Deep Inferior Epigastric Perforator Flap Breast Reconstruction

Frank J. DellaCroce, M.D.,[1] Robert J. Allen, M.D., F.A.C.S.,[1] and Scott K. Sullivan, M.D.[1]

ABSTRACT

Breast reconstruction is a critical part of the overall care plan for patients faced with a diagnosis of breast cancer and a plan that includes mastectomy. The evolution of reconstructive techniques has resulted in the development of procedures that restore form and a sense of wholeness without excessive morbidity. Perforator flaps best represent this state of the art in breast reconstructive surgery. Tissue is replaced with like tissue giving a result that is durable and as near to a natural breast as possible. Sparing of the rectus abdominus musculature differentiates this procedure from other autogenous modalities such as the pedicled and free transverse rectus abdominus. The deep inferior epigastric artery perforator (DIEP) flap has been shown to be a safe, dependable, and reproducible method of breast reconstruction. In addition to maintaining abdominal wall strength and minimizing the risk of subsequent hernia, the DIEP flap breast reconstruction patient has been shown to enjoy a shorter recovery period with less postoperative pain and a resultant high rate of satisfaction.

KEYWORDS: Breast cancer, free flap, breast reconstruction, perforator flap

Breast reconstruction is an ever-evolving art that is a worthy test of the plastic surgeon's technical skill, judgment, and sense of esthetics. Although not considered a priority in the past, there is little argument today that reconstruction is a critical part of the overall care plan for the breast cancer patient. It is not easy to quantify the impact that restoration of body image and a sense of wholeness have on the patient faced with a diagnosis of cancer and a plan that includes removal of her breast.

Advances in Breast Reconstruction; Editor in Chief, Saleh M. Shenaq, M.D.; Guest Editor, Robert J. Allen, M.D. *Seminars in Plastic Surgery*, Volume 16, Number 1, 2002. Address for correspondence and reprint requests: Dr. Frank J. DellaCroce, Division of Plastic Surgery, Louisiana State University Health Sciences Center, 4429 Clara Street, Suite 440, New Orleans, LA 70115. [1]Department of Surgery, Division of Plastic Surgery, Louisiana State University Health Sciences Center, New Orleans, LA. 1535-2188,p;2002,16,01,007,018,ftx,en;sps00002x.

Options for reconstruction are affected by a number of parameters. Expanders and implants remain the most commonly employed method in the United States. These techniques are popular because they are relatively easy to perform and most plastic surgeons have a basic comfort level with implant handling and application. Other advantages include avoidance of donor site morbidity and a generally shorter hospital stay. It is widely recognized that implants perform poorly in the face of radiation. Expanders are limited where large amounts of skin need to be recruited compared with autogenous reconstructive modalities. Implant reconstructions often lack ptosis, making them appear less natural than the normal breast. Approximately 30% of patients with implant reconstructions will require removal or replacement of the implants by 3 years for capsular contracture, infection, or implant failure.[1] The initial cost advantage associated with implant reconstruction over autogenous methods has been shown to disappear as successive revisional surgeries accumulate for these patients.[2] Reconstruction of the radical mastectomy defect with poor soft tissue coverage is not possible with implants alone. The latissimus dorsi myocutaneous flap with underlying implant has been used as a remedy for this situation with good early results, but periprosthetic fibrosis remains a significant limitation.[3]

An ideal reconstructive method would be safe, reliable, durable, reproducible, have limited or no donor morbidity, and would replace the breast with similar tissue. The continued search for this "ideal" has lead to the development and refinement of autogenous methods of reconstruction. In 1976 Fujino[4] described the gluteus maximus myocutaneous flap for breast reconstruction. This was followed in 1979 by Holmstrom's[5] use of a rectus abdominus myocutaneous free flap, and in the early 1980s Hartrampf et al.[6,7] popularized the pedicled transverse rectus abdominus (TRAM) flap. The TRAM flap remains the most popular method of autogenous reconstruction to date. This popularity is the result of the relative ease with which the procedure is performed and the fact that no microsurgical expertise is required. Proponents also argue that the pedicled TRAM is quicker to perform and thus saves operative time and expense, but this has not been borne out in the literature.[7] The pedicled TRAM has proven to be a basically reliable method of reconstruction, but the rate of partial flap necrosis may approach 25%.[8] This can prove to be an early problem when open wounds cause delays in chemotherapeutic protocols and a later concern when differentiation of fat necrosis from recurrent tumor is required. The high rate of partial flap necrosis is the result of a basic anatomic problem with the flap, which requires reversal of flow-through intramuscular choke vessels into the inferior vasculature. This, combined with folding and tunneling of the pedicle at its pivot point, can compromise vascular exchange within the flap. Tunneling may also affect the medial breast contour.[9] Additionally, the rate of abdominal "bulge" or hernia formation has been reported to range from 0.3 to 35% in patients undergoing the TRAM procedure, and many patients report significant abdominal weakness.[10–13] The free TRAM flap has been used in an effort to decrease the rate of fat necrosis, but it still suffers from the same limitation of rectus muscle sacrifice. When patients with rectus sacrifice are compared with those in which it is preserved, the importance of this consideration is clear. Kroll et al.[12] and Mizgala et al.[13] reported that the weakening of the abdominal wall was significant and proportional to the amount of rectus sacrificed. Patients reconstructed with procedures that preserve muscle (DIEP) also experience substantially less postoperative pain than those subjected to muscle sacrifice (TRAM).[14]

These issues have helped usher in the next generation of autogenous breast reconstructive techniques. In 1989 Koshima and Soeda[15] pioneered transfer of abdominal fat and skin without muscle sacrifice. In 1992 our group developed the DIEP for breast reconstruction.[16] This advance has moved the state of the art closer to the "ideal" reconstructive technique based on the premise that the inclusion of muscle in a flap designed to replace fat and skin is unnecessary. In addition to the aforementioned advantages of muscle preservation, Blondeel[17] has shown that abdominal strength is superior in the DIEP patients compared with those undergoing TRAM procedures, which translates into improved abdominal contour and lesser effects on activities of daily living in the patients spared muscle destruction. The DIEP flap therefore incorporates the advantages of the free TRAM but reduces the morbidity substantially.

