ORIGINAL RESEARCH

Functional Outcomes After Heel Pad Reconstruction Using Various Flap Techniques -A Prospective Observational Study

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ABSTRACT

Background and Aim: Heel pad loss after trauma, complicated diabetic foot ulcers, and soft tissue tumor extirpation can lead to limb amputation in the absence of a sound reconstructive approach. The expectation of regaining good functionality, sensation anddurable tissue (rather than mere wound coverage) further complicates the aims of limb salvage surgery. The present study conducted to assess the functional outcomes after heel pad reconstruction using various methods conducted at our centre.**Material and Methods**: The present institution based prospective observational study was conducted at department of Plastic and Reconstructive surgery I.P.G.M.E.R.&S.S.K.M. Hospital from October 2021 – September 2022 among 25 patients admitted to our institute during the study period with heel pad defect.Questionnaires adapted from the subjective components of the AOFAS hindfoot clinical ratings scale to determine the pain and functional outcomes according to limitations of activity, walking distance, and walking surfaces.Sensation was objectively assessed by using the Semmes-Weinstein monofilament test at the flap site.Lastly, a clinical assessment was also performed to evaluate the presence of ulcers at the flap site.**Results**: Majority of the subjects in this study were males (88%). Maximum subjects were from age group of >50 years (52%) followed by 20-35 years (32%). Most common etiology for the defect in this study was trauma. Most common flap type to repair the defect in this study was RSA (68%) followed by MPA (16%). Complications viz. marginal necrosis and ulceration was reported among 8% and 28% of the subjects respectively. In our study mean AOFAS subjective score was highest for MPA flap.**Conclusion**: In conclusion, heel pad reconstruction is challenging and flap selection and the need for sensory preservation to optimize the best outcomes remain controversial. Good functional outcomes were achieved with heel pad reconstruction in our center. Early wound coverage within a week mitigates infection, less hospital stay and enhances productivity of individual.

Keywords: Heel Pad, Trauma, AOFAS, RSA, MPA

INTRODUCTION

The heel of the foot is covered by highly specialized thick, glabrous skin containing fibroadipose tissue with numerous fibrous septae traversing the subcutaneous tissue to connect the skin to the plantar aponeurosis. These septae divide the subcutaneous tissue into small loculi that acts as a shock-absorbent and prevents the skin from shearing. Therefore, the heel is an important integrated part for walking. It is subjected to more repetitive trauma and loading stress than any other part of the body. The loss of heel pad would cause the interruption of the propelling function of the foot during walking. Hence, heel pad reconstruction is an important procedure for wound closure in the acute phase and also functional reconstruction in delayed cases[1].

Reconstruction of the heel with similar tissue is challenging because of the limited availability of glabrous local tissue. Different options for reconstruction of the heel are skin graft, locoregional flaps, cross-leg flap and different free flaps with each of them has their pros and cons[2].

Numerous studies have reported the outcomes of foot- and ankle related problems, mainly determined from patient-reported symptoms. Although various clinical tools are available to assess function, no single tool

has been found to be superior for evaluating heel pad function[3-5]. In 1994, Kitaoka et al described the American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot clinical ratings scale to objectively and subjectively assess foot function. The subjective component of this scale has been shown to be a valid health measurement[6-8]. In addition to the subjective outcomes, sensation and the avoidance of recurrent ulceration after soft tissue reconstruction of the heel pad have been shown to be associated with patient satisfaction. Furthermore, Semmes-Weinstein monofilaments can be used to evaluate the return of sensation after various flap reconstructions[9,10]. Hence, a combination of subjective and objective clinical assessments can be used to meaningfully assess the functional outcomes after pedal flap reconstruction[11,12].

The demand for limb salvage surgery has been increasing, and the orthoplastic approach has been deemed necessary to prevent amputation. Heel pad loss after trauma, complicated diabetic foot ulcers, and soft tissue tumor extirpation can lead to limb amputation in the absence of a sound reconstructive approach. The expectation of regaining good functionality, sensation, and durable tissue (rather than mere wound coverage) further complicates the aims of limb salvage surgery. The present study conducted to assess the functional outcomes after heel pad reconstruction using various methods conducted at our centre.

MATERIAL AND METHODS

The present institution based prospective observational study was conducted at Plastic surgery department, I.P.G.M.E.R.&S.S.K.M. Hospital from October 2021 – September2022 among all the patients admitted to our institute during the study period with heel pad defect. Ethical Clearance for the study was taken from the Institution Ethics Committee. 25 patients undergoing flap reconstruction for heel pad defect during the study period.

