Published in final edited form as:
Plast Reconstr Surg. 2012 November ; 130(5): 991–1000. doi:10.1097/PRS.0b013e318267efc5.

The Advantages of Free Abdominal-Based Flaps Over Implants for Breast Reconstruction in Obese Patients

Patrick B Garvey, M.D., **Mark T Villa, M.D.**, **Alexander T Rozanski, B.S.**, **Jun Liu, M.D., M.S.**, **Geoffrey L Robb, M.D.**, and **Elisabeth K Beahm, M.D.**
Department of Plastic Surgery, The University of Texas MD Anderson Cancer Center, Houston, Texas

Abstract

BACKGROUND—We hypothesized that for obese patients, abdominal-based free flap, rather than implant-based, and delayed, rather than immediate, breast reconstruction would result in fewer overall complications and reconstruction losses.

METHODS—We retrospectively analyzed consecutive implant- and abdominal-based free-flap breast reconstructions performed in obese patients between 2005 and 2010 utilizing the World Health Organization obesity classifications: class I (30.0–34.9 kg/m^2), class II (35.0–39.9 kg/m^2), and class III (≥40 kg/m^2). Primary outcome measures included flap failures and overall complications. Logistic regression analysis identified associations between patient, defect, and reconstructive characteristics and surgical outcomes.

RESULTS—The analysis included 990 breast reconstructions (548 flaps vs. 442 implants) in 700 patients. Mean follow-up was 17 months. Age ($p<0.01$), smoking ($p=0.02$), medical illness ($p=0.01$), and BMI>37 ($p=0.01$) predicted overall complications on regression analysis. Implants demonstrated a higher failure rate (15.8%) than flaps (1.5%; $p<0.001$). While failure rates were similar for immediate and delayed flap reconstructions overall (1.3% vs. 1.9%; $p=0.7$) and among obesity classifications, there was a trend toward more implant failures in immediate rather than delayed reconstructions (16.8% vs. 5.3%; $p=0.06$). Differences between immediate implant versus flap reconstruction failure rates were highest among more obese patients (class II [24.7% vs. 1.3%, respectively; $p<0.01$] and class III [25.4% vs. 0%, respectively; $p<0.01$] compared to class I [11.7% vs. 1.4%, respectively; $p<0.01$]).

CONCLUSIONS—Obese patients, particularly patients with class II and III obesity, experience higher failure rates with implant-based breast reconstruction, particularly immediate reconstruction. Free flap techniques or delayed implant reconstruction may be warranted in this population.

INTRODUCTION

Obese patients experience higher rates of wound-related complications and reconstructive failure than nonobese patients following breast reconstruction.[1–10] Given the increasing prevalence of obesity in the Western population, plastic surgeons are more frequently asked

Corresponding author: Patrick B. Garvey, M.D., Department of Plastic Surgery - Unit 1488, The University of Texas MD Anderson Cancer Center 1400 Pressler Street, Houston, Texas 77030, pbgarvey@mdanderson.org.

Financial Disclosure: None of the authors has a financial interest associated with this publication.

to provide breast reconstruction for this challenging population.[11] Studies have compared outcomes in breast reconstruction between obese and non-obese patients based on patients' body mass index (BMI), but few studies have addressed differences in outcomes according to increasing obesity severity.[7,8,12] To better stratify patients' medical risks according to the degree of obesity, the World Health Organization (WHO) has sub-classified the definition of obesity: class I/obese (30.0–34.9 kg/m^2), class II/morbidly obese (35.0–39.9 kg/m^2), and class III/superobese (≥40 kg/m^2).[13–15] The effects of increasing obesity on both patient health and the outcomes of other surgical procedures suggest that outcomes in breast reconstruction need to be similarly stratified.[7,12–19]

Few studies have evaluated breast reconstruction outcomes according to obesity classification or compared the outcomes of implant and flap reconstruction in the obese.[7–9,12,20,21] Our experience with breast reconstruction in the obese patient population led us to hypothesize that, for obese patients, abdominal-based free flap breast reconstruction, rather than implant-based reconstruction, and delayed, rather than immediate, breast reconstruction would result in fewer overall complications and reconstruction losses following skin-sparing mastectomy.

PATIENTS AND METHODS

We retrospectively reviewed a prospectively maintained database of consecutive implant and abdominal-based free flap breast reconstructions performed in obese patients (BMI≥30 kg/m^2) at a single center between 2005 and 2010. Implant reconstructions (saline and silicone) included direct-to-implant reconstructions and 2-stage tissue expander plus implant reconstructions. Flaps were classified in a standard fashion as muscle-sparing free transverse rectus abdominis musculocutaneous (MS FTRAM), deep inferior epigastric artery perforator (DIEP), or superficial inferior epigastric artery (SIEA) flaps.[22–24] We excluded patients who were not obese (BMI<30 kg/m^2), in whom the reconstruction was performed with a technique other than implant only or abdomen-based free flap, who had a "delayed-delayed" or "delayed-immediate" breast reconstruction, and who underwent latissimus dorsi– or gluteus-based flap reconstructions.[25–28]

Differences in outcomes were evaluated for implant versus flap reconstructions and immediate versus delayed reconstructions. Subset analysis evaluated patients subclassified into three groups according to the WHO obesity classifications (Figure 1).[13–15,18] Patient, treatment, defect, and reconstruction outcome data were analyzed and directly compared between patient groups. Outcome measures included the effect of BMI on overall and specific surgical complications. We also plotted each patient's BMI relative to the overall complication rate to identify any infection points along the curve where the complication rates increased.

