The reverse sural artery flap for the reconstruction of distal third of the leg and foot

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Key words
Distal third of leg; Lower limb reconstruction; Reverse sural artery flap

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Abstract
Soft tissue defects around the distal third of the leg and the foot present a major reconstructive challenge. There is limited expertise with free tissue transfers in many developing countries, necessitating consideration of other options for the closure of such defects. The versatility and reliability of sural artery flap have made it an emerging popular option for the reconstruction of such defects. Twenty patients comprising of 13 males and 7 females with soft tissue defects of the lower third of the leg and foot requiring soft tissue cover were treated between January 2006 and December 2010. The age range was 7–58 years with a mean age of 30 years. Nineteen (95%) of the defects were post-traumatic while one (5%) was post-infective. All the defects were covered with reversed sural artery flaps, which were raised on the posterior aspect of the junction of the upper and middle third of the leg. The smallest flap was $4 \times 4$ cm$^2$ while the largest measured $20 \times 12$ cm$^2$. The donor defect was closed directly in 7 (35%) patients, while split skin graft was applied in the remaining 13 (65%) patients. There was satisfactory flap healing in 17 patients (85%), while 3 patients (15%) had complete flap necrosis. Two of these patients had significant comorbidities of haemoglobinopathy and poorly controlled diabetes mellitus. Sural artery flap remains a viable option for the reconstruction of soft tissue defects of the distal third of the leg and foot. Caution should, however, be exercised in patients with some significant systemic diseases.

Introduction
The limitation of pliable soft tissue in the distal third of the leg, ankle and foot presents a challenge for the reconstruction of soft tissue defects in that region of the body. The reconstructive options of such defects get even narrower in resource-constrained environments, where the choice of free tissue transfer is not a ready option because of the infrastructural challenges and limitation of manpower with requisite skills for microvascular surgeries.

The traditional options for such defects in many centres in the developing countries have been the use of cross-leg flap or the more conservative approach of wound dressing and secondary wound closure with split-thickness skin graft.

These approaches usually result in prolonged hospitalisation with increased cost of care. The patients may also have significant donor site morbidity and joint stiffness, especially in the elderly, when fasciocutaneous cross-leg flaps are employed. In addition, hyperpigmentation of the recipient site is a common cosmetic sequel following split skin graft. As a result of these morbidities, our unit explored other reconstructive options and began using the reverse flow sural artery flap for the reconstruction of such defects in the year 2006. This effort has met with progressive success and improved patient satisfaction.

Key Messages
- sural artery flap offers a simpler and reliable option than free tissue transfer for the reconstruction of soft tissue defects of the distal third of the leg and foot and should be one of the first options to consider for such defects
Table 1  Patients’ summary

<table>
<thead>
<tr>
<th>No.</th>
<th>Sex</th>
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<th>Aetiology</th>
<th>Location</th>
<th>Size (cm²)</th>
<th>Comorbidity</th>
<th>Outcome</th>
<th>Flap D/S</th>
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<td>Partial FN</td>
<td>STSG</td>
</tr>
<tr>
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<td>F</td>
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<td>Infective</td>
<td>Heel</td>
<td>12 × 10</td>
<td>Neuropathy</td>
<td>S/healing</td>
<td>STSG</td>
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<td>S/healing</td>
<td>DC</td>
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<td>Partial FN</td>
<td>STSG</td>
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<tr>
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<td>F</td>
<td>32</td>
<td>Trauma</td>
<td>Distal 1/3rd</td>
<td>6 × 8</td>
<td>None</td>
<td>S/healing</td>
<td>DC</td>
</tr>
<tr>
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<td>M</td>
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<td>Trauma</td>
<td>Distal 1/3rd</td>
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<td>S/healing</td>
<td>STSG</td>
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<td>Tetanus</td>
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<td>None</td>
<td>Partial FN</td>
<td>STSG</td>
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<tr>
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<td>STSG</td>
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<tr>
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<td>Ankle</td>
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<td>None</td>
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<td>40</td>
<td>Trauma</td>
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<td>DM</td>
<td>Partial FN</td>
<td>STSG</td>
</tr>
<tr>
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<td>38</td>
<td>Trauma</td>
<td>Ankle</td>
<td>6 × 8</td>
<td>None</td>
<td>S/healing</td>
<td>DC</td>
</tr>
<tr>
<td>18</td>
<td>M</td>
<td>16</td>
<td>Trauma</td>
<td>Ankle</td>
<td>8 × 10</td>
<td>None</td>
<td>S/healing</td>
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<tr>
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<td>15 × 11</td>
<td>None</td>
<td>S/healing</td>
<td>STSG</td>
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<tr>
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<td>M</td>
<td>31</td>
<td>Trauma</td>
<td>Distal 1/3rd</td>
<td>14 × 11</td>
<td>DM</td>
<td>CFL</td>
<td>STSG</td>
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</tbody>
</table>

CFL, complete flap loss; DC, direct closure; flap D/S, flap donor site; partial FN, partial flap necrosis; S/healing, satisfactory healing; STSG, split thickness skin grafting.

