Variants of Extended Latissimus Dorsi Musculocutaneous Flap for Large Wounds in Extremities

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Research

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Abstract

Background: Extended latissimus dorsi musculocutaneous (LDMC) flap increasing the size of the flap and most used for breast reconstruction. This report will share our experience in designing different extended LDMC flap for large wounds in extremities.

Patients and methods: From January 2004 to December 2018, extended LDMC flaps were performed on 72 consecutive patients aged 2 to 68 years (37 men and 35 women). All the wounds were extensive, either in upper or lower limbs, the skin defect ranged from $18 \times 10 \text{ cm}^2$ to $37 \times 21 \text{ cm}^2$. Single wing and double wings extended LDMC flaps were designed and harvested based on the wounds.

Results: Seventy-two patients included this series, 5 pedicle and 67 free flaps were successfully harvested. The mean flap harvest time was 56.2 min. The donor sites were closed primarily in all patients. The venous compromise was noticed on the first postoperative day in 4 cases. Two flaps were salvaged after emergency re-exploration, another two patient's flaps were total necrosis. One of the patients was received lower extremity amputation, another patient was repaired by extended LDMC flap on the other side. The wounds healed well, providing reliable soft tissue coverage and good contour in the reconstructed areas. Five patients lost follow-up, the follow-up period ranged from 10 to 56 months (mean, 15.7 months). Patients didn't occur significant donor site morbidities that influenced their daily activities during follow-up.

Conclusion: The single wing and double wings extended latissimus dorsi musculocutaneous flaps are simple and reliable methods for large skin and soft-tissue defects in extremities.

Introduction

Large skin and soft-tissue defects in extremities are still challenges faced by plastic and reconstructive surgeons. With the development of reconstructive methods improved, chimeric, sequential, and combined perforator flap transplantation are ideal ways to repair large defects with its low donor site morbidities [1–3]. But surgical complexity, operation time, and tolerance of surgical procedures still need to be improved.

Latissimus dorsi musculocutaneous (LDMC) flap is a useful way to reconstruct large skin and soft-tissue defects [4, 5]. The flap harvest is simple and has a good blood supply. Extended LDMC flap increased the volume of the flap was first described for breast reconstruction [6–9]. However, lots of reports focus on breast reconstruction, regarding used it for reconstructions of large soft tissue defects in extremity have not widely reported.

This report shows our experience in designing different extended LDMC flaps for large defects. To our knowledge, this is the largest case series reported the variants of extended LDMC flap for large soft-tissue defects in extremities.

Patients And Methods

These procedures were conducted in the Department of Hand and Microsurgery, Xiangya Hospital at Central South University. This report followed the Xiangya Hospital Ethical Committee guidelines. The protocol was developed in accordance with the ethical standards of the Helsinki Declaration of 1975 and all subsequent revisions.

From January 2004 to December 2018, 72 consecutive patients aged 2 to 68 years (37 men and 35 women) underwent the extended LDMC flaps reconstructions, including 41 adults and 31 children. Forty-one wounds were located in the calf, 18 in the foot and ankle, 6 in the shoulder and upper arm, 4 in the thigh, 3 in the knee joint. All the wounds were extensive, the skin defect ranged from $18 \times 10 \text{ cm}^2$ to $37 \times 21 \text{ cm}^2$. Twenty-eight patients combined with fractures, and six patients with segmental bone defects (ranged in size from 3 cm to 6 cm) required secondary orthopedic procedures. Patient characteristics were summarized in Table 1.

Table 1
Demographic data of patients who underwent extended latissimus dorsi
musculocutaneous flap

Patient Characteristics*	No.
No.	72
Age (years)	25.2 ± 18.9
Demographics	
Male	37
Female	35
Cause	
Motor vehicle accident	56
Crush injury	5
Burn scar contracture	4
Chronic ulcer	3
Machine injury	2
Tumor resection	1
Motorcycle spoke injury	1
Comorbidity	
Age > 60 yr	4
Type 2 diabetes	3
Smoker	9
Peripheral vascular disease†	2
Fracture	28
Segment bone defect	6
Location	
Shoulder and upper arm	6
Thigh	4
Knee joint	3
Calf	41
Ankle and foot	18

Patient Characteristics*	No.
Skin defects(cm ²)	18 × 10 to 37 × 21
*Mean age was 25.18 years (range, 2 to 68 years).	
†Diagnosed either on computed tomographic angiography or arteriography.	