Inclusion criteria

- Between 15 to 60 years of age.
- No acquired or congenital spinal cord diseases
- Not having polyneuropathy
- No associated nerve injury of lower limb.

Exclusion criteria

- Individuals below 15 years and above 60 years.
- Acquired or congenital spinal cord abnormalities
- Polyneuropathy
- Heel pad defect associated with nerve injury

Data collection and interpretation

1. For each patient reviewed, the following data were recorded and tabulated: age, sex, concomitant medical illness, etiology, defect size, flap size, duration of surgery complications, and follow-up duration
2. Questionnaires adapted from the subjective components of the AOFAS hindfoot clinical ratings scale to determine the pain and functional outcomes according to limitations of activity, walking distance, and walking surfaces
3. Sensation was objectively assessed by using the Semmes-Weinstein monofilament test at the flap site, with 3 different monofilament sizes. (size 6.65 = 300 g for deep sensation; size 4.31 =2 g for protective sensation; normal size 3.61 = 0.4 g)
4. A clinical assessment was also performed to evaluate the presence of ulcers at the flap site or other sites of the foot.

Statistical analysis

Data so collected was tabulated in an excel sheet, under the guidance of statistician. The means and standard deviations of the measurements per group were used for statistical analysis (SPSS 22.00 for windows; SPSS inc, Chicago, USA). Difference between two groups was determined using chi square test and the level of significance was set at $p < 0.05$.

RESULTS

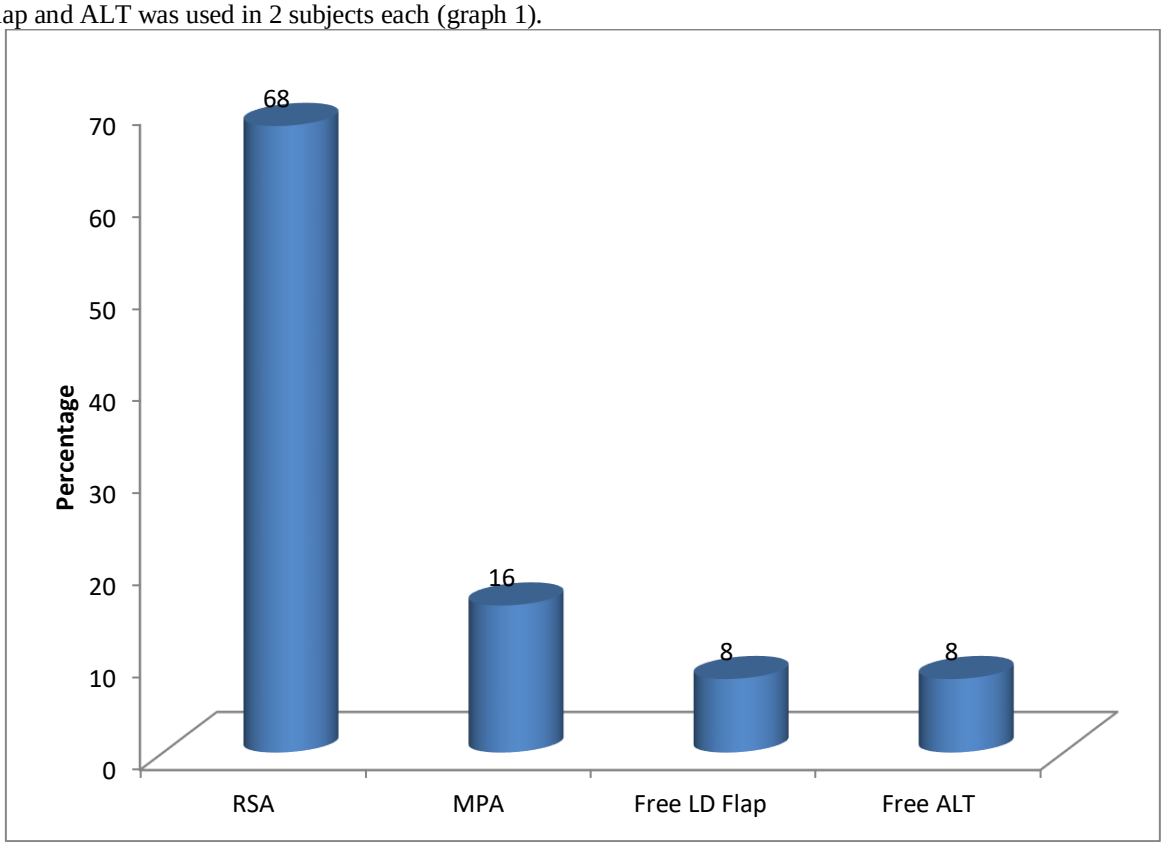
Majority of the subjects in this study were males (88%). Maximum subjects were from age group of >50 years (52%) followed by 20-35 years (32%). Most common etiology for the defect in this study was trauma (52%) followed by malignancy (24%) and diabetic ulcer (20%). Only 1 subject was reported due to burn (table1).