SURGICAL TECHNIQUE

The DIEP flap utilizes skin and fat from the lower abdomen much like a TRAM flap. The essential difference is that the flap is based on perforating vessels emerging through the rectus sheath from the deep inferior epigastric vessels (Fig. 1A). These vessels are followed through the sheath down to the main feeders, and the pedicle is resultantly much increased in length (Fig. 1B).

Preoperative markings are applied in the supine and standing position (Fig. 2A). Flap dimensions are marked out in a manner similar to abdominoplasty planning. An effort to include paraumbilical perforators, which are often dominant, may require shifting of the marked region slightly superiorly. A vertical dimension greater than 12 cm is rarely necessary. Horizontal extensions are fashioned to limit lateral "dog ears." The Doppler probe is then used to identify the main perforators of the medial and lateral branches of the deep inferior epigastric artery. On the chest, the inframammary crease is outlined. With immediate reconstruction, suggested markings are made for skin-sparing mastectomy to include the nipple–areola complex and biopsy site (Fig. 3). A radial extension may be required to improve access, especially with axillary dissection.

The patient is positioned supine with the arms tucked by her sides. A two-team surgical approach is used, with simultaneous preparation of the recipient area and flap harvest. The internal mammary vessels at the level of the third rib are preferred as the recipient vasculature (Fig. 4). The advantages over the use of the thoracodorsal vessels include ease of positioning for the microsurgical assistant, better exposure through a limited skin-sparing incision, and increased liberty with flap inset. Preoperative radiation of the internal mammary vessels has not been found to be a problem in our experience. Radiated vessels tend to be somewhat more tedious to dissect, but there has been no increased incidence of postoperative complications compared with nonradiated patients.

Flap dissection proceeds with careful elevation of the skin–fat composite from the underlying rectus fascia until the lateral perforators are encountered (Fig. 5A). If a large perforator is located, the flap can be based on this alone or with one or two other lateral perforating vessels. If no suitable perforators are identified in the lateral row, the dissection continues over to the medial row of perforating vessels. The largest perforators are selected regardless of "row," and the location of these vessels can usually be predicted preoperatively with the 8-mHz Doppler. A sensory branch of the intercostal nerves to the skin paddle can often be identified accompanying the perforating vessels. These nerves are dissected along with the vascular bundle and used to anastomose to an intercostal sensory branch in the recipient bed to provide sensation in the reconstructed breast.

Once the desired perforating vessels are selected, the defect in the anterior rectus sheath is opened around them (Fig. 5B). Loupe magnification and microsurgical technique are used to dissect the perforating artery and vein(s) through the rectus muscle. Often a second or third perforator in line with the first is maintained with the flap. The number of perforators used varies and is dependent on the intrinsic anatomy of the flap. In our experience, approximately 25% of flaps are based on one

