Bilateral Breast Reconstruction with the Deep Inferior Epigastric Perforator (DIEP) Flap

An Experience with 280 Flaps

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Abstract: Bilateral prophylactic mastectomy can reduce the incidence of breast cancer by 87 to 93% in high-risk individuals and is an appealing option for many patients if reconstruction can be provided with acceptable morbidity and outstanding esthetic results. Autogenous breast reconstruction techniques have evolved over the last 20 years to meet this goal. Familiarity with the deep inferior epigastric perforator (DIEP) flap led us to carry out simultaneous bilateral breast reconstruction with acceptable morbidity and superior esthetic outcome in 3 patient groups: (1) after bilateral prophylactic mastectomy, (2) after therapeutic and contralateral prophylactic mastectomy, and (3) after explantation of bilateral implant failures. A retrospective review of our experience with 280 flaps in 140 patients was performed. Average operating times, including time for implant removal or mastectomy and reconstruction, was 7.3 hours. Average hospitalization was 3.9 days. Significant perioperative complications occurred in 9 patients (6.4%); all returned to the operating room. This included 7 microvascular complications, 1 hematoma, 1 seroma, and 1 DVT. Less significant complications were divided into early and late. The early complications included 1.8% partial flap necrosis, 4.2% abdominal apron necrosis greater than 5 cm^2, 2.9% seromas that required intervention, and 5.7% partial breast flap dehiscence. Late complications included 12.5% fat necrosis of any size and 2.1% hernia formation. Smoking, obesity, age, history of chest wall radiation, and flap size were evaluated as risk factors for increased morbidity.

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For Western women, the lifetime risk of developing breast cancer is approximately 10%.[1] Genetic testing has identified women carrying an 85% lifetime predisposition to breast adenocarcinoma.[2] To reduce the incidence of malignancy, prophylactic mastectomy has been proposed. Studies of high-risk patients undergoing prophylactic mastectomy demonstrated breast cancer risk reductions of 90 and 94%, with the reduction in risk persisting throughout the median follow-up of 14 and 9.5 years, respectively.[3,4] Simultaneous restoration of the breasts can make bilateral mastectomy a more appealing option if the procedures can be carried out with acceptable morbidity and superior esthetic results.

Options for management of the breast after mastectomy include implant reconstruction and/or autologous tissue flaps from various donor sites. Expanders and implants are the most popular methods of breast restoration. However, results of breast reconstruction with implants deteriorate over time, especially in the setting of radiation therapy.[5–7] Breast mounds reconstructed with the patient's own tissue behave naturally, achieving the consistency of the native breast, becoming less edematous and softer as the patient ages.[8] In bilateral cases, symmetry and esthetics are consistently superior to unilateral reconstructions.[9] Use of autologous tissue is acceptable only if it can be performed with reasonable morbidity.[10,11] The pedicled transverse rectus abdominus musculocutaneous (TRAM) flap is the traditional workhorse for autologous breast restoration; however, chronic obstructive pulmonary disease, smoking, diabetes, and obesity may contraindicate its use. Although free TRAM is applicable to a wider array of patients, it is also associated with certain morbidity and limitations.[12–17]

The deep inferior epigastric perforator (DIEP) flap has recently surfaced as an alternative to TRAM flaps. This flap is harvested with preservation of the underlying musculofascial system.[18] Several series have shown the DIEP as a reliable flap for unilateral breast reconstruction, resulting in

highly esthetic results and less donor site morbidity.[19–21] Our experience with 280 flaps in 140 consecutive patients who underwent simultaneous bilateral breast reconstruction with the DIEP flap is presented.

