

Effectiveness of Medial Plantar Artery and Reverse Sural Flaps in Plantar Foot Surface Reconstruction

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Abstract

Background: Managing soft tissue defects of the foot and ankle poses a major challenge for reconstructive surgeons. The heel pad is vital for weight-bearing, shock absorption, and proprioception. Reconstruction is complicated by limited local tissue availability and poor blood supply.

Objective: To compare the effect of medial plantar artery flap (MPAF) versus reverse sural flap (RSF) in terms of flap survival in patients undergoing reconstruction of plantar surface of foot.

Study type, settings & duration: This comparative study was done at Department of Plastic & Reconstructive Surgery, Pakistan Institute of Medical Sciences (PIMS), Islamabad from September 2021 to January 2023.

Methodology: Total of 160 patients underwent surgical procedure among two groups where 80 cases in each were enrolled. Patients underwent Medial Plantar Artery Flap in MPAF group, while RSF group patients underwent Reverse Sural Flap. Follow-up was done at one weekly intervals for one month and then monthly for up to 6 months. Patients were categorized as having poor, good and excellent outcome after 4 weeks of procedure.

Results: The mean age was 42.11±13.62 years. A total of 104 (65%) patients were male and 56 (35%) were female. In Medial plantar artery flap group, excellent outcome was found among 72 (90%) of the patients, while among RSF group 63 (78.8%) patients achieved excellent outcome presenting a significant difference (p -value =0.021).

Conclusion: Excellent outcome was significantly higher among medial plantar artery flap group as compared to RSF in terms of flap survival in reconstruction of plantar surface of foot.

Key words: Planter surface, excellent outcome, medial plantar artery flap, reverse sural flap.

Introduction

Surgical reconstruction of foot's plantar surface is rare, but surely a very difficult and complex technical procedure. During reconstruction the unavailability of local available tissues needed for covering, comparatively low blood supply and specific characteristics of the structure in this area are main issues. The skin of plantar area is very

thick and glabrous like and is tightly gripped with foot's deep structure. Therefore, purpose of this restoring surgery is not only restoration of stable and sensible skin over feet but also to achieve adequacy so that it can bear weight as well as face and withstand shear force.¹

The pad of heel has a crucial role while bearing weight, absorbing any shock and proprioception. It can receive injuries again and again and also stress of load than other body parts.² Heel defects more usually are caused by trauma mostly degloving injuries, chronic wounds and excision of tumors.³ Since it is trauma prone area, it is vital for functioning of locomotor, thus the requirement of a stable wound cover is more crucial.⁴ Many options of regional tissue usage for reconstruction procedures are available. These include but are not limited to fascio-cutaneous, neuro-cutaneous, perforator flaps and micro-vascular free flaps. These multiple choices become a huge challenge for surgeons to opt an ideal method which is single-staged, reliable and has less

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Authors Contribution

SA & AKM conceptualized the project and did the statistical analysis. AKM & HS did the data collection. SK, HS & HS* did the literature search. Drafting, revision & writing of manuscript were done by AKM, SK, HS & HS*.

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operative and fast post intervention recovery time with minimal side effects or any associated morbidity.⁵ Multiple factors determine the selection of flap type from distal lower extremities, these involve size and location of defects, as well as risk of secondary procedure, cosmetic indications and donor site morbidities.⁶

In general, skin grafts can provide simple and effective coverage. There is need of high degree expertise and infrastructural support for undertaking a free flap reconstruction.^{1,7} Fasciocutaneous flaps have been preferred as they offer thin, flexible tissue which can easily be contoured and/or neurotized. They are easily molded while in setting flaps and lead to very few walking issues.⁸ According to the basis of medial plantar artery the flaps are raised from non-weight bearing instep of foot.⁹ There are numerous benefits of fasciocutaneous flap.^{7,10} RSF is another fasciocutaneous flap introduced by Masquell et al in 1992.¹¹ Its base was made upon the close relationship among the superficial median sural artery and perforator peroneal artery.¹²

At current, multiple flap options are in use in the local settings with variable outcomes. Since the unavailability of local available tissues needed for covering, comparatively low blood supply and structure in this area is problematic. There is a need to find out an ideal flap for reconstruction of heel pad. As non-effective and less efficient options can result in delayed healing or long term complications, thus, burden on healthcare settings and workers. Moreover, complications pose financial cost at personal and national level. This study aimed at comparing the flap survival between medial plantar flap and RSF in patients undergoing reconstruction of foot's plantar surface.

Methodology

This comparative study was conducted at PIMS in the Plastic & Reconstructive Surgery Department during a period of 15 months, from September 2021 to January 2023. The written consent was taken from patients/caretakers before enrollment.

After taking informed consent and assent (where applicable) patients of both genders aged 15 to 65 years presenting with soft tissue defects on the plantar surface of foot and heel region were included. Similarly, those wounds resulting from trauma, patients with tumor excision and neuropathic ulcers were also included. Patients having ischemic and venous ulcers those with peripheral vascular disease, deep venous thrombosis, chronic lymphedema and osteomyelitis

of underlying bone were excluded. Hemodynamically unstable patients, chronic smokers and those with history of previous flap surgery in the foot region were also excluded from the study.

