

Microsurgical Breast Reconstruction in Thin Patients: The Impact of Low Body Mass Indices

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Abstract

Background The purpose of this investigation was to examine patients with low body mass index (BMI) regarding the feasibility to perform autologous breast reconstruction in such patients, as well as to determine optimal donor sites and evaluate outcomes accordingly.

Patients and Methods All patients undergoing microsurgical breast reconstruction were divided into three cohorts based on BMI. Group 1 included patients with BMI greater than or equal to 22 kg/m² and was defined “low-normal BMI.” Patients with BMI 22 to 25 kg/m² were placed in Group 2, labeled as “high-normal BMI.” Group 3, defined as “overweight,” included patients with BMI greater than 25 kg/m², but less than 30 kg/m². Patients were then analyzed based on demographics, breast cancer history, intraoperative details, complications, and revisionary surgeries. F-tests, chi-square goodness-of-fit tests, and Freeman–Halton extension of the Fisher exact tests were used for statistical analysis.

Results During the study period, a total of 259 reconstructions were performed. Group 1 included 30 patients ($n = 49$ flaps), Group 2 included 58 patients ($n = 98$ flaps), and Group 3 included 69 patients ($n = 112$ flaps). Patients undergoing nipple–areolar sparing mastectomy were more likely to be in Groups 1 (39% [$n = 19$]) and 2 (37% [$n = 37$]) as compared with Group 3 (14.2% [$n = 16$]) ($p < 0.001$) as compared with the overweight cohort. Patients with increasing BMI were more likely to undergo abdominally based free flaps as compared with alternative donor sites (Group 1 = 2.26, Group 2 = 7.9, Group 3 = 27 [$p < 0.001$]).

Conclusions Abdominally based free flaps are possible in the majority of patients, however alternative harvest sites have to be used more frequently in low BMI patients.

Keywords

- ▶ low BMI
- ▶ breast reconstruction
- ▶ thin

Patients undergoing autologous breast reconstruction have been shown to have higher overall rates of long-term satisfaction when compared with patients with implant-based reconstructions.^{1–5} While there is a national trend toward increasing rates of implant-based breast reconstructions, certain centers show microsurgical breast reconstruction is

being increasingly performed for both therapeutic and prophylactic indications.^{6–10} This rise in the use of autologous tissue for breast reconstruction is likely because of both an expanding spectrum of patients who are being offered free tissue transfer as well as an overall rising incidence breast reconstruction.

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Historically, the most common type of microvascular breast reconstruction performed has been abdominally based, including transverse rectus abdominus muscle (TRAM), muscle sparing transverse rectus abdominus muscle (MS-TRAM), superficial inferior epigastric artery (SIEA), and deep inferior epigastric perforator (DIEP) flaps.^{11–14} Conventionally, patients undergoing abdominally based reconstructions have an abundant abdominal tissue that allows for an adequate breast mound to be reconstructed. However, given increasing success with alternate donor site flaps (including profunda artery perforator [PAP], transverse upper gracilis [TUG] flap, superior gluteal artery perforator [SGAP], inferior gluteal artery perforator [IGAP], lateral femoral cutaneous circumflex artery perforator [LFCAP]), as well as success with autologous fat grafting, patients who were historically not considered candidates for microsurgical reconstruction, due to limited donor sites, may now be embraced.^{15–19}

Many authors have already demonstrated acceptable results when microsurgical breast reconstruction is performed in overweight, obese, or morbidly obese patients.^{20–27} Similarly, the effect of increased weight on surgical outcomes has also been demonstrated.²⁸ Patients with higher body mass index (BMI) are at increased risk of anesthetic complications, cardiovascular events, and respiratory sequelae.²⁹ While the relationship between higher BMI patients and surgical outcomes is well established, the relationship between low BMI patients, their eligibility for autologous breast reconstruction, and respective surgical outcomes has yet to be delineated.^{30–32}

The implications of examining the influence of low BMI in autologous breast reconstruction extends beyond just identifying a possible difference in complication profile and outcomes. This cohort of women poses some unique challenges. First, unlike higher BMI patients, the donor site availability, especially in nulliparous women, is often limited especially when considering the abdomen as a donor site. Second, matching a preoperatively large breasted woman requiring bilateral reconstruction can pose a challenge using microsurgical breast reconstruction alone. Finally, increasing breast size may be difficult in patients with minimal donor sites.

