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Quality of Life and Patient-Reported Outcomes in Breast Cancer Survivors:

A Multi-Center Comparison of Four Abdominally-Based Autologous Reconstruction Methods

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Author Roles

Dr Sheina Macadam: Lead investigator. Responsible for overall management of study sites, research assistants and allocation of grant funds. Oversaw patient recruitment, creation and mailing of all patient questionnaire packages, data collection/entry. Responsible for compilation of data, initial statistical analysis and writing of manuscript including tables.
Dr Toni Zhong: Responsible for contribution of patient data and editing of manuscript.
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Abstract

Background—Approximately 20% of women select autologous tissue for postmastectomy breast reconstruction, and most commonly choose the abdomen as the donor site. An increasing proportion of women are seeking muscle-sparing procedures but the benefit remains controversial. It is therefore important to determine whether better outcomes are associated with these techniques, thereby justifying longer operative times and increased costs.

Methods—Patients from five North American centers were eligible if they had reconstruction using the deep inferior epigastric artery perforator flap (DIEP), muscle sparing free transverse abdominis myocutaneous flap (msf-TRAM), free transverse abdominis myocutaneous flap (f-TRAM), or the pedicled transverse abdominis myocutaneous flap (p-TRAM) with minimum one-year follow-up. Patients were sent the BREAST-Q©. Demographics and complications were collected by chart review.

Results—We analyzed 1790 charts representing 670 DIEP, 293 msf-TRAM, 683 p-TRAM, and 144 f-TRAM patients with average follow up of 5.5 years. Flap loss did not differ by flap type. Partial flap loss was higher in p-TRAM compared to DIEP ($p=0.002$). Fat necrosis was higher in p-TRAM compared to DIEP and msf-TRAM ($p<0.001$). Hernia/bulge was highest in p-TRAM ($p<0.001$). Physical Well-Being (Abdomen) scores were higher in DIEP compared to p-TRAM controlling for age, follow-up, BMI, laterality, abdominal surgery, mesh, radiation, income, and education.

Conclusions—Complications and patient-reported outcomes differ when comparing abdominally-based breast reconstruction techniques. The results of this study show that the DIEP was associated with the highest abdominal well-being and the lowest abdominal morbidity when compared to the p-TRAM, but did not differ from msf-TRAM and f-TRAM.

INTRODUCTION

Approximately 12% of women will be diagnosed with breast cancer at some point during their lifetime.[1] Of women who elect to have breast reconstruction following mastectomy, 13% undergo autologous tissue reconstruction utilizing tissue from the lower abdomen.[2] Surgical techniques that sacrifice only part of the rectus abdominis muscle such as the msf-TRAM and the DIEP have been developed to potentially decrease abdominal wall morbidity. The abdominal tissues used for reconstruction include either only a small piece (msf-TRAM) or none (DIEP) of the rectus abdominis muscle or the majority of the rectus muscle (f-TRAM, p-TRAM) with the overlying skin and fat (Figure 1).

Abdominal wall weakness may result from removing or injuring the muscle and muscular fascia or denervating the intercostal nerves. Reports have described abdominal wall hernia and bulge rates as high as 62% for p-TRAM[3], 27% for f-TRAM[4], 11% for msf-TRAM[5], and 10% for DIEP flaps.[6,7] While advances in abdominal wall closure techniques may minimize

hernia and bulge complications, these are unlikely to decrease abdominal wall weakness and a patient's ability to conduct activities of daily life without discomfort.[6] Multiple studies evaluating objective abdominal wall strength with functional dynamometry have demonstrated significant differences between different types of flaps.[8,9,10,11,12,13] In these studies, patients with f-TRAM and p-TRAM reconstruction have been found to have more abdominal wall weakness relative to msf-TRAM and DIEP groups. Additionally, patients who have f-TRAM or msf-TRAM reconstruction also appear to have decreased abdominal muscle strength relative to DIEP patients.

However, the benefit of muscle-sparing procedures remains controversial and it is unclear whether any clinically meaningful differences exist for the patients who undergo the different techniques.[14] Furthermore, muscle-sparing procedures are often associated with longer operative times and require specialized surgeon training. Longer operative times may impart greater peri-operative risk to patients and are associated with increased health care costs. Additionally, it has been purported that muscle-sparing techniques are associated with more flap-related complications compared to non-muscle-sparing techniques.[15,16] For these and other reasons, North American plastic surgeons are performing fewer microsurgical breast reconstructions.[17] It is therefore important to quantify the differences in outcomes associated with the various procedures.

METHODS

Ethics

Ethics approval was obtained from Research Ethics Boards at University of British Columbia (Vancouver), University Health Network (Toronto), Dartmouth University (Lebanon), the New York University (New York) and the Memorial Sloan Kettering Cancer Center (New York).

Patient Selection

Women who underwent abdominally-based reconstruction were recruited at five sites: i) University of British Columbia; Vancouver, BC; ii) University of Toronto; Toronto, ON; iii) Dartmouth College; Lebanon, NH; iv) New York University; New York, NY; and v) Memorial Sloan Kettering Cancer Center; New York, NY. Inclusion criteria were: i) abdominal flap reconstruction one to seven years prior to study initiation (range: 2002–2012); ii) p-TRAM, f-TRAM, msf-TRAM, or DIEP reconstruction; iii) patients at least 21 years of age. Patients were excluded if they were unable to read or speak English, if their address was unavailable, if they had a combination of two of the above flaps in a bilateral case, if they were deceased or refused to participate. The type of flap the patient had was determined by how the reconstruction was coded within each database at each individual institution.

Study Design

This was a cross-sectional study. Patients were sent the BREAST-Q© questionnaire, a self-addressed, postage-paid return envelope and a $5 Starbucks card as an incentive to respond. One additional copy of the questionnaire was distributed to non-responders three months

after the first mail-out.[18] Chart review was performed in order to compile demographic and surgical data.

Questionnaire

The BREAST-Q© was developed at the Memorial Sloan Kettering Cancer Center and the University of British Columbia.[19,20,21] This instrument measures patient satisfaction and health-related quality of life following breast surgery. Details of the BREAST-Q© development are previously published.[19,22,23] The BREAST-Q© scales selected for use in the study were 1) *Physical well-being: Abdomen;* 2*) Satisfaction with Breasts;* 3) *Satisfaction with Outcome;* 4) *Psychosocial well-being;* and 5) *Sexual well-being.* Scoring was performed using QScore which was developed according to the Rasch model.[24,25] All scales were scored on a 0–100 point scale with higher scores indicating greater satisfaction.