A sample size of 160 patients comprising 80 patients in each was statistically calculated. After enrolment of patients a detailed history and full general physical examination was completed for each patient. All patients were subjected to Doppler ultrasound and radiography of affected leg / foot to assess its vascular variation and skeletal changes respectively.

Patients were randomly allocated through lottery method in to two groups i.e. MPAF group patients underwent medial plantar artery flap, and RSF group patients underwent reverse sural flap. The patient information was very specific and limited that included age of patients, gender, type of flap used and the outcome of flap as its survival.

The flap is harvested from posterior side of middle third of the leg during flap extraction. In the current study, for heel cap reconstruction, the flap is based on the reverse flow in the median superficial sural artery. The second option of harvesting during heel reconstruction used in the current study was MPAF. This flap was first described by Shanahan and Gingrass¹³ and later validated and modified by Harrison and Morgan¹⁴. The MPAF is harvested from within the instep of the foot. This flap is limited in size, thus is more viable for smaller defects while it is not suggested for very large heel defects. The flap was raised from distal to proximal then the flap was transposed and inset was done.^{13,14}

Defects of soft tissues as an outcome of trauma or neurotrophic denervation were fully debrided followed by secondary flap transfer once wound cultures were free of bacterial growth. Malignant skin lesions were excised with clear margins followed by flap coverage. Patients were monitored post-operatively one hourly for first 48 hours and then 2-3 hourly until the discharge to look for signs of flap necrosis which include change in color, sluggish or brisk capillary refill, cool on palpation and scanty or brisk dark bleeding on needle scratch test.

Patients were discharged on 10th post-operative day. Follow-up was done at one weekly intervals for one month and then monthly for up to 6 months. The final study outcome was measured as patients having a poor, good and/or excellent outcome. Finally the findings were noted on the 4th week follow-up as poor, good or excellent. The outcome was considered 'excellent' when there was an uneventful outcome with no complications and the flap survived. The outcome was considered

'good' if there was partial necrosis or superficial necrosis or any tip of flap was found with necrosis. In case the flap got complete necrosis and had to undergo a redo as complete flap reconstruction, this outcome was considered 'poor'.

Data was entered and analyzed in SPSS 22.0. The mean and standard deviation were calculated for age of patients while frequency and percentages were calculated for gender, flap type and final outcome. Outcome of repair was compared amongst groups using chi-square test while student's t-test was applied to compare the age difference. A p -value of <0.05 was considered significant.

The ethical approval was obtained from the Ethical Review Board of Shaheed Zulfiqar Ali Bhutto Medical University, Islamabad vide letter no. F.1/2021/ERB/SZABMU.

Results

The overall mean age of the patients remained to be 42.11 ± 13.62 years ranging from 17 to 65 years. The mean age of 43.08 ± 12.67 years in MPAF group was comparable with mean age of 41.13 ± 14.52 years for RSF group with an insignificant difference (p -value=0.367). In MPAF group, 54 (67.5%) were male while in RSF group, 50 (62.5%) patients were males while the remaining in both groups were females and also found insignificant with (p -value = 0.507) as presented in Table-1.

Table 1: Comparison of age (years) between study groups.

Variables		Study Groups		p-value
		MPAF (n=80)	RSF (n=80)	
Age (Years)	Mean	43.08	41.13	0.367
	SD	12.67	14.52	
Gender	Male	54 (67.5%)	50 (62.5%)	0.507
	Female	26 (32.5%)	30 (37.5%)	

According to the current study, excellent final outcome was noted in 135 (84.38%) patients, good final outcome was found in 21 (13.13%) patients and poor outcome was found in 4 (2.50%) patients. The MPAF group showed significantly better outcomes (p -value =0.021) as compared to RSF group as presented in Table-2. The analysis shows no significant difference in outcomes between MPAF and RSF for participants aged ≤ 40 years (p =0.063). While apparently younger participants had excellent outcomes with MPAF (95.2%) compared to RSF (80.5%). Similarly, there was no significant difference in the >40 age group (p =0.253). Gender comparisons also showed no

significant differences (p =0.105 for males, p =0.109 for females). Although, apparently, the MPAF group had better results in all subgroups: 88.9% in males, 92.3% in females, and 95.2% in those aged ≤ 40 none of the p -value was found significant (Table-3).

Table 2: Comparison of final outcome between study groups.

		Study Groups		Total	p-value
		MPAF (n=80)	RSF (n=80)		
Final Outcome	Excellent	72 (90.0%)	63 (78.8%)	135 (84.4%)	0.021
	Good	8 (10.0%)	13 (16.2%)	21 (13.1%)	
	Poor	0 (0.0%)	4 (5.0%)	4 (2.5%)	

Table 3: Comparison of final outcome between study groups stratified according to age and gender.

