The 3-Hour Muscle-Sparing Free TRAM Flap: Safe and Effective Treatment Review of 111 Consecutive Free TRAM Flaps in a Private Practice Setting

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VIDEO+

Background: The muscle-sparing free transverse rectus abdominis muscle (TRAM) flap is a reliable technique that provides great versatility, with potentially decreased donor-site morbidity. However, because of the inherent nature of microvascular techniques, it is still regarded as a time-consuming and technically difficult procedure. The goal of this retrospective study was to document the validity of this technique in the private practice setting.
Methods: Data were reviewed retrospectively and included patient demographics, total operative time, choice of recipient vessels, outcome, and perioperative morbidities.
Results: One hundred one consecutive patients underwent 111 muscle-sparing free TRAM flap procedures for breast reconstruction (immediate, 89 patients; delayed, 12 patients).The internal mammary artery was used in 75 cases and the thoracodorsal artery was used in 36 cases. Average operative time was 185 minutes (3 hours 5 minutes). Average blood loss was 195 cc. There was no total flap loss. Revision of the microvascular anastomosis was performed in four patients, with flap salvage in all of them. Thirteen patients (13 percent) required primary mesh for abdominal wall closure. Fourteen (14 percent) had fat necrosis. Two patients had hematoma that required surgical evacuation. Abdominal wall weakness was detected in two patients (2 percent) and required mesh repair.
Conclusions: The technical difficulties associated with the free TRAM flap have been ameliorated using a well-designed surgical plan and consistent technique performed by a team familiar with the procedure to achieve an acceptable average 3-hour operating time, with minimal complications. The authors advocate the muscle-sparing free TRAM flap as the operation of choice for unilateral breast reconstruction using autogenous tissue. The technique is expeditious and relatively safe. (*Plast. Reconstr. Surg.* 120: 27, 2007.)

The abdominal wall continues to be the leading site for autogenous tissue breast reconstruction. Since being introduced by Carl Hartrampf in 1981, the transverse lower abdominal flap remains the primary choice among reconstructive surgeons.[1] This tissue has long been understood as tissue that can be transferred using a variety of means. These methods include the pedicled transfer based on the superior aspect of the rectus abdominis muscle and the microvascular transfer on either the superficial or the deep inferior epigastric system. The superficial system, while avoiding any muscle harvest, does have the negative aspect of having vessels that are inconsistent in size and location. Thus, most microsurgeons have depended on the deep inferior epigastric system for microvascular transfer of the transverse abdominal tissue.[2–6]

The deep system can be used in one of two ways. First, the use of the muscle-sparing free transverse rectus abdominis muscle (TRAM) technique wherein the central portion of the lower rectus abdominis muscle is harvested as a conduit for a number of perforators from the

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inferior epigastric system through the overlying transverse tissue. The other method is to isolate a single perforator by splitting the rectus abdominis muscle and having the deep inferior epigastric system supply the overlying abdominal tissue directly through the perforator without any muscle harvest. Discussions, and even arguments, remain between proponents of each technique. When multiple options are available and successful, each undoubtedly works and will be successful in the hands of a practitioner who is familiar with and experienced in the performance of each technique. Although it is true that many options are available for perfusion of the lower transverse abdominal tissue, the muscle-sparing free TRAM flap appears to have the most salutatory benefits, while sharing few, if any, of the disadvantages.

This article presents 100 consecutive patients with 111 free flaps using the muscle-sparing free TRAM flap technique. This series represents a random choice—in terms of when the series started and when it stopped—of the practitioner's practice during the years 2002 through 2004. The decision as to when the series began was made by the second author. This experience is in a practice of a surgeon who has 12 years' experience in free TRAM transfer before this particular series.

After canvassing reconstructive breast surgeons over the past several years, it does not appear that microsurgical breast reconstruction is growing significantly. Although the causes for this trend are multifactorial, some of the leading factors are the time it takes to perform the procedures, the possible severe complications associated with microsurgical tissue transfer, and the decreasing interest on the part of those reimbursing for these complex techniques.

