Egypt, J. Plast. Reconstr. Surg., Vol. 37, No. 1, January: 111-117, 2013

The Versatility of the Reversed Sural Artery Flap in Coverage of Soft Tissue Defects of the Foot and Ankle

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ABSTRACT

This study was conducted in Al-Razi Orthopaedic Hospital during the period from April 2009 till June 2012. The aim of this study was to evaluate the versatility of the reversed sural artery flap as a fasciocutaneous or fascial flap in reconstruction of soft tissue defects of the foot and ankle regions. It included 20 patients (17 males and 3 females). Their ages ranged between 15 and 55 years (average 33 years).They all had soft tissue defects of the foot and ankle regions. The cause of the defects was mainly trauma (in 15 patients). The size of the defects ranged between 10-20cm x 7-11cm. Fasciocutaneous flaps were used in 15 cases and fascial flaps with split-thickness skin grafts (STSG) in 5 cases. In 17 cases the flaps survived completely. One fasciocutaneous flap was completely lost and 1 had distal necrosis. In 1 fascial flap there was partial loss of the STSG. The follow-up period ranged from 6-36 months (average 11 months). All patients had good functional and aesthetic outcome.

INTRODUCTION

Soft tissue defects in the region of the foot and ankle is not an uncommon problem **[1]**. These defects face the plastic surgeon usually as a result of trauma, tumor resection, in diabetic foot infection, and deep burns **[2-5]**. The complexity of the defects in this region arises from the fact that skin is limited and thin, making tendons and bones are readily exposed, and also limited mobility and poor vascularity of skin in this region **[6]**. Open fractures or exposed tendons must be covered early to reduce complications and achieve early and rapid rehabilitation **[7]**. Many reconstructive options are available in the armamentarium of plastic surgeons but each has its own limitations. Local skin flaps can cover small defects, but will not be useful for extensive defects. Cross leg flap has been always criticized for being a staged procedure with a long period of immobilization and hospital stay **[8]**. Free flap coverage remains the ultimate option especially for extensive injuries, yet it has its limitations and it might not be suitable for every patient and always needs a skilled microvascular surgeon **[9]**.

Masquelet et al. **[10]** introduced the concept of neurocutaneous flaps, they found out that the arteries accompanying the sensory nerves give cutaneous branches to the overlying skin and are anastomosed with septo-cutaneous branches from the deep vessels. They described a distally based flap utilizing the sural nerve and the superficial sural artery running along it, vascularized by the perforators from the peroneal artery. Following that the flap got popular and has been widely used to cover defects on the distal leg, foot and ankle **[3,7,11,12]**. Since then there has been an argument between authors about the reliability of the flap, its vascular pedicle, its distal reach and limitations **[13,14]**.

The aim of this study was to report a case series of reverse flow sural flaps used to cover defects of the foot and ankle in 20 patients over 3 years time and to present the modifications in the technique of harvesting the flap that we think will increase the reliability of the flap and also to evaluate the functional and aesthetic outcome during the follow-up period.

PATIENTS AND METHODS

This study was conducted during the period from April 2009 till June 2012. It included 20 patients; 17 males (85%) and 3 females (15%), their ages ranged between 15 and 55 years (average of 33 years). They had soft tissue defects of the foot and ankle. The defect site was the foot dorsum in 9 cases (45%), heel in 5 cases (25%), medial malleolus in 4 cases (20%), tendo-Achillis in 2 cases (10%). The etiology of the defect was trauma

in 15 patients (75%), unstable scar excision in 2 patients (10%), neuropathic ulcer excision in 1 patient (5%) and Marjolin ulcer excision in 2 patients (10%). The size of the defects ranged between 10-20cm x 7-11cm. Fasciocutaneous flaps were used in 15 cases (75%) and fascial flaps with STSG in 5 cases (25%). Table (1) summarizes patients' data.

Table (1): Patients' data.

