ORIGINAL ARTICLE

ROLE OF REVERSE SURAL ARTERY FLAP FOR SOFT TISSUE DEFECTS OF LOWER LIMB: EXPERIENCE WITH 66 CASES.

Saeed Ashraf Cheema, Adnan Latif Malik*, Muhammad Asim**

Department of Plastic Surgery, Post Graduate Medical Institute, *Department of Orthopedic Surgery, Post Graduate Medical Institute, Lahore, **Department of Plastic Surgery, Faisal Hospital, Faisalabad, Pakistan

Background: Reverse sural artery flap has proved to be a good option to reconstruct soft tissue defects of lower limb and foot region. Different studies, however, speak of its use in different areas depending upon the individual experiences. Various modifications of the flap technique have been described in various studies. This study highlights many of the modifications in a single series and the fact that extending its arc of rotation, flap has capacity to deal with defects of middle and lower thirds of leg, heel, ankle, sole, dorsum and forefoot. **Methods:** In this case series, flap was utilized in 66 cases. Extension of skin paddle up to knee joint crease level increased the arc of rotation and as a result series witnessed this flap covering defects at the forefoot level. A good number of modifications suggested in literature were utilized to get optimal results. **Results:** Lower leg defects were covered in 26 cases. Heel was the site of defect in 18 patients. Dorsum foot needed soft tissue cover in other 15cases. Flap was successful in 62 cases and it failed in 4 cases. **Conclusions:** Flap due to its long arc of rotation has the capacity to deal the defects of middle and lower thirds of leg, heel, ankle, sole, dorsum and forefoot. Various modifications can be wisely utilized to increase the efficacy of the flap.

Keywords: Flaps, Lower limb Reconstruction, Perforator flaps, Reverse Sural Artery Flap

J Ayub Med Coll Abbottabad 2014;26(4):423–7

INTRODUCTION

Involvement of the lower limb in various traumatic incidences is quite common and leads to variety of injuries which demand soft tissue coverage. As compared to the upper limb and hand, the options for providing soft tissue cover to the defects in the area are quite scarce. Reverse flow flaps based on anterior and posterior tibial arteries require the sacrifice of the major vessel involved. Free flap remains the option of choice but facility itself is not widely available and so is the expertise for its execution. Several flaps have been described to provide defects at leg and foot separately. Reverse sural artery flap was first described by Masquelet *et al*[1] in 1992. Since then it has been widely studied for its various anatomical[2,3] and clinical aspects.[4,5] Immediately after its first description and simultaneous anatomical and clinical studies, flap saw its increasing use in coming years for the soft tissue defects coverage of lower limb.[6–10]

Technique also witnessed various modifications like delay of flap,[11,12] exteriorization of the pedicle[13], tunnelling the flap through the subcutaneous tissue to make it a single stage procedure,[14] mobilization of the perforators,[15] using a wider pedicle,[13,16] supercharging of the flap,[17,18] cross leg reverse sural flap,[19] making the flap a panninsular instead of an island flap,[20,21] use of boot to relieve pressure on the pedicle,[22] including a midline muscle cuff in the flap[23,24] and use of leeches for flap survival.[25] It is one of the few studies which compares majority of these modifications found in literature with the cases performed during the course of this study and hence may be a good reference for majority of these modifications. It also highlights that flap due to its long arc of rotation has the capacity to deal the defects of middle and lower thirds of leg, heel, ankle, sole, dorsum and forefoot.

MATERIAL AND METHODS

Soft tissue defects of lower limb dealt with reverse sural flap during the period from Dec 2003 to Dec 2010 were included in this case series. While considering suitable reconstruction option for all the cases with soft tissue defects of lower limb, rule of reconstructive ladder was taken as principle guideline. Only cases which were not treatable with more simple options of primary closure, skin grafting and local flaps were considered for this option. A healthy granulating wound stage was reached in all the cases by proper and adequate wound care before utilization of flap for wound coverage. Care was observed for not utilizing this option in cases where lower third of leg or neurovascular axis area was found involved in the injury. Procedure was started with freshening of the wound margins and making a template of the wound size. Skin markings were then carried out with patient in prone position. First point to be marked was at the midpoint between the lateral maleolus and tendo-achilles which was then connected to a point in the midline at the popliteal fossa. This line roughly presented the pedicle. Lower most set of perforators were then marked along this line located 5–7 cm above the lateral malleolus. Starting from this point, the arc of rotation was decided by measuring distance between this point and the wound edge. This length was marked on the line and wound template was then placed