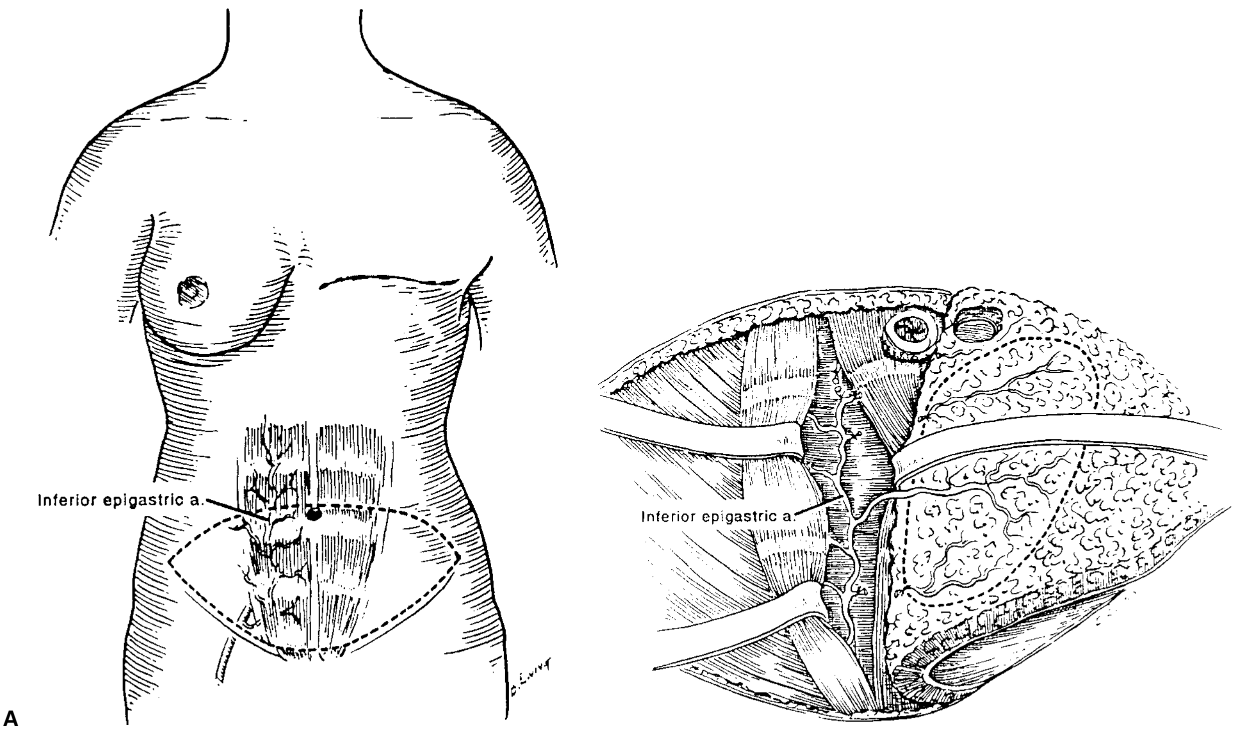


Figure 1 (A) The deep inferior epigastric vascular complex branching within the rectus abdominus muscle. (B) Perforating branches of the deep inferior epigastric vessels extend from within the muscle through the rectus fascia into the overlying skin and adipose tissue.

perforator, 50% on two, and 25% on three. As dissection continues, side branches of the vessels are divided with either bipolar coagulation, silk ligatures, or hemoclips. The muscle is split along the direction of its fibers to expose the lateral or medial branch of the deep inferior epigastric vessels. Intercostal nerves that cross the pedicle and do not lie between two selected perforators are preserved. Superior to the takeoff point of the most superior chosen musculocutaneous perforator, the pedicle is doubly ligated and divided. The anterior rectus sheath is split inferiorly, and the muscle fibers are separated to obtain the desired pedicle length, which typically ranges from 9 to 14 cm (Fig. 5C). The dissection is usually continued past the point where the medial and lateral branches converge into the main deep inferior epigastric artery and vena comitantes to assure adequately sized vessels to match the diameter of the recipient vessels. After branches of the pedicle are divided, the skin and fat flap is a tissue island based on the deep inferior epigastric artery and vein.

For patients undergoing immediate reconstruction, the mastectomy specimen is weighed, and the size and shape of skin resection are noted (Figs. 3A–G). With secondary reconstruction, the mastectomy scar is resected and the chest skin flaps are elevated. The pectoralis muscle fibers overlying the third rib at its junction with the sternum are freed with electrocautery exposing the underlying costal cartilage. Once the perichondrium is elevated, 2 to 3 cm of costal cartilage is removed. The posterior perichondrium is then carefully opened to expose the internal mammary vessels. Using loupe magnification, the vessels are isolated for a distance of 3 to 4 cm. The internal mammary artery (IMA) is usually an excellent recipient vessel with a diameter of 2 to 3 mm. Of the one or two

