The reverse sural fasciocutaneous flap for the coverage of soft tissue defect of lower extremities (distal 1/3 leg and foot)

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ABSTRACT

Soft tissue defect of the lower extremities especially over the distal third leg, ankle region, tendo achilies area, heel and foot has always been challenging for the Plastic surgeon. Though with introduction of Microsurgery, the expertise and its advances, free flap surgery to cover the defect is not possible in every center due to the sophisticated instruments, equipments and lengthy procedures. The reverse sural fasciocutaneous flap is a viable option for the soft tissue coverage of distal third leg and foot. Between Nov 2008 till Nov 2010, 11 patients with moderate size soft tissue defect (5-15 cm defect) with exposed bone, tendons and hardware of ankle joint, posterior aspect of heel, and dorsum of the hind foot and mid foot were treated with reverse sural artery fasciocutaneous flap. Out of 11cases, 10 cases had uneventful postoperative course. In one case, we encountered complete necrosis of the flap due to venous congestion that occurred in 3rd post op day. In all other cases, the flap survived completely without any marginal necrosis. Split thickness skin graft was well taken in donor site in all other cases. The sural artery fasciocutaneous flap is versatile and reliable procedure, easy and quick to elevate, due to the long pedicle, distalization up to the dorsum of the mid foot can be achieved and also a good alternative to microsurgical procedures where such facilities are not available and the surgeon is not well familiar with the procedure.

Keywords: Fasciocutaneous flap, sural artery.

INTRODUCTION

Soft tissue defect of the lower extremities especially over the distal third leg, ankle region, tendo achilies area, heel and foot (Dorsum of hind foot and mid foot) has always been challenging to the orthopedic surgeon as well as to the Plastic surgeon. Though with introduction of Microsurgery, the expertise and its advances, free flap is the best option to cover such defect, however, it is not possible in every center due to the lengthy procedures and requirements of sophisticated instruments and equipments.

The reverse sural fasciocutaneous flap is a viable option for the soft tissue coverage of distal third leg and foot. As tibia being a subcutaneous bone without any muscle in distal 1/3rd and heel being the weight bearing area, soft tissue defect in such area always required vascularized soft tissue cover (Flap).

The distally based sural artery fasciocutaneous flap, firstly described by Masquelet *et al*[1] is skin island flap supplied by arteries accompanying the superficial sensory nerve of leg. Hence, described as neurocutaneous Island flap.

Anatomical basis of flap: Masquelet *et al*[1] described the anatomical details for this flap in 1992. The reverse flow sural artery neuro fasciocutaneous flap is based on the medial superficial sural artery. This artery is a branch of the superficial artery originating from the popliteal or sural arteries and then following the course of the sural nerve 2-3 cm distal to its origin and emitting numerous branches along its suprafascial path towards the skin at the lower leg.

Popliteal artery in the popliteal region gives off a dominant arterial branch each to the medial and lateral heads of gastrocnemius. In addition to these muscular branches it also gives sural artery which divides into median, lateral and medial branches, the first one being constant and the last one being quite variable. Sometimes these medial and lateral branches may be derived from inferior genicular arteries or the muscular sural artery supplying the gastrocnemius. These medial and lateral branches are reciprocal to each other in size. There is also a reciprocal relation in size between the direct cutaneous sural vessels and muscular arteries supplying the two heads of the gastrocnemius. The median sural artery generally accompanies the sural nerve and short saphenous vein in the proximal calf. Branches of the median sural artery supply the skin and the subcutaneous area of the posterior part of the middle 1/3 of the calf. This suprafascial plexus of vascular network arborises both longitudinally and radially and anastomoses with the septocutaneous perforators of the peroneal artery in

the distal 1/3 of the calf. It is this reliable suprafascial anastomoses of vascular network of 2 different sources that forms the basis of distally based adipofascial pedicled fasciocutaneous flap from the middle 1/3 of the calf. Peroneal septocutaneous perforators are quite constant in number and the most distal one is given off well within 5 cm proximal to the tip of the lateral malleolus Fig 1.

Hence the pivot point of this distally based flap can be as distal as 5cm from the tip of the lateral Malleolus. Careful dissection and mobilization of these perforators can permit further distalisation of the pivot point of the flap to cover the defect of the dorsum of the hind foot and mid foot.

