Preliminary Report

Maximizing the Volume of Latissimus Dorsi Flap in Autologous Breast Reconstruction with Simultaneous Multisite Fat Grafting

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Abstract

Background: The pedicled latissimus dorsi (LD) flap serves an important function in breast reconstruction, but its utility is limited by its inability to provide sufficient breast volume.

Objectives: The purpose of this preliminary report was to review the techniques and outcomes of utilizing fat-grafted, volume-enhanced LD flap transfer with fat grafting recipient sites in autologous breast reconstruction.

Methods: A retrospective study was performed of 10 patients (14 breasts) who underwent autologous breast reconstruction utilizing the LD flap transfer technique and simultaneous fat grafting between August 2012 and September 2014. Multilayer, multisite fat grafting was performed to the LD muscle, LD skin paddle, mastectomy skin flaps, and the pectoralis major and serratus muscles simultaneously with the LD flap transfer.

Results: Three patients underwent an immediate breast reconstruction, four underwent a delayed breast reconstruction, and four underwent a tertiary breast reconstruction following previously failed breast reconstructions (one patient underwent each of the first two procedures, one on each breast). The average age of the patients was 55 years (range, 39-76 years), the average body mass index of the patients was 29.3 (range, 19.6-39.9), and the average fat grafting volume for the patients was 176 mL (range, 50-300 mL). There was 100% flap survival and complete wound healing. No seroma or fat grafting–related complications were clinically detected. Three patients required additional fat grafting.

Conclusions: The fat-grafted, volume-enhanced LD flap procedure with fat grafting recipient sites offers a simple and safe technique for autologous breast reconstruction, with low morbidity and fast recovery. It can be a useful alternative to utilizing abdomen-based flaps in autologous breast reconstruction or could be performed to salvage both implant-based and free-flap breast reconstructions.

Level of Evidence: 4

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The pedicled latissimus dorsi (LD) flap serves an important function in breast reconstruction, but its utility is limited by its inability to provide sufficient volume. One common strategy for enhancing breast volume in LD flap procedures is inserting an implant, but this procedure is associated with inherent risks, including capsular contracture, infection, malposition, rupture, and extrusion, which may be more likely to occur if a patient has previously undergone radiation therapy. A second approach is the extended LD flap technique, which involves a more aggressive harvest of subcutaneous tissue along with the skin paddle. The shortcomings of this technique include a higher risk of seroma, wound breakdown, contour deformities, and lumbar hernia. In 2011, the senior author of the present study (M.S.C.) described his modification of the low transverse extended LD flap procedure, which was based on the fat compartment theory. However, this technique is restricted to patients with sufficient tissue at the flap donor site. A third option is to combine the LD flap transfer with fat grafting.

Traditionally, fat grafting is performed as a revisional procedure several months after an initial breast reconstruction. Fat grafting during immediate breast reconstruction has only been aimed at the LD flap itself. However, fat grafting into multiple recipient sites while simultaneously utilizing the LD flap transfer technique can be performed in order to maximize the volume of the breast in autologous breast reconstruction. The authors have developed an algorithm for selecting fat grafting recipient sites for volume-enhanced autologous LD flap breast reconstruction.

There is limited literature on simultaneous fat grafting and LD flap harvest, and only one recent report has described immediate fat grafting–augmented LD flap breast reconstruction. This study provides a preliminary report describing the fat-grafted, volume-enhanced LD flap procedure utilizing multiple recipient sites during total autologous breast reconstruction and presents an algorithm for selecting fat grafting recipient sites as part of this procedure.

**METHODS**

A retrospective study of 10 patients who had undergone total autologous breast reconstruction utilizing the LD flap transfer technique and simultaneous fat grafting, performed by the senior author (M.S.C) between August 2012 and September 2014, was conducted. During the study period, 216 pure autologous breast reconstruction procedures were performed by the senior author (M.S.C.), of which 197 were free-flap reconstructions and 26 were pedicled LD breast reconstructions. Twelve breasts underwent only an LD flap transfer, and fourteen breasts underwent an LD flap transfer with simultaneous fat grafting.

Patients included in this study were selected following an assessment by the senior author (M.S.C.). Inclusion criteria included patients who desired a total autologous reconstruction but who had limited tissue available at potential donor sites, patients who did not have a suitable donor site for an alternative free-flap breast reconstruction, and patients who were not a candidate for or did not want to undergo a free flap breast reconstruction. Patients who did not require much breast volume and underwent only an LD flap transfer breast reconstruction and patients who underwent breast reconstruction with an LD flap transfer and implant were excluded. Patient demographics, operation details, and complications were collected via a review of the patients’ case notes.

