



# Identifying Preoperative Factors Associated with the Volume Discrepancy in Patients Undergoing Breast Reconstruction with the Extended Latissimus Dorsi Musculocutaneous Flap Coverage



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## Abstract

**Background** The latissimus dorsi (LD) flap is a versatile option for breast reconstruction. However, the indications are limited because of volume discrepancy between the breast and the flap. We conducted this study to identify preoperative factors associated with the volume discrepancy in patients undergoing breast reconstruction with the extended LD flap.

**Methods** A retrospective study was performed in 69 patients (69 breasts) who underwent breast reconstruction with the extended LD flap between March 2015 and March 2018. We evaluated age, body weight, height, preoperative body mass index (BMI), postoperative BMI, breast skin defect size, breast volume, flap volume, and volume discrepancy [breast volume – flap volume].

**Results** Mean age, height, body weight, preoperative BMI, postoperative BMI, skin defect size, breast volume, flap volume, and volume discrepancy were  $45.6 \pm 7.1$ ,  $157.8 \pm 0.1$ ,  $59 \pm 8.1$ ,  $23.7 \pm 3.2$ ,  $23.5 \pm 3.3$ ,  $16.5 \pm 9.3$ ,  $252.2 \pm 107.1$ ,  $229.4 \pm 95.6$ , and  $32.6 \pm 31.4$ , respectively. Spearman's rank correlation coefficients indicated significant positive linear correlations between volume discrepancy and preoperative BMI (correlation coefficient = 0.267,  $P = 0.027$ ), volume discrepancy and breast volume (correlation coefficient = 0.472,  $P < 0.001$ ), and between volume discrepancy and skin defect size (correlation coefficient = 0.609,  $P < 0.001$ ). Stepwise multiple regression analysis yielded the following formula: predicted log volume discrepancy (ml) =  $1.2891 + 0.0639 \times \text{skin defect size} + 0.0025 \times \text{breast volume}$  ( $R^2 = 0.421$ ).

**Conclusion** Skin defect size and breast volume were preoperative factors associated with volume discrepancy in patients who have undergone breast reconstruction with the extended LD flap. Considering these factors, we can predict the lack of volume and plan any necessary secondary procedures.

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**Keywords** Latissimus dorsi flap · Breast reconstruction · Volume

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## Introduction

The pedicled latissimus dorsi (LD) flap is a “workhorse” flap for breast reconstruction in small-breasted patients [1]. The LD flap offers a well-vascularized skin paddle and provides muscle volume [2]. Thus, it is used in patients who are at risk of diabetes mellitus and hypertension, as well as for smokers and those who are obese [3]. However, its utility is limited by its inability to provide sufficient breast volume, and it has thus become a secondary choice for autologous breast reconstruction [1].

Several secondary procedures enhance the volume of the LD flap. One strategy is to insert an implant, but this approach is associated with complications, such as infection, capsular contracture, implant rupture, migration, and extrusion [4, 5]. The extended LD flap technique has been used to avoid the use of implants and their complications and to increase flap volume by modifying the harvest boundary. This approach involves more aggressive harvesting of subcutaneous tissue under the skin paddle. Excessive harvesting, due to the lack of any standard with respect to the required volume, increases the risk of seroma, wound breakdown, contour deformities, and lumbar hernia [6, 7]. It would be useful to predict the discrepancy in volume between the breast and flap to determine the necessity for a secondary procedure and reconstruct an aesthetic symmetric breast.

Many studies have described how to estimate and measure the volume of a breast and a pedicled LD flap [8–13]. However, no study has analyzed preoperative factors that affect the discrepancy in volume between the breast and the flap. We conducted this study to identify preoperative factors associated with the postoperative volume discrepancy in patients undergoing breast reconstruction with extended LD flap coverage.

## Materials and Methods

In this single-center, retrospective study, we evaluated the medical records and computed tomography (CT) scans of patients who had undergone breast reconstruction using extended LD musculocutaneous flaps after a skin sparing mastectomy between March 2015 and March 2018. Patients were selected for LD flap reconstruction according to the following criteria (Fig. 1).