Complications evaluated included loss of the reconstruction (defined as the need to remove the reconstruction)[29], as well as the following specific complications: breast wound complications (infection, delayed healing, skin dehiscence, hematoma/seroma), mastectomy skin necrosis, perfusion-related complications (fat necrosis, partial flap necrosis), implant-related complications (malposition, rippling), microvascular complications (arterial thrombosis, venous thrombosis), compromised integrity of the abdominal wall (bulge, hernia, umbilical necrosis), and abdominal wound complications (infection, delayed healing, skin dehiscence, hematoma/seroma).

Skin dehiscence was defined as a separation of the incision ≥0.5 cm. Delayed healing was a wound requiring debridement and healing by secondary intention. Infection was an infectious process (cellulitis/abscess) treated with intravenous or oral antibiotics with/

without surgery. Hematoma and seroma were subcutaneous collections of blood or serous fluid, respectively, which required percutaneous or operative drainage. Abdominal hernia and bulging were contour deformities noted on physical examination with or without a fascial defect, respectively.[30] Fat necrosis was a palpable firmness ≥1 cm in diameter that persisted beyond 3 months postoperatively. Partial flap necrosis was necrosis of the flap skin island and underlying fat.[31] For the purpose of this evaluation, fat necrosis and partial flap necrosis, as well as hernia and bulging, were considered mutually exclusive complications. The presence of fat necrosis or partial flap necrosis was determined by clinical examination and radiographic and/or pathologic confirmation. The decision to image and/or biopsy a palpable firmness was made at the surgeons' and/or oncologists' clinical discretion. Patients were followed postoperatively at least monthly after discharge for 6 months, every 3–6 months until 1 year, and then at least yearly thereafter.

Statistical Analysis

Means and standard deviations were used to summarize continuous variables. Frequencies and proportions were used to present the categorical clinical characteristics. A two-tailed Fisher's exact test was used to test associations between categorical variables. The Wilcoxon rank sum test or Kruskal-Wallis test was used to compare ordinal variables among patient groups. A correlated logistic regression model was used to determine the association between the overall complication rate and demographic or clinical characteristics. A stepwise model selection method was used to fit a multivariate regression model. All tests were two-sided. A p-value of <0.05 was considered significant.[32] The analyses were performed in SAS 9.2 (SAS Institute Inc., Cary, NC) and R (The R Foundation for Statistical Computing). A senior staff biostatistician (J.L.) performed all statistical analyses.

RESULTS

A total of 990 breast reconstructions in 700 obese patients were analyzed. Abdominal-based free flaps were used in 548 reconstructions and implants were used in 442 reconstructions. Mean follow-up was 17 months (range, 3–118 months). Mean age was 50 years (range, 26–78 years). The average BMI was 34.5 kg/m^2 (range, 30.0–58.6 kg/m^2). The majority of the patients had class I obesity (N=483, 69%), followed by class II obesity (N=154, 22%) and class III obesity (N=63, 9%).

Patients' characteristics were noted to vary by reconstruction type (Table 1). More of the patients in the implant group had class II or class III obesity compared to the flap group ($p<0.01$). Patients in the implant group were older, more obese, and had higher incidences of coronary artery disease, diabetes mellitus, and hypertension than patients in the flap group. A higher percentage of patients in the implant group received postoperative chemotherapy and a lower percentage received preoperative radiation therapy and chemotherapy compared with the flap group.

Overall and Obesity Group Differences in Surgical Technique for Implants vs. Flaps

The majority of the reconstructions performed were immediate (793, 80.1%). More of the delayed reconstructions were flap, compared with implant, reconstructions (29.0% vs. 8.6%; $p>0.01$) (Table 2). More of the bilateral reconstructions were implant rather than flap reconstructions (63.1% vs. 56.0%; $p=0.03$).

The different types of flap procedures (DIEP, SIEA, and MS FTRAM) were performed with similar frequency among the obesity classifications, except that class I obesity patients underwent MS1 FTRAM reconstruction more often than the other two obesity groups (Table

3). There were no differences in the choice of recipient vessels or the use of mesh reinforcement of the abdominal wall closure among the obesity classification groups.

In the implant reconstruction patients, there did not appear to be any obesity group differences with respect to reconstructive strategy (i.e. tissue expanders vs. direct-to-implant), reconstructive technique (i.e. total submuscular vs. dual plane vs. acellular dermal matrix [ADM]), type of ADM used, or time to tissue expander exchange for a permanent implant (Table 4). There were no differences in the initial tissue expander fill volume among the groups, but the initial expander size and final size of the permanent implant did increase with increasing obesity classification. The time to removal of the last surgical drain was shorter for the class I obesity patients (21 ± 9 days) than for the class II (25 ± 17 days) and class III (25 ± 14 days) obesity patients (p=0.02).