In view of the above, it would seem that, to the benefit of the patients, more microsurgical breast reconstruction would be performed if surgeons had a more time-efficient, safer technique with fewer complications. The technique presented in this article is straightforward and predictable. The vessels used for the microsurgical anastomosis are large and constant. The perfusion of the TRAM flap is arguably the best available, thus increasing flow to the TRAM flap to its maximum and reducing the incidence of subsequent fat necrosis. The abdominal wall, although violated by harvesting a small piece of muscle, is easily closed directly, rarely requires overlay mesh support, and is uncommonly associated with postoperative abdominal wall weakness. A detailed presentation of the technique will be presented, along with an accompanying E-video to demonstrate the technical refinements of the procedure. For the purposes of this article, all references to free TRAM flap are specifically referring to a muscle-sparing free TRAM flap unless otherwise specified.

PATIENTS AND METHODS

The data were reviewed retrospectively and included patient demographics, operative time, choice of recipient vessel, contralateral breast, outcome, and perioperative morbidities. All data were collected from the anesthesia sheet, the nurse's operative sheet, and the surgical notes. All procedures were performed by the senior author (L. F. E.) with the presence of a surgical assistant and, occasionally, a fellow.

Surgical Technique

The internal mammary vessels are currently preferred for a variety of reasons. First, their medial location on the anterior chest wall facilitates subsequent breast shaping and avoids distribution of any of the TRAM tissue into the axilla. Second, the vessels are reliable and, in most cases, undissected and unscarred. Third, the vessels are large, with excellent blood flow. Finally, because fewer axillary dissections are being performed, the thoracodorsal vessels are less often fully exposed after the general surgical procedure.

The main drawbacks to the use of the internal mammary vessels are that one must resect a rib to expose an adequate length of the internal mammary vessels and that the internal mammary vein is slightly more thin-walled than the thoracodorsal vein. The thinness of the wall makes its handling slightly more problematic than the thoracodorsal vessels, but with experience this becomes less and less a factor.

A third or fourth rib is chosen. Deep to the perichondrium, internal mammary vessels are dissected for a 1.0- to 1.5-cm length. Dissection of these vessels is facilitated by the use of the microbipolar instrument.

It does not appear to matter which pedicle is chosen—ipsilateral or contralateral—for the muscle-sparing free TRAM flap. Using electrocautery *on the coagulation setting only*, an incision is made through the rectus muscle laterally from the level of the umbilicus to two-thirds of the way between the umbilicus and the pubis. The inferior epigastric vessels are consistently located deep to the rectus abdominis muscle.

The incision can now be made medially through the anterior rectus sheath and underlying rectus muscle elevating the flap in the caudal direction. Electrocautery on the coagulation setting is used for the division of the muscle throughout and we assume we are incorporating eight to 12 musculocutaneous perforators in this central segment of rectus abdominis muscle that is harvested with the overlying skin and fat. Usually, only a 5- to 6-cm vascular pedicle is necessary for easy anastomosis to the internal mammary vessels. However, if the thoracodorsal vessels are going to be used, dissection to the origin of the inferior epigastric vessels is preferred, as this gives a greater length of more than 7 to 8 cm of the vascular pedicle. The approximate time taken for flap harvest is 30 to 45 minutes.

The venous anastomosis is performed first, using the coupling device. The use of the coupling device for the venous anastomosis is another time-saving tip. We have found that the anastomotic device reduces the time of the venous anastomosis from approximately 12 minutes to 3 minutes if one begins from a comparable starting point. The arterial anastomosis is sewn using standard microvascular technique, as the artery is too thick-walled for the coupling device.

The abdominal fascial closure is performed using a running double-stranded 0 nylon suture. We almost always add a contralateral plication of the anterior abdominal fascia to centralize the umbilicus and give balance to the abdominal wall closure. This closure is then reinforced with fascial staples bilaterally, which give further security to the abdominal wall closure.

Because the mastectomy specimen has been weighed and the TRAM itself has been weighed sterilely, we have excellent benchmarks for reducing the TRAM flap in size. Of course, the first areas of the TRAM to be removed are the portions contralateral to the pedicle. The flap is then placed into the chest pocket and the TRAM skin needed to complete the reconstruction is marked. The other skin is removed with the scissors technique and the flap is then carefully placed into the chest pocket and tacked medially and superiorly to the pectoralis major muscle. The lateral breast contour can be defined in one of two ways. The first is to tack the TRAM flap itself to the lateral chest wall and the second is to tack the lateral breast skin to the chest wall. If the inframammary line has been disrupted by the mastectomy, this should be reestablished internally to match the opposite side.

