

Research Article

Extended Pedicle Reverse Sural Artery Flap: A Novel Technique To Reduce Distal Flap Necrosis

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Abstract

Introduction: Standard reverse sural artery flap is a valuable option for reconstruction of soft tissue defects of lower third of leg, hind foot and dorsum of foot, but it is prone to develop venous congestion. We have introduced a novel technique of extended pedicle reverse sural artery flap which has shown better flap survival and outcome.

Methodology: This was a retrospective review of data of patients who underwent standard or extended pedicle reverse sural artery flap for post traumatic wounds of lower leg, ankle, heel and mid foot dorsum, over a period of 6 years (September 2015 to September 2021). Data was retrieved from hospital admission and operation records and case files of the patients for analysis. Outcome variables like flap survival and pattern of necrosis were recorded.

Results: Of the 56 patients who underwent reverse sural artery flap coverage for distal lower extremity, Standard reverse sural artery flap was done in 30(53.6%) and Extended pedicle flap done in 26(46.4%) patients. The mean±SD age of the patients was 15.96±11.3 years. Males accounted for 66.1% (n=37) of patients. Non weight bearing heel was the most common site (n=25, 44.7%), whereas wheel spoke injury was the most common cause(n=33, 58.9%). Mean size of wound was 8.2x6.5 cm for which dimensions of flap elevated were 9x7 cm. Rate of complications was significantly less in extended pedicle reverse sural artery flap (p value 0.037). Flap survival was 25(96.2%) in Extended pedicle reverse sural artery flap group (p value 0.008) with Excellent outcome (p value 0.006).

Conclusion: Extended pedicle reverse sural artery flap is reliable option for coverage of defects around ankle and heel with better flap survival and excellent outcome.

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Keywords | Standard Reverse Sural artery flap, extended pedicle RSAF, Venous congestion, Flap survival.

Introduction

Reverse sural artery flap (RSAF) is one of the common procedures done for the reconstruction of soft tissue defects around ankle and foot.¹ While the standard RSAF is a pedicle flap which brings tissue from posterior leg to fill the defect of foot, there have been a number of modifications described by different authors to achieve better flap survival.²

The most common complication of Standard RSAF is

venous congestion leading to partial or total flap necrosis. Several studies describe different rates up to 36%.³ Various modifications have been suggested in RSAF harvesting technique to prevent venous congestion. These modifications are based on width of the pedicle, dimensions of Skin Island, or improving vascularity of flap as single or two-stage procedure. Some of these modifications have shown promising results with reduced flap necrosis but till now no technique has

been standardized for this flap.

We have devised a new modification in which the pedicle of the flap is extended for 2-3 centimeter above the skin island design. We have found that this maneuver significantly improves the flap survival and markedly enhances the distal flap vascularity. In this study we aim at comparing surgical outcome of extended pedicle reverse sural artery flap (Extended Pedicle RSAF) with standard reverse sural artery flap for reconstruction of foot defects proximal to toes in terms of distal flap necrosis and reliability of technique in our population.

Methods

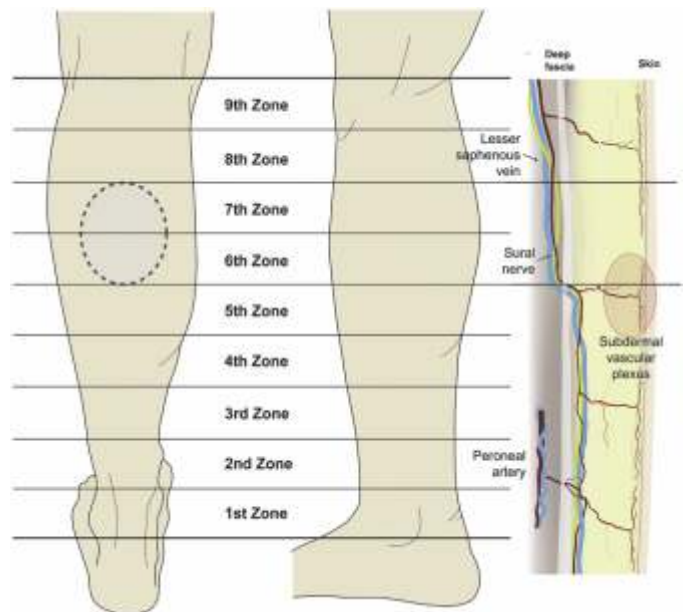
This retrospective comparative study was conducted in Plastic surgery/ Burn unit, Mayo hospital, Lahore. During a period of 6 years from September 2015 to September 2021, all patients between 5 to 50 years of age, who underwent standard or extended pedicle reverse sural artery flap for post traumatic wounds of lower leg, ankle, heel and midfoot dorsum, were included in this study. We excluded patients having wound or scarring on posterior calf, history of smoking, uncontrolled diabetes, and patient with deranged liver function.

