

CLINICAL THERAPEUTICS

Breast Reconstruction after Surgery for Breast Cancer

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This Journal feature begins with a case vignette that includes a therapeutic recommendation. A discussion of the clinical problem and the mechanism of benefit of this form of therapy follows. Major clinical studies, the clinical use of this therapy, and potential adverse effects are reviewed. Relevant formal guidelines, if they exist, are presented. The article ends with the author's clinical recommendations.

A 45-year-old woman undergoes core needle biopsy of a breast mass 4 cm in diameter and fine-needle aspiration of a palpable axillary lymph node, the results of both of which are found to be consistent with invasive ductal carcinoma of the breast. After discussion with her surgical oncologist, the patient elects to undergo right breast mastectomy and an axillary lymph-node dissection, expressing her disinterest in breast-conserving therapy. She is referred to a plastic surgeon for consideration of postmastectomy breast reconstruction and is noted to have a B-cup breast with minimal ptosis and a flat abdomen.

THE CLINICAL PROBLEM

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Approximately 178,500 women in the United States will receive a diagnosis of breast cancer this year, of whom about two thirds will elect to undergo breast-conservation treatment and one third will elect to undergo mastectomy.¹⁻³ Survey studies make clear that an important factor in the choice of mastectomy is fear of recurrence, whereas a major determinant of the choice of breast conservation is concern about the cosmetic result.⁴⁻⁶ For those women who choose mastectomy as part of their approach to breast-cancer therapy or prevention, reconstruction may be offered as an option by the oncologic and plastic surgeons. The goal of reconstruction is to restore a breast mound and to maintain the quality of life without affecting the prognosis or detection of recurrence of cancer.⁷⁻¹¹ Approximately 56,000 women in the United States underwent breast reconstruction during the past year, which is a doubling from just over a decade ago.^{12,13} A large proportion of these women (70%) elected to undergo implant-based breast reconstruction, with the rest undergoing some form of autogenous tissue-based reconstruction.

PATHOPHYSIOLOGY AND EFFECT OF THERAPY

Mastectomy is a relatively straightforward surgical procedure that usually results in a hospital stay of 1 to 2 days. The functional deficits that occur as a consequence of mastectomy include the inability to breast-feed and loss of sensation of the skin of the chest. Loss of the breast mound alters the patient's personal appearance and can make wearing some types of clothing problematic. The use of an external prosthesis to address these issues can be inconvenient and uncomfortable, particularly for a woman with large breasts. However, the most important consequence of mastectomy is the psychosocial effect of the physical and aesthetic deformity, which can include anxiety, depression, and negative effects on body image and on sexual function.^{14,15} Studies suggest that breast reconstruction restores body image; im-

proves vitality, femininity, and sexuality; and positively affects the patient's sense of well-being and quality of life.^{7,16,17}

CLINICAL EVIDENCE

Randomized trials comparing mastectomy with breast reconstruction and mastectomy without breast reconstruction have not been performed and are unlikely to be performed, since it would be difficult to justify requiring that patients accept a random assignment to undergo elective surgery. Therefore, data supporting the benefits of breast reconstruction have been derived from cohort studies, which have often compared early or "immediate" breast reconstruction and delayed reconstruction, mastectomy alone, or breast-conserving surgery. The limitations of such studies are that patients who elect to undergo reconstructive surgery differ significantly from those who do not. For example, one retrospective cohort study of 1957 patients found that women who had undergone reconstruction were more likely to be younger and to have a partner, and to be college-educated, affluent, and white, than those undergoing either mastectomy alone or lumpectomy.¹⁴ Another analysis found that women seeking early breast reconstruction showed higher rates of psychosocial impairment and functional disability than those undergoing delayed reconstruction.¹⁸

One retrospective cohort study evaluated 577 patients who had had either wide local excision (254 patients), simple mastectomy (202), or breast reconstruction (121).¹⁹ The three groups had significantly different rates of satisfaction with the cosmetic result (91%, 73%, and 80%, respectively), perception of decreased sexual attractiveness (18%, 68%, and 25%), anxiety (38%, 69%, and 55%), and depression (7%, 10%, and 2%). Other analyses, however, including one smaller prospective study, have not found such differences.^{14,20,21} The entirety of the evidence strongly suggests that the benefits of breast reconstruction are dependent on the individual circumstances and preferences of patients.

CLINICAL USE

The decision to choose or decline breast reconstruction should be made by the patient after she has had the opportunity to learn about, discuss, and consider the possible options. Contributions

from all of the patient's care providers, including the oncologic surgeon, medical oncologist, radiation oncologist, and plastic surgeon, may be useful in arriving at an appropriate decision. Studies confirm that the patient's satisfaction with the decision reached is likely to be highest when the patient has been adequately informed and when her level of involvement in the decision is consistent with her own wishes and expectations.^{22,23} It is also important to recognize that the issue of breast reconstruction may play a role in the patient's decision to elect for mastectomy as opposed to breast-conserving surgery.

