Original Article

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Use of Adipofascial Reverse Sural Artery Flap for Distal Leg and Ankle Region Reconstruction- A Prospective Cohort Study

Surgery Section

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ABSTRACT

Introduction: Though distally based sural artery fasciocutaneous flap is a good choice for distal leg and ankle reconstruction, shortcomings like venous congestion and flap bulkiness are matters of concern.

Aim: To assess the utility of adipofascial flap for distal leg and ankle reconstruction, complications, and long-term functional results with range of motion at ankle joint.

Materials and Methods: A prospective cohort study (January 2018 to December 2019) was conducted at Safdarjung Hospital, New Delhi, India on patients having distal leg defect and ankle defects reconstructed with Distally Based Sural Artery Adipofascial Flap (DBSAAF). Participants of any age and aetiology were included in the study while polytrauma patients, life-threatening injuries, mangled extremity patients were excluded. Postoperatively flap survival, complications and functional outcome were assessed.

Results: Total 21 patients with above defects had undergone DBSAAF reconstruction. Fifteen (71.4%) patients were males and 6 (28.6%) were females, with mean age of 34.85 years. Causes of defect were road traffic injury in 6 (28.6%) patients, additional Tendoachilles tear was repaired in 5 (23.8%) patients. Four (19%) patients had avulsion injury, 3 (14.3%) patients had postburn unstable scar, and chronic ulcer was found in 3 (14.3%) patients. The maximum defect size was 8.5×7 cm (mean of 5.24×4.34 cm). The width of flap pedicle was kept at 4 cm maximum (mean=3.04 cm). All flaps were transported to the defect site by incising the intervening bridge, tunneling was not done. Fourteen patients did not have any co-morbidity, whereas four patients were chronic smokers, and three were diabetics. Flap survived completely in all patients. Three patients had partial graft loss and one patient had chronic discharge. Follow-up for maximum of six months (mean=4.04 months) were done.

Conclusion: DBSAAF is a reliable flap for defects of distal leg and ankle region. Advantages are aesthetically better donor area, normal contour, and minimal scarring. It does not require a secondary debulking making it a one stage procedure and allowing patients to use their normal footwear.

Keywords: Adipofascial flap, Distally based flap, Leg reconstruction, Soft tissue reconstruction, Trauma reconstruction, Turnover flap

INTRODUCTION

Defects of distal leg and ankle region remain a challenge for reconstructive surgeons all over the world. With the evolution in the concepts of reconstructive surgery in past decades, preservation of the limb with optimum functional outcome and improved quality of life becomes our major goals. Defects with soft tissue loss and exposed bones or tendons around the ankle joint require flap coverage and the choice of flaps for such defects depends on factors like robust vascularity, arc of rotation, stable coverage, ability to provide necessary range of motion, satisfactory shape, protective sensations, without loss of major vessels as well as with minimal donor site morbidity. Although free flaps are a reliable option for these defects, availability of microsurgery set-up and operating time are the major limitations [1,2].

The available flap options for the defects around ankle include dorsalis pedis artery flap [3], abductor digiti minimi flap, and Abductor Hallucis muscle flap [4,5]. Nevertheless, due to the limitation of available tissue for flap harvest and restricted arc of motion these choices are not feasible in many cases. Other available locoregional alternatives are peroneal artery flap, anterior tibial artery flap and posterior tibial artery flap [6-8], but these flaps have major disadvantage of sacrificing a major artery in a limb with already compromised vascularity [6].

A well accepted method for reconstruction of distal leg and ankle defects is reverse (distally based) sural artery fasciocutaneous flap. It was originally described by Donski PK and Fogdestam I and later popularised by Masquelet AC et al., as a neurocutaneous flap based on superficial nerves [9,10]. The good vascularity of the flap is due to the dense arterial plexus formed around superficial nerves between vasa nervorum and branches of the septocutaneous perforators of leg. Nakajima H et al., expanded the vascular anatomy of this flap by including the short saphenous vein [11,12]. Partial flap loss due to venous congestion is the most common complication of this flap. It is often a staged procedure; hence a second surgery is usually required. The flap is bulky and wearing footwear in a reconstructed limb also remains a major concern. Donor site morbidity with large unsightly scar due to grafted skin is another shortcoming of the classic reverse sural artery fasciocutaneous flap. Since then, many modifications have been described aiming at reducing its complications of partial flap necrosis especially of the distal most part, wound dehiscence and epidermolysis [13,14].

