INTRODUCTION

Obesity and its related comorbidities have been associated with increased complication rates in patients undergoing autologous breast reconstruction.1–13 Of the autologous options, the pedicled myocutaneous latissimus dorsi (LD) flap has lower complication rates compared with free tissue transfer, particularly in the obese population.14–18 However, a traditional LD flap is limited in the volume it can achieve in reconstruction. Modifications such as implant placement or extended dissection have improved volume but add additional risks.14,19–23 Implant placement negates a totally autologous reconstruction and is subject to infection, malposition, capsular contraction, and extrusion.24 Extended dissection is associated with higher rates of donor-site wounds, seroma, and lumbar hernia.25,26

Recently, immediate fat grafting has been described to improve the volume that can be achieved with the LD flap.20,27–32 However, no study has looked specifically at the results of breast reconstruction in the obese population undergoing LD with immediate fat grafting. The aim of this study is to compare complication rates of the immediately fat-grafted LD to free tissue transfer in the obese population.

Methods: In this retrospective cohort, 82 patients (149 breasts) from 2015 to 2019 were included. Patients underwent either unilateral or bilateral breast reconstruction with either LD with immediate fat grafting or abdominal-based free tissue transfer. Included patients had a body mass index ≥ 30 kg/m² at the time of surgery. Complication data were recorded as minor, major, and medical complications. Procedure characteristics and postoperative data were also studied.

Results: Minor complication rates between the LD with immediate fat grafting and free tissue transfer cases were similar (26.9% versus 26%, respectively). The free tissue transfer group had a significantly higher rate of major complications (20.3% versus 3.8%; P = 0.048) and medical complications (10.6% versus zero). Finally, the LD with immediate fat grafting group had significantly shorter operating room times, hospital length of stay, and fewer donor-site revisions.

Conclusions: LD with immediate fat grafting offers the benefit of a totally autologous reconstruction without the risks of abdominal-based microvascular free tissue transfer or an implant. Favorable complication rates, shorter operative times, and shorter hospital length of stay make this reconstructive option a safe alternative to free tissue transfer in the obese population.

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study directly comparing these autologous breast recon-
struction options in obese patients.

PATIENTS AND METHODS

A retrospective review was approved by the institutional
review board at Baylor Scott & White Medical Center—
Temple to identify patients who underwent autologous
breast reconstruction from January 2015 through January
2019. Surgeries were performed by 2 surgeons with uni-
form surgical and postoperative protocols. Patients were
identified by Common Procedural Terminology codes
19361 for LD flaps and 19364 for free tissue transfer.

Patient-identifiable intrastitutional National Surgical
Quality Improvement Program data were used to obtain
patient demographics and comorbidities, and chart
review was conducted when these data were unavailable.
Demographic data included age and BMI. Comorbidities
included diabetes (insulin and noninsulin dependent),
smoking status within the last year, pulmonary disease,
hypertension requiring medication, chronic steroid use,
presence of a bleeding disorder, and American Society
of Anesthesiologists’ (ASA) classification. Timing of
breast reconstruction was recorded as either immediate
or delayed. Delayed reconstruction also included patients
who may have had a tissue expander placed at the time
of mastectomy, otherwise known as delayed-immediate
reconstruction (Fig. 1). Data regarding abdominal flap
classification, mastectomy type, nonhormonal neoadju-
vant chemotherapy, and perioperative requirement of
radiotherapy were also collected.

The World Health Organization’s definition of obesity
(BMI $\geq$ 30) was used as the inclusion criteria. Chart review
was conducted to identify which LD cases included imme-
diate fat grafting and exclude all others. Free tissue trans-
fers that were not abdominal-based were excluded.

Incidents of postoperative complications were identi-
fied by chart review and were divided into minor or major
surgical complications (recorded per breast and respec-
tive donor site) and medical complications (per patient).
Minor complications were defined as those of the donor
site and reconstruction site that required management in
the outpatient setting: donor-site complications, breast
wound healing issues, infection requiring oral antibiot-
ics, and seroma requiring aspiration. Major complications
were those that required return trips to the operating
room: donor-site complications, hematoma, flap loss,
infection/abscess, breast wound debridement, and flap
thrombosis. Medical complications were included if they
required inpatient admission but no surgical intervention.
A pooled variable was generated to include major com-
lications requiring reoperation or medical complications.

