient, who is halfway through a 6-week course of three-beam postmastectomy radiation therapy; 300 cc of saline was removed before initiation of postmastectomy radiation therapy, and 300 cc of saline remained in the expander during postmastectomy radiation therapy. Partial deflation improves the geometry for radiation delivery in the superomedial aspect of the chest wall (dashed white circle), which allows for the use of an anterior electron beam field in addition to the two photon beam fields. The three-beam field allows for treatment of the internal mammary nodal basins and minimizes injury to the heart and lungs. (Above, center) Postirradiation view 3 months after postmastectomy radiation therapy. Two weeks after the completion of postmastectomy radiation therapy, the patient was reinfated with 300 cc of saline into the expander, to bring the total volume in the expander to the predeflation volume of 600 cc. (Above, right) Skin-preserving delayed reconstruction with a latissimus dorsi myocutaneous flap and silicone breast implant.
radiation therapy and who desire breast reconstruction are considered candidates for delayed-immediate breast reconstruction.

Delayed-immediate reconstruction allows for skin-preserving delayed breast reconstruction after radiation therapy in patients with stage IIA (and some with stage I in addition to patients with extensive microcalcifications on mammography) disease in whom the need for radiation therapy becomes apparent after review of the permanent pathologic sections after mastectomy. Implementation of this protocol increased appreciation of the benefits and importance of breast skin preservation in terms of lowering complication rates of definitive breast reconstruction and improving aesthetic outcomes of breast reconstruction after radiation therapy. Preserving the breast skin envelope in patients who have undergone radiation therapy allows for direct placement of an implant (usually along with fat grafting) after postmastectomy radiation therapy and decreases the need for or dimensions of the skin island for a latissimus dorsi, deep inferior epigastric perforator (DIEP), or gluteal artery perforator flaps, which improves the aesthetic outcome of the reconstructed breast, decreases donor-site morbidity (latissimus dorsi or thoracodorsal artery perforator), and allows for bilateral hemiabdominal flaps for bilateral breast reconstruction because of decreased skin requirements for the irradiated breast.

In light of the successful outcomes in patients treated under this protocol, expanding the use of this approach to include patients with locally advanced breast cancer (clinical stage IIB and III disease), all of whom require radiation therapy, became a possibility. Patients with locally advanced breast cancer traditionally have not been eligible for skin-preserving mastectomy because of concerns about local recurrence of breast cancer and the inability to preserve the three-dimensional breast skin envelope for reconstruction after radiation therapy. The absence of a breast skin envelope makes delayed breast reconstruction after radiation therapy extremely challenging because of the increased need for skin and volume replacement and the tendency for wound healing problems to occur at the interface between the irradiated chest wall and autologous tissue flaps, which often are used to reconstruct the breast. An additional issue for patients with locally advanced breast cancer is they traditionally awake from mastectomy without a breast.