Table 1: Profile of the study subjects

Gender	**N=25**	**%**
Male	22	88
Female	3	12
Age Group (in years)		
20-35	8	32
36-50	4	16
>50	13	52
Comorbidities		
Diabetes	4	16
Hypertension	3	12
Etiology		
Trauma	13	52

Malignancy	6	24
Diabetic Ulcer	5	20
Burn	1	4

Most common flap type to repair the defect in this study was RSA (68%) followed by MPA (16%). Free LD Flap and ALT was used in 2 subjects each (graph 1).



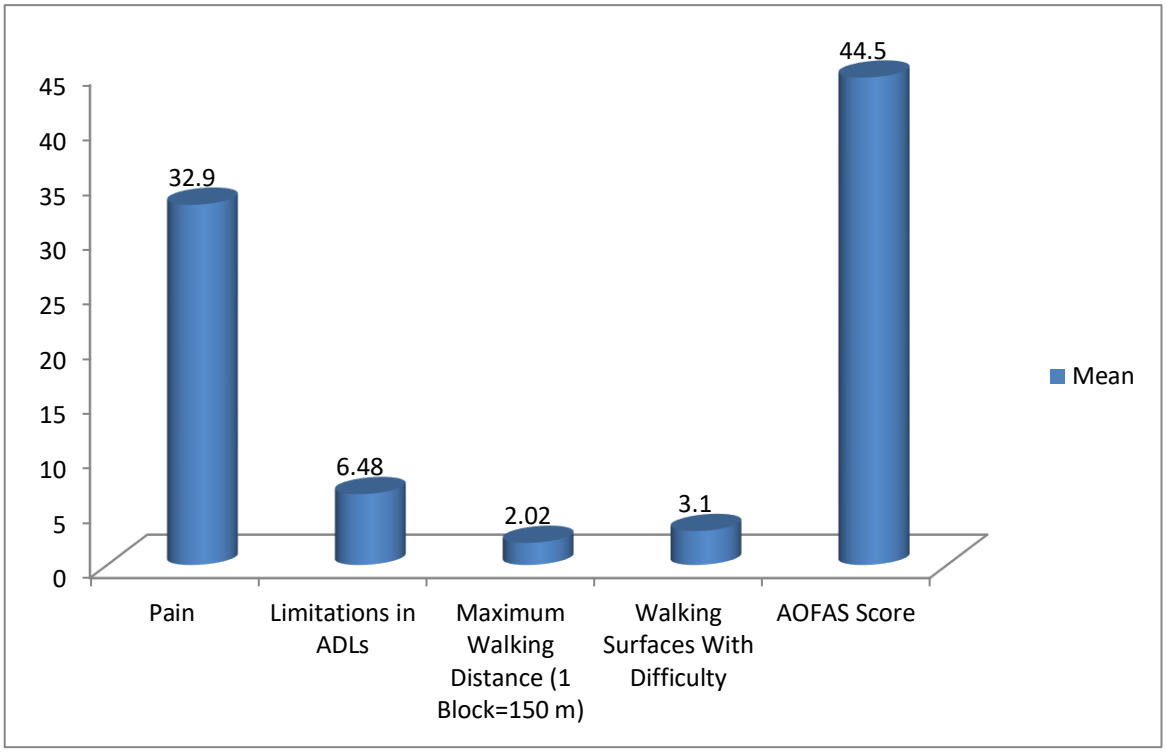
Graph 1: Flap type among the study subjects

Mean±SD operative time (hrs) among the study subjects was 4.29±1.83. Mean±SD hospital stay among the study subjects was 37.62±18.41 days (table 2). Complications viz. marginal necrosis was reported among 8% of the subjects. Tip necrosis of the rotation flap was managed with debridement followed by secondary suturing while marginal necrosis of the extended RSA flap was managed with secondary healing.

Table 2: Operative time (hrs) and hospital stay (in days) among the study subjects

	Mean	SD
Operative time (hrs)	4.29	1.83
Hospital stay (in days)	37.62	18.41

Overall mean AOFAS score among the study subjects was 44.5±5.32 (graph 2).



