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Versatility of Reverse Sural Artery Flap (RSAF) in management of lower limb defects: Our experience

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Abstract
Background: Wounds around the lower 1/3rd of leg and foot are difficult to manage. Treatment options like skin grafting, healing by secondary intention can result in an unstable scar. Free tissue transfers and Regional flaps has its own disadvantages. To circumvent these difficulties a fasciocutaneous flap harvested from sural angiosome was proposed. In this study, we have made an attempt to find out different scenarios in which this flap can be used as a management option and ways to minimize the complications associated with this flap.
Methods: A retrospective observational study was conducted over 2 years. 30 patients were studied. Patient details was obtained from the case record, operative notes and postoperative follow-up.
Results: Patients between the age of 10 years to 65 years were studied. RSA flap with adipofascial pedicle and fasciocutaneous pedicle was done in 21 and 9 patients respectively. Delaying of flap was done in 9 patients, with most common indication as distal defect. Common site of defect which were reconstructed was on the Tendoachilles region, Heel region. Various complications were loss of graft used to cover adipofascial pedicle, Venous congestion, hematoma formation and partial skin necrosis of the flap. None of the patients complained of any effect on routine activity during postoperative follow up.
Conclusion: It is a versatile flap and different scenario can be managed with customization in plan. With proper selection of patients, it can be judiciously used to manage different leg defects.

Keywords: Reverse sural artery, venous congestion, adipofascial, fasciocutaneous

Introduction
Reverse Sural artery flap is a distally based fasciocutaneous flap [1, 2]. It is based on peroneal artery perforators and anastomosis between the peroneal artery septocutaneous perforator and sural arterial network [3, 4, 5]. It does not involve sacrificing any major vessel of limb.
Fasciocutaneous Sural flap described by Ponten in 1981, underwent various modifications over a period of time [6]. Donski and Fogdestram later came up with a distally based fasciocutaneous flap from the sural angiosome for repair of soft tissue defect of foot and distal 1/3rd of leg [6, 7]. In 1992, Masquelet *et al.* introduced the concept of Sural neurocutaneous island flap. This flap included an adipofascial pedicle and sural nerve, it was referred to as "Reversed Sural artery flap" [1, 2, 8].
Wounds around the lower 1/3rd of leg and foot are difficult to manage because of poor circulation. Often, these wounds are associated with exposed bones, tendons and implants [8, 9]. Simple treatment options like skin grafting, healing by secondary intention is difficult as it can result in an unstable scar. Free tissue transfer is an ideal option for most of these defects, but it has disadvantages like prolonged operative time, need of an expertise in microsurgery and distant donor site morbidity [9, 10]. Regional flaps based on Peroneal artery, Posterior tibial artery or Anterior tibial artery results into sacrifice of a major blood vessel of the lower limb [9]. To circumvent these difficulties a fasciocutaneous flap harvested from sural angiosome was proposed [9].
In this study we have made an attempt to find out different scenarios in which this flap can be used as a management option and look at the ways to minimize the complications associated with this flap.

Aims and Objectives

1. To study the use of Reverse sural artery flap (RSAF) in our practice.
2. To study post-operative complications of RSAF.
3. To study various means to minimize complications associated with RSA flap.

Materials and Methods

The institutional ethical committee clearance was obtained (IEC NO- EC/OA-110/2018). This was a retrospective observational study which was conducted for 2 years. A total of 30 patients, reconstructed with the reverse sural artery flap for defect of foot and lower leg, were studied. Patient details regarding age, sex, comorbidities, etiology of the defect, location of the defect, size of defect, radiological evidence of associated fracture, type of flap done, complications and details of post-operative follow up (i.e., outcome) was obtained from the case record, operative notes and their follow-up in outpatient department. Details obtained were entered into a predesigned case evaluation form. Based on this a MS excel worksheet was prepared. This data was then used to draw the results.

