

# Technique for Minimizing Donor-site Morbidity after Pedicled TRAM-Flap Breast Reconstruction: Outcomes by a Single Surgeon's Experience

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**Background:** Breast reconstruction with pedicled transverse rectus abdominis myocutaneous (TRAM) flap can result in significant abdominal wall donor-site morbidity. We present our technique of transversely dividing the anterior fascia and rectus abdominis combined with reinforcement above the arcuate line for closure of the anterior abdominal wall defect to prevent contour deformities performed by a single senior surgeon and compare these results with those of our prior series.

**Methods:** We described our new technique of closure of the abdominal wall defect and retrospectively performed the comparison between the results of pedicled TRAM flaps using the new closure technique and those of 420 pedicled TRAM flaps from our 2003 publication in terms of abdominal bulging and hernia.

**Results:** Sixty-seven pedicled TRAM flaps in 65 patients were compared with 420 pedicled TRAM flaps of the 2003 series. The new technique was associated with 5 partial TRAM flap necroses (8%). There was no total flap loss with the new technique. The median follow-up period was 13 months (range, 4–36 months). There were no instances of abdominal hernia and bulge during follow-up in the new series. Compared with the previous 2003 series, the new technique was superior in terms of occurrence of abdominal wall hernia or bulging.

**Conclusions:** We are still performing pedicled TRAM flap for autologous breast reconstruction. Using the technique of transversely dividing the anterior fascia and rectus abdominis combined with reinforcement above the arcuate line can reduce the occurrence of abdominal bulging and hernia. (*Plast Reconstr Surg Glob Open* 2015;3:e476; doi: 10.1097/GOX.0000000000000451; Published online 3 August 2015.)

The transverse rectus abdominis myocutaneous (TRAM) flap has been the gold standard in breast reconstruction for many years, but the donor-site morbidity remains a major concern when the rectus muscle is harvested. Common long-term abdominal contour abnormalities of the lower

abdomen after performing TRAM flap breast reconstruction include abdominal bulge, epigastric fullness, and hernia.<sup>1,2</sup> These complications can occur after various techniques for creating flaps, such as the pedicled TRAM, free TRAM, and the deep inferior epigastric perforator flaps, with an incidence ranging from 0% to 35%.<sup>3–8</sup> The wide range of incidence is most likely related to the differences in

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techniques of harvesting the flap and closure of the abdominal wall.

Management of the abdominal wall at the donor site of TRAM flap is thus a challenge. Several techniques have been described for the closure of the anterior abdominal wall defect, including the use of relaxing incisions, one- or two-layer fascial closure, preservation of the rectus muscle and anterior rectus sheath,<sup>1,9</sup> and the use of a synthetic mesh,<sup>10-12</sup> all designed to reduce morbidity at the donor site after harvesting the flap. Currently, there is no consensus on the best surgical technique for closure of the abdominal wall defect.<sup>2,13</sup>

We present a technique for the closure of the anterior abdominal wall to prevent abdominal bulging and hernia (contour deformities) by transversely dividing the anterior fascia and rectus abdominis at the arcuate line in combination with reinforcement sutures above this level. We compare the results of this procedure with the results of our last publication in 2003 before the introduction of this new technique.<sup>14</sup>

## PATIENTS AND METHODS

From September 2010 to January 2013, 65 patients who underwent 67 pedicled TRAM flap procedures for delayed breast reconstruction ( $n = 18$ ) or immediate breast reconstruction ( $n = 47$ ) were included in the present study. Patients' age, weight, height, body mass index, smoking history, and associated comorbidities (diabetes mellitus, hypertension, and dyslipidemia) were recorded as patient risk factors. Surgical factors, including previous abdominal surgery, mode of reconstruction, duration of operation, and outcomes of reconstruction, were also recorded. In our series, patients with previous radiotherapy or neoadjuvant chemotherapy were not included. Exclusion criteria included patients with a history of previous abdominoplasty, inadequate tissue in the lower abdomen, and substantial weight loss. Surgical outcomes focused on the incidence of abdominal hernia and bulging because these complications cause considerable discomfort to patients.

