Reverse Sural Artery Flap for Dorsum of Foot Reconstruction

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ABSTRACT

Introduction: Loss of skin over the dorsum of foot is a common clinical entity. Infection, trauma, and vascular disease represent the most common etiological factors. Salvage of foot in these cases has a bearing upon the quality of life of the patient. The reconstruction process is often complex and varied as per exigencies. Reverse sural artery flap is an easy and reliable option for reconstruction of dorsum of foot defect.

Protocol and operative steps: Reverse sural artery draws its vascularity from the communication of the peroneal artery and the median sural artery. The flow of the flap is from the distal to the proximal and represents an elegant option for dorsum of foot. We have described the peninsular variant of the reverse sural artery.

Conclusion: The coverage of the defects of the dorsum of foot in trauma can be performed either immediately if the wound conditions are favorable or we may have to delay the procedure of definitive cover by a few days till the wound conditions improve by use of vacuum assisted closure (VAC) application. Split thickness graft, reverse sural artery flap, and free flaps provide safe and viable options for dorsum of foot defects. Reverse sural artery is reliable option in the armamentarium of the reconstructive surgeon.

Keywords: Case series, Foot, Free flaps, Skin grafting, Sural artery.

INTRODUCTION

Skin loss over the dorsum of foot is commonly encountered by the plastic surgeon. The etiology includes trauma, diabetic foot, peripheral vascular disease, and venous insufficiency. It is very important to ascertain that the local infection has been adequately controlled before a definitive wound cover is provided. The patient’s comorbidities, such as diabetes and concomitant illnesses, also need to be addressed prior to surgical intervention. As the skin over the dorsum of foot is very thin, without much subcutaneous tissue, its loss may lead to exposure of underlying tendons and bones. Exposure of vital structures will necessitate a full thickness cover. Skin graft alone may not be enough in majority of the cases and one must look for local, locoregional, or distant options for providing a full thickness cover. The reconstruction should facilitate use of footwear. An ideal cover for the dorsum of foot should be soft, supple, thin, and durable. Reverse sural artery flap is a versatile flap for dorsum of foot reconstruction.

Protocol and Operative Steps

The choice of cover is based on the wound condition. If the bed has adequate granulation tissue and no secondary procedure is planned in future, a split thickness skin graft can be used. However, if a secondary procedure in the form of tendon reconstruction or bone grafting is planned, a vascualized cover in the form of a flap is provided.

The final choice of technique is determined by patient factors and availability of local or regional flaps. Patient factors like peripheral vascular disease may preclude the use of a perforator-based flap. The paucity of local options may force the surgeon to choose a distant flap for cover. The risk of prolonged anesthesia also has bearing on the decision-making. Logistic issues like operation theater time, availability of a microsurgeon may also determine the final plan for reconstruction. Last but not the least, the financial constraints of the patient should also be taken into consideration.

These factors are considered and a final plan for reconstruction is devised.

Here, we describe the operative steps of the reverse sural artery flap. The reverse sural artery flap can be raised in three designs: Peninsular, islanded, and adipofascial. The technique described here is a peninsular design of the reverse sural artery flap.

Vascular Anatomy

The reverse flow sural artery flap draws its blood supply from the perforators that communicate between the peroneal artery and median sural artery around the ankle joint. The most consistent perforators are at a distance of 4–7 cm from the lateral malleolus. The flap also derives its blood supply through the vasa vasorum of the short saphenous vein (veno cutaneous perforators) and the vasa nervorum of the sural nerve. As the blood flows from distal end to the proximal end of the flap, it is named as “reverse” sural artery flap.

Indications

The flap typically covers defects around the ankle joint, dorsum of foot, instep area, and distal leg. It can also be used to cover defects in the middle third of the leg, although it is not the first choice. The only prerequisite to perform the flap is to ensure the availability of a strong Doppler signal around the ankle joint.
Contraindications
The relative contraindications to the flap are fibula fracture, history of chronic smoking, and peripheral vascular disease.