proximal to this point as skin paddle to be harvested. As a next step, width of the pedicle was marked along the axis line. Width of the pedicle depended on the width, location and size of the skin paddle to be harvested. In cases where pedicle was tunnelled to the defect site it was de-epithelialized. Dissection was then started from proximal border of the skin paddle. Lesser saphenous vessels, sural nerve and artery were identified and ligated one cm proximal to the skin paddle. Dissection plane was immediately reached deep to deep fascia and then proceeded distally just above the underlying muscles. The fascia was sutured to the skin of the flap to avoid shearing forces on the small vessels traversing between the fascia and the subcutaneous tissue. Pedicle was exteriorized in cases where subcutaneous tunnel was not considered enough to accommodate it in the post-operative period. Similarly, a case where whole of the width and length of the calf was utilized to cover extensive defects, the interpolation flap was utilized. In cases where delaying of the flap was carried out, second stage of raising flap was carried out ten days after the delay procedure. Flap was sutured to the defect site in layers and the donor site was covered with split skin graft in all the cases. In cases requiring second stage of division and in setting, it was carried out after an interval of three weeks. Patients were advised regular massage of grafted skin area at donor site after removal of stitches to get smooth and pliable skin. Cases were regularly followed for six months in outdoor.

RESULTS

A total of 66 cases of lower limb soft tissue defects were dealt with reverse sural flap. It included 57 males and 9 females. Age of the patients ranged from 6 years to 56 years. Majority of the cases, i.e., 30, were in the third decade of their life. Road traffic accidents were the most common aetiology of these soft tissue defects with 42 cases, followed by post traumatic defects in 14 cases. Soft tissue defects resulted from burn injuries in five cases (Table-1).

Heal area was involved in 18 cases. Defects at lower third of leg were covered in 15 cases. Dorsum of foot was covered in 15 cases. Defects at lower half and middle third of the leg were covered in 11 cases. Ankle was site of defect in 5 cases (Table-2).

Flap was delayed in two cases and both of them had defect at dorsum of the foot. Twenty three of the flaps at lower leg were tunnelled to the defect site. In seven cases interpolation flap was utilized. In rest of the cases pedicle was exteriorized. In two of the cases flap pedicle area was involved in the injury and as a result cross leg flap was harvested.

Flap failure was observed in four cases. In two of these cases, the cause was direct pressure on the pedicle area of the flap due to non-compliance of the patient. Rest two of the cases were known diabetic and in spite of every possible care the flap got failed. Cause remained unclear. These cases were then dealt by simple skin grafting with less suitable results. In three other cases only distal most parts showed necrosis and that was limited to couple of centimetre strip area. The resulting defects in these cases healed by secondary intention. There was epidermolysis in two of the cases but it healed uneventfully. The flap area showed minor pressure ulceration in two cases during late postoperative period which healed with conservative approach by removing the pressure on the area. Similarly, during late postoperative follow up, minor contour deformity at flap coverage area were corrected by de-bulking in four cases.

Figure-1: Wound after road traffic accident was covered and heel reconstructed with Reverse Sural Flap

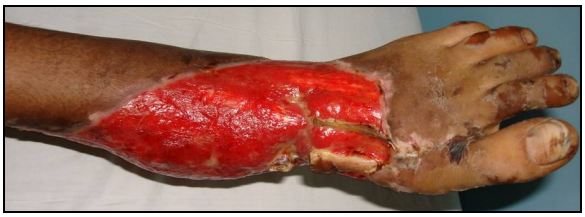

Figure-2: Another case with soft tissue defect resulting from run over by a bus. Tendons and metatarsal bones are visible

Figure-3: Medial aspect of the same foot in Fig 2 showing the extensiveness of the area involved.

Figure-4: Interpolation flap has been marked with its proximal border at the right crease and width equals that of back of the leg

Figure-5: Post operative view of the same case,

Table-1: Various etiologies of the soft tissue defects

Aetiology	Number	Percentage
Road Traffic Accidents	42	64
Trauma	14	21
Burns	5	8
Diabetic wound	3	4
Fire arm injury	2	3

Table-2: Utilization of flap at different areas.

