Reverse-flow anterolateral thigh flap without antegrade venous reconstruction for knee soft-tissue reconstruction

Hsuan-Keng Yeh, Chung-Chen Hsu*, Cheng-Hung Lin, Yen-Chang Hsiao, Yi-Chieh Chen, Yu-Te Lin, Chih-Hung Lin

Department of Plastic and Reconstructive Surgery, Chang Gung Memorial Hospital, Chang Gung University, Taipei, Taiwan

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Summary For soft-tissue defects around the knee area, the pedicled gastrocnemius flap is classically the first choice for reconstruction. However, the gastrocnemius flap is not always sufficient, and it carries certain donor site morbidity. When local lower limb flaps are insufficient or unavailable, free-tissue transfer is considered. Because few recipient vessels are located around the knee, free-tissue reconstruction remains challenging. In addition, the optimal donor site for large soft-tissue defects has not been clearly established. The anterolateral thigh (ALT) flap is easily accessible and has minor donor site morbidity. We evaluated the reverse-flow ALT pedicled flap as a candidate for the reconstruction of large soft-tissue defects around the knee. We performed a retrospective review of charts between 2005 and 2008. A total of four patients underwent reverse-flow ALT flap for reconstructing large soft-tissue defects around the knee. None of the flaps were augmented in venous drainage with a venous supercharge. We reviewed the defect characteristics, flap size, patient factors, and reconstructive outcomes. The soft-tissue defects were successfully reconstructed for all patients intraoperatively. However, venous congestion of varying degrees developed postoperatively in all patients. Two of the patients had partial flap necrosis but were successfully treated with debridement and skin grafting or local flap repair. The reverse-flow ALT flap can be used to reconstruct large soft-tissue defects around the knee successfully. However, venous congestion remains the main cause of flap complication. In such clinical scenarios, we suggest either using a smaller flap or performing venous supercharge to enhance venous return and improve the survival ratio of the flap.

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* Corresponding author. Department of Plastic and Reconstructive Surgery, Chang Gung Memorial Hospital, 5 Fu-Hsing Street Kuei-Shan, Taoyuan, Taiwan.
E-mail address: shu3506@yahoo.com.tw (C.-C. Hsu).

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1. Introduction

Reconstruction of soft-tissue defects around the knee remains a challenge. The main goals of soft-tissue reconstruction around the knee area are to restore the contour of the knee and to preserve knee function. Large soft-tissue defects with underlying tendon, bone, or even bone fixation implant exposure are not uncommon during soft-tissue reconstruction in the knee area. Because of the limited choice of local cutaneous and muscle flap options in this area, free-tissue transfer is often required. However, the choice of recipient vessels around the knee area is limited.1

The reverse-flow anterolateral thigh (ALT) flap was first described by Zhang2 in 1990. Pan et al.3 conducted an anatomic study of the reverse-flow ALT flap in 2004. They found that every 10 of 11 patients have type I or type III perforators according to Shieh et al.’s4 classification of ALT perforators, meaning that most of the perforators are derived from the descending branch of the lateral circumflex femoral artery; thus, the reverse-flow ALT flap is an easily accessible flap to harvest. Limited data are available on reverse-flow ALT flap for knee area reconstruction. In this study, we present our experience regarding soft-tissue reconstruction around the knee area by using reverse-flow ALT flap without antegrade venous supercharge.

2. Materials and methods

Between June 2005 and November 2008, a total of four patients with soft-tissue defects around the knee area underwent reconstruction by using ipsilateral pedicled reverse-flow ALT flap. All patients were male. The average age at the time of reconstruction was 33.5 years (range, 19–46 years). The defects in the knees in two patients were caused by crush injuries in road accidents. The third patient sustained an electric burn in the knee and proximal lower leg with patellar tendon exposure. The fourth patient had a soft-tissue defect in the knee region as a result of fasciotomy for necrotizing fasciitis. The size of the defects in these patients ranged from 6 cm × 7 cm to 22 cm × 20 cm.

2.1. Surgical technique

Preoperative planning routinely begins with identification of the perforators by using a handheld Doppler machine. The flap is designed according to the size of the defect. All sizable perforators are identified, and the ideal perforator from the descending branch of lateral circumflex femoral artery is dissected in a retrograde manner. The pedicle of the flap is isolated distally until the pivot point is reached. The pivot point is located proximal to the division of the descending branch, which is approximately 6–7 cm above the upper margin of the patella. Before the proximal end of the descending branch of the lateral circumflex femoral artery is ligated, a vascular clamp is applied to the proximal end to ensure that the “reverse-flow” perfusion is adequate to supply the entire flap. After the adequacy of the flap perfusion is confirmed, the pedicle is then ligated proximally exactly at the bifurcation points of the descending branch. The flap is then transferred to the defect area subcutaneously through tension-free pedicle placement.