Fig. 1. A 48-year-old woman with BMI 36 kg/m². ASA class 2. The patient had a remote history of left
breast invasive ductal carcinoma, for which she underwent lumpectomy and radiation. The patient was
subsequently found to be BRCA1 positive and underwent bilateral prophylactic skin sparing mastec-
tomies with immediate placement of bilateral pre-pectoral tissue expanders. (A and B) Right and left
oblique views before bilateral prophylactic mastectomies and tissue expander placement. The patient
underwent delayed immediate reconstruction with bilateral LD flaps and 460 mL (230 mL right, 230 mL
left) immediate fat grafting 3 months post-mastectomy. The patient required 1 revision procedure with
fat grafting (200 mL right; 200 mL left). Within this revision, the patient also underwent bilateral bra-
chioplasty, right lateral thoracic dermatolippectomy, and dermatolippectomy to the bilateral breasts for
symmetry. The patient did not desire nipple-areolar reconstruction. (C and D) Right and left oblique
views of the 9-month final reconstruction result.
requiring admission. Abdominal bulge or hernias requiring surgical intervention during the follow-up period were also noted for free tissue transfers.

Additional data were collected to characterize the procedures and perioperative period. Outcomes of interest included mean operative duration, volume of fat grafted immediately to LD flaps, number of breast and donor-site revisions, volume of revision fat grafting, mastectomy weight, requirement of implant during revision, hospital length of stay, and time of drain in situ.

Surgical Technique

The included LD with immediate fat grafting patients were marked preoperatively with the patient in an upright position. The skin paddle was designed transversely to lie within natural creases in the back and maximize the skin paddle’s size and volume. Fat harvest donor sites for LD with immediate fat grafting commonly included the abdomen, flanks, and medial and lateral thighs and were based on each patient’s individual body habitus and fat distribution. Details of the flap harvest have been described previously. The LD donor site was closed directly with the use of progressive tension sutures to obliterate empty space, and 2 drains were routinely placed at each donor site. Fat grafting recipient sites for LD with immediate fat grafting included the LD muscle, flap skin paddle, pectoralis major and serratus muscles, and mastectomy skin flaps. Selection of fat grafting recipient sites has also been described previously.

For patients who underwent free tissue transfer, abdominal flap markings were made preoperatively with the patient in sitting, standing, and flexed positions. The majority of flaps were deep inferior epigastric artery perforator flaps. Flaps were converted to muscle-sparing transverse rectus abdominis myocutaneous flaps or transverse rectus abdominis myocutaneous flaps as needed based on each patient’s vascular anatomy. Free tissue transfer donor sites were closed with progressive tension sutures to obliterate empty space, and 1 drain was routinely placed on each side of the abdomen. Fascial defects were closed with permanent sutures, and a synthetic mesh was used as needed for fascial defects.

For postoperative analgesia, donor sites for the LD with immediate fat grafting and the free tissue transfer groups were routinely injected with an analgesic cocktail consisting of 60 mL of 0.25% bupivacaine, 50 mcg dexametomidine, 30 mg ketorolac, and 4 mg dexamethasone mixed in 250 mL of normal saline. This was injected in a transversus abdominis plane for abdominal donor sites and in a subcutaneous, peri-incisional plane for back donor sites.

Statistical Analysis

Sample characteristics were described using descriptive statistics. Frequencies and percentages were used to describe categorical variables, while means, SDs, medians, and ranges were used for continuous variables. Nonparametric univariate analysis was conducted using Fisher exact test for categorical variables and Mann–Whitney U-test for continuous variables. Mastectomy type and obesity were analyzed using the \( \chi^2 \) test. All analyses were 2-tailed and statistical significance was considered at \( P \leq 0.05 \).