Breast reconstruction generally consists of two stages: restoration of the breast mound and reconstruction of the nipple-areola complex. Reconstruction of the breast mound itself can be performed with the use of either implants or autogenous tissues. The choice of technique is dictated by a variety of factors that include the size and shape of the native breast, the location and type of cancer, the availability of tissues around the breast and at other sites, the age of the patient, the patient's medical risk factors, and the type of adjuvant therapy. The final decision is often made on the basis of the patient's preference. The patient's selecting the technique and understanding its nature will result in the best aesthetic result and, more importantly, maximize her satisfaction and quality of life.^{24,25}

Reconstruction of the nipple-areola complex is typically performed once both reconstruction of the breast mound and administration of any adjuvant therapy are complete. For patients who will undergo unilateral reconstruction, surgery (breast reduction, augmentation, or lift) may be performed on the contralateral breast to maximize breast symmetry. This matching procedure may be performed at the time of unilateral reconstruction or at a second stage.

RECONSTRUCTION WITH IMPLANTS

Current options for implant-based reconstruction include immediate reconstruction with a standard or adjustable implant, two-stage reconstruction with a tissue expander followed by an implant, or reconstruction with the combination of an implant and autogenous tissue.

Single-stage implant reconstruction is appropriate for the rare patient who has a small, nonptotic breast and an adequate amount of good-quality skin and muscle that will permit immedi-

ate placement of the implant. The disadvantage of the single-stage approach is that aesthetic outcomes tend not to be as good as two-stage reconstructions and, in many cases, a second, revisionary procedure is necessitated. Consequently, this approach is not used for the majority of implant-based reconstructions.

For two-stage reconstruction, a tissue expander is placed in the submuscular position (usually under the pectoralis major and serratus anterior muscles) at the time of mastectomy (Fig. 1). In the early postoperative period, the tissue expander is serially inflated with saline during weekly office visits. Expansions may be performed concurrently with the administration of adjuvant chemotherapy. Once the expansions are completed (after 6 to 8 weeks), the tissues are allowed to

relax and adjust to the new position for another 1 to 2 months (or until after the adjuvant chemotherapy is completed). The exchange of the tissue expander and the final implant is then performed as an outpatient procedure. The two-stage technique of tissue expander–implant reconstruction has become the most common approach to implant-based reconstruction.²⁶⁻²⁸

Many patients who are candidates for implant reconstruction have a skin–muscle envelope that is inadequate for expansion. In such cases, the addition of autogenous tissue (most commonly the latissimus myocutaneous flap) may be required for adequate coverage of the expander and implant.²⁹ Contributing factors may include a large skin resection at the time of mastectomy and multiple scars and radiation injury to the skin or muscle,