3. Results

All of the defects were initially reconstructed by using reverse-flow ALT flap (Table 1). The sizes of the flaps ranged from 12 cm × 6 cm to 20 cm × 10 cm (average, 140 cm²), and the donor sites were primarily closed. The lengths of the pedicles ranged from 8 cm to 16 cm (average, 12.8 cm). The pivot points of the flaps were 5–13 cm (average, 7.75 cm) proximal to the upper margin of the patella. Although the procedures for the flap transfer were uneventful, various degrees of venous congestion occurred after the operation. The period of congestion was 3–7 days (average, 4.5 days). Two flaps had venous congestion for 3 days and survived completely. Flaps measuring 20 cm × 10 cm had venous congestion for 5 days and, therefore, necrotized (4 cm × 8 cm). A local rotational flap was used for wound closure. Another flap measuring 22 cm × 8 cm had venous congestion for 7 days, and, therefore, more than two-thirds of it necrotized; the wound was closed using a split-thickness skin graft.

<table>
<thead>
<tr>
<th>Age (y)/sex</th>
<th>Defect size (cm)</th>
<th>Pedicle length (cm)</th>
<th>Flap size (cm)</th>
<th>Number of perforators</th>
<th>Pivot point (cm proximal to patella proximal margin)</th>
<th>Days of venous congestion</th>
<th>Complications</th>
<th>Second procedure</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>19/M</td>
<td>10 × 6</td>
<td>15</td>
<td>12 × 6</td>
<td>1</td>
<td>13</td>
<td>3 days</td>
<td>Partial flap necrosis</td>
<td>Defatting and scar revision</td>
<td>Healed</td>
</tr>
<tr>
<td>27/M</td>
<td>10 × 10</td>
<td>16</td>
<td>20 × 10</td>
<td>2</td>
<td>5</td>
<td>5 days</td>
<td>Healed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40/M</td>
<td>6 × 7</td>
<td>12</td>
<td>16 × 7</td>
<td>1</td>
<td>8</td>
<td>3 days</td>
<td>&gt;2/3 flap necrosis, wound infection</td>
<td>STSG to knee</td>
<td>Healed</td>
</tr>
<tr>
<td>46/M</td>
<td>22 × 20</td>
<td>8</td>
<td>22 × 8</td>
<td>1</td>
<td>5</td>
<td>7 days</td>
<td>Healed</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.1. Case 1

A 19-year-old man presented with a 6-cm transverse laceration located 5 cm below the lateral knee as a result of motorcycle accident. Two days after the primary repair, the wound became erythematous, swollen, and tender. A large blood clot beneath the wound with anterior tibialis and peroneus longus muscle necrosis was found during debridement. The soft-tissue defect measured 10 cm × 6 cm and was located below the knee (Fig. 1).

The patient underwent ALT flap reconstruction on the 9th day after the injury. The pedicled flap measuring 12 cm × 6 cm was harvested from the ipsilateral thigh to repair the defect (Fig. 2). The muscular perforator of the flap was identified and skeletonized throughout the descending branch of the lateral circumflex femoral artery. The flap was then transposed to the defect area without tension. The pivot point was 13 cm above the proximal margin of patella. The wound was closed primarily (Fig. 3).

The flap turned bluish on Day 2 postoperation as a result of venous congestion. Therefore, the limb was elevated and the patient was treated through intermittent flap massage. The congestion subsided after 2 days of massage management. The entire flap survived, and no remarkable limitation of the range of motion was observed (Figs. 4 and 5).

Figure 1  Soft tissue defect 10 cm × 6 cm in size after debridement.

Figure 2  Pedicled reverse-flow anterolateral thigh flap 12 cm × 6 cm was designed.

Figure 3  Immediate result after flap inset.

Figure 4  At the 4-month follow-up.

Figure 5  There was 120° range of motion.
3.2. Case 2

A 27-year-old man sustained a deep friction burn in the left lower leg as a result of a traffic accident. After several debridement procedures, a soft-tissue defect in the left knee region with patellar exposure was observed and measured to be 10 cm x 10 cm.

A reverse-flow ALT flap that had two well-preserved muscular perforators and measured 20 cm x 10 cm was designed and harvested. The flap was transferred to the defect area, with the pivot point 5 cm proximal to the proximal margin of the patella.

However, the distal third of the flap became congested and bluish. The wound was managed through flap massage and evacuation of the blood clot beneath the flap (Fig. 6). Five days after intensive local care, the congestion improved considerably. However, the distal margin of the flap was necrotic, with the necrotic area measuring approximately 4 cm x 8 cm (Fig. 7). A fasciocutaneous rotational flap was harvested from the medial aspect of the lower leg to cover the flap defect. The wound healed well through meticulous wound care management. The knee range of motion at an 8-year follow-up examination was 120° (Figs. 8 and 9).