This flap can also be raised as distally based adipofascial flap with described advantages of ease of harvest, minimal donor site morbidity, no requirement of secondary thinning procedure [15-17] and excellent functional and aesthetic outcome. This study was done to assess the versatility of distally based adipofascial sural artery flap for coverage of distal leg and ankle region defects.

Anatomy: The sural nerve is the sensory nerve supplying lateral and posterior aspects of the lower third of the leg. In most cases (67%) the sural nerve is formed by medial sural cutaneous nerve which is a branch of tibial nerve and the lateral sural cutaneous nerve which is also termed as peroneal communicating branch. Sural nerve is formed in distal leg after joining of the two branches. In rest of the cases branches do not join, in such case sural nerve is continuation of medial cutaneous sural branch, in rare instances when medial cutaneous branch is absent, it is extension of lateral cutaneous sural branch [12].

Arterial supply: The blood supply of distally based sural artery flap is based on mainly the vascular interconnections between median superficial sural artery and perforators of peroneal artery forming around sural nerve [18,19]. The peroneal perforators which are average 3 to 6 in numbers pass between the fibula and flexor hallucis longus proximally and between soleus and peroneus longus more distally. The most distal perforator is approximately 4 to 7 cm from tip of lateral malleolus. Also the other major contributors are: 1) Venocutaneous perforators from the lesser saphaneous vein; and 2) Neurocutaneous perforators from the sural nerve. Nakajima H et al., in his study has demonstrated the presence of neurocutaneous perforators and venocutaneous perforators arising from the small arteries accompanying the sural nerve and the lesser saphenous vein, respectively [11,12]. Therefore, inclusion of sural nerve and lesser saphanous vein provides an important source of arterial supply in addition to fascial plexus.

Venous drainage: Venous drainage of the flap is mainly through lesser saphaneous vein which has numerous valves preventing retrograde blood flow, but these valves get stretched due to high pressure after flap elevation. Secondly, there are one or more smaller collateral veins that run parallel to the lesser saphenous vein which has anastomotic connections with the lesser saphenous vein, which allows blood to bypass the valves of the lesser saphenous vein and flow in a retrograde fashion. Venous blood can then either drain directly from this small vein into the concomitant vein of a perforator from the peroneal artery or it can drain back into the lesser saphenous vein. These venous perforators parallel the arterial perforators. Each arterial perforator is generally accompanied by one or two concomitant veins [19].

MATERIALS AND METHODS

A prospective cohort study was performed in the Department of Burns, Plastic and Reconstructive Surgery, Safdarjung Hospital, New Delhi, India between January 2018 to December 2019. Institute Ethical Committee approval (IEC/VMMc/SJH/Project/January/2018) was taken.