RESULTS

Patients and Characteristics

A total of 149 breasts in 82 obese patients met final inclusion criteria. Patients’ mean age was 51 years and mean BMI was 35.7 kg/m². It should be noted that while the BMI between groups was similar, the BMI ranged widely. The highest BMI in the LD with immediate fat grafting group was 52.6 kg/m², while the highest BMI in the free tissue transfer group was only 35.2 kg/m².

Procedure-specific patient characteristics are reported in Table 1. Sixteen patients (26 breasts) underwent LD with immediate fat grafting, while 66 patients (123 breasts) underwent free tissue transfer. Patients undergoing LD with immediate fat grafting tended to be older. Mean BMIs were comparable between the LD with immediate fat grafting and free tissue transfer patients. The majority of patients in both groups underwent skin-sparing mastectomy and delayed reconstruction (Figs. 2, 3). Of these patients, 2 who received LD with immediate fat grafting underwent delayed-immediate reconstruction with tissue expander placement at the time of mastectomy (Fig. 1). No significant difference was observed in the number of patients receiving neoadjuvant chemotherapy or radiotherapy. All radiation was completed before definitive autologous reconstruction.

Importantly, patients in the LD with immediate fat grafting group tended to be significantly more comorbid according to ASA class (ASA class > 2; 87.5% versus 56.1%; \( P = 0.023 \)). No significant differences existed in prevalence of diabetes, hypertension, smoking status, pulmonary disease, chronic steroid use, or bleeding disorders. All patients had a minimum follow-up of 6 months, but the duration was longer in the free tissue transfer cohort (mean [SD], 36.1 [13.8] versus 23.2 [11.0] months; \( P = 0.002 \)).

Procedure characteristics appear in Table 2. Average operative durations for bilateral free tissue transfers were 2.1 hours longer (\( P = 0.018 \)), and those for unilateral transfers were 2.6 hours longer than LD with immediate fat grafting (\( P = 0.019 \)). Mean hospital stay of 2.05 days was significantly (\( P < 0.001 \)) longer for free tissue transfers. No significant difference for duration of drains (donor site or breast) in situ was observed between groups. Mastectomy weight was similar between groups. Of note, in the LD with immediate fat grafting group, a mean of 188.9 mL of autologous fat was grafted immediately during primary reconstruction. Both groups required a similar number of subsequent breast revisions, with a median of 1 revision each. The free tissue transfer donor site required significantly more subsequent revisions than the donor site for LD with immediate fat grafting (0.78 [0.82] versus 0.23 [0.59] times; \( P < 0.001 \)). The LD with immediate fat grafting group required a larger volume of fat grafting during subsequent revisions (194.3 [168.4] versus 108.8 [155.1] mL; \( P = 0.01 \)). This trend was also noted for the total

Statistical Analysis

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sum of fat grafting volume received, including during the index procedure for the LD with immediate fat grafting group ($P = 0.01$). Eight free tissue transfer patients required augmentation with implants compared with zero LD with immediate fat grafting patients.

Complication data are demonstrated in Table 3. The total number of minor complications between groups was similar. In contrast, free tissue transfers resulted in significantly more major complications (20.3% versus 3.8%; $P = 0.048$). Delayed wound healing of the breast requiring in-office debridement was the most common individual minor complication in both groups. Breast wound healing issues requiring operative debridement were the most common (6.5%) major complication for free tissue transfers. The only major complication for LD with immediate fat grafting was a hematoma necessitating reoperation. More than 10% of free tissue transfer patients were readmitted for nonoperative medical complications in contrast to zero LD with immediate fat grafting patients ($P = 0.336$). Medical complications included venous thromboembolism, myocardial infarction, opioid overdose (requiring reversal with Naloxone), and pneumonia. Free tissue transfer patients were significantly more likely to experience either a reoperation due to a major surgical complication or readmission due to a medical complication (36.4% versus 6.3%; $P = 0.031$). Finally, 4 (6.5%) patients who underwent muscle-sparing transverse rectus abdominis flaps required repair of donor-site-related hernias.