Recent concept of venocutaneous perforators from the arterial branches accompanying the short saphenous vein can also supply these distally based flaps independent of the neurocutaneous perforators. Hence theoretically and practically these distally based flaps can include the skin and subcutaneous tissue of the proximal 1/3 of the calf (Type B1 and D1 lesser saphaenous VA flaps of Nakajima) provided the flap is raised with the short saphenous vein without damaging accompanying artery.

MATERIALS AND METHODS

Eleven patients with moderate size soft tissue defect (5-15 cm defect) with exposed bone, tendons ankle joint, posterior heel, and dorsum of the hind foot were treated with reverse sural artery neurocutaneous flap during the period of 2 years between Nov 2008 till Nov 2010.

Among them 8 were men and 3 were women. The age ranged from 5 to 71 years with mean age of 38 years. Most of the patients had sustained road traffic accident. The soft tissue defect were located on non weight bearing area of heel and posteriors aspect of the foot in 4 patients, Antero medial aspect of distal third tibia in 1 patient, dorsum of the foot with exposed cuneiform bone and metatarsal bone in 2 patients, medial malleolar region in 3 patients and 1 case of chronic osteomyelitis with exposed navicular bone. The associated fractures were treated with external fixator. The flap size is measured in length and breadth and recorded.

All the patients underwent basic laboratory investigations (CBC, Hb, RBS, Electrolytes, RFT, Chest X-ray, ECG) and peroneal perforators were identified by using handy Doppler flow meter.

PROCEDURE

In 7 cases regional anesthesia was given where as in 4 cases general anesthesia was given. Pre operatively 2-3 peroneal perforators were identified by handy Doppler and marked.

With the patient in a prone position / Lateral, position the recipient raw area was measured with sterile paper then the flap with radius of 0.5 cm more than that of recipient raw area is designed Fig 2. In case of fasciocutaneous flap, the measured paper flap design was drawn on the posterior aspect of the calf on its middle 1/3 vertically in relation to the recipient raw area and pivot point. In case of adipo fascial flap, the proximal and distal limits of the flap was marked. The pivot point of the flap was marked 5 cm (3 Fingers Breadth) above the tip of lateral malleolus Fig 1.

With application of the tourniquet, flap dissection was started. If an adipo fascial flap was harvested, the skin over the flap was undermined leaving at least one fat globule over the fascia to protect the fascial plexus. The pedicle of the flap between the pivot point and proximal margin of the flap is exposed with linear skin incision. The subdermal layer is dissected to expose the sural nerve, accompanying superficial sural vessels and short saphenous vein. In case of fasciocutaneous flap, the islanded fasciocutaneous flap is elevated with the deep fascia anchored to the skin in order to prevent the shearing between skin and deep fascia, securing the supra fascial plexus of the vessels. At the distal end of the flap the sural nerve and short saphenous vein is identified, included in the flap and then ligated and cut Fig 3. The pedicle is dissected subdermally of appropriate length

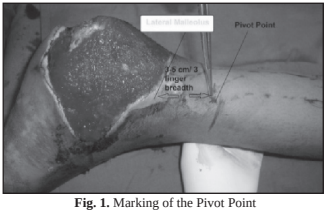


Fig. 1. Marking of the Pivot Point

Fig. 2. Flap and Pedicle length measured with sterile paper

Fig. 3. Sural nerve identified and included

and elevated including the deep fascia with minimum of 2-2.5 cm width Fig 4. After complete elevation of the Skin Island and fascial pedicle, the tourniquet is deflated and viability of the flap is assessed carefully with visual assessment the flap marginal capillary circulation and evaluation of the axial vessel using handy Doppler maintaining the sterility. The flap is left over for 3-5 min in a outstretched position or covered with warm saline soaked gauze to increase the flap circulation.

After confirmation of viability, the flap is transferred to the recipient area by opening the skin bridge, taking care of no undue tension over the pedicle. The flap is sutured loosely applying few sutures without any tension. Drains are inserted under the flap. In case of adipo fascial flap, the flap is covered with split thickness skin graft after the inset. It can be done after few days in case of doubt of flap perfusion Fig 5.

The donor defect covered with split thickness skin graft cover. The pedicle site above the pivot point skin sutured directly. Non-adherent dressing over the grafted site and pedicle. Mild compression bandage with a window to inspect the flap at regular intervals. The limb is elevated with care to prevent any compression over the pedicle and grafted area. Applying these techniques, most of the defects measuring between 5 cm -15 cm can be covered of distal third leg, ankle joint, posterior heel, and dorsum of the hind foot.