PATIENTS AND METHODS

The medical records of 140 patients who underwent simultaneous bilateral breast reconstruction with the DIEP flap between January 1994 and January 2003 were reviewed (Table 1). Demographic information, tobacco use, tumor stage, operative time, operative technique, flap size, blood loss, length of hospitalization, adjuvant therapy received, length of follow-up, and complications were evaluated. Complications were divided into early (Table 2), late (Table 3), flap-specific (Table 4), and patient-specific (Table 5). Risk factors considered were smoking, body mass index (BMI) > 30, age > 60, radiotherapy, and flap weight > 700 g. The areas of interest in the early cohort for this study included (1) *Partial flap loss*; any ischemic tissue loss within the first 30 days of surgery associated with loss of skin and underlying soft tissue, regardless of volume involved. Patients with partial flap loss were considered to have fat necrosis. (2) *Breast Flap Dehiscence*: Any size of wound breakdown of the DIEP flap including infections. Patients with partial flap loss were not included in this category. (3) *Abdominal Seroma*: any palpable fluid collection within the first 30 days of surgery and requiring intervention. (4) *Abdominal Apron Necrosis*: Abdominal skin necrosis or wound breakdown, including infection requiring I.V. antibiotics involving at least a 5-cm^2 area. The endpoints of interest in the late group included (5) *Fat necrosis*: Any ischemic soft-tissue loss characterized by palpable subcutaneous firmness present after 30 days since surgery, regardless of size and not caused by recurrence, was considered fat necrosis. The diagnosis of fat necrosis was usually made by exclusion. Some indurations were examined by biopsy to exclude the possibility of recurrent carcinoma. (6) *Hernia*: A fascial defect, regardless of size, presenting with herniation of abdominal tissue was considered a hernia. (7) *Cancer Recurrence*: Patients who had a recurrence of malignancy in the previously resected site.

Results were tabulated in a Microsoft Excel Spreadsheet,Version 2001 (Microsoft Corporation, Redmond, WA). All statistical analyses were performed using StatView for Windows, Version 4.57 (Abacus Concepts, Inc., Berkeley, CA). A 2-group χ^2 test was used to determine significance. χ^2 P values of <0.05 were considered significant. If an expected value was less than 5, Fisher exact test was used and P values <0.05 were considered significant.

TABLE 1. Demographics of Patients Undergoing Simultaneous Bilateral DIEP Flap Breast Reconstruction (Range)

Number of patients/flaps	140/280 flaps
Average age (y)	49 (27–72)
Average follow-up (mo)	14.6 (6–76)
Average hospital stays (days)	3.9 (2–9)
Average blood loss (mL)	434± 147
Average flap weight (g)	556 ± 208 (159–1177)
Average BMI	27 ± 5
Abdominal drains removed (d)	7.75 ± 3 (3–20)
Average operative time (h)	7.3 ± 1.4 (5–12)
Immediate reconstruction	156 flaps (55.7%)
After prophylactic mastectomy	91 flaps (32.5%)
After mastectomy for cancer	61 flaps (21.7%)
Other	4 flaps (1.4%)
Delayed reconstruction	124 flaps (44.3%)
After prophylactic mastectomy	59 flaps (21.1%)
After mastectomy for cancer	55 flaps (19.6%)
Other	10 flaps (3.6%)
Smokers	26 (18.6%)
Obese patients (BMI > 30)	28 (20%)

BMI, body mass index.

TABLE 2. Early Complications

Type	Number (% of Total)*
Vascular complications	
Anastomotic venous thrombosis	4 (1.4%)*
Venous congestion/leech therapy	1 (0.4%)*
Arterial ischemia/hyperbaric O_2	2 (0.8%)*
Total flap loss	0 (0.0%)*
Partial flap loss	5 (1.8%)*
DVT	1 (0.8%)
Abdominal complications	
Apron necrosis/dehiscence (>5 cm^2)	6 (4.2%)
Seromas (with intervention)	4 (2.9%)
Seromas (no intervention)	26 (18.6%)
Infection (IV antibiotics)	1 (0.8%)
Breast flap partial dehiscence	16 (5.7%)*

*Flap specific.
DVT, deep vein thrombosis.

TABLE 3. Late Complications

Type	Number (% of total)
Fat necrosis, any size	30 (12.5%)
Hernia, abdominal bulging	3 (2.1%)
Cancer recurrence	3 (2.1%)

TABLE 4. Flap-Specific Complications and Associated Risk Factor

	Fat Necrosis (%)	*P* Value	Partial Flap Loss (%)	*P* Value	Breast Dehiscence (%)	*P* Value
Smoker	15.4	0.4858	3.8	0.2328	15.4	0.0033
Nonsmoker	11.8		1.3		3.5	
Obese	10.7	0.6514	5.4	0.0563	5.4	0.7279
Nonobese	12.9		0.9		4.5	
Radiation	4.2	0.6109	4.2	0.2080	12.5	0.0399
No radiation	13.1		1.3		4.4	
Age >60	20.6	0.1282	0.0	0.4016	2.9	0.6149
Age >60	11.4		2.0		4.9	
Flap >700 g	14.5	0.5864	3.2	0.3067	4.8	0.9999
Flap <700 g	11.9		1.4		6.0	