Preoperative Preparation
The preoperative preparation includes marking of the flap and planning in reverse. First, the leg is divided into thirds. The midpoint of the knee joint line is marked. Another point is marked at the midpoint of lateral malleolus and the highest point of the Achilles tendon. The two points are connected and this line forms the axis of the flap. The length of the line is measured and is divided into thirds. The typical extent of the flap is up to the proximal part of the middle third. The Doppler is used to mark the perforator along the axis of the flap around the ankle joint. The typical location for the perforators is between 4 and 7 cm from the lateral malleolus along the axis of the flap. The flap can be based on either of the perforator depending on the area to be covered by the flap. The more distal the defect a more distal perforator can be chosen and this point will be called the pivot point of the flap (Figs 1 and 2).

Planning in reverse is performed by drawing a pattern and placing it over the defect. The pattern is connected to the pivot point using a gauze piece. The entire mock flap is transferred to the posterior leg and the flap outline is marked (Fig. 3). If the most proximal end of the flap extends into the proximal third, then the flap needs to be delayed (Fig. 4). Intravenous fluids are started preoperatively.

Operative Steps
The patient is to be positioned in prone or lateral position. Regional or general anesthesia can be used. An inverse T-shaped incision is made in the proximal part of the flap and deepened. The median sural artery, short saphenous vein, and sural nerve are ligated and cut (Fig. 4). The distal segment of the structures needs to be included in the flap. The fascia is stitched to the dermis to avoid shearing. The skin incision is made and the flap is elevated in the subfascial plane. The base of the flap is kept at least 4 cm wide to avoid venous drainage. The flap is elevated up to the planned pivot point. The flap is then transferred on to the defect and inset is completed. The raw area on the donor site is covered with a split thickness skin graft. The patient is dressed and a special splint is applied that avoids pressure on the base of the flap. In the second stage, the flap can be divided and proximal part returned after 2 weeks.

Figs 1A to C: Reverse sural artery flap: (A) X-ray right foot showing fractured bones of foot; (B) Appearance of the wound before debridement; (C) Appearance of wound after vacuum assisted closure (VAC) therapy session

Figs 2A and B: Reverse sural artery flap: (A) Planning in reverse step 1; Template placed on the wound; (B) Planning in reverse step 2
Postoperative Care

The patient can be positioned in the lateral position with the lateral side of the leg up. A prone position may also be given if the patient tolerates.

Discussion

Several options are available for covering dorsum of foot defects. The choice of the modality depends on the site of the defect, the exposed structures, secondary procedures if needed, and the functional outcomes achievable. The decision also depends on the age of the patient, comorbid illnesses, and other injuries present at the time of presentation. Some of the prerequisites for the reconstruction are a stable cover, non-bulky tissue, and esthetic appeal.

Vacuum-assisted dressing of the dorsum of the foot defect provides an excellent option for infection control at the local wound. They reduce inflammation, promote angiogenesis, and decrease the overall bacterial burden in the wound. The resultant granulation tissue is generally healthy and covers the tendons and makes the bed ready for skin graft take. It is also helpful in cases where a flap is planned as it reduces the bacterial load and reduces the incidence of wound-related complication after the flap has been performed.

Split thickness skin graft provides an easy option to achieve wound closure. The procedure is simple, less time-consuming, and with reliable outcomes. It does not increase the bulk and contours better to the dorsum. It does not cause any hindrance to footwear use in the postoperative period. However, there is the possibility of breakdown of the epithelial cover in the long run and the fact that secondary procedure cannot be planned through the skin-grafted area. Hence, split thickness graft is an option where only the skin is lost, no secondary procedures are planned, and in cases where prolonged surgery is difficult.