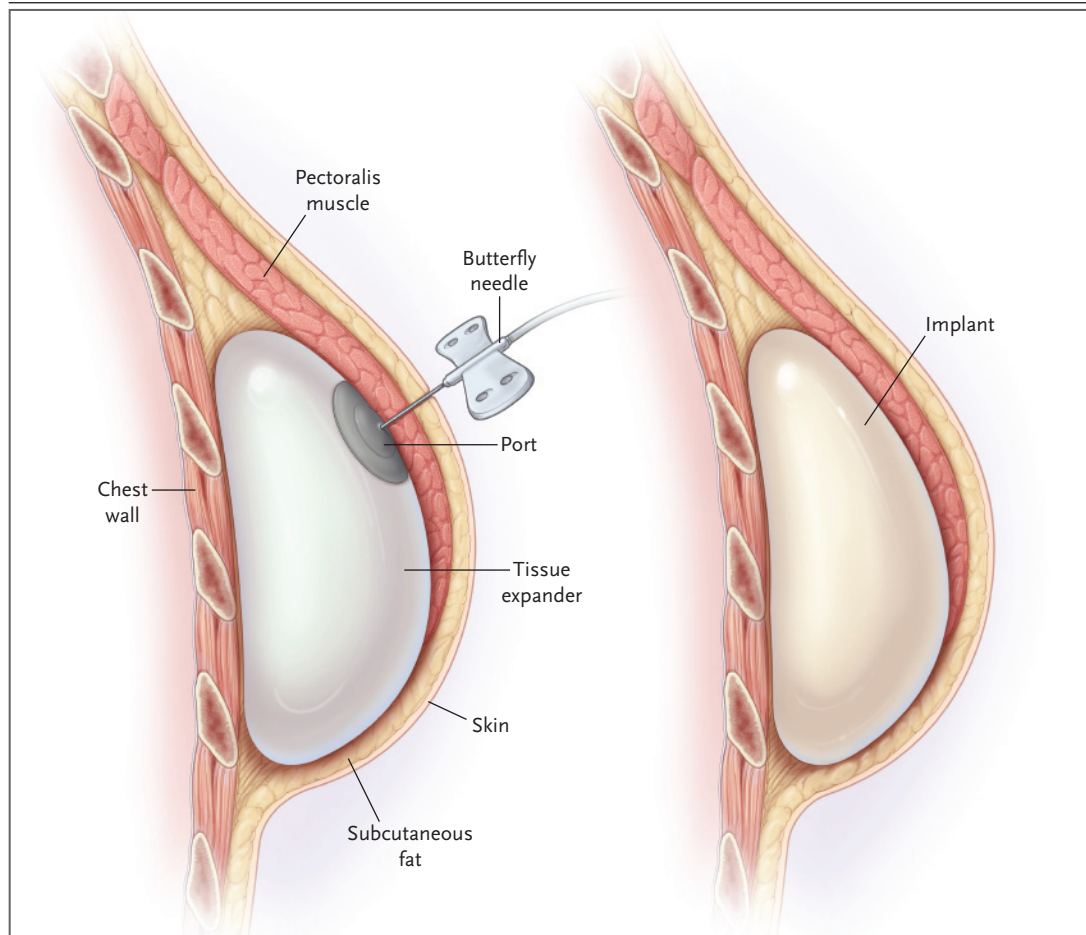


Figure 1. Breast Reconstruction Involving a Tissue Expander and Implant.

A tissue expander is placed in the submuscular position underneath the pectoralis major and serratus anterior muscles. The expander is filled with saline through a butterfly needle inserted into a self-sealing port. The total volume of expansion is usually about 20 to 30% greater than the volume of the final implant. Once the tissue expander is removed, the inframammary fold is reconstructed and an implant is placed under the expanded muscle and skin.

creating a nonexpandable pocket.³⁰ The addition of autogenous tissue to implant reconstruction increases the length and complexity of the procedure, as well as the potential morbidity at the donor site on the back. Thus, the combination of autogenous tissue-based reconstruction and tissue-implant reconstruction is generally reserved for highly selected patients.

The breast implants themselves are of two basic types: saline and silicone gel. The outside shell for all implants is made from solid silicone and can be either textured or smooth. Both types of implants can be anatomically shaped (as teardrops) or round. Most plastic surgeons think that silicone implants tend to provide a softer, more natural feel and tend to maintain their shape better than saline implants. Although there has been much controversy generated by the use of silicone over the past two decades, it is now clear that silicone and breast implants are not linked to cancer, immunologic or neurologic disorders, or any other systemic disease.³¹⁻³⁴ The potential risk to patients remains in the possibility that silicone can leak into local tissues. Although this creates no known risk to the patient,^{35,36} for some, saline implants will provide greater peace of mind. On the other hand, saline implants tend to be firmer, provide less natural fullness in the upper portion of the breast, and are much more likely to lead to visible rippling.

AUTOGENOUS TISSUE-BASED RECONSTRUCTION

The breast mound can also be reconstructed using the patient's own tissue. A variety of donor sites have been described for reconstruction of the breast, including the abdomen, back, buttocks, and thighs.^{37,38} In all cases, a flap of tissue is transferred to the chest to reconstruct the mound. Skin, fat, and muscle are transferred either as a pedicled flap, with its own vascular supply, or as a free flap which requires microvascular reattachment of the blood vessels.

The most common pedicled myocutaneous flap is the transverse rectus abdominis myocutaneous (TRAM) flap (Fig. 2).^{39,40} This flap consists of excess skin and soft tissue in the infraumbilical area overlying the rectus abdominis muscle, together with the rectus muscle itself, which is perfused by the superior epigastric vessels.⁴¹ The myocutaneous flap is transferred through a tunnel created under the skin of the abdominal wall, up to the chest. The anterior rec-

tus sheath is often sutured closed, but in some cases, particularly if both rectus muscles are used, synthetic mesh may be necessary for closure. The skin of the abdomen is closed, leaving a low, horizontal abdominal scar, and the umbilicus is set into the newly positioned abdominal skin.

Skin and fat overlying the latissimus dorsi muscle can also be transferred to the chest (Fig. 3).⁴² The blood supply to the latissimus dorsi flap is derived from the thoracodorsal vessels that originate from the axillary vessels. This flap is rotated from the back of the chest to the front. The volume of fat and skin transferred through this approach is much more limited than that when a TRAM flap is used, and therefore the latissimus dorsi flap is used only to reconstruct very small breast mounds. It is more often used in combination with implants to provide cover for the prosthesis in patients with insufficient skin or in those who have previously undergone radiation in whom tissue expansion is not possible.⁴³

Tissue can also be transferred to the chest from distant sites by reattaching the principal flap vessels to blood vessels in the chest, a process called free-flap reconstruction. The two most common recipient vessels for breast reconstruction are the thoracodorsal and internal thoracic vessels.⁴⁴ The thoracodorsal vessels in the axilla are accessed through either the axillary-dissection incision or the mastectomy incision. The internal thoracic vessels require removal of the third or fourth rib cartilages to provide adequate access.

