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ORIGINAL PAPER

Using pedicled TRAM flap in conjunction with the bony anchoring reinforcement system (BARS) for abdominal wall reconstruction

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Abstract
Background Pedicled transverse rectus abdominis myocutaneous (TRAM) breast reconstruction is associated with increased abdominal wall morbidity. We present a method of abdominal wall reconstruction using an adjunct technique to validated procedures of hernia repair.
Methods This study is a retrospective, single-surgeon analysis of 21 patients between 2005 and 2012. Patients had bony suture anchoring of synthetic polypropylene mesh to the anterior superior iliac spine bilaterally and the pubic symphysis after the abdominal fascia was reconstructed.
Results Patient mean follow-up was 62 months. Of the series, five patients underwent bilateral pedicled TRAM breast reconstruction. None of the 21 patients developed abdominal wall hernias. One patient developed postoperative bulging, which was retreated successfully. Two patients developed mesh infections; none required radical removal of mesh. There were no flap failures or loss in the series.
Conclusions The BARS technique for abdominal wall reconstruction provides excellent reinforcement of abdominal reconstruction in conjunction with pedicled TRAM breast reconstruction.
Level of Evidence: Level IV, therapeutic study.

Keywords TRAM · Mesh · Abdominal · Reconstruction

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Introduction

Autologous tissue breast reconstruction has been widely recognized as the standard to most closely approximate the tactile and aesthetic properties of the breast. In addition, autologous reconstruction offers the advantage of obviating a need for a prosthetic device in settings of potential prosthesis-related complications such as previously irradiated tissue field, prior prosthetic failure, or patient choice. With the advent of microsurgical tissue transfer techniques, autologous breast reconstruction has undergone an evolution from pedicled to perforator vessel-based flaps.

The initial description of the pedicled transverse rectus abdominis myocutaneous (TRAM) flap by Hartrampf [1] in 1982 paved the way for a reliable reconstruction with predictable results, resulting in its application as the most common method of autologous breast reconstruction in the USA. Reliability of the procedure stems from a well-described understanding of the blood supply and underlying anatomy. The flap blood supply is based on the deep superior epigastric vessels; given that this has been described as a secondary blood supply, increased rates of partial flap/skin loss and fat necrosis have been described in large flaps and in patients with history of smoking or obesity. Ligation of the dominant, deep inferior epigastric vessels prior to elevation of the flap and the resulting "delay" phenomenon with augmentation of blood flow through choke vessels have been described to improve the reliability of the superior epigastric blood supply to the flap [2].

On the basis of being a pedicled flap, there is obligate sacrifice of the rectus abdominis muscle for each pedicled TRAM-based reconstruction. As a consequence, abdominal wall morbidity including bulging [3] and hernia formation at rates of 2.6 % [4] has been described, with more significant morbidity associated with bilateral reconstructions with sacrifice of both recti [5]. Abdominal reconstruction with placement of prosthetic mesh repair has been described as the standard of care in these settings.

Combined with closure of the flap donor site, improvement in abdominal contour may be achieved.

With the application of microvascular techniques, the transfer of a "free" TRAM based on the dominant deep inferior epigastric pedicle was developed. As the pedicle is based on the dominant inflow vessels, the need for "delay" procedures is eliminated and overall reliability of the flap tissues is increased. Additionally, the freedom from a constraining pedicle afforded by microvascular anastomosis of the pedicle to recipient vessels on the thorax allowed the surgeon to better position the flap for optimal aesthetic effect. Although a subtotal length of the rectus muscle may be harvested with the flap, the full width of the muscle is taken, described by Nahabedian as MS0 [6], thus resulting in the similar issues of abdominal wall morbidity associated with the pedicled TRAM, with reported rates of bulges ranging to 7 % [6]. Furthermore, microsurgical anastomoses required for tissue transfer require specialized expertise, equipment, and instrumentation; microsurgery may also increase operative time and associated risks of complications. Unique to microsurgical anastomosis, blood flow to the flap is at risk for interruption as a consequence of technical imperfections or underlying patient conditions such as a hypercoagulable state. Finally, there has been debate as to the trade-off value of sacrificing the left internal mammary artery as a recipient for free flap breast reconstruction in balance with its potential use in any future cardiac bypass surgery if needed by the patient [7].

We report a technique which combines the reliability of the pedicled TRAM with a mesh-based abdominal wall reconstruction, the bony anchoring reinforcement system (BARS), which we have developed as a robust new paradigm for abdominal wall reconstruction; the combination of these two procedures permits autologous breast reconstruction without microsurgical expertise or instrumentation while addressing compromise to the abdominal wall, the primary driving force for evolution of breast reconstruction flaps. In our hands, the pedicled TRAM-BARS is reliable, comprehensively addresses abdominal bulging/hernias while decreasing operative time and length of inpatient stay.