After admission, complete history and examination was done and wounds prepared in standard way. Review of pre-operative data from the patients' charts included size and location of wound, degree of involvement of underlying structures, and findings on X-ray such as underlying fracture of tarsal or metatarsal bones. Written informed consent was taken from each patient before starting treatment.

During surgical procedure, adequate debridement was done under tourniquet control and defect geometry evaluated again by senior consultant. Considering the vascular anatomy of the posterior leg according to zones (Figure 1), Standard reverse sural flap raised as an adipo-fasciocutaneous flap from posterior aspect of same leg with patient in prone position. Flap was based distally on 2 suitable perforators (5,7 or 10 cm) proximal to lateral malleolus with axis of flap directed towards an imaginary line which connects midpoint of popliteal fossa to a point midway between lateral malleolus and Achilles tendon. Flap was marked over the middle third of posterior leg as per defect dimension with 1 cm extra for flap contraction and tension free inset.

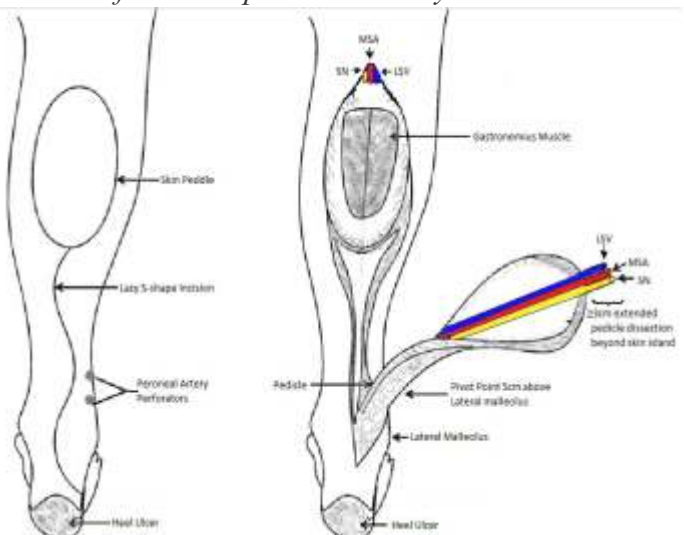
For Extended pedicle sural flap, the pedicle dissection was started in subdermal plane proximal to the standard

skin island. Flap pedicle was elevated at least 3 cm proximal to the proximal limit of marked flap and was loosely tagged while inseting at defect site (Figure 2). Rest of the flap was elevated in standard way and



its perfusion checked after deflating tourniquet.

Figure 1: Illustration of zones in the lower leg and associated anatomy. The posterior and lateral aspects of the leg also depicted with arbitrarily defined zones. Key neurovasculature structures are illustrated along the lower leg (Right). The sural nerve and lesser saphenous vein are depicted in yellow and blue, respectively, and the accompanying arteries in red. The perforating branch from the peroneal artery is shown on the



lower left side⁴.

Figure 2: Illustration of Marking of RSAF and Associated Anatomy

a) Marking of Standard RSAF

b) Extended Pedicle RSAF with 3cm Pedicle Extension

in Proximal Posterior Leg

After elevation of flap by both variations, it was transposed and secured in place and raw area of carrier pedicle and donor site was covered with split skin graft. See through dressing was done to check flap survival and splint applied to restrict limb movement.

Post-operatively, operated foot was kept elevated to reduce edema and pain and flap was monitored 6 hourly from dressing window. In all patients first dressing was changed on 2nd day and then on alternate days. Assessment of flap survival in terms of tip epidermolysis or flap necrosis was done by Senior consultant on day 5. Color and capillary refill of flap were main determinants of the flap survival. Patients with uneventful healing of flap were discharged on day 5 while patients having dusky color with rapid capillary refill (signs of venous congestion) were kept in hospital for further management. All patients were followed up after one week of discharge for stitch removal and after 3 weeks, flap was divided and final inseting done.

Data related to patient demographics (age, gender, mode of injury), clinical data (defect site, depth and dimensions), flap dimensions, flap survival (complete, partial or distal tip necrosis) and outcome (excellent, fair, poor) was collected from patients charts and recorded on a proforma.