Statistical Analysis

Differences in patient characteristics between groups were compared using Pearson's chi-square test (categorical variables) and analysis of variance (ANOVA; continuous variables). Statistically significant differences on ANOVA comparisons for the 4 surgical groups were explored using appropriate follow-up tests (i.e., Tukey's or Games-Howell tests) for pairwise comparisons. Mean scores and standard deviations on the BREAST-Q© subscales were calculated for each group; the group means for each subscale were compared using ANOVA with appropriate follow-up tests. Analyses of covariance (ANCOVAs) were used to examine the same mean differences on the BREAST-Q© subscales controlling for age, time since surgery, BMI, laterality, mesh, history of abdominal surgery, radiation, income and education level. Differences in abdominal morbidity scores between each group were assessed using Pearson’s chi-square test. Hierarchical logistic regressions were then used to examine these differences controlling for the same covariates. Given the relatively high number of analyses, a more conservative alpha of .010 was used to determine statistical significance.

RESULTS

Response Rate

2031 charts were reviewed. 241 patients were excluded for follow up time < 1 year, combination of different flaps if a bilateral procedure, no patient address, patient death and patient refusal to participate. The remaining 1790 patients were contacted by mail and 943 responded (53% overall response rate). Chart review was performed on all 943 responders and 847 non-responders.

Patient Demographics

The demographic and surgical characteristics for each patient group (responders and nonresponders) were compared (Tables 1 and 2), Patients in the p-TRAM group were significantly older and had lower BMI than patients in the other groups. Length of follow up was longest in the f-TRAM group. Patient groups also differed for stage of disease, receipt of radiation therapy, and smoking status (highest percentage of smokers in the DIEP group). Additionally, patient groups differed for immediate versus delayed surgery, laterality, mesh

placement (highest in msf-TRAM and lowest in DIEP) and type of suture used for abdominal fascial repair. Patients differed across all socioeconomic variables except for marital status and employment (Table 3).

Complications

Tables 4a and 5a show the flap- and donor site-related complication profiles across patient groups including both responders and nonresponders. Fat necrosis and infection were highest in the p-TRAM group (25% and 15.7% respectively). Pairwise comparison (Tables 4b, 5b) revealed these differences to be significant when comparing the p-TRAM to the DIEP and msf-TRAM groups only ($p<0.001$). Partial flap loss was also highest in the p-TRAM group (8.9%) and reached statistical significance only when comparing p-TRAM to DIEP ($p=0.002$). Total flap loss did not differ between groups and was universally low (1–2%) as was the occurrence of deep vein thrombosis and pulmonary embolism (1–1.6%). DIEP patients had the highest occurrence of hematoma (8.4%) and this reached significance only when comparing the DIEP to p-TRAM groups ($p=0.001$). The p-TRAM bulge rate (11%) and the bulge/hernia rate (16.6%) were highest on comparison to all other groups ($p<0.001$). The rate of hernia and hernia/bulge requiring repair were lowest in the DIEP group ($p<0.001$), but this only reached significance when comparing DIEP to p-TRAM. All significant results remained after controlling for age, time since surgery, BMI, laterality, history of abdominal surgery, mesh placement, radiation, income, and education level.

BREAST-Q© Scores

Mean scores from the 5 BREAST-Q© scales were compared across the four flap groups (Table 6). Using pairwise analysis there were significantly higher scores in the DIEP group compared to the p-TRAM group for the *Physical Well-Being Abdomen* scale (83.5 vs. 76.2; $p<0.001$), and this remained significant after controlling for confounders. There was a trend towards significance for higher *Satisfaction with Outcome* in the DIEP group compared to the p-TRAM group ($p=0.015$). The other group differences were not significantly different. Patients scored similarly on the *Satisfaction with Breasts*, *Psychosocial well-being*, and *Sexual well-being* scales.

Responders vs. Non-Responders

Compared to non-responders, DIEP responders were significantly older, had less follow up time, were less likely to have had mesh placed and less likely to have had an absorbable suture placed for abdominal fascial repair. p-TRAM responders and non-responders differed for cancer pathology, receipt of pre-operative chemotherapy (higher in the non-responders), and receipt of radiation (higher in the non-responders). There were no differences between responders and non-responders in the msf-TRAM and f-TRAM groups (Table 7).

DISCUSSION

In the setting of breast reconstruction surgery, patient satisfaction and quality of life (QOL) may be the most important outcome variables in evaluating surgical success. When using patient-reported QOL as an outcome measure, Atisha *et al.* have shown that autologous reconstruction is the gold standard. In a study of over 7000 breast cancer patients these

authors identified a spectrum of post-operative satisfaction scores. Using breast conserving surgery (BCS) as a reference, patients that underwent mastectomy and no reconstruction scored lowest, patients that underwent reconstruction with implants scored on average 8.6 points lower than those with BCS and patients that underwent abdominal flap reconstruction scored 5.6 points higher than BCS.[26] Since the original description of the p-TRAM by Hartrampf[27], refinements in abdominally-based autologous reconstruction have led to inclusion of less rectus abdominis muscle and overlying fascia.[28,29,30,31] Previous studies have shown advantages of the DIEP flap when compared to the f-TRAM flap for abdominal strength, postoperative pain, and cost.[10,32,33,34,35] Similarly, advantages of the DIEP have been shown when comparing it to the p-TRAM for occurrence of hernia/bulge, lower rate of fat necrosis, lower hospital stay, better abdominal contour and decreased postoperative pain.[7,26,36] However, many authors have suggested that the higher rate of flap loss in the more difficult microsurgical reconstructions (DIEP) should be considered as a downside when choosing between the different abdominally-based techniques.