Material and methods

This work presents a single-surgeon experience over 8 years between 2005 and 2012 in the form of a retrospective chart review. Briefly, abdominal exposure was afforded by TRAM flap harvest. Foley catheters were inserted in all patients to decompress the bladder, and the patients were placed in Trendelenburg position to better redistribute the abdominal contents. Closure of the abdominal fascia was achieved through mesh inlay or bridging mesh [16]. The fascial repair was reinforced by placement of a biologic mesh or polypropylene over the fascial incision line. Then, a second onlay polypropylene mesh was tailored and anchored to secure bone structures. No sutures were placed in or around the inguinal ligament to prevent injury to the ilioinguinal or genitofemoral nerves. Typically, seven bone anchors were used to secure the synthetic mesh, three at the pubic symphysis and two bone anchors to each anterior superior iliac spine (ASIS) bilaterally (Fig. 1). The superior aspect of the prosthetic mesh was sutured to the fascia avoiding any incorporation of the costal perichondrium. Quilting sutures were used to secure the mesh to the rest of the abdominal fascia (Fig. 1). Postoperative drains were used in all patients.

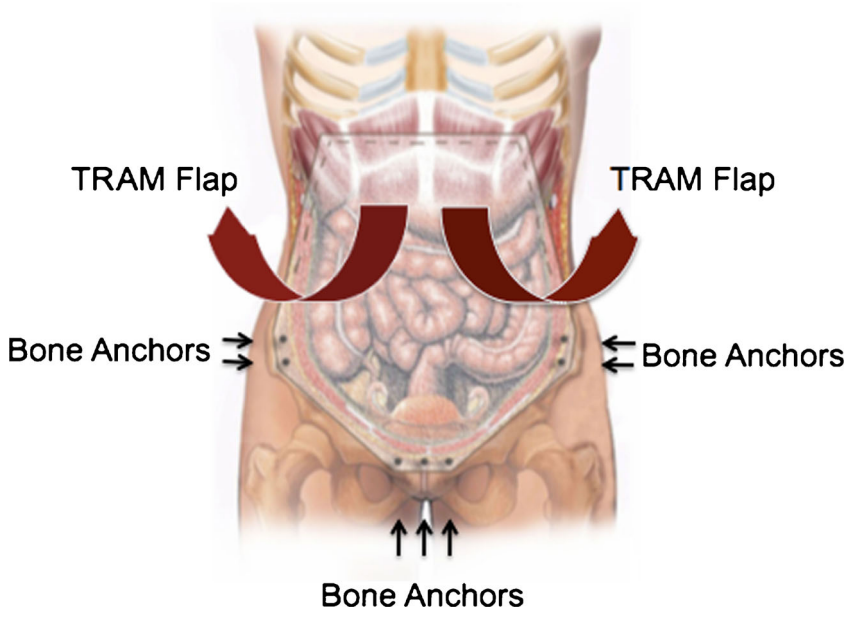

Fig. 1 Fixation points of mesh with bony anchoring reinforcement system (BARS) as indicated by *short black arrows*. The bilateral TRAM flaps are reflected cephalad to the chest as indicated by the *thick arrows*. Abdominal wall reconstruction is thus reinforced by BARS

Results

A total of 21 patients were included in this study. Demographic characteristics of the patients are shown in Table 1. Age of patients ranged from 36 to 61 years. BMI ranged from 18.8 to 38.2 with an average of 24.5. All patients underwent pedicled TRAM-BARS reconstruction. Unilateral reconstruction was performed in 16/21 and bilateral reconstruction was performed in 5/21 patients. Synthetic polypropylene (Marlex®; Bard Medical, Covington, GA) mesh was used in all 21 patients. Fascial imbrication was performed on 2/21 patients; the remaining 19/21 patients underwent mesh overlay without imbrication. Average operative time was 214 min ranging from 130 to 322 min. All patients were admitted postoperatively; surgical details are shown in Table 2.

Patients were followed up for a period of 96 months, with an average follow-up of 62.36 months. Postoperative complications included 1/21 patient reporting nerve pain which was treated successfully medically with Lyrica (Pfizer NY, NY, USA) with complete resolution. A single (1/21) patient developed a hematoma which was evacuated on postoperative day 1. Minor wound dehiscence was noted in 2/21 patients which resolved with standard local wound care. Postoperative wound infection developed in 1/21 patient which was treated with antibiotics. There were two mesh-related infections, but removal of a large section of mesh was not needed in any patient. Abdominal bulging was noted in 1/21 patient; subsequent hernia repair in this patient was successful. Of note, 20/21 patients, of which 5 were bilateral, underwent pedicled TRAM-BARS reconstruction without developing abdominal bulging or hernia. Further surgery was required in 4/21 patients. There were no instances of flap loss or take back. A summary of complications is provided in Table 3.