No.	Age/ Sex	Cause	Site	Size (cm)	Flap type	Operative time (minutes)	Hospital stay (Days)	Follow-up (Months)
1	30/M	Trauma	Foot dorsum	18 X 10	Fasciocutaneous	90	10	6
2	30/M	Trauma	Foot dorsum	15 X 9	Fascial+ STSG	160	10	10
3	16/M	Trauma	Heel	12 X 7	Fasciocutaneous	95	10	8
4	19/M	Trauma	Heel	14 X 7	Fasciocutaneous	120	10	12
5	15/M	Trauma	Heel	15 X 8	Fasciocutaneous	110	10	6
6	45/M	Unstable scar	Heel	13 X 8	Fasciocutaneous	130	10	7
7	50/M	Trauma	Medial malleolus	17 X 10	Fasciocutaneous	135	11	6
8	55/F	Marjolin ulcer	Foot dorsum	19 X 10	Fascial + STSG	180	10	9
9	16/M	Trauma	Medial malleolus	16 X 9	Fasciocutaneous	120	10	10
10	15/M	Trauma	Medial malleolus	15 X 7	Fasciocutaneous	120	10	36
11	17/M	Trauma	Tendo-Achillis	12 X 7	Fascial + STSG	170	10	20
12	48/M	Marjolin ulcer	Foot dorsum	17 X 10	Fasciocutaneous	110	11	24
13	35/M	Neuropathic ulcer	Heel	15 X 10	Fasciocutaneous	135	10	10
14	20/F	Unstable scar	Foot dorsum	20 X 11	Fasciocutaneous	140	10	6
15	42/M	Trauma	Foot dorsum	20 X 11	Fasciocutaneous	135	10	7
16	33/M	Trauma	Medial malleolus	18 X 9	Fasciocutaneous	120	10	8
17	49/M	Trauma	Foot dorsum	18 X 11	Fasciocutaneous	110	10	9
18	51/F	Trauma	Foot dorsum	16 X 10	Fasciocutaneous	130	12	6
19	37/M	Trauma	Foot dorsum	16 X 10	Fascial + STSG	160	12	7
20	39/M	Trauma	Tendo-Achillis	10 X 7	Fascial + STSG	150	10	6

Anatomical bases of flap elevation:

This flap was described by Masquelet et al. **[10]** on the back of the leg, centered over the medial sural cutaneous nerve as its axis. This nerve, which is commonly referred to as the sural nerve **[9]**, passes between the two heads of the gastrocnemius muscle where it converges with the superficial sural artery. Then they descend together deep to the deep fascia in the upper third of the leg. At the midpoint of the leg this pedicle pierces the deep fascia and runs subcutaneously, the artery gives branches to the nerve as well as the skin. The medial sural cutaneous nerve and its accompanying artery descend obliquely in the leg towards the back of the lateral malleolus where the artery anastomoses with branches of the peroneal artery **[7,9]**. Nakajima et al. **[15]**, stated that the sural flap has two pedicles and called the previously described one as the deep pedicle. They described the superficial pedicle to be passing with the short saphenous vein superficial to the deep fascia. The deep pedicle is connected to the deep fascia and the overlying short saphenous vein by a mesentery that contains multiple perforators which contribute to the vascularity of the reverse flow sural flap **[9]**.

Surgical technique:

Surgery was performed in the prone or lateral position under mid-thigh tourniquet control. A template was made for the defect and it was used to mark the skin island on the calf skin. The flap was limited superiorly by the popliteal fossa and

bilaterally by the lateral midlines of the calf. The adipofascial pedicle is marked from the pivot point which was about 5-7cm above the lateral malleolus to the skin island. The skin island is incised all around, deep to the deep fascia, except at the lower border near the adipofascial pedicle, and then dissection continued in the subfascial plane and care was taken to include the medial sural cutaneous nerve and the accompanying superficial sural artery by meticulous dissection preserving the mesentery containing the perforators between the 2 pedicles [9]. Dissection of the adipofascial pedicle then proceeded distally and stopped at the pivot point (5 to 7cm above the lateral malleolus). We always made the width of the adipofascial pedicle as wide as possible. After completion of flap elevation, tourniquet was released to check flap viability and to secure bleeding points. Then, the flap was rotated to cover the defect. We never used subcutaneous tunnels but we skin grafted the adipofascial pedicle.

The donor sites were always closed by split thickness skin grafts STSG.

A bulky dressing was applied to the leg to alleviate any pressure on the flap or its pedicle with posterior below knee splint. A window is made in the dressing to allow for flap monitoring. Post-operatively the leg was kept elevated using two pillows. Dangling was started 10-12 days post-operatively. Compression garments were used for 3 months after starting dangling.