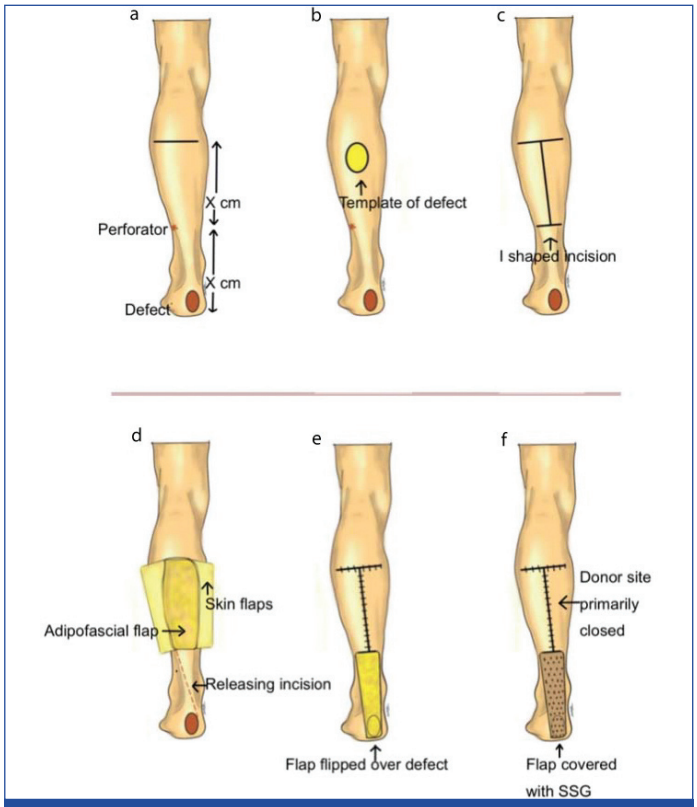
Inclusion criteria: After taking written and informed consent, the patients having distal leg and ankle region defects of any age and cause were included in the study.

Exclusion criteria: Polytrauma patients with other life-threatening injuries, mangled extremity with distal third both bone fracture and very large defect were excluded from the study.

Total 21 patients were operated with DBSAAF for soft tissue defect in distal leg and ankle region, within the study period. Patient's demographic data, associated co-morbidities (conditions affecting wound healing such as chronic smoking, diabetes mellitus, hypertension, vascular disorders and connective tissue disorders), aetiology, defect site and size, flap's size, pivot point, complications, and range of motion of the ankle joint on last follow-up was recorded. No specific investigations were performed to rule out vascular pathologies in patients however detailed history about co-morbidities and smoking was taken as per routine departmental policy.

Surgical Technique

All patients underwent preoperative clinical evaluations for flap planning. Peroneal artery perforators were identified with handheld doppler and marked, preferably choosing a perforator above 7 cm from tip of lateral malleolus. Leg was divided in equal thirds. Anatomic landmarks such as mid popliteal point, tip of lateral malleolus and tendoachilles tendon were marked. Procedure was preferably performed in the prone position, but in patients in whom it was technically difficult to prone, lateral position was used. At first with patient in spinal/epidural anaesthesia under tourniquet control thorough debridement of wound was done, defect created, and flap markings were done with keeping flap dimensions slightly larger than (0.5 cm all around) the defect's size. Taking marked perforator as the pivot point while keeping the foot in neutral position, the distance between pivot point and distal most edge of defect was measured, and this distance was transposed over the proximal leg area. Depending upon the size of defect and distance from pivot point flap paddle can lie over middle third or may extend to lower part of upper third. Authors have used Loupe magnification in all cases for better dissection. An I-shaped incision [Table/Fig-1], T or S shaped incision [Table/Fig-2] was used over posterior calf for harvesting the flap. Thin skin flaps with a layer of fat were elevated to prevent necrosis of skin flaps exposing the adipofascial layer. Dimensions of flap paddle were marked over the adipofascial layer.



[Table/Fig-1]: Illustration of surgical technique; a) Distance from perforator to distal margin of defect transposed over donor area; b) Template of defect marked over donor area; c) I-shaped incision marked over donor area d) Skin flaps raised for adipofascial flap dissection and releasing incision given over intervening area; e) Flap flipped over defect; f) Adipofascial flap covered with split thickness skin graft and donor area primarily closed.

[Table/Fig-2]: S-shaped incision in donor area.

Distal margin of the flap was incised first and inclusion of lesser saphenous vein and sural nerve was confirmed before proceeding with further dissection of flap. After confirmation lateral margins were incised keeping pedicle width between 3 to 4 cm to reduce venous congestion and the flap was raised in proximal to distal direction upto pivot point.