The most hotly debated issue is by far that of abdominal wall morbidity. Arguably, the best way to determine if there is a difference in abdominal wall morbidity between the different techniques is to study surgical outcomes and patient reported experience. We have studied patients from five North American centers representing the largest cohort of patients to be compared for results following abdominally-based breast reconstruction. The BREAST-Q© was chosen to determine differences in patient experience because it provides a scientifically rigorous and clinically valid means to examine the impact of breast reconstruction from the patients' perspective.[22,37] Our study has documented experiential differences in satisfaction with DIEP patients expressing significantly higher physical well-being of the abdomen and a trend to higher overall satisfaction with outcome when compared to the p-TRAM reconstruction patients. This finding did not reach significance when comparing the DIEP to the msf-TRAM and f-TRAM groups. BREAST-Q© data which address issues such as "tightness or pulling in the abdomen" and "difficulty doing everyday activities requiring the use of your abdominal muscles" are powerful because the questions asked relate directly to the types of problems patients face as they move on after breast reconstruction. By using a sensitive outcome measure (i.e. calibrated to detect a difference in our target population), we feel confident in reporting that a real difference exists in long-term postoperative satisfaction for abdominal well-being and overall outcome when comparing the DIEP to the p-TRAM patient.

When looking at clinical measures of abdominal wall morbidity, we found DIEP patients to display the lowest rate of hernia/bulge requiring surgery (3.1%) and this reached significance when comparing the DIEP to the p-TRAM. p-TRAM patients had the highest rate of bulge and hernia/bulge compared to all other flap types. Previous studies have corroborated our results. Garvey *et al.* compared 94 p-TRAM flaps to 96 DIEP flaps and showed a 16% incidence of hernia in the p-TRAM group versus a 1% incidence of hernia in the DIEP group. They however found a high incidence of bulge in both the DIEP (9.4%) and p-TRAM groups (14.9%).[7] Knox *et al.* compared 165 DIEP procedures to 443 p-TRAMs and found eight times the odds of hernia/bulge in the p-TRAM group after controlling for confounders.[36] These studies support our finding that DIEP reconstruction confers a lower risk of hernia/bulge when compared to the p-TRAM reconstruction.

Comparisons of the DIEP flap to the f-TRAM flap and the msf-TRAM flap are more variable. A meta-analysis conducted by Man *et al.* (861 flaps) found DIEP patients to display a 3.1% incidence of bulge and TRAM patients 5.9%; DIEP patients had a 0.8% incidence of hernia compared to 3.9% in the TRAM patients.[15] However in this analysis f-TRAM and msf-TRAM patients were combined in one group. A systematic analysis that exclusively compared DIEP to f-TRAM showed no significant difference in the incidence of bulge, however the total number of patients in each group was small.[38] Vyas *et al.* compared 37 f-TRAM flaps to 182 msf-TRAM and 128 DIEP flaps.[39] They found a 13.5% incidence of hernia/bulge in the f-TRAM group compared to 3.9% in the DIEP group. msf-TRAM patients had a 6.6% incidence of hernia/bulge and they concluded that while there was a significant difference between the f-TRAM and DIEP groups, there was no difference between msf-TRAM and DIEP groups. Another study by Nelson *et al.* (n=144) showed no difference in hernia formation when comparing DIEP (0%) to msf-TRAM (4%).[40] A recent study by Zhong *et al.* used propensity to scores to control for selection bias. This method considers potential confounders that may affect outcome, but also factors that contribute to selection of the reconstruction procedure. For example, a planned DIEP flap may be converted to an msf-TRAM procedure if there is no single dominant perforator and the patient is a smoker or diabetic. This may lead to an increased number of msf-TRAM flaps in the smoking or diabetic population who may be at inherently higher risk for hernia/bulge. After controlling for confounders and using propensity score analysis, this group found a 2.7 times increased risk of abdominal wall hernia or bulge in the msf-TRAM group compared to the DIEP group.[41] While we found that DIEP flaps conferred a lower risk of abdominal wall morbidity compared to p-TRAM, differences between the DIEP and f-TRAM and the DIEP and msf-TRAM were non-significant. Additionally, hernia/bulge and bulge rates are lower in all groups compared to the p-TRAM group, but there was no significant difference on comparison between the DIEP, msf-TRAM and f-TRAM groups. It is unclear why abdominal wall morbidity is worse in the p-TRAM compared to the f-TRAM given that both approaches sacrifice the entire rectus muscle. This may be a result of the fact that the rectus fascia is not completely closed in the pedicled technique which may alter the mechanical advantage of the internal oblique muscles.

We have shown that across 1790 patients there is no difference in total flap loss between the DIEP, msf-TRAM, f-TRAM and p-TRAM groups. Fat necrosis was highest in the pTRAM group (25%) compared to the DIEP and msf-TRAM. This is likely a result of the use of the dominant blood supply to the flap in the latter three reconstruction techniques. A similar mechanism can be inferred to explain the higher rate of partial flap loss in the p-TRAM group (8.9%) compared to the DIEP (4%).

In general, studies have shown increased satisfaction with autologous reconstruction compared to implant reconstruction.[25,42,43] It is thus important to note that if a surgeon's preference is for the p-TRAM flap, this may still be considered preferable to an alloplastic reconstruction. While our study suggests that DIEP reconstruction leads to less abdominal morbidity, it must be acknowledged that microsurgical breast reconstruction is not available in many centers in North America. Microsurgical breast reconstruction requires a dedicated perioperative environment including sophisticated monitoring and postoperative care. It is therefore difficult to incorporate free flap breast reconstruction techniques into many

community medical centers.[44,45,46] In these practice settings, patients should still be encouraged to consider p-TRAM reconstruction. Furthermore, while p-TRAMs can be planned pre-operatively, performing a DIEP flap must take into consideration intraoperative factors. If a DIEP flap is planned and there is no single dominant perforator then conversion to an msf-TRAM or a f-TRAM may be indicated. If the patient is diabetic, or has other factors that may affect perfusion to the flap a f-TRAM reconstruction may be preferable. Keeping these factors in mind, we engage the patient in an extensive preoperative discussion outlining our algorithm for reconstructive choice and are clear about the expected outcomes of each reconstructive technique.

