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Surg Clin N Am 87 (2007) 453–467

SURGICAL
CLINICS OF
NORTH AMERICA

Breast Reconstruction

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During the last century, breast reconstruction after mastectomy has become an important part of comprehensive treatment for patients who have breast cancer. Breast reconstruction initially was created to reduce complications of mastectomy and to diminish chest wall deformities. Now, however, it is known that reconstruction also can improve the psychosocial well-being and quality of life of patients who have breast cancer [1]. The primary goal of breast reconstruction is to recreate form and symmetry by correcting the anatomic defect while preserving patient safety and health. The primary reconstructive options involve the use an implant (usually with an expander first), the patient's own tissue (autogenous tissue reconstruction), or both. The reconstructive process can start at the time of the mastectomy (immediate reconstruction) or any time afterwards (delayed reconstruction).

Historical background

Silicone breast implants were introduced in the early 1960s [2], but in 1992, the Food and Drug Administration (FDA) placed a moratorium on silicone implants due to concern regarding its safety of use in patients. Since then saline implants had been exclusively used in the United States, until recently. In November 2006, after an extensive scientific review revealed no significant risks, the FDA approved the use of silicone implants for breast reconstruction in women of all ages. Now that the silicone implant has been deemed safe, the FDA is requiring a 10 year follow-up to continue to monitor these implants as part of a post-approval study [3]. The initial implant reconstructions were placed under the thin mastectomy skin flaps

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0039-6109/07/$ - see front matter
doi:10.1016/j.suc.2007.01.004 *surgical.theclinics.com*

without prior expansion of the tissue, a practice that led to frequent complications such as skin loss. The introduction of the latissimus dorsi myocutaneous flap provided better soft tissue coverage over the implant and decreased postoperative complications [4]. In 1982, Radovan [5] introduced tissue expansion with placement of an uninflated implant under the residual skin and muscle, followed by intermittent filling of the implant. This process resulted in a gradual expansion of the overlying tissue. As the final stage of breast reconstruction, permanent implants replaced the expander implant. This technique, however, remained plagued by complications such as capsular contracture (scarring around the implant). Breast reconstruction advanced further with the popularization of the transverse rectus myocutaneous (TRAM) flap by Hartrampf and colleagues [6] in 1982, followed by the microsurgical free TRAM flap. The latest technical advances in breast reconstruction, perforator flaps, were introduced by Allen and colleagues in 1994 and 1995 [7,8].

The other major advance that has occurred in breast reconstruction has been on the health policy front. In 1998, the federal government passed the Women's Health and Cancer Rights Act (WHCRA), which mandated insurance coverage of reconstruction if the insurance plan provided mastectomy coverage. The law also mandated coverage of breast symmetry procedures and the treatment of surgical complications at all stages of the mastectomy and reconstruction [9].

Goals

In keeping with the Hippocratic oath, one of the goals of breast reconstruction is to "first do no harm." Reconstruction after mastectomy should not impede the patient's oncologic treatment (ie, delay administration of chemotherapy or radiation therapy), should not delay the diagnosis of a recurrence, and should not add an unacceptable increase in operative morbidity or mortality. Current data indicate that reconstruction is safe and does not delay adjuvant therapy or the detection of cancer recurrence [10–12]. In addition, although the most frequent site of recurrent breast cancer is in the remaining chest wall skin, immediate reconstruction has not been shown to increase the rate of local recurrence in the long term [10].

The specific surgical goals of the plastic surgeon are to optimize the aesthetic result while keeping in mind the patient's preferences and surgical limitations. For instance, some women may be happy with recreation of just a breast mound, whereas other women may desire supple soft tissue and complete nipple reconstruction.

Preoperative counseling

After appropriate discussion between the oncologic team and the patient, if the woman desires reconstruction, a consultation with a plastic surgeon

should be offered at the time of initial surgical decision making. This preoperative consultation should cover several areas, such as the type and timing of reconstruction. Reconstructive options are based on the patient's overall goals, physical examination, and clinical factors. For example, autogenous tissue reconstructions are best in women who value the creation of the most natural-looking and -feeling breast. Other women may place more value on limiting potential morbidity to other body areas, such as the abdomen, and therefore prefer an expander/implant reconstruction. Clinical contraindications or significant risk factors to reconstruction, such as obesity, nicotine use, chronic obstructive pulmonary disease, diabetes, and other chronic conditions, should be assessed. (Such contraindications are discussed in further detail later in this article.) Although patient preference certainly is important, the highest priority is providing appropriate treatment of the breast cancer. Thus, input from a multidisciplinary team consisting of oncologic surgeons, medical and radiation oncologists, as well as reconstructive surgeons is necessary to provide the most comprehensive and appropriate treatment.