Area	Number	Percentage
Heel	18	27
Lower third of leg	15	23
Dorsum foot	15	23
Middle third of leg	8	12
Ankle	5	8
Lower half of leg	3	4
Sole of foot	2	3

DISCUSSION

Modernization, rapid increase in use of automobiles and lack of traffic sense has all contributed to increased trauma to lower limb in our setup. Road traffic accidents remain the biggest cause of lower limb trauma in this part of world[26] and study had 42 cases (70%) with aetiology of road traffic accidents.

Reverse sural artery flap has extensively been used for reconstructing the soft tissue defects of lower limb and the foot (Figure-1). In majority of the cases, a particular study would speak about its use at a particular area.[10,27–29] This series, however, saw its extensive usage in lower leg, heel, ankle and foot areas including sole, dorsum and forefoot. Although some of the studies[30,31] from this region mentioned this flap covering the soft tissue defects at the hind foot only, this study witnessed soft tissue defects at forefoot covered with this flap.

Heel was the most commonly involved area in these soft tissue defects with 18 cases. Number of studies have found this flap a good option for reconstructing defects in this area.[17,27,28] This flap was used in various soft tissue defects of lower leg. Most common was the involvement of lower one third with 15 cases. Another group of 8 cases had soft tissue defects at middle one third. Lower half of the limb was involved in 3 other cases. Whereas flap was mostly tunnelled to the defects at leg and reconstruction was a single stage procedure, the defects around ankle and foot required exteriorization of the pedicle thus making this a staged procedure.

Coverage of this spectrum of the soft tissue defects, starting from lower half of the leg to forefoot and sole, was possible only because of the long arc of rotation of the pedicle. It also helped to cover large areas where soft tissue defects were quite extensive. This series saw three cases of feet run over by bus which had been advised amputations. Salvage was planned with reverse sural flap and in all the cases feet survived (Figure-2 & 3). Study witnessed this arc extending up to the knee joint crease in some of these cases. Fig. 4.Studies have mentioned to be cautious while raising this flap from the proximal third of the lower leg.[6,8,21,32–34] These studies believe that flap circulation depends on direct coetaneous branches of the sural artery which are present only in the superficial portion of the artery, i.e., in the lower two third of the lower leg. It has therefore been suggested that flap survival is not predictable in the upper third portion of the lower leg. However, as the flaps for heel, sole and forefoot area demand

the longest flap dimensions, majority of the flaps covering these areas came from the upper one third of the lower leg and survived successfully (Figure-5). It can therefore be concluded that flaps coming from upper one third may be as safe as those from lower two thirds provided: 1) the vascular network in the loose areolar tissue is kept intact, 2) width of the pedicle is increased, 3) lowest point along the axis of the pedicle is moved bit higher to include more of the perforators in the base and last but not the least 4) perhaps these are the cases that would require delay of the flap to be sure of the vascularity of the upper third as well.

Flap delay and increase in the width of the pedicle, both of these, are carried out to increase the vascularity of the skin paddle included in the flap. As extending the proximal limit of the flap, to the upper third of the back, puts the vascularity of the area in question, so both of these modifications are helpful to maximize the vascularity of flap. Moreover, great care in required to exercise this modification in patients with associated co morbidities, in cases of atherosclerosis or history of smoking. In these cases not only modification needs to be avoided rather decision of the flap must also be revisited.

Flap anatomy has been studied in detail[2-5] and location of the perforators has been described in detail. This detail has been very useful in planning the flaps during this study especially because in none of the flaps help of Doppler was taken due to non-availability of this instrument at the department. Although it was a shortcoming of this study, yet it also showed that results of these studies were quite reliable in various ethnic groups. However, use of Doppler is highly recommended to stay safe and status of the peroneal artery must also be evaluated preoperatively.

Width of the flap base has been a topic that needs elaboration and also how to decide what must be width of the pedicle. Whereas the perforators can be skeletonized to reduce the pedicle bulk, increased width of the pedicle has been recommended as a modification in difficult cases.[13,16] Therefore, in cases where skin paddle width equalled the width of the calf, it was found necessary to increase the width of the pedicle accordingly. It also highlights that width of the pedicle has to be individualized. Mobilization of the peroneal perforators in inter-muscular septum has also been recommended as a modification to gain the length.[15] However, it was utilized only in few cases where distal most edges of the flap were under tension. Author does not recommend the frequent use of this option as it may jeopardize the vascularity of the flap and every attempt must be made to leave the perforator undisturbed.