These considerations, together with positive experience with skin-preserving delayed reconstruction in patients with earlier stage breast cancer and the increasing evidence that neoadjuvant chemotherapy and radiation therapy plus skin-preserving mastectomy in patients with locally advanced breast cancer results in favorable long-term local control and survival rates, led to the 2003 implementation of a multidisciplinary protocol, delayed-delayed breast reconstruction (Fig. 6), for skin-preserving delayed breast reconstruction after radiation therapy in patients with locally advanced breast cancer and other patients known preoperatively to require radiation therapy. The purpose of this protocol was to improve aesthetic outcomes, decrease complication rates, and reduce the substantial psychological disadvantages associated with standard non–skin-sparing delayed reconstruction after radiation therapy. First, patients undergo neoadjuvant chemotherapy, which can decrease the need to resect breast skin at mastectomy and treat subclinical involvement of the dermal lymphatics, which can increase the likelihood of recurrence after mastectomy despite the use of postmastectomy radiation therapy. After completion of neoadjuvant chemotherapy, patients with clinical stages IIB and III disease are evaluated by a multidisciplinary breast cancer team to determine their eligibility for skin-preserving delayed reconstruction. The only patients excluded from skin-preserving delayed reconstruction are those with inflammatory breast cancer and those for whom breast skin cannot be preserved with negative tumor margins. However, in patients with involvement of the breast skin with tumor, the use of neoadjuvant chemotherapy may subsequently allow for preservation of breast skin if the patient has tumor regression from chemotherapy. Patients then proceed to skin-preserving mastectomy with immediate placement of a saline-filled, textured tissue expander to preserve the shape and dimensions of the breast skin envelope and provide complete coverage with acellular dermal matrices. Before computed tomographic simulation for planning radiation delivery, the expander is partially deflated (varies by angulation of the patient’s chest wall and expander size in relation to chest wall dimensions; however, approximately one-half to one-third of saline volume is removed from the expander) in the plastic surgery clinic to create a flat chest wall surface in the superomedial aspect of the chest wall to allow for three-beam radiation therapy. Among patients with clinical stage IIB breast cancer who are treated with primary systemic chemotherapy followed by surgery, those with
clinical T3N0 disease are advised to undergo postmastectomy radiation therapy. Those with T2N1 disease who achieve a pathologic complete response to primary systemic chemotherapy may not need postmastectomy radiation therapy; however, all patients who have positive axillary lymph nodes after primary systemic chemotherapy are advised to undergo postmastectomy radiation therapy. Patients with clinical stage IIB breast cancer who are treated with primary surgery followed by adjuvant chemotherapy are considered to be at an intermediate risk for locoregional recurrence and receive individualized treatment recommendations based on factors such as primary tumor size, number of positive axillary lymph nodes, presence or absence of lymphovascular invasion and extracapsular lymph node extension, patient age, and percentage of harvested lymph nodes positive for cancer. In accordance with national breast cancer treatment guidelines, all patients with clinical stage III disease, even those with a pathologic complete response to primary systemic chemotherapy, are advised to undergo postmastectomy radiation therapy. Several weeks after completion of postmastectomy radiation therapy and resolution of any radiation-induced skin desquamation, the
tissue expander is reinflated to the predeflation saline fill volume. Approximately 3 months after completion of postmastectomy radiation therapy and reinflation of the tissue expander, the expander is removed and definitive reconstruction is performed using the preserved breast skin envelope.

A study of 47 patients found no locoregional recurrences of breast cancer according to a multidisciplinary protocol.11 There was no statistically significant difference in 3-year relapse-free survival between the skin-preserving protocol group and a control group that underwent standard delayed reconstruction after radiation therapy. These findings may have major implications for the future of breast reconstruction, resulting in a paradigm shift in the care of patients with clinical stage IIB and III locally advanced breast cancer, such that the breast skin envelope can be preserved for subsequent delayed reconstruction after radiation therapy (Fig. 7).

**BREAST RECONSTRUCTIVE TECHNIQUE INNOVATIONS OPTIMIZE OUTCOMES**

**Two-Stage Implant Reconstruction: Tabbed Tissue Expander and Acellular Dermal Matrix Placement followed by Exchange of the Expander for a Permanent Breast Implant along with Fat Grafting**

The advent of tabbed tissue expanders, acellular dermal matrix, and autologous fat grafting has enhanced the outcomes of implant-based breast reconstruction. Tissue expanders are now available with suture-secure tabs to suture to the chest wall to prevent postoperative displacement. Increasingly, surgeons are using acellular dermal matrix to provide coverage of the lower pole of the expander and the pectoralis major muscle for the upper pole. A recent trend is to provide complete coverage of the expander with acellular dermal matrix to potentially decrease the occurrence