Timing of reconstruction

Immediate reconstruction

"Immediate" reconstruction is defined as reconstruction that starts at the same time as the mastectomy. This option can be an excellent one for women who have ductal carcinoma in situ and stage 1 or stage 2 disease. The advantages of immediate breast reconstruction are multiple. Women who have immediate reconstruction have less distress and better body image, self-esteem, and satisfaction, in general, than women who have delayed reconstruction [13]. From an aesthetic standpoint, autogenous tissue reconstructions performed at the time of the mastectomy generally have produced a better aesthetic result than delayed procedures because the skin envelope is preserved [14,15]. The overall cost is less because fewer major operations are needed, the patient is anesthetized already, the defect does not have to be recreated, and the patient can recover from the mastectomy and the reconstruction simultaneously [16].

Disadvantages of immediate reconstruction include the potential delay of adjuvant therapy should a postoperative complication such as delayed wound healing occur. Most studies, however, have not shown reconstruction to delay therapy [12]. Another potential pitfall of immediate reconstruction is the partial loss of the mastectomy skin flaps, especially if the oncologic surgeon needs to create thin skin flaps. In addition, residual disease or close surgical margins may necessitate the use of postoperative radiation therapy, which can adversely affect the reconstruction.

Relative contraindications to immediate reconstruction include advanced disease (stage 3 or higher), need for postoperative radiation (although this

contraindication is controversial and varies by center), and medical comorbidities such as use of nicotine, morbid obesity, or cardiopulmonary disease. In addition, use of implants is a relative contraindication in women who have rheumatologic disorders.

Delayed reconstruction

Delayed reconstruction, defined as a reconstructive procedure that starts after the mastectomy, can be started any time after the wound has healed and adjuvant therapy has been administered. Postradiation skin changes should have stabilized, and the hematologic effects of chemotherapy should have normalized before reconstruction is begun. Delayed reconstruction has its own advantages. First, all guess work regarding whether radiation therapy will be required is eliminated, so surgeons and patients can appraise to their reconstructive options more accurately. Second, studies have shown that delayed reconstructions have overall fewer complications than immediate reconstruction [10]. Disadvantages of delayed reconstruction include prolonging the overall treatment of the patient, a poorer cosmetic result with autogenous tissue reconstruction because the skin envelope is not preserved, and potentially higher costs to the health care system.

Reconstructive techniques

Implant without tissue expansion

The simplest reconstruction for a mastectomy defect involves the placement of an implant, without prior expansion of the remaining tissue envelope. This simple technique requires that the skin flaps remaining after the mastectomy to be sufficient to cover the implant. Often, the remaining flaps are not sufficient. If an implant is placed without prior expansion, there is a greatly increased risk of skin necrosis secondary to tension. In addition, implants placed under nonexpanded mastectomy skin flaps often have poor cosmetic results because of constricted skin envelopes. For these reasons, this technique is generally discouraged.

Tissue expansion followed by permanent implant placement

Indications/contraindications

Tissue expansion followed by permanent implant placement is a frequently used technique in breast reconstruction. The most appropriate patients for this type of reconstruction are patients who do not qualify for autogenous reconstruction, patients who do not want additional scars from other donor sites, patients who prefer a typically quicker postoperative recovery period, and patients who have relatively small breasts. A

contraindication for this type of reconstruction is mastectomy flaps that are too thin for adequate implant coverage. In these cases, one should consider using a latissimus dorsi muscle flap for additional coverage. Another relative contraindication is the completed or planned use of adjuvant radiation therapy because of higher implant complication rates [17].