Exteriorization of pedicle and leaving skin intact over the pedicle have been used as modification of the flap raising technique.[13,20,21] During this series, pedicles of the flaps covering soft tissue defects at leg were tunnelled to the defect sites. However, flap pedicles for the foot and ankle were exteriorized. In cases with lager skin paddles utilizing the maximum length and width of calf skin, interpolation flaps were utilized. Flap was tunnelled to the defect site only in the cases where tunnel size was adequate to accommodate the pedicle freely and also had the capability of accommodating post-operative oedema. In any case where the skin in the area was found tight and was not considered accommodative for pedicle, the pedicle was exteriorized.

Delaying of flap has been recommended in some of the studies to enhance the blood supply of the flap.[11,12] It was utilized in two of the cases where bigger size of the flap, reaching the upper third of the leg, demanded this precaution and the vascularity of the area was doubtful. Similarly, in two of the cases cross leg reverse sural flap was utilized.

Reconstruction of soft tissue defects at tendo Achilles, heel and sole of foot may pose a problem as pressure on pedicle in supine position jeopardizes the blood supply. A modification of a boot made of plaster of Paris has been recommended in some of the studies[22] but these were not adopted. In such cases, patient may simply be asked to rest in prone position and avoid pressure on the pedicle. However, we took advantage of the positioning of foot in various cases. As it is apparent, the cases requiring coverage at distal most sole or dorsum of the foot would require maximum length of the arc and subsequently would also have tension on the pedicle length. Dorsiflexion at ankle in cases of defects at dorsum and plantar flexion in cases of defects at sole or heel area would relieve tension on the pedicle. This measure was adopted in the series with good results. Dorsiflexion can be maintained by simple crepe bandage passing around the knee area and sole of foot with both the knee and ankle joints in flexion. A pillow beneath the foot with patient in prone position suffices to hold the foot in plantar flexion. In any instance direct pressure on the flap or pedicle was avoided.

CONCLUSIONS

The study advocates that surgeon must be aware of various modifications in the technique, analyze them well before drawing any conclusion and try to

practice these to enlarge the spectrum of the defects getting benefited by this flap. Although flap is being widely used, most of the studies find its use at particular area. However, its arc of rotation can very safely be extended to knee joint crease for most distant and large defects provided certain precautions have been taken care of. Delay of flap, increase in the width of the pedicle and avoiding the manipulation of perforators all play vital role to make this modification a success.