We continue to see an upsurge in the cases of open fractures and extensive avulsion injuries, especially in the lower third of the leg from rising commercial motorcycle accidents and injuries from other forms of intercalated transportation in what seems to be an emerging lower limb trauma epidemic in the sub-region.

This makes it imperative for Plastic and Reconstructive surgeons, especially those practicing in the low- and middle-income countries (LMICs) to be aware of this relatively simple procedure as one of the first-line options in the surgical armamentarium for the reconstruction of soft tissue defects of the distal third of the leg, ankle and foot.

The aim of this study is to review and present our experience with the first 20 consecutive patients who were managed with the reverse sural artery flap in our unit.

Patients and methods

We present a review of the first 20 consecutive patients managed with the reverse sural artery flap at the University College Hospital, Ibadan over a period of 5 years between 2006 and 2010. The hospital is an 850-bedded referral teaching hospital in the south-western Nigeria. The study comprised of 20 patients with soft tissue defects in the distal third of the leg, ankle, heel and dorsum of the leg. The information obtained from each patient include the demographic data, the site and size of the defect, the etiology, flap dimension, method of closure of the secondary defect, the postoperative result and complications. The comorbidities in the patients were also noted. The article comprised cases done as emergency as well as elective procedures. All but one of the patients had traumatic defects. The location of the defects ranged from the distal third of the leg in 13 (65%) patients, ankle in 4 (20%) patients, heel in 2 (10%) and the dorsum of the foot in 1 (5%) patient. The smallest of the defects measured 4 × 4 cm², while the largest defect measured 20 × 12 cm².

Operative technique

General anaesthesia was employed for the procedure in three patients, while the remaining patients had spinal anaesthesia. The patients were subsequently maintained in the prone or semi-prone position depending on the location of the defect. A tourniquet was employed using the esmarch bandage for all the cases after relative exsanguination by limb elevation. The localisation of the supra malleolar peroneal artery perforators was done by subjective anatomical localisation for most of the cases, while Doppler localisation of the perforators was done
Sural artery flap for lower limb reconstruction

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Figure 2 Defect at the ankle.

Figure 3 Marking of the flap.

Figure 4 Dissection of the flap.

Figure 5 In setting of flap.

Figure 6 Immediate postoperative picture with split skin graft applied to donor site.

Figure 7 Ankle and hind foot defect covered with sural artery flap.

for the last three patients in the series. The dissection and mobilisation and in-setting of the flap was done as described by Masquelet (1). The flap donor site was either closed directly or with split skin graft as dictated by the size. Extra care was taken to avoid kinking or tension over the pedicle and a light dressing exposing part of the flap was put in place.
Results

A total of 20 patients were managed with the reverse sural artery flaps over the 5-year period. There were 13 (65%) males and 7 (35%) females with an M:F ratio of 1:9:1. The mean age of the patients was 30 years, with a range of 7–58 years. The aetiology of all but one of the defects was post-traumatic following vehicular accidents. One of the patients had an infective wound around the heel, which required wound debridement and reverse sural artery flap cover. There was a wide variation in the size of the defects, which ranged between $4 \times 4$ cm$^2$ and $20 \times 12$ cm$^2$ in dimension. The mean length of the defects was 11.45 cm, while the mean breadth was 9 cm.

The defect was located in the distal third of the leg in 13 patients (65%), ankle in 4 patients (20%), heel in 2 (10%) and dorsum of the foot in 1 patient (5%).

There was satisfactory healing of the flaps in 17 (85%) patients. Five of these patients had varying range of minor dehiscence and necrosis of some part of the flap. Three patients had complete flap necrosis, necessitating debridement and secondary wound cover with split thickness skin graft.

We were able to achieve direct closure of the flap donor site in seven (35%) patients in the series, while the remaining patients had to have split-thickness skin to resurface the donor site.

Six of the patients had significant comorbidities of which diabetes mellitus was the most common (three patients). The other comorbidities were haemoglobinopathy in one patient, tetanus infection in another and amyloid neuropathy in the last. Table 1 shows the patients’ summary while Figures 1–8 are the pre, intra and post operative photographs of some of the patients managed with the sural artery flap.

Discussion

The aetiology of soft tissue defects in the distal third of the leg and the foot varies widely from trauma to vascular ulcers, diabetic foot disease, pressure ulceration and infections.

Apart from one patient who had post-infective wound around the heel, all the other patients managed and reported in this study sustained their defects from vehicular and motorcycle trauma, buttressing the fact that trauma is the commonest cause of defects in this region of the body. All the patients reported in this study had the reconstruction of their defects with the reverse sural artery flap.

The reverse sural artery flap was first described by Masquelet et al. (2) in 1992 as a neurocutaneous flap raised from the central part of the calf, centred over the sural nerve. The nerve converges with the superficial sural artery in the middle of the calf and proceeds together distally under the fascia in the upper third of the leg. The nerve and the artery pierce the fascia between the upper and middle third to assume a subcutaneous position and continue towards the lateral malleolus (2). This forms the course along which the pedicle of the flap is raised.