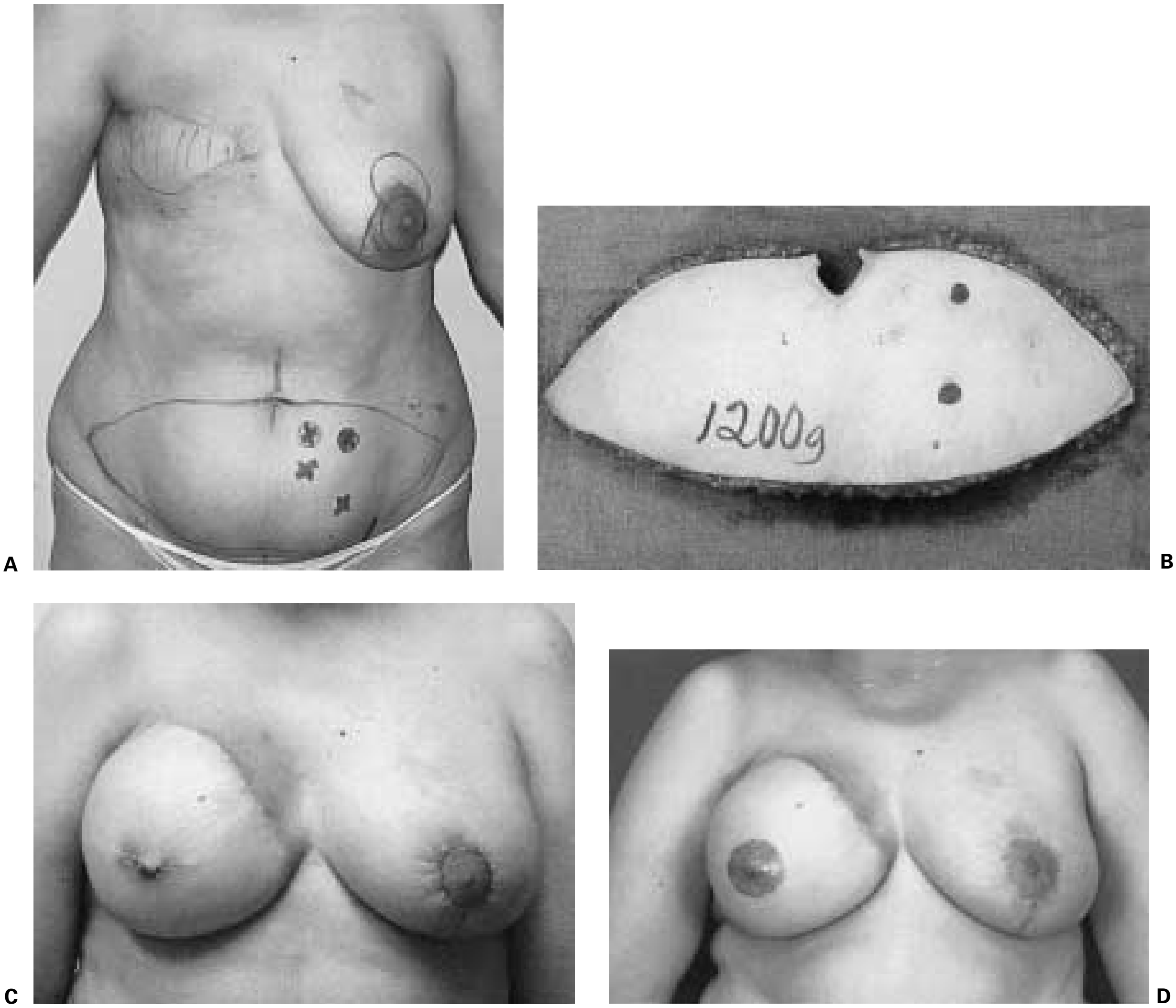
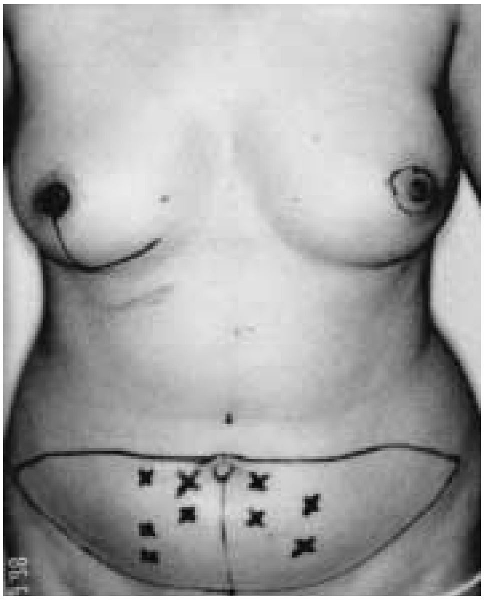


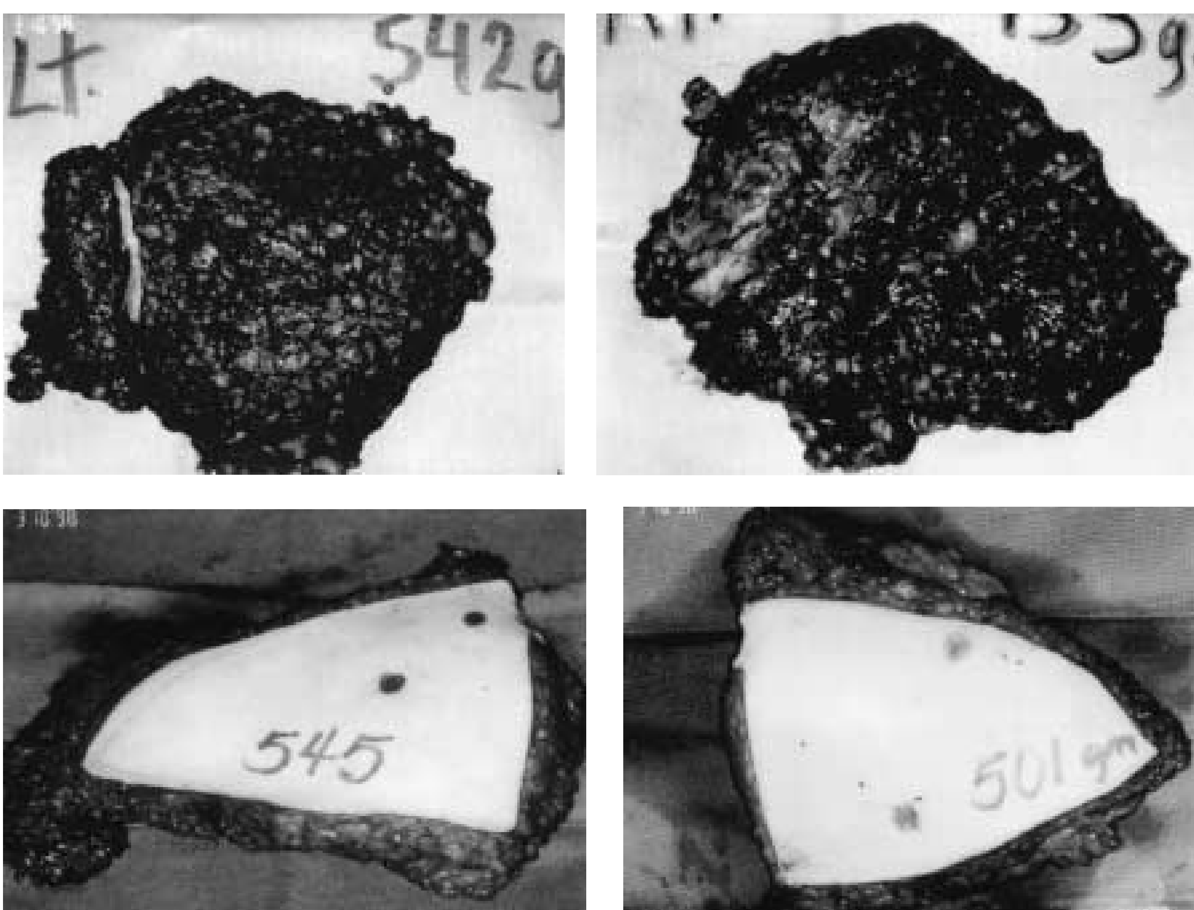
Figure 2 (A) Thirty-nine-year-old post–right-modified radical mastectomy with postoperative chemotherapy and radiation. Previous low-transverse C-section. Right inframammary fold marked. Abdominal flap dimensions marked with perforating vessel signal points shown as detected with handheld Doppler probe. (B) Flap harvested on two lateral row perforators. Initial weight 1200 g. Flap reduced to 842 g after shaping prior to inset. (C) Early postoperative result after right nipple reconstruction and left reduction mammaplasty for symmetry. (D) Final result after right nipple tattooing.