### DISCUSSION

The effects of obesity on breast reconstruction have been well described. However, a consensus on the best reconstructive modality for the obese population has not been reached. In a national review of 12,986 patients who underwent breast reconstruction, Hanwright et al. demonstrated that obese patients who underwent tissue expander reconstruction experienced fewer surgical and medical complications as well as fewer reoperations than those who underwent autologous reconstruction. Conversely, in a single-center review of 700 patients, Garvey et al. demonstrated that obese patients experienced higher failure rates with implant reconstruction than with autologous free-flap techniques. Nonetheless, obesity has been shown to significantly increase perioperative,
Fig. 2. A 49-year-old woman with BMI 37 kg/m² and past medical history of diabetes mellitus and hypertension. ASA class 3. The patient underwent bilateral skin sparing mastectomies with left axillary lymph node dissection and adjuvant chemoradiation for invasive ductal carcinoma of the left breast. (A and B) Right and left oblique views post-mastectomy and post-radiation to the left breast. The patient underwent delayed reconstruction with bilateral LD flaps and 500 mL (200 mL right, 300 mL left) immediate fat grafting 9 months after completing radiation. The patient required 2 revision procedures with fat grafting (total 580 mL right; 350 mL left) and dermatoliposuction to the bilateral breasts for symmetry. The patient did not desire nipple-areolar reconstruction. (C and D) Right and left oblique views of the 1-year final reconstruction result. (E and F) LD donor site—preoperative and 4 months postoperative.

Fig. 3. A 47-year-old woman with BMI 38 kg/m² and past medical history diabetes mellitus, hypertension, and pulmonary disease. ASA class 3. The patient underwent bilateral skin sparing mastectomies for left breast IDC. The patient did not require adjuvant radiation. (A and B) Right and left oblique views 3 months post-mastectomy. The patient underwent bilateral LD flaps and 200 mL (100 mL right, 100 mL left) immediate fat grafting 5 months post-mastectomy. The patient required 1 revision procedure for dermatoliposuction to the bilateral breasts for symmetry. The patient did not require any additional fat grafting after the primary reconstruction. (C and D) Right and left oblique views of the 2-year final reconstruction result after nipple areolar reconstruction.
postoperative, and medical complications, regardless of reconstructive modality.\textsuperscript{11,36}

Whether chosen by surgeon selection or patient preference, autologous breast reconstruction should aim to minimize complications, achieve an aesthetic result, and offer an acceptable postmastectomy quality of life. A patient-individualized approach is necessary to choose the best autologous option. Microsurgical advances have led to a variety of flap options for free tissue transfer.\textsuperscript{28,37–42} Despite these advances, surgeons need to proceed judiciously and on a case-by-case basis because a variety of patient characteristics may be relative contraindications to free tissue transfer.\textsuperscript{13,43,44} These contraindications include obesity, diabetes, smoking history, bleeding or clotting disorders, and prior abdominal surgeries.

The pedicled LD has been described as an excellent autologous alternative to free tissue transfer.\textsuperscript{7,14–18,35} The versatility and reliability of the LD flap make it a reasonable option for nearly any patient.\textsuperscript{14} However, the LD is limited by the volume it can achieve. In the past, this constraint was addressed by extending the flap dissection and, if needed, placing an implant. To avoid these modifications and their associated morbidity, immediate fat grafting has been described to augment the volume.

The present study demonstrated multiple advantages of LD with immediate fat grafting over abdominal-based free tissue transfer for obese patients. Despite the LD with immediate fat grafting group having a higher ASA class, similar minor complication rates were observed between groups. These complications, all managed in the outpatient setting, occurred at similar rates in other large retrospective studies.\textsuperscript{1–3,6,11,16}

Donor-site morbidity in LD with immediate fat grafting was also favorable as compared to the free tissue transfer donor site. Dissection and transfer of the LD muscle is generally well tolerated with minimal to no long-term loss of shoulder function.\textsuperscript{45–47} Of note, seroma is the complication most frequently encountered in LD donor sites.\textsuperscript{26}