The flap has been referred to by various names since it was first described; these include the sural fasciocutaneous flap (3), sural artery neurocutaneous flap (4,5). Distally based superficial sural neurocutaneous flap (6) and the distally based sural fasciomusculocutaneous flap in which a rim of gastrocnemius muscle was incorporated (7).

The indications for the reverse sural artery flap include defects in the posterior aspects of the heel and Achilles tendon, the anterior and lateral aspects of the ankle, the dorsum of the foot, the lateral aspect of the hind foot, and the anterior crest of the lower third of the leg (2,8,9). The relative indications of the flap are coverage of the totality of the heel and of defects of the medial aspect of the lower leg. These two areas are not too distant from the pivot point, but their coverage might involve kinking of the pedicle or the flap might provoke partial arterial insufficiency or a difficulty in venous return (1). The advantages of the flap include its durability, good skin texture, reliable vascularity, good arc of rotation, ease of dissection and minimum donor site morbidity (2,3,10,11).

The paucity of pliable tissue in the distal third of the leg and foot make reconstruction of soft tissue defects in the region challenging. In addition, an unreliable lower limb subdermal plexus translates to notoriously poor wound healing using cutaneous flaps (12). Various reconstructive options have been developed over the years to meet the reconstructive needs in the region. These include cross-leg flaps and free tissue transfer. These options are not without their own challenges. Cross-leg flaps require multistage procedures or flap elevation, division and in setting of flap with or without additional debulking procedures. This necessarily increases the duration of hospitalisation and the cost of care. In addition, it poses the risk of positional discomfort and joint stiffness in the elderly patient. Free tissue transfer, on the other hand, requires specialised skill and dedicated infrastructural facilities, which are often lacking in many LMICs.

The other options for the reconstruction of defects in the distal third of the leg, ankle and heel include the medial distal septocutaneous flap based on the intermuscular posterior tibial (8), the posterior tibia perforator flap (3,11), lateral supramalleolar skin flap (3,13). However, the main challenges with these options are their difficult dissection and steep learning curve (3,8,11,13).

The introduction of the distally based sural fasciocutaneous flap provides a reliable and effective method to cover skin defects of the distal leg, foot and ankle (2,14). The advantages of the sural flap compared with other covering methods are
the simplicity of the design and dissection of the pedicle flap that can be carried out with a loupe magnification and without the need for microsurgical instrumentation or anastomosis, the preservation of the principle vascularisation of the lower limb and the need for only one operation (3). The sural pedicled flap constitutes a well-vascularised cutaneous islet and reliable flap, offering the possibility of covering a broad range of areas with cutaneous defects in the distal tibia, heel and ‘up to the’ rear foot (3).

Trauma constituted the commonest cause of defect in our series (95%). This is probably one of the series with the highest aetiology of trauma. Similar studies (15–20) also reported trauma as the commonest aetiology. However, Baumeister et al. (9) contrary to this, reported unstable/chronic ulcers as the dominant causative factor in 75% of patients in a series of multi-morbid patient groups.

Of the 20 patients in our series, there was complete coverage of the wounds in 17 (85%) patients. Of these 12 patients (60%) had complete healing of the flap, while 5 patients (25%) had varying degrees of wound dehiscence and marginal necrosis of the flap. These complications could have resulted from poor patient positioning postoperatively or compromise on the vascular pedicle from tight dressings. Three patients (15%) had complete flap necrosis, necessitating debridement and secondary wound cover with split-thickness skin graft. Two of these patients had significant comorbidities. One patient had haemoglobinopathy, while the other had poorly controlled diabetes. There was no obvious reason for the failure of the flap in the third patient. Undue pressure on the pedicle could have also been the reason for the failure.

Akhtar (15), in his series of 84 patients, observed flap survival in 78.5%, partial necrosis in 16.5% and complete necrosis in 9.5%. Similarly, a review of the complication rate of sural artery flap in 70 consecutive patients reported a total complication rate of 59%. This included partial flap necrosis in 17% and complete necrosis in 19% of the cases (9).

A meta-analysis of 50 articles that reported the use of 720 distally based sural flaps suggested 82% success rate of the flap. Complete flap necrosis was reported in 3-3%, and partial or marginal flap necrosis in 11% (21).

We were able to achieve direct closure of the donor site in 7 of the patients, while split-thickness skin grafting was applied in the remaining 13. The size of the flap donor site ranged from 4 × 4 cm² to 10 × 8 cm² giving an average length of 7-1 cm and an average breadth of 5-7 cm. We did not record any flap donor site morbidity in any of the patients.

Conclusion

The reverse sural artery flap remains a versatile option for the reconstruction of soft tissue defects of distal third of the leg and foot. Caution should, however, be exercised in patient selection, as those with significant systemic diseases may be at increased risk of flap failure and other complications.

Acknowledgement

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References