The Distally Based Lesser Saphenous Venofasciocutaneous Flap for Ankle and Heel Reconstruction

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Finding an appropriate soft-tissue grafting material to close a wound located over the ankle and heel can be a difficult task. The distally based lesser saphenous venofasciocutaneous flap mobilized from the posterior aspect of the upper leg, used as an island pedicle skin flap, can be useful for this purpose. The vascular supply to the flap is derived from the retrograde perfusion of the accompanying arteries of the lesser saphenous vein. These arteries descend along both sides of the lesser saphenous vein to the distal third of the leg, either terminating or anastomosing with the septocutaneous perforators of the peroneal artery. Between February of 1999 and March of 2001, four variants of this flap were applied in 21 individuals, including 11 fasciocutaneous, five fascial, three sensory, and two fasciomyocutaneous flaps. Skin defects among all patients were combined with bone, joint, and/or tendon exposure. The authors found that the flap was reliable and technically simple to design and execute. This one-stage procedure not only preserves the major arteries and the sural nerve of the injured leg, but it also has proved valuable for covering a weight-bearing heel and filling a deep defect, because it potentially provides protective sensation and a well-vascularized muscle fragment. When using such flaps, however, a major artery is killed and an already injured lower leg might be jeopardized. Microsurgery can be used to remedy these problems, but such a technique requires a microvascular surgical team and appropriate equipment.

The loss of soft tissue at the level of the ankle and heel, with the exposure of tendon or bone, represents a challenging reconstructive problem because of the lack of locally available tissue, relatively poor circulation of the skin, and weight-bearing requirement of the region. Therapeutic options include local, regional, and free flaps. Each of these methods, however, has some drawbacks limiting its clinical application.

A local flap as a surgical solution may not be possible either because of inadequate tissue available to be moved from areas adjacent to the defect or because of limited flap mobilization. An inferiorly based soleus muscle flap is associated with limitations of bulkiness and unreliability owing to the flap’s variable vascular anatomy distally. Reversed septocutaneous flaps such as the peroneal artery flap, anterior tibial artery flap, and posterior tibial artery flap are other options. When using such flaps, however, a major artery is killed and an already injured lower leg might be jeopardized. Microsurgery can be used to remedy these problems, but such a technique requires a microvascular surgical team and appropriate equipment.

Since Masquelet et al. first described the concept of the distally based neurocutaneous island flap supplied by the vascular axis around the sural nerve, similar flaps have been reported subsequently and shown to be appropriate for the reconstruction of medium-to-large defects of the ankle and heel. In most of these reports, attention was focused only on the accompanying arteries of the sural nerve. In Nakajima et al.’s anatomical study, the lesser saphenous vein also exhibited its own accompanying arteries giving off several cutaneous perforators during the suprafascial course of the vein. The distally based lesser saphenous venofasciocutaneous flap was...
developed by using these accompanying arteries as vascular relays. We used this flap to treat 21 patients, and the experience obtained from the management of these cases formed the basis of this report.

Surgical Anatomy

The accompanying arteries of the lesser saphenous vein derive from the median superficial sural artery and consist of two vessels.\(^\text{15}\)

They descend along both sides of the lesser saphenous vein. In the upper half of the leg, the anatomical relationship between the lesser saphenous vein and the sural nerve is such that each runs independently in different layers (Fig. 1, above). The lesser saphenous vein with its accompanying arteries pierces the deep fascia at the upper fourth of the leg and then runs above the deep fascia. The sural nerve with its accompanying arteries courses under the deep

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**Fig. 1. (Above)** In the upper half of the leg, the lesser saphenous vein and the sural nerve run independently in different layers. **(Below, left)** In the lower half of the leg, the lesser saphenous vein and the sural nerve run close together above the deep fascia. **(Below, right)** After retracting the lesser saphenous vein, one of the accompanying arteries of the lesser saphenous vein joins the accompanying artery of the sural nerve at the midpoint of the leg and becomes the common accompanying artery of the lesser saphenous vein and the sural nerve. LSV, lesser saphenous vein; SN, sural nerve; DF, deep fascia; accompanying arteries (arrowheads); CAA, common accompanying artery.
fascia until it reaches the midpoint of the leg, where it penetrates the deep fascia. In the lower half of the leg, both the sural nerve and the lesser saphenous vein course closely to each other above the deep fascia (Fig. 1, below, left). One of the two accompanying arteries of the lesser saphenous vein, joining the accompanying artery of the sural nerve at the midpoint of the leg, becomes the common accompanying artery of the lesser saphenous vein and the sural nerve (Fig. 1, below, right). The other accompanying artery is solely located on the opposite side of the lesser saphenous vein. These arteries give off branches not only to the venous wall but also to the overlying skin for the entire length of the vein.