The authors examine their large volume experience with microsurgical breast reconstruction in lower BMI patients to determine optimal donor site and outcomes.

Patients and Methods

After obtaining Institutional Review Board approval (R S12–03035), all patients undergoing microsurgical breast reconstruction at the New York University Langone Medical Center between November 2007 and November 2011 were reviewed. Patients with BMI greater than or equal to 30 kg/m² were included for analysis in this investigation. Patients with BMI less than 30 kg/m² or no documented BMI were excluded from the investigation. All reconstructions were performed by six senior surgeons (P.S., B.A., C.A., M.C., J.P.L., and N.S.K.).

The National Institutes of Health categorizes BMI into different groups. Those with BMI less than 18.5 kg/m² are classified as “underweight,” whereas people with BMI

between 18.5 and 24.9 kg/m² are “normal weight.” If BMI is between 25 and 29.9 kg/m², then a patient is classified as “overweight.” “Obesity” is defined as BMI greater than or equal to 30 kg/m² (http://www.nhlbi.nih.gov/guidelines/obesity/e_txbk/txgd/411.htm).

From the selected group, patients with BMI less than 30 kg/m² were separated into three cohorts. Those patients in Group 1, labeled as “low normal,” had BMI between 18.5 and 22 kg/m². Women in Group 2, identified as “high normal,” had BMI between 22 and 25 kg/m². Finally, Group 3 patients, labeled as “overweight,” had BMI between 25 and 29.9 kg/m².

Reconstructions were compared based on age, incidence of unilateral/bilateral reconstructions, type of mastectomy, timing of reconstruction, indication for surgery (therapeutic/prophylactic), breast cancer stage, chemotherapy and radiation therapy history, mastectomy specimen weight, flap weight, and flap type. Complications were also analyzed and included both acute complications (arterial thrombosis, venous thrombosis, and hematoma) and long-term complications (fat necrosis, infection, and abdominal wall hernia). Revisionary surgeries were also examined and included breast revision, donor site revision, use of autologous fat grafting as an adjunct, and volume of autologous fat grafting.

Statistical analyses were descriptive (mean, standard error of mean, and range). When appropriate, F-tests, chi-square goodness-of-fit tests, and Freeman–Halton extension of the Fisher exact tests were used (FHE-FET).

Results

Between November 2007 and November 2011, 199 patients underwent 324 consecutive microsurgical breast reconstructions at New York University Langone Medical Center by six senior surgeons (P.S., B.A., C.A., M.C., J.P.L., and N.S.K.). Of the 199 patients, 42 (66 flaps) were excluded because they had a BMI less than 30 kg/m². Therefore, a total of 157 patients undergoing 259 flaps met inclusion criteria. The majority of patients ($n = 102$ [65%]) underwent bilateral reconstructions, whereas 55 patients (35%) had unilateral reconstructions.

The study group of women was divided into three groups based on BMI: Group 1 (“low-normal BMI” between 18.5 and 22 kg/m²) included 49 flaps in 30 patients, Group 2 (“high-normal BMI” between 22 and 25 kg/m²) constituted 98 flaps in 58 patients, and finally the largest cohort, Group 3 (“overweight BMI” between 25 and 29.9 kg/m²) had 112 flaps in 69 patients.

Demographics

The mean age of the patients in Group 1 was 44 ± 8.73 years, in Group 2 was 50 ± 8.66 years, and in Group 3 it was 51 ± 8.16 years. Statistical analysis (F-test) demonstrated that lower BMI patients were more likely to be younger in age ($p < 0.001$). The average BMI was 21 ± 1.07 kg/m² for Group 1, 24 ± 0.83 kg/m² for Group 2, and 27.3 ± 1.2 kg/m² for Group 3. There was a statistically significant difference among the groups when comparing BMI (F-test, $p < 0.001$).