Technique of fascial flap elevation:

Using a template of the defect to mark the territory of the fascial flap to be harvested, then a longitudinal lazy-S incision on the back of the calf stopped at the pivot point (5-7cm proximal to the lateral malleolus) was done. Skin flaps were dissected bilaterally in a plane leaving equal amount of subcutaneous fat between the skin and the fascia. After elevation of the planned fascial flap, the dissection proceeded as described before. Insetting of the flap and its coverage by STSG then followed, the donor site was closed directly. Post-operatively the same measures were applied as for the fasciocutaneous flaps.

RESULTS

The operative time ranged from 90 to 180 minutes (mean 131 minutes), while hospitalization time ranged from 10 to 12 days (mean 10 days). In 17 cases (85%) the flaps survived completely. Two flaps (10%) had venous congestion; one of these two had partial distal necrosis. One flap was totally lost (5%). One patient (5%) had partial loss of the skin graft over the fascial flap, the fascial flap underneath was viable and was regrafted after wound preparation. We had no loss of skin grafts on the donor site of the flaps. Two cases (10%) had slight hypertrophy of the skin graft over the donor site and was treated by massage and pressure garments. None of our flaps developed ulceration over pressure areas during the follow-up period. Table (2) illustrates the post-operative complications in our patients. The follow-up period ranged from 6 to 36 months (average 11 months). Five patients (25%) complained of sensory impairment along the lateral aspect of the foot due to sacrifice of the sural nerve and improved during the follow-up period.

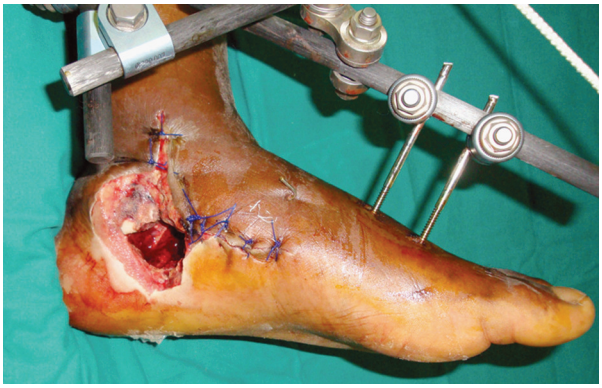
Case 1: A 33 year old male with soft tissue loss on the medial surface of the left ankle caused by blunt trauma to the foot with ankle fracture. Bone was fixed by external fixator and soft tissue loss was reconstructed successfully by reversed sural flap. Good functional and aesthetic outcome was achieved and maintained at 4 months post-operative (Fig. 1).

Case 2: A 35 year old male patient with soft tissue loss over the right heel following trauma to the foot with necrosis of the skin of the heel. After wound debridement and preparation, soft tissue loss was reconstructed by reversed sural flap. Good functional and aesthetic outcome was achieved and maintained at 10 months post-operative (Fig. 2).

Case 3: A 39 year old male patient with skin loss of the tendo-Achillis following trauma to the foot with skin necrosis. After wound preparation, the wound was repaired by reversed sural fascial flap, covered by STSG. Good functional and aesthetic outcome was achieved and maintained at 6 months post-operative (Fig. 3).

Table (2): Postoperative complications.

Complication	No. of patients (%)
Total flap loss	1 (5%)
Partial flap loss	1 (5%)
Partial skin graft loss over fascial flap	1 (5%)
Skin graft loss over the donor site	0
Osteomyelitis	0
Hypertrophy of the skin graft	2 (10%)
Ulceration of the flap	0



(A)