### Inclusion criteria

1. Diagnosis of breast cancer.
2. History of radiation therapy or planned radiation therapy.
3. Contraindication for TRAM/DIEP flap.

4. Postoperative evaluation, including clinical and aesthetic outcomes, and radiological examination at 3 months postoperatively.

### Exclusion criteria:

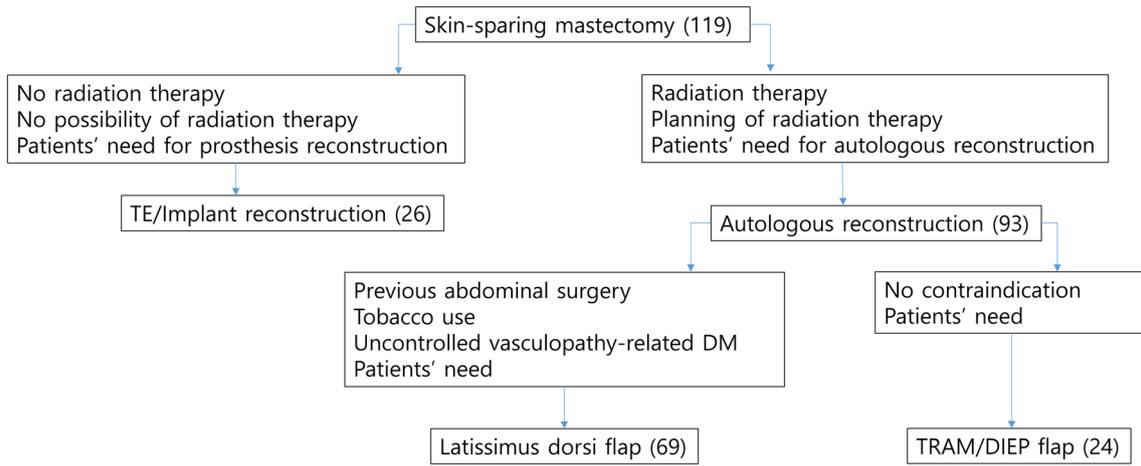
1. Delayed breast reconstruction.
2. Procedures affecting the breast tissue (augmentation, fat injection, foreign body injection).
3. No perioperative data (demographic and excised skin size and breast weight data).
4. No preoperative or postoperative CT scans.
5. No postoperative evaluation (because the patient did not visit the outpatient clinic of the Department of Plastic and Reconstructive Surgery of our medical institution at 3 months postoperatively).

The present study was approved by the institutional review board (IRB) of our medical institution (IRB Approval No. OC18RESI0076). The requirement for informed consent was waived due to the retrospective nature of the study.

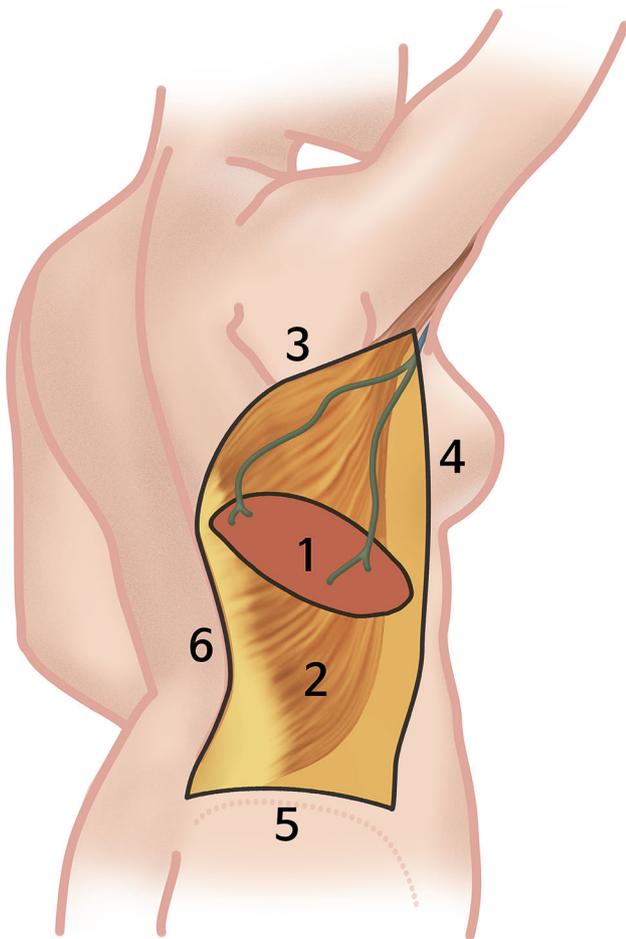
We evaluated a number of factors, including patient age, body weight, preoperative body mass index (BMI), postoperative BMI, breast skin defect size, breast volume, flap volume, and volume discrepancy [breast volume – flap volume]. In addition, we assessed the correlations between volume discrepancy and other factors.