The majority of flaps in all the three groups were performed for immediate reconstructions (Group 1 = 82%

[$n = 40$], Group 2 = 78% [$n = 76$], and Group 3 = 69% [$n = 77$]). No statistical difference was noted among the groups when considering timing of reconstruction (chi-square, $p = 0.15$). Patients undergoing nipple-areolar sparing mastectomy were more likely to be in Groups 1 (38% [$n = 19$]) and 2 (38% [$n = 37$]) as compared with Group 3 (14.2% [$n = 16$]) (chi-square, $p < 0.001$) (► **Table 1**).

Breast Cancer History

In all the three groups, microsurgical reconstruction was performed for both prophylactic and therapeutic indications. There was no statistically significant difference in the number of reconstructions following prophylactic indications (Group 1 = 53% [$n = 26$], Group 2 = 48% [$n = 47$], and Group 3 = 44% [$n = 49$]); (chi-square, $p = 0.54$). When the groups were compared for neoadjuvant or adjuvant radiation, there was no statistically significant difference in the groups (FHE-FET, $p > 0.92$). Similarly, no differences were found among the groups when looking at delivery of induction or adjuvant chemotherapy (chi-square, $p > 0.65$) (► **Table 2**).

Surgical Procedure

The authors offer the full spectrum of microsurgical breast reconstruction, including the deep inferior epigastric artery perforator (DIEP), the muscle-sparing transverse rectus abdominis muscle (MS-TRAM), SIEA, and stacked DIEP flaps. When abdominal tissue is not available or contraindicated, alternative flaps were performed including the PAP ($n = 12$ flaps, 14.1%), transverse upper gracilis (TUG, $n = 6$ flaps, 7.0%), or SGAP ($n = 1$ flap, 1.2%) flaps. However, the majority of flaps performed were abdominally based ($n = 66$ flaps, [77.6%]). Of these 66 flaps, 57 were DIEP flaps, 5 MS-TRAM flaps, 2 SIEA flaps, and 2 stacked DIEP flaps.

In the 49 flaps performed in the Group 1 cohort, 34 (69.4%) were abdominally based flaps (DIEP = 25, MS-TRAM = 8, stacked DIEP = 1). The remaining 15 (30%) were from alternative donor sites (PAP = 11, TUG = 3, and SGAP = 1). As such, the ratio of abdominally based flaps to flaps from alternative donor sites (abdominal/alternative flap ratio) in Group 1 was 2.26 (34/15).

Looking at Group 2, 87 (88%) flaps were from the abdomen (DIEP = 69, MS-TRAM = 15, stacked DIEP = 2, and SIEA = 1), whereas 11 (12%) were from alternative sites (PAP = 5 and TUG = 6). The abdominal/alternative flap ratio for Group 2 was 7.9 (87/11). Finally in Group 3, 108 flaps (96%) were from the abdomen (DIEP = 68, MS-TRAM = 39, SIEA = 1), whereas 4 flaps (4%) were from alternative sites (PAP = 4). The abdominal/alternative flap ratio for Group 3 was 27 (108/4).

The abdominal/alternative flap ratio was statistically compared among all three groups (Group 1 = 2.33, Group 2 = 8.09, and Group 3 = 27). There was a statistically significant difference among all groups (chi-square, $p < 0.001$). In all groups, the majority of flaps were abdominally based. However, higher BMI patients were more likely to get abdominally based flaps when compared with the lower BMI patients.