The collected data was analyzed by SPSS20 statistical software. Descriptive variables were presented by proportions, mean values and percentage as appropriate by data distribution. Quantitative variables like age, size of wound, dimensions of flap and outcome were compared by Chi square test. Qualitative variables like gender, site of wound, complications and flap survival were compared using T-test in both groups; Group A (Standard) & Group B (Extended pedicle). Statistical significance was defined by p-value of <0.05.

Results

A total of 56 patients underwent flap coverage for ankle and foot defects during period of September 2015 to September 2021. Among them, 30(53.6%) patients underwent Standard RSAF and 26 (46.4%) had Extended pedicle RSAF. Mean follow up period after surgery was 38 months (3.2 years) with range of 8-54 months (0.67-4.5 years).

The mean \pm SD age of the patients was 15.96 ± 11.3 years with median age of 13 years. Wheel spoke injury was most common cause for such wounds (n=33,

58.9%). Most of patients belonged to the younger age group of <22 year age (n=39, 69.6%), and were males (n=37, 66.1%). Mean dimensions (length \times width) of the wound at presentation was 8.2x6.5 cm with range of 6.2 \times 5.5 cm to 15 \times 11 cm. 41(73.2%) had exposed tendons, 33(58.9) had exposed bone with or without fracture, and 5 (8.9%) had exposed joint capsule with ligaments. Mean dimensions of flap elevated were 9 \times 7cm with range of 7 \times 6cm to 16 \times 10cm. Comparison of both groups in Age, gender, Anatomical location, cause of wound and size of wound was not statistically significant.

Venous congestion to variable flap extent was most common complication and it was seen commonly in Standard RSAF patients (n=15,50%) as compared to Extended pedicle RSAF showing it only in 1 (3.8%) cases. This difference was found to be statistically significant with a p-value of 0.037. Other complications included wide and hypertrophic scar in 11 (36.7%), wound healing issues 5 (16.6%) and graft loss in 2 (6.7%) in Standard RSAF. Extended pedicle RSAF group showed fairly less complications, with hypertrophic scar seen in 4 (15.3%), wound healing issues 1 (3.8%) and skin graft loss in 1 (3.8%). Table 1 shows further details of all the patients included in this study.

It was observed that flap survival was better in Extended Pedicle flap group as tip epidermolysis was seen in 1 patient only (3.8%). In Standard RSAF group, tip-epidermolysis was seen in 6 (20%), distal tip necrosis in 5(16.7%), partial flap necrosis in 2(6.7%) and complete flap necrosis in 2 patients (6.7%). This difference was found to be statistically significant (p-value 0.008). Epidermolysis was managed conservatively while in distal tip necrosis, debridement followed by flap advancement was done.

Outcome was measured on basis of flap survival. In Standard RSAF group, it was found to be excellent in 15(50%), fair in 11(36.7%) and poor in 4(13.3%) cases. Extended pedicle RSAF group patients showed excellent outcome in 25 (96.2%) and fair in 1 (3.8%) with no poor outcome. Comparison of both groups for outcome was also found to be statistically significant (p-value 0.006).

Discussion

Masquelet described in detail, the anatomy and surgical technique of reverse sural artery flap in 1925. Since then, it is considered a mainstay flap for the reconstruction of soft tissue defects of distal lower extremity

Table 1: Main patient characteristics.

