Secondary Operations of the Anterior Abdominal Wall following Microvascular Breast Reconstruction with the TRAM and DIEP Flaps

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Background: Secondary operations of the anterior abdominal wall following breast reconstruction with abdominal flaps are sometimes performed to improve outcome. The purpose of this study was to review a single surgeon's experience with secondary abdominal wall operations following breast reconstruction with the deep inferior epigastric perforator (DIEP) and free transverse rectus abdominis musculocutaneous (TRAM) flaps.

Methods: Over a 7-year period, 330 women had microvascular breast reconstruction using abdominal flaps. Indications for secondary abdominal operations that were considered necessary included bulge, abdominal skin necrosis (wound), hematoma, neuroma, and seroma. Indications that were considered elective included lateral dog-ear scars and lipodystrophy. Mean follow-up time was 40 months (range, 3 to 84 months).

Results: Secondary abdominal operations were performed in 59 women (17.9 percent). The cumulative number of indications was 64. The indications were considered necessary in 33 women (10 percent) and elective in 31 women (9.4 percent). Lower abdominal bulge was the most common necessary indication and was repaired in 9.3 percent of free TRAM flaps and 4.7 percent of DIEP flaps. Dog-ear scars were the most common elective indication and were revised in 29 women (8.8 percent). Neuromas of the anterior abdominal wall were diagnosed in three women (0.9 percent). Secondary procedures for indications with a low frequency included skin necrosis ($n = 3$), hematoma ($n = 3$), seroma ($n = 1$), and lipodystrophy ($n = 2$).

Conclusions: The incidence of secondary procedures of the abdominal wall following microvascular breast reconstruction using abdominal flaps approximates 20 percent, with an equal distribution between necessary and elective procedures. Women considering breast reconstruction using a free TRAM or DIEP flap should be advised of these statistics. (*Plast. Reconstr. Surg.* 120: 365, 2007.)

With the introduction of muscle-sparing flaps for breast reconstruction, donor-site morbidity has declined.[1,2] This is especially true of the abdominal donor site, where preservation of the rectus abdominis muscle and the anterior rectus sheath has maintained the ability of many women to perform their activities of daily living.[3,4] This has been accomplished by maintaining the continuity, innervation, and vascularity of the rectus abdominis muscle and minimizing the extent to which the anterior rectus sheath is violated. Previous studies have demonstrated that these muscle-sparing flaps will have a minimal impact on the functional and supportive elements of the anterior abdominal wall.[1,5–7] However, this alone does not always translate into total patient satisfaction with the appearance of the abdomen because other abnormalities may occur.

The most recognized morbidities following breast reconstruction with abdominal flaps are weakness and abnormal contour.[4–9] However, there are several other patient concerns related to the abdominal donor site that might be brought to the attention of the plastic surgeon. These can be diagnosed in the immediate post-

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operative period and include hematoma, delayed healing, and tissue necrosis, or in the later postoperative period and include seroma, chronic pain, abnormal contour, and complex scar.[10–12] All of these conditions will most likely require a secondary operation. Some will be necessary and others will be elective.

The purpose of this study was to review a single surgeon's experience with major and minor morbidities of the anterior abdominal wall following microvascular breast reconstruction with the free transverse rectus abdominis musculocutaneous (TRAM) and deep inferior epigastric perforator (DIEP) flaps and to review the secondary operations to correct these morbidities. The goal of this study was to determine the incidence of these procedures, identify women who are at risk, and provide recommendations for prevention.

PATIENTS AND METHODS

Over a 7-year consecutive time frame, 330 women had microvascular breast reconstruction with a free TRAM or DIEP flap. This included 162 women who had a free TRAM flap and 168 women who had a DIEP flap. Of the women who had a free TRAM, 123 procedures were unilateral and 39 were bilateral, for a total of 201 flaps. The type of free TRAM flap performed was MS-0 ($n = 34$), MS-1 ($n = 27$), and MS-2 ($n = 140$). The muscle-sparing classification for free TRAM and DIEP flaps has been described previously.[6] Of the women who had a DIEP flap, 120 were unilateral and 48 were bilateral, for a total of 216 flaps. The mean patient age was 48 years (range, 24 to 82 years) and the mean follow-up was 40 months (range, 3 to 84 months).