Overall Complication Rates for Implants vs. Flaps in Obese Patients

The overall complication rate for breast reconstruction in our study was 39.5%. There were more complications in the flap reconstruction group (42.3%) than in the implant reconstruction group (35.9%; p=0.04) (Table 5). Reconstruction loss was significantly more frequent in the implant (15.8%) compared to the flap (1.5%; p<0.001) reconstructions. Implants demonstrated higher rates of infection (11.3% vs. 3.8%; p<0.001) and hematoma/seroma (13.8% vs. 4.9%; p<0.001) compared to flaps. The flap group demonstrated higher rates of delayed wound healing than did the implant group (7.5% vs. 4.3%; p=0.01).

The implant and flap reconstruction groups required additional surgery for complications (25.3% vs. 21.7%; p=0.20, respectively) and to improve symmetry (54.3% vs. 60.2%; p=0.07, respectively) at similar rates. More of the flap reconstructions underwent nipple reconstruction than did the implant reconstructions (39.2% vs. 11.3%; p<0.001). Sixty-three percent of the implant reconstructions underwent a tissue expander exchange for an implant. Of the seven total flap losses in the study, six (85.7%) of the patients eventually underwent a second reconstruction attempt (3 tissue expander/implants, 2 latissimus dorsi/implant, and 1 latissimus dorsi alone). However, only 10 (14.3%) of the 70 patients with implant reconstruction losses eventually underwent a second reconstruction attempt (9 tissue expander/implants and 1 latissimus dorsi alone). The difference in second breast reconstruction attempts between flap and implant reconstructions was statistically significant (p=0.0002).

Complications for Implants vs. Flaps by Obesity Classification

Patients with class I obesity demonstrated overall complication rates that were significantly higher for flaps (42.3%) than for implants (31.6%; p<0.01) (Table 6). Flap and implant reconstructions demonstrated similar rates of overall complications in class II (40.9% vs. 44.8%; p=0.59) and class III (46.8% vs. 40.0%; p=0.68) patients. Fewer flap than implant reconstructions were lost for all three obesity classifications.

Immediate and delayed flap reconstructions experienced similar rates of overall complications and flap losses (Table 7). While we did see higher rates of implant losses among the immediate vs. delayed implant reconstructions for all obesity classifications, these differences were not statistically significant.

Complications for Implants vs. Flaps by BMI

When the overall complication rate was analyzed with respect to BMI, inflection points for both the implant and flap groups were demonstrated at BMI≥37 kg/m^2 (Figure 2). When patients were then grouped into two cohorts, BMI<37 kg/m^2 and BMI≥37 kg/m^2, the overall

complication rate was significantly higher for the population with BMI≥37 kg/m^2 (47.1% vs. 37.4%, respectively; p=0.01).

Among the BMI<37 kg/m^2 patients, the implant reconstruction group had a significantly lower overall complication rate compared with the flap reconstruction group (31.2% vs. 41.3%, respectively; p<0.01). However, among the BMI≥37 kg/m^2 patients, the overall complication rates were equivalent between the implant and flap reconstructions (46.4% vs. 48.6%, respectively; p=0.77). Implant loss rates were significantly higher than flap loss rates for both of these BMI groups, with the difference being more pronounced in the BMI≥37 kg/m^2 group (24.6% vs. 2.7%; p<0.001) than in the BMI<37 kg/m^2 group (11.8% vs. 1.3%; p<0.01) (Table 8).

Factors Predictive of Complications

Regression analysis demonstrated age (p<0.01), active smoking (p=0.02), BMI>37 (p=0.01), and the presence of at least one medical co-morbidity (p=0.01) to be risk factors for overall complications among all patients, irrespective of type of reconstruction. Subgroup analysis of the implant patients demonstrated greater expander size and final expander fill volume to be significantly associated with complications (p<0.01 for both factors). Subset regression analysis of the flap reconstruction group failed to demonstrate additional factors associated with overall complications.

DISCUSSION

In this largest study to date evaluating outcomes following breast reconstruction in obese patients, we had hypothesized higher complication rates for implant reconstructions in comparison to abdominal flap reconstructions. However, what we actually observed was a higher overall complication rate for flap reconstructions (p=0.04) and a higher reconstruction loss rate for implant reconstructions (p<0.001). This observed difference in the reconstruction loss rate was more pronounced for class II and class III obesity patients than for class I obesity patients. In contradistinction to implant loss rates, flap loss rates remained similar irrespective of increasing obesity classification (p=0.803). The timing of the reconstruction also played an important role in the outcomes of our obese patients, although not exactly as we had hypothesized. Whereas the rates of overall complications and reconstruction losses were similar for the immediate vs. delayed flap reconstruction patients overall and by obesity classification, the majority of the implant reconstruction losses occurred in the immediate tissue expander plus implant reconstructions.