Planning and Surgical technique

The detailed history of patients was taken including age, personal history (smoking, tobacco chewing), comorbidities (Diabetes Mellitus, Peripheral Vascular Disease, Hypertension). Preoperative anesthetic checkup was done. Depending upon above details and location of the defect decision was taken regarding delaying of the flap. Delay of flap was done for the patients with comorbidities and distal defect [11, 12].

Marking of the axis of flap

A horizontal line is drawn between lateral and medial malleolus and the midpoint of the line is then marked. Posterior aspect of leg is divided into three parts, with most proximal line along popliteal skin crease. Midpoint of this line is marked. This point is joined with the midpoint of intermalleolar line which marks the vertical axis of the leg. With the help of hand held doppler perforators of Peroneal artery are marked. Distal most perforator is usually 5-7cms proximal to intermalleolar line and lateral to vertical axis of the flap [11].

The most important source of arterial supply to distally based sural flap is from septocutaneous perforators of Peroneal artery, which are three to six in number. The most distal perforator is located 4-7cm above the lateral malleolus between the tendon of peroneus longus and Tendoachilles [6, 7, 13, 14]. These perforators communicate with superficial sural artery. Sural flap also gets additional blood supply from the perforator of posterior tibial artery. The, inclusion of Sural nerve and short saphenous vein provides additional arterial supply along with septocutaneous perforators of Peroneal and posterior tibial artery.

Venous drainage of the flap depends mainly on the small collateral veins which accompany the short saphenous vein and have anastomotic connections with the short saphenous vein. This, allows the blood to bypass the valves of short saphenous vein and flow in retrograde fashion [6, 7, 15].

Surgery was done under regional or general anesthesia whichever was suitable. With patient in prone position, a pneumatic tourniquet was applied to the thigh. Thorough debridement of the wound was done and wash given. Template of the size of defect was made. Length of the carrying segment is then determined from the most prominent perforator marked and then the template is transferred and marked on the posterior aspect of leg. Thus, the flap planning was done in reverse. This, helped to avoid traction, kinking of the carrying segment and to assess the reach of the flap. A tongue (fig 1) was added to the skin paddle for comfortable inset.

Fig 1: Marking of adipofascial pedicle

Fig 2: Marking of fasciocutaneous pedicle

If extension of the flap into proximal third of the leg is more than 1/3rd of the width of the flap, then decision for delaying of flap was undertaken (fig 3). All the flaps which required delay underwent two stages of surgery. In the first stage delay was done and in second stage flap was interpolated to the defect. Incisional delay was done with raising of flap up to half of its length, flap was lifted off its bed and a sterile plastic drape was placed between the flap and its bed to avoid adhesion. Flap was then sutured back along its incision margin. Second stage of surgery was performed after 7 to 10 days in which previously delayed flap was raised to its full length and interpolated to defect.

Fig 3: Incisional Delay for a flap extending more proximally on calf

For adipofascial pedicle the first incision was taken along the length of the flap, which is along the previously marked vertical axis of the leg (fig.1). Sural nerve and Short Saphenous vein were identified. Skin flap with minimal adipose tissue underneath was raised on both sides. Adipofascial pedicle of the width of 3.5-4cms was designed. Incision was then taken along the leading edge of the skin island. Skin, superficial fascia and deep fascia was incised in step ladder manner to include extra fascia, about 1cm, beyond the skin incision. Sural nerve and short saphenous vein were then divided and ligated along with the fascia. Skin island along with adipofascial pedicle was raised, with gentle handling, up to just short of the most prominent peroneal artery perforator marked previously. Flap was then interpolated to defect and insetting was done.

Fig 4: Skin island with triangular tail and adipofascial pedicle

Interpolation can be done in three ways (fig 5 & 6): a) exteriorizing the pedicle and wrapping the pedicle with split skin graft; b) incising the skin bridge between the defect and the base of the flap, insetting triangular tongue into it; c) tunneling the flap. The first method requires second surgery for division and insetting of pedicle while the latter two are single stage procedures.