The factors that were evaluated included delayed healing, tissue necrosis, chronic pain, fluid collection, complex scar formation, lipodystrophy, and abnormal abdominal contour. To appreciate and standardize these morbidities, definitions are necessary. Delayed healing and tissue necrosis are often related and can include suture line dehiscence, focal ulceration, or full-thickness necrosis, which can involve the skin and subcutaneous fat of the anterior abdominal wall. Neuromatous pain can be secondary to injury to the ilioinguinal, iliohypogastric, intercostal, lateral femoral cutaneous, or genitofemoral nerves. Fluid collections can represent a seroma or hematoma. Complex scar refers primarily to the lateral abdominal dog-ear but might also include painful or irregular scars. Abnormal contour is defined as a bulge, a hernia, or lipodystrophy.

The technical and operative details of the free TRAM and DIEP flaps have been well described and will not be reviewed here.[13–16] However, salient aspects of these operations that are relevant to this study include flap design, degree of undermining, anterior sheath incision, and method of closure. It is important to recognize that the details described are my preferred routine and might not be practiced universally. The flap design was constant for all women in this study. The anterior superior iliac spine was marked bilaterally and represented the lateral apices of the abdominal incision (Fig. 1). The upper abdominal incision was placed just above the umbilicus to capture the periumbilical perforators. The upper adipocutaneous flap was undermined to the xiphoid process of the sternum and the inferior costal margin for both the free TRAM and the DIEP flaps. The anterior rectus sheath was incised in a linear fashion for the DIEP flap (Fig. 2) and in a "lollipop" shape for the free TRAM. The anterior rectus sheath was repaired by approximating the fascia of the external and internal oblique with a nonabsorbable suture in a figure-of-eight fashion, after which plication sutures were placed laterally, superiorly, or inferiorly as needed (Fig. 3). The repaired anterior rectus sheath was occasionally reinforced with a synthetic mesh. This was applied in an onlay fashion when the quality of the fascia was poor and when the patient was considered to be at increased risk for a bulge. This procedure was necessary in four women and was applied whenever small tears occurred in the anterior rectus sheath upon suture ligation. Two closed-suction drains were inserted and remained in place for 5 to 7 days or until the individual output was less than 30 cc per 24 hours (Fig. 4). The adipocutaneous layer was closed in three layers that included Scarpa's fascia, dermis, and skin. The abdominal closure was performed either by the principal surgeon (M.Y.N.) or by the assisting resident under close supervision. Postoperatively, all women remained in a partially flexed position for 3 to 5 days to minimize tension on the abdominal closure.

Secondary procedures were performed immediately after diagnosis in the event of a hematoma, at 3 months for a bulge or lateral dog-ear scar, and after 6 months for abdominal wall neuroma. Delayed healing and seroma were managed when deemed appropriate by the surgeon. The correction of a bulge in all patients included plication of the anterior rectus sheath followed by an onlay Marlex mesh. The specific technique was determined according to the size of the bulge. For the large bulge (>12 cm in width), the Marlex mesh

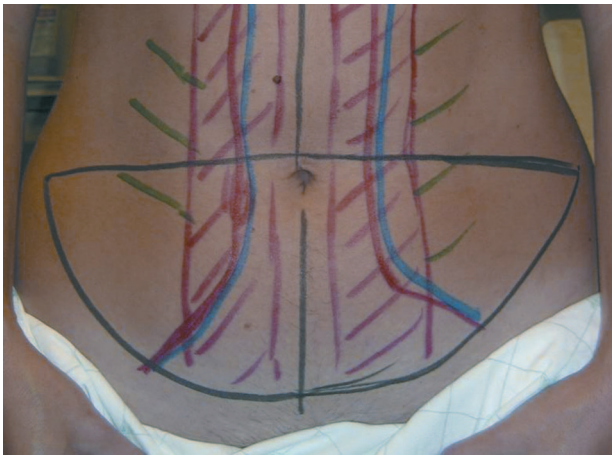

Fig. 1. Preoperative photograph of the flap outline. The patient is marked in the standing position. The lateral apices are positioned at the anterior superior iliac spine. The inferior extent of the flap is delineated but not determined until the patient is positioned on the operating table.