In Le Fourn et al.’s anatomical study,16 the authors reported a constant relationship between the gastrocnemius muscles and the vascular axis of the sural nerve. At least one or two constant and direct perforators arose from the lower third of the gastrocnemius muscles, near the intergastrocnemius groove, to the neurovascular axis. Hence, a distally based gastrocnemius muscle flap can be raised and revascularized by the reverse flow of the accompanying arteries around the lesser saphenous vein and the sural nerve.

In the distal third of the leg, the accompanying arteries of the lesser saphenous vein anastomose with the septocutaneous perforators of the peroneal artery, either directly or through the interlacing suprafascia network.10,11,14,15 There exist from three to five peroneal septocutaneous perforators in this region, with the major one typically located about 5 cm above the tip of the lateral malleolus, which is considered to be the potential pivot point for the distally based lesser saphenous venofasciocutaneous flap.

Operative Technique

The surgical maneuver of the distally based lesser saphenous venofasciocutaneous flap is similar to that of the distally based superficial sural artery flap, which has been well described in previous publications.11–14 With the patient in a prone position, the flap can be raised anywhere in the posterior aspect of the leg, corresponding to the long suprafascial course of the lesser saphenous vein. A skin marking, with its size determined by the defect to be repaired, is made along the center line of the posterior aspect of the leg, at the location of the axis of the lesser saphenous vein and the sural nerve. The width of the flap is basically designed not to extend forward beyond the medial and lateral midaxial lines of the leg. The pivot point is also marked on the site of 5 cm above the tip of the lateral malleolus.

With the aid of tourniquet control and loupe magnification, the operation is performed with the patient under spinal or general anesthesia. The fascial pedicle will be taken through a zigzag skin incision. The subdermal layer is dissected to expose the lesser saphenous vein, accompanying superficial sural vessels, and sural nerve. Sparing the sural nerve, the subcutaneous fascial pedicle is raised, for a width of 3 cm, to include the lesser saphenous vein and accompanying vessels. At the proximal margin of the skin flap, the vein and its accompanying arteries are ligated and divided. The flap and its vascular pedicle are then elevated, with the deep fascia, toward the pivot point of the lower leg, where the flap can easily be made to reach the defect without tension and the reverse blood flow can be preserved. The tourniquet is then released, and the integrity of the vascular flow to the flap is ascertained.

If a thin flap is preferred, such as for resurfacing the exposed Achilles tendon, or if a linear scar of the posterior calf is required, a flap of fascia alone can be raised safely and covered with a split-thickness skin graft. If an innervated flap is needed for weight-bearing heel coverage,17–19 the lateral sural nerve must be meticulously dissected and sectioned proximally to obtain enough length for neurorrhaphy, after which the lateral sural nerve is coapted to the common sural nerve at the recipient site. If a muscle flap is needed for filling a deep defect of the ankle or heel, a skin island and the gastrocnemius muscles can be harvested on the middle part of the calf, corresponding to the lower part of the gastrocnemius muscles.

The elevated flap is rotated 180 degrees and transferred to the defect either through a skin tunnel or by a direct incision on the skin bridge. The donor-site defect can be closed directly when the width of the flap is less than 4 cm. A larger donor-site defect must be covered with a split-thickness skin graft.

Patients and Methods

Between February of 1999 and March of 2001, we treated 21 individuals who had suffered soft-tissue defects over the ankle and heel using four variants of the distally based lesser
saphenous venofasciocutaneous flap. These patients’ clinical data are summarized in Table I. Malignant melanoma, trauma, chronic ulcer, and painful scar were the preexisting conditions that necessitated subsequent reconstruction. For all patients, grafting was contraindicated because of the exposure of tendons and/or bones at the wound site. The patients included 15 men and six women, ranging in age from 22 to 70 years. The donor tissue variants included 11 fasciocutaneous, five fascial, three sensory, and two fasciomyocutaneous flaps. Thirteen recipient sites were situated in ankle areas, five in non-weight-bearing heel locations, and three in weight-bearing heel locations. The size of the flap ranged from 4.5 × 4 cm to 11 × 8 cm. The donor defects were resurfaced with split-thickness skin graft for 15 patients and were closed primarily for the remaining six patients. Patients who received different variants of the flap are presented in Figures 2 through 5.

**RESULTS**

Nineteen flaps survived fully. Two flaps that developed distal margin necrosis were treated successfully with a subsequent split-thickness skin graft for 15 patients and were closed primarily for the remaining six patients. Patients who received different variants of the flap are presented in Figures 2 through 5.

**CASE REPORTS**

**Case 1**

A 70-year-old man revealed a malignant melanoma over the posterior aspect of the left heel. After wide tumor resection, a teardrop-shaped distally based lesser saphenous venofasciocutaneous flap, 3.5 cm in radius, was elevated. The flap was completely viable after surgery, and the contour of the heel was nicely restored (Fig. 2).