### Table 2. Procedure Characteristics

|                      | LD + Immediate Fat Grafting | Free Tissue Transfer |
|----------------------|-----------------------------|----------------------|
|                      | Number or Mean ± S.D. | Percentage or Median (Range) | Number or Mean ± S.D. | Percentage or Median (Range) | P      |
| Operative duration (minutes)* | 294.4 ± 80.3 | 282 (205–403) | 448.1 ± 76.6 | 474 (299–533) | 0.019  |
| Bilateral cases      | 482.4 ± 104.7 | 477 (329–666) | 608.0 ± 154.3 | 596 (342–933) | 0.018  |
| Length of stay (days) | 2.6 ± 1.4 | 2 (1–6) | 4.6 ± 1.6 | 4 (2–9) | < 0.001 |
| Drain time (days)    | 17.3 ± 5.8 | 16 (10–29) | 16.3 ± 6.3 | 14 (4–34) | 0.341  |
| Mastectomy weight (g) | 956.7 ± 286.8 | 921 (590–1642) | 864.1 ± 336.9 | 817 (183–1788) | 0.161  |
| Volume immediate fat graft (mL) | 188.9 ± 92.2 | 200 (60–120) | — | — | —      |
| Presence of breast revision | 20 | 76.9% | 88 | 71.5% | 0.638  |
| No. breast revisions† | 1.15 ± 0.88 | 1 (0–3) | 1.19 ± 1.035 | 1 (0–4) | 0.916  |
| No. donor-site revisions | 0.25 ± 0.59 | 0 (0–2) | 0.78 ± 0.82 | 1 (0–3) | < 0.001 |
| Volume subsequent fat graft (mL) | 194.3 ± 168.4 | 178 (0–580) | 108.8 ± 135.1 | 80 (0–675) | 0.01   |
| Total fat graft volume (mL) | 383.2 ± 174.8 | 355 (100–780) | 108.8 ± 135.1 | 80 (0–675) | 0.01   |
| Requirement of implant | 0 | 0% | 8 | 6.5% | 0.351  |

* Operative duration and length of stay expressed per patient.
† Number of breast revisions excludes nipple reconstruction procedures.
LD, latissimus dorsi.

### Table 3. Minor, Major, and Medical Complications

|                      | LD + Immediate Fat Grafting | Free Tissue Transfer |
|----------------------|-----------------------------|----------------------|
|                      | Number | Percentage | Number | Percentage | P      |
| Minor surgical complication, per breast\* | 7 | 26.9% | 32 | 26.0% | 1.000  |
| Donor site‡ | 1 | 3.8% | 9 | 7.3% | 1.000  |
| Delayed wound healing (breast) | 3 | 11.5% | 19 | 15.4% | 0.767  |
| Infection (breast) | 1 | 3.8% | 4 | 3.3% | 1.000  |
| Fluid collection (breast) | 2 | 7.7% | 1 | 0.8% | 0.079  |
| Major surgical complication requiring reoperation, per breast | 1 | 3.8% | 25 | 20.3% | 0.048  |
| Donor site§ | 0 | 0.0% | 5 | 4.1% | 0.587  |
| Hematoma (breast) | 1 | 3.8% | 3 | 2.4% | 0.540  |
| Flap loss (breast) | 0 | 0.0% | 4 | 3.3% | 1.000  |
| Infection/abscess (breast) | 0 | 0.0% | 4 | 3.3% | 1.000  |
| Wound (breast) | 0 | 0.0% | 8 | 6.5% | 0.351  |
| Flap thrombosis | 0 | 0.0% | 1 | 0.8% | 1.000  |
| Medical complication requiring readmission† | 0 | 0.0% | 7 | 10.6% | 0.336  |
| Patients experiencing any major medical or surgical complication | 1 | 6.3% | 24 | 36.4% | 0.031  |
| Hernia requiring surgical repair† | — | — | 4 | 6.50% | —      |

\* Minor, major, and individual surgical complications analyzed per breast.
† Medical complications and hernia formation analyzed per patient.
‡ Minor donor-site complications included infection, seroma, and wound separation.
§ Major donor-site complications included infection, hematoma, and wound separation.