Technique

The most common technique used for expander/implant placement is placing the expander in a subpectoral pocket (Fig. 1). For immediate tissue expander reconstructions, the goal is to obtain total submuscular coverage that protects the implant from becoming exposed if a minimal amount of skin necrosis occurs. To achieve this coverage, a portion of the serratus muscle is raised laterally and is plicated to the pectoralis major muscle. Occasionally, the superior aspect of the rectus abdominis muscle must be elevated also. Overall, the pocket size should match the size of the expander (as determined preoperatively based on measurements of the patient's chest wall). It is critical to not alter or undermine the inframammary fold, because this important landmark is difficult to reconstruct and is crucial to the long-term cosmetic result. If there is concern that the mastectomy flaps have compromised vascular supply, the expander placement should be delayed. Typically, the expansion is done weekly, and the volume instilled depends on patient comfort and skin quality (eg, tightness, erythema). The expander typically is overexpanded by 25% to improve the skin drape over the implant, to allow for the skin recoil that occurs after expansion, and to allow for differences in the profile of the expander versus the implant.

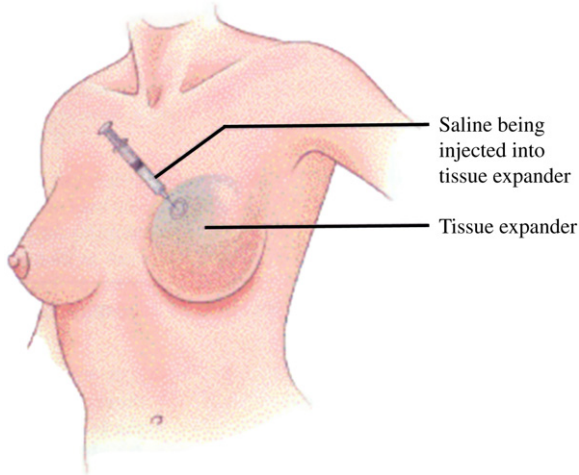

Fig. 1. Tissue expander technique. (*From* Wilkins E. The University of Michigan Breast Reconstruction Handbook. p. 3. Available at: http://www.med.umich.edu/surgery/plastic/clinical/breast/index.shtml. Accessed September 20, 2006; with permission.)

Advantages/disadvantages

Advantages of this technique include the avoidance of donor site morbidity and the low overall functional impairments for the patient. Expander and subsequent implant placement often requires less operative time than autogenous reconstruction, and the recovery period is shorter (typically patients are discharged on postoperative day one). One major disadvantage of this technique is the overall time required. Typically, tissue expansion is started 2 to 3 weeks postoperatively (if the wounds are healed), followed by weekly expansions in the clinic that can last several months before the tissue envelope is sufficiently expanded. Once expansion is complete, an additional 2 to 4 months are allowed for tissue equilibrium to occur before the skin envelope is ready for the expander to be exchanged for a permanent implant. The exchange of the expander for the implant also requires an additional, albeit relatively short, surgery. In addition, implants lack natural ptosis (or droop) and usually feel unnatural (especially saline implants).

Complications

Complications associated with expander/implant reconstructions can occur in the acute and long-term settings. Acute complications that often require removal of the expander or implant include exposure of the device, infection, malposition, or deflation. In addition, a hematoma or seroma may occur. Long-term complications include capsular contracture (scar tissue around the implant causing visible deformity and/or discomfort), visible wrinkling of the implant (especially with saline implants in thin women), and implant deflation (the devices typically last 10–15 years). The rate of reported complications with tissue expander/implant reconstructions in the setting of radiation approaches 50% [17–19].

Pedicled transverse rectus myocutaneous flap

Indications/contraindications

Many surgeons prefer to use autogenous tissue (ie, TRAM flap), in part because of greater patient satisfaction with these techniques [20,21]. Patient indications for the TRAM flap include patients in whom non-TRAM reconstruction was unsuccessful, who have mastectomy defects requiring a large amount of tissue for reconstruction, or who have a history of chest wall irradiation. TRAM reconstructions are also useful in women who have a ptotic contralateral breast that will be hard to match using an implant. For TRAM reconstructions, women must have adequate soft tissue in the lower abdomen and, preferably, have a body mass index less than 30. Contraindications to this procedure include prior abdominal surgery that may have divided the pedicle or blood supply, such as an open cholecystectomy, coronary artery bypass graft using the internal mammary artery or an abdominoplasty that transects the perforator blood vessels to the skin. Obesity also is a contraindication: it is well documented that complications are

directly associated with a higher body mass index [10,22]. With increased abdominal fat, the blood supply to the skin and subcutaneous fat becomes unreliable, leading to partial flap loss or fat necrosis. Other relative contraindications include severe comorbidities (eg, vascular disease, chronic obstructive pulmonary disease) or active use of nicotine.