It seems that detection of flap perfusion problems occurred later in dark-skinned patients. In these patients, one of the modalities, color, is not available in most cases. For that reason, temperature strips are applied to the TRAM skin island and the native presternal skin to aid postoperative monitoring in the pigmented patient (Fig. 1). Patients are generally discharged to home 2 to 4 days after surgery.

Fig. 1. Temperature strip technique for monitoring dark-skinned patients.

RESULTS

One hundred one patients underwent 111 free TRAM flap procedures for breast reconstruction (immediate, 89 patients; delayed, 12 patients) (Figs. 2 and 3). The internal mammary artery was used in 75 cases and the thoracodorsal artery was used in 36 cases. Ten patients had bilateral reconstruction. Average operative time was 185 minutes for unilateral cases (range, 170 to 220 minutes).

Blood loss is minimal and transfusions are infrequent using the technique described above. Average blood loss was 195 cc. Six patients received transfusions; four of these were patients who were taken back to the operating room on an emergency basis for exploration of the operative site. Otherwise, transfusions are extremely rare. Forty patients underwent contouring procedures (mastopexy, 28 patients; reduction, nine patients; augmentation, three patients) for the contralateral breast during the same procedure.

Three major risk factors were identified: smoking, obesity, and previous abdominal scars. Flap complications and abdominal wall morbidity were stratified against these factors. Thirteen patients (13 percent) were identified as active smokers, 27 patients as past smokers, and 60 patients as nonsmokers. There was an observed increased wound-healing time in smokers versus the nonsmoking

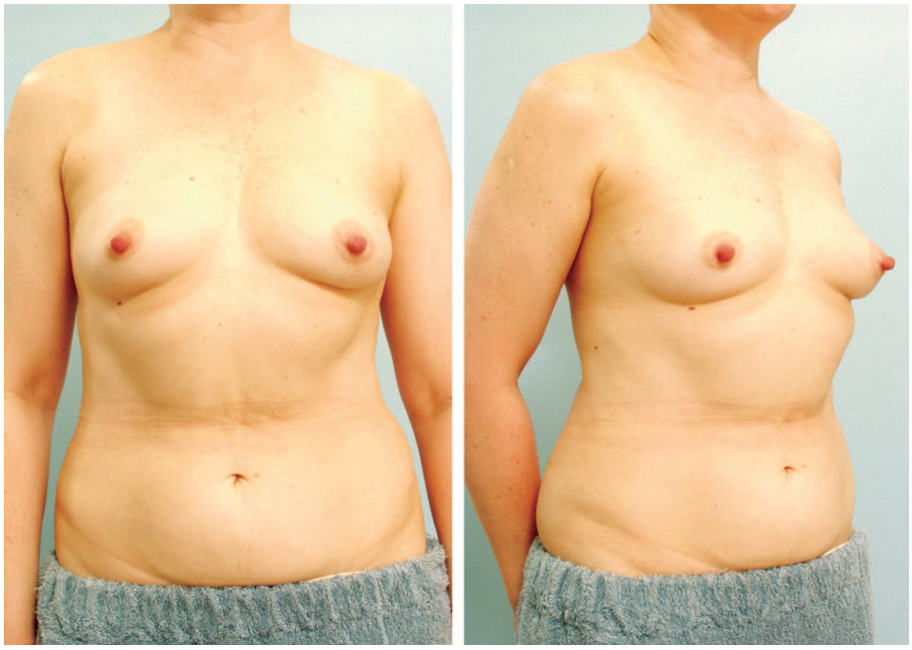

Fig. 2. Preoperative anteroposterior (*left*) and oblique (*right*) views.

group. However, this was not statistically significant because of the small sample size (Table 1).

Sixty-two patients had previous abdominal incisions versus 38 patients with no previous incisions. There was an observed increase in seroma occurrence and wound healing in the group with previous abdominal incisions (Table 2).

Fifty-five patients were identified with a body mass index greater than 25.There was an observed increase in flap fat necrosis and wound healing in this group of patients (Table 3).

Polypropylene mesh was used primarily in 13 patients (13 percent), who were judged intraoperatively to have significant abdominal weakness. Eighty-seven patients had primary closure of their fascia.

There was no total flap necrosis in this series. Fourteen patients suffered from fat necrosis that necessitated minor revisions. Fat necrosis was diagnosed as firmness in the flap postoperatively that did not resolve in 3 months. Fat necrosis in these patients was documented as being less than 15 percent of the flap in all cases except one. One patient had 40 percent fat necrosis. Four patients developed postoperative thrombosis of the vascular anastomosis and required revision; all flaps were salvaged. Two patients developed postoperative hernias that required mesh repair.