veins present, the larger vein's diameter varies from 2 to 4 mm. Although these veins are often thin walled, damage during the dissection has not been problematic when meticulous technique is employed. Care should be taken to avoid opening the pleura. This has occurred in fewer than 1% of our cases and even in those two cases has not resulted in pneumothorax. The flap is harvested by dividing the pedicle and passing it under any crossing intercostal nerves. The flap is then weighed and transferred to the chest wall. It is rotated 180 degrees, and the pedicle is laid into the recipient site, taking care to avoid any twisting of the vessels. The flap is secured in place with #0 silk suture and the operating microscope is set up. The larger or only internal mammary vein is ligated distally and divided. Anastomosis is completed to the flap vein with a microvascular coupling device. Attention is then

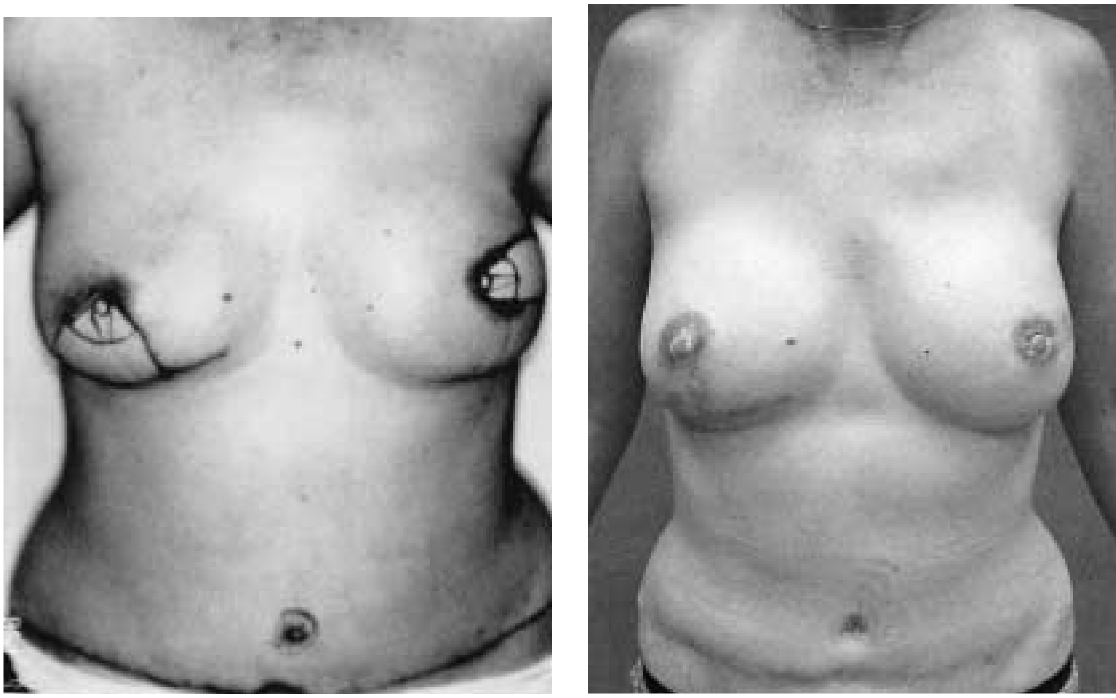


A

Figure 3 (A) Forty-one-year-old with left-sided invasive ductal carcinoma. Patient's mother died of breast cancer at age 52. Marked for skin-sparing, left-modified radical mastectomy and right simple mastectomy. Abdominal flap dimensions and perforating vessel locations also marked. (B) Left mastectomy specimen weight 542 g. (C) Right mastectomy specimen weight 455 g. (D) Right abdominal flap (545 g) harvested with two perforators for reconstruction of the left breast. (E) Left abdominal flap (501 g) harvested with two perforators for reconstruction of the right breast.



B C D E



F G

Figure 3 ***(Continued)*** (F) Early postoperative result. Note orientation left skin paddle as required for radial extension into axilla. (G) Final postoperative result with good shape and symmetry.