**Case 2**

A 23-year-old man sustained open comminuted fractures of the distal tibia and fibula in a motor vehicle accident. After débridement and external fixation of the fractured bones, there was a large-tissue loss with exposure of tendons and bones over the anterior aspect of the left ankle. The defect was covered with a distally based fascial flap, 11 × 8 cm in size, and a split-thickness skin graft. However, a few days later partial necrosis of the distal part of the flap was noted. An additional 2 weeks later, the necrotic tissue was excised and the defect was covered with another skin graft (Fig. 3).

**Case 17**

A 25-year-old man suffered from repetitive ulceration and scar contracture of a previous skin graft over the plantar aspect of the right heel. After scar revision, a distally based sensory flap, 10 × 5 cm in size, was raised for reconstruction of the weight-bearing heel. The lateral sural

**TABLE I**

<table>
<thead>
<tr>
<th>Case</th>
<th>Age/Sex (years)*</th>
<th>Mechanism</th>
<th>Site of Defect</th>
<th>Type of Flap</th>
<th>Size of Flap (cm)</th>
<th>Complication</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>70/M</td>
<td>Melanoma</td>
<td>Posterior heel</td>
<td>Fasciocutaneous</td>
<td>3.5 (radius)</td>
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</tr>
<tr>
<td>2</td>
<td>38/M</td>
<td>Trauma</td>
<td>Lateral malleolus</td>
<td>Fasciocutaneous</td>
<td>5 × 4</td>
<td>No</td>
</tr>
<tr>
<td>3</td>
<td>43/F</td>
<td>Chronic ulcer</td>
<td>Lateral malleolus</td>
<td>Fasciocutaneous</td>
<td>6 × 4</td>
<td>No</td>
</tr>
<tr>
<td>4</td>
<td>23/M</td>
<td>Trauma</td>
<td>Anterior ankle</td>
<td>Fasciocutaneous</td>
<td>8 × 4</td>
<td>No</td>
</tr>
<tr>
<td>5</td>
<td>28/M</td>
<td>Trauma</td>
<td>Medial malleolus</td>
<td>Fasciocutaneous</td>
<td>5 × 3</td>
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<td>6</td>
<td>45/F</td>
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<td>Achilles tendon</td>
<td>Fasciocutaneous</td>
<td>7 × 5</td>
<td>No</td>
</tr>
<tr>
<td>7</td>
<td>56/F</td>
<td>Chronic ulcer</td>
<td>Medial malleolus</td>
<td>Fasciocutaneous</td>
<td>6 × 5</td>
<td>Partial loss of distal flap</td>
</tr>
<tr>
<td>8</td>
<td>40/M</td>
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<td>Posterior heel</td>
<td>Fasciocutaneous</td>
<td>9 × 6</td>
<td>No</td>
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<tr>
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<td>Pressure sore</td>
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<td>Fasciocutaneous</td>
<td>7 × 4</td>
<td>No</td>
</tr>
<tr>
<td>11</td>
<td>65/M</td>
<td>Melanoma</td>
<td>Posterior heel</td>
<td>Fasciocutaneous</td>
<td>9 × 5</td>
<td>No</td>
</tr>
<tr>
<td>12</td>
<td>23/M</td>
<td>Trauma</td>
<td>Anterior ankle</td>
<td>Fascia</td>
<td>11 × 8</td>
<td>Partial loss of distal flap</td>
</tr>
<tr>
<td>13</td>
<td>58/F</td>
<td>Trauma</td>
<td>Lateral malleolus</td>
<td>Fascia</td>
<td>7 × 5</td>
<td>No</td>
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<tr>
<td>14</td>
<td>35/M</td>
<td>Trauma</td>
<td>Lateral malleolus</td>
<td>Fascia</td>
<td>6 × 4</td>
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</tr>
<tr>
<td>15</td>
<td>45/M</td>
<td>Chronic ulcer</td>
<td>Achilles tendon</td>
<td>Fascia</td>
<td>9 × 6</td>
<td>No</td>
</tr>
<tr>
<td>16</td>
<td>36/F</td>
<td>Trauma</td>
<td>Medial malleolus</td>
<td>Fascia</td>
<td>8 × 5</td>
<td>No</td>
</tr>
<tr>
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<td>25/M</td>
<td>Painful scar</td>
<td>Weight-bearing heel</td>
<td>Sensory</td>
<td>10 × 5</td>
<td>No</td>
</tr>
<tr>
<td>18</td>
<td>30/M</td>
<td>Painful scar</td>
<td>Weight-bearing heel</td>
<td>Sensory</td>
<td>8 × 6</td>
<td>No</td>
</tr>
<tr>
<td>19</td>
<td>43/M</td>
<td>Trauma</td>
<td>Weight-bearing heel</td>
<td>Sensory</td>
<td>8 × 4</td>
<td>No</td>
</tr>
<tr>
<td>20</td>
<td>56/F</td>
<td>Chronic ulcer</td>
<td>Lateral calcaneus</td>
<td>Fasciomyocutaneous</td>
<td>4.5 × 4</td>
<td>No</td>
</tr>
<tr>
<td>21</td>
<td>52/M</td>
<td>Trauma</td>
<td>Medial calcaneus</td>
<td>Fasciomyocutaneous</td>
<td>7 × 4</td>
<td>No</td>
</tr>
</tbody>
</table>