An hernia was defined as a protrusion of the abdominal wall with dehiscence of the fascial closure, and an abdominal bulge was any asymmetrical abdominal contour developing after the TRAM procedure but without an associated fascial defect.<sup>15,16</sup> All patients signed an informed consent for breast

reconstruction before the operation. All TRAM flap procedures were performed by one surgeon, and patients were clinically examined for the presence of abdominal bulge or hernia at 6, 12, and 18 months after reconstruction. We compared these results with the results of 420 pedicled TRAM flaps in a 2003 publication.<sup>14</sup>

## OPERATIVE TECHNIQUE

### Flap Elevation

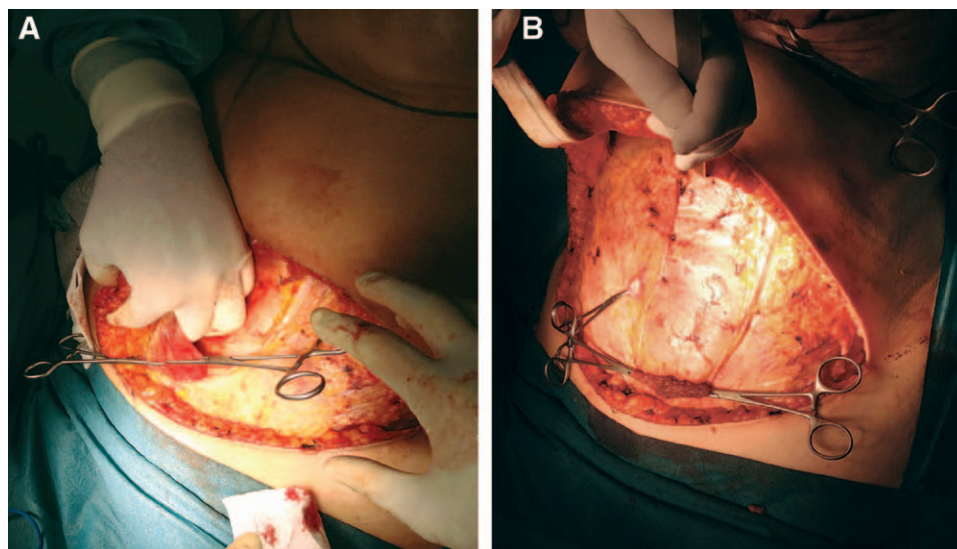
The TRAM flap is harvested through a standard elliptical incision at the lower abdomen. The abdominal flap is dissected in the direction from the lateral part to the medial part of the flap, identifying the arterial perforators along the way. The lateral border of the rectus muscle is always clearly identified. We routinely leave 2 cm of the lateral anterior rectus fascia on the pedicle side and leave 1 cm of the linea alba or the first perforator visualized. This will preserve the linea semilunaris and its fibrous part for mesh fixation during abdominal closure. Before harvesting the flap at distal cut edge of the rectus muscle, the location of the arcuate line is determined. We ensured that the lower border of the rectus muscle and fascia does not retract below this landmark by transversely clamping it with 2 Kocher clamps (Fig. 1), thereby demarcating the lower limit of the posterior layer of the rectus sheath. This lower point necessitates repair to insure abdominal strength. The anterior fascia and rectus abdominis are transversely divided at the arcuate line (Fig. 1). At this level, the inferior epigastric vessels can be visualized and doubly clipped. It is important to precisely identify the perforating vessels both below and above the umbilicus to preserve a part of anterior rectus fascia, which will facilitate suture of the abdominal defect with mesh.

In the previous 2003 series, we began cutting the distal edge of the rectus muscle by placing the fingers between the muscle and the inferior epigastric vessels below the arcuate line. The anterior fascia and muscle are then sharply incised the full width. The distal cut edge of the rectus muscle often retracted to below the arcuate line, making it difficult to suture the distal rectus end to the posterior sheath at the level of the arcuate line.

### Closure of the Abdominal Wall Defect

The anterior sheath fascial defect is closed by using polyester mesh. In most cases, the mesh is sutured to the medial remnant of the rectus sheath in layers, beginning with a continuous running suture. The lateral remnant of the rectus sheath is fixed to the mesh with 3 or 4 interrupted sutures at the edge

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**Fig. 1.** A, Determination of the location of the arcuate line and transversely clamping the lower border of the rectus muscle and fascia with 2 Kocher clamps. B, The anterior fascia and rectus abdominis have been transversely divided at the arcuate line.

of posterior layer, incorporating a part of an anterior layer of the rectus sheath. The extent of the mesh used to close the defect runs from the arcuate line up to the costal margin. The posterior rectus sheath, reinforced with mesh, is sutured to the cut edge of the rectus muscle and anterior fascial sheath, after taking off the Kocher clamps (Fig. 2), at the level of the arcuate line (Figs. 2, 3). A key point is that horizontal mattress sutures be used. Suturing the distal rectus end to the posterior sheath and mesh at this location without excessive tension is crucial.