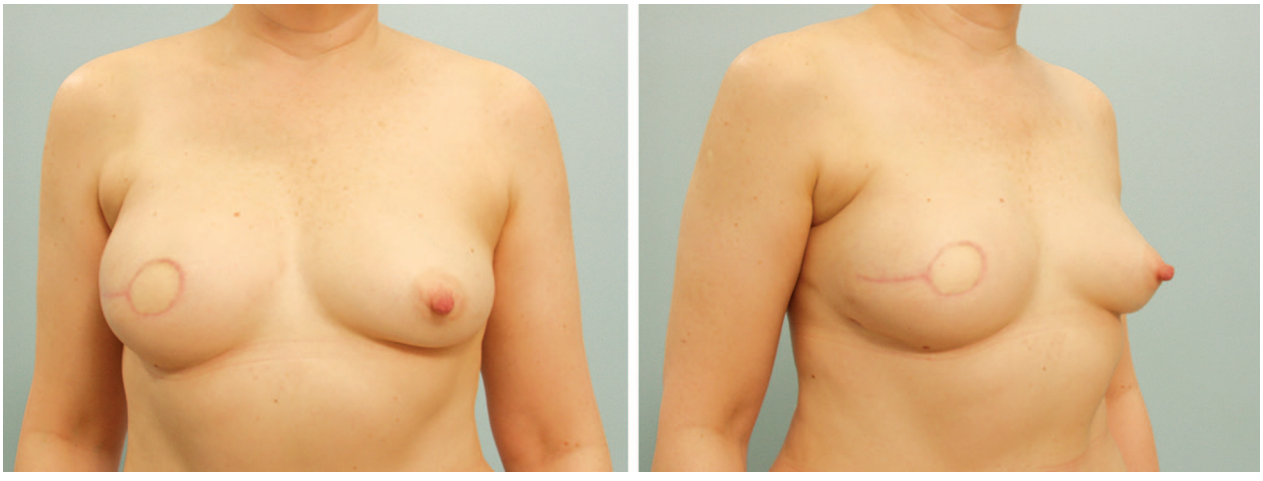

Fig. 3. Postoperative anteroposterior (*left*) and oblique (*right*) views.

Table 1. Stratification of Morbidity According to Smoking Status

	Smokers (n = 13)	Nonsmokers (n = 87)
Fat necrosis	4	10
Wound healing	5	10
Seroma	2	9
Hematoma	2	2
Polypropylene mesh	9	4
Bulge	0	2
None	5	52

Table 2. Stratification of Morbidity According to Presence of Abdominal Scars

	Abdominal Scars (n = 61)	No Scars (n = 39)	p
Fat necrosis	7	7	0.389
Wound healing	12	3	0.151
Seroma	8	3	0.521
Hematoma	3	1	1.000
Polypropylene mesh	6	7	0.361
Bulge	1	1	1.000
None	30	27	0.063

Table 3. Stratification of Morbidity According to Body Mass Index

	BMI ≤25 (n = 45)	BMI >25 (n = 55)	p
Fat necrosis	3	11	0.082
Wound healing	3	12	0.048
Seroma	5	6	1.000
Hematoma	3	1	0.324
Polypropylene mesh	6	7	1.000
Bulge	1	1	1.000
None	29	28	0.224

BMI, body mass index.

Fifteen patients had minor delayed abdominal wound healing and 10 patients had delayed breast wound healing. One patient developed postoperative deep venous thrombosis. There was no pulmonary embolism in this series; however, one patient was ruled out and found to have pulmonary edema from fluid overload. Sixty-two patients underwent nipple reconstruction and tattooing following breast reconstruction.

DISCUSSION

This patient study covers 101 consecutive free TRAM flap patients operated on by a single surgeon during the years 2001 through 2003. These operations were performed approximately 10 years after the surgeon began performing free TRAM flap procedures. Ten patients underwent bilateral reconstruction. We have not made a significant attempt to analyze or discuss bilateral free TRAM flaps because the numbers are small.

We routinely perform contralateral breast procedures, if indicated, at the time of initial immediate breast reconstruction with a free TRAM flap. This would include breast augmentation, mastopexy, or breast reduction, depending on the patient's needs and desires. It is our philosophy that one should achieve as close to the final goal on the initial operation, leaving as little as possible to be done for "fine tuning" at the time of nipple-areola reconstruction.