The mean mastectomy specimen weight was 406.9 ± 186.5 g (range, 190–935 g), while the mean flap weight was 481.7 ± 193.7 g (range, 192–1,010 g). The mean mastectomy specimen weight (grams) was statistically different among Group 1 (297 g), Group 2 (466 g), and Group 3 (628 g) (F-test, $p < 0.001$). The average flap weight (grams) was also statistically different between Group 1 (378 g), Group 2 (367 g), and Group 3 (690 g) (F-test, $p < 0.001$). Notably, in each cohort, the average flap weight was greater than the average mastectomy specimen weight.

Recipient vessels in all 262 flaps were the internal mammary artery and vein. In the majority of flaps, recipient site exposure was performed through resection of the third rib ($n = 200$ flaps, 76.5%).

Complications

Examination of adverse events following 262 reconstructions demonstrated that fat necrosis was the most common complication. Eleven flaps in Group 2 (11.2%) and eleven flaps in Group 3 (9.8%) had fat necrosis, whereas no reconstructions in Group 1 (0%) had fat necrosis. This was the only statistically significant difference in complication rates among the groups, with a difference in Groups 2 and 3 when compared with Group 1 (FHE-FET, $p < 0.05$). There was no statistically

Table 1 General patient characteristics

Characteristic	Group 1	Group 2	Group 3	Statistical test	p value
Patients	30	58	69	NA	NA
Flaps	49	98	112	NA	NA
Unilateral, n (%)	11 (36)	18 (31)	26 (37)	NA	NA
Bilateral, n (%)	19 (64)	40 (69)	43 (63)	NA	NA
Age (y), mean \pm SD	44 \pm 8.73	50 \pm 8.7	51 \pm 8.2	F-test	< 0.001
Body mass index (kg/m ²), mean \pm SD	20.6 \pm 1.07	24 \pm 0.83	27.3 \pm 1.2	F-test	< 0.001
Immediate, n (%)	40 (81.6)	76 (78)	77 (69)	χ^2	0.15
Delayed, n (%)	9 (18.4)	22 (22)	35 (31)	χ^2	0.15
Nipple areolar sparing, n (%)	19 (39)	37 (37.8)	16 (14.2)	χ^2	< 0.001

Abbreviations: NA, not applicable; SD, standard deviation.

Table 2 Cancer characteristics

	Group 1, n (%)	Group 2, n (%)	Group 3, n (%)	Statistical test	p value
Therapeutic indication	23 (47)	51 (52)	69 (66)	χ^2	0.54
Prophylactic indication	26 (53)	47 (48)	49 (44)	χ^2	0.54
Neoadjuvant radiation	4 (8)	7 (7)	9 (8.4)	FHE-FET	1
Adjuvant radiation	5 (10)	8 (8.2)	10 (8.6)	FHE-FET	0.92
Neoadjuvant chemotherapy	5 (10)	8 (8.2)	12 (10.7)	χ^2	0.81
Chemotherapy	6 (12)	13 (13.3)	19 (16.7)	χ^2	0.65

Abbreviation: FHE-FET, Freeman–Halton extension of the Fisher exact tests.

significant difference in the incidence of seroma when looking at both BMI cohorts and donor sites. ► **Table 3** summarizes the complications.

Revisionary Surgery

Recipient and/or donor site revision was offered to all patients. No statistically significant difference was noted in the postoperative breast or donor site revision rates when Groups 1 to 3 were compared (chi-square, $p > 0.09$). Autologous fat grafting at the reconstructive breast site was performed in Group 1 (28%), Group 2 (29%), and Group 3 (18%) flaps. No statistically significant difference was noted in the rate of fat grafting (chi-square, $p = 0.11$). Similarly, in patients who received fat grafting, there was no statistically significant difference in transferred volume (Group 1 = 174 mL, Group 2 = 173 mL, Group 3 = 155 mL; F-test = 0.55). For each group, the average volume of fat grafting was compared with the mean flap weight for that group. This ratio of fat grafting volume to mean flap weight was 0.42 for Group 1, 0.51 for Group 2, and 0.32 for Group 3, yielding a statistically significant difference (F-test, $p < 0.001$), with a greater ratio of fat graft volume to flap volume in nonoverweight patients. Patients did not require mastopexy or breast reduction on the contralateral breast in patients undergoing unilateral reconstruction.