The lateral part of the anterior rectus fascia is then sutured onto the mesh and posterior fascia with a running horizontal mattress suture followed by an over and over stitch (Fig. 3). This additional layer of fascia and row of sutures will improve the integrity of the abdominal wall, especially when the patient is awake during the recovery period. Another row of reinforcement sutures above the arcuate line, suturing the distal rectus and anterior sheath to the mesh and posterior fascia should also help in preventing abdominal contour abnormalities (Fig. 4). An interrupted vertical row of figure-of-eight sutures for plicating the contralateral anterior sheath fascia helps centralize the umbilicus (Fig. 4). To reduce tension of the abdominal skin closure, we fixed 3 stitches at umbilicus and anterior sheath to the dermis of the upper part of the abdominal skin before closing the lower abdomen.

In Figure 5, we diagrammatically compare the current technique of suturing the distal end of the rectus muscle and anterior sheath to the posterior fascia and mesh at the arcuate line with the previous (2003) technique of suturing the mesh to the distal rectus and sheath below the arcuate line.

### Statistical Analysis

Data analysis was performed using Stata version 12 (Stata Corp, College Station, Tex.). Quantitative data were summarized as mean and SD and/or range. Qualitative data were summarized as counts and percentage and tested for differences between independent groups using Fisher's exact test. A two-sided *P* value of 0.05 or less was considered statistically significant.

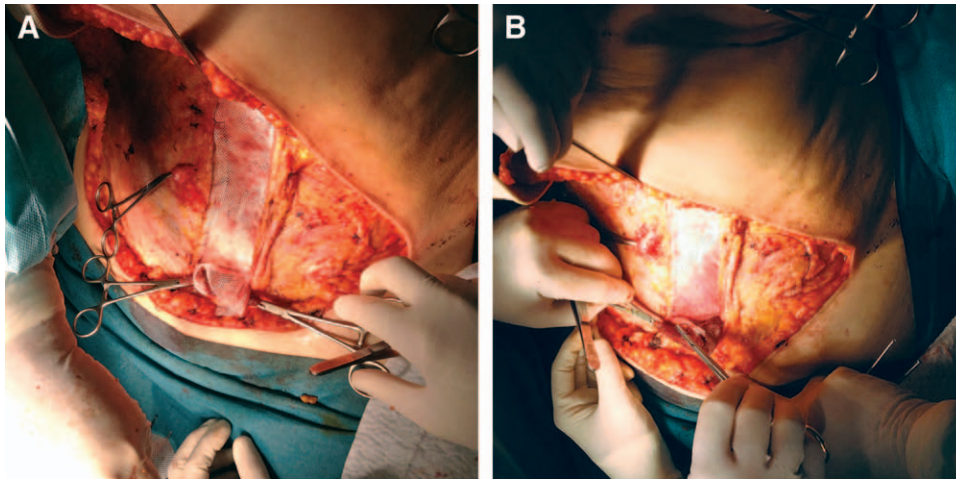
## RESULTS

As shown in Table 1, patients in the present series were only slightly older than those in the 2003 series. Although the data in 2003 seemed more variable, the mean weight and body mass index were similar for the 2 series. There were a higher, but nonsignificant, proportion of smokers in the 2003 series. More significant was the considerably higher proportion of pre-TRAM radiation therapy in the present series of patients.