Limitations of this study include the response rate which is lower than the average proposed rate of 60% considered optimal for clinical research.[47,48] Analysis of non-responders showed differences in characteristics between groups and we controlled for these differences by entering factors assumed to have an impact on outcome into our logistic regression model. Differences in surgeon technique and pre- and intra-operative decision-making cannot be accounted for in our retrospective analysis. For example, patients coded as a DIEP at one institution may have been considered an msf-TRAM at another institution thereby confounding our results. Additionally there was a disproportionately higher usage of mesh at the MSKCC site when compared to other sites. This may have affected abdominal wall morbidity outcomes. We attempted to control for this by including mesh usage in our regression analysis. Lastly, the cross-sectional nature of this study provides information about patients at a single time point (on average 5.5 years post reconstruction) and does not account for dynamic changes in patient perception. A multi-center prospective study with strictly defined preoperative and intraoperative decision-making algorithms would provide a more accurate comparison of the four studied breast reconstruction techniques.

Conclusion

This is the first study to use the BREAST-Q© to compare patient-reported outcomes in patients undergoing breast reconstruction utilizing the four most common abdominally-based breast reconstruction techniques. We have shown that patients who undergo DIEP flap reconstruction have higher satisfaction with abdominal physical well-being when compared to patients that undergo p-TRAM reconstruction, but do not differ from msf-TRAM and f-TRAM patients. p-TRAM patients were found to have the highest rates of hernia/bulge compared to msf-TRAM, f-TRAM and DIEP, but there was no difference between the other groups. There was no difference in total flap failure when comparing the four groups in this large sample of patients. While choice of autologous technique will depend on surgeon training and intra-operative decision-making, the differences we have found in patient-reported symptoms and abdominal donor site outcomes may shift the practice of plastic surgeons towards utilizing methods with lower donor site morbidity and higher patient-reported satisfaction.

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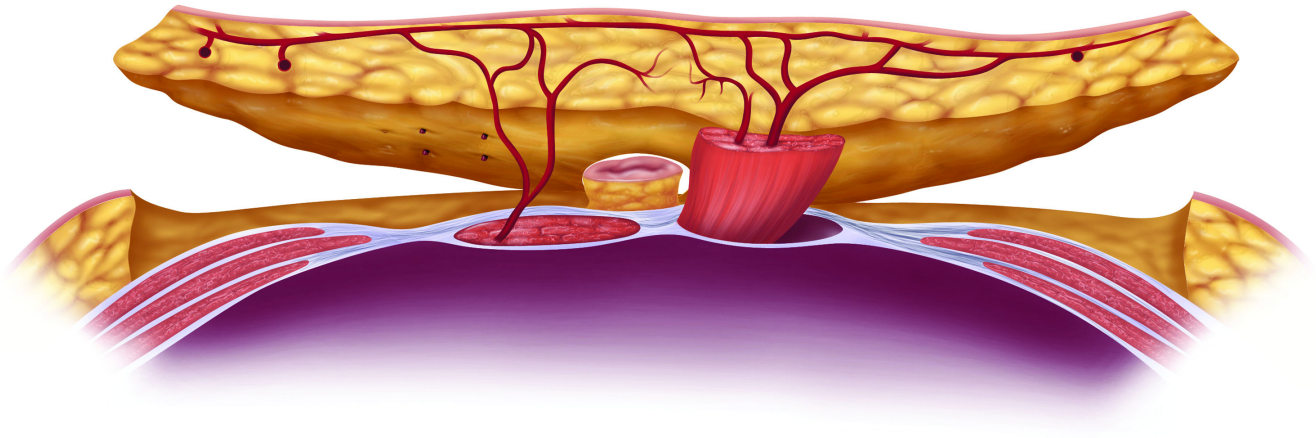

Figure 1.
The abdominal tissues used for breast reconstruction include subcutaneous fat +/− skin +/− rectus abdominis muscle.

Table 1

Demographics – Clinical

Variable	DIEP n=670 Mean (SD)	msTRAM n=293 Mean (SD)	pTRAM n=683 Mean (SD)	fTRAM n=144 Mean (SD)	p
Age at surgery	49.0 (8.4)	49.6 (7.9)	50.3 (8.2)	47.8 (7.7)	.003*
Length of follow-up (months)	53.7 (27.8)	61.4 (24.2)	71.2 (28.8)	87.1 (36.7)	<.001*
BMI	27.3 (4.8)	28.4 (4.9)	26.7 (4.2)	28.3 (5.3)	<.001*
Variable	**DIEP n=670 n (%)**	**msTRAM n=293 n (%)**	**pTRAM n=683 n (%)**	**fTRAM n=144 n (%)**	**p**
Pathology					<.001*
Invasive	452 (67.8)	196 (68.5)	404 (65.5)	86 (60.6)	
In situ	156 (23.4)	76 (26.6)	196 (31.8)	50 (35.2)	
Prophylactic	57 (8.5)	13 (4.5)	14 (2.3)	6 (4.2)	
Noncancerous	2 (0.3)	1 (0.3)	3 (0.5)	0 (0)	
History of Abdominal Surgery					.044
Yes	301 (46.8)	122 (44.4)	345 (52.8)	74 (52.9)	
No	342 (53.2)	153 (55.6)	309 (47.2)	66 (47.1)	
Chemotherapy					.340
Yes	344 (51.4)	149 (51.0)	371 (55.6)	72 (50.3)	
No	325 (48.6)	143 (49.0)	296 (44.4)	71 (49.7)	
Pre-operative chemotherapy					.015
Yes	293 (43.8)	106 (36.3)	284 (42.5)	45 (31.7)	
No	376 (56.2)	186 (63.7)	384 (57.5)	97 (68.3)	
Post-operative chemotherapy					<.001*
Yes	59 (8.8)	48 (16.4)	111 (16.7)	30 (21.1)	
No	610 (91.2)	244 (83.6)	553 (83.3)	112 (78.9)	

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Radiation					.008*
Yes	281 (42.0)	130 (44.5)	328 (49.2)	51 (35.9)	
No	388 (58.0)	162 (55.5)	339 (50.8)	91 (64.1)	
Pre-operative radiation					.023
Yes	262 (39.2)	123 (42.1)	268 (40.2)	39 (27.5)	
No	406 (60.8)	169 (57.9)	399 (59.8)	103 (72.5)	
Post-operative radiation					<.001*
Yes	21 (3.1)	8 (2.7)	65 (9.8)	12 (8.5)	
No	647 (96.9)	284 (97.3)	597 (90.2)	130 (91.5)	
Smoker					.010*
Yes	69 (10.5)	16 (5.5)	42 (6.2)	10 (7.0)	
No	589 (89.5)	277 (94.5)	636 (93.8)	132 (93.0)	
Diabetic					.035
Yes	19 (2.8)	15 (5.1)	24 (3.6)	0 (0)	
No	650 (97.2)	278 (94.9)	649 (96.4)	143 (100)	
History of pregnancy					.780
Yes	505 (87.2)	221 (84.7)	404 (86.3)	117 (87.3)	
No	74 (12.8)	40 (15.3)	64 (13.7)	17 (12.7)	