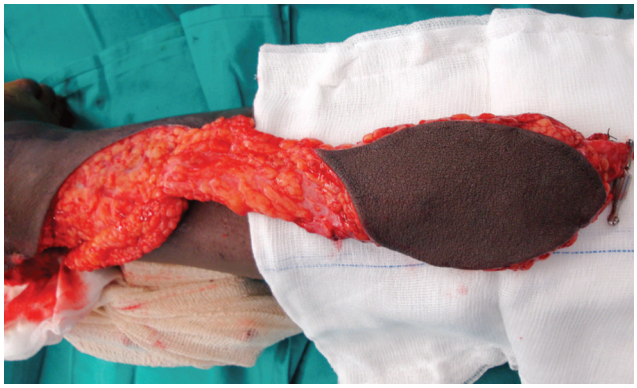


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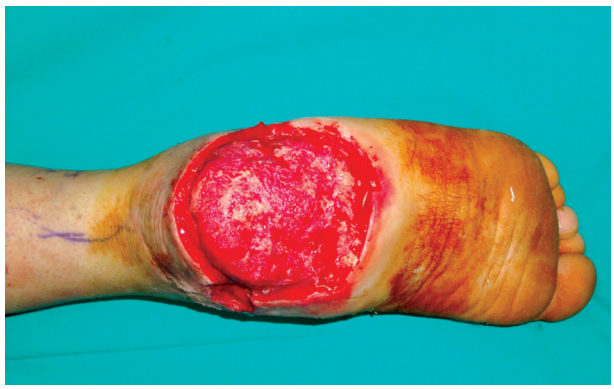
Fig. (1): A, Preoperative view showing a soft tissue defect of the medial surface of the left ankle. B, Reversed sural flap with wide fascial pedicle. C, Immediate postoperative view after skin grafting of the flap donor site and the fascial pedicle. D, Four months postoperative with stable wound coverage.

(A)



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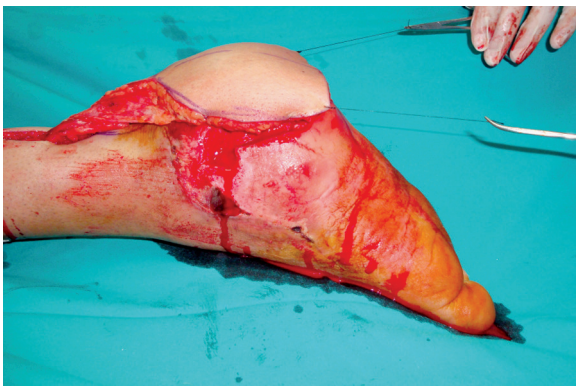

(C)

(D)

Fig. (2): A, Right heel ulcer following trauma to the foot and heel skin necrosis. B, After wound excision. C, The flap is rotated 180 degrees to cover the heel. D, 10 months postoperative with good functional and aesthetic outcome.

Fig. (3): A, Chronic wound with exposed tendo-Achilles. B, After wound debridement. C, After elevation of the reversed sural fascial flap. D, Rotation of the flap 180 degrees to cover the defect. E, Coverage of the fascial flap by STSG. F, Stable wound coverage after 6 months.

DISCUSSION

Reconstruction of soft tissue defects of the foot and ankle region has been always a major challenge to plastic surgeons and remains one of the most demanding procedures in plastic surgery **[16]**. There are several flaps in the armamentarium of the plastic surgeon to cover such defects and each has its own limitations. Free tissue transfer is always the preferred option for reconstruction of soft tissue defects of the foot and ankle region with high success rates, it enables reconstruction of defects of any size even with different components in one stage with high success rate **[17]**, however it may not be suitable for all patients and it always requires a special operating set and well trained team **[11]**.

Cross leg flap has been widely used for coverage of such defects successfully, but still has the disadvantage of prolonged immobilization in a discomfortable position for up to 3 weeks and the need for multi-staged surgical procedure **[18]**. Fasciocutaneous flap based on the posterior tibial, peroneal or anterior tibial artery always has the disadvantage of scarifying a major artery of the leg **[19]**.

The distally based sural neurocutaneous flap plays an important role in reconstruction of soft tissue defects in the distal leg and foot. It has many advantages over other reconstructive options; it can be elevated in a short time, has a wide arc of