TABLE 5. Patient-Specific Complications and Associated Risk Factors

	Takeback (%)	*P* Value	Hernia/Bulge (%)	*P* value	Abd. Necrosis (%)	*P* Value	Abd. Seroma (%)	*P* Value
Smoker	7.7	0.6417	3.8	0.9999	26.9	0.2535	23.1	0.8204
Nonsmoker	5.3		3.5		15.8		21.1	
Obese	3.6	0.9999	3.6	0.9999	10.7	0.2699	35.7	0.0394
Nonobese	6.3		3.6		19.6		17.9	
Age >60	0.0	0.2788	11.8	0.0521	17.6	0.9807	23.5	0.8218
Age <60	6.5		2.4		17.9		21.1	
Flap >700 g	3.2	0.6846	3.2	0.9999	19.4	0.8051	25.8	0.5008
Flap <700 g	6.4		3.7		17.4		20.2	
XRT	11.1	0.1140	NA	NA	NA	NA		NA
No XRT	3.3		NA		NA		NA	

XRT, radiation therapy.

Surgical Technique

Preoperative markings are performed with the patient in the standing and supine positions. The superior margin of the flap is shifted slightly above the umbilicus to include periumbilical perforators (Figs. 1 and 3). Vertical dimensions of the flap rarely exceed 12 cm, allowing for closure under minimal tension. Perforators are identified with a Doppler (Koven, Inc., St. Louis, MO) probe. For immediate reconstruction, suggested markings are made for the skin-sparing mastectomy. The inframammary crease is marked for reference. Using a 2-team approach, the DIEP flaps are elevated during the mastectomy. The internal mammary vessels at the level of the third rib are the recipient vessels of choice. The pectoralis major muscle is divided to expose the costal cartilage. The perichondrium is elevated to allow removal of 2 cm of cartilage. The posterior perichondrium is opened to expose the internal mammary vessels. Mastectomy specimens are weighed. In failed implant cases, a pericapsular dissection is preferred and the specimen is weighed after removal. The DIEP flap is elevated from lateral to medial in a suprafascial plane. The superficial inferior epigastric vein (SIEV) is preserved. Once the lateral perforators are identified, the panniculus is split down the midline into 2 flaps. Skin and fat are elevated from the midline laterally until the medial row perforators are seen. The largest perforators are selected. The anterior rectus sheath is opened around the perforating vascular bundle, allowing the perforators to be traced to the deep inferior epigastric vessels. Intercostal nerves should be left intact to avoid denervating the muscles medially. Sensory nerves can be dissected for flap innervation. The rectus sheath and muscle are separated to allow isolation of the pedicle.

After dividing the pedicle, the flap is weighed and brought to the chest for anastomosis to the internal mammary vessels. Vessel anastomosis is performed with 9–0 nylon for the artery and with a vessel coupler (Medical Companies