Discussion

Breast reconstruction remains a common reconstructive procedure performed by plastic surgeons. While there has been a nationwide trend toward increasing numbers of prosthetic

reconstructions, microvascular reconstructions have shown higher rates of patient satisfaction in the long term.^{1–5,8} There are several theories to account for this disparity. Outside of major medical centers, microsurgical breast reconstruction can be daunting and only attempted with the ideal surgical candidate. Moreover, patients with low-normal BMI (range, 18.5–22 kg/m²) are often not even considered to be candidates for microsurgical breast reconstruction secondary to apparent lack of adequate donor sites. However, recent advancements in respect to alternative donor site flaps in addition to the use of autologous fat grafting as an adjunct to reconstruction have broadened the indications for autologous microvascular reconstruction. In addition, recent cost-efficiency data revealed microsurgical breast reconstructions to be superior to traditional two-stage tissue expander/implant and direct to implant reconstructions.³³

This series looks at 262 consecutive microsurgical breast reconstructions in patients with BMI less than 30 kg/m² and constitutes the, to our knowledge, largest series in the literature evaluating outcomes and indications for microsurgical reconstructions in patients with low-normal BMI. When comparing patients with low-normal BMI to normal and overweight patients, low-normal BMI patients were more likely to be younger (44 vs. 50 vs. 51 years), received alternative donor site flaps (PAP, SGAP, and TUG), and higher ratio of fat graft volume to flap volume (0.42 vs. 0.32). This shows that especially very low BMI patients may initially not have adequate amounts flap tissue to entirely reconstruct a breast mound, however, the flaps provide an ideal matrix for future fat grafting with the adjunct of which sufficient volumes may be generated. As such, one may argue that patients who were

Table 3 Complications

	Group 1 (n = 49)	Group 2 (n = 98)	Group 3 (n = 112)	Statistical test	p value
Arterial thrombosis, n (%)	0 (0)	0 (0)	1 (0.9)	FHE-FET	1
Venous thrombosis, n (%)	1 (2)	2 (2.0)	3 (2.7)	FHE-FET	1
Partial flap loss, n (%)	1 (2)	2 (2)	2 (1.8)	FHE-FET	1
Hematoma, n (%)	0 (0)	3 (3.1)	2 (1.8)	FHE-FET	0.61
Infection, n (%)	0 (0)	0 (0)	0 (0)	FHE-FET	1
Hernia, n (%)	0 (0)	3 (3.1)	1 (0.9)	FHE-FET	0.411
Fat necrosis, n (%)	0 (0)	11 (11.2)	11 (9.8)	FHE-FET	0.028

Abbreviation: FHE-FET, Freeman–Halton extension of the Fisher exact tests.

formerly not considered potential candidates may now be offered autologous reconstruction. However, in this series (even in low-normal BMI patients) abdominally based flaps, specifically DIEP flaps, remain the most common donor site for reconstruction.

