

How to Cite:

Kumar, V. N., Kakola, M. G., Raj, P. S., & Chandrashekar, M. S. (2022). Medial plantar artery flap: An indispensable classic for sensate heel reconstruction. *International Journal of Health Sciences*, 6(S6), 2977–2983. <https://doi.org/10.53730/ijhs.v6nS6.10531>

Medial plantar artery flap: An indispensable classic for sensate heel reconstruction

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Abstract---Background: The unique ability of the thick glabrous skin of the plantar heel to withstand body weight while also providing protective sensory feedback makes soft-tissue coverage of the plantar heel a particularly challenging aspect of foot reconstruction. In this study, we present the outcomes and complications associated with medial plantar artery perforator (MPAP) flap reconstruction of plantar heel. Methods: The study was a retrospective study conducted over four years, and included 22 patients with soft-tissue injury to the plantar heel. All patients underwent MPAP flap for coverage of the defect. We studied the mode of injury, defect size, flap size, duration of the procedure, complications associated with the flap and donor site, time to full weight bearing and return of protective sensation and 2-point discrimination in comparison with opposite heel. Results: We studied 22 cases with soft-tissue defects of the heel that included post-traumatic defects (7), non-healing diabetic ulcers (6), trophic ulcers (4) and post-tumor excision defects (melanoma-3, squamous cell carcinoma-2). Mean flap dimension was 24 sq.cm. 18 flaps had complete survival, while 2 flaps had necrosis of the distal edge and 2 flaps underwent complete necrosis. In all cases except those with complete flap necrosis, the MPAP provided reliable wound coverage with protective sensation comparable to the opposite foot. Conclusion:

The MPAP flap provides reliable and robust soft tissue coverage of the plantar heel, with replacement of sensate glabrous skin to the heel. The technique offers a relative ease of learning with few complications when performed meticulously.

Keywords---heel reconstruction, medial plantar artery flap.

Introduction

The unique ability of the thick glabrous skin of the plantar heel to withstand body weight while also providing protective sensory feedback makes soft-tissue coverage of the plantar heel a particularly challenging aspect of foot reconstruction.^{1,2} Reconstructive options to the plantar foot are therefore limited, and the option of choice must aim to provide reliable soft tissue coverage with minimal donor site morbidity and permit near normal ankle movements. The medial plantar artery flap provides the most versatile solution for medial or plantar heel reconstruction, providing tissue of similar quality.³ It was originally described 45 years ago by Taylor and Hopson⁴ as a cross-foot flap, and the technique was further refined to be used as an instep island flap for hindfoot reconstruction by Harrison and Morgan.⁵ The anatomic basis for the flap is the medial plantar artery and nerve, that provide vascularity and sensory innervation of the medial 2/3rd of the plantar concavity. A flap as large as 6x10cm can be harvested, and the donor site can be skin grafted.³

Aims and Objectives

To assess the functional outcome and complications associated with MPAP flap in plantar heel reconstruction.

Materials and Methods

The study was a retrospective study performed in the Department of Plastic surgery, K R hospital, attached to Mysore medical college and research institute from July 2019 to May 2022. The subject size was 22 and Institutional ethical clearance was obtained. Parameters recorded in the study were as follows-

- mode of injury
- flap size
- complications associated with the flap and donor site
- time to full weight bearing
- return of protective sensation
- 2-point discrimination in comparison with opposite heel
- duration of the procedure

Operative Technique

All subjects chosen were those with palpable posterior tibial and dorsalis pedis arteries. A handheld doppler was used preoperatively to localize medial plantar artery (MPA). All surgeries were performed under regional or general anaesthesia

and under tourniquet control. The defect size was first measured after adequate debridement of the wound, and the flap designed based on previously marked location of pedicle on instep of the foot according to the measured defect size. The dissection was carried distally to proximally, with plane of dissection being deep to the plantar aponeurosis. The medial plantar artery and nerve were identified, and digital branches of MPA were divided. Perineurial dissection of the nerve was done to elevate the plantar cutaneous branches along with the flap. Dissection was carried upto the lateral border of abductor hallucis, and the muscle was divided if additional pedicle length is required for mobilization of the flap for inset. After rotation and flap inset, the donor site was covered by split-thickness skin graft and sterile dressing was placed.

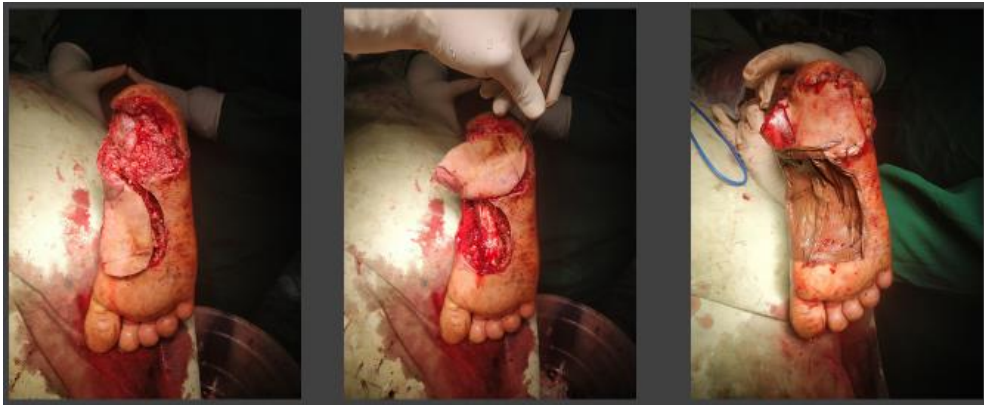


Fig 1. Flap design and elevation from the plantar instep, flap rotation into defect, flap inset and donor site skin grafting.