Graph 2: Mean AOFAS Score and range (Maximum Mean Score 60)

No relevant differences was found in the functional results between different flap types and free or pedicle techniques used for reconstruction of the weight-bearing sole. In our study mean AOFAS subjective score was highest for MPA flap followed by RSA flap. Out of 17 cases of RSA flap, 15 gained deep sensation at an average period of 6.2 months (3-8months), but only 4 patients had protective sensation with a mean of 9.3 months (8-12 months). Out of 4 cases of MPA flap, all gained deep sensation at an average period of 6.1 months (3-7 months) while protective sensation was found among 3 subjects. None of the subject in Free LD and ALT FLAP had neither deep nor protective sensation (table 3). At followup, ulceration was reported among 16% of the subjects (table 11).

Table 3: Outcome analysis using different flaps

Flap Type	Cases	Average Size (cm)	Complication (n)		Mean AOFAS Score	Sensory Recovery (n)		
			Immediate (Marginal Necrosis)	Delayed (Ulceration)		Deep	Protective	Touch
RSA	17	9*8	2	3	46.4	15	4	0
MPA	4	4*4	0	0	46.8	4	3	0
Free LD Flap	2	14*15	0	1	41.2	0	0	0
Free ALT	2	15*14	0	0	41.5	0	0	0
p value			0.19		0.08	0.023*		

*: statistically significant

DISCUSSION

There are various methods for heel pad reconstruction with each one having its prons and cons. For the reconstruction of defects at the anterior weight-bearing part of the heel, the medial plantar artery, and local flaps are preferred because they have a thick epidermis and dermis which is similar to heel skin[13]. Use of local flaps like V-Y advancement, transposition, and rotation usually limited to cover small size anterior heel defects. Medial plantar artery islanded flap best suited for moderate-sized anterior heel defects in terms of matching, durability, and cosmesis[14]. If there is a trauma in the instep region or the course of the medial plantar artery, then other regional flaps like distally based fasciocutaneous flaps from the leg or free flaps can be used for reconstruction of the weight-bearing part of the heel[15]. The present institution based prospective observational study was conducted at department of Plastic and Reconstructive surgery I.P.G.M.E.R.

&S.S.K.M. Hospital from October 2021 – September 2022 among 25 patients admitted to our institute during the study period with heel pad defect. The aim of the study was to assess the functional outcomes after heel pad reconstruction using various methods conducted at our centre.

Majority of the subjects in this study were males (88%). In a study by Deepak Krishna et al[54], similar male dominancy was reported. KohKhaiLuenet al[16] in their study revealed approximately equal distribution of male and female.

Maximum subjects were from age group of >50 years (52%) followed by 20-35 years (32%) in this study.In a study by KohKhaiLuenet al[16], mean age of the patients was 42 years which is similar to the present study. According to Deepak Krishna et al[17], the mean age of the study participants was 39.37 year.

Most common etiology for the defect in this study was trauma (52%) followed by malignancy (24%) and diabetic ulcer (20%). Only 1 subject was reported due to burn in this study.In a study by Deepak Krishna et al[17], the most common cause of heel defect was traumatic injury (21; 52.5%) followed by neuropathic ulcer (12; 30%), burn injury (5; 12.5%), and malignancy (2; 5%). Similar distribution of etiology was revealed by Koh Khai Luen et al[16] in their study.

Most common flap type to repair the defect in this study was RSA (68%) followed by MPA (16%). Free LD Flap and ALT was used in 2 subjects each. No relevant differences was found in the functional results between different flap types and free or pedicle techniques used for reconstruction of the weight-bearing sole. In our study mean AOFAS subjective score was highest for MPA followed by RSA flap. Regarding the free musculocutaneous flaps, the low mean AOFAS score was attributed to the flap's bulk, which impaired the walking distances and the ability to walk on different surfaces. We prefer extended RSA flap as a first choice to reconstruct complete heel defects because, it is an easy, safe, less time-consuming procedure and not requiring any additional microsurgical procedure.

According to Ruiz, the principle of proximity and simplicity should be followed to select (muscle) flaps with sufficient blood supply, an appropriate amount of soft tissue, a good cushioning effect, and resistance to friction for repair. They believe that the preferred flap for a simple repair of the plantar region of the heel should be the medial plantar island flap. If the trauma is deep or combined with myelitis, the abductor pollicis could be used to form a myocutaneous flap. The medial plantar island flap was first reported by Morrison in 1983 and has since been widely adopted[18].

Wan et al demonstrated that sensate medial plantar flaps used to reconstruct heel pad defects have an earlier return of deep sensation at 6 months and are identical to the instep of the contralateral foot[19].Similarly Koh Khai Luen et al[16] in their study showed that the mean AOFAS scores were greatest for those who had received a sensate medial plantar artery flap, followed by those who had received a distally based reverse sural flap or a musculocutaneous flap. Similarly Deepak Krishna et al[17] in their study found that AOFAS subjective score was highest for islanded RSA flap followed by MPA flap.