Fig. 2. The anterior sheath is incised in a linear fashion with the DIEP flap.

Fig. 3. The anterior rectus sheath is closed primarily following bilateral DIEP flap harvest. Plication sutures are used as needed to improve the abdominal contour.

Fig. 4. Two closed-suction drains are inserted and extended superiorly.

extended from the costal margin to the pubic bone and laterally toward the anterior axillary line. Nonabsorbable sutures were placed in an interrupted fashion with extensive quilting. For the small bulge (<12 cm), the Marlex mesh was applied over the fascia to a limited extent after plication.

RESULTS

Secondary Abdominal Operations

Secondary abdominal operations were performed in 59 women (17.9 percent). In 5 women, more than one indication was present, for a total of 64 operations. Table 1 lists the abdominal morbidities for each flap category. The operations were considered necessary in 29 women (8.8 percent) and elective in 30 (9.1 percent). The number of indications was similar for the free TRAM and DIEP groups (33 and 31, respectively); however, the distribution varied.

Lower Abdominal Bulge

Lower abdominal bulge was the most common necessary indication and was repaired in 9.3 percent of free TRAM flaps and in 4.7 percent of DIEP flaps (Fig. 5). The relative rate of occurrence was 6.5 percent for the unilateral free TRAM, 17.9 percent for the bilateral free TRAM, 4.2 percent for the unilateral DIEP, and 6.3 percent for the bilateral DIEP. All bulges were secondary to attenuation of the anterior rectus sheath except for one true hernia resulting from a unilateral free

Table 1. Abdominal Morbidities for Each Flap Category

Group	No. of Patients	Scar	Bulge	Hematoma	Seroma	Neuroma	Wound	Lipodystrophy	Total
UFT	123	9	8	0	0	2	1	0	20
BFT	39	4	7	0	1	0	0	1	13
UD	120	11	5	1	0	1	2	1	21
BD	48	5	3	2	0	0	0	0	10
Total	330	29	23	3	1	3	3	2	64

UFT, unilateral free TRAM; BFT, bilateral free TRAM; UD, unilateral DIEP; BD, bilateral DIEP.

TRAM. In three women who had a small bulge (<12 cm) that was repaired using mesh in a limited fashion, a recurrent bulge was noted. In these cases, another repair was completed by applying the mesh over the entire anterior abdominal wall as described.

Neuroma

Neuroma formation involving the anterior abdominal wall was diagnosed and treated in three women. The involved nerves included the ilioinguinal, iliohypogastric, and lateral femoral cutaneous. Presenting symptoms included localized pain, exacerbation with stretch, and lateral thigh dysthesia. One woman experienced injury to the ilioinguinal and iliohypogastric nerves and entrapment of the lateral femoral cutaneous nerve. The other two women had injury to the ilioinguinal and iliohypogastric nerves, respectively. All women were referred to a specialist and managed operatively by resection of the neuroma and burial of the proximal nerve segment into the rectus abdominis muscle. This resulted in complete resolution of pain in all cases.

Delayed Healing

Delayed incisional healing with associated necrosis of the distal anterior abdominal wall occurred in three women. All required a secondary operation to correct. No woman had extensive necrosis of the anterior abdominal wall. The causes were tobacco use in the first woman, a right upper quadrant scar in the second (Fig. 6), and fat necrosis in the third (Fig. 7). All healed without incident after excision and secondary closure after the wounds had clearly demarcated.

Complex Scar

Revision of complex scar was the most common elective indication and included dog-ear scars of the lateral abdomen (Fig. 8). These scars occurred in women who were overweight or obese. The scars were revised in 29 of 330 women (8.8 percent). The relative frequency was 7.3 percent for the unilateral free TRAM, 10.3 percent for the bilateral free TRAM, 9.2 percent for the unilateral DIEP, and 10.4 percent for the bilateral DIEP. Secondary procedures for hematoma, seroma, and lipodystrophy were rare in this series.

