

# Complex Technique of Large Sural Flap: An Alternative Option for Free Flap in Large Defect of the Traumatized Foot

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**Abstract-** The distally based sural fasciocutaneous flap has become a main part of the reconstruction of the lower leg, heel and foot. However, perfusion problems and venous congestion have been reported. Over the past decade, several flap modifications have been reported to improve flap viability and to solve a myriad of reconstructive needs. The purpose of this paper is to describe our experience in harvesting the reversed large sural flap from the proximal and middle third of the leg for large defects on the foot. We applied the extended reversed sural flap from the proximal third of the leg in traumatized patients which had large defects on their foot. The technique was done in 3 parts: 1- the flaps were designed in the proximal third of the leg five centimeter lipofascial tissue was protected around the pedicle in distal part; 3- The pivot point was located in seven to eight cm proximal the lateral malleolus before the first fasciocutaneous perforators arising from the peroneal artery. Sural flaps from the proximal and middle third of the leg were designed in 13 patients who had large defects on their foot. No flap necrosis or split thickness skin graft loss occurred. The flaps healed by the 3<sup>rd</sup> week excluding two patients. This study supports the application of our technique as a safe, easy and useable method in large defects of the foot. The results showed low rates of ischemia, venous congestion, dehiscence, infection and flap necrosis. Proximal extended and large distally based sural flap is an alternative to free tissue transfer for large defect reconstruction of the foot.

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## Introduction

The reconstruction of soft tissue defects in the lower one-third of the leg: the Achilles tendon, ankle, calcaneal area and foot present a challenging problem (1). Reconstructive options include the use of cutaneous flaps, fascial or fasciocutaneous flaps, muscle flaps, and free flaps (2, 3). Masquelet et al reintroduced the sural flap in 1992 with a thorough description of the relevant anatomy and the surgical procedure (4). The flap provides a wide arc of rotation, constant vascularity, and easy and quick elevation with acceptable donor-site morbidity (5). However, perfusion problems and venous congestion have been reported (1-4). Unfortunately, when the soft-tissue defect is large and located at the dorsum of the mid-foot, distal marginal necrosis of the flap usually occurs and is the exact part of the flap that is needed most on the distal of the mid-foot (1).

Over the past decade, several flap modifications have been reported to have improved flap viability and to have solved a myriad of reconstructive needs (2,3,5,6). In the standard technique, the flap is not usually harvested from the proximal third of the leg due to the deep course of the sural nerve between the two heads of the gastrocnemius muscle (4). The proximal extension of the distally based neurofasciocutaneous sural flap has been considered a random type flap that provides a long lengthening but its survival is not predictable (7,8). Free tissue transfers provide excellent tissue coverage for large defect of the foot but require a microvascular team, equipment, accompanies long operative time, donor morbidity, and a risk of complete failure (3).

So we designed a large modified distally based sural nerve flap in the proximal third of the leg. Based on the conventional reversed sural flaps in addition to the proximal extension, wide-base and preserves the

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cutaneous branch of the peroneal artery seven cm upon the lateral malleolus. The purpose of this study is to describe our experience in harvesting the reversed large sural flap from the proximal of the leg for large defects on the foot. This study was performed to highlight its reliability, safety and potential for large traumatized foot defect reconstruction.

## Patients and Methods

From March 2006 to March 2009, 32 distally based neurofasciocutaneous reverse sural flaps were used for the reconstruction of soft-tissue defects of the traumatized lower leg: around the heel, ankle and dorsum of the foot (Figure 1). The large reverse sural flap from the proximal and middle third of the leg was performed on the large defects (more than 12 cm in diameter) of 13 patients' foot. Seven patients had open fracture in ankle, weight bearing heel and the mid-foot bone. Others had an exposed bone. Data, including demographics, mechanism of injury, dept of the wound, site of defect, dimension of flap, postoperative results and complications were recorded. All patients were followed up in outpatients department (clinic) for 6 months. They were visited in the first, third, and sixth weeks and afterwards monthly until their recovery was obtained. The setting of the flap and functional outcome was also recorded.