Previous studies have demonstrated a higher risk of reconstruction failure for both abdominal-based free flaps and implants in obese patients compared to nonobese patients.[2,8,10] A 2008 study evaluating 1170 tissue expander plus implant reconstructions at a single center demonstrated that the 108 obese patients (BMI>30 kg/m^2) in the study had more complications and reconstructive failures than the nonobese patients.[10] A 2000 study compared the outcomes of free TRAM flaps in 64 obese patients (BMI≥30 kg/m^2) to those in 442 normal weight (BMI=18.5–24.9 kg/m^2) and 212 overweight (BMI=25–29.9 kg/m^2) patients and found the obese patients had higher rates of overall flap and donor site complications and total flap loss.[2] Neither of these studies performed subgroup comparisons to try to identify whether any particular class of obesity or BMI level experienced more complications, nor did they directly compare outcomes between implant and flap reconstruction in the obese.

A 2011 study retrospectively reviewed the outcomes of abdominal-based free flap breast reconstruction performed in 25 patients with class III obesity (BMI≥40 kg/m^2) compared to 379 patients whose BMI was less than 40 kg/m^2.[8]. Two (8%) of the 25 class III obesity

patients suffered total flap loss, compared to the 0.5% flap loss rate for the control group (p=0.02); the authors concluded that flap failure is significantly more common among patients with class III obesity. However, to reach this conclusion, superobese patients were compared to a control group comprised of not only obese and morbidly obese patients but also normal weight (BMI=18.5–24.9 kg/m^2) and overweight (BMI=25–29.9 kg/m^2) patients. When this 2011 study analyzed flap failures by BMI category, the authors found no significant difference in flap loss rates between any of the BMI groups (i.e., normal weight, overweight, obese, morbidly obese, or superobese), which is similar to what we observed in our study. As in our study, delayed wound healing of the donor site incision was also more common among the superobese, whereas the abdominal hernia rate was similar. This study also had fewer obese patients than our study and did not evaluate outcomes for implant reconstruction.

For our study, we directly compared implant to flap reconstruction in the obese; however, direct comparison between specific complications in these two groups is not possible. As such, we selected overall complications and loss of the reconstruction as our primary outcome measures for comparison. The metric of overall complications includes both donor and recipient site complications for flaps, yet only includes recipient site complications for implants. Multiple studies have demonstrated patients' quality of life and satisfaction with their breast reconstruction to be less favorable if they have a complication, irrespective of whether it is at the recipient or donor site.[33–37] Interestingly, among the very obese (class II and III obesity) in our study, the overall complication rate for one surgical site in the implant patients was equivalent to the overall complication rate for two surgical sites in the flap patients.

Previous studies have reported rates of premature tissue expander removal ranging between 1.8% and 5.7% for all patients, regardless of obesity status.[10,20,38–41] Such studies have demonstrated conflicting conclusions regarding the effects of obesity (BMI>30 kg/m^2) on implant failure rates and have not analyzed differences in outcomes according to increasing BMI.[10,39] Implant loss rates for non-obese patients have been reported to be similar for both immediate and delayed implant breast reconstructions,[20] but no study, to our knowledge, has evaluated the effect of timing on reconstruction outcomes among obese patients. While implant loss may be perceived as a less significant complication than the loss of a free flap, any reconstructive loss is a tremendous psychological setback.[34,36] This is highlighted by our finding that only 14.3% of the implant patients vs. 85.7% of the flap patients who lost their reconstruction ultimately chose to undergo a second attempt at breast reconstruction. Unfortunately, the retrospective design of our study prevents our discovering whether this discrepancy reflects differences in patient- or surgeon-driven decision-making, as the patients who elected to undergo the added initial morbidity of free flap breast reconstruction may simply have represented a self-selected group that was more motivated with regard to breast reconstruction in general. Given the known psychological implant of a reconstruction failure, our surgeons do go to great lengths to try to salvage both failing free flaps and implants. For implants, this may entail intravenous antibiotics, operative washouts, or implant replacement.[42]

We believe our data support flap reconstruction over implant reconstruction for class II and III obesity patients; however, some patients simply either refuse flap reconstruction, are not healthy enough for the prolonged anesthesia times associated with flap reconstruction, or have an overhanging abdominal pannus sizable enough to preclude an abdominal flap reconstruction. Our findings suggest that such patients with class II and III obesity who seek implant reconstruction may be better served with a standard mastectomy followed by a delayed, rather than immediate, implant reconstruction, ideally after successful completion of a medically supervised weight reduction program. Alternatively, latissimus dorsi flap

reconstruction or a staged implant-based reconstruction after initial reduction mammoplasty may prove to be more attractive strategies to traditional delayed reconstruction in these patients, but our data can neither support nor refute these approaches, as we lacked sufficient numbers of such patients to include them in this study and produce meaningful data.[43,44]