This study was approved by the Institutional Review Board (IRB) of the Mayo Clinic (Rochester, MN), and informed consent was obtained from all study patients. The flap design and operative technique is described below.

**Flap Design**

Each patient was marked preoperatively in an upright position. The location of the skin paddle was designed to lie along the natural resting tension lines and natural creases of the back, to maximize the skin paddle’s volume and size. The skin paddle’s design could be accentuated by having the patient bend to the ipsilateral side of the LD donor site (Supplementary Video 1, available as Supplementary Material on www.aestheticsurgeryjournal.com). Fat harvest donor sites were determined according to the distribution of natural fat deposits, based on the patient’s body habitus. Donor sites commonly included the abdomen, the flank, and the thigh.

The LD flap harvest and transfer were carried out with the patient in the lateral decubitus position. Details of the LD flap harvest procedure have been described previously. The donor site for the fat harvest was closed directly, without additional undermining. The skin flaps of the donor site were quilted to the underlying tissue with progressive tension sutures, to minimize the dead space left by the harvested fat and decrease tension at the suture line. Two drains were routinely placed in each harvest site. The skin was then closed in layers with 2, 0 Vicryl and 3-0 Monocryl sutures. Exparel (Pacira Pharmaceuticals, Inc.; Parsippany, NJ) was injected after being diluted by 20–120 mL in unilateral surgeries, and to 240 mL in bilateral surgeries. A total of 120 mL of Exparel was injected per LD flap donor site, to maximize the postoperative pain control. Each patient was then repositioned supine, and the mastectomy skin flaps were elevated.

**Fat Grafting Recipient Sites**

There were four principal potential fat grafting recipient sites, which were chosen to maximize the breast reconstruction.
volume. These included the LD skin paddle, the LD muscle caudal to the skin paddle, the pectoralis major and serratus muscles, and the mastectomy skin flaps (Figure 1). Factors that influenced the recipient sites chosen for fat grafting included whether an immediate breast reconstruction vs a delayed breast reconstruction was being performed and whether a prophylactic mastectomy vs a mastectomy to remove breast cancer was being performed. For a delayed breast reconstruction (including a salvage of a failed breast reconstruction), fat was grafted into all four possible recipient sites. For an immediate breast reconstruction after a prophylactic mastectomy, fat was grafted into the LD skin paddle, the LD muscle caudal to the skin paddle, the pectoralis major and the serratus muscles, and the non-undermined portion of the mastectomy skin flaps. For an immediate breast reconstruction after cancer removal, fat was only grafted into the LD skin paddle and the LD muscle caudal to the skin paddle. The algorithm for selecting fat grafting recipient sites is summarized in Figure 2.

**Fat Harvest and Fat Grafting**

Fat harvest was performed simultaneously with the LD flap harvest, utilizing a two-team approach, in order to minimize the operation time. The donor sites were injected with 0.5% lidocaine, with 1:100,000 epinephrine solution. Fat was harvested with a Koume cannula (14G × 20 cm; Marina Medical Inc., Sunrise, FL), collected directly into a REVOLVE system (LifeCell, Co.; Bridgewater, NJ), washed with lactated Ringer’s solution, and aspirated into 10 mL syringes. Multilayer, multisite fat grafting was performed into both the donor site and recipient site of the newly
reconstructed breast (Figure 1). Fat was injected with a Koume cannula (14G × 15 cm) in small quantities, in a retrograde, layered, and fan-shaped fashion. The injection was halted when the recipient site was saturated and could not absorb any additional fat. The mastectomy skin flaps as well as the pectoralis major and serratus muscles were fat grafted before the inset of the LD flap (Supplementary Videos 2 and 3, available as Supplementary Material at www.aestheticsurgeryjournal.com). For the LD flap, fat was grafted into the subcutaneous layer of the skin paddle, the LD muscle caudal to the skin paddle, and under the muscle fascia (Supplementary Video 4, available as Supplementary Material at www.aestheticsurgeryjournal.com).

As required, additional fat grafting was performed 3 to 6 months following the initial breast reconstruction procedure. The fat grafting injections focused on correcting upper pole efficiency and increasing the projection of the reconstructed breast. If additional breast volume was required, the thoracoabdominal advancement flap (TAF) could be utilized to correct contour deformity and/or skin efficiency.

RESULTS

Ten patients (14 breasts) were included in this study (Table 1). Three patients (four breasts) underwent immediate breast reconstructions, four patients (six breasts) underwent delayed breast reconstructions, and four patients (four breasts) underwent tertiary breast reconstructions following a previous failed reconstruction (Figure 3) (one patient underwent both an immediate breast reconstruction [right breast] and a delayed breast reconstruction [left breast]; see Table 1). Five patients (five breasts) had undergone pre-reconstruction radiotherapy.