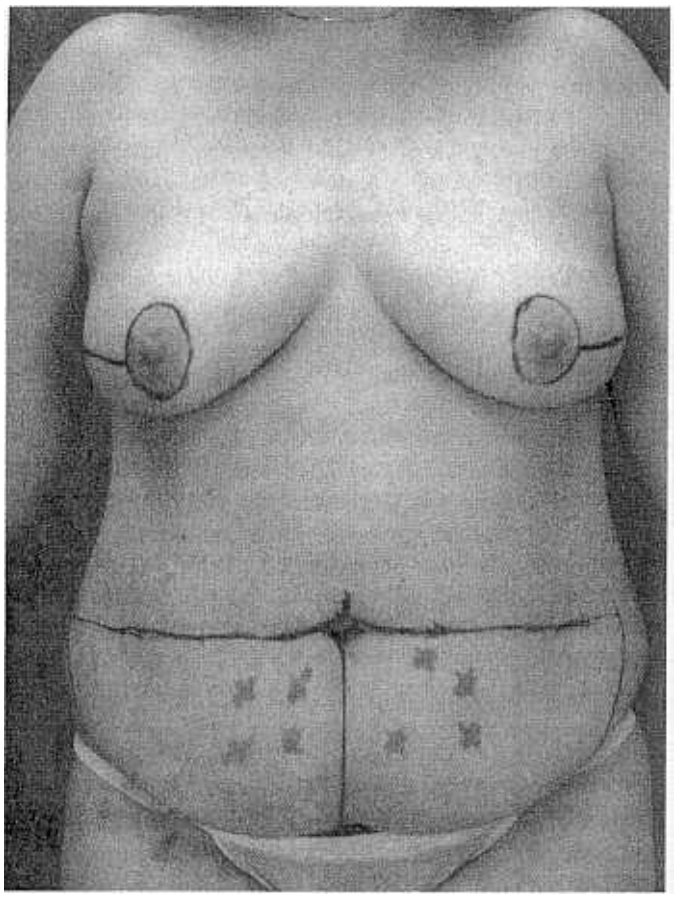

FIGURE 1. AP view of 45-year-old patient with preoperative markings before bilateral skin-sparing mastectomy and immediate DIEP flap breast reconstruction.

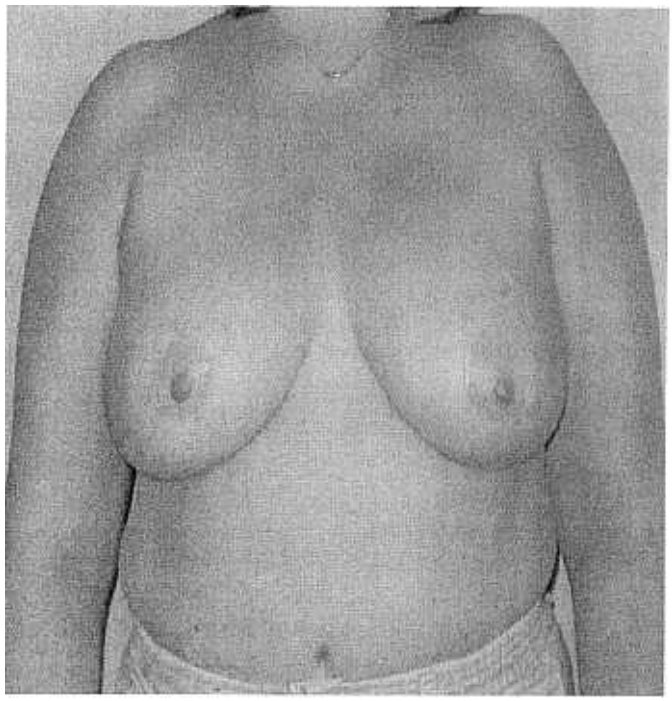

FIGURE 2. The final result in the same patient.

Alliance, Inc., Bessemer, Alabama) for the vein. A neurorrhaphy can be performed between the flap sensory nerve and the fourth intercostal nerve. An implantable Doppler (Cook Vascular Incorporated, Leechburg, PA) is placed around the vein for postoperative monitoring. The flaps are tailored to desired breast shape and contour. Each opening in the rectus sheath is closed without tension. The abdominal apron is advanced and closed in routine fashion.

RESULTS

The mean age was 49 ± 9 years, 26 patients (18.6%) with a recent history of or actively smoking tobacco and 28 patients (20%) with a BMI above 30. Additional demographic details are given in Table 1. The internal mammary vessels were used in 279 of the 280 flaps (99.6%). The SIEV was used with a vein graft to the thoracodorsal vein for flap venous congestion twice. The most common reason for performing a delayed reconstruction was failed implants (70), while 54 flaps were performed in unreconstructed patients. Most patients were staged at T1/T2 level, with only 5 T3 tumors. Ten patients had a second primary or recurrent cancer, previously treated with lumpectomy and radiation, and 10 patients had bilateral breast cancer at presentation.