Table 2

Demographics - Surgical

Variable	DIEP n=670 n (%)	msTRAM n=293 n (%)	pTRAM n=683 n (%)	fTRAM n=144 n (%)	p
Unilateral	383 (57.2)	185 (63.1)	541 (79.2)	114 (79.2)	<.001*
Bilateral	286 (42.8)	108 (36.9)	142 (20.8)	30 (20.8)	
Timing					<.001*
Immediate	389 (58.2)	190 (65.1)	482 (70.7)	103 (71.5)	
Delayed	248 (37.1)	99 (33.9)	191 (28.0)	40 (27.8)	
Both	31 (4.6)	3 (1.0)	9 (1.3)	1 (0.7)	
Mesh					<.001 *
Yes	123 (18.5)	159 (54.3)	232 (35.3)	47 (32.9)	
No	543 (81.5)	134 (45.7)	426 (64.7)	96 (67.1)	
Suture					<.001*
Absorbable only	94 (14.3)	18 (6.2)	30 (4.6)	1 (0.7)	
Non-absorbable only	284 (43.2)	102 (35.2)	205 (31.2)	38 (26.4)	
Both	280 (42.6)	170 (58.6)	422 (64.2)	105 (72.9)	

Table 3

Demographics – Socioeconomic Status

Variable	DIEP n=670 n (%)	msTRAM n=293 n (%)	pTRAM n=683 n (%)	fTRAM n=144 n (%)	p
Ethnicity					<.001*
South Asian	8 (2.1)	1 (0.9)	7 (2.0)	0 (0)	
Asian	22 (5.9)	4 (3.4)	21 (5.9)	0 (0)	
Black	13 (3.5)	7 (6.0)	9 (2.5)	5 (7.1)	
Hispanic	5 (1.3)	0 (0)	2 (0.6)	0 (0)	
White	313 (83.2)	93 (80.2)	296 (83.6)	57 (81.4)	
White/Hispanic	9 (2.4)	10 (8.6)	5 (1.4)	8 (11.4)	
Native	6 (1.6)	1 (0.9)	14 (4.0)	0 (0)	
Education					<.001*
Some high school	12 (3.1)	3 (2.5)	17 (4.7)	1 (1.4)	
High school diploma	40 (10.5)	11 (9.2)	72 (19.9)	8 (10.8)	
Some college	58 (15.2)	19 (15.8)	76 (21.1)	13 (17.6)	
College diploma	158 (41.4)	42 (35.0)	134 (37.1)	28 (37.8)	
Some Masters	25 (6.5)	9 (7.5)	17 (4.7)	5 (6.8)	
Masters	89 (23.3)	36 (30.0)	45 (12.5)	19 (25.7)	
Marital status					.562
Married	280 (73.1)	78 (65.5)	264 (73.3)	48 (64.9)	
Living with other	30 (7.8)	7 (5.9)	18 (5.0)	6 (8.1)	
Widowed	12 (3.1)	4 (3.4)	14 (3.9)	2 (2.7)	
Separated	9 (2.3)	3 (2.5)	8 (2.2)	3 (4.1)	
Divorced	33 (8.6)	14 (11.8)	38 (10.8)	9 (12.2)	
Single	19 (5.0)	13 (10.9)	18 (5.0)	6 (8.1)	
Annual income					<.001*
< 20K	17 (4.7)	4 (3.6)	27 (8.1)	2 (3.0)	
20–40K	29 (8.0)	12 (10.7)	65 (19.4)	7 (10.6)	

Variable	DIEP n=670 n (%)	msTRAM n=293 n (%)	pTRAM n=683 n (%)	fTRAM n=144 n (%)	p
40–60K	35 (9.7)	14 (12.5)	61 (18.2)	17 (25.8)	
60–80K	48 (13.3)	17 (15.2)	54 (16.1)	2 (3.0)	
80–100K	61 (16.9)	9 (8.0)	38 (11.3)	12 (18.2)	
> 100K	172 (47.5)	56 (50.0)	90 (26.9)	26 (39.4)	
Employment					.017
Full-time	201 (52.5)	66 (55.5)	168 (46.7)	41 (55.4)	
Part-time	58 (15.1)	15 (12.6)	56 (15.6)	5 (6.8)	
Volunteer	5 (1.3)	4 (3.4)	10 (2.8)	3 (4.1)	
Homemaker	40 (10.4)	9 (7.6)	29 (8.1)	7 (9.5)	
Student	2 (0.5)	1 (0.8)	2 (0.6)	1 (1.4)	
Retired	57 (14.9)	13 (10.9)	73 (20.3)	13 (17.6)	
Disabled	14 (3.7)	4 (3.4)	20 (5.6)	4 (5.4)	
Unemployed	6 (1.6)	7 (5.9)	2 (0.6)	0 (0)	

Table 4

a Complications – Flap					
Variable	**DIEP n=670 n (%)**	**msTRAM n=293 n (%)**	**pTRAM n=683 n (%)**	**fTRAM n=144 n (%)**	**P**
Hematoma (any) requiring surgery					.001 *
Yes	56 (8.4)	13 (4.4)	26 (3.8)	5 (3.5)	
No	614 (91.6)	280 (95.6)	655 (96.2)	139 (96.5)	
Seroma (any)					<.001 *
Yes	34 (5.1)	20 (6.8)	78 (11.5)	15 (10.4)	
No	636 (94.9)	273 (93.2)	598 (88.5)	129 (89.6)	
Fat necrosis					<.001 *
Yes	109 (16.3)	44 (15.0)	171 (25.3)	24 (16.7)	
No	561 (83.7)	249 (85.0)	505 (74.7)	120 (83.3)	
Flap loss					.820
Yes	11 (1.6)	4 (1.4)	8 (1.2)	3 (2.1)	
No	659 (98.4)	289 (98.6)	668 (98.8)	141 (97.9)	
Partial flap loss					.002 *
Yes	47 (4.0)	14 (4.8)	60 (8.9)	11 (7.6)	
No	643 (96.0)	279 (95.2)	616 (91.1)	133 (92.4)	
DVT or PE					.929
Yes	8 (1.2)	4 (1.4)	11 (1.6)	2 (1.4)	
No	660 (98.8)	289 (98.6)	665 (98.4)	142 (98.6)	
Infection (any)					<.001 *
Yes	42 (6.3)	21 (7.2)	106 (15.7)	14 (9.7)	
No	628 (93.7)	272 (92.8)	569 (84.3)	130 (90.3)	