Flap Design

The soft tissue defect was first radically debrided and measured. The defect template would guide us to choose a suitable variant of extended LDMC flaps. The skin paddle of the extended LDMC was used to cover the essential part, such as exposed bone with fracture, tendons, and joints. If the essential part located at the edge of the large wound, we preferred to use the single-wing extended LDMC flap. If the essential part located at the center of the large wound, we preferred to use the double-wings extended LDMC flap. For the design of single-wing extended LDMC flap, the axis of the flap was the line connecting the midpoint of the axilla and the posterior superior iliac spine. The design of double-wings LDMC flap was a little bit different from single-wing, the axis of the flap was parallel to the single wing design, which could give some space to harvest another wing. The schematic picture of the different extended LDMC flap design was shown in Fig. 1. Of note, we routinely performed the skin pinch test to confirmed that the donor site could be closed primarily after the flap harvest.

Surgical Technique

The following surgical procedures were used to harvest extended LDMC flaps^[10]. The patient was placed on his or her side. We first incised the skin and subcutaneous tissue based on the design, then we detached the subcutaneous tissue with the latissimus dorsi muscle around the skin flap. Afterward, we harvested single wing or double wings latissimus dorsi muscle. Once the latissimus dorsi muscle was dissected, the attention would be turned to the thoracodorsal vessels. The thoracodorsal vessels were identified and underwent retrograde dissected until we saw the circumflex scapular artery.

The extended LDMC flap was transferred to the recipient site and covered extensive soft-tissue defects. The skin paddle of the extended LDMC was used to cover the essential part, the remaining muscle flap could then be covered with split-thickness skin grafts. All the split-thickness skin grafts were harvested from the anterolateral thigh. The thoracodorsal artery and paired vein were anastomosed to the recipient's vessels with either end-to-side or end-to-end. The donor site was closed primarily.

Repaired extremities were warmed and elevated postoperatively. Postoperative monitoring included constituted hourly flap checks to evaluate color, capillary refill, turgor, and surface temperature. After surgery, patients also received appropriate antibiotics according to wound microbiological cultures, physical deep vein thrombosis prophylaxis, and multi-modal pain management.

Secondary orthopedic procedures such as vascularized iliac crest bone graft and Ilizarov technique were used in segmental bone defects, all the procedures were conducted within 4 to 8 weeks after the initial reconstruction.

Results

In the 72 patients included this series, 5 pedicle and 67 free flaps were successfully harvested, including 64 single wing and 8 double wings extended LDMC flaps. The mean flap harvest time was 56.2 min (Table 2). The additional subcutaneous veins were anastomosed to the recipient's vessels in 14 patients. The donor sites were closed primarily in all patients. The venous compromise was noticed on the first postoperative day in 4 cases. Two flaps were salvaged after emergency re-exploration. Two patient's flaps were total necrosis, one of the patients received lower extremity amputation, another patient was repaired by extended LDMC flap on the other side.

Table 2
Intra-operative data, complications and follow-up for patients who underwent extended latissimus dorsi musculocutaneous flap

Parameter	No.
Flap size (cm ²)	19 × 11 to 37 × 22
Type of transfer	
Pedicle	5
Free	67
Flap harvest time, min	56.4 (ranged 30 to 120)
Recipient vessels	
Radial artery	1
Descending branch of the LCFA	2
Descending genicular artery	2
Lateral superior genicular artery	2
Branch of the popliteal artery	4
Anterior tibial artery	34
Posterior tibial artery	16
Peroneal artery	2
Medial sural artery	4
Orthopedic procedures	
Bone graft	2
Ilizarov	4
Complications	
Venous comprise	4
Flap failure	2
Hypertrophic donor-site scars	8
Type of microvascular anastomoses	
end-to-end	42
end-to-side	25
Follow-up	

Parameter	No.
Loss of follow-up	5
Follow-up period (months)	15.7 (ranged 10 to 56)
LCFA, lateral circumflex femoral artery	

The recipient vessels and type of microvascular anastomoses are shown in Table 2. Six patients needed secondary orthopedic procedures, 2 patients with segmental bone defects repaired by vascularized iliac crest bone graft, another 4 patients were reconstructed by Ilizarov. All the patients' bone defects achieved reunion finally. The wounds healed well, providing reliable soft tissue coverage and good contour in the reconstructed areas. Most of the patients achieved good function recovery at the recipient site. Five patients lost follow-up, the mean follow-up was 15.7 months (ranged from 10 to 56 months). Patients didn't show significant donor site functional limitations that influenced their daily activities during follow-up. Eight patients have donor site hypertrophic scar, 3 patients in the back, 5 patients in the anterolateral thigh.