Although there was no incidence of flap loss in this consecutive series, four patients were returned to the operating room for exploration. One patient had a hematoma impinging on the flap and the anastomosis that did not require anastomotic revision, but only evacuation of the hematoma. Three other patients had vascular problems, two being arterial and one venous. Because the numbers were small, we could not find an association of take-backs with risk factors. The main point is to immediately perform exploration of patients about whom there is a question of a problem on observation of the TRAM flap.

Two patients developed postoperative abdominal bulges that required secondary repair. In both cases, Prolene mesh was used secondarily and alleviated the problem. Because patient numbers were small, we could not associate the occurrence of the abdominal wall bulge with particular risk factors. We have not observed a true abdominal wall hernia after TRAM flap harvest; instead, these entities are more accurately termed bulges and probably, in most cases, result from the retraction of the internal oblique component of the anterior rectus fascia, leaving only the external oblique component, which, by itself, does not have enough strength to secure the abdominal wall.

We are concerned about the internal oblique component on every TRAM/abdominal closure. If there is any question that there is too much tension on the closure, even in the case of a unilateral muscle- and fascia-sparing free TRAM flap, a double layer of Prolene mesh overlying the abdominal closure is added at the time of the first operation. We have not seen a bulge occur when polypropylene mesh is used primarily; however, the mesh was only used primarily in 13 percent of the patients.

Patients are generally not mobilized on the evening of surgery but certainly are the next morning. Lower extremity compression devices are used in every patient, beginning preoperatively and continuing postoperatively until mobilization. Nonetheless, there was one incidence of

deep vein thrombosis, although pulmonary embolus was never documented.

The incidence of fat necrosis was not increased statistically in any of the three at-risk groups—active smokers, patients with abdominal scars, and obese patients (body mass index >25). There was an increase in the incidence of fat necrosis in the obese patient versus the nonobese patient, but there was not an increase in fat necrosis in the smokers or the patients with abdominal scars. There was a single case of fat necrosis, which amounted to 50 percent of the TRAM flap. In every other case of fat necrosis, this amounted to less than 10 percent of the TRAM flap, and no additional tissue was required to complete a successful reconstruction.

The operative procedure described in this study is safe and expedient because of several pertinent and vital portions of the technique. One of the most important among these is the use of a single assistant. This is more important than the use of two teams.

Another significant technical advantage is the use of electrocautery alone for intramuscular dissection. Because there are a number of perforators in the muscle-sparing free TRAM flap, electrocautery on the coagulation setting can be safely used to cut through the muscle without injuring adjacent vessels or perforators and therefore reduces time of muscle harvest (please refer to the E-video). This method of electrocautery use is probably the most significant time-saving technique in the entire operation.

The pace and sequence of this operation are carefully planned to facilitate expediency, but also to ensure safety and reassessment during the entire procedure. On completion of revascularization, the TRAM flap is placed within the skin pocket on the chest and temporarily stabilized there. Repair of the abdominal wall is then completed and even closure of the abdominal skin and insetting the umbilicus is performed, leaving the revascularized TRAM flap on the chest wall undisturbed. This gives an interval of approximately 30 minutes, thereby giving the surgeon time to reassess the flap to confirm that there are no microvascular problems. Once abdominal wall closure is complete, the vessels are reinspected. If both anastomoses are doing well, the flap can then be deepithelialized, shaped, and inset as the operation is completed. This organization should minimize microvascular complications and take-back rates.

It has been said that if all aspects of the operation have been performed correctly, but the breast shaping is not successful, the patient will not be happy. Thus, the surgeon begins to shape the new breast in his or her mind at the time of the preoperative markings and during the elevation of the TRAM flap. Weighing of the resected specimen and of the elevated TRAM flap is also helpful in achieving the very best shape. We generally try to leave a slightly larger reconstruction than we ultimately want. Achieving this "slightly larger" reconstruction is facilitated if the exact weights are known.