Table 2 Surgical details

Mesh used	Marlex in all cases (21)
Average operation time	3 h and 34 min
Simultaneous mastectomy	7
Bilateral	5
Unilateral	16
Delay of TRAM flap	15

Discussion

Autologous breast reconstruction has undergone evolution since Hartrampf's [1] 1982 description of the pedicled TRAM flap; much of this evolution has grown hand in hand with the development of microsurgical techniques and the pursuit of minimizing morbidity to the abdominal wall after TRAM flap harvest. Thus, variations of the pedicled TRAM such as the free TRAM, muscle-sparing TRAM (MS-TRAM), and deep inferior epigastric artery perforator (DIEP) were elaborated, each with diminishing amounts of sacrificed abdominus rectus, as a direct response to maintaining abdominal wall integrity as measured by reduction or elimination of abdominal wall bulging or hernia and preservation of truncal core strength.

The evolution of breast reconstruction flaps based on abdominal tissues naturally followed a path toward decreasing abdominal wall morbidity. Predictably, techniques were developed to minimize the amount of rectus muscle harvested with the flap, leading to the development of muscle-sparing free TRAM (MS-TRAM) flaps. Nahabedian further classified MS-TRAM flaps as MS1 with preservation of the lateral segment or MS2 with preservation of both lateral and medial segments [6]. In principle, the preservation of the abdominus rectus muscle should mitigate the abdominal morbidity otherwise seen in the pedicled TRAM and free TRAM to a level comparable to a complete sparing of the rectus muscle by the DIEP flap. However, this expected reduction in abdominal morbidity in MS-TRAM is not always observed [6, 8–10]. This may readily be explained by sacrifice of the intercostal nerve innervation of the abdominus rectus muscle during the course of the MS-TRAM flap harvest, resulting in muscle mass which is preserved in situ but is not otherwise functional.

The development of techniques focusing on harvesting of flaps based upon perforating vessels has broadly expanded the diversity of flaps available for reconstruction and led to the development of the DIEP flap, Nahabedian class MS3, in autologous breast reconstruction. Based upon at least a single perforating artery and vein from the deep inferior epigastric pedicle, the DIEP flap is developed as a skin and fat flap

Table 1 Patient demographics

Patients	21
Age	48.38±8.04
Height	65.83±2.88
Weight	150.90±20.06
BMI	24.46±3.66
Average follow-up	62.36 months

Table 3 Postoperative complications

Mesh infection	2
Hematoma	1
Wound dehiscence	2
Hernia occurrence	1
Further surgery	4
Mortality	0
Flap loss (partial or full)	0
Take back	0

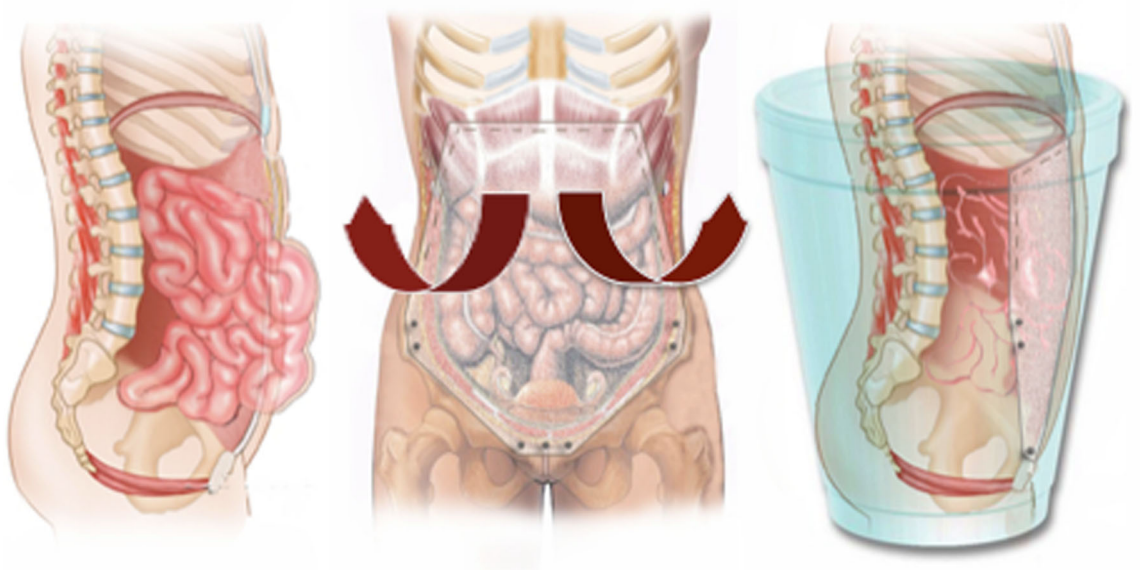

Fig. 2 Abdominal wall reconstruction with BARS. Abdominal wall insufficiency (*left panel*), after harvest of TRAM flaps and resultant absence of abdominal recti, is restored with BARS (*center*); *arrows* indicate reflection of TRAM flaps. Abdominal contents are redirected down into the pelvis as opposed to out in the lower abdomen (*right panel*)