Fifty patients (35.6%) experienced a total of 81 complications. Thirty patients experienced 2 or more complications, and 20 patients experienced a single complication. Nineteen patients experienced early complications (Table 2). The majority of these were minor, amenable to in-office treatment. Nine patients (6.4%) experienced major perioperative complications. All 9 returned to the operating suite: 4 venous thrombosis, 1 venous kinking, 1 arterial occlusion, 1 hematoma, 1 seroma, and 1 venous congestion not due to vessel thrombosis and requiring leech therapy. One flap required hyperbaric oxygen treatment with salvage after 8 dives. Five (1.8%) partial flap losses occurred. The patient requiring leech therapy developed partial flap loss. No complete flap loss occurred. A small dehiscence occurred in 16 flaps (5.7%). Smokers ($P = 0.016$) and patients with preoperative radiotherapy had higher incidences of breast flap dehiscence ($P = 0.039$). Four patients required treatment of abdominal seroma (2.9%). Small seromas were identified in another 26 patients; none required treatment and were not considered complications of surgery (Table 5). Overall, obesity significantly increased the incidence of seromas ($P = 0.0394$). Six developed abdominal apron necrosis of 5 cm^2 or greater and required revision (4.2%). One required intravenous antibiotics for infection. No statistical significance was found between risk factors and incidence of this complication.

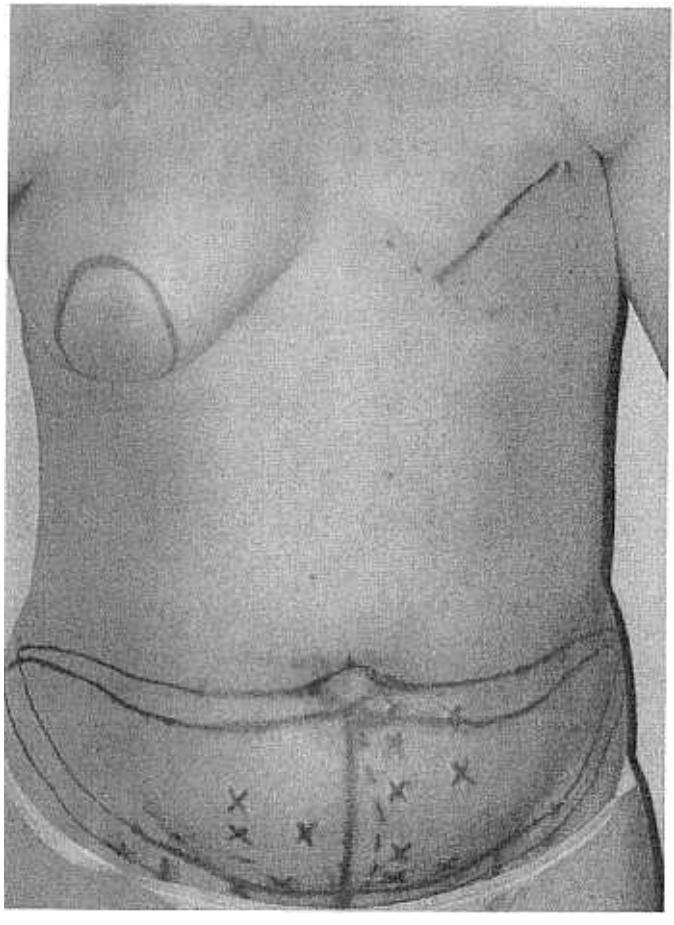

FIGURE 3. A 46-year-old woman with preoperative markings for delayed reconstruction of the left breast and immediate prophylactic skin-sparing mastectomy on the right breast with DIEP flaps.

Late complications occurred in 31 patients (Table 3). Fat necrosis was found in 35 flaps (12.5%) in 30 patients. Patients with partial flap loss were considered to have fat necrosis. Although not statistically significant, the incidence of fat necrosis was slightly higher in smokers, patients > 60, and flap weight > 700 g (Table 4). Three patients developed abdominal hernia or bulging (2.1%). On examination, 2 were clearly identified as incisional hernias and 1 as a bulge. On exploration, the bulging was caused by fascial attenuation. Only 1 hernia was repaired with mesh. Contrary to previous studies, smoking and obesity did not increase the rate of hernia formation (Table 5). Three patients experienced cancer recurrence (2.1%), at intervals of 6, 10, and 26 months following reconstruction.