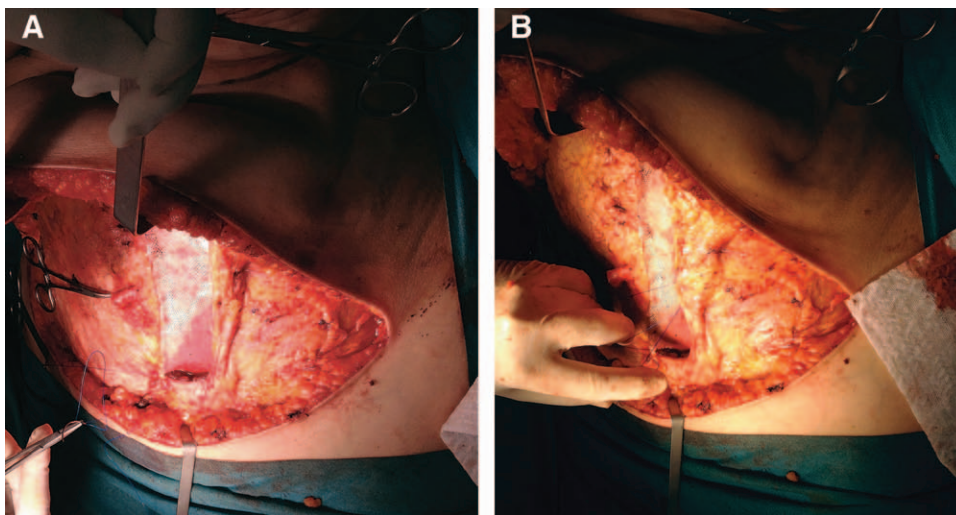
In the present series, 16 patients (25%) had prior abdominal surgery, which included a right lower quadrant incision in 8 patients, a right upper quadrant incision in 1 patient, and a Pfannenstiel incision in 7 patients. Compared with the series in 2003, there were significantly fewer bipedicled TRAMs, significantly more mesh placements, and more immediate reconstructions in the present series (all *P* value < 0.001; Table 1).

### Postoperative Complications

Proportions of postoperative complications and type of complications as well as incidences of donor-site complications after pedicled TRAM flap are shown in Table 2. There was a slightly higher, but



**Fig. 2.** A, Removal of the Kocher clamps at the distal rectus muscle remnant and anterior sheath. B, Suturing the anterior fascial sheath and rectus muscle to the posterior rectus sheath reinforced with mesh, at the level of the arcuate line.



**Fig. 3.** A, Completion of the first row of sutures at the arcuate line. B, The lateral anterior sheath is sutured to the mesh and posterior sheath.

nonsignificant, proportion of flap or donor-site necrosis in the 2003 series.

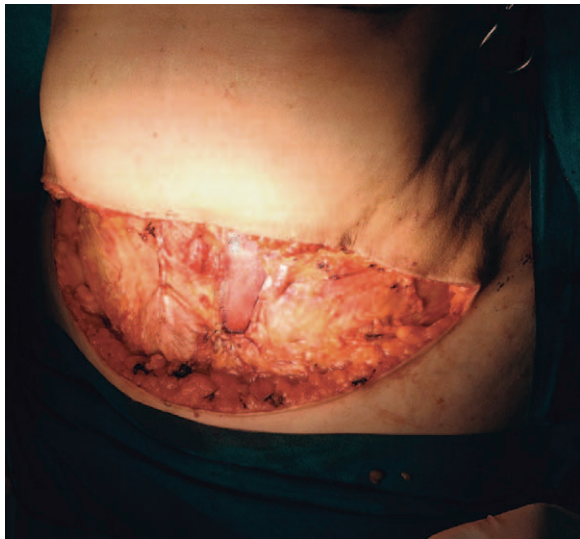
In the present series, abdominal wound necrosis, partial wound dehiscence, and partial flap necrosis were seen in 1 (2%), 1 (2%), and 5 cases (8%), respectively, and all cases required reoperation. There was no total flap loss with our new technique. No flap or abdominal wound infection was observed. Abdominal wall seroma occurred in 1 case (2%). We found fat necrosis in 2 flaps (3%).

No patient developed abdominal wall hernia or bulge in the present series, after a median follow-up time of 13 months (range, 4–36 months). The proportion of hernia occurrence was higher in the 2003 series, but this was not statistically significant. How-

ever, the proportion of bulging and umbilicus displacement was significantly higher in the 2003 series.