The average age of the patients was 55 (range, 39-76 years), and the patients’ average body mass index (BMI) was 29.3 (range, 19.6-39.9). The average operation time per breast was 293 minutes (range, 199-374 minutes). The size of the patients’ skin paddles ranged from 15 × 6 cm to 30 × 12 cm. The average fat grafting volume per breast was 176 mL (range, 50-300 mL). Mastectomy weight was recorded for eight breasts, and the mean mastectomy weight of these breasts was 443 g (range, 180-830 g). The average length of patient hospitalization was 2.4 days (range, 1-6 days).

The average follow-up duration was 14.3 months (range, 6-30 months). There was 100% flap survival and complete wound healing in all cases. There was no clinical evidence of seroma, fat necrosis, or other fat grafting related complications for either the recipient or donor sites. Within the current follow-up period, there have been no instances of disease recurrence. The transverse LD flap donor site scar was easily concealed within the bra line, with no obvious contour deformities. Three patients (five breasts), one of whom had previously undergone radiotherapy, required additional fat grafting. Patient demographics and operative data are summarized in Table 1.

DISCUSSION

Since Tansini introduced the technique in 1896, utilizing the LD flap has presented a versatile option for breast reconstruction. However, with the increasing popularity of utilizing abdominal-based perforator flaps, the LD flap has become the secondary choice for autologous breast reconstruction. The LD flap alone cannot always provide sufficient volume for the reconstructed breast. Two classic methods have been applied for LD flap volume enhancement: implant insertion and extended LD flap harvest. Implant insertion is associated with potential complications, such as infection, unnatural breast contour, capsular contraction, implant migration, and implant extrusion. Extended LD flap harvesting can provide additional volume without inserting an implant, but aggressive tissue harvesting may lead to increased risks of seroma, wound dehiscence, and contour deformity. In addition, this technique is restricted to patients with sufficient tissue at the flap donor site, which is usually associated with a higher BMI.

Fat grafting offers a less invasive method of volume enhancement. Since the 2009 reversal of the American Society of Plastic Surgeons’ moratorium on fat grafting, research in this area has increased dramatically.
studies have shown that fat grafting can significantly improve breast contour and provide additional volume in both autologous and implant-based reconstructions and is also associated with relatively few complications, such as infection and fat necrosis.\textsuperscript{12,22,26-28} In addition, fat injection to the breast does not impede cancer surveillance, and fat necrosis can be reliably differentiated from malignancy in fat-grafted breasts.\textsuperscript{17,29,30}

Traditionally, fat grafting has been carried out as a revisional procedure several months after the initial autologous breast reconstruction.\textsuperscript{11-18} In 2010, Sinna et al described the largest case series of second-stage fat grafting in LD flap autologous breast reconstruction, which included 200 patients and 244 injection sessions.\textsuperscript{11} In that study, the mean volume of fat grafted per breast was 176 mL (range, 30-405 mL), and complications included minor local infection (0.8\%) and cytotosteatonecrosis (2.0\%).\textsuperscript{11} The author did not clearly state in which layer the fat was injected, because all the fat grafting revisional procedures included in the study were performed via “blind” injection. The body of literature on simultaneous fat grafting and autologous tissue breast reconstruction is very limited, with only a single recent report of immediate fat grafting–augmented LD flap breast reconstruction.\textsuperscript{19} In this article, fat was injected into the adipose layer and muscle fascia of the flap skin paddle for volume enhancement of the lower pole, with a mean injected fat volume of 101 mL (range, 60-150 mL).\textsuperscript{19} In this cohort, multi-site simultaneous fat grafting would be safely performed with LD flap harvest and did not result in an increased risk of flap or specific fat grafting related complications.

There is evidence to demonstrate that muscle is a suitable recipient site for fat grafting which may be attributable to a robust supply, but this is limited to animal studies and a few case series. In a rat model study, muscle thickness continued to increase for 6 months following intramuscular fat grafting, and the fat survival rate of the intramuscular grafting group was larger than the subcutaneous grafting group at 12 months.\textsuperscript{31} In a study in rabbits, fat injected into the subcutaneous plane was completely absorbed at 9 months, while the only site in which autologous fat remained was the rectus muscle.\textsuperscript{32} Additional research in a rabbit model found improved fat survival rate in the submuscular layer over the subcutaneous layer 6 months after transplantation.\textsuperscript{33} Clinical research on volume augmentation when fat wasgrafted into muscles in the gluteal, breast, or facial area has also shown promising results.\textsuperscript{34-36} This highlights that muscle offers a reliable potential fat grafting site to maximize volume at the recipient site.