Donor area is closed primarily as much as possible and the remaining donor area is covered with split skin graft. Corrugated drain is placed beneath the flap.

Fig 5: Exteriorized pedicle in defect around ankle

Fig 6: Incised skin bridge with triangular tongue inset

Fasciocutaneous pedicle was done in patients with comorbidities (fig 7). In these cases, the donor site raw area is larger as compared to adipofascial pedicle. Donor area is reduced and covered with split skin graft.

Fig 7: RSA flap with fasciocutaneous pedicle

Cross leg RSA was done in patients with middle 1/3rd and upper 1/3rd leg defect for which other treatment options were not suitable.

Fig 8: Cross RSA flap for defect of middle third of opposite limb

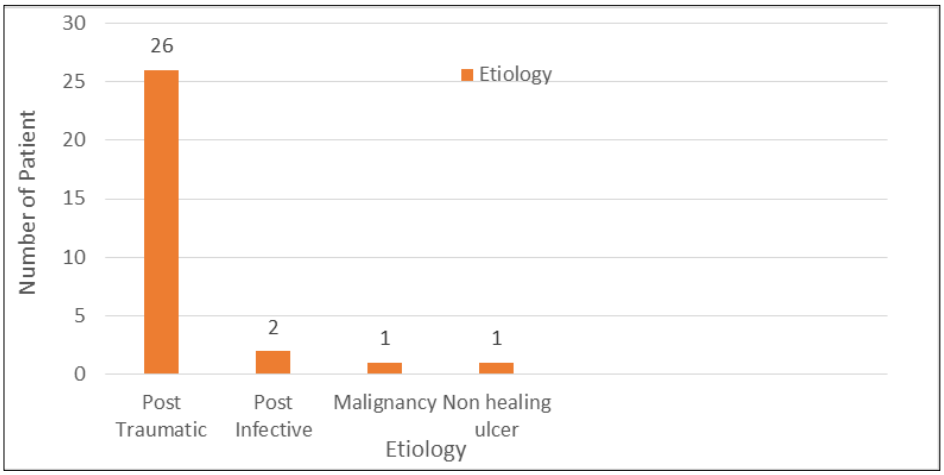
Fig 9: Post op follow up shows well settled flap

Dressing was done by using Gamgee (cotton) rolls and Plaster of Paris slab was applied on posterior aspect of leg. To avoid pressure on pedicle and flap we used glove balloons for molding the plaster slab (fig 10). Post operatively limb elevation was given to decrease the oedema.

Fig 10: Glove balloons used for molding of plaster slab. A proximal empty space shows a molded plaster after removal of glove balloon

Results

It was a retrospective observational study of cases operated over a duration of 2 years. A total of 30 patients between the age of 10 years to 65 years were studied. 25 patients were male and 5 were female. Flap was harvested from ipsilateral side in 27 patients and from opposite leg as cross leg RSA flap in 3 patients. RSA flap with adipofascial pedicle and fasciocutaneous pedicle was done in 21 and 9 patients respectively. Most common etiology for which this procedure was done was post traumatic leg defect (26 patients). Other etiologies were post infective leg defect (2 patients), one patient each of non-healing ulcer and malignancy (melanoma).



Bar Diagram 1: Etiology

Decision regarding delaying of flap was taken in 9 patients. Most common indication for delay was distal defect (Sole/Heel). Three patients had compromised vascularity of leg due absent anterior tibial artery, two patients had Peripheral vascular disease and other two had Diabetes mellites' patient each had history of tobacco chewing and Hypertension. Most common site of defect which was reconstructed with the flap was on the Tendoachilles region (7 patients) followed by Heel region (6 patients). Defect on lower 1/3rd leg and lateral malleolus was reconstructed in 4 patients each. The cross-leg flap done for middle third and upper third defect of opposite leg.