## DISCUSSION

There are several techniques for preventing late abdominal wall complications at the donor site of the pedicled TRAM flap. These techniques consist of 2 major steps. The first step is the harvesting of the flap. The second step is the closure of the anterior abdominal wall. Techniques for harvesting the flap by partial preservation of abdominal wall structures, such as muscle-sparing flap elevation or whole muscle with sheath sparing flap elevation, may reduce but do not eliminate the risk of abdominal contour abnormalities. Partial preservation of the rectus abdominis mus-



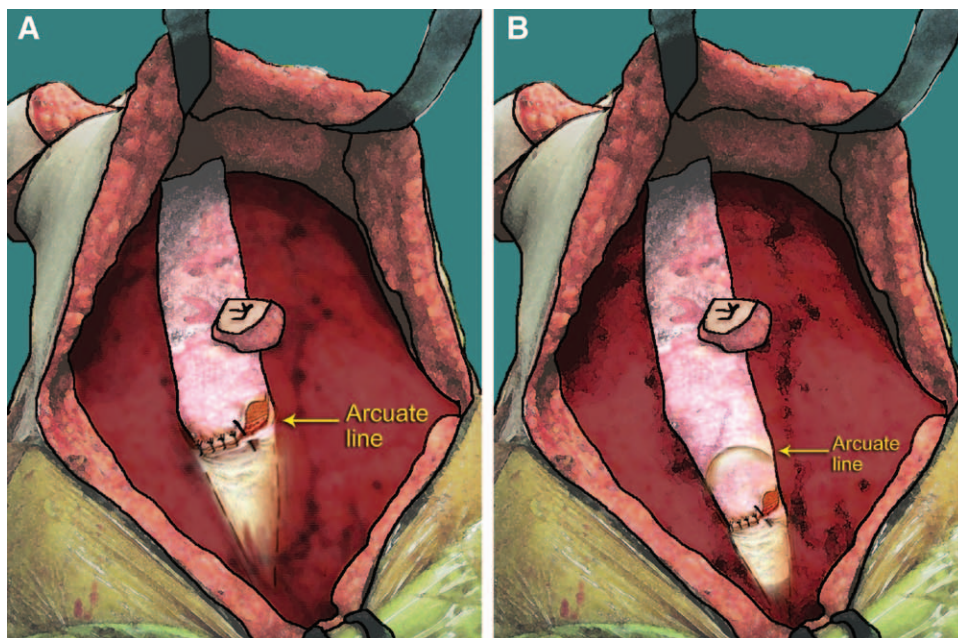
**Fig. 4.** Completed second row of sutures at and above the arcuate line, showing vertical plicating sutures at the contralateral anterior rectus sheath to help centralize the umbilicus.

cle and anterior rectus sheath may be associated with late atrophy and fatty degeneration of the muscle, which could result in a weakened abdominal wall.<sup>2</sup>

Nahabedian et al<sup>17</sup> reported that muscle-sparing TRAM flap surgery was associated with a significant reduction in abnormal abdominal contour in bilateral reconstructions when unilateral and bilateral pedicled TRAM, free TRAM, and deep inferior epigastric perforator flap reconstructions were com-

pared. Kroll et al<sup>2</sup> showed no differences in terms of abdominal strength, bulging, and hernia between pedicled and free TRAM flap reconstructions, but there was a difference in the patients' ability to sit up. No study, however, focused on the technique of cutting the distal edge of the rectus muscle during flap elevation to prevent abdominal contour complications. We presented our technique of transversely dividing the anterior fascia and rectus abdominis at the arcuate line because below this level the abdominal wall often needs repair.

Following the transfer of a pedicled TRAM flap, closure of the rectus sheath in 2 layers is essential to prevent abdominal wall complications. Several techniques have been described for the closure of the anterior abdominal, which could reduce morbidity at the donor site after harvesting the flap (Table 3). Despite this, several studies still recommend the use of mesh to improve aesthetic and functional outcome of the abdominal wall.<sup>2,18,19</sup> Several methods of primary repair of the anterior rectus sheath using a synthetic mesh have been reported, such as an overlay mesh or as an inlay graft with the edge of the mesh sutured to the edge of the fascial defects, or as an onlay graft that is positioned over the repaired anterior rectus sheath, or fascial repairing with an interposition synthetic mesh and imbrication of the contralateral sheath.<sup>18,20</sup> There is still a significant incidence of abdominal wall hernia and bulge among patients who had abdominal wall reconstruction with mesh.



**Fig. 5.** A, Diagram showing the current technique of suturing the distal rectus and anterior sheath to the posterior sheath and mesh at the arcuate line. B, Diagram showing the previous (2003) technique of suturing the distal rectus muscle and anterior sheath to the mesh below the arcuate line.