Case Reports

Case 1

A 20-year-old woman who was involved in a road traffic accident, presented with a large soft-tissue defect with 7 cm tibial bone defect on the right lower leg (Fig. 2A). After radical debridement, the tibial bone defect was managed by external fixator application. Then, we designed a single-wing extended LMDC flap (Fig. 2B). The skin paddle of the extended LMDC flap was $28 \times 7 \text{ cm}^2$, the dimension of the muscle flap was $25 \times 8 \text{ cm}^2$. The flap was harvested and transferred to the recipient site (Fig. 2C and D). The skin paddle of extended LMDC was used to cover a large area of exposed tendons and bones. The exposed part of the muscle flap and the residual wounds were covered with a split-thickness skin graft. The thoracodorsal artery and paired vein were anastomosed to anterior tibial vessels. The postoperative course was uneventful. The Ilizarov was used to reconstruct the bone defect at postoperative 4 weeks. During the 27 months follow-up, all the flap remained viable, and the wound healed well (Fig. 2E and F). At the last follow-up, the patient was able to ambulate freely without assistance (Video 1).

Case 2

A 4-year-old girl suffered a road traffic accident that caused an injury with the right foot and ankle. After radical debridement, leaving a large soft-tissue defect at the foot and ankle (Fig. 3A). A double-wings extended LMDC flap was designed and harvested to reconstruct the large wound in one stage (Fig. 3B and C). The skin paddle of the double-wings extended LMDC flap was $21 \times 6 \text{ cm}^2$, the size of the muscle flap was $11 \times 4 \text{ cm}^2$ and $11 \times 4 \text{ cm}^2$. The flap was transferred to the recipient site. The skin paddle

covered the larger areas of the ankle joint. The exposed part of the latissimus dorsi muscle flap was covered with a split-thickness skin graft (Fig. 3D). The thoracodorsal artery and paired vein were anastomosed to anterior tibial vessels. The postoperative course was uneventful. The flap remained viable, and the wound healed well during the follow-up (Fig. 3E and F). The patient was able to walk without assistance at the 12-month follow-up. (Video 2).

Discussion

Large soft-tissue defects caused by high-energy trauma and war are challenges to micro-surgeon^[11–13]. Those kinds of defects are usually combined with exposed bones, tendons, and joints, flap coverage is essential to these defects. The local flap is limited in this situation, for there is little expendable donor tissue for large defect coverage. A large single flap has been previously reported to cover the extensive wound^[14, 15]. The literature reported some large flaps, such as anterolateral thigh (ALT) flap $40 \times 20 \text{ cm}^2$, deep inferior epigastric perforators (DIEP) flap $50 \times 17 \text{ cm}^2$. But the donor site morbidities may limit using these large flaps. Even if no other complication occurs, the cosmetic appearance of donor sites will be poor because of closing them with skin grafts.

To reduce the donor site morbidities, sequential chimeric flaps were used to repair large soft-tissue defects^[16–18]. Qing et al reported using the bilateral chain-linked ALT perforator flaps for large defects^[19]. All the patients have got a good result with limited donor site morbidities. However, this method requires using more than one flap involves multiple donor sites as well as extra surgical risks associated with each flap. Moreover, the flap harvest needs too much intra-muscle dissection process, which increased the complexity of the surgery.

The LDMC flap, since its first description by Tanzini in 1906, has been used for breast reconstruction and other parts of bodies^[20, 21]. With the introduction of the thoracodorsal artery perforator flap (TDAP), the LDMC flap is gradually disregarded because of donor site morbidities^[22, 23]. But it still plays an important role in large skin and soft-tissue defects^[24, 25]. Ma et al used the pedicle LDMC flap for large defects in the upper extremity^[26]. All the patients had good functional results, the wound was primary healing with minor complications. Yu also reported used bilateral LDMC flaps to cover large soft tissue defects in the lower limbs of children^[27]. With bilateral LDMC flaps combined transplantation, it can repair even larger wounds without significant functional impairments at the donor site. However, the cross-bridge flaps from the contralateral leg were used in four of their cases because no vessels were available for anastomosis at the recipient site. Thus, various modifications to increase the volume of the flap have been reported to simplify the operation and avoid additional vascular anastomosis. The extended LDMC flap was first reported in the breast reconstruction to get enough volume of tissue. Moreover, the extended LDMC flap in breast reconstruction usually was transverse design, which was a benefit for the contour of the breast and left a hidden scar. But in our report, we used an oblique design to get enough length of the skin flap. With latissimus dorsi muscle designed as a single wing or double wings, the donor site can close primary without much tension. Currently, there are no reports regarding those two variants for large soft tissue

defects in extremities. This is also the largest case series as we know to share the experience in using extended LDMC flap for large wounds.