b Pairwise Comparisons: Patient Surgical Complications

Variable	DIEP n=670 (%)	pTRAM n=683 (%)	fTRAM n=144 (%)	msTRAM n=293 (%)	X^2	p
Hematoma requiring surgery						
Yes	56 (8.4)[a]	26 (3.8)[b]	5 (3.5)[ab]	13 (4.4)[ab]	15.7	.001
No	614 (91.6)	655 (96.2)	139 (96.5)	280 (95.6)		
Seroma						
Yes	34 (5.1)[a]	78 (11.5)[b]	15 (10.4)[ab]	20 (6.8)[ab]	20.3	<.001
No	636 (94.9)	598 (88.5)	129 (89.6)	273 (93.2)		
Fat necrosis						
Yes	109 (16.3)[a]	171 (25.3)[b]	24 (16.7)[ab]	44 (15.0)[a]	23.4	<.001
No	561 (83.7)	505 (74.7)	120 (83.3)	249 (85.0)		
MFN requiring dressings						
Yes	79 (11.8)[a]	72 (10.7)[a]	12 (8.3)[a]	35 (11.9)[a]	1.8	.617
No	591 (88.2)	604 (89.3)	132 (91.7)	258 (88.1)		
MFN requiring surgery						
Yes	55 (8.2)[ab]	82 (12.1)[b]	6 (4.2)[a]	21 (7.2)[ab]	13.5	.004
No	615 (91.8)	594 (87.9)	138 (95.8)	271 (92.8)		
Wound healing delay						
Yes	103 (18.5)[a]	174 (28.2)[b]	26 (22.4)[ab]	51 (26.7)[ab]	16.2	.001
No	454 (81.5)	443 (71.8)	90 (77.6)	140 (73.3)		
Flap loss						
Yes	11 (1.6)[a]	8 (1.2)[a]	3 (2.1)[a]	4 (1.4)[a]	0.9	.820
No	659 (98.4)	668 (98.8)	141 (97.9)	289 (98.6)		
Partial flap loss						
Yes	47 (4.0)[a]	60 (8.9)[b]	11 (7.6)[ab]	14 (4.8)[ab]	15.1	.002
No	643 (96.0)	616 (91.1)	133 (92.4)	279 (95.2)		

b Pairwise Comparisons: Patient Surgical Complications

Variable	DIEP n=670 (%)	pTRAM n=683 (%)	fTRAM n=144 (%)	msTRAM n=293 (%)	X^2	p
DVT or PE						
Yes	8 (1.2)[a]	11 (1.6)[a]	2 (1.4)[a]	4 (1.4)[a]	0.5	.929
No	660 (98.8)	665 (98.4)	142 (98.6)	289 (98.6)		
Infection						
Yes	42 (6.3)[a]	106 (15.7)[b]	14 (9.7)[ab]	21 (7.2)[a]	36.4	<.001
No	628 (93.7)	569 (84.3)	130 (90.3)	272 (92.8)		

* Groups with different superscript letters (a, b, c) are significantly different from each other.

Table 5

a Complications – Donor Site

Variable	DIEP n=670 n (%)	msTRAM n=293 n (%)	pTRAM n=683 n (%)	fTRAM n=144 n (%)	P
Abdominal hernia					<.001 *
Yes	13 (1.9)	14 (4.8)	46 (6.7)	4 (2.8)	
No	657 (98.1)	279 (95.2)	636 (93.3)	140 (97.2)	
Abdominal bulge					<.001 *
Yes	18 (2.7)	15 (5.1)	74 (10.9)	5 (3.5)	
No	652 (97.3)	278 (94.9)	608 (89.1)	139 (96.5)	
Abdominal bulge or hernia					<.001 *
Yes	28 (4.2)	24 (8.2)	113 (16.6)	8 (5.6)	
No	642 (95.8)	269 (91.8)	569 (83.4)	136 (94.4)	
Abdominal bulge or hernia requiring surgery					<.001 *
Yes	21 (3.1)	18 (6.1)	68 (10.0)	5 (3.5)	
No	649 (96.9)	275 (93.9)	614 (90.0)	139 (96.5)	

b Pairwise Comparisons: Donor Site Complications

Variable	DIEP n=670 (%)	msTRAM n=293 (%)	pTRAM n=683 (%)	fTRAM n=144 (%)	X^2	p
Abdominal hernia						
Yes	13 (1.9)[a]	4 (4.8)[ab]	46 (6.7)[b]	4 (2.8)[ab]	19.9	<.001
No	657 (98.1)	279 (95.2)	636 (93.3)	140 (97.2)		
Abdominal bulge						
Yes	18 (2.7)[a]	15 (5.1)[a]	74 (10.9)[b]	5 (3.5)[a]	41.6	<.001
No	652 (97.3)	278 (94.9)	608 (89.1)	139 (96.5)		

b Pairwise Comparisons: Donor Site Complications

Variable	DIEP n=670 (%)	msTRAM n=293 (%)	pTRAM n=683 (%)	fTRAM n=144 (%)	X^2	p
Abdominal bulge or hernia						
Yes						
No	28 (4.2)[a]	24 (8.2)[a]	113(16.6)[b]	8 (5.6)[a]	63.8	<.001
	642 (95.8)	269 (91.8)	569 (83.4)	136 (94.4)		
Abdominal bulge or hernia requiring surgery						
Yes	21 (3.1)[a]	18 (6.1)[ab]	68 (10.0)[b]	5 (3.5)[ab]	29.1	<.001
No	649 (96.9)	275 (93.9)	614 (90.0)	139 (96.5)		

*Groups with different superscript letters (a, b, c) are significantly different from each other.