DISCUSSION

The advantages of using the abdomen as the donor site for autologous breast reconstruction are numerous and include improvement in contour and maintenance of function. With the muscle-sparing free TRAM and the DIEP flap, little to no rectus abdominis muscle is removed, thus allowing for most women to continue with their activities of daily living with minimal interruption. With the use of aesthetic surgery techniques, the postoperative abdomen usually has the same appearance as that of an abdominoplasty.[17] Morbidity is generally low and women are usually very

Fig. 5. A postoperative photograph of a large abdominal bulge following a bilateral free TRAM flap.

satisfied with the functional and aesthetic outcomes of the anterior abdominal wall. Despite the low donor-site morbidity associated with these flaps, secondary operations continue to be performed to correct a complication or to improve the aesthetic outcome. The indications for these operations are varied and are included in Table 1. Table 2 lists potential risk factors and some preventative measures to assist in the identification of women at risk for these morbidities.

Fig. 6. A postoperative photograph demonstrating delayed healing following a unilateral DIEP flap in a woman with a right upper quadrant scar.

Fig. 7. A postoperative photograph demonstrating abdominal fat necrosis and delayed healing following DIEP flap reconstruction.

Fig. 8. A postoperative photograph demonstrating a lateral dog-ear scar following DIEP flap reconstruction.

Complex Scar

The most common indication, as expected, was revision of the lateral dog-ear scar. Prevention of these scars is often unavoidable, especially in a patient with moderate to severe lipodystrophy. The adipocutaneous component in overweight and obese women often extends circumferentially toward the posterior abdominal wall, and avoidance of a dog-ear scar is usually not possible (Fig. 8). Fortunately, it can be corrected easily during a secondary operation by liposuction or by direct excision of the excess skin and fat. Although some women will inquire about circumferential excision of abdominal skin and fat, this is usually not performed during the initial reconstruction but could be offered during the second stage.

Lower Abdominal Bulge

Although one would intuitively think that a bulge or hernia should not occur with a DIEP flap, its occurrence has forced us to consider the mechanism at work. On the basis of personal observation and analysis, attenuation of the anterior rectus sheath seems to be the principal cause.[4,9] Earlier studies have demonstrated that the occurrence of a bulge following a DIEP flap ranged from 0 to 2 percent.[8] However, with our long-term follow-up now approaching 6 years, the incidence has increased to 4.2 percent for the unilateral DIEP flap and 6.3 percent for the bilateral DIEP flap. Although the majority of these contour issues are minor, they have been brought to our attention because most women expected an absolutely flat abdomen. Although it has been our general practice to avoid using synthetic mesh to reinforce the anterior abdominal wall at the time of the initial

Table 2. Specific Morbidity, Risk Factors, and Potential Preventative Measures Associated with Secondary Abdominal Operations

Morbidity	Risk Factor	Prevention
Bulge	Previous facial incision, bilateral reconstruction	Facial plication, facial reinforcement
Neuroma	Neural suture or clip	Identify sensory nerve, bury in rectus abdominis muscle
Seroma	Facial skeletonization, loose areolar disruption	Preserve loose areolar layer, drains
Hematoma	Medications, hypertension, coagulopathy	Control medications and hypertension, drains
Delayed healing	Previous skin incisions, tobacco use, tension on suture line	Limited undermining, no tobacco, flexion
Dog-ear scar	Lipodystrophy	Flap design

closure, using Marlex mesh during the secondary repair of the bulge has been generally successful.

Fluid Collection

The occurrence of an abdominal seroma or hematoma has been reported as a common donor-site complication. Despite reports demonstrating an incidence ranging from 2 to 10 percent for seroma, only one woman developed a seroma in this series of 330 women.[2,18,19] Although the exact mechanism of seroma formation following this operation is poorly understood, it is my opinion that a contributing cause in some cases is disruption of the loose areolar tissue overlying the anterior rectus sheath (Fig. 9). This is a highly vascular layer that promotes adherence, primary scar formation, and healing of the sheath and the overlying adipocutaneous flap after closure. My technique for preserving this layer is to separate the anterior rectus sheath from the upper abdominal flap using a continuous or pulsed cautery device set on coagulation mode at low intensity.

Fig. 9. Intraoperative photograph demonstrating the abundant vascular plexus contained within the loose areolar tissue of the anterior rectus sheath.