DISCUSSION

In the last decade, muscle-sparing abdominal flaps have evolved in an effort to minimize abdominal morbidity while continuing to provide the benefits of autologous breast restoration. In particular, the DIEP flap is harvested with preservation of the underlying musculofascial system of the abdominal wall. Early reports of the DIEP flap were encouraging, demonstrating lower abdominal wall morbidity combined with highly esthetic breast reconstructions.[19–21] However, since Kroll et al[22] reported their initial experience with the DIEP flap, many have questioned whether perforator dissection is of benefit when compared with other muscle-sparing flaps.[23] Whether DIEP flap reconstruction can be accomplished safely in the setting of bilateral reconstruction must be critically analyzed. We have carried out bilateral DIEP flap breast restoration with an acceptable overall morbidity of 36% in 140 patients. Our average operative times of 7.3 hours were less than that for both bilateral free (8.6 hours) and pedicled (9.6 hours) TRAM flaps.[10,14] Based on these data, we conclude that perforator dissection can be accomplished without additional time even in the setting of bilateral flap harvest. Furthermore, average operating times for the first 30 patients was 9.2 ± 1.4 hours and for the last 30 patients 6.1 ± 0.7 hours. Increased experience and modifications in technique led to a 34% reduction in operative time.

Focus on the rate of fat necrosis with the DIEP flap has increased over the last few years. Previously reported fat necrosis rates for large series of DIEP flaps range from 6 to 10%.[19–21] In this series, thirty patients experienced fat necrosis for a flap-specific rate of 12.5% (35/280). Partial flap loss occurred in 5 breasts (1.8%). No correlation was found between smoking, age, radiation, obesity, flap weight, and the incidence of fat necrosis or partial flap loss (Table 4). Kroll et al[22] reported fat necrosis rates in the order of 62.5% for DIEP flaps. In this series, using stringent inclusion criteria, we did not experience such high rates of fat necrosis. In a recent study of TRAM versus DIEP flap, the fat necrosis rate was reported at 10%.[23] When compared with unilateral DIEP flap reconstructions, our rate is double that seen by other surgeons. This elevated rate of fat necrosis may be due to the inability to turn to the other side of the abdomen and choose the most ideal perforator(s) to carry the flap. As described by Keller,[21] there is no "safety net" with the use of bilateral flaps. Each flap must be transferred on ipsilateral perforating vessels, which are occasionally less than ideal. Despite this, our results compare favorably with reports on fat necrosis rates with bilateral pedicled and free TRAM flaps (7–13%).[14] After appropriate observation, fat necrosis was removed, with only 2 patients requiring a local intercostal flap to supplement areas of excised tissue.

Wound dehiscence was observed in 16 breast flaps (5.7%). Smokers ($P = 0.016$) and those receiving radiation ($P = 0.039$) were more likely to have this complication. Six of these dehiscences were associated with infection, and 2 required IV antibiotics. Age, obesity, and higher flap weight were found not to be significant risk factors leading to dehiscence. Most wounds resolved with conservative dress-

ing changes. The morbidity to the abdominal wall is largely eliminated with preservation of muscle and fascia. Complete closure of the abdominal wall can be accomplished without tension and without mesh. Only 3 (2.1%) patients in this series experienced abdominal hernias or bulges. Smoking did not affect the incidence of bulge or hernia formation in this series ($P = 0.99$). Most series of DIEP flaps involving unilateral reconstructions have reported similarly low rates of hernia or bulge formation (0–5%).[19–21,23] In a study of bilateral free TRAM flaps, Khouri et al[10] reported an incidence of hernia and bulge formation of 11.6%, almost 3 times our rates. Kroll et al[24] stated that the risk of hernia formation is independent of the type of TRAM flap used, as long as secure fascial repair is performed and that abdominal weakness as measured by the ability to do sit-ups was significantly decreased when both rectus muscles were used as compared with unilateral flaps.[24] Blondeel et al[25] compared patients undergoing unilateral free TRAM versus unilateral DIEP flaps and found a statistically significant reduction in trunk flexing and upper trunk rotational strength in the free TRAM group. Although no formal testing of abdominal strength was done in this series, 92% of patients expressed no significant reduction in abdominal strength with exercise and daily life activities at the 1-year follow-up visit. Preservation of musculofascial components with the DIEP flap has been shown to reduce postoperative pain and shorten hospital stay.[26,27]

Obesity did not affect the rate of hernia formation but did significantly increase the incidence of abdominal seroma, 35.7% in obese and 17.9% in nonobese patients ($P = 0.039$). Twenty six patients with seromas did not require treatment and resolved in the observation period. Four seromas required intervention and were considered true complications. Age, smoking, and flap weight had no effect on the rate of seroma formation. We recommend that drains be left in place in obese patients for an extended period to account for additional serous drainage. Abdominal skin necrosis and seroma formation were not affected by age, flap weight, obesity, or smoking history.