rotation, preservation of major arteries of the leg, skin match with the recipient site and relatively low rate of complications [20,21,22]. The major disadvantages of the flap include questionable reliability of its blood supply especially venous drainage, its distal reach in cases of foot defects and also its donor site morbidity [7,9,21]. The flap gained popularity and became a versatile option for reconstruction of soft tissue defects of the distal leg, foot and ankle. For the sake of flap vascular reliability it was suggested by Masquelet [10] to limit the flap to the lower two thirds of the leg. Many authors presented their modifications of the flap design and elevation technique trying to overcome its potential disadvantages; increasing its distal reach and its vascular reliability. Al-Qattan [13,23] reported marked reduction in the incidence of ischemic events with this flap when including a 3cm cuff of the gastrocnemius muscle around the proximal subfascial sural pedicle. Many authors [9,24] found that inclusion of the muscle cuff might be complicated by partial muscle necrosis and/or hematoma around the muscle. They stated that inclusion of the muscle cuff was unnecessary as careful dissection could preserve the mesentery containing the perforators between the deeper and superficial pedicles without the need of inclusion of a gastrocnemius muscle cuff. In this series we did not include a muscle cuff, we first ligated the sural pedicle about 2cm proximal to the proximal part of the flap then meticulous dissection of the deep pedicle between the two heads of the gastrocnemius and dissection proceeded as described before. Delay procedures were also described to increase the vascular reliability and reach of the reverse sural flap. Köse et al. [22] suggested the use of the expanded reverse sural flap for female patients with large defects to allow for direct closure of the donor site and also for patients older than 40 years of age with associated comorbidities as diabetes mellitus, peripheral arterial disease or venous insufficiency. We believe this is an additional surgical procedure which will prolong the hospital stay and it will be less effective compared to a single step procedure like microsurgical tissue transfer. Kneser et al. [20] recommended that if a two-stage surgical procedure was anticipated, the delay procedure by whatever method could be considered to increase the versatility and reliability of the flap.

In this series, none of the donor sites of the fasciocutaneous flaps could be closed primarily. All were closed by STSG. The aesthetic appearance of the donor site of this flap remains a negative point especially in female patients. Afifi et al. [9] suggested that pierce-string suturing of the donor site could reduce the size of the skin grafted area significantly. The donor site of the fascial flaps in our series had a much better aesthetic appearance. In this series we had 1 case of total flap loss on the 2nd post-operative day; this was a 51 years old female patient with uncontrolled diabetes and we suggest the cause of failure to be due to micro angiopathy. Two cases in this series developed venous congestion on the first and the second post-operative days. One case responded to foot elevation and relieving any pressure on the pedicle and it recovered completely. The other case unfortunately did not respond well to this conservative maneuver and ended up by partial flap necrosis. Venous congestion and distal flap necrosis was noticed by many authors to be of the most common complications of this flap [24,25]. Vergara-Amador [7] suggested the cause of venous congestion was the pressure applied on the pedicle by the skin of the roof of the tunnel created to the defect. He suggested to make the tunnel as wide as possible or open the tunnel, dissect it well and then suture it again and if still not wide enough he suggested exteriorization of the pedicle to be divided later. Some authors [9,24] suggested inclusion of skin with the flap pedicle to improve the venous drainage of the flap and reduce venous congestion. In our series, we never used subcutaneous tunnels, we opened the skin all through to the defect and we skin grafted the pedicle. The lesser saphenous vein was included in all our flaps. The majority of authors [9,26] believe that including the lesser saphenous vein within the flap will help improve the venous drainage and reduce venous congestion. Xu and Lai-Jin [21] suggested that including the lesser saphenous vein within the flap may be the cause of venous congestion and they reported no serious venous congestion in their series after started ligating the lesser saphenous vein at the pivot point.

Sensory impairment in the form of anesthesia, hypoesthesia or numbness may occur in some patients along the lateral aspect of the foot due to sacrifice of the sural nerve [25,26]. In our series five patients developed such complaints and they were reassured and the condition improved during the follow-up period. Vergara-Amador [7] reported the use of distally-based sural flap for reconstruction of foot and ankle defects in 16 children (with an average age of 9 years) and he did not report any sensory impairment following sacrifice of the sural nerve in any of his patients. He suggested that these sensory problems are more likely to occur in adults than children.

Conclusion:

Based on the results of this study and the reports of other authors; we believe the reverse sural artery flap is a good option for reconstruction of soft tissue defects of the foot and ankle. It is a simple and rapid procedure with minimal donor site morbidity and preservation of the leg vessels. It provides thin pliable skin with good color match. It can also be used as a fascial flap in appropriate patients. In order to increase its vascular reliability and distal reach, it is recommended to include both the superficial pedicle with the short saphenous vein together and the deep pedicle with the medial sural cutaneous nerve. Also it is recommended to take the fascial pedicle as wide as possible.

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