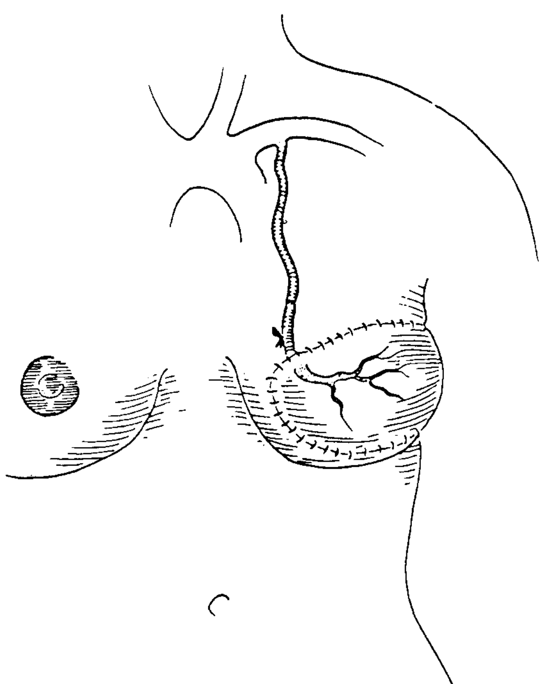
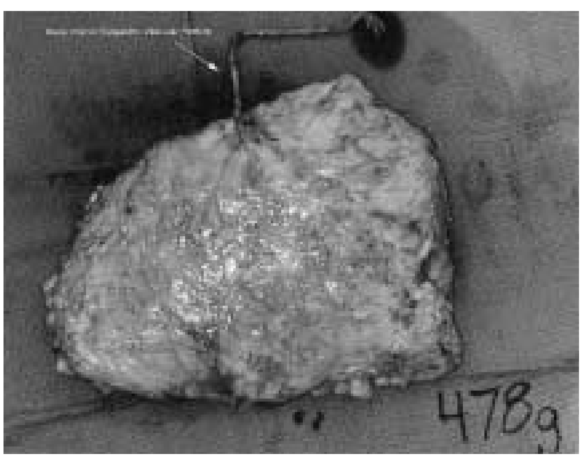


Figure 4 Internal mammary vessels serve as reliable recipient vasculature.

directed to completion of the anastomosis of the IMA to the deep inferior epigastric artery with 9–0 nylon suture. Upon completion of microvascular anastomosis, an implantable Doppler cuff is placed around the vein to provide postoperative monitoring. The cuff is stabilized with 9–0 nylon suture, and the wire protector is secured to the chest wall. The handheld Doppler probe is then used to mark the location on the skin paddle where the perforating arteries enter.

The flap is then tailored to achieve the desired breast size and shape, paying close attention to the weight recorded of the mastectomy specimen. Using the IMA as the recipient vessel facilitates medial positioning. Lateral fullness may be minimized with tacking sutures to the serratus or lateral pectoralis major muscle. A closed suction drain is placed and the skin island, incorporating the arterial perforator marking, is sutured into place. A temperature strip is then applied to the skin island and a control site to further the postoperative monitoring.