Skin bridge communicating the area between the pivot point and defect's proximal margin was incised. Tourniquet deflated, flap's vascularity confirmed and haemostasis achieved. Flap was flipped over to the defect in all cases to avoid kinking of the pedicle and inset was done with keeping the foot in neutral position [Table/Fig-1]. Flap was covered with intermediate thickness skin graft. Foot was splinted

in neutral position with the help of plaster of paris splint. Antibiotics and anti-inflammatory drugs were prescribed as per institutes protocol. First dressing was generally done on 2nd postoperative day depending upon wound condition and soakage. Patients were generally discharged after 2nd dressing depending on wound condition. The mean hospital stay was 8.43 (range 5-21 days). Full weight bearing was allowed only after flap settles in patients with no underlying bone or tendon pathology, but the patients with underlying bony pathology were sent for orthopaedic consultation for decision on weight bearing. Full range of motion of ankle joint was assessed at the last follow-up.

STATISTICAL ANALYSIS

Data was recorded on pre-designed proforma and managed on Microsoft Excel spread sheet (Microsoft Inc. Washington US, version 2019 16.0.6742.2048). All categorical variables were summarised by frequency and percentage. Quantitative variables were assessed for appropriate normality and summarised by Mean±Standard Deviation (SD)/Range as appropriate.

RESULTS

Twenty-one patients were enrolled in the study. Among them, 15 (71.4%) patients were males and 6 (28.6%) were females. Mean age of the patients in the study was 34.85 years (SD 7.57). Aetiology of defect was road traffic injury in 6 (28.6%) patients, sports injury leading to Tendoachilles tear which was repaired primarily in 5 (23.8%) patients. Four (19.0%) patients presented with avulsion injury, 3 (14.3%) patients had postburn unstable scar, and chronic ulcer was found in 3 (14.3%) patients. Site of defect was heel in 5 (23.8%) patients, average defect size in the study was of 5.24×4.34 cm [Table/Fig-3].

The flap was raised 0.5 cm larger than the estimated defect's size on all sides to avoid tension during insetting of flap, the maximum dimensions of flap raised in this study was 9.5 cm in length and 8 cm in width with average of 6.10×5.34 cm. Mean thickness of flaps was 7 mm. Of the 21 patients, 14 (66.7%) patients had no co-morbidity, whereas 4 (19%) patients were chronic smokers for an average of 4.5 years, and 3 (14.3%) of them had isolated diabetes for an average of 7 years.

The average width of the flap pedicle was kept 3.04 cm (range 3-4 cm) to improve vascularity and reduce venous congestion. All the flaps were transported to the defect site by incising the intervening bridge no flap was tunneled under skin to avoid compression of the pedicle. During surgery the proximal most perforator was preferably used as the pivot point (average 6.9 cm) from the tip of lateral malleolus to increase the vascularity and decrease venous congestion of the flap. Donor site was primarily closed in all patients [Table/Fig-4,5].

All the flaps survived without any complications except in 4 (19.0%) patients, three had partial skin graft loss which was managed conservatively with regular dressings. Authors found this problem was seen in patients who were chronic smokers or had diabetes. One patient complained of chronic discharge which continued till two months and was finally managed with secondary debridement by raising the flap and removing all the infected bone. Authors assessed the functional results by measuring the range of motion of ankle joint (mean 51.33°) range 37-65°, lower range of motion was seen in patients of Road Traffic Accident (RTA) with bony injury, while patients without bony or tendon injuries recovered early with normal range of motion. Patients were followed-up for a maximum of 6 months (mean 4.04 months) and none of the patients reported

