Clinical Application of Posterior Calf Fascio-Cutaneous Pedicle Flap in Leprosy Foot Ulcer

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INTRODUCTION

Damage to the sensory, autonomic and motor nerves in the leprosy patient are followed by anesthesia, dryness of the skin and muscular paralysis. Most plantar ulcers in leprosy patients are caused by repetitive moderate stress. Minor injuries such as bruising sustained as a result of the misuse of anesthetic limbs may lead to ulceration, scar formation and secondary infection. Cellulitis develops and destroys subcutaneous tissue resulting in an infection which can reach the bone1). As a result of osteomyelitis, bone is absorbed, sequestra are extruded and the architecture of the foot is distorted, resulting in severe disability.

The most common sites of the plantar ulceration are over the metatarsal heads, the base of the fifth metatarsal, the base of the proximal phalanx and the calcaneus.

The standard approach for the treatment of the upper and middle thirds of the lower leg
uses the superficial calf muscle and/or the local fascio-cutaneous flaps. The paucity of simple and reliable alternatives for the distal third of the leg, however, has made this region require a free muscle transfer for wound coverage. Even at the best medical centers, the microsurgical transfer of these tissues is a lengthy procedure with an inherent rate of major complications in the lower extremity approaching 25%\textsuperscript{2,3}).

The patient may not tolerate a regular free flap procedure well for wound coverage in distal third of the leg because of the lack of facilities and medical personnel in a leprosy sanatorium hospital. Skin defects of the lower leg have in the past been reconstructed in many ways including cross-leg flap, local random flap, free flap and cross-leg fasciocutaneous flap\textsuperscript{4,5}). The axial pattern fasciocutaneous flap in the calf allows a safer, longer, much larger quantity of skin to be transferred as a cross-leg flap than it would be possible with a random pattern cross-leg flap since the report of Ponten 1981\textsuperscript{6}). In addition, the pedicle of the flap allows considerable flexibility for the positioning of the legs.

**ANATOMY OF POSTERIOR CALF FASCIO-CUTANEOUS FLAP**

Several fascio-and musculo-cutaneous perforators are dispersed in the posterior calf. They take part of the blood supply to the skin in the posterior calf region. The axial-pattern cutaneous artery along the sural nerve, known as the superficial sural artery or subfascial descending cutaneous branch of the popliteal artery, is important in the fasciocutaneous flap in the lower leg\textsuperscript{7,8}). The deep fascial of the posterior calf is well supplied with a subfascial the suprafascial vascular plexus. A dominant subfascial axial vascular pedicle has been shown to safely supply a cutaneous territory of the upper two-thirds of the posterior calf from medial to lateral midaxial lines\textsuperscript{8,10}). The artery originates from the popliteal or the lateral sural artery and infrequently the medial sural artery. There is variation in the origin of the superficial sural artery\textsuperscript{11,12}). The relationship between the superficial sural artery and cutaneous sural nerve is unclear; the artery runs sometimes along the sural nerve and sometimes along the the lateral sural nerve. Arterial size ranges from 1.0 to 2.0 mm in external diameter, with an average diameter of 1.2 mm\textsuperscript{8,9,11,12}). One or two venae comitantes accompany the dominant artery.

**OPERATIVE PROCEDURE**

The Doppler probe identifies the course of the dominant axial vascular pedicle. A pulsating sound can be heard longitudinally in the calf over the course of the subfascial descending branch of the popliteal artery. The width of the flap is confined to the interval between these two points of the medical and lateral midaxial lines of the leg. Flap length can extend from the superior flexion crease of the calf to the middle and lower thirds of the leg.

Walton\textsuperscript{8}) reported that, within these boundaries, the largest clinical flap measured 11 \times 19 cm and the smallest flap 4 \times 7 cm. The prone or lateral decubitus position is best suited for the operation.

The skin incision extends down to deep fascial medially and laterally. The lesser saphenous vein is identified deep to the fascia and included with the flap. Because the superficial sural artery may occasionally lie in proximity to the sural nerve or the lateral sural nerve, elevation of the flap off the sural nerve may carry the risk of serious injury to the blood supply of the flap. Incorporation of the sural nerve with subfascial flap elevation is considered the best alternative with regard to avoiding the injury of the vessel. The subfascial flap elevation is relatively bloodless, with little risk of hematoma\textsuperscript{13}). After cleaning the recipient
site, the pedicle flap is transferred to the skin defect and a split-thickness skin graft is applied at the donor site. A tie-over dressing is then applied to the site of the skin graft. The firm, accurate fixation method that is used includes plaster cast with window at the time of operation. Division of the flap was performed at the time between 2 and 3 weeks. Staged division is sometimes performed for delay after 2 weeks.