While microsurgical breast reconstruction was first described by Fujino et al in 1976 using the gluteal area as the donor site and further popularized by Shaw in 1983, the abdomen quickly became the workhorse of microsurgical breast reconstruction after published work by Holmström and Hartrampf et al in 1982^{34–37} and currently remains the primary donor site for microsurgical breast reconstruction.^{38,39} However, after their initial descriptions, there has been a secondary rise in alternative donor site flaps in the past 10 years starting with the SGAP/IGAP flaps in the 1990s, TUG's in the late 2000s, and PAP flaps in 2010.³⁸ These flaps, while not preferred to the abdomen, have been shown in several series to provide a valuable alternative for patients who do not have adequate abdominal donor sites. Baumeister et al report an average BMI of 22.5 kg/m² in their series of SGAP reconstructions, but they did not mention the average flap weight. They additionally laud it as a safe and reliable flap.⁴⁰ Granzow et al review of 170 SGAP flaps showed an average flap weight 124% of the average mastectomy weight, proving that adequate tissue can be gained from this location.⁴¹ The TUG flap, which was first described by Yousif in 1992, suggests the medial thigh as a donor site, but may cause seroma formation and has been shown to offer only small volumes of tissue. Locke et al also have found an average flap weight of 312 g (range, 167–480 g), but they did not mention either the mastectomy specimen weight or the BMI of the patient in their investigation. They do however, point out a higher incidence of lipofilling in patients undergoing TUG flaps because of loss of volume over time as well as contour abnormalities.⁴² In our cohort, the average flap weight was 378 g for the low-normal BMI population, which is similar to the mean found by Locke et al for their cohort of TUG flaps. The average BMI described in patients undergoing PAP flap reconstruction as described by Allen et al was shown to be 23.2 kg/m² (range, 18.2–27.5 kg/m²), with a mean flap weight of 385 g (range, 235–695 g).¹⁷

In this series, the majority of reconstructions were performed immediately in all cohorts. There was no statistically significant difference when comparing the numbers of immediate and delayed reconstructions in the three cohorts and also no difference in cancer characteristics when looking at each cohort, with equivalent incidences of reconstructions performed for prophylactic and therapeutic indications. Interestingly, the average mastectomy specimen weight was less than the average flap weight in the low-normal BMI cohort (378 vs. 287 g). This finding is somewhat counterintuitive and might lessen the fear to perform autologous breast reconstruction in low BMI patients. When performing autologous reconstruction, the main concern remains creating a breast with adequate volume. In this series with larger flap weights than specimen weights that goal was achieved for this particular group of patients.

This investigation has several limitations. First, it is a retrospective review and inherent bias cannot be avoided. Our institution strongly believes in microsurgical breast

reconstruction and therefore offers this type of reconstruction to the majority of patients. In addition, one of the senior authors (R.J.A.) popularized the use of alternative donor site flaps with the use of PAP, SGAP, and IGAP flaps, therefore, our sample may not be representative for other centers around the country.^{17,18,38}

Furthermore, there is a low incidence of both acute and long-term complications in all cohorts. Therefore, the study may lack the appropriate power to determine a difference between the cohorts. While many studies have shown increased risk of complications for high-BMI patients undergoing autologous reconstruction, when evaluating our cohort we found overall low complication rates, however, they were evenly distributed among the groups. Contrary to what one might anticipate, complication rates did not go down with decreasing BMI. One should also bear in mind that when trying to harvest maximal amounts of tissue from rather thin patients, contour deformities and increased rates of wound dehiscences as well as poor scarring because of undue tension may result.

In the low-normal BMI cohort, there occurred no cases of fat necrosis. However, fat necrosis is known to be associated with obesity, which is not included in our cohort. Finally, we lack data looking at patient reported satisfaction and esthetic outcomes.

In summary, the choice to undergo microvascular breast reconstruction is multifaceted and the abdomen remains the first line choice for donor site. However, when the abdomen provides an inadequate donor site, surgeons must look to either the thigh or the buttock as an alternative. This flap choice is based on patient preference, surgeon experience, and donor site availability. Furthermore, this study demonstrates the feasibility of performing autologous breast reconstruction also in low BMI patients with overall few complications. While adequate volumes can generally be generated also when using alternative donor sites, the adjunct of fat grafting appears to be especially valuable in low BMI patients.

Conclusion

Abdominally based free flaps are possible in the majority of patients. In low-normal BMI patients, the harvested flap weight and the mastectomy weight are similar to each other but smaller than both normal BMI and overweight patients. When not desired or unavailable, the use of alternative donor sites remains a viable option. Fat necrosis is more likely in higher BMI patients, and, if utilized, the average volume of fat grafting is similar among various BMI patients. Microsurgical breast reconstruction should be considered a viable option in most patients, regardless of BMI.

Conflict of Interest

No conflict of interest to report.

Financial Disclosure

None.

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