Refinements in technique lowered the time involved with bilateral DIEP flap reconstruction (Table 6). Use of the internal mammary vessels allows medial placement of the flap with greater comfort for the assistant during anastomosis and leads to a more esthetic breast restoration. Consequently, use of the thoracodorsal vessels, which frequently lie in a secondary bed of scar tissue or may be damaged during mastectomy, can be more complicated and time consuming.[28] Schusterman et al[16] experienced a 5% incidence of upper extremity neuropraxia due to patient positioning when using the thoracodorsal pedicle as recipients. This complication did not occur in our series. Use of the venous coupler device for anastomosis was felt to be a contributing factor in reducing operative time. The implantable venous Doppler aids with postoperative flap monitoring, but its real value is seen during flap contouring and insetting. At this time, potentially obstructive kinks in the pedicle are likely to occur. The surgeon is made aware of such problems and can rectify the situation while still in the operating suite. Dissection of the SIEV as an outlet for venous congestion facilitates postoperative flap management.

TABLE 6. Refinements in the DIEP Flap Leading to a Decrease in Operative Time

Increased experience
Increased coordination
Use of 2 teams
Dissection of DIEP flap during mastectomy
Preferred use of the IMA
Use of the venous coupler
Use of the implantable Doppler
Preservation of SIEV as an outlet for venous congestion

IMA, internal mammary artery; SIEV, superficial inferior epigastric vein.

CONCLUSION

We have been using the DIEP flap as our workhorse for autogenous breast reconstruction since 1992. This flap re-

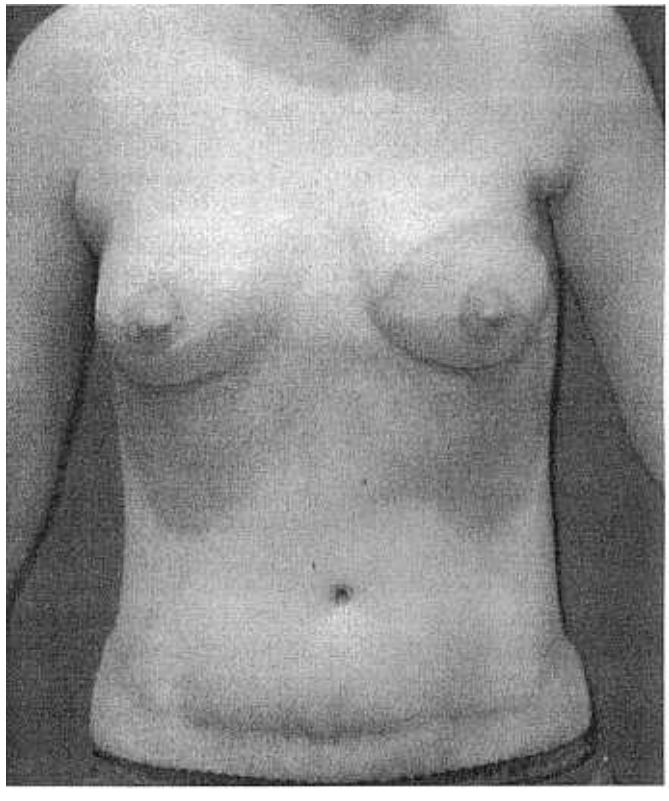

FIGURE 4. The final result shows a highly esthetic, symmetrical breast reconstruction and good abdominal contour.

ceives its blood supply via indirect perforating vessels originating from the deep inferior epigastric artery. These vessels can be dissected while sparing the musculofascial system of the abdominal wall to nourish the flap. The experience presented demonstrates that the DIEP flap fares well in bilateral breast reconstruction when measured against other reconstructive options. Smoking history increases the incidence of breast flap dehiscence, but not the rate of fat necrosis or hernia formation. With a high rate of success, comparable rates of fat necrosis, and low abdominal wall morbidity (Figs. 2 and 4), this method of reconstruction seems well suited for patients in the high-risk category for bilateral breast carcinoma, and these patients will receive maximal benefit from having preservation of their abdominal wall. The DIEP flap represents a natural progression in the evolution of breast reconstruction techniques. The time required for perforator dissection is worthwhile because it eliminates virtually all of the major abdominal morbidity, reduces postoperative pain, and can shorten hospital stay.

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