Fig. 4. Subdermal Dissection of the pedicle

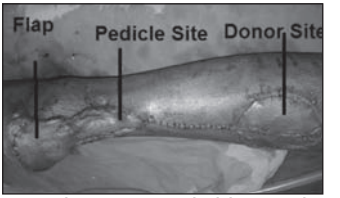


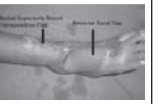
Fig. 5. Flap Inset/ Donor site and Pedicle site covered with STSG


71 Yrs Male, Heel Defect — 4 Months Post Op

Case No 9 :- Heel defect covered by Reverse sural artery fasciocutaneous flap

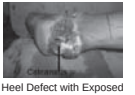
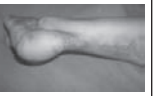

48 Years Male/ Medial Malleolar Defect With Exposed Hardware — 1 Month Post Op

Case No 10 :- Post traumatic wound defect medial malleolus region with exposed hardware covered with reverese sural artery fasciocutaneous flap

5 Years Female/ RTA, Soft Tissue Defect with Exposded D/3 Tibia and Cuneiform Bone — 1 Year Post Op

Case No 1 :- Open fracture Distal third tibia, Gustillo III B with large area soft tissue defect covered with reverse sural fasciocutaneous flap dorsum of the foot and superiorly based transposition flap to cover exposed dital third tibia

Heel Defect with Exposed Calcanium Bone — 1 Month Post Op

Case no 3:- Post traumatic heel defect with exposed calcaneum covered with reverse sural fasciocutaneous flap

RESULTS

During 2 years period total 11 cases were operated. The etiology of most of the cases were road traffic accident, which were 8 (72.7 %) in our study. The other three cases were of different etiology: - fall from the height, wound defect following posterior medical release for clubfoot and chronic osteomyelitis.

Out of 11 cases, 10 cases had uneventful post operative course. In one case, we completely loss the flap Table-1. Venous congestion occurred on 3rd post of day. After episode of debridement, the wound was covered with SSG. The two adipo fascial flap survived completely and skin graft was done on 2nd post of day. In one case, along with reverse sural fasciocutaneous flap medially superiorly based transposition flap was done to cover the exposed distal third tibia. The other10 cases the flap survived completely without any marginal necrosis and did not require any secondary procedure.

There was no graft loss of donor and pedicle site. One patient complained of hypoesthesia over the sural distribution site. None of them had any functional deficit due to sural hypoesthesia.

DISCUSSION

Coverage of the Soft tissue defects over the dorsum of the foot, ankle, heel and distal third leg has always been challenging and demanding task for the plastic surgeons. There are several procedure that have been described for the coverage of defects in distal third Leg and foot starting from the simple split thickness skin graft [3,4] to the different types of the flaps including muscle flap,[5,6] septocutaneous flap,[7,8] axial flaps[9,10] and free flaps.[11-13] After the development of modern advance technique (Microsurgery), it has solved many problems of larger soft tissue coverage with exposed tendons and bones, which were thought impossible to cover in the past, and the wound was left over until the granulation tissue cover the wound and ultimately ended with simple split thickness skin graft coverage.

Split thickness skin graft remains the best option to cover the superficial defects over the dorsum of the foot. STSG can be used to cover the larger area of superficial soft tissue defect with minimal donor site morbidity. This procedure is being practiced by various plastic surgeons of the world till now, due to its faster intake and early neurotization,[3,4] however it is not indicated when bones and tendons are exposed.

Large size local random pattern flaps has high incidence of the failure rate with distal end tip necrosis. Superiorly or Inferiorly based fasciocutaneous flap of leg are short to cover the heel defects and large sized wound defects. The medial planter island flap[14] and lateral calcaneal island artery flap[15] are choice of flaps for the pressure bearing area heel defects, as it is a sensate flap. However,