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**Fig. 7.** (Above, left) Delayed-delayed breast reconstruction in a 36-year-old woman with left stage III breast cancer (T2N3M0) who underwent neoadjuvant chemotherapy. The patient underwent a left skin-preserving modified mastectomy using a circumareolar incision and a counter–left axillary incision to perform the lymphadenectomy. (Above, right) Postoperative view 1 month after mastectomy and placement of a subpectoral tissue expander with an intraoperative saline fill of 400 cc. (Below, left) Two months after surgery, the patient had postmastectomy radiation therapy. The patient is 3 weeks into a 6-week course of postmastectomy radiation therapy with the expander partially deflated to optimize radiation delivery, especially to the internal mammary nodal basin. Two weeks after the completion of postmastectomy radiation therapy, the tissue expander was reinflated with saline to the predeflation volume before partial deflation for postmastectomy radiation therapy (400 cc). (Below, center) Several months after the completion of postmastectomy radiation therapy, the tissue expander was removed and replaced with a DIEP flap. Exchange for a breast implant and fat grafting also could have been performed, but with a higher potential for complication. (Below, right) Three years after skin-preserved delayed reconstruction with a DIEP flap. A contralateral breast implant was also performed for symmetry.
of capsular contracture. Using this technique, the entire expander is covered with a large sheet of acellular dermal matrix, and the pectoralis major muscle is sewn over the acellular dermal matrix in a vest-over-pants fashion. (See Video, Supplemental Digital Content 1, which displays a technique for providing complete coverage of the expander with acellular dermal matrix to potentially decrease the occurrence of capsular contracture. This video is available in the “Related Videos” section of the full-text article on PRSJournal.com or at http://links.lww.com/PRS/B264.) Because acellular dermal matrix allows for intraoperative saline filling of the expander, a more ptotic-shaped breast can be reconstructed that enables more easily achieved symmetry with the contralateral native breast and reduces the number of postoperative expansion visits. Before the advent of acellular dermal matrix with intraoperative saline filling, symmetry could be achieved only with bilateral implant-based breast reconstruction. The increasing use of autologous fat grafting also has contributed to enhanced aesthetic outcomes using implant-based breast reconstruction. When fat grafting is performed during or at the exchange for the permanent implant, the acellular dermal matrix that is placed during the first stage (placement of the tissue expander) allows for injection of fat grafts into the lower mastectomy flap which, without acellular dermal matrix, is not always possible and it also accommodates a more secure closure of the mastectomy incision. [See Video, Supplemental Digital Content 2, which displays fat grafting of the inferior breast skin envelope at the time of tissue expander exchange for the permanent implant. The previously placed acellular dermal matrix at stage 1 (expander placement) allows for a tissue plane for injection of fat graft within the breast skin envelope at the time of the exchange for the permanent breast implant and provides for a more secure closure. This video is available in the “Related Videos” section of the full-text article on PRSJournal.com or at http://links.lww.com/PRS/B265.] Surgeons have begun to perform fat grafting as a preliminary step after radiation therapy and before the exchange for the permanent implant. The objective is to decrease subsequent wound healing problems and implant dehiscence during the second stage (exchange for the permanent implant). Future research will need to focus on the best timing at which to apply fat grafting to a reconstructed breast. Often, surgeons perform additional fat grafting at any subsequent revision operations or as patient needs arise. The advent of acellular dermal matrix and fat grafting also has decreased the need for the addition of a local flap such as a latissimus dorsi or thoracodorsal artery perforator flap to reconstruct a ptotic and aesthetically pleasing implant-based breast. These adjuvant procedures also have changed the approach to the revision of...
implant-based reconstruction. Acellular dermal matrix allows for repositioning of a malpositioned implant, and both acellular dermal matrix and fat grafting correct some of the adverse aesthetic effects of implant rippling.