Table 1  POSTERIOR CALF FASCIOCUTANEOUS PEDICAL FLAP

<table>
<thead>
<tr>
<th>AGE</th>
<th>SEX</th>
<th>PATHOLOGY</th>
<th>FLAP SIZE(cm x cm)</th>
<th>FLAP TYPE</th>
<th>SURVIVAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>51</td>
<td>M</td>
<td>1st metatarsal head ulcer</td>
<td>8 x 18</td>
<td>superior</td>
<td>complete</td>
</tr>
<tr>
<td></td>
<td></td>
<td>for over 20 years</td>
<td></td>
<td>cross-leg</td>
<td></td>
</tr>
<tr>
<td>73</td>
<td>F</td>
<td>ulcer on mid-lateral side</td>
<td>8 x 18</td>
<td>superior</td>
<td>complete</td>
</tr>
<tr>
<td></td>
<td></td>
<td>of foot for 3 years</td>
<td></td>
<td>cross-leg</td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>F</td>
<td>ulcer on mid-lateral side</td>
<td>8 x 18</td>
<td>superior</td>
<td>complete</td>
</tr>
<tr>
<td></td>
<td></td>
<td>of foot for 5 years</td>
<td></td>
<td>cross-leg</td>
<td></td>
</tr>
<tr>
<td>65</td>
<td>M</td>
<td>bone exposure on distal</td>
<td>8 x 20</td>
<td>superior</td>
<td>complete</td>
</tr>
<tr>
<td></td>
<td></td>
<td>third of tibia for 15 years</td>
<td></td>
<td>cross-leg</td>
<td></td>
</tr>
<tr>
<td>47</td>
<td>M</td>
<td>after failing latissimus</td>
<td>9 x 20</td>
<td>superior</td>
<td>complete</td>
</tr>
<tr>
<td></td>
<td></td>
<td>dorsi m. free flap on 1st</td>
<td></td>
<td>cross-leg</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>MT head ulcer for 10 years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>M</td>
<td>ulcer on mid-lateral side</td>
<td>7 x 18</td>
<td>superior</td>
<td>complete</td>
</tr>
<tr>
<td></td>
<td></td>
<td>of foot for 2 years</td>
<td></td>
<td>cross-leg</td>
<td></td>
</tr>
<tr>
<td>53</td>
<td>M</td>
<td>1st metatarsal head ulcer</td>
<td>8 x 20</td>
<td>distal</td>
<td>upper</td>
</tr>
<tr>
<td></td>
<td></td>
<td>for 2 years</td>
<td></td>
<td>half necrosis</td>
<td></td>
</tr>
</tbody>
</table>

Case 1

A 51-year-old male patient was suffered from the long standing ulcer with oozing on the metatarsal head portion of the right foot for over 20 years. He was diagnosed with leprosy 35 years ago. He has tested negative in bacteriological examination, since 10 years ago. Due to persistent chronic osteomyelitities, the bony segment of 1st and 2nd metatarsal head was absorbed(Fig.1.1), but first and second toes were intact. They plantar ulcer was manifested with thickened marginal scars, hyperpigmented skin and central unhealthy granulation tissue(Fig.1.2).

Pre-operatively, the superficial sural artery was identified by the Doppler flowmeter in the contra-lateral calf. Under spinal anesthesia, the patient was laid down in prone position. A 8 x 18 cm superior based flap, of which distal portion was broader than that of the base, was raised in subfascial plane including superficial sural artery. The ulcer of the recipient site was debrided with marginal thickened scars. The flap was transferred in cross-leg pattern. Fixation was done by plaster cast for 3 weeks, and it followed the staged division of flap on post-operative for 2 weeks. No marginal flap necrosis was experienced(Fig.1.3).
Fig. 1.1: Radiologic finding of case 1
Destruction of the bony portion of 1st and 2nd metatarsal head and M-P joint
Pointing of the second metatarsal

Fig. 1.2: Preoperative finding of case 1
Plantar ulcer with thickened marginal scars and hyperpigmented skin and central granulation tissue

Fig. 1.3: Postoperative finding of case 1
Flap with excellent contour to the surrounding soft tissues
Case 2