Characteristics		Final Outcome	Study Groups		Total	p-value*
			MPAF (n=80)	RSF (n=80)		
Age (Years)	≤ 40	Excellent	40 (95.2%)	33 (80.5%)	73 (88.0%)	0.063
		Good	2 (4.8%)	6 (14.6%)	8 (9.6%)	
		Poor	0 (0.0%)	2 (4.9%)	2 (2.4%)	
	> 40	Excellent	32 (84.2%)	30 (76.9%)	62 (80.5%)	0.253
		Good	6 (15.8%)	7 (17.9%)	13 (16.9%)	
		Poor	0 (0.0%)	2 (5.1%)	2 (2.6%)	
Gender	M	Excellent	48 (88.9%)	39 (78.0%)	87 (83.7%)	0.105
		Good	6 (11.1%)	10 (20.0%)	16 (15.4%)	
		Poor	0 (0.0%)	01 (2%)	01 (1.25%)	
	F	Excellent	24 (92.3%)	24 (80.0%)	48 (85.7%)	0.109
		Good	2 (7.7%)	3 (10.0%)	5 (8.9%)	
		Poor	0 (0.0%)	3 (10.0%)	3 (5.4%)	



Figure 1: Flap raised and inserted into defect.



Figure 2: Dissection of medial plantar artery flap.



Figure 3: Well healed flaped and skin graft.

The dissection, medial plantar flap intervention and healing process of the study patients has been shown in images which can be seen in figures (Figure 1-3).

Discussion

According to the findings of the current study MPAF is superior to RSF in managing heel's plantar surface. Though a variety of procedures are available for reconstruction of heel area. It is well studied and proven that in the ankle, the skin and tissues covering it are tough to manage or treat mainly due to lack of local tissue availability and weight bearing of the area. Many surgeons have reviewed a number of these options and witnessed no single ideal or superior technique.¹⁵ In present study, significantly more patients in the MPAF technique were found to have excellent outcome

when compared with the RSF technique (p -value =0.021). Mahmoud et al presented in their study survival of flap in all cases in medial plantar group, however, in RSF group they witnessed necrosis in 1 patient. In their study, weight bearing was significantly earlier in the MPAF group (5.8 ± 0.3 wks vs 6.9 ± 0.2 wks; $p = 0.003$), and no one was found with an ulceration or recurrence of problem. The frequency of complications was found lesser in the MPAF group than in the RSF group (p -value =0.01). An overall greater improvement was witnessed in functional outcome of patients after MPAF management (p value =0.004).¹

A study witnessed that the MPAF is a better technique for repairing defects of heel as it entails high flap survival rate and lesser complications of flap or donor site.¹⁶ Another study perceived flap survival and excellent outcome in 93.3% of the patients in MPAF group while they found excellent outcome in 80% in the RSF group.¹ A study concluded that the MPF is a better option than RSF in the context of viability of flap and patient's functional movements in the later life. They found out that all patients in MPAF group survived without any flap loss, however, in the RSF group, 2 patients had a loss of flap due to diabetes in terms of vascular insufficiency and kinking.¹⁷ There are several other studies which reported that MPAF is an effective option for reconstruction of defects of soft tissues on heel and ankle.^{18,19} Defects whether recent or chronic lesions are problematic to handle difficult to cover and require a well vascularized reconstruction having a good durability and sensation because of its location and repeated friction by footwear. Similarly, another study reported that out of 25 flaps, 20 showed complete survival (80%). Partial flap loss was found in 2 patients (8%), marginal flap necrosis in 2 patients (8%), and complete loss in 1 patient (4%). Venous congestion, not a lack of arterial supply, is the most significant reason for flap necrosis.²⁰

Siddiqi et al used the medial plantar artery-based flap for coverage of tissue defects around the heel and found that all the flaps healed uneventfully without any major complications requiring surgical revision.²¹ On the other hand Oh et al studied the use of the medial plantar sensate flap for weight bearing plantar reconstruction and found that minor skin graft loss at the donor site was observed in 35% patients.²² In the present study, no complication of the donor site was observed in this regard proving medial plantar flap to be more convenient and efficient graft technique. Skin and tissue grafting for any lost passage of body part is very crucial, nevertheless if it's a routine weight bearing part like foot heel than the dependence

becomes more important. The effective and efficient graft donor site and healing of the heel cap makes MPAF an ideal technique in the local settings and a sigh of relief for the plastic and reconstructive surgeons.

This study highlights the importance of the heel pad and plantar area, as well as interventions for their reconstruction. It benefits from a reasonably sized randomized sample, allowing clear assessment of the reconstruction procedures. However, it faced limitations due to reduced patient presentation during the COVID-19 pandemic and a narrow data collection scope, lacking details on clinical presentation, wound condition, and grading. Given the healthcare system's challenges, this study has significant programmatic and practical implications. With a large gap between healthcare services, providers, and patient demand, the availability of an effective and efficient intervention like MPAF for heel defects is crucial for reducing both costs and the burden on health facilities.

The study concludes that the MPAF technique demonstrated significantly better outcomes than the RSF method, particularly in terms of flap survival for reconstructing the plantar surface of the foot. While these findings are promising, further large-scale studies across diverse populations and healthcare settings are necessary to confirm their generalizability. Nonetheless, MPAF currently stands as a safe and effective option for plantar foot reconstruction.

Conflict of interest: None declared.

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