Technique

The blood supply to the TRAM flap is considered bipedicled (double), from the superior and inferior epigastric arteries, with the most direct supply from the inferior epigastric artery. In a pedicled TRAM flap, the inferior epigastric artery is severed, and the rectus muscle and overlying skin and subcutaneous tissue are rotated into the mastectomy defect based on the superior epigastric artery and the periumbilical perforators (Fig. 2). When this superior pedicle is used, the blood flows through the choke vessels (vessels that dilate based on need, Fig. 3) between the two pedicles before reaching the skin through perforating arteries. When the blood supply may be more tenuous (as in obese patients and patients who use nicotine), or when a large amount of tissue is needed for the reconstruction, the surgeon can dilate the choke vessels by severing the inferior epigastric artery 2 to 3 weeks before the actual reconstruction. This surgical-delay procedure is thought to improve the blood flow through these choke vessels and can be done at the time of the general surgeon's sentinel lymph node biopsy. Another way to improve the arterial inflow and venous outflow to the pedicled TRAM flap is to take the inferior epigastric vessels and anastomose it

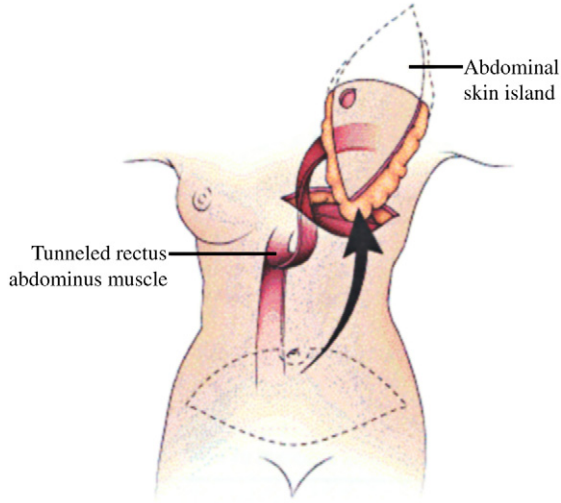

Fig. 2. Pedicled transverse rectus myocutaneous flap technique. (*From* Wilkins E. The University of Michigan Breast Reconstruction Handbook. p. 9. Available at: http://www.med.umich.edu/surgery/plastic/clinical/breast/index.shtml. Accessed September 20, 2006; with permission.)

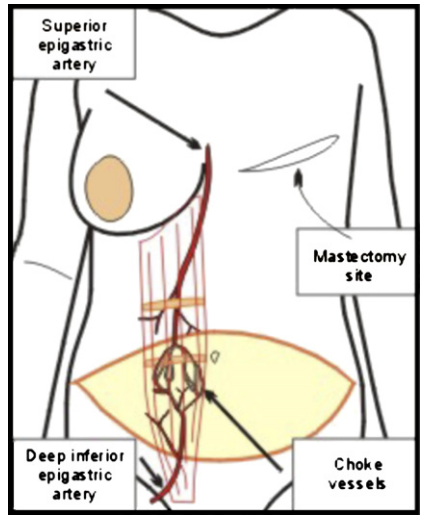

Fig. 3. Buntic R. Blood supply and choke vessels for the transverse rectus myocutaneous flap technique. (*From* Buntic R. Available at: www.microsurgery.net; with permission.)

microsurgically to the thoracodorsal or internal mammary vessels, a procedure termed ''supercharging.''

Advantages/disadvantages

Advantages of the TRAM flap include a natural-appearing and -feeling reconstruction that will have an aging process similar to an unreconstructed breast. Disadvantages of this type of reconstruction include a long operative time (4–6 hours), relatively long hospitalization (3–5 days), and long postoperative recovery. It takes most women 2 to 4 months to return to their preoperative physical functioning.