The strengths of our study include the large number of breast reconstructions performed by multiple surgeons using similar techniques at a single center, careful study design to compare morbidity among obese patients stratified by BMI, data obtained from a prospectively entered patient database, and regression analyses. Study limitations include its retrospective design, potential surgeon selection bias affecting the reconstruction choice, exclusion of other forms of breast reconstruction such as latissimus dorsi– or gluteal-based flap reconstruction, lack of comparative aesthetic outcomes data, and inability to analyze for patients' fat distribution and body composition.[45]

CONCLUSIONS

We hope that the data presented will enable surgeons to optimally guide the reconstructive choices (flap vs. implant and immediate vs. delayed breast reconstruction) of obese patients. Although obese patients represent a higher surgical risk group than normal weight patients, obesity is not an absolute contraindication to breast reconstruction.[1,2,4,7,8] However, our data emphasize the importance of choosing the correct reconstructive strategy for this elevated-risk patient population, especially when also presenting with advanced age, active smoking, BMI>37, or medical co-morbidities. The greater failure rates for implants versus flaps in this population and the consequences of reconstruction failure with respect to patients choosing to undergo a second attempt at breast reconstruction suggest that strong consideration should be given to performing flap- rather than implant-based breast reconstruction in the obese, particularly patients with class II and III obesity, and that a delayed rather than immediate reconstruction be considered an option for obese patients seeking implant-based breast reconstruction.

Acknowledgments

Financial Support: This research was supported in part by the National Institutes of Health through MD Anderson's Cancer Center Support Grant CA016672.

The authors wish to recognize former and current members of the Department of Plastic Surgery at The University of Texas MD Anderson Cancer Center for their support and/or contribution of patients to this series: Drs. David M. Adelman, Donald P. Baumann, Charles E. Butler, David W. Chang, Melissa A. Crosby, Matthew M. Hanasono, Steven J. Kronowitz, Scott D. Oates, Gregory P. Reece, Jesse C. Selber, and Roman J. Skoracki, and former colleagues Drs. Bonnie J. Baldwin, Pierre M. Chevray, Mennen T. Gallas, Lior Heller, Stephen S. Kroll, Howard N. Langstein, Michael J. Miller, and Justin M. Sacks. The authors also thank Dawn Chalaire from The University of Texas MD Anderson Cancer Center, Department of Scientific Publications for assistance with scientific editing. Lastly, the authors would like to acknowledge the hard work and dedication of our fellows and residents who helped with these cases.

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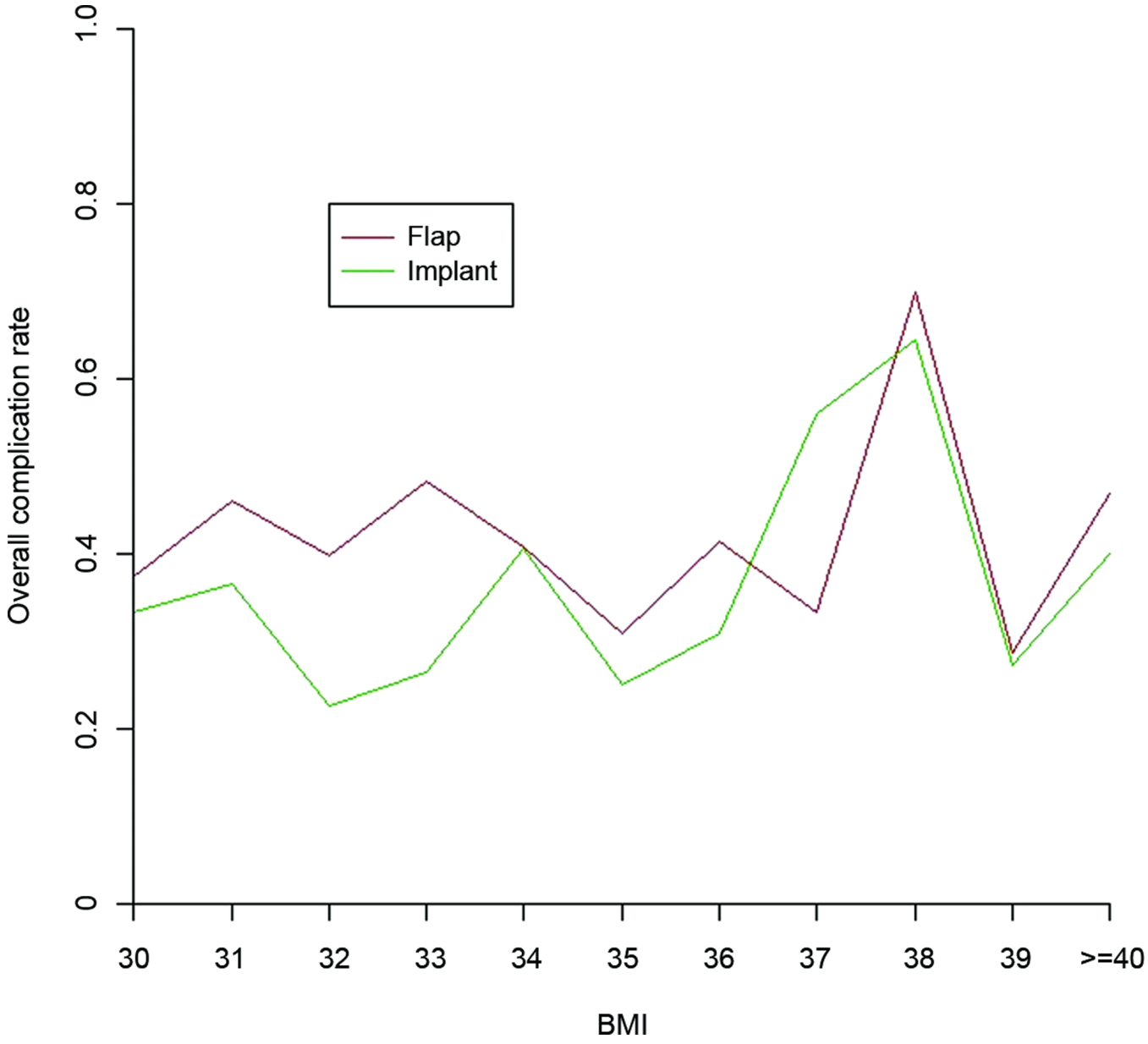

