INTRODUCTION

Latissimus dorsi (LD) flaps have been widely used for autologous breast reconstruction after mastectomy for their safety, ease of harvest, and minor donor-site morbidity. However, conventional LD flaps have an insufficient amount of tissue. Various strategies have been proposed to increase flap volume, including extended LD flaps such as the fleur-de-lis LD flap, as well as the concept of additional zones of fat harvest.1–4 Nonetheless, for thin patients who have little subcutaneous fat, sufficient tissue cannot be secured even with extended LD flaps in many cases. Lumbar artery perforator (LAP) flaps are advantageous for thin patients because they allow for the addition of a large amount of fat, the vascular pedicle is short and vascular grafts are often required. To address these shortcomings, we propose here a LD-LAP chimeric flap. Specifically, the LD flap and LAP flap are elevated as one piece, and the 6th or 7th intercostal artery perforators and lumbar artery perforators, which are harvested together with the flap, are connected via intra-flap crossover anastomosis. Anastomosis for both intercostal artery perforators and lumbar artery perforators was performed about 1 cm away from the flap. Indocyanine green angiography performed after anastomosis showed improved blood flow to the LAP flap portion of the chimeric flap. The chimeric flap was used in 4 patients, with a mean flap volume of 460 ml (range, 300–690 ml) and mean duration of 439 minutes (393–484 minutes) for reconstruction surgery. During the mean follow-up period of 29.5 months (range, 16–40 months), sufficient tissue volume was obtained and none of the patients developed flap necrosis. Although our method requires vascular anastomosis and may extend operative time, it substantially increases LD flap volume and thus is likely to be an effective auxiliary component to breast reconstruction using LD flaps. (Plast Reconstr Surg Glob Open 2020;8:e3222; doi: 10.1097/GOX.0000000000003222; Published online 25 November 2020.)
PATIENTS AND METHODS

This study was approved by the Institutional Review Board of Osaka International Cancer Institute. From February 2017 to December 2018, we performed breast reconstruction using the LD-LAP chimeric flap after mastectomy in 4 patients who had unilateral breast cancer. All surgeries were conducted by co-author HT. With the patient in the lateral position, we designed an oblique skin paddle of 5.5–7 cm × 22–25 cm for which primary closure was possible. We identified the 6–7th ICAPs and LAPs, which were confirmed by color Doppler preoperatively. To elevate the LD-LAP chimeric flap, the superficial layer was dissected under the superficial fascia, and the back surface of the flap was dissected over the chest wall, ensuring that deeper fat layers beneath the superficial fascia were included in the flap for the entire LD muscle and the caudal region up to the iliac crest (Fig. 1). ICAPs were ligated above the chest wall, and LAPs were dissected deep enough to secure a length of roughly 2 cm, ligated, and incorporated into the flap (Fig. 2). Undermining was not performed for the gluteal extension. After confirming the thoracodorsal vessels, insertion of the LD muscle was cut at a level proximal to the bifurcation to the serratus vessel branch, preserving the thoracodorsal nerve. After elevation, the flap was folded, and ICAPs and LAPs were anastomosed in an end-to-end fashion under microscopy with 10-0 nylon for arteries and a coupler device for veins (Fig. 3). To avoid tension at the anastomosis site, the LD flap and LAP flap were fixed to the region surrounding the anastomosis site using absorbable sutures. Next, the folded flap was carefully moved through a subcutaneous tunnel to the chest. Patients were then shifted to the supine position, and the breast was shaped by fixing the flap to the pectoral muscle with absorbable sutures. Quilting sutures were used for the donor site to prevent seroma formation.

We evaluated demographics, operative data including flap volume measured by Archimedes’ principle, and complications such as flap necrosis caused by postoperative blood flow insufficiency. Cosmetic evaluations were also performed by four plastic surgeons using the Harvard scale proposed by Harris et al.⁸

RESULTS

Mean age was 47.5 years (range, 39–55 years), mean body mass index was 23.8 kg/m² (range, 19.3–29.9 kg/m²), mean flap volume was 460 ml (range, 300–690 ml), mean operative time for reconstruction was 439 minutes (range, 395–484 minutes), and mean follow-up period was 29.5 months (range, 16–40 months) (Table 1). Vessel diameters at the anastomosis sites for ICAPs and LAPs...
were about 1 mm for arteries and 1.5–2 mm for veins. Anastomosis was performed about 1 cm away from the flap for both ICAPs and LAPs. During the anastomosis procedure, pulsatile bleeding was noted for ICAPs, and indocyanine green angiography after anastomosis revealed improved blood flow in the LAP flap portion. (See Video [online], which shows the change in blood flow before and after declamping of anastomosed vessels.) All flaps survived, and there were no complications resulting from blood flow insufficiency such as partial flap necrosis and fat hardening during the follow-up period. Complications such as donor-site seroma also were not observed. Postoperative cosmetic outcomes were evaluated as excellent for 2 patients, good for 1 patient, and fair for the remaining patient (possibly due to flap displacement). Representative images are provided in Supplemental Digital Contents 1 and 2 (See figure, Supplemental Digital Content 1, which displays preoperative and postoperative views, respectively, of Patient 1 at 23 months after right breast reconstruction. http://links.lww.com/PRSGO/B504.) (See figure, Supplemental Digital Content 2, which displays preoperative and postoperative views, respectively, of Patient 3 at 10 months after right breast mastectomy and immediate reconstruction. http://links.lww.com/PRSGO/B505.)