## Surgical Technique

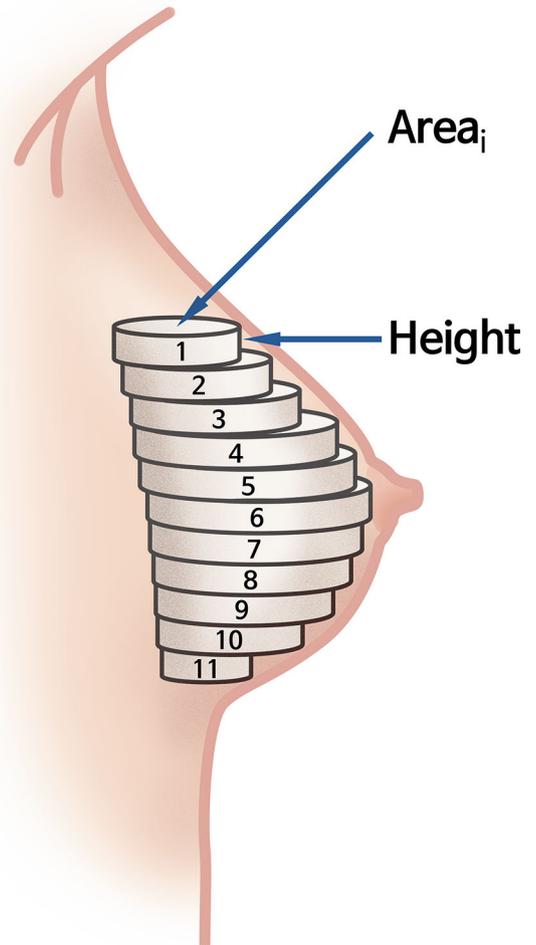
The flap was designed obliquely and was harvested in the lateral decubitus position. The skin paddle was incised to the subcutaneous fat, which was then subcutaneous fat was then divided to the level of the superficial layer of the thoracolumbar fascia. All five fat compartments were raised: fat overlying the muscle, the periscapular fat pad, fat underlying the cutaneous paddle, fat located at the anterior border of the LD muscle, and the suprailiac fat pad. The harvested borders of the extended LD flap were set as follows: lower one-third of the scapula as the upper border, superior iliac crest as the lower border, vertebrae as the medial border, and serratus anterior muscle as the lateral border (Fig. 2 & Supple. Fig. 3) [14]. The inserted tendon of the LD muscle was divided, but the thoracodorsal nerve was preserved. The flap was then transposed to the anterior chest through a subcutaneous tunnel created on the axillary fold. The inset of the flap and closure of the donor site were performed as described previously [1, 7, 12, 15].



**Fig. 1** Algorithm for selection of breast reconstruction option



**Fig. 2** Harvesting the borders of the extended latissimus dorsi (LD) flap. (1: adipose tissue located under the skin paddle, 2: adipose tissue on the surface of the LD muscle, 3: lower one-third of the scapula as the superior border, 4: serratus anterior muscle as the lateral border, 5: iliac crest as the inferior border, 6: vertebrae as the medial border)



**Fig. 3** Breast volume was calculated using the Cavalieri method by mathematically integrating the area on axial sections

## Quantitative Measurements of Breast and Flap Volume

Breast volume was calculated using the Cavalieri method, by mathematically integrating the area on axial sections of the preoperative chest CT scan for the breast cancer workup (Fig. 3 & Supple. Fig. 1) [16–18]. The volume of the extended LD flap was also calculated in the same manner based on follow-up chest CT.