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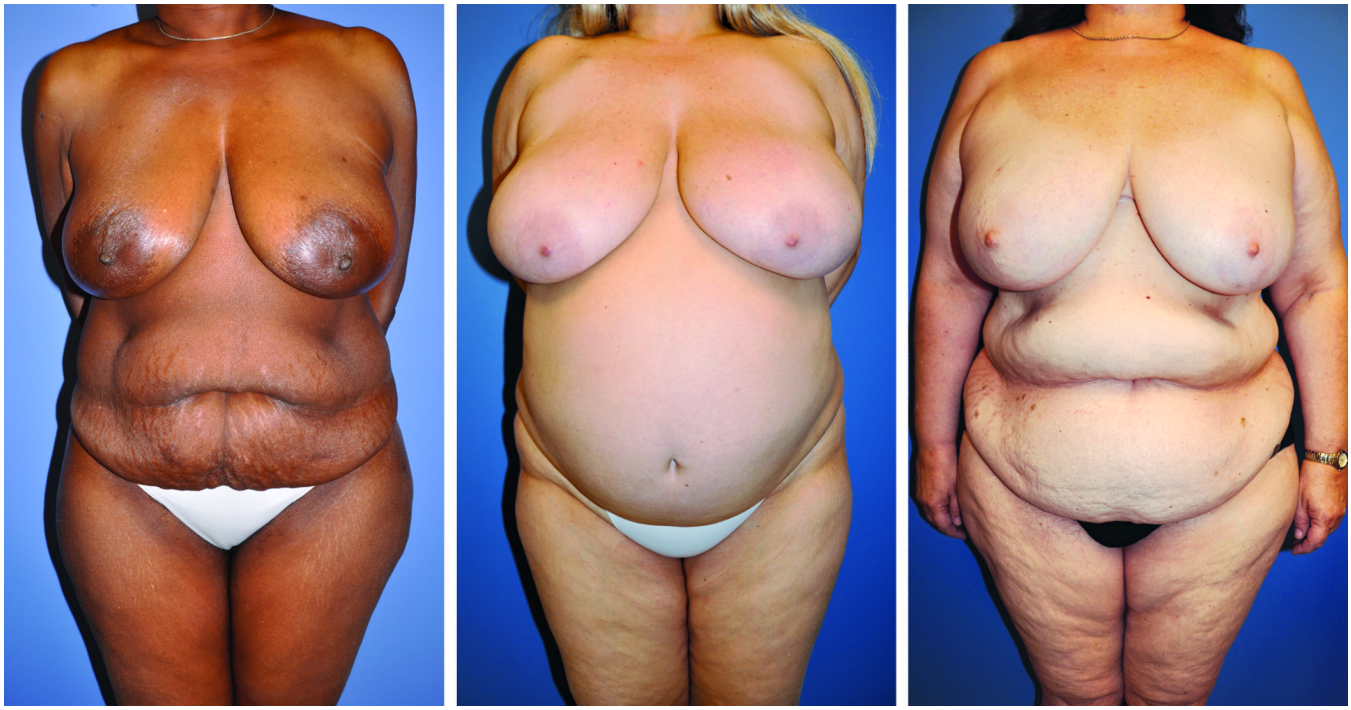