The occurrence of a hematoma is multifactorial and can include the use of anticoagulants, herbal medicines, hypertension, and drain malfunction. It has been our practice to administer 3000 to 4000 units of intravenous heparin before division of the in situ vascular pedicle. Heparin is not used after anastomosis is complete. Hemostasis is obtained using electrocautery for small fascial perforators and hemoclips or sutures for larger fascial perforators. The use of all herbal medicines and aspirin is discontinued 10 days before the operation. Maintaining a normal blood pressure is critical, especially when the patient is awakening from anesthesia, and requires close cooperation with the anesthesiologist. Although the use of suction drains will generally not prevent a hematoma, it will assist in early identification and encourage a prompt return to the operating room.

Neuroma

An uncommon sequela after elevation of abdominal flaps is the painful neuroma. It is well recognized that several sensory nerves are susceptible to injury in this region, including the ilioinguinal, iliohypogastric, intercostal, genitofemoral, and lateral femoral cutaneous nerves.[14,20,21] Although the occurrence and management of a neuroma following abdominoplasty was reported in 1994,[22] the occurrence following a TRAM flap has been reported only recently.[12] The incidence of abdominal neuroma in this study was 0.9 percent. Neuroma formation of the ilioinguinal, lateral femoral cutaneous, and genitofemoral nerves can generally be prevented because the anatomic pathways of these nerves are generally constant and can be identified based on specific anatomic landmarks.[23,24] Visualization of these nerves can be difficult because they are thin, they traverse within

the subcutaneous tissue plane, and they are well camouflaged by fat. Neuroma formation of the iliohypogastric and intercostal nerves is difficult to prevent because these nerves often course with the perforating arteries and veins that pierce the anterior rectus sheath. Hemoclips are often used when transecting the nonessential neurovascular bundles. It has become my recent practice, on the basis of a recently published study, to identify the sensory nerve, divide it, and bury the proximal portion into the rectus abdominis muscle.[12]

Delayed Healing

With the evolution from the conventional TRAM to the DIEP flap, there has also been a dramatic reduction in the incidence of abdominal wall necrosis. This has resulted in part from less undermining of the anterior abdominal wall and, consequently, improved blood supply to the remaining tissue. Tobacco use and the presence of abdominal scars are also recognized as secondary causes of this complication and continue to be so with the muscle-sparing flaps such as the free TRAM and DIEP. Our current practice is to cease tobacco use 2 weeks before surgery. Previous abdominal incisions can also compromise the vascularity of the anterior abdominal wall; this is especially true for subcostal incisions such as the traditional cholecystectomy and chevron (Fig. 8). Although these are not absolute deterrents, care must be exercised to minimize the degree of undermining and maintain adequate blood supply to the anterior abdominal tissues.

CONCLUSIONS

Minor morbidities of the anterior abdominal wall following microvascular breast reconstruction using the free TRAM and DIEP flap do occur. The incidence of secondary procedures approximates 20 percent with an equal distribution between necessary and elective procedures. Lower abdominal bulge was the most significant indication, but abdominal scar revision was the most common. The incidence of these morbidities can be minimized by paying close attention to the anatomic subtleties of the anterior abdominal wall. On the basis of this study's results, women considering breast reconstruction using a free TRAM or DIEP flap should be advised of these values.

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DISCLOSURE

The author has no financial interests to disclose.