A B



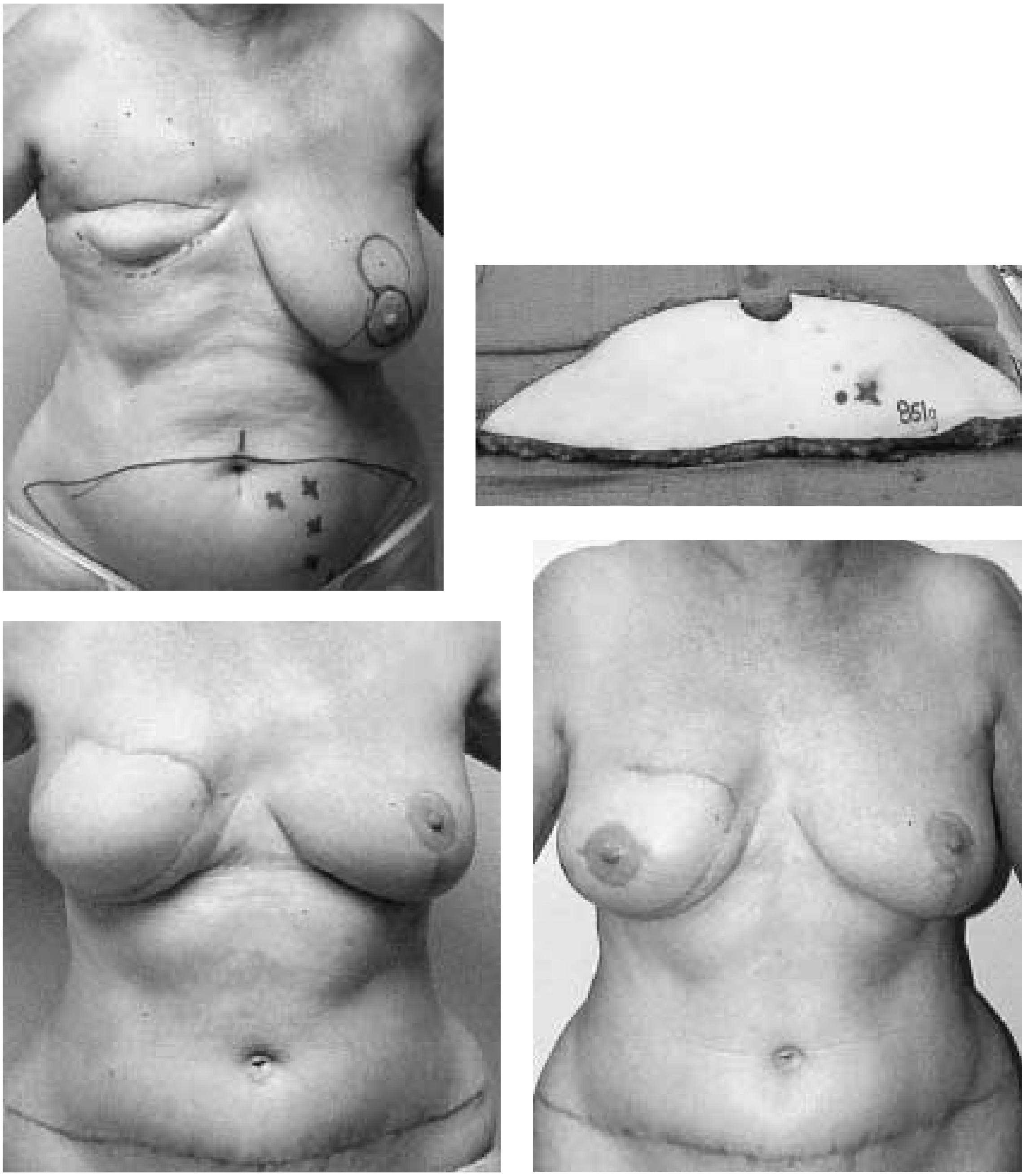
C

Figure 5 (A) DIEP flap elevated superficial to rectus sheath with dominant medial row perforator. (B) Close-up view of perforating vessels with rectus sheath opened around their base. (C) Completed flap dissection showing deep surface of skin/fat island with deep inferior epigastric pedicle of 17 cm.

The opening in the anterior rectus sheath is closed without tension. The remainder follows standard abdominoplasty closure of the skin flaps with umbilicoplasty. A suction drain is brought out through the lateral incision.

Postoperatively, the patient is monitored in the surgical intensive care unit for 24 hours. No anticoagulants are given during or after surgery. Often a unit of autologous blood is given, but banked blood is rarely needed. Monitoring by the nursing staff consists of flap skin color, capillary refill, temperature referenced to control, and venous and arterial Doppler signal confirmation. Usually on the morning after surgery, the Foley catheter is removed, the intravenous fluids are stopped, and the patient is cleared to get out of bed. Oral analgesics are typically sufficient at this point, and the patient is usually discharged home on the fourth postoperative day. Activities are resumed over the next several weeks, and the patient is given precautionary instructions, including avoidance of prone positioning for 3 to 4 weeks.

Nipple reconstruction and any necessary donor site revisions are carried out at a second stage 6 to 12 weeks after the initial surgery (Fig. 6 C,D). Those patients with immediate reconstruc-



A B C D

Figure 6 (A)Fifty-seven-year-old post–right-modified radical mastectomy for intraductal comedo carcinoma. Flap dimensions with perforating vessel points marked as detected with Doppler probe. Left breast marked for reduction. (B) Flap harvested on single medial row perforator. Initial weight 851 g; final weight 639 g after shaping prior to inset. (C) Post-reconstruction right breast with 228g reduction on left side. (D) Final result after nipple reconstruction and tattooing.

tions and skin-sparing techniques are often afforded the esthetic benefit of little or no visible or residual flap skin paddle (Figs. 3F,G). Nipple tattooing follows as the third and final stage of the reconstructive protocol (Figs. 2C,D).

DISCUSSION

The evolution of breast reconstruction has been fueled by the extraordinarily high incidence of breast cancer throughout the industrialized world. Recent revisions of mammographic screening guidelines and improved diagnostic technology have resulted in more women undergoing mastectomies than ever before. Modern treatment centers now include restorative surgery as an essential part in the overall care plan for these patients.

As experience with the DIEP flap has grown throughout the country, so has the acceptance of the procedure as a significant step forward in reconstructive surgery of the breast. Avoidance of muscle destruction with a resultant decrease in abdominal weakness and hernia are the basic factors that have established the DIEP flap's place in the reconstructive menu. Arguments against the use of this flap as a first-line choice for the mastectomy patient have included increased operative time and the need for microsurgical expertise. The need for microsurgical proficiency is a given. The procedure requires meticulous technique and attention to detail. The "occasional" microsurgeon is likely better served by a less-demanding operation. Microsurgery has evolved to the point that high failure rates and marathon surgical times are no longer a valid counterargument against using a free flap for breast reconstruction, especially when the patient is afforded less morbidity compared with pedicled and free TRAM reconstructions. Our review of over 700 cases performed at our institution has shown that the operative times are no longer than the free TRAM and may on occasion be shorter, as mesh repair of the abdomen is never required with the DIEP. The average operative time in this series was 5.4 hours for unilateral reconstructions and 8 hours for those undergoing bilateral procedures. We have found that the DIEP flap is particularly well suited for simultaneous bilateral reconstruction. Harvesting two skin flaps from the lower abdomen without any sacrifice of the anterior rectus sheath or rectus abdominus muscle significantly reduces the donor site morbidity often associated with bilateral TRAM flap reconstruction. Avoiding a tight fascial closure and the use of synthetic mesh allows the patient to be ambulatory on the first postoperative day. We have found that most patients are comfortable on oral analgesics alone by postoperative day 1. Hospital stay averages 4.3 days in our patient population.

Early complications were found to be comparable with other procedures in this series. The incidence of take-back to the operative suite was 6.5%. The venous occlusion rate was 5%, and the arterial occlusion rate was 1%. Since adopting the coupling device as our preferred method of venous anastomosis, our take-back rate has dropped even further. Hematoma occurred in 1% of patients, and the total flap loss rate was 1%.