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Table 1

Patient Characteristics by Reconstruction Type

Characteristics	Implant N= 442	Flap N=548	P-value
Age (years)	52.2 ± 10.3	48.9 ± 8.9	<**0.01**
BMI	35.3 ± 4.9	33.9 ± 3.8	<**0.001**
Length of Follow-up (months)	17.4 ± 19.7	17.8 ± 18.7	0.74
Obesity Classification			
Class I (Obese)	275 (62.2%)	406 (74.1%)	
Class II (Morbidly Obese)	107 (24.2%)	110 (20.1%)	
Class III (Superobese)	60 (13.6%)	32 (5.8%)	<**0.01**
Pre-op Chemo	130 (29.4%)	287 (52.4%)	<**0.01**
Pre-op XRT	16 (3.6%)	170 (31%)	<**0.01**
Post-op Chemo	58 (13.1%)	39 (7.1%)	<**0.01**
Post-op XRT	49 (11.1%)	34 (6.2%)	**0.01**
Co-morbidity			
Coronary Artery Disease	18 (4.1%)	7 (1.3%)	0.01
Diabetes Mellitus	66 (14.9%)	33 (6%)	<**0.01**
Alcohol Abuse	0 (0%)	27 (7.5%)	<**0.01**
HTN	161 (36.4%)	161 (29.4%)	**0.02**
Pulmonary Disease	18 (4.1%)	12 (2.2%)	0.10
Smoking			
Non-smoker	417 (94.3%)	519 (94.7%)	
Active Smoker	25 (5.7%)	29 (5.3%)	0.89
Medical Illnesses			
None	181 (41%)	287 (52.4%)	
One	152 (34.4%)	177 (32.3%)	
Two or more	109 (24.7%)	84 (15.3%)	<**0.01**

BMI, body mass index; XRT, radiation therapy; HTN, hypertension

Table 2

Surgical Characteristics by Reconstruction Type

Characteristics	Implant N=442	Flap N=548	P value
Timing			
Immediate	404 (91.4%)	389 (71.0%)	
Delayed	38 (8.6%)	159 (29.0%)	**<0.01**
Laterality			
Unilateral	163 (36.9%)	241 (44.0%)	
Bilateral	279 (63.1%)	307 (56.0%)	**0.03**
Side			
Right	215 (48.6%)	274 (50.0%)	
Left	227 (51.4%)	274 (50.0%)	0.70

Table 3

Flap Reconstruction Characteristics by Obesity Classification

Characteristics	Total N=548	Class I N=406	Class II N=110	Class III N=32	P value
Flap Type					
DIEP	162 (29.6%)	120 (29.6%)	35 (31.8%)	7 (21.9%)	
SIEA	34 (6.2%)	25 (6.2%)	4 (3.6%)	5 (15.6%)	
MS FTRAM	352 (64.2%)	261 (64.2)	71 (64.6%)	20 (62.5%)	0.20
MS0 FTRAM	33 (9.4%)	23 (8.8%)	8 (11.3%)	2 (10.0%)	
MS1 FTRAM	69 (19.6%)	61 (23.4%)	5 (7.0%)	3 (15.0%)	
MS2 FTRAM	181 (51.4%)	126 (48.3%)	43 (60.6%)	12 (60.0%)	**0.02**
Unknown	69 (19.6%)	51 (19.5%)	15 (21.2%)	3 (15.0%)	
Recipient Vessels					
Internal Mammary	490 (89.4%)	355 (87.4%)	103 (93.6%)	32 (100%)	
Thoracodorsal	52 (9.5%)	46 (11.3%)	6 (5.5%)	0 (0%)	
Other Vessels	6 (1.1%)	5 (1.2%)	1 (0.9%)	0 (0%)	0.86
Donor Site Closure					
Primary Closure	451 (82.3%)	332 (81.8%)	92 (83.6%)	27 (84.4%)	
Mesh Closure	97 (17.7%)	74 (18.2%)	18 (16.4%)	5 (15.6%)	0.92
Prosthetic	89 (91.7%)	69 (93.2%)	17 (94.4%)	3 (60.0%)	
Bio-prosthetic	8 (8.3%)	5 (6.8%)	1 (5.6%)	2 (40.0%)	0.06

DIEP, deep inferior epigastric artery perforator; SIEA, superficial inferior epigastric artery; MS FTRAM, muscle-sparing free transverse rectus abdominis musculocutaneous

Table 4

Implant Reconstruction Characteristics by Obesity Classification

Variable	Total N =442	Class I N=275	Class II N=107	Class III N=60	P value
Strategy					
Direct to Implant	15 (3.4%)	9 (3.3%)	6 (5.6%)	0 (0%)	
Staged TE Implant	427 (96.6%)	266 (96.7%)	101 (94.4%)	60 (100%)	0.16
Reconstruction Technique					
Total Submuscular	206 (46.6%)	134 (48.7%)	44 (41.1%)	28 (46.7%)	
Dual Plane	130 (29.4%)	74 (26.9%)	32 (29.9%)	24 (40%)	
Acellular Dermal Matrix	106 (24%)	67 (24.4%)	31 (29%)	8 (13.3%)	0.10
Human	69 (15.6%)	40 (14.5%)	22 (20.6%)	7 (11.7%)	
Bovine	19 (4.3%)	12 (4.4%)	7 (6.5%)	0 (0%)	
Porcine	14 (3.2%)	12 (4.4%)	1 (0.9%)	1 (1.7%)	
Other	4 (0.9%)	3 (1.1%)	1 (0.9%)	0 (0%)	0.17
Size of Expander	570 ± 137	530 ± 126	612 ± 133	677 ± 112	**<0.01**
Initial Fill Volume of Expander	236 ± 179	218 ± 162	262 ± 200	276 ± 205	0.09
Final Fill volume of Expander	665 ± 251	633 ± 220	731 ± 294	700 ± 285	**<0.001**
Size of Final Implant	702 ± 130	676 ± 120	721 ± 127	812 ± 135	**<0.01**
Time to TE Exchange for Implant	257 ± 209	246 ± 163	274 ± 292	285 ± 269	0.70
Time to Removal of Last Drain	22 ± 12.8	21 ± 9	25 ± 17	25 ± 14	**0.02**