A 55-year-old woman was shown with chronic ulceration surrounded with vegetating granulation tissue and elevated hypertrophic scars on the lateral side of the mid portion of the sole (Fig. 2.2). No bacilli has been seen in bacteriologic studies since she has been diagnosed with leprosy. The ulcer skin of the sole did not reveal any malignancy from pathological examination. The radiological finding of the involved foot revealed the bone absorption in distal phalanx of 5th toe (Fig. 2.1). A 8 × 18 cm flap, of which base was slender, and the distal flap broader, was raised in subfascial plane and transferred to the recipient area. The donor site of calf was covered by the split thickness skin graft and followed by the tie-over dressing (Fig. 2.3). The flap survived completely after surgery. The fixation was in plaster cast for 3 weeks, and severed the flap and thereafter returned the flap to original site (Fig. 2.4). 6 months after transferring the flap, the epidermal cyst beneath the flap was formed, swollen, and inflamed. Thereafter removing the cyst, the postoperative course was good (Fig. 2.5).
Fig. 2.3: Intraoperative view of case 2 Cross-leg flap transfer with tie-over dressing of donor site.

Fig. 2.4: At 6 months, epidermal cyst beneath the flap was formed. After removing the cyst, the postoperative course was good.

Fig. 2.5: Returning the flap to original site.
Fig. 3.1.1: Right ankle AP view reveals skin defect, bony sclerosis, thick periosteal reaction and deformity compatible with underlying chronic osteomyelitis on lower third of tibia.

Fig. 3.1.2: Preoperative finding of case 3 Soft tissue defect and recurrent bouts of osteomyelitis on right distal third of lower leg for 20 years.

Fig. 3.2: Postoperative 6 months finding of case 3

Fig. 3.3: Donor site scar in opposite calf was acceptable.
Table 2: The pathogenesis of disability following nerve damage in leprosy (From Leprosy, 2nd ED., 1979)
Case 3

A 65-year-old man, who had been suffering from leprosy for over thirty years, was referred to the hospital. He had been treated with soft tissue covering of the distal third of exposed right tibia which occurred after deep thermal burn on that site with anesthesia twenty years ago. The bone exposed to the ulcer for a long time.

At the time of admission, a soft tissue defect of 7 by 10 cm appeared in the distal third of right tibia (Fig. 3.1). The simple X-ray examination showed the partial absorption of the cortical bone and found the superficial osteomyelitis.

In the first operation, we performed Latissimus dorsi muscle free flap transfer with chiseling off devitalized bone from tibia. But, the operation ended in a failure because venous thrombosis caused flap necrosis. 2 weeks after the first operation, we elevated posterior calf fasciocutaneous flap in superior based cross-leg pattern and covered the soft tissue defect of the bone exposed. The flap was delayed before severing which was performed at 21 days. Satisfactorily, most of the flap survived completely after operation. The skin graft of the donor site healed well (Fig. 3.2 and 3.3).

DISCUSSION

Of all the complications of leprosy, plantar ulcer is the most unpleasant and annoying. It occurs in about 12% of leprosy. Plantar ulcers occur on any insensitive sole, where the patient still walks. The three most common sites are the base of the big toe, the base of the fifth toe and heel, explained by the dynamic pressure triangle of the sole14).

The arch support determines the distribution of forces between the hindfoot and metatarsal head area. Leprosy patient has a tendency of the collapse in the arch of the sole15).

The precipitating factor in producing the plantar ulcer of leprosy is pressure unbalanced to the arch in both amount and time. Repetitive pressure on a particular hard pressed spot produce inflammation, blister, necrosis and trophic ulceration16). These ulcer become infected secondarily and also many lead to bony destruction. The ultimate result of healing is scarring. Further progress involves the vicious cycle of scar-ulcer-scar17). Price18) has summarized the natural history of the plantar ulcers in four phases; primary tissue damage, primary plantar ulcer, collapse of the foot and secondary ulcer (Table 2).

Fortunately, trophic ulcers frequently heal in thin plaster cast immobilization for six weeks1-19). The surgical intervention for blocking of the vicious cycle, however, should be required for the prevention of the ulcers as well as reducing the duration of the hospitalization, supplying the more strong healthy coverage than scar tissue and giving the favorable cosmetic appearance than the amputation method. Excessive scarring and resistant ulcer on the forefoot has been traditionally managed by forefoot amputation followed by the use of well moulded special footwear19). But this must be resisted until amputation is really unavoidable. Complete excision of the ulcerated area and scar tissue followed by split thickness skin graft (STSG) used to give good coverage and provide a more suitable bed for regrowth of subcutaneous tissue than that provided by scar tissue1). The lack of adequate subcutaneous tissue may require the more thickened soft tissue padding under prominent bony portion such as metatarsal head and/or calcaneus.