The most common free-flap donor site for breast reconstruction is the abdomen. One type of flap originating from the abdomen is a myocutaneous flap based on the inferior epigastric vessels that supply the rectus abdominis muscle (free TRAM flap) (Fig. 4). Another is a skin-and-fat "perforator" flap based on one or two perforating vessels that pass from the inferior epigastric vessels through the rectus muscle into the fat and skin (deep inferior epigastric perforator [DIEP] flap).^{45,46} Other free flaps include those from the infraumbilical area (superficial inferior epigastric artery [SIEA] flap)^{47,48} and the buttocks (gluteus myocutaneous free flap or superior gluteal artery perforator [SGAP] flap).⁴⁹⁻⁵³

IMMEDIATE VERSUS DELAYED RECONSTRUCTION

Breast reconstruction may be performed either immediately or after a delay. Historically, reconstruction was purposefully delayed so that the patient

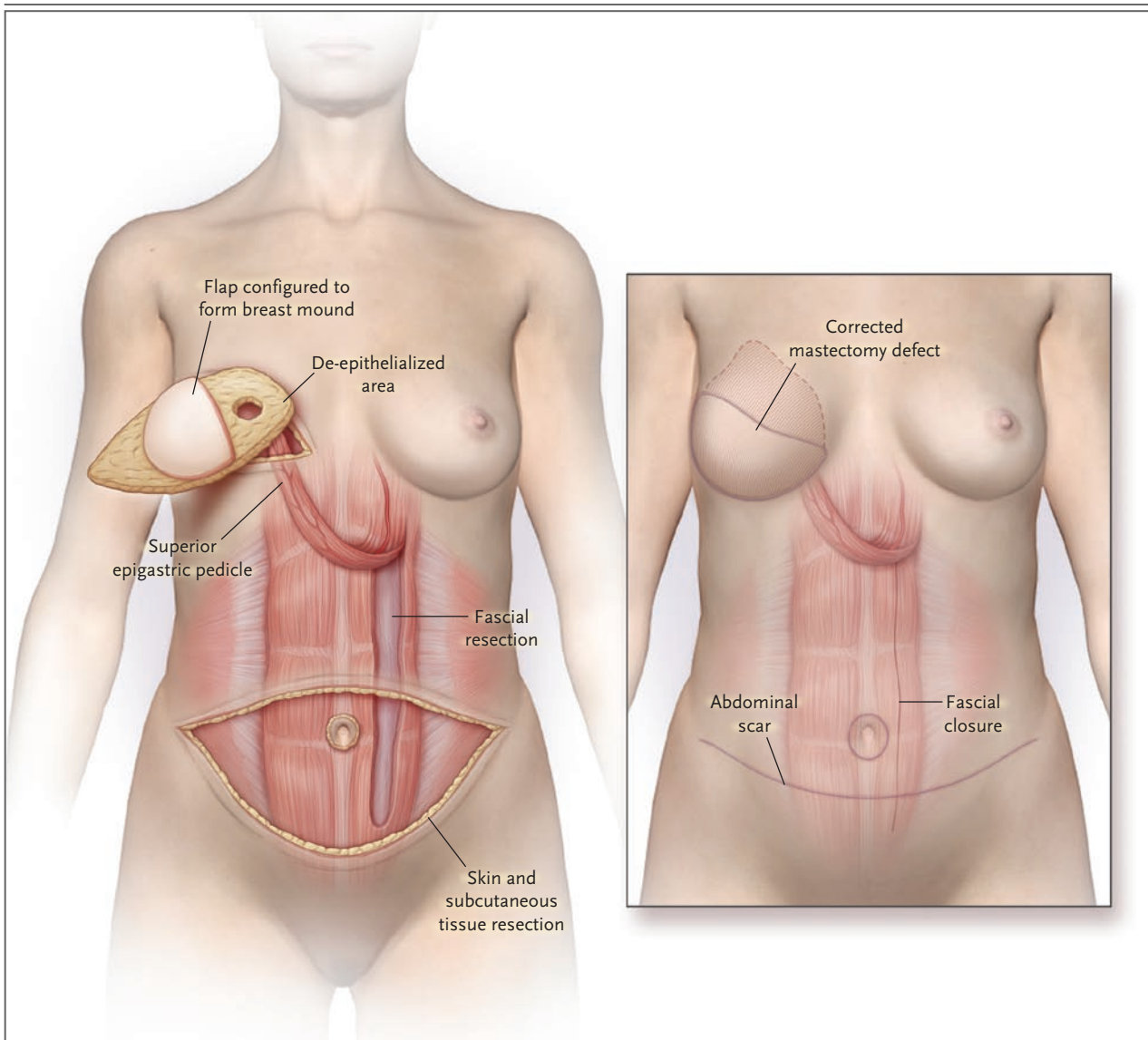


Figure 2. Breast Reconstruction Involving a Pedicled Transverse Rectus Abdominis Myocutaneous (TRAM) Flap.