TE, tissue expander

Table 5

Complication Rates by Reconstruction Type

Complications	Implant N=442	Flap N=548	P value
Overall Complications	159 (35.9%)	232 (42.3%)	**0.04**
Loss of Reconstruction	70 (15.8%)	8 (1.5%)	**<0.001**
Breast Wound–Related Complications			
Infection	50 (11.3%)	21 (3.8%)	**<0.001**
Delayed Healing	19 (4.3%)	41 (7.5%)	**0.01**
Skin Dehiscence	28 (6.3%)	25 (4.6%)	0.25
Hematoma/Seroma	61 (13.8%)	27 (4.9%)	**<0.001**
Mastectomy Skin Necrosis	58 (13.1%)	90 (16.4%)	0.15
Perfusion-related Complications			
Fat Necrosis	--	38 (6.9%)	--
Partial Flap Necrosis	--	21 (3.8%)	--
Implant-related Complications			
Implant Malposition	8 (1.8%)	--	--
Implant Rippling	4 (0.9%)	--	--
Microvascular Complications			
Arterial Thrombosis	--	6 (1.1%)	--
Venous Thrombosis	--	4 (0.7%)	--
Donor Site Complications			
Bulge	--	19 (3.5%)	--
Hernia	--	10 (1.8%)	--
Umbilical Necrosis	--	25 (4.6%)	--
Donor Site Wound-related Complications			
Delayed Wound Healing	--	34 (6.2%)	--
Skin Dehiscence	--	31 (5.7%)	--
Skin Necrosis	--	6 (1.1%)	--
Hematoma/Seroma	--	23 (4.2%)	--

Table 6

Complications for Implants vs. Flaps by Obesity Classification

Class I Obesity (BMI 30–34.9 kg/m^2)			
	Implant N=275	**Flap N=406**	**P value**
Overall Complications	87 (31.6%)	172 (42.3%)	**<0.01**
Loss of Reconstruction	31 (11.3%)	6 (1.5%)	**<0.01**
Class II Obesity (BMI 35-39.9 kg/m^2)			
	Implant N=107	Flap N=110	P value
Overall Complications	48 (44.8%)	65 (40.9%)	0.59
Loss of Reconstruction	25 (23.4%)	2 (1.8%)	**<0.01**
Class III Obesity (BMI ≥ 40 kg/m^2)			
	Implant N=60	Flap N=32	P value
Overall Complications	25 (40%)	15 (46.8%)	0.68
Loss of Reconstruction	14 (23.3%)	0 (0%)	**<0.01**

BMI, body mass index

Table 7

Complication Rates for Immediate vs. Delayed Flap vs. Implant Reconstruction in Obese Patients

	Class I	Class II	Class III
Overall Complications			
Flap			
Immediate	125/284 (44.0%)	28/78 (35.9%)	13/27 (48.2%)
Delayed	47/122 (38.5%)	17/32 (53.1%)	2/5 (40%)
P-value	0.32	0.13	>0.99
Implant			
Immediate	81/248 (32.6%)	46/101 (45.5%)	24/55 (43.6%)
Delayed	6/27 (22.2%)	2/6 (33.3%)	0/5 (0%)
P-value	0.38	0.69	**0.05**
Loss of Reconstruction>			
Flap			
Immediate	4/284 (1.4%)	1/78 (1.3%)	0/27 (0%)
Delayed	2/122 (1.6%)	1/32 (3.1%)	0/5 (0%)
P-value	>0.99	0.45	>0.99
Implant			
Immediate	29/248 (11.7%)	25/101 (24.7%)	14/55 (25.4%)
Delayed	2/27 (7.4%)	0/6 (0%)	0/5 (0%)
P-value	0.75	0.33	0.34

Table 8

Complications Rates for BMI < 37 kg/m^2 vs. BMI ≥ 37 kg/m^2

	Implant	Flap	P-value
Overall Complications			
BMI < 37 kg/m^2 N=778	95/304 (31.3%)	196/474 (41.4%)	**<0.01**
BMI ≥ 37 kg/m^2 N=212	64/138 (46.4%)	36/74 (48.9%)	0.77
Loss of Reconstruction			
BMI < 37 kg/m^2 N=778	36/304 (11.8%)	6/474 (1.3%)	**<0.01**
BMI ≥ 37 kg/m^2 N=212	34/138 (24.6%)	2/74 (2.7%)	**<0.001**

BMI, body mass index