In our report, most of the patients have achieved good results. The mean flap harvest time was 56.2 min. All the patients' donor sites closed directly without a skin graft. Although the donor site scar is hard to hide, the donor site function was not significantly reduced. All the patients didn't show late wound complications or breakdown during the follow-up. The extended LDMC flap has the following advantages. First, flap harvest time is short, which doesn't need much intra-muscle dissection. The surgery technique is not complex compare with combined transplantation of perforator flaps. Second, there is no need for an extra flap donor site for covering large defects. Split-skin grafted muscle flaps have been claimed to as stable as fasciocutaneous flaps^[28]. In our series, no cases are requiring combined or fabricated chimeric perforator flaps based on thoracodorsal vessels. Third, the donor site has sufficient area, which allows us customized design based on the defect template. Besides, the donor site can be closed directly without skin graft, most of the patients are satisfied with the cosmic appearance of the donor site.

The extended fleur-de-lis LDMC flap is one of the other variants and was first introduced by McGraw and Papp in 1991 for breast reconstruction, but later it was applied in other reconstructions as well^[29]. Pedro Ciudad et al also used modified extended fleur-de-lis LDMC flap for large defects^[30]. This design is similar to the double-wings extended LDMC flap. But it is useful for multi-directional defects with a single flap by positioning vertical and horizontal parts in different combinations. The donor site is closed as Y shaped scar. All donor sites in our report were closed with a linear scar. This kind of flap is also useful to repair large defects in extremity, but we don't have much experience in this design.

One of the biggest concerns about the use of the extended LDMC flap is the donor site functional loss because of harvesting lots of latissimus dorsi muscle. In our patients, the donor site function has not significantly reduced during the follow-up, all the patients can regain normal daily activities at postoperative 3 months. The muscle-sparing descending branch latissimus dorsi flap may be a useful way to reduce donor site complications, we recommended to use it if the defect was not extensive^[31]. Some of the patients showed signs of venous congestion in the early stage. In our report, no one observed venous comprised when anatomized extra subcutaneous vein. According to our experience, we highly recommended harvesting additional subcutaneous vein anatomized to the recipient's vessels. Although some authors reported that donor site hypertrophic scar^[32], we also observed in 3 patients. We think the pinch test is a simple and effective way to evaluate donor site tension to reduce the incidence of the donor site scar. In addition, five patients complained about the anterolateral thigh hypertrophic scar. The "graft back" method and hydrocolloid dressings for donor sites may be helpful to improve the cosmetic outcomes.^[33, 34].

Conclusions

In summary, our report represents the largest series of extended LDMC flap repairs of large skin and soft tissue defects in extremities. The single wing and double wings extended LDMC flap is a simple and reliable method for large wounds.

Primary limitations of this report were the lack of a comparative group

and lack of a standardized measure for long-term outcomes after large wound reconstruction. Comparing outcomes against chimeric, sequential, or combined perforator flap transplantation between extended LDMC flap with other pre-expanded flap repairs may represent is an area for further study and improvement.

Declarations

Acknowledgments

Not applicable

Authors' contributions

He and Juyu Tang conceived and designed the study. Wu, Qing, Zhou, and Yu performed all the extended latissimus dorsi musculocutaneous flap surgery, reviewed, and edited the manuscript. All authors read and approved the manuscript.

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Availability of data and materials

The datasets used during the current study are available from the corresponding author upon reasonable request.

Ethics approval and consent to participate

This report had IRB approval from the Xiangya Hospital Ethical Committee.

Consent for publication

Written informed consent was obtained from the patients or the guardians of the patients.

Competing interests

None of the authors has any financial interest related to this report.

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Figures

Figure 1

The schematic diagram of designing variants of extended latissimus dorsi musculocutaneous (LDMC) flap. (a) Single wing extended LDMC flap design; (b) Double wings extended LDMC flap design.

Figure 2

A 20-year old woman (a) After radical debridement, leaving large skin and soft tissue defect and segment bone defect; (b) Single wing extended LDMC design; (c) Single wing extended LDMC harvest; (d) Intraoperative view of the flap; (e, f) Postoperative view of the recipient site and donor site at 27 months follow up.

Figure 3

A 4-year old girl (a) After radical debridement, the right foot and ankle exposed large skin and soft tissue defects; (b) Double wings extended LDMC design; (c) Double wings extended LDMC harvest; (d) The flap transferred to the recipient site to cover the exposed foot and ankle; (e, f) Postoperative view of the recipient site and donor site at 1-year follow up.

Supplementary Files

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