## Quantitative Measurement of the Skin Defect

The area of the breast skin defect was designed preoperatively using ImageJ processing software via Java plugins (National Institutes of Health, Bethesda, MD, USA) [19, 20]. This method has been applied to measure the area and volume of various tissues [18]. The number of pixels in select images of the skin defect was determined using ImageJ. The region of interest was measured by calculating the pixel number per unit area.

**Table 1** Baseline characteristics and demographic data of patients

Variables	Mean $\pm$ SD	Median (Q1–Q3)
Age (years)	45.6 $\pm$ 7.1	47 (41–51.5)
Height (cm)	157.8 $\pm$ 0.1	157.9 (153–161.1)
Body weight (kg)	59 $\pm$ 8.1	57.4 (53.4–63.4)
Preoperative BMI (kg/m <sup>2</sup> )	23.7 $\pm$ 3.2	23.1 (21.8–24.8)
Postoperative BMI (kg/m <sup>2</sup> )	23.5 $\pm$ 3.3	23.2 (21.4–24.7)
Skin defect size (cm <sup>2</sup> )	16.5 $\pm$ 9.3	15.3 (9.6–23)
Breast volume (ml)	252.2 $\pm$ 107.1	250 (160–300)
Flap volume (ml)	229.4 $\pm$ 95.6	189.7 (154.4–288.5)
Volume discrepancy	32.6 $\pm$ 31.4	20.3 (9.9–47.4)

**Table 2** Correlation coefficients between variables of interest and volume discrepancy

Variables	Spearman correlation coefficient with VD	P value
Age	– 0.068	0.581
Pre-BMI	0.267*	0.027
Post-BMI	0.229	0.058
SDS	0.609**	< 0.0001
BV	0.472**	< 0.0001

VD volume discrepancy, Pre-BMI preoperative body mass index, Post-BMI postoperative body mass index, SDS skin defect size, BV breast volume

\*Correlation is significant at the 0.05 level

\*\*Correlation is significant at the 0.01 level

## Statistical Analysis

Statistical analyses were performed using SPSS for Windows software (ver. 18.0; SPSS Inc., Chicago, IL, USA). All data are expressed as mean  $\pm$  standard deviation. We evaluated Spearman's rank correlation coefficients to investigate the associations between volume discrepancy and the variables of interest. Stepwise multiple regression analyses were performed with log transformation of dependent variable. Volume discrepancy was a dependent variable, while age, preoperative BMI, postoperative BMI, skin defect size, and breast volume were independent variables. *P* value < 0.05 was considered significant.