**One-Stage Implant Reconstruction**

The safety of nipple-sparing mastectomy has led to increased use of this operation in patients seeking risk-reducing mastectomy and for those with early-stage breast cancer. The indications for nipple-sparing mastectomy likely will broaden in the near future. Preserving the nipple-areola complex maintains the three-dimensional shape of the breast skin envelope and allows for immediate insertion of a permanent implant. Implant-based reconstruction with nipple-sparing mastectomy is preferred because it allows for the mastectomy incision to be camouflaged in the lateral breast crease or inframammary fold. These incision locations do not provide access to the internal mammary blood vessels to serve as recipient vessels for microvascular breast reconstruction. Mastectomy incisions radial to the nipple-areola complex that displace nipple position and those that interfere with blood supply to the nipple-areola complex should be avoided. In addition, patients who are undergoing nipple-sparing mastectomy have early-stage breast cancer and undergo sentinel lymph node biopsy only; therefore, use of the thoracodorsal vessels to serve as recipient vessels for microvascular breast reconstruction necessitates dissection of the axilla, which may predispose the patient to lymphedema.

Nipple-sparing mastectomy, along with acellular dermal matrix, can more easily result in symmetry with the contralateral normal breast with unilateral implant-based breast reconstruction. The addition of an acellular dermal matrix sling to support the permanent implant can reduce the compression of the blood supply to the preserved breast skin and nipple-areola complex. Intraoperative fluorescence imaging also can help to determine whether adequate perfusion is retained to the breast skin envelope for immediate insertion of the permanent breast implant. Although the one-stage approach allows for reconstruction with a single surgical procedure, it presents increased potential for complications. In contrast, one-stage implant reconstruction is less costly than a two-stage option and tends to better maintain the ptotic shape of the breast, which results in a more natural-appearing reconstructed breast.

**Muscle-Only Latissimus Dorsi or Thoracodorsal Artery Perforator Flap**

The use of a latissimus dorsi myocutaneous flap to perform reconstruction after mastectomy has become less necessary because of the increasing use of acellular dermal matrix and breast skin-preserving techniques. However, muscle-only latissimus dorsi and the deepithelialized thoracodorsal artery perforator flap continue to serve important roles in mastectomy reconstruction. These flaps are good options for obese patients, for whom it is not always safe to perform an implant-only reconstruction because of the risk of infection. These flaps also are suitable for patients who have undergone radiation therapy for whom the additional blood supply provided to the reconstructed breast can assist in healing through transfer of nonirradiated cellular elements to the irradiated breast. The muscle-only latissimus dorsi and deepithelialized thoracodorsal artery perforator flaps also can help reabsorb postoperative inflammatory fluid, which can serve as a source for infection and subsequent implant loss, especially in patients who tend to have extensive lymphadenectomies.

**DIEP Flap**

In clinical practices that routinely perform DIEP flap breast reconstruction, the use of computed tomographic angiography can serve as a “road map” to optimally position the flap overlying the perforating blood vessels and to hasten the selection and dissection of the perforating blood vessels. For patients who have had radiation therapy and no skin preservation who undergo delayed reconstruction (i.e., standard delayed reconstruction after radiation therapy) and thin patients without suitable gluteal tissue, a modification of a bipedicled DIEP flap that is referred to as the double-DIEP flap can provide an aesthetically pleasing breast reconstruction (Fig. 8). (See Video, Supplemental Digital Content 3, which displays the double-deep inferior epigastric perforator flap. This video is available in the “Related Videos” section of the full-text article on PRSJournal.com or at http://links.lww.com/PRS/B266.)

The double-DIEP flap is versatile and can be folded (vertical folded) or rotated (horizontally rotated) to increase projection and width (skin replacement) of the reconstructed breast, respectively. The double-DIEP flap also can provide axillary fill volume (horizontally folded with
The innovative approach to insetting the double-DIEP flap allows for use of both the antegrade and retrograde internal mammary blood vessels without the need for vein grafts or cumbersome microsurgery. The double-DIEP flap is especially useful for thin patients who need additional volume to reconstruct the breast or for patients who have had radiation therapy who need a large amount of skin replacement.