To our knowledge, this is the first study to describe the immediate, multisite, and multilayer fat grafting technique for breast reconstruction. Simultaneous fat grafting into
the LD flap was performed in all the cases in this series, and no fat grafting–related complications, fat embolism, or compromised LD flap vascularity as a result of this technique were observed in this cohort. The average and maximal fat grafting volume in this case series was 176 mL and 300 mL, respectively, which were both higher than the volumes reported in the only previously published study of simultaneous fat grafting.19

Figure 3. This 40-year-old woman presented with a history of bilateral skin-sparing mastectomies, a bilateral immediate deep inferior epigastric perforator (DIEP) breast reconstruction, and a failed left DIEP breast reconstruction, due to venous thrombosis. Six months following the preliminary failed breast reconstruction, the left breast was re-reconstructed utilizing the fat-grafted, volume-enhanced latissimus dorsi (LD) flap procedure (simultaneous fat grafting volume, 250 mL). Two subsequent fat grafting procedures were performed on the left breast (160 mL and 210 mL, respectively). A periareolar mastopexy was performed on the right breast simultaneously with the first revisional procedure. (A, C, E) Photographs obtained 2 weeks after the DIEP breast reconstruction and (B, D, F) 12 months following the second revisional procedure performed on the left breast.
The preliminary results of this case series confirmed that fat grafting can safely be performed into the subcutaneous layer of the LD skin paddle, under muscle fascia, and within the muscular fibers caudal to the skin paddle during immediate breast reconstructions, at the same time as an LD flap transfer. Performing the fat-grafted, volume-enhanced LD flap procedure with fat grafting recipient sites can serve as a useful alternative to utilizing abdomen-based flaps in autologous breast reconstruction, especially to salvage a failed implant or to perform an LD flap breast reconstruction. This is an easy technique for performing autologous breast reconstruction in patients with a wide variety of BMIs (range, 19.6-39.9) that also offers low morbidity and fast recovery. Although no volumetric breast measurements were performed in this series, it can be deduced from the mastectomy weight measured for each patient (mean weight, 443 g; range, 180-830 g) that a large, variable breast volume can be achieved with the technique. Utilizing the TAF flap as well, especially in cases of delayed breast reconstruction, can provide a significant additional source of recent tissue in which to graft fat, which allows further volume enhancement and serves as a very useful additional fat grafting recipient site when all other such sites have been saturated.

This paper highlights the extended options for fat grafting recipient sites and Figure 2 demonstrates the approaches and recipient site choice which is different depending on cancer status, and immediate versus delayed reconstruction. The pectoralis major and serratus muscles were not fat grafted in immediate breast reconstructions following cancer removal, because of the concern that the injection may disseminate any residual tumor tissues, leading to local metastases. In addition, fat is not injected into the mastectomy skin flaps in immediate breast reconstructions following cancer removal, because it may lead to vascular compromise, in addition to the previously discussed local metastases. However, in immediate breast reconstructions following a prophylactic mastectomy, fat can be injected into the non-undermined mastectomy skin flaps as well as the pectoralis and serratus muscles.

The concept and theory of injection metastasis remains controversial, and there is very little clinical evidence to support a lack of cancer risk as a result of a breast reconstruction. In vitro studies have mainly alluded to an increased risk of breast reconstruction promoting cancer or metastases, although these results have not been confirmed in vivo. We have not observed this association in our practice, although long-term oncologic follow-up is required for both autologous and implant-based breast reconstructions. In 2015, Alharbi et al reported two cases of breast cancer recurrence in an LD flap after lipofilling. The authors of this study suggested that, although there was no strong scientific evidence in the literature for an association between breast cancer and fat grafting in the breast, it is important to be vigilant and systematically follow patients who received fat grafting. However, our technique and its associated algorithm represent a more prudent approach to choosing safe fat grafting recipient sites in particular for women undergoing immediate reconstruction, and if the mastectomy is performed for cancer.

Five patients (five breasts) in this series had previously undergone repeated pre-reconstruction radiation therapy, and one of these patients had previously undergone repeated fat grafting procedures. The small cohort of this study limits the interpretation of our results and our ability to perform a statistical analysis to determine the frequency and durability of fat grafting performed on breasts that had previously undergone radiation therapy. It has been reported that adipose-derived stem cells may improve the vascularity of an irradiated tissue bed and reduce radiotherapy-related complications by increasing neovascularization in local skin, which could be beneficial in both implantations and autologous breast reconstructions. Improvement of local skin vascularity is vital for wound healing and complications related to poor blood supply (for example skin necrosis) of the mastectomy skin flaps or the flap.