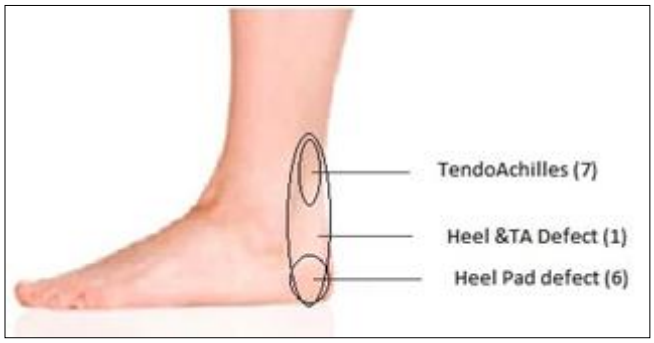


Fig 11: Location of defect

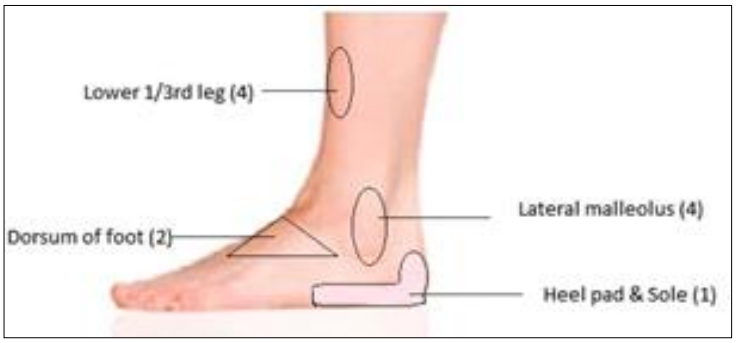


Fig 12: Location of defect

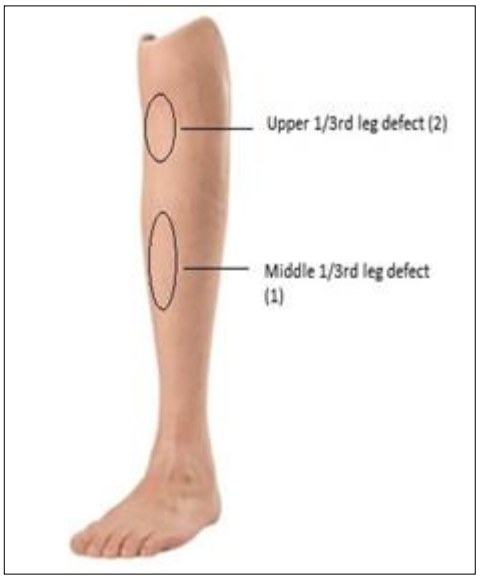


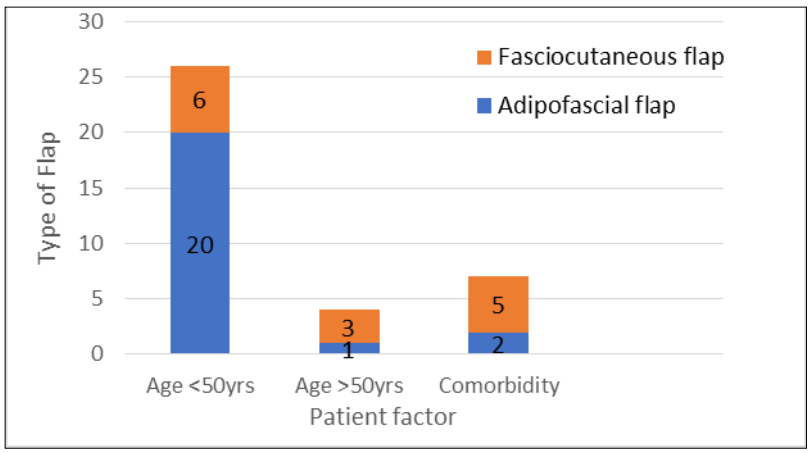
Fig 13: Location of defect

Fig 14: Location of defect

Operating time of surgery ranged from minimum of 90 minutes to maximum of 180 minutes with mean operating time of 124 minutes. We have reconstructed wound size ranging from maximum of 20X10cms to minimum size of 5X3cms. We have raised flap ranging from 9- 16cms in length and 5-20cms in width. For all flaps, the pivot point was at least 5cms proximal to intermalleolar line.