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The absence of this complication in our cohort is likely related to the authors’ flap design, use of progressive tension sutures to eliminate empty space, and placement of 2 drains at each LD donor site. On the contrary, 14 (11.4%) free tissue transfer patients in the present study developed donor-site complications, 5 (4.1%) of which required reoperation. Donor-site complications, hernia, or abdominal bulge following free tissue transfer are significant and associated with increased health care costs, which are even higher among obese patients.

Collectively, patients in the free tissue transfer group were nearly 6 times more likely to require a reoperation or inpatient admission for medical complications. Medical complications add significant morbidity to breast reconstruction and highlight another important contrast in safety profile between procedures. The discrepancy may be related to the longer exposure to general anesthesia (2.1 hours longer in bilateral and 2.6 hours longer in unilateral), longer hospital stays (2.05 days longer), delayed return to activity, or the anatomy of the surgical dissection itself. In a review of autologous breast reconstruction in the United States that corroborated this finding, Pien et al. demonstrated longer hospital stays and higher costs in free tissue transfers.

One concern that surgeons may have with volume augmentation through fat grafting is the consideration of fat graft resorption. Nonetheless, in our study, both procedures required a similar number of revisions. The type of revision procedure did, however, differ between groups. LD with immediate fat grafting revisions were to a greater extent directed at continuing to improve volume with additional grafting (194 mL of additional fat on average) versus free tissue transfer (109 mL on average). The free tissue transfer patients required more than 3 times the number of subsequent revisions to the donor site compared with the LD with immediate fat grafting group. This difference was likely related to the impact of delayed wound healing on scar cosmesis and the more conspicuous location of an abdominal scar versus a back scar. Finally, 8 patients who underwent free tissue transfer actually required augmentation with implants, while zero LD with immediate fat grafting patients required implants.

Prior reports of LD with immediate fat grafting have described flap harvest, fat grafting, inset, and donor-site management techniques, all with favorable complication rates. Santanelli et al. first described the LD with immediate fat grafting to the flap skin paddle and LD muscle. In 2015, Zhu et al. reported on LD with immediate fat grafting and presented an algorithm for selecting recipient sites (LD skin paddle, LD muscle, pectoralis major, and serratus, and mastectomy skin flaps) as part of the procedure. Economides et al. described volumes up to 359.6 mL and a multilayer injection technique without major complications. In comparison, the amount of fat grafted simultaneously with flap harvest in the present study averaged 186.19 mL per breast. However, importantly, the authors’ technique involves harvesting the LD with a large transverse skin paddle. Additional authors have also described their experience with LD with immediate fat grafting. However, no prior studies have directly compared the LD with immediate fat grafting to its autologous counterpart, free tissue transfer, in the obese population. This patient population requires larger reconstruction volumes, is at a higher surgical risk, and generally experiences a higher rate of surgical complications with breast reconstruction. LD with immediate fat grafting addresses the issue of volume while offering shorter hospital length of stay, lower costs, and lower rate of flap loss, making it an attractive option for obese patients requiring autologous breast reconstruction.

This study demonstrates significant advantages of LD with immediate fat grafting over free tissue transfer in the obese population. It is however, limited by its retrospective nature. Furthermore, while follow-up time in each group is adequate to fully capture complications data, it is important to acknowledge that follow-up time for the LD with immediate fat grafting group was shorter. Therefore, the number of revisions required may differ with longer-term follow-up, especially considering fat graft resorption. Finally, the study design does not allow for the true impact of the mastectomy on the reconstructive outcomes to be elucidated. Future directions entail expanding the sample size for further review of safety, assessing esthetic and patient satisfaction scores, and analyzing cost-effectiveness.

CONCLUSIONS

LD with immediate fat grafting provides a totally autologous, less morbid reconstruction in patients who are not ideal candidates for microsurgical reconstruction. Obese patients undergoing LD with immediate fat grafting experienced lower rates of major and medical complications, decreased need for donor-site revisions, and shorter operative duration and hospital length of stay. These findings demonstrate that LD with immediate fat grafting is a sound autologous alternative to free tissue transfer in the obese population.
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