REFERENCES

1. Masquelet AC, Romana MC, Wolf 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, Fukuzumi S, Minabe T, Fukui Y, Miyasaka T, *et al.* Accompanying arteries of the lesser saphenous vein and sural nerve: anatomic study and its clinical applications. Plast Reconstr Surg 1999;103:104–20.
3. Le Fourn B, Caye N, Pannier M. Distally based sural fasciomuscular flap: anatomic study and application for filling leg or foot defects. Plast Reconstr Surg 2001;107**:**67-72.
4. Imanishi N, Nakajima H, Fukuzumi S, Aiso S. Venous drainage of the distally based lesser saphenous-sural veno-neuroadipofascial pedicled fasciocutaneous flap: A radiographic perfusion study. Plast Reconstr Surg 1999;103:494–98.
5. Coert JH, Dellon AL. Clinical implications of the surgical anatomy of the sural nerve. Plast Reconstr Surg 1994; 94:850–55.
6. Hasegawa M, Torii S, Katoh H, Esaki S. The distally based superficial sural artery flap. Plast Reconstr Surg1994;93:1012–20
7. Jeng SF, Wei FC. Distally based sural island flap for foot and ankle reconstruction. Plast Reconstr Surg 1197;99:744–50
8. Huisinga RL, Houpt P, Dijkstra R, Storm van Leeuwen JB. The distally based sural artery flap. Ann Plast Surg 1998;41:58–65.
9. Coskunfirat OK, Velidedeoglu HV, Sahin U, Demir, Z. Reverse neurofasciocutaneous flaps for soft-tissue coverage of the lower leg. Ann Plast Surg 1999;43:14–20.
10. 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
11. Tosun Z, Özkan, A, Karaçor Z, Savaci N. Delaying the reverse sural flap provides predictable results for complicated wounds in diabetic foot. Ann Plast Surg. 2005;55:169–73
12. Karacalar A, Idil O, Demir A, Guneren E, Simsek T, Ozcan M. Delay in neurovenous flaps: experimental and clinical experience. Ann Plast Surg 2004;53:481–7.
13. Lo JC, Chen HC, Chen HH, Santamaria E. Modified reverse sural artery flap. Changgeng Yi Xue Za Zhi. 1997;20:293–8.
14. Hassanpour SE , Mohammadkhah NM, Arasteh E. Is It Safe to Extract the Reverse Sural artery Flap from the Proximal Third of the Leg? Arch Iran Med 2008;11:179–85.
15. Hollier L, Sharma S, Babigumira E, Klebuc M. Versatility of the sural fasciocutaneous flap in the coverage of lower extremity wounds. Plast Reconstr Surg 2002;110:1673–9.
16. Foran MP, Schreiber J, Christy MR, Goldberg NH, Silverman RP. The modified reverse sural artery flap lower extremity reconstruction. J Trauma 2008;64:139–43.
17. Ayyappan T, Chadha A. Super sural neurofasciocutaneous flaps in acute traumatic heel reconstructions. Plast Reconstr Surg 2002;109:2307–13.
18. Tan O, Atik B, Bekerecioglu M. Supercharged reverse-flow sural flap: a new modification increasing the reliability of the flap. Microsurgery 2005;25:36–43.
19. Gozu A, Ozyigit T, Ozsoy Z. Use of distally pedicled sural fasciocutaneous cross-leg flap in severe foot and ankle trauma: a safe alternative to microsurgery in very young children. Ann Plast Surg 2005;55:374–7.
20. Price MF, Capizzi PJ, Watterson PA, Lettieri S. Reverse sural artery flap: caveats for success. Ann Plast Surg 2002;48:496–504.
21. Yilmaz M, Karatas O, Barutcu A. The distally based superficial sural artery island flap: clinical experiences and modifications. Plast Reconstr Surg 1998;102:2358–67.
22. Ahmed SK, Fung BK, Ip WY, Fok M, Chow SP. The versatile reverse flow sural artery neurocutaneous flap: A case series and review of literature. J Orthop Surg Res 2008,3:15
23. Al Qattan MM. A modified technique for harvesting the reverse sural artery flap from the upper part of the leg:inclusion of gastrocnemius muscle 'cuff' around the sural pedicle. Ann Plast Surg 2001;47:269–74.
24. Al-Qattan MM. Lower-limb reconstruction utilizing the reverse sural artery flap-gastrocnemius muscle cuff technique. Ann Plast Surg 2005;55:174–8.
25. Gideroglu K, Yildrim S, Akan M, Akoz T. Immediate use of medicinal leeches to salvage venous congested reverse pedicled neurocutaneous flaps. Scand J Plast Reconstr Surg Hand Surg 2003;37:277–82.
26. Dandona R, Kumar GA, Ameer MA, Ahmed GM, Dandona L. Incidence and burden of road traffic injuries in urban India. Inj Prev 2008;14:354–9.
27. Hyakusoku H, Tonegawa H, Fumiiri M. Heel coverage with a T-shaped distally based sural island fasciocutaneous flap. Plast Reconstr Surg. 1994;93:872–6.
28. Mak KH. Distally based sural neurocutaneous flaps for ankle and heel ulcers. Hong Kong Med J 2001;7(3):291–5.
29. Dolph JL. The superficial sural artery flap in distal lower third extremity reconstruction. Ann Plast Surg 1998;40:520–2.
30. Akhtar S, Hameed A. Versatility of the sural fasciocutaneous flap in the coverage of lower third leg and hind foot defects. J Plast Reconstr Aesthet Surg. 2006;59:8.839–45.
31. Mahmood F, Mehrose MY, Tasneem S, Mahmood N, Raza A. Distally based superficial sural artery flap for foot and ankle reconstruction in children. J Ayub Med Coll Abbottabad 2011;23(4):40–2.
32. Costa-Ferreira A, Reis J, Pinho C, Martins A, Amarante J. The distally based island superficial sural artery flap: clinical experience with 36 flaps. Ann Plast Surg 2001; 46:308–13.
33. Rajacic N, Darweesh M, Jayakrishnan K, Gang RK, Jojic S. The distally based superficial sural flap for reconstruction of the lower leg and foot. Br J Plast Surg 1996;49:383–9.
34. Price MF, Capizzi PJ, Watterson PA, Lettieri S. Reverse sural artery flap: caveats for success. Ann Plast Surg 2002;48:496–504.

Address for Correspondence:

Dr Saeed Ashraf Cheema, 116. S.D.,PAF Falcon Complex, Gulberg-III, Lahore, Pakistan.
Cell: +92-300-8434042
Email: sacheema2002@yahoo.com