S. No.	Age (years)/ Sex	Cause of defect	Defect size (cm×cm)	Defect site	Flap size (cm×cm)	Pivot point above tip of lateral malleolus	Co-morbidity	Complication	Follow-up (months)	Range of motion (°)
1	23/M	Avulsion injury	8×7	Heel	9×8	6	No	None	3	65
2	45/M	Avulsion injury	7×6	Heel	8×7	8	Smoker	Partial graft loss	4	52
3	37/F	Unstable scar	5×4	Dorsum of proximal foot	6×5	9	No	None	2	58
4	22/M	Tendoachilles tear	3×3	Supraheel	4×4	9	No	None	3	52
5	28/M	Avulsion injury	7.5×5	Heel	8.5×6	8	Smoker	Chronic discharge	5	46
6	43/F	RTA with bony injury	8.5×6	Lower leg	9.5×7	6.5	Diabetes	Partial graft loss	4	51
7	39/M	Chronic ulcer	6×5.5	Lateral malleolus	7×6.5	7	No	None	3	39
8	25/M	RTA with bony injury	6×4	Medial malleolus	7×5	8	No	None	4	37
9	32/M	RTA with bony injury	5.5×4.5	Dorsum of proximal foot	6.5×5.5	6	No	None	2	41
10	47/M	Unstable scar	4×3	Dorsum of proximal foot	5×4	8	Smoker	None	5	60
11	39/F	Tendoachilles tear	3.5×3	Supraheel	4.5×4	6	No	None	3	60
12	27/F	RTA with bony injury	4.2×3.7	Heel	5.2×4.7	6.7	No	None	4	38
13	33/M	RTA with bony injury	5.7×4.3	Lateral malleolus	6.7×5.3	7.5	No	None	5	49
14	25/M	Tendoachilles tear	7.4×5.4	Lower leg	8.4×6.4	8	No	None	3	62
15	37/M	Avulsion injury	6×7	Dorsum of proximal foot	7×8	6	No	None	6	59
16	42/M	Chronic ulcer	4.3×5.2	Medial malleolus	5.3×6.2	7	Diabetes	None	5	45
17	43/M	Tendoachilles tear	2.7×2.2	Supraheel	3.7×3.2	8	No	None	4	60
18	35/F	Chronic ulcer	3.2×2.6	Heel	4.3×3.7	6.5	Smoker	Partial Graft Loss	5	42
19	28/M	RTA with bony injury	5.6×4.3	Lateral malleolus	6.7×5.3	7	No	None	6	47
20	37/F	Tendoachilles tear	2.4×2	Supraheel	3.4×3	7.5	No	None	3	55
21	45/M	Unstable scar	4.6×3.5	Lower Leg	5.6×4.5	8	Diabetes	None	6	60

[Table/Fig-3]: Demographic details along with clinical details of patients.

[Table/Fig-4]: A 27-year-old male with: a) Soft tissue defect over left medial malleolus; b) Skin flap raised for adipofascial flap dissection; c) Flap flipped over defect with donor area primarily closed; d) Flap covered with Split thickness skin graft; e,f) Well settled flap with healed donor area.

[Table/Fig-5]: A 33-year-old male with: a) Soft tissue defect over posterior distal leg; b) Skin flaps raised and adipofascial flap dissected; c) Flap flipped over the defect; d) Flap covered with split thickness skin graft with primarily closed donor area; e) Well settled flap with healed donor area.

any other complications requiring any secondary procedures, also none of the patient required secondary thinning procedure for either aesthetic or functional reasons [Table/Fig-6]. Footwear fitting was good in all patients, and patients were able to use their previous footwear without the need of any special footwear.

[Table/Fig-6]: A 33-year-old male: a) 12-month-old picture showing well settled flap with minimal donor area scarring; b,c) Range of motion of ankle joint showing no restriction of motion.

DISCUSSION

Reverse sural artery adipofascial flap is a reliable alternative without any donor site morbidity, it provides additional benefit of being less bulky and so not requiring secondary thinning procedures. Distally based sural artery fasciocutaneous flap provides a versatile reconstructive option, as it is simple to perform, have a reliable vascular pedicle, while without sacrificing any major artery. But there always have been few major concerns with this flap such as dubious venous drainage, donor site scar, sensory loss in sural nerve territory and bulky flap requiring secondary thinning procedures to allow wearing of shoes [20]. Numerous technical modifications have been described such as proximal vein microanastomosis [21] and delayed procedures [20] but they seem to complicate a simple surgical procedure without significantly lowering complications.