## Results

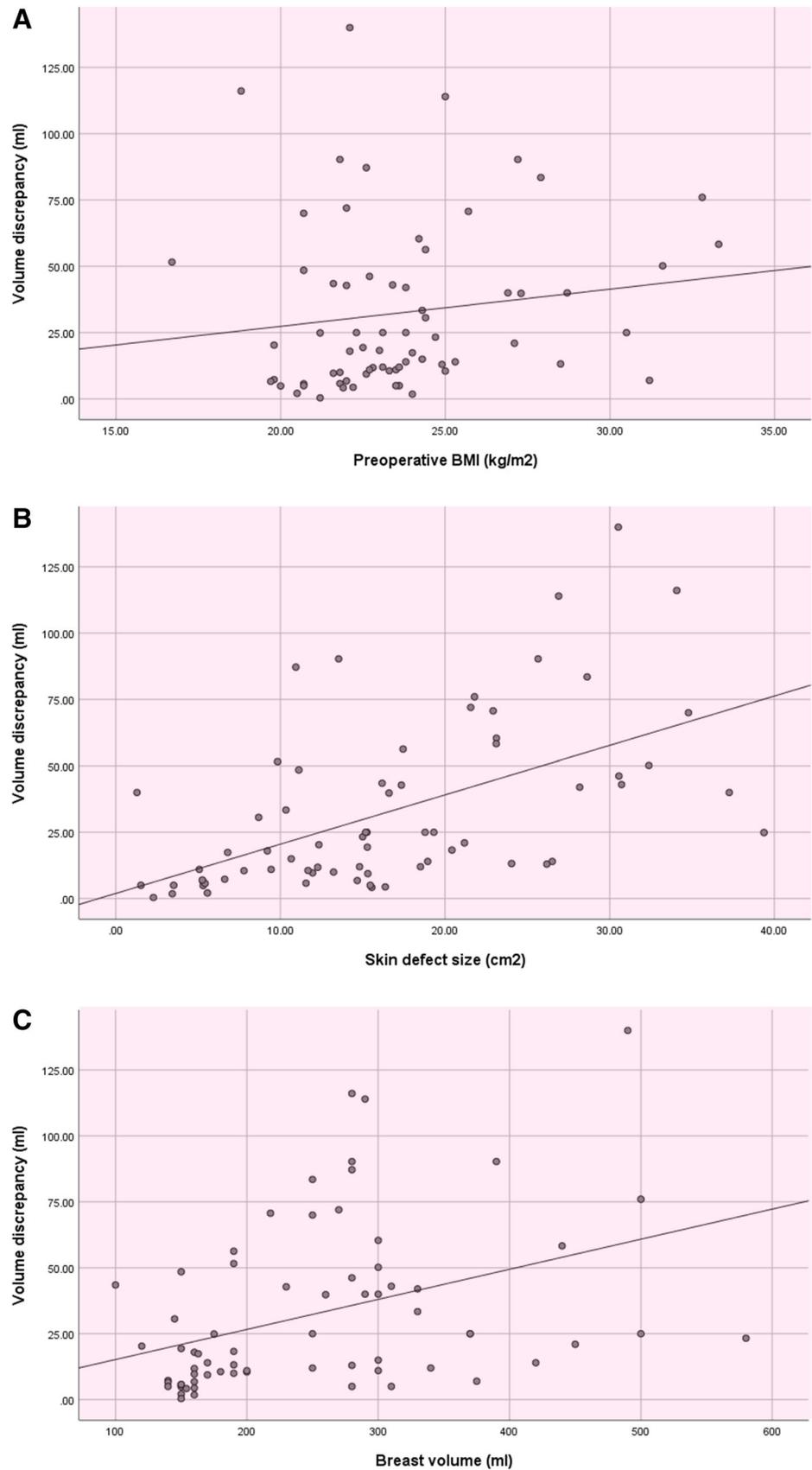
A total of 69 patients were included in this study. The baseline characteristics and demographic data of the patients are summarized in Table 1 and Supplementary Table 1. Spearman's rank correlation coefficients indicated significant positive linear correlations between volume discrepancy and BMI ( $r = 0.267$ ,  $P = 0.027$ ), volume discrepancy and breast volume ( $r = 0.472$ ,  $P < 0.001$ ), and between volume discrepancy and skin defect size ( $r = 0.609$ ,  $P < 0.001$ ) (Table 2; Fig. 4). Stepwise multiple regression analysis yielded the following formula: Predicted log volume discrepancy (ml) = 1.2891 + 0.0639  $\times$  skin defect size + 0.0025  $\times$  breast volume ( $R^2 = 0.421$ ) (Table 3).

## Discussion

The goal of breast reconstruction is to create a natural, symmetrical, and aesthetically satisfying breast, rather than merely to achieve coverage of breast soft tissue defects. Therefore, the most appropriate method among various reconstruction options should be selected for the individual patient. Since Tansini introduced the technique in 1896 [21], the LD flap has served as a versatile option for breast reconstruction. However, with the increasing popularity of abdominal-based perforator flaps, the LD flap has become the secondary choice for autologous breast reconstruction [1].

Furthermore, LD flaps cannot be tailored like free flaps, and it is difficult to weigh the harvested flaps intraoperatively. Although a weighing method has been reported [12], it is not used commonly because a suspension scale is needed and the connected pedicle causes tension on the flap, resulting in weighing errors. Therefore, it is necessary to predict the volume discrepancy to establish the surgical plan.