The double-DIEP flap has become a commonly used and valuable option at M. D. Anderson. Harvest of each side of a double-DIEP flap is the same as harvest of a standard unipedicle DIEP flap with the exception of a few technical details. The flap harvest procedure described here is used for the three most common insets, all of which involve positioning of zone 2 of each side of the flap superiorly on the reconstructed breast. If the surgeon prefers the suture closure to be positioned
inferiorly on the reconstructed breast to conceal 
the scar, the steps below should be reversed. For 
delayed reconstruction after postmastectomy radia-
tion therapy, placement of the suture closure be 
positioned superiorly on the reconstructed breast 
because this allows for zone 2 of the ipsilateral 
halfl of the DIEP flap (which will become the 
lateral aspect of the reconstructed breast) to be 
deepithelialized and placed within an axillary sub-
cutaneous pocket to replace the axillary fat pad 
that is resected as part of a nodal dissection. In 
addition, when the suture closure is positioned 
superiorly, the resulting invagination pushes the 
central deepithelialized region of the flap inferi-
orly, increasing the lower pole projection of the 
reconstructed breast. Shown are the three most 
commonly used insets for the double-DIEP flap. 
However, for any of these options, the inset can be 
rotated 180 degrees to position the suture closure 
of the ipsilateral and contralateral sides of the flap 
on the inferior, rather than the superior, aspect of 
the reconstructed breast to conceal the scar.

Rotated Inset with Axillary Extension
The rotated inset with axillary extension (Fig. 8, 
center) is similar to the rotated inset, except that 
Zone 2 of the ipsilateral side of the flap is only par-
tially suture plicated to the contralateral side of the 
flap and is deepithelialized and placed within an 
axillary subcutaneous pocket. The axillary exten-
sion restores axillary volume that is lost when the 
axillary fat pad is resected during axillary nodal dis-
section. Consequently, the rotated inset with axil-
lar extension can be ideal for patients undergoing 
delayed reconstruction after modified radical mas-
tectomy and postmastectomy radiation therapy.

Vertical Folded Inset
The vertical folded inset (Fig. 8, below) is 
well suited for patients who do not need substan-
tial replacement of breast skin and for those who 
undergo axillary sentinel lymph node biopsy with-
out subsequent resection of the axillary fat pad. 
The vertical folded inset is most commonly used 
for thin patients with medium to large breasts who 
undergo immediate breast reconstruction after 
total mastectomy and axillary sentinel lymph node 
biopsy and for those who have not received preop-
erative radiation therapy and are not expected to 
require postmastectomy radiation therapy. 
The contralateral side of the flap is positioned 
superficially to the ipsilateral side of the flap, which 
is folded under the contralateral side of the flap 
directly on the chest wall and pectoralis major mus-
cle. The vertical folded inset increases the projection 
of the lower pole of the reconstructed breast; this

Video 3. Supplemental Digital Content 3 displays the double-
deep inferior epigastric perforator flap. This video is available in 
the “Related Videos” section of the full-text article on PRSJour-
nal.com or at http://links.lww.com/PRS/B266.

Video 3.

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can be helpful for patients with a full contralateral native breast or a contralateral native breast that has previously been augmented with a breast implant.

Because the vascular pedicles from both sides of the double-DIEP flap are in close proximity to the internal mammary recipient vessels, the length of the vascular pedicles of the flap is not an issue. However, two rib cartilage segments are still removed to ensure adequate recipient vessel length and avoid tension on the vascular pedicles attributable to gravity when the patient is upright.

In patients for whom a vertical folded inset is ideal, after microvascular reperfusion—but before placement of the flap within the breast skin envelope—the ipsilateral side of the flap, which will be positioned posteriorly, is deepithelialized. This avoids the need to remove the flap from the breast skin pocket after the desired inset has been achieved. It is imperative that the perforators and vascular pedicle of the posterior aspect of the reconstructed breast (ipsilateral side of the flap) not be compressed by the overlying anterior aspect of the reconstructed breast (contralateral side of the flap).