The TRAM flap is formed from abdominal skin and fat and the rectus abdominis muscle. The flap is tunneled subcutaneously into the chest wall defect. Blood flow is supplied to the flap and maintained through the superior epigastric vessels in the pedicle of the rectus abdominis muscle. The subcutaneous fat is shaped into a breast mound. The fascia of the anterior rectus sheath is sutured closed to prevent hernia formation, and the umbilicus is sutured into its new position.

would be able to first live with her deformity and thus better appreciate her reconstructed result. In addition, it was assumed that the absence of a reconstructed breast mound would allow for more effective monitoring of the patient for recurrence. However, subsequent studies have failed to show a psychological advantage of delaying reconstructive surgery,⁵⁴ and there is now clear evidence that neither implant-based nor autogenous tissue-based reconstruction has any effect

on the incidence or detection of cancer recurrence.^{10,11,55-61} Technically, immediate reconstruction allows for the preservation of critical anatomical structures such as the inframammary fold and maximizes the amount of native skin available for the reconstructive process, thereby maximizing the overall aesthetic result. In addition, the preservation of body image, femininity, and sexuality through the immediate reconstruction of a breast mound can be psychologically benefi-

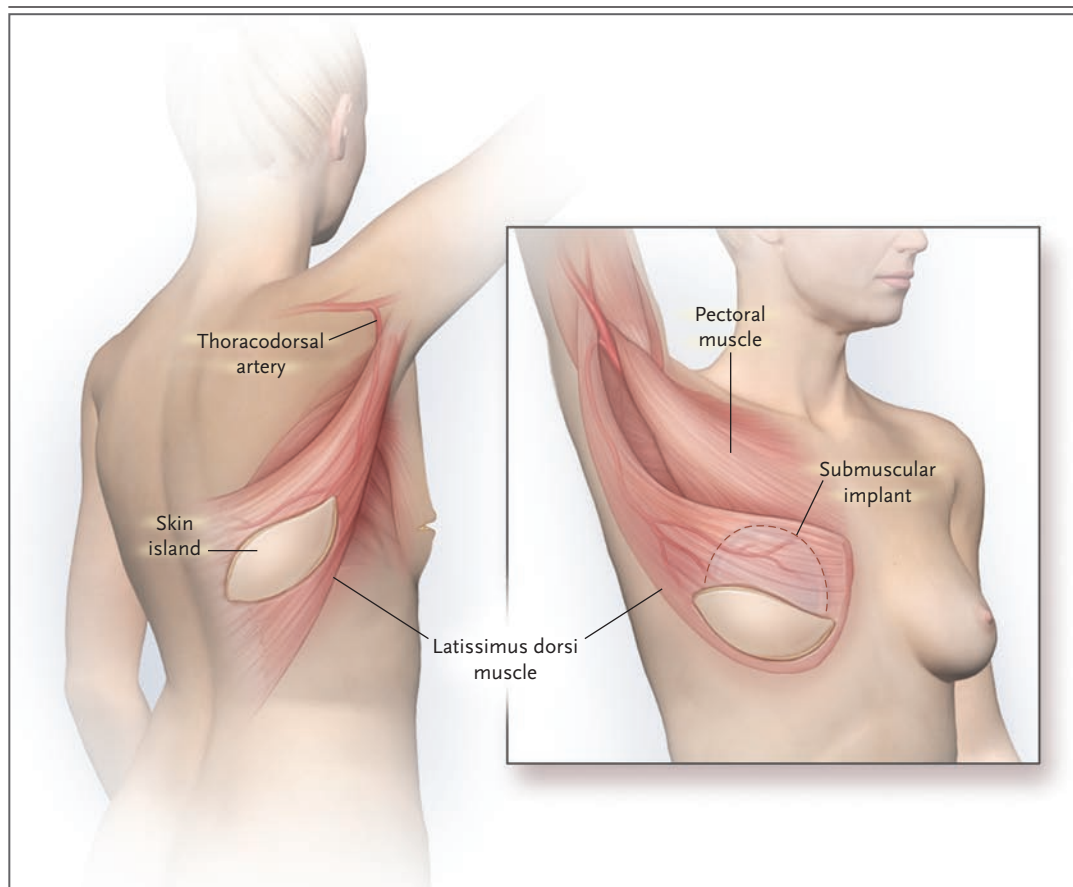


Figure 3. Breast Reconstruction Involving a Latissimus Dorsi Flap, Tissue Expander, and Implant.