Out of 21 patients in which Island flap with adipofascial paddle was done; all, but one, were less than 50years of age. Out of this one patient had Tobacco addiction and one had absent ATA. The patient who was more than 50 years of age, developed complication of necrosis of the lateral skin flaps, which were raised while harvesting adipofascial pedicle.

Out of 9 patients in which Fasciocutaneous pedicle was done, six patients were less than 50years of age; of which five patients had comorbidity (absent major vessel, Peripheral vascular disease) (Chart 2) and other three patients who were more than 50 years of age, one had Hypertension and other one had Diabetes mellitus.

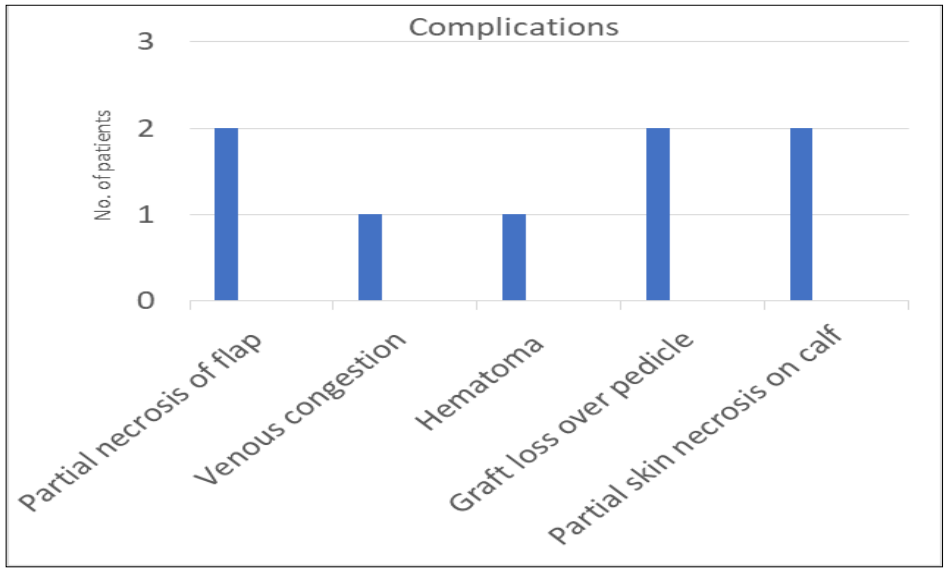


Bar diagram 2: Patient factors

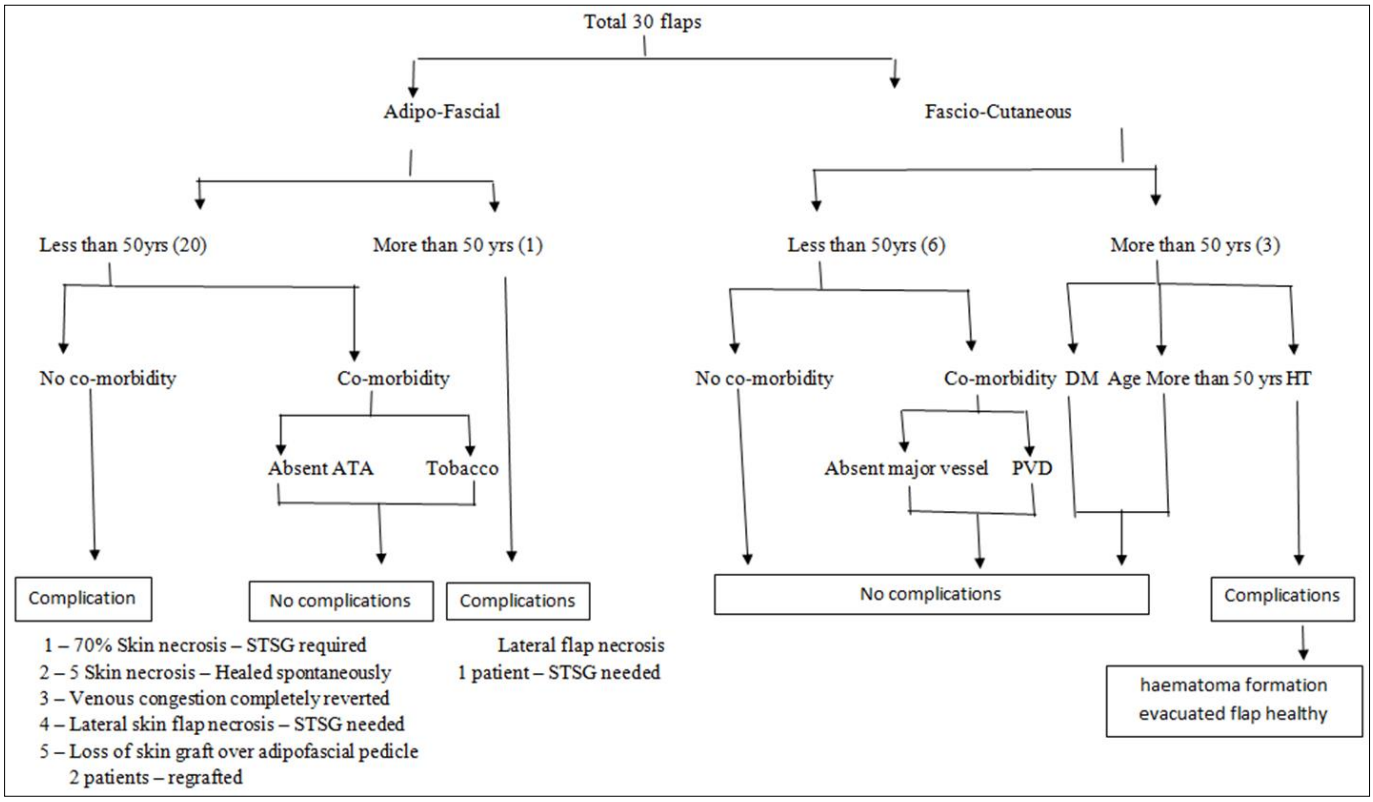
All the flaps survived except for one which underwent partial necrosis, done in patient who underwent Syme's amputation for post traumatic leg defect. necrosed skin of the flap was debrided and grafted. Most common complications were; loss of graft used to cover adipofascial pedicle along with skin tongue, in cases were insetting of skin tongue alone would cause compression of pedicle (2 patients) and necrosis of skin flap on calf raised while harvesting adipofascial pedicle (2 patients). In both cases raw area formed was later grafted. Venous congestion; hematoma formation and Partial skin necrosis, up to 5% of the flap, which healed spontaneously, were other complications which occurred in one patient each, but all these flaps were salvaged. None of the patients complained of any effect on routine activity during postoperative follow up.

Fig 15: Necrosis of skin in adipofascial pedicle

Fig 16: Partial necrosis of flap



Bar diagram 3: Complications



Note – All flaps were salvaged

Flowchart: Summary of all flaps co-morbidity and Complications

Discussion

The soft tissue defect around the foot, ankle and lower leg are difficult to reconstruct due notoriously poor wound healing secondary to poor blood supply [9]. Reconstruction with free tissue transfer is an ideal option. However, it has limitations such as long operating time, surgeon's microsurgical expertise and donor site morbidity [9, 10]. Introduction of distally based fasciocutaneous flap and its latter modification by Masquelet *et al.* [2] into neurocutaneous island flap offers a viable alternative to conservative options like foot offloading, repeated debridement or amputation of limb. And also, such procedure has shorter operating time, learning curve; harvest is straight forward and it preserves major vessels of limb [16].