Reconstruction of soft tissue defects of the lower third and foot continues to challenge plastic surgeons seeking a technically easy and safe procedure with minimal morbidity at the donor site20).

The local skin flap from the insensible sole
often have been unreliable and many increase the hard pressed spots which is pliable to pressure, resulting in forming blister easily\(^\text{12}\)\). The most commonly used procedures include the skin grafts, local pedicle flap, cross-leg flap, distal based flap and free flap. The distal tibia is an area where local muscle flap are not of much value. The choice for the coverage of this area is frequently between a free flap and/or distal based fasciocutaneous flap\(^\text{21,22}\)\). A free flap technique remains a time-consuming procedure, requires a well-trained team in medical facilities, and contraindicated in vasculopathy\(^\text{20}\)\). Skinsnes determined the pathogenesis of extremity deformity from amputated specimens in leprosy\(^\text{23}\)\). Abnormalities were seen in the blood vessels and nerves in most cases. The arteries were affected by varying degrees of medial and intimal thickening causing luminal narrowing\(^\text{19}\)\).

Several reversed fasciocutaneous flaps have been described. Hong\(^\text{24}\) described such a flap on the posterior tibialis artery. Wee\(^\text{25}\) based on the anterior tibial artery, and Yoshimura\(^\text{4,5}\) based it on the peroneal artery. Masqualet\(^\text{26}\) designed the lateral supra-malleolar flap and the medialis pedis flap.

Although these flaps are presented as an alternative to free flaps, those flap are delicate to dissect\(^\text{20}\)\). Morris stated that Distally based flaps had a very high incidence of necrosis and should be avoided\(^\text{28}\)\). We also experienced a distal half necrosis in distal based posterior calf flap in one case.

Heartsch\(^\text{13}\) stated in a post-mortem investigation of the blood supply to the skin of the leg that in the lower third there is a relative lack of perforating vessels and considered to explain the poor healing in this area. Apart from the perforators there are two axial-type vessels supplying the fascial plexus, the saphenous artery and the cutaneous branch of the popliteal artery in his study. Therefore it is resonable to suggest that long flap of the leg should be based proximally and raised to accomodate this axial input\(^\text{13}\)\).

The improved knowledge of blood supply to fasciocutaneous flaps in call\(^\text{29,30}\) since the report of Ponten in 1981 allows the design of a safer, longer and more useful flap for reconstructive procedures in the lower leg. Fix\(^\text{21}\) stated that clinical experience, fasciocutaneous flap in the leg are applied to a length of 26 to 27 cm. When an axial vessel or significant septocutaneous perforator is included in the base, the length-to-width perforator ratio can be extended past 3:1. The protective blood supply allows a very much greater area of the skin to be transferred than is possible with conventional cross-leg flap and much more freedom of leg position\(^\text{20}\)\).

**SUMMARY**

Lower extremities of the leprosy patients are characterized by the decreased sensation of the foot from peripheral nerve damage. As a result, repetitive foot ulcers are frequently seen. When these repetitive shallow ulcers become infected, they result in deep soft tissue ulcers and even osteomyelitis. The treatment of these ulcers in leprosy is a challenging problem both to the patient himself and to medical personnel. Conventional treatment methods for these ulcers include, according to the wound condition, skin graft, local flap, long-term cast immobilization, wedge resection of the joint and even amputation in severe cases. But all these methods have the disadvantages of frequent recurrences, long hospitalization periods and permanent foot deformities. Recently in Korea, despite the decreased occurrences of new patients and the decreased frequencies of facial and hand deformity formation due to the active early diagnosis and treatment, there still exists a large number of foot deformities resulting from decreased foot sensation. Moreover, treatment modalities are not definitely establised. In fact,
there are many environmental difficulties in applying the free flap transfer to the foot ulcer of leprosy patients in leprosy sanatorium as opposed to treating the non-leprosy patients.

And so, from 1990 to 1993, we performed 6 superior-based posterior calf cross leg flap transfers and 1 distal-based flap transfer, under spinal anesthesia, referred by the leprosy sanatorium for deep foot ulcers. We obtained favorable results in 6 patients and partial necrosis in a patient who received distal based flap transfer.

**REFERENCES**

21) Fix, R.J. and Vasconez, O.L.: Fasciocutaneous flaps in reconstruction of the