The pedicled TRAM flap changed the breast reconstruction paradigm when introduced by Hartrampf in 1982.[1] The introduction of a reliable method of creating a new breast totally with the patient's own tissue elevated reconstructive plastic surgeons to a completely new level of achievement. For the following two decades, the pedicled TRAM flap continued to be widely used by reconstructive surgeons.[1,7–12] However, because of an observation of both flap and donor-site complications, and a sense that the blood flow was better through the inferior epigastric vessels than through the superior epigastric vessels, microsurgeons began to use the free TRAM flap instead of the pedicled TRAM flap. The free TRAM flap and the deep inferior epigastric perforator (DIEP) flap were introduced into the literature in 1989 and then later popularized as a means of minimizing the complications related to the abdominal wall and difficulties with decreased perfusion that were associated with the pedicled TRAM flap.[2–4] The pedicled TRAM flap was found to be simpler and easier to teach, though, than the free flap or DIEP flap. However, the perfusion of the pedicled TRAM flap was not as reliable as the surgeon often wanted and the muscle harvest was considerable. To obviate these problems, Hartrampf all along argued for a muscle-sparing technique in harvesting the pedicled TRAM, even though others advocated using the entire muscle to ensure profusion.

When the free TRAM flap was introduced, the same arguments ensued: that is, whether there should be a full width harvest of the rectus muscle or if this should be only a partial harvest of the rectus muscle with the vascular pedicle only. To most microsurgeons, the introduction of the DIEP flap ended the question of whether a full-width harvest of the rectus muscle was necessary in using the free TRAM flap technique. Although a system of classifying various skin-sparing techniques was introduced,[13–17] it rapidly became evident that the so-called MS-2 (muscle-sparing) free TRAM flap used the least amount of muscle and, most im-

portantly, fascia, but ensured the greatest degree of perforator inclusions in the flap. This is the technique presented in this particular article.

The muscle-sparing free TRAM flap is also the technique that should be most appropriately compared with results obtained using the DIEP flap. Unfortunately, in much of the literature concerning the DIEP flap, comparisons have been drawn between the MS-0 (full muscle harvest) free TRAM flap and the DIEP flap.[18–21] This comparison is unfortunate for two reasons: (1) this is not the usual free TRAM flap technique used by most microsurgeons and (2) it is the most radical of the free TRAM flap techniques in terms of muscle harvest. When comparing the muscle-sparing free TRAM (MS-2) versus the DIEP flap, results seem at least comparable when one compares abdominal wall results. There are occurrences of abdominal wall bulge, albeit small in number, with each technique.[14,18,22–24] However, it seems that profusion is better using the muscle-sparing free TRAM flap, as evidenced by the incidence of fat necrosis and by the diversion of DIEP flaps to muscle-sparing free TRAM flaps if adequate perforators are not found.

Our concept of the muscle-sparing free TRAM is a myocutaneous flap, with anywhere from eight to 12 perforators in the central one-half to one-third of the rectus muscle beginning at the umbilical level and extending caudad approximately two-thirds of the way to the pubis. It is not necessary to document these perforators specifically during the operation, as we know they are present from many previous injection studies, abdominoplasty procedures, and careful dissections of the abdominal wall during the performance of DIEP flaps. This is the reason the muscle-sparing free TRAM flap has better vascularity in general than the DIEP flap. There is no question that DIEP flaps work in a significant number of patients. However, even if one assumes that there is a single dominant perforator in a particular TRAM flap, recruitment of additional perforators in the area could not do anything but help overall profusion, both arterial and venous, of the overlying TRAM flap.

If vascularity is as good or better and the abdominal wall results are as good or better using the muscle-sparing free TRAM, then what other factor is important in making the decision as to which type of TRAM flap should be used? The answer is time. As demonstrated in this article and its accompanying video, the muscle-sparing free TRAM flap can be performed, without hurrying, in approximately 3 hours. This is a significant difference from any other reported DIEP flap series, and we believe this is a deciding factor for making the muscle-sparing free TRAM flap the procedure of choice for years to come.

In fact, microsurgical breast reconstruction, in general, has not seen a general increase in popularity among reconstructive surgeons, probably because of the complexity of the procedures, the time commitment necessary, low reimbursement, and the specter of total flap loss (generally not present with the use of the pedicled TRAM flap). These problems must be overcome for microsurgical breast reconstruction to penetrate more broadly into the plastic surgery community.

CONCLUSIONS

The muscle-sparing free TRAM flap is a safe and effective technique for breast reconstruction. The technical difficulties associated with the procedure have been ameliorated using a well-designed surgical plan and consistent technique performed by a team familiar with the procedure to achieve an acceptable average 3-hour operating time, with minimal complications.

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DISCLOSURE

None of the authors has a financial interest in any of the products, devices, or drugs mentioned in the article.

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