Table-1: Patient Summary

Case	Age (yrs) Sex	Etiology of Defect	Site of the Defect	Type of Flap	Size of the Flap	Flap Morbidity	Donor Site Morbidity
1	5/f	RTA	Dorsum of the Foot	Fasciocutaneous	6.5x4 cm	N/A	N/A
2	8/m	RTA	Dorsum of the Foot	Adipofascial	4x3 cm	N/A	N/A
3	36/f	RTA	Posterior aspect of Heel	Fasciocutaneous	7x4 cm	N/A	N/A
4	51/m	Fall from Ht	D/3 Leg	Fasciocutaneous	8x3.5 cm	N/A	N/A
5	8/m	RTA	Medial Malleolus	Adipofascial	8x3 cm	N/A	N/A
6	35/m	COM	Medial Aspect of Foot	Fasciocutaneous	10 x 7.5 cm	Total Loss	N/A
7	6/F	Post PMR	Medial Aspect of Foot and Ankle Joint	Fasciocutaneous	9cm x 5cm	N/A	N/A
8	5/M	RTA	Medial Aspect of Foot, ankle joint and 1/3 Heel	Fasciocutaneous	8x5 cm	N/A	N/A
9	71/M	RTA	Heel Defect	Fasciocutaneous	6x5 cm	N/A	N/A
10	48/M	RTA	Medial Aspect of Foot	Fasciocutaneous	7.5x4 cm	N/A	N/A
11	13/M	RTA	Heel Defect	Fasciocutaneous	9x6.5 cm	N/A	N/A

it requires good experience and due to its small size, larger defects difficult to cover. Free flap requires team of expertise with good microsurgical skills and medical team with modem advance appliances and equipments, which is generally not available in every center.

Since the discovery of distally based sural artery flap in 1992 by Masquelet *et al*,[1] it has been used to cover the wound defect of distal third leg. The distally based superficial sural artery flap is vascularized by a superficial sural artery with reverse flow, which takes septocutaneous perforators from the peroneal artery in the distal part of the leg. On the basis vascular axis around the superficial sensory nerves which ensures the vascularization of the nerve and the cutaneous branches of the accompanying arteries of the superficial nerve are anastamosed with the septocutaneous perforators from peroneal artery The use of this flap received quick recognition with more clinical results and practiced all over the world since then.

Nakajima *et al*[2] had investigated in 10 cadavers by injecting lead oxide gelatin mixture, found accompanying arteries lying along the lesser saphenous vein and sural nerve and nourishing the skin through venocutaneous and neurocutaneous perforators and elevated lesser sapheno adipo fascial and lesser sapheno sural veno neurocutaneous adipofascial flap to cover the defect, and got good result. These fasciocutaneous and adipo fascial flap has constant fasciocutaneous perforators ensuring perfusion of the flap.[1,19,20]

Jeng *et al*[16,18] elevate 19 reverse sural artery flap (4 adipo fascial and 15 fasciocutaneous flap to cover the lower limb defect and confirmed that the vascular supply of distally based sural island flap originates cutaneous perforating branches of peroneal artery. Huising *et al*[17] showed that the reverse flow is through the anastamosis between the peroneal artery and vascular network of the accompanying artery of sural nerve. Due to its large arc of rotation, more distalization of the flap achieved and the greatest advantage is, it does not require the scarification of the major artery and can be performed even in the patient with arterial injury, if the peroneal artery is preserved.

In our cases, the defect size were larger (largest defect was around 9x7 cm in size and smallest 3.5 x 3 cm in size). Delayed primary closure was not possible and healing with secondary intention along with split thickness skin graft was not done due to exposed tendons, joint and bone. Applying the above-mentioned technique, we were able to elevate 11 distally based reverse sural artery flap. 10 out of 11 cases showed good result without any functional deficit of the donor site. We completely loss one case of skin islanded fasciocutaneous flap in chronic osteomyelitis wound defect. We noted that careful subfascial elevation of the flap and meticulous dissection and mobilization of the perforators enabled us to cover the more distal area of the foot. We also noted that preoperative identification of the distal peroneal perforators with the help of handy Doppler is useful in elevation of the pedicle and more distalization of the flap. As the donor area is considered highly vascular, the split thickness skin grafts were taken well without any donor site morbidity.

The advantage of the flaps are, easy to raise the flap with minimal blood loss and with preservation of major vascular structures, long pedicle length for more distalization of the flap, 90-180 deg arc of rotation of the flap. Neurocutaneous and venocutaneous perforators making a good arterial network providing reliable blood supply for the flap. However, the disadvantage of the flaps are, prone surgical position (can be done in later position but elevation is easier in prone position), decrease sensation over the sural nerve distribution area, bulky pedicle and the flap which can be avoided by sub cutaneous tunneling the pedicle and de-bulking the flap after 6-12 months period.