Table 6

BREAST-Q scores

Variable	DIEP n=387 Mean (SD)	msTRAM n=123 Mean (SD)	pTRAM n=359 Mean (SD)	fTRAM n=74 Mean (SD)	p
Physical well being – abdomen	83.5 (17.4)	78.1 (22.8)	76.2 (21.8)	78.6 (23.4)	<.001[1]
Satisfaction with outcome	78.6 (19.3)	72.9 (23.3)	73.9 (24.2)	76.4 (22.2)	.015[2]
Satisfaction with breasts	71.9 (17.3)	68.7 (18.7)	69.8 (20.7)	71.7 (21.0)	.319
Psychosocial well being	79.9 (18.4)	75.9 (22.7)	79.6 (20.4)	79.1 (21.7)	.307
Sexual well being	59.0 (21.5)	56.0 (23.8)	57.3 (24.0)	59.4 (25.0)	.538

[1] Games-Howell testing revealed that the statistically significant difference is between DIEP and pTRAM

[2] Games-Howell testing revealed that the statistically significant difference is between DIEP and pTRAM

Table 7

Demographics for Responders vs. Non-Responders

DIEP				
Variable	**Non-responders (N=304) Mean (SD)**	**Responders (N=354) Mean (SD)**	**F**	**P**
Age at surgery	47.7 (8.1)	50.0 (8.5)	12.0	.001*
Length of follow-up (months)	59.0 (29.4)	50.1 (26.1)	16.3	<.001*
BMI	27.7 (4.9)	27.1 (4.7)	2.2	.143
Variable	**Non-responders - n (%)**	**Responders -** n (%)	**X^2**	**P**
Pathology			2.2	.526
Invasive	185 (66.3)	264 (68.9)		
In situ	68 (24.4)	87 (22.7)		
Prophylactic	26 (9.3)	30 (7.8)		
Noncancerous	0 (0)	2 (0.5)		
History of abdominal surgery			0.1	.786
Yes	124 (45.9)	173 (47.0)		
No	146 (54.1)	195 (53.0)		
Chemotherapy			3.4	.064
Yes	132 (47.1)	209 (54.4)		
No	148 (52.9)	175 (45.6)		
Pre-operative chemotherapy			5.9	.015
Yes				
No	107 (38.2)	183 (47.7)		
	173 (61.8)	201 (52.3)		
Post-operative chemotherapy			0.1	.757
Yes				
No	26 (9.3)	33 (8.6)		
	254 (90.7)	351 (91.4)		
Radiation			1.0	.321
Yes	111 (39.6)	167 (43.5)		
No	169 (60.4)	217 (56.5)		
Pre-operative radiation			0.5	.480
Yes				
No	105 (37.5)	154 (40.2)		
	175 (62.5)	229 (59.8)		

Post-operative radiation			0.2	.696
Yes	8 (2.9)	13 (3.4)		
No	272 (97.1)	370 (96.6)		
Smoker			0.3	.614
Yes	31 (11.1)	37 (9.9)		
No	248 (88.9)	337 (90.1)		
Diabetic			0.1	.739
Yes	7 (2.5)	11 (2.9)		
No	272 (97.5)	363 (97.1)		
History of pregnancy			0.1	.714
Yes	219 (86.9)	284 (87.9)		
No	33 (13.1)	39 (12.1)		
Unilateral vs. bilateral	169 (60.1)	213 (55.5)	1.5	.229
	112 (39.9)	171 (44.5)		
Timing			5.9	.053
Immediate	162 (57.7)	223 (58.4)		
Delayed	112 (39.9)	135 (35.3)		
Both	7 (2.5)	24 (6.3)		
Mesh			18.1	<.001*
Yes	73 (26.0)	50 (13.0)		
No	208 (74.0)	334 (87.0)		
Suture			10.3	.006*
Absorbable	42 (15.2)	52 (13.7)		
Non-Absorbable	100 (36.1)	184 (48.4)		
Both	135 (48.7)	144 (37.9)		

p-TRAM

Variable	**Non-responders (N=304) Mean (SD)**	**Responders (N=354) Mean (SD)**	**F**	**P**
Age at surgery	49.6 (8.3)	51.1 (8.2)	5.5	.019
Length of follow-up (months)	74.3 (29.2)	70.0 (28.5)	3.9	.048
BMI	26.6 (4.3)	26.8 (4.1)	0.8	.392

Variable	**Non-responders (N=304) Mean (SD)**	**Responders (N=354) Mean (SD)**	**X^2**	**P**
Pathology			12.7	.005*
Invasive	204 (72.3)	194 (59.5)		

In situ	73 (25.9)	120 (36.8)		
Prophylactic	5 (1.8)	9 (2.8)		
Noncancerous	0 (0)	3 (0.9)		
History of abdominal surgery			6.1	.014
Yes	138 (46.9)	194 (56.7)		
No	156 (53.1)	148 (43.3)		
Chemotherapy			4.5	.033
Yes	175 (59.5)	179 (51.1)		
No	119 (40.5)	171 (48.9)		
Pre-operative chemotherapy			11.8	.001*
Yes				
No	144 (48.8)	124 (35.4)		
	151 (51.2)	226 (64.6)		
Post-operative chemotherapy			0.9	.355
Yes				
No	45 (15.4)	63 (18.1)		
	248 (84.6)	285 (81.9)		
Radiation			6.9	.008*
Yes	160 (54.4)	154 (44.0)		
No	134 (45.6)	196 (56.0)		
Pre-operative radiation			9.0	.003*
Yes				
No	135 (45.9)	120 (34.3)		
	159 (54.1)	230 (65.7)		
Post-operative radiation			0.2	.624
Yes				
No	31 (10.7)	33 (9.5)		
	260 (89.3)	315 (90.5)		
Smoker			0.1	.730
Yes	20 (6.6)	21 (6.0)		
No	282 (93.4)	331 (94.0)		
Diabetic			0.6	.426
Yes	12 (4.0)	10 (2.9)		
No	288 (96.0)	339 (97.1)		
History of pregnancy			0.9	.343
Yes				
No	170 (84.6)	227 (87.6)		
	31 (15.4)	32 (12.4)		