Late complications included seromas in 4% of patients and delayed abdominal wound healing in 2%. As mentioned, mesh was never required for fascial repair. Hernia formation in five of our patients was found to be the result of unraveling in a continuous suture used to repair the fascial incision, which was easily repaired with resuturing at a second operation. Fat necrosis requiring revisional surgery occurred in 16 of our patients. These revisions were usually done at the same time as nipple reconstruction and abdominal scar revisions when required.

Smoking was not found to significantly increase the incidence of early complications; however, late complications of delayed wound healing and fat necrosis were significantly increased. The incidence of fat necrosis requiring revision for smokers was 13.5% compared with 3% for nonsmokers. This compares with previous reports that are as high as 26%.[18] The incidence of delayed wound healing was 9% in smokers and 3% in nonsmokers. Other series have reported rates ranging from 8 to 27%.[19]

The effects of radiation therapy on our patients have been under recent review. We have found that postoperative radiation significantly increases the late occurrence of fat necrosis in the reconstructed breast and can substantially compromise the esthetic result. We no longer recommend immediate reconstruction for patients who are scheduled for radiation after surgery. Delayed reconstruction is undertaken in this group 6 months after completion of their therapy to allow the acute effects of their treatments to settle.

CONCLUSION

Perforator flaps represent the state of the art in autogenous breast reconstruction. The DIEP flap has proven reliability and a low complication rate. Avoidance of muscle sacrifice in the abdomen ultimately translates into greater patient satisfaction. The increased demands in terms of surgical expertise are more than offset by decreased postoperative pain and donor site morbidity. This procedure has taken us one step closer to the "ideal" in breast reconstructive surgery.

REFERENCES

1. Mentor Large Simple Trial (LST) and Saline Prospective Trial (SPS). Mentor Corporation, July 2000
2. Kroll SS, Evans G, Reece RD, et al. Comparison of resource costs between implant-based and TRAM flap breast reconstruction. Plast Reconstr Surg 1996;97:364–372
3. Schneider WJ, Hill HL, Brown RG, et al. Latissimus dorsi myocutaneous flap for breast reconstruction. Br J Plast Surg 1977;30:277–281
4. Fujino R, Harashina R, Enomoto K. Primary breast reconstruction after a standard radical mastectomy by free flap transfer. Plast Reconstr Surg 1976;58:371–374
5. Holmstrom H. The free abdominoplasty flap and its use in breast reconstruction. Scand J Plast Reconstr Surg 1979; 13:423–427
6. Hartrampf CR, Scheflan M, Black PW. Breast reconstruction with a transverse abdominal island flap. Plast Reconstr Surg 1982;69:216–225
7. Hartrampf CR, Bennet GK. Autogenous tissue reconstruction in the mastectomy patient: a critical review of 300 patients. Ann Surg 1987;205:508–519
8. Kroll SS, Evans G, Reece RD, et al. Comparison of resource costs of free and conventional TRAM flap breast reconstruction. Plast Reconstr Surg 1996;98:74–77
9. Baldwin BJ, Schusterman MD, Miller MJ, et al. Bilateral breast reconstruction: conventional versus free TRAM. Plast Reconstr Surg 1994;93:1410–1416
10. Zienowicz RJ, May JW. Hernia prevention and aesthetic contouring of the abdomen following TRAM flap breast reconstruction by the use of polypropylene mesh. Plast Reconstr Surg 1995;96:1346–1350
11. Kroll SS, Marchi M. Comparison of strategies for preventing abdominal wall weakness after TRAM flap breast reconstruction. Plast Reconstr Surg 1992;89:1045–1051
12. Kroll SS, Schusterman MA, Reece GP, et al. Abdominal wall strength, bulging, and hernia after TRAM flap breast reconstruction. Plast Reconstr Surg 1995;96:616–619
13. Mizgala CL, Hartrampf CR, Bennet GK. Assessment of the abdominal wall after pedicled TRAM flap surgery: 5 to 7 year follow-up of 150 consecutive patients. Plast Reconstr Surg 1994;93:988–1002
14. Kroll SS, Sharma S, Koutz C, et al. Postoperative morphine requirements of free TRAM and DIEP flaps. Plast Reconstr Surg 2001;107:338–341
15. Koshima I, Soeda S. Inferior epigastric artery skin flap without rectus abdominus muscle. Br J Plast Surg 1989; 42:645–648
16. Allen RJ, Treece P. Deep inferior epigastric perforator flap for breast reconstruction. Ann Plast Surg 1994;32:32–38
17. Blondeel PN, Vanderstraeten GG, Monstrey SJ, et al. The donor site morbidity of free DIEP flaps and free TRAM flaps for breast reconstruction. Br J Plast Surg 1997;50:322–330
18. Padubidri AN, Yetman R, Browne E, et al. Complications of post mastectomy breast reconstruction in smokers, exsmokers, and non-smokers. Plast Reconstr Surg 2001; 107:342–349
19. Kroll SS. Necrosis of abdominoplasty and other secondary flaps after TRAM flap breast reconstruction. Plast Reconstr Surg 1994;94:637–643
20. Grotting JC, Urist MM, Maddox WA, et al. Conventional TRAM flap versus free microsurgical TRAM flap for immediate breast reconstruction. Plast Reconstr Surg 1989; 83:828–841