**Table 1. Comparison of Patient Risk Factors and Operative Characteristics**

Characteristics	TRAM in 2011–2013 (N = 65)	TRAM in 2003 (N = 420)	P
Age (y), mean (SD and/or range)	52.2 (8.0) (31–69)	48.0 (26–74)	NA
Weight (kg), mean (SD and/or range)	68.3 (11.1) (52–98)	65.3 (40–135)	NA
BMI (kg/m <sup>2</sup> ), mean (SD and/or range)	25.8 (3.8) (20.3–40.8)	24.8 (14.7–45.6)	NA
Comorbidity (DM, HT, dyslipidemia), n (%)	9 (14)	NR	NA
Smoker, n (%)	11 (17)	108 (26)	0.163
RT before TRAM flap surgery, n (%)	45 (69)	160 (38)	<0.001
RT after TRAM flap surgery, n (%)	8 (12)	NR	NA
Previous abdominal surgery, n (%)	16 (25)	NR	NA
Duration of operation (min), mean (SD)	255.2 (65.4)	NR	NA
Breast reconstruction			
Immediate, n (%)	47 (72)	170 (41)	<0.001
Delayed, n (%)	18 (28)	250 (59)	
TRAM			
Bipedicled, n (%)	2 (3)	149 (36)	<0.001
Monopedicled, n (%)	63 (97)	271 (64)	
Mesh, n (%)	65 (100)	345 (82)	<0.001

BMI, body mass index; DM, diabetes mellitus; HT, hypertension; NA, not applicable; NR, not reported; RT, radiation therapy.

**Table 2. Complications of TRAM Flap**

Complications of TRAM	TRAM in 2011–2013 (N = 65)	TRAM in 2003 (N = 420)	P
Immediate			
Necrosis (flap or abdomen), n (%)	6 (9)	52 (12)	0.544
Abdominal wound necrosis, n (%)	1 (2)	NR	NA
Abdominal wound dehiscence, n (%)	1 (2)	NR	NA
Partial flap necrosis, n (%)	5 (8)	NR	NA
Flap or abdominal wall infection, n (%)	0	8 (2)	0.605
Hematoma, n (%)	0	8 (2)	0.605
Delayed			
Abdominal wall seroma, n (%)	1 (2)	NR	NA
Abdominal wall fistulae, n (%)	0	7 (2)	0.601
Fat necrosis at flap, n (%)	2 (3)	NR	NA
Hernia, n (%)	0	11/229* (3)	0.374
Bulging, n (%)	0	33/229* (14)	0.014
Umbilicus displacement, n (%)	0	87/229* (38)	<0.001

\*Only 229 patients were evaluated for these complications in the 2003 series. NA, not applicable; NR, not recorded.

Therefore, currently, there is no consensus in the literature on the best surgical techniques for closure of the abdominal flap to prevent abdominal wall complications after TRAM flap reconstruction. We present an alternative approach to close the abdominal wall defect by mesh reconstruction and plication in 2 layers followed by an over and over stitch at the lateral margins of the rectus sheath over the mesh and the posterior fascia combined with second row of reinforcement suture above the arcuate line. The reapproximation of tissues above the arcuate line is still essential to prevent bulging. This new technique could restore the competence, and maintain the strength, of the abdominal wall.

In the present study, there were no instances of abdominal wall hernia and abdominal bulge during the follow-up. In the literature, the reported incidences of abdominal bulge and hernia ranged from 0% to 55% and 0% to 16%, respectively (Table 3).

The results of our new technique therefore compare favorably with those reported in the literature.

We also compared the results of the present series of patients with the results of our series in 2003.<sup>14</sup> Patients in both series underwent pedicled TRAM flaps, but with different techniques of closure of the abdominal donor site (Fig. 5). There were significant differences between the 2 series of patients in terms of important baseline characteristics. The current series had a significantly higher proportion of pre-TRAM radiation treatment, higher proportion of immediate reconstructions, a much lower proportion of bipedicled TRAM, and all patients had mesh repairs. Nonetheless, there were no significant differences in early wound and flap complications, although there was a tendency for fewer necrotic complications for the patients in the current series. Although the occurrence of abdominal wall hernia was not significantly different between series as well, there was a significantly lower incidence of abdomi-