The ideal cover over the dorsum of foot should be thin, pliable, and allow comfortable shoe wearing. It becomes mandatory to provide a full thickness cover in situations where future reconstructive procedures are warranted. Such situations could be reconstruction of missing tendons and replacing the missing bony segments. The local viable flaps can cover only smaller defects. However, larger tissue requirements can be met with locoregional flaps such distally based sural artery based skin or fasciocutaneous flaps. A preliminary delay procedure is needed if a larger flap is needed. For larger defects, free flaps, such as an anterolateral thigh flap, latissimus dorsi, or gracilis muscle flap, become very handy. These flaps can fill up the contour defects and provide a well-vascularized environment for effectively combating infection. The earlier belief that muscle flaps are better in improving local infection and promote healing as compared to a fasciocutaneous flap have been refuted in the recent “equivalence” studies. The fasciocutaneous flap makes flap reelevation and
secondary procedures a lot easier than a muscle flap. Following a fasciocutaneous flap cover, the patient may need to undergo multiple thinning procedures to achieve the final contour. The “muscle based flap” undergoes atrophy and may eventually contour to the dorsum of the foot defect.

The reverse sural artery is a neurocutaneous flap that maybe harvested from the ipsilateral leg and a reliable local option. The cross leg flap from the contralateral leg is a regional option available and used as a “life boat” in cases of failed primary attempts to reconstruction. The free anterolateral thigh and gracilis flaps have the advantages of execution under regional anesthesia without change of position and with minimal donor site morbidity. The latissimus dorsi flap has the advantage of providing a large amount of tissue. However, it requires general anesthesia and a change of position for flap harvest. The radial artery forearm flap provides relatively large skin island and can be performed with two teams simultaneously.

Fasciocutaneous flaps gained popularity after Pontén described them in 1981. Since then, a variety of distally based fasciocutaneous flaps were planned and performed for foot defects based on the perforators of the posterior tibial, the anterior tibial, and the peroneal artery perforators. Masquelet described the distally based superficial sural artery flap for small to medium sized foot defects. The flap is long with reliable vascularity. The flap has been designed in an islanded, peninsular, or adipofascial fashion. Delay procedures are described as refinements to enhance flap safety. The flap is an excellent local option and very reliable for small to medium sized defects (Fig. 5).

The reconstruction of dorsal foot defect becomes trickier as the size of the defect increases. There are no local options available; this necessitates a microvascular tissue transfer. The popular choices for free tissue transfer is and anterolateral thigh flap, latissimus dorsi flap, gracilis flap, and radial artery forearm. The anterolateral thigh flap is an option that replaces like with reliable skin paddle. The procedure can be performed in supine position with regional anesthesia. The donor site morbidity of the flap is also minimal. Any secondary procedure if planned can be performed with ease. The other options like gracilis, latissimus dorsi, and radial artery forearm have their own advantage and disadvantages when used for reconstruction of the dorsum of foot defects. The microvascular transfers of tissue have substantially increased the flexibility of options. This in turn has increased the chances of limb salvage and decreased the frequency of amputation for complex defects. Flowchart 1 represents a free anterolateral thigh flap being used to reconstruct the dorsum of foot.

An algorithm for management of the defects of the foot dorsum are shown in Flowchart 1.

**Flowchart 1: Proposed algorithm for reconstruction of the defects on the dorsum of the foot**

1. Dorsal foot defect
2. Debridement/VAC
3. Requires secondary procedure (tendon/bony)
   - Yes: Vascularised cover (FLAP)
   - No: Split thickness skin graft

**Conclusion**

Reconstruction of the dorsum of foot defects is a challenge to the reconstructive surgeon and requires a great amount skills and...
planning. The various techniques follow a classic ascendance up the reconstructive ladder from a simple to a complex solution. The split thickness graft, reverse flow sural artery flap, and free anterolateral thigh flap described in the article are all highly reliable options for dorsal foot reconstruction. The reverse sural artery flap represents a reliable, easily available local option for dorsum of foot defects. It forms an integral part of the armamentarium of the plastic surgeon. The modern day reconstructive options and protocols make salvage of severely injured feet possible, thus decreasing the amputation rates for such limbs.

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