Patient characteristics	Standard RSAF (%)	Extended Pedicle RSAF (%)	Total n(%)	P value
Patient Number	30 (53.6)	26 (46.4)	56 (100)	-
Age				-
5-22 years (n=39)	20 (66.7)	19 (73.1)	39 (69.6)	
23-50 years(n=17)	10 (33.3)	7 (26.9)	17 (30.4)	
Gender				-
Male (n=37)	19 (63.3)	18 (69.2)	37 (66.1)	
Female (n=19)	11 (36.7)	8 (30.8)	19 (33.9)	
Anatomical location				
Non weight bearing heel (n=25)	14 (46.7)	11 (42.3)	25(44.7)	-
Weight bearing heel (n=12)	7 (23.3)	5 (19.2)	12 (21.4)	
Dorsum of foot (n=7)	4 (13.3)	3 (11.5)	7 (12.5)	
Lower leg and ankle (n=12)	5 (16.7)	7 (27)	12 (21.4)	
Clinical data				
Cause of wound	18 (60)	15 (57.7)	33 (58.9)	-
Wheel spoke injury	5 (16.6)	6 (23.1)	11 (19.6)	
Degloving injury	2 (6.7)	1 (3.8)	3 (5.4)	
Post contracture release	3 (10)	3 (11.6)	6 (10.7)	
Post infective	2 (6.7)	1 (3.8)	3 (5.4)	
Post tumor excision				
Size of wound				
< 50 cm ²	21 (70)	19 (73.1)	40 (71.4)	
> 50 cm ²	9 (30)	7 (26.9)	16 (28.6)	-
Structure exposed (Depth)				
Tendons	22 (73.3)	19 (73.1)	41 (73.2)	
Bone	16 (53.3)	17 (65.3)	33 (58.9)	
Joint capsule with ligaments	2 (6.7)	3 (11.5)	5 (8.9)	
Surgery Complications:				
Flap venous congestion	15 (50)	1 (3.8)	16 (28.6)	0.037
Wound healing issues	5 (16.6)	1 (3.8)	6 (10.7)	
Skin Graft loss	2 (6.7)	1 (3.8)	3 (5.4)	
Wide & Hypertrophic scar	11 (36.7)	4 (15.3)	15 (26.7)	
Flap Survival:				
Tip Epidermolysis	6 (20)	1 (3.8)	7 (12.5)	0.008
Distal tip necrosis (<25%)	5 (16.7)	---	6 (10.7)	
Partial flap necrosis (<50%)	2 (6.7)	---	2 (3.6)	
Complete flap necrosis (100%)	2 (6.7)	---	2 (3.6)	
Outcome:				
Excellent (no flap necrosis)	15 (50)	25 (96.2)	40 (71.4)	
Fair (<1cm flap necrosis)	11 (36.7)	1 (3.8)	12 (21.4)	0.006
Poor (> 1 cm flap necrosis)	4 (13.3)	---	4 (7.1)	

and hind foot. With improvement in anatomical knowledge and surgical skills, many technical modifications have been suggested to improve viability of this flap.^{6,7}

In this observational study, it was found that in both standard and extended pedicle RSAF groups, males (66.1%) are more likely to have foot trauma, and spoke wheel injury is the most common cause, followed by degloving injury due to RTA. These findings are similar to various studies.^{8,9,10} Most common anatomical site of the wound on foot found in our patients was non-weight bearing heel (44.7%) followed by weight bearing heel (21.4%) and it was similar to that seen in another

study.³ Mean defect size in our cases was 53.3 cm² which was comparable to other studies.¹¹

Several modifications have been discussed to be considered while elevating standard RSAF in order to increase flap viability including elevating deep fascia and fat, taking short saphenous vein and sural nerve with flap, flap delay, taking cuff of gastrocnemius muscle around the pedicle and protecting collaterals of peroneal artery by taking a wide pedicle.^{11,12} All these variations have variable flap survival in different centers and still venous congestion in distal flap leading to flap necrosis is most common complication related to Standard RSAF (50%

in our study). In order to solve this problem, we suggested a modification in which dissection of the flap pedicle is extended proximally up to 3cm, saving the oblique cutaneous branches. This led to minimize the venous congestion to 3.8 % in extended pedicle RSAF. Rest of the surgery related complications like wound healing issues, skin graft loss and wide hypertrophic scar were comparable to other studies.¹³

In our study, Standard RSAF had flap survival issues in 50% of cases in terms of tip epidermolysis, distal tip necrosis, partial flap necrosis and complete flap loss. Various studies show comparable flap survival issues in Standard RSAF.¹⁴ Extended pedicle RSAF modification showed good flap survival with only 1 (3.8%) case having tip epidermolysis which was managed conservatively. Also outcome was found to be Excellent in Extended pedicle RSAF group with 96.2% success rate and Fair in only 3.8 cases. However Standard RSAF group had excellent outcome in 50% of cases, Fair in 36.7% and Poor outcome in 13.3% cases which is comparable to other studies.¹⁵

Our study has certain strength and limitations. Strengths of our study are that it gives detailed analysis on demographical, clinical, and outcome data with respect to Standard and Extended pedicle RSAF. It also gives thorough information about surgical approach to both techniques. Also, high quality outcome data in terms of flap survival and overall outcome is measured. The main limitation of our study is that it is a retrospective cohort from a single center leading to more chances of selection bias. Patient number was also small and results were based on relatively short follow-up period.

Conclusion

Our modification of extended pedicle RSAF proved efficacious in minimizing venous congestion and hence flap necrosis. Compared with Standard RSAF, our method yielded higher flap survival rate. This novel approach can lead to reconstruction of hind foot defects with significantly reduced incidence of flap loss.

Conflict of Interest

None

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