The Boomerang Flap

Another commonly used option for breast reconstruction is a redesign of the gluteal artery perforator that is referred to as the "boomerang flap" (Fig. 9) (Level of Evidence: Therapeutic, IV). The standard elliptical-shaped gluteal artery perforator flap was redesigned to be a more reliable option for breast reconstruction and to improve cosmetic outcomes, especially in large-breasted patients, because it provides a larger volume of tissue and tissue for both the superior and lateral aspects of the reconstructed breast. Although many reconstructive surgeons still consider gluteal flaps to be a second-line option for autologous breast reconstruction, use of these flaps is increasing,
especially for patients who have already had a transverse rectus abdominis myocutaneous flap reconstruction for contralateral breast cancer with a new ipsilateral breast cancer or are found afterward to have the BRCA gene mutation, those with a failed transverse rectus abdominis myocutaneous flap reconstruction, those who have undergone a previous aesthetic abdominoplasty, or patients who have little abdominal subcutaneous tissue or no laxity in the abdominal musculofascial system. In these scenarios, the boomerang flap is useful, especially for patients who have received prior radiation therapy to the chest wall, in which case breast implants may not be a preferred option.

Nipple Reconstruction with Cartilage Graft

Another important refinement in breast reconstruction relates to nipple reconstruction, patient dissatisfaction that occurs with loss of projection, and the poor results seen with use of biologics. The use of costochondral cartilage grafts harvested, sculpted, and subsequently banked under the breast skin at the time of microsurgical breast reconstruction and subsequently retrieved for nipple reconstruction improves the outcome of nipple reconstruction without the additional cost of biologics (Fig. 10). This low-cost and safe method refines the outcome of nipple and areola reconstruction, can be combined with other revision procedures such as fat grafting, and can be performed under local anesthesia in an outpatient setting. The cartilage graft does not reabsorb and maintains long-term nipple projection (but is not hard or overprojecting), which results in high levels of patient satisfaction.

Current Recommendations and Summary

The question remains: Should an oncoplastic repair be performed at the time of the partial mastectomy or afterward? In a patient with localized disease and negative intraoperative tumor margins, repair at the time of mastectomy seems reasonable. However, in patients with multifocal disease or concerns about the status of the intraoperative tumor margin, oncoplastic repair after a review of the permanent sections, but before radiation therapy, is probably best.

Patients with A- or B-cup breasts are not always good candidates for breast conservation, and, if they can avoid radiation therapy, they...
should instead consider a nipple-sparing mastectomy with immediate reconstruction and no radiation therapy. The breast remodeling, mastectomy, or rotation advancement technique can be ideal for many patients with C-cup breasts and can set the stage for autologous fat grafting after radiation therapy. Breast reduction techniques can result in excellent outcomes in patients with large breasts. Options for delayed repair after radiation therapy depend on the type of radiation therapy that was delivered.

CONCLUSIONS

The optimal timing for breast reconstruction after mastectomy remains a topic of controversy. Some centers perform immediate reconstruction even if a patient will require radiation therapy, whereas others prefer to stage the reconstruction, place a tissue expander at mastectomy, and perform definitive reconstruction after radiation therapy. The safety of breast skin preservation in patients with stage 3 breast cancer has been demonstrated, and now these patients are more routinely undergoing skin-preserving reconstruction. Adjunct techniques for implant-based reconstruction after mastectomy include the use of acellular dermal matrix and autologous fat grafting, for which capsular contracture and various timings of fat graft injection are being explored, respectively, especially in the setting of radiation therapy. Techniques also include a more focused use of perforator-based autologous tissue flaps only in the setting of radiation therapy with increasing use of new options such as the double-DIEP flap and the boomerang gluteal flap.

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