**Table 3. Studies Evaluating the Incidence of Abdominal Hernia or Bulge in Pedicled TRAM Flap**

Author	Year	No. Cases	Sides	Technique of Flap Elevation	Technique of Closure Abdominal Flap	Bulge (%)	Hernia (%)
Hartrampf and Bennett <sup>21</sup>	1987	194	Unilateral	Muscle sparing	Two-layered closure with mesh	0.8	0.3
		106	Bilateral	Muscle sparing	Two-layered closure with mesh	0	0
Lejour and Dome <sup>20</sup>	1991	33	Unilateral	Whole muscle technique	A Teflon mesh buried in the rectus sheath	0	0
Kroll and Marchi <sup>4</sup>	1992	24	Bilateral	The entire width of the rectus abdominis muscle was harvested	The anterior sheath was closed in one layer	25	NR
		72	All				
Mizgala et al <sup>22</sup>	1994	20	All	The medial two thirds of the rectus abdominis muscle was harvested	A two-layered fascial closure with mesh	35	NR
		38	All	The one fifth of the muscle was preserved	A two-layered fascial closure with mesh	5	NR
Zienowicz and May <sup>18</sup>	1995	662	All	Muscle sparing	A two-layered closure of permanent suture incorporating the internal oblique fascia	1.8	1.3
		80	Unilateral	Muscle sparing	Closure without mesh	NR	NR
Paige et al <sup>23</sup>	1998	127	Unilateral	Muscle sparing	Closure without mesh	NR	NR
		130	Bilateral	Muscle sparing	Closure without mesh	NR	NR
Nahabedian and Manson <sup>8</sup>	2002	30	All	Whole muscle technique	Interposition (inlay) synthetic mesh and imbrication of the contralateral rectus sheath	0	1.5%
		94	All	Whole muscle technique	Closure with mesh	NR	3.9 (unilateral)
Garvey et al <sup>24</sup>	2006	105	Unilateral	Whole muscle technique	Closure with mesh	11	5.4 (bilateral)
		105	Unilateral	Whole muscle technique	Reinforced with an onlay polypropylene mesh	14.9	0
Ascherman et al <sup>25</sup>	2008	12	Bilateral	Muscle sparing	Reinforced with an onlay polypropylene mesh	1.7	16
		161	Unilateral	Whole muscle technique	Closure with mesh	17.2	0.85
Rossetto et al <sup>26</sup>	2010	58	Unilateral	Muscle sparing	Closure with mesh	17.2	1.7
		148	Bilateral	Muscle sparing	Closure with mesh	10.8	4.7
Chun et al <sup>27</sup>	2010	105	Bilateral	Whole muscle technique	Closure with mesh/ADM/dermal graft	2.9	2.9
		161	Unilateral	Whole muscle technique	Closure with mesh/ADM/dermal graft	9.5	3.9
Momoh et al <sup>28</sup>	2012	18	Bilateral	Whole muscle technique	A double-layered polypropylene mesh fold over technique	5.7	0
		35	Bilateral	Whole muscle technique	Reinforced using a Prolene mesh (Ethicon)	10%	NR
Bharti et al <sup>29</sup>	2013	20	Unilateral	Whole muscle technique	Reinforced using a self-fixating Parietex ProGrip mesh (Covidien)	55%	NR
Sværdborg and Damsgaard <sup>30</sup>	2013	20	Unilateral	Whole muscle technique			

ADM, acellular dermal matrix; NR, not recorded.

nal bulge and umbilicus displacement. It seems that the current technique of abdominal wall defect closure is superior to that of the 2003 series. It remains to be seen whether this lower abdominal wall contour deformity can be explained by the lower proportion of bipediced TRAM and the routine use of mesh reinforcements in the present series.

There are several limitations of the present study. The new technique was performed by only one surgeon, and thus the sample size was relatively small and the results might not be generalizable. In addition, clinical data were collected from the senior surgeon's clinical notes, and there were no independent or blinded assessment, raising the possibility of observer bias. Although the period of follow-up does not cover more than 3 years after surgery, it is long enough to detect abdominal contour abnormalities of the lower abdomen. More comparative studies with larger number of patients are required to more accurately determine if differences really do exist and to develop improved techniques of abdominal wall closure at the TRAM flap donor site.

### CONCLUSION

Although reports in the literature have mentioned concern over high rates of abdominal contour abnormalities after pedicled TRAM flap surgery, focusing on the anatomy of arcuate line, the technique of closure of the anterior abdominal wall at this point can be performed to optimize flap survivability while minimizing donor-site morbidity to the greatest extent possible.

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