M, male; F, female.
nerve was reinnervated by coaptation to the common sural nerve in the area of the heel. The patient was allowed to bear weight fully on the injured heel 8 weeks postoperatively. Flap viability was good and there was no functional problem while walking. At the 12-month follow-up examination, this innervated flap was sensitive to light touch and its static two-point discrimination threshold was greater than 20 mm (Fig. 4).

Case 20

A 56-year-old man suffered from chronic ulcer with osteomyelitis over the lateral aspect of the right calcaneus. After débridements, there was some soft-tissue loss and a noted bony defect. A distally based fasciomyocutaneous flap, 4.5 × 4 cm in size, was harvested and the muscle fragment was used to fill the bony cavity. Subsequently, the patient’s postoperative course was uneventful (Fig. 5).

**DISCUSSION**

The distally based neuroskin island flap supplied by the accompanying arteries of the sural nerve is reliable for distal leg and ankle reconstruction, but its main disadvantage is the need to sacrifice the sural nerve with the consequent complaint of paresthesia at the lateral part of the foot. Another limitation is that the skin portion of the flap is confined to the region distal to the midpoint of the leg where the sural nerve penetrates the deep fascia. On the contrary, the distally based lesser saphenous venofasciocutaneous flap can preserve the sural nerve, and the skin portion of the flap, which is nourished through venocutaneous perforators.
from the accompanying arteries of the lesser saphenous vein, can be freely located within the suprafascial course of the lesser saphenous vein from the upper fourth of the leg to the lateral malleolus. The venous drainage of this flap passes through the suprafascial venous networks of the superficial sural vein, lesser saphenous vein, and septocutaneous veins of the peroneal vein.

The ideal replacement for the plantar aspect
FIG. 4. (Above, left) A postinjury hypertrophic scar with repetitive ulceration was noted over the plantar aspect of the right heel. (Above, right) A distally based sensory flap was elevated with the lateral sural nerve (arrowhead). (Below, left) Immediately after the operation, the weight-bearing heel was restored with the flap and the lateral sural nerve was coapted to the common sural nerve at the heel. (Below, right) At the 1-year follow-up examination, there seemed to be no functional problem while walking and the innervated flap was sensitive to light touch. The static two-point discrimination threshold was greater than 20 mm.
of the heel should provide anatomical contour, durable skin, protective sensibility, and relative soft-tissue fixation to the underlying structures that can stand the stress of ambulation. An innervated distally based lesser saphenous venofasciocutaneous flap can be used to reconstruct a weight-bearing heel with protective sensation. Furthermore, the skin flap can re-
duce shearing force to a minimum, and it provides a good contour because the flap itself is thin.

Another important consideration is whether or not the sural nerve should be included in the fasciomyocutaneous flap. Le Fourn et al. maintained that the sural nerve should be included to preserve the perforators between the lower third of the gastrocnemius muscles and the neurovascular axis. However, from our experience, there seems to be no need to sacrifice the sural nerve during elevation of the fasciomyocutaneous flap. Instead, the sural nerve can be preserved with minimal destruction of the arterial networks because the lesser saphenous vein and the sural nerve run closely in the same layer and have a common accompanying artery in the lower half of the leg.

The distally based lesser saphenous venofasciocutaneous island flap is a new flap concept that depends on a nonobvious blood supply. The advantages of this flap are as follows:

1. The blood supply is constant and reliable, and the elevation of the flap is easy and quick.
2. Major arteries and the sural nerve are not killed. Therefore, this flap can be used on a traumatized leg with damaged major arteries and the sensation of the lateral aspect of the foot can be preserved.
3. This flap can be elevated in all parts of the posterior aspect of the leg and can reach as far as the heel pad and dorsal aspect of the ankle.
4. The procedure is a single-stage operation without the need for microsurgical techniques.
5. The flap potentially provides protective sensation for weight-bearing heel coverage.
6. The well-vascularized fasciomyocutaneous flap seems to be a good alternative to free muscle flaps for obliterating dead space and preventing infection.

We believe that this new flap has special characteristics that may be suitable for reconstructing soft-tissue defects of the ankle and heel.

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