whose pedicle is isolated from the abdominus rectus via careful intramuscular dissection [11]. By preservation of the rectus muscle and its innervation, the DIEP flap maintains the muscular integrity of the abdominal wall with reported decrease in the incidence of hernias and bulges to a range of 1–4 % [8, 12]. In addition, by sparing the rectus muscle, patients experience less pain than in free TRAM and have overall shorter hospital stay than patients undergoing free TRAM reconstructions [13]. Critiques of the DIEP reconstruction center around the potentially tedious intramuscular dissection of the vessels and potential risk of injury to the pedicle, need for microsurgical surgeon expertise and instrumentation, variation and unpredictability of perforator vessel anatomy, and ability of the vessel to perfuse the entirety of the flap [14]. There is also debate about the difference, if any, in abdominal wall morbidity between DIEP and MS-TRAM, which requires a less demanding dissection [9, 10, 15]. Chun and colleagues examined their series of 105 patients who underwent bilateral pedicled TRAM with 58 patients who had undergone DIEP flap reconstruction and found no

Fig. 3 Preoperative (*upper panel*: en face and lateral views) and postoperative (*lower panel*: en face and lateral views) images of a representative patient who had left unilateral pedicled TRAM breast reconstruction and right mastopexy for symmetry in addition to BARS abdominal reconstruction. Note improvement of abdominal contour postoperatively

significant differences in donor site morbidity, functional outcome, or patient satisfaction [16, 17].

Since 1982, techniques for abdominal wall reconstruction and hernia repair have also evolved significantly with the wide utilization of component separation [18], durable synthetic, and now biologic mesh material. These advances have permitted the reconstruction de novo of the abdominal wall which may have been extirpated by oncologic procedures, compromised by underlying patient disease, trauma, or surgery such as after multiple ostomy placements. Recent reports demonstrate a reduction in abdominal wall bulging and hernia after pedicled TRAM breast reconstruction after abdominal mesh placement [19]. Thus, with these materials and techniques in hand, the genesis of abdominal bulging and hernia in the setting of pedicled TRAM flap harvest may be neutralized.

We have described a novel paradigm utilizing rigid fixation of overlay mesh material in abdominal wall reconstruction, the bony anchoring reinforcement system (BARS) technique. By anchoring the mesh to the pubic symphysis and to the bilateral anterior superior iliac spines of the pelvis and by further redirection of abdominal contents into and toward the pelvis (Fig. 2), the BARS technique has proven to be a reliable, reproducible, and durable solution to abdominal wall reconstruction and hernia repair (Fig. 3). A case report presented the anchoring of reconstructive mesh to the iliac crest for flank incisional hernia repair [20], and a series of seven hernia patients who were repaired with a bone-anchored mesh technique cited the need for larger patient series; [21]. Indeed, we have carried out a larger survey of 63 patients (manuscript submitted) which extends this theme and encompasses many different modalities of hernia repair which are rendered more effective as a direct consequence of the BARS procedure in addition to its efficacy as an adjunct to pedicled TRAM reconstruction.

A criticism of MS-TRAM- and DIEP-based reconstructions has been the requirement of specialized microsurgical technique and instruments, prolonged operative time, intensive use of resources in the operating room, and in the frequent required postoperative monitoring of flap perfusion. Furthermore, it is unclear after the commitment of these resources that patient benefit is clearly demonstrable or measurable by objective means when patients undergoing reconstructions with MS-TRAM or DIEP are compared to patients who had undergone pedicled TRAM-based reconstructions. In addition to these objective measures, there is debate from a subjective patient satisfaction perspective as well.

The TRAM-BARS technique described here permits a wide range of plastic surgeons to apply the proven robustness of the pedicled TRAM flap to reconstruct an esthetically pleasing, natural breast without the resource constraints of microsurgery and reconstructing the abdominal donor site in a way that precludes the formation of postoperative abdominal wall bulging or hernia formation. Limitations of this study include its relatively small sample size and retrospective format. However, by addressing these key parameters of autologous breast reconstruction, we welcome a discussion of the clear merits of this technique.

Conflict of Interest None

Ethical standards The study has been approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. All persons gave their informed consent prior to their inclusion in the study.

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