Debridement of the recipient area was done while the patient was in the prone position. Our technique was based on the conventional reversed sural flaps. It had three main parts: 1- the flap was designed in the proximal third of the leg and was protected by a loose fibro-adipoareolar tissue which existed between the two heads of the gastrocnemius; 2- five centimeter lipofascial tissue was protected around the pedicle in distal part; 3- The pivot point was located in seven to eight cm proximal the lateral malleolus before the first fasciocutaneous perforators arising from the peroneal artery. A large skin island was marked along the axis of the sural nerve (Figure 2). The sural nerve and artery, and lesser saphenous vein were ligated 1 cm proximal to the border of the flap (Figure 2). The dissection was then continued around the distal aspect of the flap in the subfascial plane. The main consideration during the procedure was meticulous dissection of the vascular plexus around the sural nerve, sural artery, and lesser saphenous vein in the loose fibro-adipoareolar tissue between the two heads of the gastrocnemius muscle. One cm in proximal and 2.5 cm in distal of the pedicle in each side of the flap was saved to maintain a wide

pedicle (increasing the width from proximal to distal for the neurovascular axis protection). The pivot point was marked just above the perforator from the peroneal artery which dissection was stopped 7 - 8 cm above the lateral malleolus (Figure 3). This preserved all cutaneous perforators including a perforator from the lateral calcaneal artery, a perforator from the posterior lateral malleolus artery, and one to three septocutaneous perforators from the peroneal artery (9). The template of the defect of recipient area is made. This flap can be located anywhere in the mid-foot. The flap is now transposed through division of the skin bridge between the donor site and the defect is done (Figure 3). In all cases pedicle is covered with a split thickness skin graft (STSG). We used subcuticular pursing suture (round block suture) in the donor site and remainder area is then covered with a STSG. A well-padded dressing is applied making sure that there is no compression on the pedicle.



**Figure 1.** Traumatized lower leg: dorsum of the foot, exposed bone



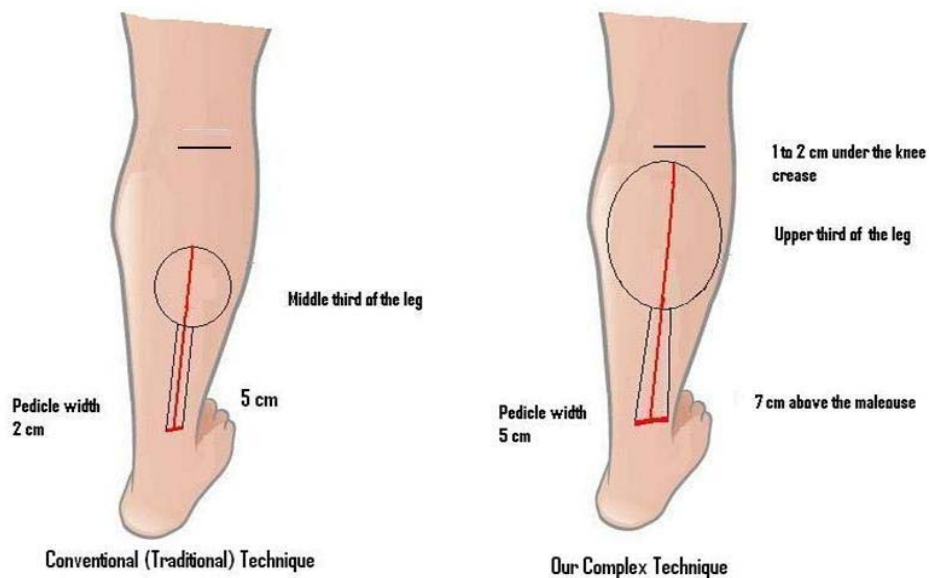
**Figure 2.** The flaps are designed in proximal third of the leg, 2-4 centimeter from the popliteal fossa



**Figure 3.** The flaps are designed in proximal third of the leg, the pivot point, wide pedicle, heel and lateral malleolus reconstruction



**Figure 4.** Four weeks after operation



**Figure 5.** Schematic of conventional and our complex techniques for sural flap

The flap is left exposed for observation. The dressing is changed on 5th postoperative day in recipient site. The flap usually heals by 3rd week but full weight bearing on flap for heel defects, should be avoided for ten weeks (Figure 4).