Complications

Complications in the acute period include infection (12%), hematoma or seroma of the breast or abdomen (4%), umbilical necrosis, and partial (16%) or total flap loss (1%) [10]. In the long term, potential complications include abdominal wall laxity or hernia (8%) [10].

Microsurgical transverse rectus myocutaneous flap

Another option with the TRAM flap is to perform a microsurgical or ''free'' transfer of the abdominal tissue to the mastectomy defect (Fig. 4). In this procedure, the blood supply is the deep inferior epigastric artery and its venae comitantes, which are severed at their origin. These vessels are anastomosed microsurgically to the thoracodorsal or internal mammary vessels. Relative indications for this procedure are similar to those for the pedicled TRAM flap. Unlike the pedicled TRAM flap, however, this

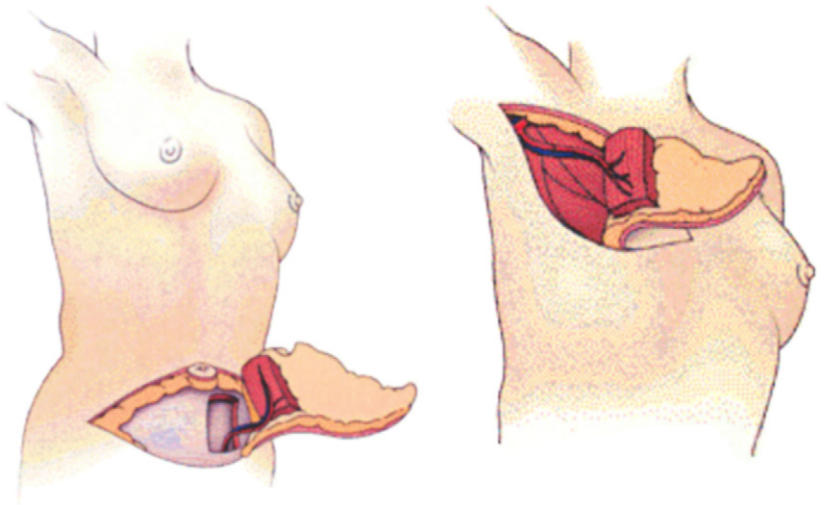

Fig. 4. Free transverse rectus myocutaneous flap technique. (*From* Wilkins E. The University of Michigan Breast Reconstruction Handbook. p. 12. Available at: http://www.med.umich.edu/surgery/plastic/clinical/breast/index.shtml. Accessed September 20, 2006; with permission.)

technique can be used when the superior epigastric artery has been divided (eg, in a patient who has had a previous open cholecystectomy). Some surgeons also believe that this procedure provides a more robust blood supply than obtained with a pedicled technique. Disadvantages of this technique include a potentially longer operating time and the need for microsurgical expertise. Complications in the acute period include infection (18%), hematoma or seroma of the breast or abdomen (4.5%–9%), umbilical necrosis, and partial (15%) or total flap loss (1.5%) [10]. In the long term, potential complications include abdominal wall laxity or hernia (12%) [10]. Although the microsurgical technique often is considered in obese patients, these patients still have a significantly higher risk of certain complications (total flap loss, flap hematoma, flap seroma, mastectomy skin flap necrosis, donor-site infection, donor-site seroma, and hernia) than normal-weight patients [23].

Perforator flaps

Deep inferior epigastric perforator

A more recently described technique, the deep inferior epigastric perforator (DIEP) flap, is similar to the free TRAM flap, but the blood supply to this flap is based on only one or two of the perforator arteries off of the deep inferior epigastric artery. This procedure does not require harvest of the rectus abdominis muscle, resulting in less abdominal wall morbidity. Specifically, the incidence of abdominal wall laxity or hernia is less than with techniques that remove abdominal wall fascia with the rectus muscle. A recent study also has reported a shorter hospitalization and faster

recovery because there is less abdominal wall pain with perforator flaps than with traditional TRAM flap reconstructions [24]. This technique still has disadvantages. Significant microsurgical expertise is required, operative times are longer, and the incidence of partial or total flap loss is higher than with traditional TRAM procedures [25]. Earlier studies showed that the DIEP flap had a less robust blood supply, leading to an increased risk for fat necrosis [25]. More recent studies, however, suggest that the rates of fat necrosis or partial flap loss are no higher with perforator flaps than with pedicle TRAM procedures [15]. Nevertheless, the choice between the free TRAM and the DIEP flap should be based on the patient's weight, the breast volume required, the amount of abdominal fat available, and on the number, caliber, and location of the perforating vessels [26]. For the properly selected patient, some microsurgeons now prefer the DIEP flap to the free TRAM flap.