4. Discussion

For knee area soft-tissue reconstruction, several options for pedicle flaps have been reported. Of these options, the pedicled gastrocnemius flap is widely used. The flap can provide sizable and bulky soft tissue for covering defects around the knee area. The vascular supply is reliable and can easily be harvested. It has now become the standard flap in knee area reconstruction. However, there are some limitations of pedicled gastrocnemius flap including its donor site morbidity, limited skin paddle for reconstruction, and lack of versatility for its thickness of muscle component. Although it can resolve the problem of soft-tissue defect around the knee, pedicled gastrocnemius flap remains unsuitable in situations of extensive defect.

The ALT flap was first described by Song et al. in 1984. Clinically, it is versatile for reconstruction of the skin and soft-tissue defects. It has several advantages, including reliability, a considerably long pedicle, and limited donor-site morbidity.

Although the perforator variability of the ALT flap is a major concern, the dissection technique has been well established. Regarding reverse-flow ALT flap, the
Reverse-flow anterolateral thigh flap

anatomical study performed by Pan et al revealed that regardless of whether the perforator of the flap originates from the descending branch or the transverse branch of the lateral circumflex femoral artery, the flap pedicle can be traced distally to connect with the lateral superior genicular artery or profunda femoral artery.

Shieh et al presented type I and type III perforators derived from the descending branch of the lateral circumflex femoral artery, which are considerably easier to use for flap harvesting. They also proved that the arterial perfusion of reverse-flow ALT flap is adequate by measuring the blood pressure of the pedicle stumps. The mean proximal antegrade and retrograde blood pressures were 78.6 ± 13.0 mmHg and 45.8 ± 11.6 mmHg, respectively. The distal antegrade and retrograde blood pressures were 65.8 ± 11.6 mmHg and 61.1 ± 17.1 mmHg, respectively.

In our series, the largest flap used measured 20 cm × 10 cm, with a mean of 140 cm². By using the larger flap designs, we could easily reconstruct soft-tissue defects around the knee without tension. All of the reverse-flow ALT flaps reached the distal margin of the defects with adequate arterial perfusion. Zhou et al described a case of one ipsilateral knee and one contralateral lower leg reconstruction performed using pediced reverse-flow ALT flap. The flap size was large (22 cm × 12 cm). Liu et al reported three cases in which reverse-flow ALT flap was used for knee defect reconstruction. The flap size in their study ranged from 6 cm × 3 cm to 26 cm × 8 cm. All flaps survived. Demirseren et al published several cases in which knee area reconstruction was conducted using a single flap. In their series, the mean flap size was small, with the largest flap measuring only 16 cm × 10 cm.

In our series, venous congestion was observed in all four patients. In two patients, partial flap necrosis was observed, and secondary procedures were required. Venous congestion is a critical problem resulting from reverse-flow ALT flap that must be resolved. According to a literature review and our experience, larger flaps tend to have a higher incidence of venous congestion. In our series, the largest flap measured 20 cm × 10 cm, and the second largest flap was 22 cm × 8 cm. In both cases, almost one-third to two-thirds of the flap necrotized. In Demirseren et al’s series, partial necrosis was observed in flaps measuring 10 cm × 14 cm and 6 cm × 13 cm. In the study by Liu et al, two flaps measuring 26 cm × 8 cm and 15 cm × 6 cm underwent marginal necrosis. On the basis of these data regarding flap viability, we suggest that flaps measuring >80 cm² have a high incidence of partial or marginal necrosis, although there is no up-to-date quantitative scientific evidence supporting this inference.

To resolve venous congestion, Demirseren et al suggested transferring flaps with a cuff of the vastus lateralis muscle included around the pedicle to protect the pedicle from shear forces and increase venous flow. Gravanis and Britto mentioned that insufficient venous drainage could be caused by resistance of the venous valves, and a longer pedicle length could therefore increase the risk of venous congestion. They performed end-to-end anastomoses of the proximal stump of the descending branch of the lateral circumflex femoral vein to an adjacent superficial vein to resolve the congestion. The same method was reported by Komorowska-Timek et al, but they anastomosed the proximal ends of both the descending branches of the lateral circumflex femoral artery and vein to the anterior tibia artery and vein. This supercharge procedure maintained adequate arterial supply and venous drainage in large flaps (12 cm × 28 cm). In our study, we swung the proximal flap pedicle cranially. The major concomitant pedicle vein was then anastomosed to the great saphenous vein, substantially reducing venous congestion. Kim et al achieved the same success in resolving venous congestion by using great saphenous vein supercharge.

5. Conclusion

The reverse-flow ALT flap has versatile functions and limited donor site morbidity, as observed in conventional ALT flap. It is another option for soft-tissue reconstruction around the knee and even the proximal lower leg. However, more reliable application of the reverse-flow ALT must be based on smaller flap design or antegrade venous supercharge to reduce the risk of venous congestion.

References