## Results

A total of 32 traumatized lower legs were covered with neurofasciocutaneous reverse sural flaps for the

reconstruction of soft-tissue defects. Sural flaps from the proximal and middle third of the leg were designed in 13 patients who had large defects on their foot. The causes of injuries were motorcycles (spoke injury), car accidents, and crush injury in six, four and three patients respectively. Demographic data, mechanism of injury, wound depth (whether bone or joint was exposed), site of defect, size of defect, dimension of flap, postoperative results, venous congestion and complications were all recorded (Table 1).

**Table 1.** Demographics, technical and result data

No	Sex/age	Etiology	Wound size (cm)	Flap size(cm)	pivot point (cm)	site of defect	Joint or bone expose	Results	comp complication
1	F / 48	motorcycles	16 × 10	17 × 11	8	Dorsum of foot	+	Heal	Mild congestion
2	F / 28	car accidents	15 × 9	16 × 10	7	Heel & sole	+	Heal	Mild congestion
3	M / 21	motorcycles	14 × 10	15 × 11	7	Dorsum of foot	+	Heal	-
4	M / 24	motorcycles	14.5 × 8.5	16 × 9.5	7	Heel & sole	+	Heal	-
5	M / 24	car accidents	12.5 × 7	14 × 8	8	Heel & sole	-	Heal	-
6	M / 28	Crush	12 × 6	13 × 7	7	Dorsum of foot	+	Heal	moderate congestion
7	M / 31	motorcycles	13.5 × 7.5	15 × 8.5	8	Heel & malleolus	+	Heal*	infection , dehiscence**
8	M / 35	motorcycles	12 × 6.5	13 × 8	7	Heel	+	Heal	Mild congestion
9	M / 35	car accidents	14.5 × 8	16 × 9	8	Heel & sole	+	Heal	-
10	M / 42	Crush	15 × 8	16 × 9	7	Dorsum of foot	+	Heal	-
11	M / 44	motorcycles	15.5 × 10	16.5 × 10.5	8	Heel & sole	+	Heal	-
12	M / 53	Crush	12 × 6	15 × 8	7	Heel & sole	-	Heal*	infection , dehiscence***
13	M / 55	car accidents	12 × 8.5	13 × 9.5	7	Heel & sole	+	Heal	-

\*= wound infection and dehiscence in recipient site, \*\*= smoker, \*\*\*= diabetic

Venous congestion was treated with elevation. Defect sizes ranged from 12×7 to 16×10 cm. They were located on the heel, sole and dorsum of the foot (mid-foot). The size of the skin islands ranged from 13×8 to 17×11 cm.

The proximal borders of the flaps were 2 to 3 cm from the popliteal skin crease. The pedicle width was 2 cm in proximal and 4 cm in distal (increasing from proximal to distal). We used subcuticular purse suture in the donor site and the remainder area was then covered with a split thickness skin graft. It decreased the need for STSG in donor site 50% - 60 %. The wound infection and dehiscence occurred in 2 patients. One of them was diabetic and the other a smoker. They were successfully treated by repeated debridements and suture on the bed with local anesthesia. One patient had seroma in the donor site which was treated with opening two sutures and compressive dressing. One patient had moderate venous congestion. We did not observe any flap necrosis and split thickness skin graft loss. Excluding 2 patients (the diabetic and the smoker), the flap healed by the 3<sup>rd</sup> week in all of them. Full weight bearing on the flap defects was avoided for ten weeks.

## Discussion

The present study supports the application of this complimentary technique as a safe, easy and applicable method in large foot defects. The results show low rates of ischemia, venous congestion, dehiscence, infection and flap necrosis.