Unilateral vs. bilateral	252 (82.9) 52 (17.1)	269 (76.0) 85 (24.0)	4.7	.030
Timing			2.2	.331
Immediate	217 (71.6)	246 (69.5)		
Delayed	84 (27.7)	101 (28.5)		
Both	2 (0.7)	7 (2.0)		
Mesh			3.7	.053
Yes	119 (39.1)	113 (31.9)		
No	185 (60.9)	241 (68.1)		
Suture			8.9	.012
Absorbable	17 (5.6)	13 (3.7)		
Non-Absorbable	110 (36.3)	95 (27.1)		
Both	176 (58.1)	243 (69.2)		
msf-TRAM				
Variable	**Non-responders (N=170) - Mean (SD)**	**Responders (N=123) Mean (SD)**	**F**	**P**
Age at surgery	49.0 (8.0)	50.5 (7.8)	2.7	.102
Length of follow-up (months)	61.6 (24.6)	61.0 (23.7)	0.1	.828
BMI	29.0 (5.0)	27.7 (4.5)	5.1	.025
Variable	**Non-responders - n (%)**	**Responders - n (%)**	**X^2**	**P**
Pathology			2.6	.452
Invasive	112 (67.9)	84 (69.4)		
In situ	47 (28.5)	29 (24.0)		
Prophylactic	6 (3.6)	7 (5.8)		
Noncancerous	0 (0)	1 (0.8)		
History of abdominal surgery			0.2	.661
Yes	71 (45.5)	51 (42.9)		
No	85 (54.5)	68 (57.1)		
Chemotherapy			0.2	.678
Yes	85 (50.0)	64 (52.5)		
No	85 (50.0)	58 (47.5)		
Pre-operative chemotherapy			0.1	.943
Yes				
No	62 (36.5)	44 (36.1)		
	108 (63.5)	78 (63.9)		

Post-operative chemotherapy			0.9	.346
Yes				
No	25 (14.7)	23 (18.9)		
	145 (85.3)	99 (81.1)		
Radiation			2.3	.132
Yes	82 (48.2)	48 (39.3)		
No	88 (51.8)	74 (60.7)		
Pre-operative radiation			2.4	.125
Yes				
No	78 (45.9)	45 (36.9)		
	92 (54.1)	77 (63.1)		
Post-operative radiation			0.2	.633
Yes	4 (2.4)	4 (3.3)		
No	166 (97.6)	118 (96.7)		
Smoker			1.4	.234
Yes	7 (4.1)	9 (7.3)		
No	163 (95.9)	114 (92.7)		
Diabetic			0.5	.486
Yes	10 (5.9)	5 (4.1)		
No	160 (94.1)	118 (95.9)		
History of pregnancy			0.1	.912
Yes	125 (84.5)	96 (85.0)		
No	23 (15.5)	17 (15.0)		
Unilateral vs. bilateral	113 (66.5)	72 (58.5)	1.9	.165
	57 (33.5)	51 (41.5)		
Timing			0.2	.910
Immediate	111 (65.7)	79 (64.2)		
Delayed	56 (33.1)	43 (35.0)		
Both	2 (1.2)	1 (0.8)		
Mesh			1.6	.212
Yes	87 (51.2)	72 (58.5)		
No	83 (48.8)	51 (41.5)		
Suture			0.1	.951
Absorbable	11 (6.5)	7 (5.8)		
Non-Absorbable	60 (35.5)	42 (34.7)		
Both	98 (58.0)	72 (59.5)		
f-TRAM				

Variable	Non-responders (N= 70) Mean (SD)	Responders (N=73) Mean (SD)	F	P
Age at surgery	46.3 (7.6)	49.3 (7.6)	5.8	.018
Length of follow-up (months)	90.6 (35.8)	83.5 (37.6)	1.2	.275
BMI	27.6 (5.1)	28.8 (5.3)	2.0	.162
Variable	**Non-responders (N= 70) Mean (SD)**	**Responders (N=73) Mean (SD)**	**X^2**	**P**
Pathology			0.9	.645
Invasive	45 (64.3)	41 (56.9)		
In situ	22 (31.4)	28 (38.9)		
Prophylactic	3 (4.3)	3 (4.2)		
Noncancerous	0 (0)	0 (0)		
History of abdominal surgery			0.02	.888
Yes	35 (52.2)	39 (53.4)		
No	32 (47.8)	34 (46.6)		
Chemotherapy			0.7	.403
Yes	33 (47.1)	39 (54.2)		
No	37 (52.9)	33 (45.8)		
Pre-operative chemotherapy			0.7	.398
Yes				
No	20 (28.6)	25 (35.2)		
	50 (71.4)	46 (64.8)		
Post-operative chemotherapy			1.4	.234
Yes	12 (17.1)	18 (25.4)		
No	58 (82.9)	53 (74.6)		
Radiation			0.3	.556
Yes	27 (38.6)	24 (33.8)		
No	43 (61.4)	47 (66.2)		
Pre-operative radiation			1.9	.171
Yes	23 (32.9)	16 (22.5)		
No	47 (67.1)	55 (77.5)		
Post-operative radiation			1.4	.237
Yes	4 (5.7)	8 (11.3)		
No	66 (94.3)	63 (88.7)		
Smoker			1.8	.174
Yes	7 (10.0)	3 (4.2)		

No	63 (90.0)	69 (95.8)		
Diabetic			--	--
Yes	0 (0)	0 (0)		
No	70 (100)	72 (100)		
History of pregnancy			0.4	.517
Yes	58 (89.2)	59 (85.5)		
No	7 (10.8)	10 (14.5)		
Unilateral vs. bilateral	56 (80.0)	57 (78.1)	0.1	.778
	14 (20.0)	16 (21.9)		
Timing			2.3	.320
Immediate	53 (75.7)	50 (68.5)		
Delayed	16 (22.9)	23 (31.5)		
Both	1 (1.4)	0 (0)		
Mesh			1.1	.286
Yes	26 (37.1)	21 (28.8)		
No	44 (62.9)	52 (71.2)		
Suture			1.1	.582
Absorbable	1 (1.4)	0 (0)		
Non-Absorbable	18 (25.7)	20 (27.4)		
Both	51 (72.9)	53 (72.6)		