Out of 17 cases of RSA flap, 15 gained deep sensation at an average period of 6.2 months (3-8months), but only 4 patients had protective sensation with a mean of 9.3 months (8-12 months). Out of 4 cases of MPA flap, all gained deep sensation at an average period of 6.1 months (3-7 months) while protective sensation was found among 3 subjects. None of the subject in Free LD and ALT FLAP had neither deep nor protective sensation in this study.In a study by Deepak Krishna et al[17], all the patients gained deep sensation at an average period of 5.8 months (3-8months), but only 26 patients had protective sensation with a mean of 9.6 months (8-14 months). Only two cases of medial plantar artery flaps, used after tumor excision, and two cases of the advancement of avulsed heel flaps used for posterior heel defects showed touch sensation at 10.75 months (11-12 months). These findings are approximately similar to the present study.

Koh Khai Luen et al[16] in their study showed that sensate medial plantar flaps had a return of deep pressure sensation at 6 months postoperatively, and, in 2 patients, a return of protective sensation at 1 year. A return of deep sensation occurred with the reverse sural flap, in addition to hyperalgesia, at the 1-year follow-up assessment. Regarding the free musculocutaneous flaps, the low mean AOFAS score was attributed to the flap's bulk, which impaired the walking distances and the ability to walk on different surfaces. A return of deep sensation was found only after 24 months of follow-up for the musculocutaneous flaps. These findings are approximately similar to the present study.Wan et al demonstrated that sensate medial plantar flaps used to reconstruct heel pad defects have an earlier return of deep sensation at 6 months and are identical to the instep of the contralateral foot. Muscle flaps will eventually have a return of deep sensation, such as was shown in 1 of our patients at 24 months, after reconstruction using a serratus anterior muscle flap[19].

Complications viz. marginal necrosis was reported among 8% of the subjects. Tip necrosis of the rotation flap was managed with debridement followed by secondary suturing while marginal necrosis of the extended RSA flap was managed with secondary healing. Delayed complication viz. ulceration was revealed in 16% of the patients.It was reported that the ulceration rate can be as great as 42.9% for muscle flaps used for heel pad reconstruction in children. Potparic and Rajac reported ulceration in 33% (2 of 6 patients) of fasciocutaneous flaps and 33% (3 of 9 patients) of muscle flaps in their series[1].KohKhaiLuenet al[16] in their study too stated

that ulceration is the most common complication observed in heel pad reconstruction.Deepak Krishna et al[17] in their study too revealed similar complications. Schwarz and Negrini reported delayed ulceration in 7/50 (14%) MPA flaps performed for heel reconstruction[20]. Yucel et al observed the recurrence of ulceration in 1 out of 20 cases in his study on soft tissue reconstruction of sole and heel defects with free tissue transfer[21].

We have recognized the advantage of local regional tissues, especially the instep medial plantar flap, as our preferred flap. Nevertheless, only a certain amount is available. Free tissue transfer with muscle and skin grafting has also been our choice for traumatic large defects.

In our series, all instep medial plantar flaps and reverse sural flaps were harvested as fasciocutaneous flaps. Both flaps were easier to mold during flap inset, resulted in fewer walking gait disturbances, and fewer marked size differences between the reconstructed heel pads and the other 2 muscle flaps. Fasciocutaneous flaps provide thin, pliable tissue that is easily contoured and neurotized.

In contrast, muscle flaps do not have a subcutaneous plane and the modulus of shear within the flap is high; however, this will be attenuated as the muscle undergoes atrophy and fibrosis. Therefore, it might later provide a better contour than fasciocutaneous flaps. The major disadvantage is that muscle flaps cannot be neurotized to provide protective sensation and might be prone to recurrent ulcers. Reconstruction with a muscle flap and skin graft often require a second debulking and revision surgery owing to the excess in muscle volume.

LIMITATIONS

These are some limitations of the present study:

1. Small sample size
2. Single Centre study
3. Strictly observational study
4. Lack of long term follow up

Our main aim of this study is to give statistical comparison that can be used in future study focusing on heel pad reconstruction

CONCLUSION

It can be concluded from the results that no relevant difference was found w.r.t. functional outcome between different flap types. Selection of flap as per location and size of the heel defect is crucial to achieve good function. Need of sensate flap to optimize the best outcomes remain controversial. Good functional outcomes were achieved with heel pad reconstruction in our center. For long-term results, these patients need to be followed up regularly and proper footwear has to be worn lifelong.

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