A myocutaneous latissimus dorsi flap is elevated. Blood supply to the flap is derived from the thoracodorsal vessels. The flap is tunneled subcutaneously to the mastectomy defect. The latissimus dorsi muscle is sutured to the greater pectoral muscle and the skin of the inframammary fold, so that the tissue expander or implant is completely covered by muscle. An implant is usually required to provide adequate volume and projection of the reconstructed breast; if a tissue expander is initially placed, it can be exchanged after tissue expansion for the final implant.

cial and can significantly reduce postoperative emotional stress.⁵⁴ For these reasons, immediate reconstruction is generally preferred.

COSTS

The initial costs for implant-based reconstruction tend to be lower than those for autogenous tissue-based reconstruction. In an analysis from one institution of procedures performed between 1987 and 1997, the mean initial cost of implant-based procedures was \$15,497 (range, \$6,422 to \$40,015), whereas for autogenous procedures it was \$19,607 (range, \$11,948 to \$49,402).⁶² However, these figures do not take into account the costs of subsequent procedures for implant recipients, including replacement of the tissue expander with the implant, as well as revisionary proce-

dures that tend to be more common for implant recipients. Thus, the cost advantage of implants may diminish over time.⁶³

ADVANTAGES AND DISADVANTAGES

All procedures for breast reconstruction are associated with an increase in morbidity beyond that associated with mastectomy alone. Each procedure has advantages and disadvantages that must be weighed by the patient and her physicians to reach an appropriate decision.

IMPLANTS

The advantages of implant reconstruction include a relatively short procedure and period of anesthesia (1 to 2 hours) and no scars or other com-