Soft tissue defects of the distal third of the leg, ankle, heel, and foot are difficult to reconstruct. The sural flap is a useful and versatile reconstructive option in patients with soft-tissue defects of the foot and lower leg (1,3). Despite these successes, flap necrosis and other complication rates remain significant. Several studies described different rates from 5% to 36% (8, 10-13). Kneser *et al.* also did not observe any complete or near complete flap necrosis in their study (2). These studies have been performed on patients with small to moderate sized defects on the distal part of the leg, Achilles tendon, ankle, malleolus and heel (2,5).

Large soft-tissue defects of the heel; sole and dorsum of the foot are a challenging problem and are usually treated by free tissue transfer. This is because free flaps provide reliable single-stage coverage (2-4).

However, there are some disadvantages to this technique which are: donor-site morbidity, increased operation time, the use of a major vessel of the leg and the necessity of microsurgical expertise. An alternative approach for large defect coverage of these areas is the distally based neurofasciocutaneous sural flap. The major advantages of the distally based neurofasciocutaneous sural flap are a quick and safe surgery, a wide arc of rotation of the flap, preservation of major arteries of the leg, and acceptable donor-site morbidity (2,3). At the other hand, the disadvantages are perfusion problems, venous congestion, partial necrosis and length limitation. The proximal extension of the distally based sural flap has been considered a random type flap and its survival is not predictable (7,8,10). Some of authors have presented modifications to secure the extension of the Fasciocutaneous Island to the proximal leg. Such modifications included delaying (11,12), a pedicle wider than usual (5), and harvesting a midline cuff of the gastrocnemius muscle with the flap (13). Venous supercharging is a microsurgical technique that should be considered in patients with venous insufficiency (3). It has been shown that delay can significantly increase blood circulation in the distal portion of the random pattern skin flaps (5,14,15). Some authors had previously mentioned about fibro-adipo-areolar tissue between the two heads of the gastrocnemius muscle and made a mesentery like structure that was important for flap elevation (9, 16). The upper limits of the flap's dimensions have been best explored by Ayyappan and Chadha, who have reported that they left as little as 1 to 2 cm of skin distal to the popliteal crease with a pivot point only 4 to 5 cm proximal to the lateral malleolus (16).

To reach our end, we considered many studies about distally based sural flaps. We reached to a conclusion that the survival of a large sural flap is the result of the function of many different parameters: vascular risk factors, patient's age, smoking, defect size, kinking of the pedicle area, insufficient skin mobilization at the base of the flap, tunneling of the flap, and large flap dimensions as well as tissue trauma due to accidents which may have negatively influenced perfusion of the entire flap. We performed proximal extended and large distally based sural flap for large defect on the foot as an alternative to free flap. Flap designing had three main parts which were explained in the surgical technique. The benefits of the proximal design of the flap were larger flap and pedicle lengthening, which cover a larger area without stretching. Widening of the pedicle preserved venous and arterial connection and helped to

prevent pedicle kinking and flap transfer through skin bridge division between the donor site and the defect that prevented pedicle compression. The pivot point was located in seven to eight cm proximal to the lateral malleolus. The dissection stopped there, which preserved all cutaneous perforators including a perforator from the lateral calcaneal artery, a perforator from the posterior lateral malleolus artery, and one to three septocutaneous perforators from the peroneal artery. No delay or "cuff" of gastrocnemius muscle was used. The result of this study can be considered a favorable result compared to other reports. Also the flaps in this study were significantly larger than the flaps reported by other investigators (2,7,9,13,17-20). The large defects were situated on the foot and were caused by multiple traumas. In addition, no complete or near complete flap necroses were observed in this study. Also, two patients had dehiscence and infection (the diabetic and the smoker). Finally, all patients underwent successful reconstruction with the sural flap. In conclusion, proximal extended and large distally based sural flap is an alternative to free tissue transfer for large defect reconstruction of the foot. Application of a complex technique, as was explained above for large defect reconstruction of the foot, is recommended to all similar cases.

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