Trauma was the most common cause of leg defect in our study, which was similar to many other studies [8, 9]. Other indications for which we used this flap was post infective defect, osteomyelitis, chronic non healing ulcer, amputation stump reconstruction (Syme's amputation) [8, 9, 17].

In literature of this flap continues to be associated with complications like flap necrosis, venous congestion and other complications [6, 7, 8]. In our study one patient each had partial flap necrosis and venous congestion, which is less (6%) compared to studies which had reported a rate of 5-36% of major ischemic event, like partial or total flap necrosis, with reverse sural artery flap [18, 19, 20].

It has been mentioned in many studies that venous congestion and not the inadequate blood supply is a major cause of flap necrosis [9]. In our patients to minimize these complications we took measures mentioned in literature [5, 6, 8, 9, 11, 15] and also by using some of our custom modifications. Various measures taken by us to improve venous drainage includes; 1) incorporating saphenous vein in flap (which helps to incorporate noncontinuous perforators), 2) exteriorize the pedicle (to avoid compression of the pedicle; thus improving the venous drainage), 3) wide pedicle with extra fascial cuff beyond the distal skin margin of the flap (it helps to incorporate the additional arterial anastomotic network along the length of pedicle and thus further improving the vascularity of the flap), 4) gentle handling of flap (thus reduces trauma and post-operative inflammation in the flap), 5) use of glove balloons to mold the plaster slab to avoid pressure, 6) post-operative limb elevation of about 30 degrees to improve the venous drainage.

We have successfully used the flap for distal defect of sole, midfoot region (1 case) and dorsum of foot (2 cases). In all these patients we preferred delaying of flap. It has been shown that a delay can significantly increase blood circulation, where the distal portion of the flap is random pattern [8, 11], Some of the important intraoperative considerations we included in all of our procedures were: a) Loupe magnification for dissection; b) Meticulous dissection to avoid shearing of vascular pedicle and Sural nerve from the flap; c) Inclusion of fascia beyond the distal margin by making incision in step ladder manner; d) Lastly, use of glove balloon for molding of plaster dressing to avoid pressure over vascular pedicle.

As seen in literature, some believe that reverse sural artery flap is not suitable for reconstruction of weight bearing area of foot as it is associated with numbness [17]. In our study, total nine patients underwent reconstruction of weight bearing area (i.e., heel, sole), none of the patient had numbness significant enough to interfere with routine activities. Also, to further increase the success rate we designed adipofascial pedicle; in young patients, those without comorbidities and addiction; to increase reach of the flap and decreases donor site morbidity. Other precautions that we took to decrease the donor site complication in this set of patients were, raising the skin flap with adequate adipose tissue carpet to preserve the subdermal plexus [6]. Inspite, of which two patients had skin flap necrosis on calf; of which one had tobacco addiction and other patent was more than 50years of age. Hence a fasciocutaneous pedicle is a better option in >50 years patients and those with co-morbidities.

With all these precautions and modifications reverse sural artery flap can be very effectively used for reconstruction of distal limb defect when more complex options like free tissue transfer is not possible.

Conclusion

The Reverse sural artery flap can be used as a very effective alternative to free flap for various distal leg and foot defects. It is a versatile flap and different scenario can be managed with customization in plan; For example, in patients with vascular disease and older age, delaying of flap and fasciocutaneous flap are preferred method. On the other hand, in young patients it can be used with an adipofascial pedicle, as a single stage procedure. We can use this flap in patients with compromised vascularity, single vessel limb where free flap and cross leg flap is difficult. Thus, with proper selection of patients, RSA can be judiciously used to manage different leg defects.

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