The impact of performing simultaneous fat grafting with an LD flap transfer in a patient that has undergone radiation therapy, along with determining safe fat grafting volumes and fat survival in this context, is an area that requires further research.

The volume of fat grafted during a simultaneous fat grafting session and the number of sessions of subsequent fat grafting required were both multifactorial and individualized, impacted by the patient’s habitus, the size of the patient’s LD muscle and LD skin paddle, the contralateral breast volume, possible fat grafting recipient sites, and the patient’s expectations for their reconstruction. Patients with a large LD muscle and LD skin paddle usually have more fat grafting recipient tissues available. Harvesting the largest potential skin paddle and the entire LD muscle is critical for achieving the largest desired breast volume. The design of the skin paddle can be made by assessing the donor site skin groove and performing a pinch test, which can help to plan the largest skin paddle and maintain a well-concealed donor site scar.

Three patients (five breasts) in this case series underwent repeated fat grafting revisional procedures, of which two patients (four breasts) underwent one session and one patient (one breast) underwent two sessions. The small cohort of this study limits our ability to determine the relationship between repeated fat grafting sessions and potential confounder variables such as radiotherapy, BMI, breast size, comorbidities etc. The number of repeat fat grafting sessions a patient undergoes (if any) is dictated by the patient’s final desired breast shape and volume. In addition, only a portion of the grafted fat survives, which may necessitate additional grafting procedures; however, the grafted fat that does survive provides long-lasting results. A staged approach to fat grafting is
commonly required, and may improve the final shape and overall cosmesis of the reconstructed breast. Carrying out a stage of fat grafting simultaneously with flap transfer can be performed safely and can reduce the total number of subsequent fat grafting procedures that a patient undergoes, even if just by one additional surgical procedure. We appreciate that true impacts of repeated fat grafting sessions can only be determined with longer prospective studies with larger patient cohorts, which may be best carried out with a multicenter prospective study design.

Simultaneous fat grafting with autologous LD flap transfer has several unique benefits. It allows direct, visualized fat injection (as opposed to “blind” injection), which avoids injuring the flap pedicle and the thoracic cavity. The absence of scar tissue in the recipient area allows for a smoother injection technique, with more accurate fat graft placement, and obviates the need for at least one fat grafting revisional procedure. As clinical and experimental studies have demonstrated, grafting adipose tissue improves the quality of the skin in an irradiated area and early fat grafting could potentially minimize radiation-induced tissue damage when patients are expected to receive postoperative radiation. Recently, fat grafting has been proven to be a promising therapeutic approach for scar management after burns and physical trauma. Therefore, there is evidence to suggest that early fat grafting may help reduce scar tissue formation. This technique can be employed in the setting of an LD flap/tissue expander/implant reconstruction, and could also be expanded to other autologous breast reconstruction options, including the transverse upper gracilis flap, the profunda artery perforator flap, and the deep inferior epigastric perforator/musclesparing free transverse rectus abdominus myocutaneous flap breast reconstruction.

This preliminary report describes our early experiences with utilizing the fat-grafted, volume enhanced LD flap transfer and fat grafting recipient sites in purely autologous breast reconstruction. The interpretation of our results is limited by this study’s small number of patients and short follow-up period for patients. Multiple sessions of fat grafting are still needed in some cases to achieve the patient’s desired results, depending on her final desired volume for the reconstructed breast. There is a paucity of data in the aesthetic surgery literature describing this technique; therefore, larger longitudinal cohort studies are required to fully evaluate the technique’s efficacy and perform a cost-benefit analysis.

**CONCLUSION**

This preliminary study demonstrated that the combining the LD flap transfer with simultaneous fat grafting in a delayed or immediate breast reconstruction is a simple and safe technique for autologous breast reconstruction. Our experience has shown that fat grafting can be performed safely and easily along with the autologous LD flap transfer using a multisite, multilayer approach. This strategy can potentially be employed in tertiary breast reconstruction as well and can be successfully carried out in patients who have previously undergone radiation therapy, without an increased risk of complications, including fat necrosis. The technique offers an alternative approach to autologous breast reconstruction that can provide larger breast volumes without the need for aggressive LD flap harvesting, which is associated with increased donor site morbidity. Utilizing fat-grafted, volume enhanced LD flap transfer and fat grafting recipient sites is a promising approach for complete autologous breast reconstruction in patients with limited donor site availability.

**Supplementary Material**

This article contains supplementary material located online at www.aestheticsurgeryjournal.com.

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