Postoperatively, customized offloading footwear were given initially, and weight bearing initiated 5-6 weeks after surgery.

Results

Among the 22 subjects enrolled in the study, the male : female ratio was found to be 6:5 (12 male and 10 female patients). The age varied between 8 to 75 years, the average being 49.7 years of age. The various etiologies among the subjects included post-traumatic defects (7), non-healing diabetic ulcers (6), trophic ulcers (4), post- tumor excision defects (5) which included 3 cases of plantar heel melanoma and 2 cases of squamous cell carcinoma.

Table 1
Etiology of plantar heel defects

Sl. No.	Etiology	Number	Percentage
1	Post-traumatic defects	7	32%
2	Non-healing diabetic ulcers	6	27%
3	Trophic ulcers	4	18%
4	Post- melanoma excision	3	14%
5	Post- excision of squamous cell carcinoma	2	9%



Fig 2. Etiology of heel defects (L-R)- Squamous cell carcinoma, Melanoma, trophic ulcer, diabetic foot ulcer, non-healing post-traumatic wound.

The average flap size was noted to be 24 cm², and the flaps varied between 6x9cm (largest) to 4x3.5cm (smallest flap size), depending upon the size of the defect. The average duration of the procedure was 86 +/- 6 minutes, with the longest span taken being 124 minutes and the shortest span being 78 minutes. The complications pertained to flap edge necrosis or rarely total flap loss, and donor site complications such as graft loss. It was noted that the average time taken for return of protective sensation was 5 +/- 3 days among all patients, however, one patient did not have return of protective sensation. The regained sensation in all subjects were reported to be inferior on comparison with that of the contralateral heel with native soft tissue cover. 3 patients reported a transient loss of sensation over the hallux and all regained sensation by the 3rd postoperative week.

Table 2
List of complications

Sl. No.	Complication	Number
1	Partial graft loss	2
2	Total graft loss	1
3	Flap distal edge necrosis	2
4	Total flap loss	1
5	Loss of return of protective sensation	1

All patients were initially advised customized offloading footwear for mobilization, and were allowed partial weight bearing by the 3rd postoperative week, and were subsequently able to fully bear weight by the 6th to 8th postoperative week. The subject who reported no return of protective sensation was advised continuation of offloading footwear. The static 2 point discrimination (S2PD) was evaluated in all subjects with a 10G Semmes-Weinstein monofilament on all follow-up visits, and the average S2PD was seen to be 10.5mm. On long term follow-up, the S2PD was noticed to have improved in most of the subjects. However, in all the cases, the S2PD at the flap site was found to be greater than contralateral side (average-6mm).



Fig 3. Long term results of MPAP flap reconstruction

Discussion

The medial plantar artery is the lesser of two terminal branches of the posterior tibial artery, and supplies the medial 2/3rd of plantar instep through direct cutaneous branches and through musculocutaneous branches by way of the abductor hallucis⁶. The flap can be raised either as a fasciocutaneous flap, or along with abductor hallucis when additional pedicle length or bulk is required. The MPAP flap is unique when compared to the other common reconstructive options to the plantar hindfoot such as the reverse sural artery flap, in that it replaces the lost tissue with closely matched tough and adherent glabrous skin of the plantar instep, providing a “like-for-like” reconstruction^{3,7}. The principal drawback of the MPAP flap is the requirement of split skin grafting for the donor site, which, however, is relatively expendable being a non-weight bearing area of the sole³. Therefore, it is important to ensure that the instep is not a primary weight-bearing surface (i.e., there is no collapse of the medial plantar arch such as in a Charcot’s osteoarthropathy), as this would be a relative contraindication to using this flap.

Donor site complications can frequently be encountered in MPAP flaps, such as graft loss and hyperkeratosis. In our center, we encountered 2 partial graft losses, both of which were managed by regular dressings and healed secondarily, while one case had complete graft loss. Few subjects were seen to develop hyperkeratosis of the grafted donor site, which was specially prominent in those who had a partial loss of skin graft. The donor site complications are comparable to the studies conducted by Miyamoto⁸, Baker et al⁹ and Rashid et al¹⁰. One of the main advantages of the MPAP flap is the ability to give sensate soft tissue cover, and meticulous dissection and preservation of cutaneous innervation is imperative. The identification and elevation of plantar cutaneous branches while preserving the nerve supply to the hallux by perineurial dissection under loupe magnification is an important step in the procedure. All subjects except one involved in the study had return of protective sensation and were able to return to full weight bearing by 6-8 weeks of surgery. However, the sensation was unanimously reported to be lesser on comparison with the contralateral normal heel, which is also noted in other studies.^{8,11}

One subject, a 67 year old who had diabetic neuropathy and had diminished sensation of the plantar instep preoperatively, did not recover sensation, and was

advised to continue usage of off-loading footwear beyond 8 weeks. Two subjects had distal edge necrosis of the flap inset, both of whom were managed conservatively with serial debridement and the wounds healed by secondary intention. One subject had complete necrosis of the flap. The subject was 75 year old with a history of chronic smoking with diffuse atherosclerosis, and presented with a non-healing post traumatic wound over the plantar heel. The patient was managed conservatively with vacuum dressings, and later underwent split skin grafting with postoperative offloading. The flap site complications are comparable to other studies^{12,13,14} or lesser than those reported in studies by Reading¹¹ and Oh et al¹⁵. The patients were followed up for an average of 10 months, with the longest follow-up period being 44 months. None of the patients have reported any ulceration upon followup, and the 2 point discrimination is noted to have improved in long term.

Conclusion

The MPAP flap provides reliable and robust soft tissue coverage of the plantar heel, with replacement of sensate glabrous skin to the heel. The technique offers a relative ease of learning with few complications when performed meticulously.

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