The DBSAAF is based on blood supply formed by vascular connections of vasa nervorum of sural nerve and vasa vasorum of short saphaneous vein as described by Imanishi N et al., [19]. Small caliber network of veins surrounds the sural nerve which allow bypass of valves of short saphaneous vein. Therefore, it is recommended that sural nerve and short saphaneous vein both should be included in the flap for robust blood supply [22]. Short saphaneous vein was included in all cases in present study, authors did not encounter any significant venous congestion in the flaps, as described to be a concern with adipofascial flaps due to lack of skin, in contrast it may be advantageous in the regard that lymphoedema exudes through the graft [23]. It has been documented that the distal perforators near to malleolus are smaller in dimension which might compromise flap's venous drainage therefore the more proximal perforator atleast above of minimum described distance of 4-7 cm above tip of lateral malleolus should be chosen [23].

Authors turned over the flap in all patients as turning over the flap reduces the chance of venous congestion by preventing kinking of the pedicle [24], also it allows more distal reach than conventional rotational fasciocutaneous flap. Turning over the flap also allows application of skin graft immediately over the flap, however if the flap is transposed with adipose layer superficially graft should be stored and applied after few days allowing the granulation to come for better take of graft.

All the flaps survived with only complication of partial graft loss in three patients which healed conservatively with dressings, this was seen in patients who were either chronic smokers or had diabetes. Baumeister SP et al., in his study has described diabetes, arteriosclerosis, and venous insufficiency as 'unhappy triad' which is in concordance with present study results [13]. Still if the flap is raised with sural nerve and saphaneous vein both and the pedicle is kept wide and not tunneled flaps viability could be better assured even in patients with co-morbidities.

Five patients underwent this flap for heel defect with no complications following weight bearing implying that this flap is a reliable option for pressure bearing areas, this was also shown in the study by Schmidt K et al., and Kim KJ et al., as they found no complications with adipofascial flap in heel area and described it as a tolerable option in high pressure zones [25,26].

Donor area was primarily closed in all the cases with minimally recognisable scar after few months and the skin grafted area lies lower in the well camouflaged sock area. There was no contour deformity at donor area which was a major aesthetic concern especially for female patients as reported by Rashid M et al., [27]. No secondary thinning procedure was performed as DBSAAF are not bulky and do not require secondary debulking procedures providing cosmetic advantage over their popular fasciocutaneous variant [28]. The circumferential thickness around ankle is significantly lesser in comparison to reverse sural artery fasciocutaneous flap making it acceptable for footwears, patients were able to wear their normal footwear as before [29].

One of the patients complained of chronic discharge from margin of the flap, which was most probably due to the inadequate debridement of the underlying infected bone, secondary debridement was performed for this patient two months after initial procedure. Whole flap was conveniently raised by entering through flap margin, no difficulty was encountered in raising the flap. There were no further complaints of discharge afterwards and the patient eventually was able to walk with satisfactory range of motion.

Loss of sensations over lateral side of foot remains a major concern in patients with this flap, as stated by Rashid M et al., in their study the sensitivity improves if the other nerves of the leg are intact [27]. In present study, none of the patients complained of significant long term sensory disturbance over lateral border of foot.

Limitation(s)

This study had limitations that there was lack of comparison with reverse sural fasciocutaneous flap or other flaps and the follow-up period was comparatively shorter.

CONCLUSION(S)

Distally Based Sural Artery Adipofascial Flap (DBSAAF) is an excellent option for reconstruction of distal and ankle region defects. It has an added advantage of no contour deformity with almost unrecognisable scar at the donor site. The flap was not bulky as compared to the fasciocutaneous variant hence does not required secondary debulking procedures thereby allowing better shoe fit. Keeping the pedicle broad and not tunneling under skin bridge prevents venous congestion. Thus, concluding that DBSAAF is a great option for distal leg and ankle defects with better aesthetic donor and recipient sites.

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