REFERENCES

1. Arnez, Z. M., Khan, U., Pogorelec, D., and Planinsek, F. Rational selection of flaps from the abdomen in breast reconstruction to reduce donor site morbidity. *Br. J. Plast. Surg.* 52: 351, 1999.
2. Gill, P. S., Hunt, J. P., Guerra, A. B., et al. A 10-year retrospective review of 758 DIEP flaps for breast reconstruction. *Plast. Reconstr. Surg.* 113: 1153, 2004.
3. Nahabedian, M. Y., and Manson, P. N. Contour abnormalities of the abdomen following TRAM flap breast reconstruction: A multifactorial analysis *Plast. Reconstr. Surg.* 109: 81, 2002.
4. Nahabedian, M. Y., Dooley, W., Singh, N., and Manson, P. N. Contour abnormalities of the abdomen following breast reconstruction with abdominal flaps: The role of muscle preservation. *Plast. Reconstr. Surg.* 109: 91, 2002.
5. Nahabedian, M. Y., Momen, B., and Tsangaris, T. Breast reconstruction with the muscle sparing (MS-2) free TRAM and the DIEP flap: Is there a difference? *Plast. Reconstr. Surg.* 115: 436, 2005.
6. Blondeel, P. N., Vamderstraeten, G. G., Monstrey, S. J., et al. The donor site morbidity of free DIEP flaps and free TRAM flaps for breast reconstruction. *Br. J. Plast. Surg.* 50: 322, 1997.
7. Futter, C. M., Webster, M. H. C., Hagen, S., and Mitchell, S. L. A retrospective comparison of abdominal muscle strength following breast reconstruction with a free TRAM or DIEP flap. *Br. J. Plast. Surg.* 53: 578, 2000.
8. Nahabedian, M. Y., Momen, B., Galdino, G., and Manson, P. N. Breast reconstruction with the free TRAM or DIEP flap: Patient selection, choice of flap, and outcome. *Plast. Reconstr. Surg.* 110: 466, 2002.
9. Nahabedian, M. Y., and Momen, B. Lower abdominal bulge after DIEP flap breast reconstruction. *Ann. Plast. Surg.* 54: 124, 2005.
10. Reece, G. P., and Kroll, S. S. Abdominal wall complications: Prevention and treatment. *Clin. Plast. Surg.* 25: 235, 1998.
11. Kroll, S. S. Necrosis of abdominoplasty and other secondary flaps after TRAM flap breast reconstruction. *Plast. Reconstr. Surg.* 94: 637, 1994.
12. Rosson, G. D., and Dellon, A. L. Abdominal wall neuroma pain after breast reconstruction with a transverse abdominal musculocutaneous flap. *Ann. Plast. Surg.* 55: 330, 2005.
13. Allen, R. J., and Treece, P. Deep inferior epigastric perforator flap for breast reconstruction. *Ann. Plast. Surg.* 32: 32, 1994.
14. Blondeel, P. N., and Boeckx, W. D. Refinements in free flap breast reconstruction: The free bilateral deep inferior epigastric perforator flap anastomosed to the internal mammary artery. *Br. J. Plast. Surg.* 47: 495, 1994.
15. Grotting, J. C. Immediate breast reconstruction using the free TRAM flap. *Clin. Plast. Surg.* 21: 207, 1994.
16. Schustermann, M. A., Kroll, S. S., and Weldon, M. E. Immediate breast reconstruction: Why the free TRAM over the conventional TRAM flap. *Plast. Reconstr. Surg.* 90: 255, 1992.
17. Munhoz, A. M., Sturtz, G., Montag, E., et al. Clinical outcome of abdominal wall after DIEP flap harvesting and immediate application of abdominoplasty technique. *Plast. Reconstr. Surg.* 116: 1881, 2005.
18. Chang, D. W., Reece, G. P., Wang, B., et al. Effect of smoking on complications on patients undergoing free

TRAM flap breast reconstruction. *Plast. Reconstr. Surg.* 105: 2374, 2000.
19. Garvey, P. B., Buchel, E. W., Polkaj, B. A., Gray, R. J., and Samson, T. D. The deep inferior epigastric perforator flap for breast reconstruction in overweight and obese patients. *Plast. Reconstr. Surg.* 115: 447, 2005.
20. Nahabedian, M. Y., and Dellon, A. L. Outcome of the operative management of nerve injuries in the ilioinguinal region. *J. Am. Coll. Surg.* 184: 265, 1998.
21. Nahabedian, M. Y., and Dellon, A. L. Meralgica paresthetica: Etiology, diagnosis, and outcome of surgical decompression. *Ann. Plast. Surg.* 35: 590, 1995.
22. Liszka, T. G., Dellon, A. L., and Manson, P. N. Iliohypogastric nerve entrapment following abdominoplasty. *Plast. Reconstr. Surg.* 93: 181, 1994.
23. Mandelkow, H., and Loeweneck, H. The iliohypogastric and ilioinguinal nerves: Distribution in the abdominal wall, danger areas in surgical incisions in the inguinal and pubic regions and reflected visceral pain in their dermatomes. *Surg. Radiol. Anat.* 10: 145, 1988.
24. Rab, M., Ebmer, J., and Dellon, A. L. Anatomic variability of the ilioinguinal and genitofemoral nerve: Implications for the treatment of groin pain. *Plast. Reconstr. Surg.* 108: 1618, 2001.