**Fig. 4 a.** Relationship between volume discrepancy and preoperative BMI (body mass index) ( $r = 0.267$ ,  $P = 0.027$ ), **b** relationship between volume discrepancy and skin defect size ( $r = 0.609$ ;  $P < 0.001$ ), **c** relationship between volume discrepancy and breast volume ( $r = 0.472$ ;  $P < 0.001$ )



**Table 3** Multiple linear regression by stepwise selection

Variables	Simple			Multiple		
	$\beta$	SE	<i>P</i>	$\beta$	SE	<i>P</i>
Age	− 0.0198	0.0194	0.3108			
Pre-BMI	0.0881	0.0415	0.0374			
Post-BMI	0.0778	0.0402	0.0576			
SDS	0.0742	0.0118	< 0.0001	0.0639	0.0122	< 0.0001
BV	0.0045	0.0012	0.0003	0.0025	0.0011	0.0219

*Pre-BMI* preoperative body mass index, *Post-BMI* postoperative body mass index, *SDS* skin defect size, *BV* breast volume

**Fig. 5** Preoperative and postoperative 6-month photographs of patients with large breast size

In multivariate analyses, skin defect size and breast volume were significantly associated with volume discrepancy. The skin defect area itself does not contribute to the volume difference, but anatomical support decreases as the skin resection area and volume-filling requirement increase [22]. In patients with large breasts, the flap volume of the back tissue does not follow breast volume, and the volume discrepancy is high.

In the prediction model, body weight and BMI were not significantly associated with volume discrepancy but did show significant associations with flap volume in this study; as the BMI increased, so too did the breast volume (correlation coefficient = 0.625,  $P < 0.001$ ). However, as the volume of flap that can be harvested also increased (correlation coefficient = 0.644,  $P < 0.001$ ), obese women can also obtain sufficient volume from the LD flap alone (Fig. 5). Breast reconstruction with LD flap alone was not beneficial in lean patients with moderate-to-large breast size, but it was beneficial in obese patients with small-to-moderate breast size. In the prediction model of multiple regression analyses, postoperative BMI was also not associated with volume discrepancy.

The volume discrepancy was determined by skin defect size and breast volume in a multiple regression analysis.

Although the correlation in the multiple regression analysis was not strong ( $R^2 = 0.421$ ), it was useful for predicting the postoperative breast volume and made it possible to consider whether to use the LD flap alone or in combination with a secondary procedure, such as a fat graft or implant, when planning the breast reconstruction. According to the predicted requirements, the volume of the extended LD flap can be expanded using several methods. The method of transferring fat from an area where it is present in excess, such as the abdomen or thighs, to the LD flap to improve breast volume and shape has been used successfully in reconstructive breast surgery [23]. This method can be applied repeatedly and focally. Another method is the combination with prosthesis for volume restoration [5]. This method has been shown to be safe and to have good subjective and objective long-term results.

This study had several limitations. First, this study had a retrospective design with a small sample size and short period of follow-up CT to evaluate postoperative volume. Therefore, this study had potential patient selection bias among the options for breast reconstruction, including extended LD flap, free abdominal tissue transfer, and staged implant insertion. In addition, there may be interindividual differences when harvesting LD flaps;

however, the harvest range and plane were predefined, and the operations were performed in the same manner, to counter this problem. Further studies on volume discrepancy, including a tool for evaluating aesthetic outcomes, such as BREAST-Q, will be needed.

## Conclusion

The LD flap is versatile and reliable for breast reconstruction. However, a discrepancy between breast volume and flap volume is apparent so the indication is limited. We showed that the excised skin area and breast volume were preoperative factors associated with volume discrepancy. Taking these factors into consideration during operative planning allows determination of whether the LD flap should be used alone or in combination with a secondary procedure to enhance volume, as the required volume can be estimated.

## Compliance with Ethical Standards

**Conflict of interest** The authors declare that they have no conflict of interest.

## Statement of Human and Animal Rights or Ethical Approval

This article does not contain any studies with human participants or animals performed by any of the authors.

**Informed Consent** For this type of study, informed consent is not required.

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