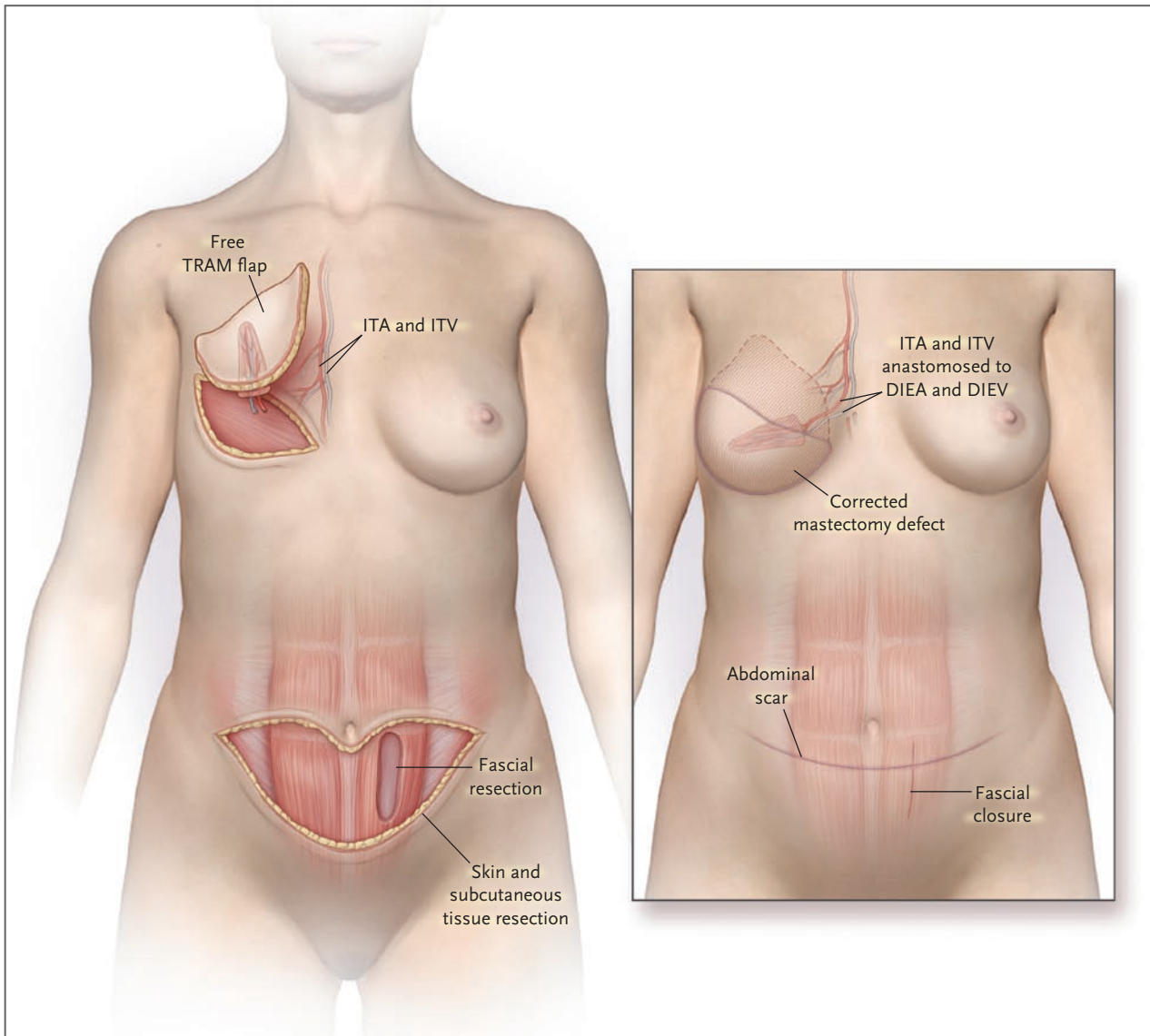


Figure 4. Breast Reconstruction Involving a Free Transverse Rectus Abdominis Myocutaneous (TRAM) Flap.

The abdominal flap consisting of skin and fat from the infraumbilical area is harvested along with the deep inferior epigastric vessels and a small portion of the rectus muscle and fascia to form a free TRAM flap. The anterior rectus fascia is sutured closed. The flap is then transferred to the chest, and the deep inferior epigastric artery (DIEA) and vein (DIEV) are anastomosed to either the thoracodorsal or internal thoracic artery (ITA) or vein (ITV) with the use of microsurgical techniques.

plications at a donor site. Important disadvantages of implant-based reconstruction include the prolonged time to achieving a breast mound and multiple visits to the plastic surgeon for inflation of the tissue expander. Early complications after placement of the tissue expander include infection, hematoma, and extrusion of the implant.²⁶ Late complications may occur after insertion of the final implant and include capsular contracture (scarring and contracture around the implant,

causing deformity), leak or rupture, and infection, any of which can potentially lead to removal or exchange of the implant.²⁷ The incidence of complications is significantly increased in patients with a history of irradiation and those who receive radiation after mastectomy.^{26,27,64,65} For many of these patients, autogenous tissue may be a better option for reconstruction (see the Areas of Uncertainty section).

The ultimate aesthetic result achieved with im-

plant reconstruction is also limited because the shape of the final breast mound is more rounded in appearance and there is limited projection of the lower portion of the breast and minimal-to-no ptosis (Fig. 5A, and photograph 1 in the Supplementary Appendix, available with the full text of this article at www.nejm.org). Thus, unless the patient has a contralateral breast that has the appearance of an implant, modification procedures to the other breast (augmentation mammoplasty, mastopexy, and reduction mammoplasty) become necessary in order to improve breast symmetry (such as that achieved in bilateral implant-based reconstruction) (Fig. 5B, and photograph 2 in the Supplementary Appendix).

AUTOGENOUS TISSUE–BASED RECONSTRUCTION

The advantage of reconstruction with autogenous tissue includes the creation of a softer, more ptotic and natural-appearing breast mound in a single procedure (Fig. 5C, and photograph 3 in the Supplementary Appendix).^{24,66} The TRAM flap especially provides a substantial amount of skin and fat for reconstruction. Disadvantages of autogenous tissue–based reconstruction include longer duration of anesthesia (5 to 10 hours), more blood loss, a longer recovery period, risk of necrosis of portions of the transferred fat and skin, and problems at the donor site, which can include wide, unsightly scars, abdominal weakness, and abdominal bulge or hernia.^{62,67-69} The risk of complications tends to be higher in older and more obese patients as well as those with compromised vascular microcirculation, such as smokers and patients with diabetes.

Free-flap procedures have the advantage that less muscle is harvested at the donor site; the free TRAM flap, for example, uses only a small part of the rectus abdominis muscle, as compared to the entire muscle in a pedicled TRAM.⁷⁰ Free flaps often create better aesthetic contours, since there is no bulging of muscle in the tunnel through the upper abdomen (Fig. 5D, and photograph 4 in the Supplementary Appendix).⁶⁷ Free flaps also generally provide the optimal blood supply to the transferred tissues, reducing the risk of necrosis of fat.⁴⁵ The disadvantages of free-tissue transfer include the increased duration of surgery (6 to 8 hours) and the potential risk of thrombosis of microvascular anastomoses.