**DISCUSSION**

Various types of extended LD flaps have been proposed, such as flaps with a modified skin paddle design and flaps that incorporate fatty zones of the back (ie, surface of the muscle, scapular fat pad, anterior fatty zone, and supra-iliac fat pad). However, for thin women, it is often difficult to secure an adequate amount of tissue. LAP flaps, on the other hand, can include a large amount of fat even for thin women, while they too suffer from drawbacks such as the need for vascular grafts due to a short vascular pedicle compared with other types of flaps. The LD-LAP chimeric flaps used in the present study can secure a larger amount of tissue compared with when the LD and LAP flaps are used separately. In addition, the need for vascular grafts is avoided due to intra-flap crossover anastomosis of LAPs to ICAPs in the LD flap. Moreover, because the proportion of muscle tissue in the entire flap is lower compared with when reconstruction is performed with the LD flap alone, flap atrophy rates are relatively low even if muscle atrophy occurs postoperatively. On the other hand, this method may be of little value in bilateral reconstruction, in which the size of the reconstructed breast can be adjusted.

The blood supply to the LD muscle is classified as Mathes and Nahai type V, with the main supply coming from the thoracodorsal artery and collateral supply from
ICAPs. When elevated as an LD flap, blood supply from reverse-flow via linking vessels from the thoracodorsal artery is expected from the ICAP on the flap side. We used this blood supply in our method and relied on arterial flow to the LAP flap region resulting from anastomosis of ICAPs and LAPs. With regard to venous flow, some reverse-flow is likely to occur as well. The ‘avalvular bypass theory’ (which involves communicating and collateral branches) and the ‘valvular incompetence theory’ (which involves increased venous pressure, denervation, and simultaneous proximal and distal filling) are suggested as mechanisms underlying venous drainage for reverse-flow flaps often used in limb reconstruction. For LD-LAP chimeric flaps, we speculate that the main mechanism for venous drainage in the LD muscle can be explained by the avalvular bypass theory, and for the region near the vascular anastomosis site, the valvular incompetence theory is the main mechanism. Yet, because venous valves are present in the region near the anastomosis site, it is safest to resect the region containing the venous valves and perform anastomosis when obstruction of venous return is expected.

Because the present method relies on folding the flap and anastomosing vessels, there is no need for extended detachment of the vascular pedicle, and shaping the lower pole of the breast is made easier. However, ICAPs and LAPs need to have a sufficient diameter for vascular anastomosis. Thus, when anastomosis is deemed difficult at the stage of preoperative ultrasound or intraoperatively, a different method for volume augmentation should be considered.

**CONCLUSIONS**

We report on breast reconstruction using the LD-LAP chimeric flap, which compensates for the shortcomings

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Table 1. Patient Characteristics

| Patient | Age (y) | BMI (kg/m²) | Mastectomy Subtype | Timing of Reconstruction | Mastectomy Volume (mL) | Flap Volume (mL) | Skin Paddle Size (cm) | Operative Time (min) | Complications | Cosmetic Outcome | Follow-up Period (mo) |
|---------|---------|-------------|--------------------|-------------------------|------------------------|------------------|-----------------------|---------------------|---------------|------------------|---------------------|
| 1       | 39      | 29.9        | NSM                | Delayed                | 470                    | 690              | 6 × 22                | 453                 | —             | Excellent        | 40                  |
| 2       | 43      | 24          | NSM                | Immediate              | 250                    | 300              | 5.5 × 25              | 427                 | —             | Fair             | 38                  |
| 3       | 55      | 22          | NSM                | Immediate              | 300                    | 390              | 6 × 25                | 484                 | —             | Excellent        | 24                  |
| 4       | 53      | 19.3        | MRM                | Immediate              | 220                    | 460              | 7 × 24                | 393                 | —             | Good             | 16                  |

BMI, body mass index; NSM, nipple-sparing mastectomy; MRM, modified radical mastectomy.
of both LD and LAP flaps. The method requires vascular anastomosis and thus extends operative time, but markedly increases the LD flap volume with minimal sacrifice to the donor site. Reconstruction with the LD-LAP chimeric flap is likely to be an effective auxiliary component to breast reconstruction using LD flaps.

Hiroki Tashima, MD
Department of Plastic and Reconstructive Surgery
Graduate School of Medicine, Osaka University
2-2 C11 Yamadaoka, Suita
Osaka 5650871, Japan
E-mail: hitagood@yahoo.co.jp

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