Superficial inferior epigastric artery flap

Another option that is used less frequently is the superficial inferior epigastric artery (SIEA) flap. This flap option was presented by Allen [27] in 1990 but was dismissed at that time because of a high flap failure rate (in three of seven clinical cases). A more recent prospective study comparing the SIEA flap with the DIEP and free TRAM flaps found a 2% flap loss with the SIEA [28]. Advantages of the SIEA flap include minimal donor-site morbidity because the rectus abdominis fascia and muscle are not violated and less postoperative pain [28].

Gluteal artery perforator flap

For patients who do not have sufficient abdominal tissue for breast reconstruction but still prefer the use of autologous tissue, an option is the use of the buttock as donor tissue. This donor site can also be used for unilateral or bilateral breast reconstructions. There are two options for blood supply to the flap. When the superior gluteal artery is used, the flap is called a "superior gluteal artery perforator" (SGAP) flap, and the upper buttock tissue is used. The scar lies in the upper buttock region and is hidden easily with underwear. When the inferior gluteal artery is used, the flap is called an "inferior gluteal artery perforator" (IGAP) flap, and the lower buttock tissue is used. The scar lies within the lower buttock crease.

The advantage of these flaps is the readily available donor tissue in most patients. Disadvantages include the technical challenge of raising this flap, the potential risk of injury to the sciatic nerve or postoperative pain from an insufficiently padded sciatic nerve, and a potentially disfiguring donor site. Although the selection of the donor site depends on preference and the patient's anatomy, Allen and colleagues [29] recently reported his preference for using the IGAP, rather than the SGAP, as the primary alternative to the DIEP flap because of its better aesthetic outcome.

Latissimus dorsi flap

Indications/contraindications

Another reliable workhorse for breast reconstruction is the latissimus dorsi muscle or myocutaneous (muscle and skin) flap. Indications for this flap include previous implant or TRAM flap failure, need to reconstruct a partial mastectomy or lumpectomy defect, abdominal obesity, or extreme thinness resulting in inadequate infraumbilical soft tissue. Contraindications to this technique include prior surgery that may have interrupted the blood supply (eg, posterior thoracotomy), the inability of the patient to be positioned on her side, severe comorbidities, and the patient not desiring implant placement.

Technique

The dominant blood supply to this flap is the thoracodorsal artery (off the subscapular artery), with segmental blood supply from the posterior intercostals and lumbar vessels (Fig. 5). If the thoracodorsal artery is damaged more proximally during the mastectomy, this flap also may survive on retrograde blood flow from the serratus branch off the thoracodorsal artery. This flap can be transferred either on its pedicle or as a free tissue microsurgical transfer.

Advantages/disadvantages

The advantages of this technique include the ability to provide single-stage implant reconstruction (the latissimus muscle is excellent soft tissue coverage of the implant) and its reliability. Most plastic surgeons, however, believe that a better aesthetic result is obtained by first using a tissue expander under the flap and then replacing the expander with a permanent implant. Disadvantages of this flap include a significant donor-site scar

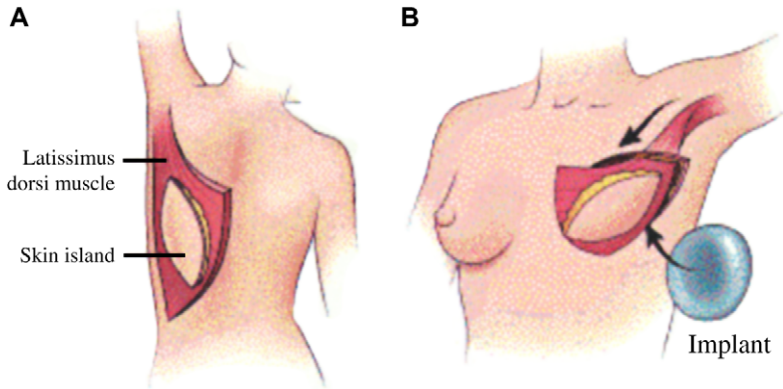

Fig. 5. Latissimus flap. (*From* Wilkins E. The University of Michigan Breast Reconstruction Handbook. p. 16. Available at: http://www.med.umich.edu/surgery/plastic/clinical/breast/index.shtml. Accessed September 20, 2006; with permission.)