AREAS OF UNCERTAINTY

Patients who require radiation therapy for management of their breast cancer pose a unique set of challenges to the reconstructive surgeon. For the patient who has already received radiotherapy before reconstructive surgery, implant-based procedures are often problematic. Tissue expansion is difficult in the previously irradiated tissues, and the risk of infection, the need for a tissue expander, and the risk of subsequent extrusion of an implant are increased.²⁹ Therefore, the most predictable results after breast irradiation usually involve the use of autogenous tissue that was not exposed to the radiation. However, as noted above, some patients are not ideal candidates for flap-based procedures.

For the patient who has not yet received radiotherapy, the reconstructive procedure itself is less complicated. However, subsequent irradiation has an unpredictable effect on the outcome of both implant-based and autogenous tissue–based reconstruction. If the administration of adjuvant radiotherapy is anticipated, many plastic surgeons will not immediately perform reconstruction with either implants or autogenous tissue because of the potential for significant capsular contracture in implant reconstructions and severe fibrosis or atrophy of the autogenous-tissue flap.⁷¹ However, one option for patients who will be receiving radiation therapy but who wish to receive an implant is to initiate tissue expansion immediately after mastectomy, completing the process (inserting the final implant) several weeks before the therapy begins.⁷² Thus, satisfactory planning for reconstructive surgery in the patient who has received or will receive radiotherapy requires consideration of a range of issues, and the best approach for an individual patient is not always clear.

GUIDELINES

No major medical or surgical societies have published formal guidelines specifically addressing the role of breast reconstruction after surgery for breast cancer. The National Comprehensive Cancer Network, in its 2008 Clinical Practice Guideline on breast cancer, lists the available options for breast reconstruction as well as the issues concerning radiation therapy.⁷³ It notes in particular



Figure 5. Anteroposterior Views of Breast Reconstruction.

Panel A shows reconstruction of the left breast with an implant. The reconstructed breast has a rounded appearance. Although implant-based reconstruction does not provide perfect symmetry with respect to the contralateral, natural breast, adequate breast symmetry can be achieved. Panel B shows a bilateral breast reconstruction with implants and subsequent nipple-areola reconstruction. Excellent results can typically be achieved in bilateral, implant-based reconstruction, since breast symmetry can be optimized. Panel C shows a right breast reconstructed with the use of a unilateral, pedicled transverse rectus abdominis myocutaneous (TRAM) flap. The patient also underwent reduction mammoplasty of the left breast. Use of the unilateral TRAM flap provides excellent breast symmetry — even in an attempt to match the more ptotic, contralateral breast. Whenever breast skin needs to be replaced with abdominal skin, the resulting appearance of a skin island does detract from the aesthetic result. Panel D shows a left breast reconstructed with the use of a unilateral, free TRAM flap, after a skin-sparing mastectomy performed through a periareolar incision, with an outstanding result. Subsequent reconstruction of the nipple-areola complex was also completed. Nipple reconstruction is performed within the periareolar skin island and can result in an almost exact duplication of the contralateral nipple.

the increased risk of complications after reconstructive surgery in smokers and concludes that smoking should be considered a relative contraindication to breast reconstruction, and patients should be made aware of the risks. The American Society of Plastic Surgeons provides an undated physician's counseling guide on breast reconstruction.⁷⁴ It lists selection criteria and risk factors for undergoing reconstructive surgery and states that the indication for reconstruction is that the patient is interested in undergoing surgery to reconstruct her breast mound or mounds "for reasons that may include the maintenance of personal, family or sexual relationships."

RECOMMENDATIONS

In order to optimize the care of the patient presented in this vignette, she should be evaluated by an experienced multidisciplinary cancer team including a plastic surgeon who is familiar with all techniques of reconstructive breast surgery. It is important that the patient's expectations for surgery be discussed in advance and that she receive information about the risks of the procedure as well as the potential aesthetic outcomes. The final decision should be made by the patient on the basis of her preferences and understanding of the options.

In theory, this patient is a candidate for either implant-based or autogenous reconstruction with the use of a gluteal flap, since her abdomen is flat

and is therefore likely to have inadequate tissue to serve as a donor site. However, it appears that she has stage II breast cancer and thus will probably undergo postoperative chemotherapy and possibly radiation therapy. I would therefore be more inclined to perform immediate reconstruction using a tissue expander and implant as opposed to immediate reconstruction using autogenous tissue. In this setting, the tissue expander would be placed at the time of mastectomy and tissue expansion would be performed during chemotherapy. Four weeks after the completion of chemotherapy, the tissue expander would be exchanged for a permanent implant and radiation therapy would be initiated 4 weeks after the exchange procedure. At any point after the administration of radiotherapy, if the patient desired autogenous tissue reconstruction, a gluteal flap would remain a viable option. Alternatively, if the patient did not wish to pursue implant-based reconstruction initially, I would suggest performing autogenous tissue-based reconstruction in a delayed fashion, so as to avoid potentially devastating aesthetic complications that can arise after radiation of a tissue flap.⁷¹

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