In our conclusion, reverse sural artery fasciocutaneous flap distally based on peroneal perforators is a good option to cover the soft tissue defect of distal third leg, ankle, heel and dorsum of the hind foot. As the flap can cover the larger area of the defects, does not require modern advance technique and team of expertise and the procedure itself is easy and quick to harvest, it has become the versatile flap to cover the distal third leg and foot defect. Due to its constant and reliable arterial network the survivability of the flap are high and does not require sacrificing any major arteries. Its long pedicle helps more distalization of the flap. The flap is a good alternative to microsurgical procedures where such modern advance appliances are not available and the surgeon is not so much familiar with microsurgical procedures.

REFERENCES

1. Masquelet AC, Romana MC, Wolt G. Skin island flaps supplied by the vascular axis of the sensitive superficial nerves: anatomic study and clinical experience in the leg. *Plast Reconstr Surg* 1992; 89: 1115-21.
2. Nakajima H, Imanishi N, Fukusumi S *et al*. Accompanying arteries of the lesser saphenous vein and sural nerves: anatomical study and its clinical application. *Plast Reconstr Surg* 1999; 103: 104-20.
3. Lister GD. Use of an innervated skin graft to provide sensation to the reconstructed heel. *Plast Reconstr Surg* 1978; 62: 157-61.
4. Maquieira NO. An innervated full-thickness skin graft to

restore sensibility to finger tips and heels. *Plast Reconstr Surg* 1974; 53: 568-75.

5. Hartrampf CR Jr, Scheflan M, Bostwick J. The flexor digitorum brevis muscle island flaps. A new dimension in heel reconstruction. *Plast Reconstr Surg* 1980; 66: 264-70.
6. Townsend PL. An inferiorly based soleus muscle flap. *Brit J Plast Surg* 1978; 31: 210-3.
7. Yoshimura M, Imura S, Shimamura K, Yamauchi S, Nomura S. Peroneal flap for reconstruction in the extremity: Preliminary report. *Plast Reconstr Surg* 1984; 74: 402-9.
8. Chang SM, Zhang F, Yu GR, Hou CL, Gu YD. Modified distally based peroneal artery perforator flap for reconstruction of foot and ankle. *Microsurg* 200; 24: 430-6.
9. Lin SD, Chou CK, Lin TM, Wang HJ, Lai CS. The distally based lateral adipofacial flap. *Brit J Plast Surg* 1998; 51: 96-102.
10. Voche P, Merle M, Stussi JD. Lateral supra-malleolar flap: Experience with 42 flaps. *Ann Plast Surg* 2005; 54: 49-54.
11. Meland NB. Microsurgical reconstruction: The weight bearing surface of the foot. *Microsurg* 1990; 11: 54-8.
12. Goldberg JA, Adkin P, Tsai TM. Microvascular reconstruction of the foot: weight-bearing pattern gait analysis and long-term follow up. *Plast Reconstr Surg* 1993; 92: 904-11.
13. Chen SL, Chuang CJ, Chou TD, Chen TM, Wang HJ. Free medial sural artery perforator flap for ankle and foot reconstruction. *Ann Plast Surg* 2005; 54: 39-43.
14. Harrison DH, Morgan BD. The instep island flap to resurface planter defects. *Brit J Plast Surg* 1981; 34: 315-8.
15. Grabb WC, Argenta LC. The lateral calcaneal artery skin flap. *Plast Reconstr Surg* 1981; 68: 723-30.
16. Jeng SF, Wei FC. Distally based sural island flap for foot and ankle reconstruction. *Plast Reconstr Surg* 1997; 99: 744-50.
17. Huisinga RL, Houpt P, Dijkstra R, Storm van Leeuwen JB. The distally based sural artery flap. *Ann Plast Surg* 1998; 41: 58-65.
18. Jeng SF, Wei FC, Kuo YR. Salvage of the distal foot using the distally based sural island flap. *Ann Plast Surg* 1999; 43: 499-505.
19. Donski PK, Fogdestam I. Distally based fasciocutaneous flap from the sural region. A preliminary report. *Scan J Plast Reconstr Surg* 1983; 191-6.
20. Yang D, Moris SF. Reverse sural island flap supplied by the lower septocutaneous perforators of the peroneal artery. *Ann Plast Surg* 2002; 49: 375-8.