(especially if skin is also harvested) and the frequent need for implant and/or tissue expander placement because of insufficient tissue.

Complications

Most complications related to this procedure are related either to the implant or the donor site. Implants have a risk of rupture, displacement, contracture, or infection. The donor site is at risk of hematoma, seroma, infection, and hypertrophic scarring. There also is a risk of flap necrosis at the recipient site.

Treatment of the contralateral breast

Once the mastectomy site has been reconstructed, often the next challenge for the plastic surgeon is to create symmetry with the contralateral breast. Ideally, the contralateral breast should be evaluated preoperatively (at the same time as consultation for reconstruction), and discussion with the patient should elicit her preferences and explain her realistic options. Surgery to achieve contralateral symmetry can be performed at the time of the initial reconstruction or later. In addition, surgery to create contralateral symmetry can be considered in patients who undergo breast-conservation treatment. The 1998 WHCRA mandates that alteration of the contralateral breast in cases of breast cancer reconstruction be covered by insurance.

Options for symmetry procedures include breast reduction, breast augmentation, mastopexy (breast lift), or a combination of the procedures [30]. For example, in a woman who has very large breasts and undergoes a mastectomy with reconstruction, a contralateral breast reduction would improve symmetry and patient comfort. A woman who has small breasts may require an augmentation on the contralateral side for symmetry. Although autogenous reconstruction often provides a better overall outcome when contralateral surgery is not performed, breast reconstruction rarely produces a breast that is symmetrical to the contralateral breast.

Nipple and areolar reconstruction

The final stage of total breast reconstruction is nipple and areolar reconstruction. Typically, this reconstruction is performed as a separate procedure and can be done any time after the reconstructed breast form has stabilized (at least 6–8 weeks after reconstruction). This procedure can be performed either in the operating room or under local anesthesia in an office setting. The goal of nipple and areolar reconstruction is to achieve symmetry of position of the nipple-areolar complex in the bilateral breasts with comparable appearance and color, because even small discrepancies are obvious.

Areolar reconstruction may be achieved by using a full-thickness skin graft or by tattooing alone [31]. Possible donor sites for the skin graft

include the contralateral areola (if large), remnant excess abdominal tissue at the incision after a TRAM is performed, the medial thigh, or the mastectomy scar. A favorable aesthetic outcome also can be achieved with medical tattooing alone.

The type of papule reconstruction often is based on surgeon preference and the patient's size preference. Typically, local tissue is raised to create flaps for papule projection. Nipple projection decreases postoperatively, requiring a 50% overcorrection at the time of surgery. Another option includes a nipple-sharing technique that uses a papule graft from the contralateral nipple. There is, however, a risk of complications at the site of the contralateral nipple, including scarring and loss of nipple sensation, and thus use of local skin flaps is often the procedure of choice.

Nonsurgical options

Some women may choose not to have breast reconstruction or are poor surgical candidates for reconstruction. For these women, a breast prosthesis is an option. The advantages of not wearing a breast prosthesis include simplicity, comfort, and convenience [32]. The disadvantages include a feeling of imbalance and difficulty wearing certain clothes [32]. Prostheses can be purchased at surgical supply stores, pharmacies, custom lingerie shops, or through a private home shopping service [32]. Some stores have trained fitters who can help the woman find the appropriate prosthesis that fits her chest and matches the contralateral breast. Specialty clothing is available with pockets to hold the prosthesis in place, and some prostheses come with adhesive Velcro patches to keep the prosthesis in place on the chest. Most insurances cover a new prosthesis every 2 years and two brassieres with a prosthesis pocket each year [31].

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