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Case Series

Surgery Section

Medial Plantar Artery Flap for Reconstruction of Weight-bearing Sole Defect- A Series of Ten Cases

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ABSTRACT

Weight-bearing areas of feet are at risk of developing ulcers due to various reasons like a neuropathic foot in diabetes mellitus, acute trauma, post-tumour excision etc., Various reconstructive options have been described in literature from split-thickness skin graft to free flap. This case series reports 10 patients with sole defects. Out of 10 patients, seven patients had heel defect and three patients had the plantar aspect of the forefoot defect. For patients with heel defect, authors used a proximally based medial plantar flap as a reconstructive tool while for forefoot sole defect distally based (reverse) Medial Plantar Artery (MPA) flap was used. The most common cause of heel defect was postdebridement defect in diabetic foot in five cases, postmelanoma excision defect in three cases, postsquamous cell carcinoma excision defect in one case and postelectric burn defect in one case. Flap size ranged from 5x5 cm to 10×7 cm. All flaps offered stable, durable, and cosmetically acceptable skin cover. No patient had a recurrent ulcer during follow-up period. Partial flap necrosis in one case was managed conservatively. The MPA flap offers excellent cover which is a sturdy, durable, cosmetically acceptable cover for medium size defect over the sole i.e., the weight-bearing part of forefoot and heel.

Keywords: Diabetic foot, Durable, Reverse medial plantar flap

INTRODUCTION

The plantar aspect of foot skin has special anatomical characteristics to bear the weight of the entire body while walking, jumping, and running. The glabrous skin and subcutaneous tissue enclosed in numerous fibrous septa absorb pressure. The sole of the foot is resistant to load-induced injury [1].

Reconstruction of the defect of the plantar aspect weight-bearing area is a challenge for plastic and reconstructive surgeon. Reconstruction of the defect with split-thickness skin graft, subjects the sole to recurrent ulceration, hyperkeratosis and even contractures [1]. The distally based sural flap does not always cover and reach most of the area of the sole. Cross-leg flap takes longer treatment time and requires multiple surgeries. Both flaps are bulkier and do not match with sole skin. Free flaps like gracillis, anterolateral thigh flap etc., require microsurgical expertise and setup [1].

CASE SERIES

A case series of 10 patients (6 males and 4 females) with heel and forefoot defects due to various aetiological factors is presented. Out of 10 flaps, 7 flaps (70%) were proximally based medial artery flaps and 3 flaps (30%) were distally based. Flap size ranges from 4x4 cm to 9x6 cm [Table/Fig-1,2]. A total of seven defects were reconstructed over weight-bearing area of the plantar heel and three defects over the forefoot. Trophic and postinfective ulcers 5 (50%), tumour excisional defects 4 (40%) and postelectric burns defect (10%) were aetiological factors. All donor sites were covered with split-thickness skin grafts. There was partial loss of skin graft in two patients which was managed conservatively. Out of 10 flaps, one flap had partial marginal necrosis which was managed conservatively (secondary healing with dressings). Almost all flaps survived well. Proximally based flaps offered sensate, durable cover to heel. Distally based flaps were insensate but offered good cover to forefoot defects. The appearance of flap was cosmetically acceptable to all patients. There was no recurrence of ulcer or tumour during follow-up period. Longest follow-up period was of four years.

Patient	Age in years	Sex	DM	Aetiology	Defect site	Defect size
1	45	Male	Yes	Trophic ulcer	Right Heel	5×4.5 cm
2	39	Male	Yes	Postinfective ulcer	Right plantar fore foot	5×4 cm
3	35	Male	No	Trophic ulcer	Left heel	4×4 cm
4	50	Female	Yes	Trophic ulcer	Left heel	6×5 cm
5	55	Female	Yes	Trophic ulcer	Right heel	6×5 cm
6	47	Female	No	Melanoma	Left heel	9×6 cm
7	49	Male	No	Melanoma	Left heel	5×4 cm
8	56	Male	No	Melanoma	Left heel	6×4 cm
9	60	Female	No	Squamous cell carcinoma	Right plantar fore foot	6×5 cm
10	18	Male	No	Postelectric burns	Right plantar fore foot	5×4 cm

[Table/Fig-1]: Details of patients with aetiological factors and defect [Table/Fig-3a-10b]. DM: Diabetes mellitus

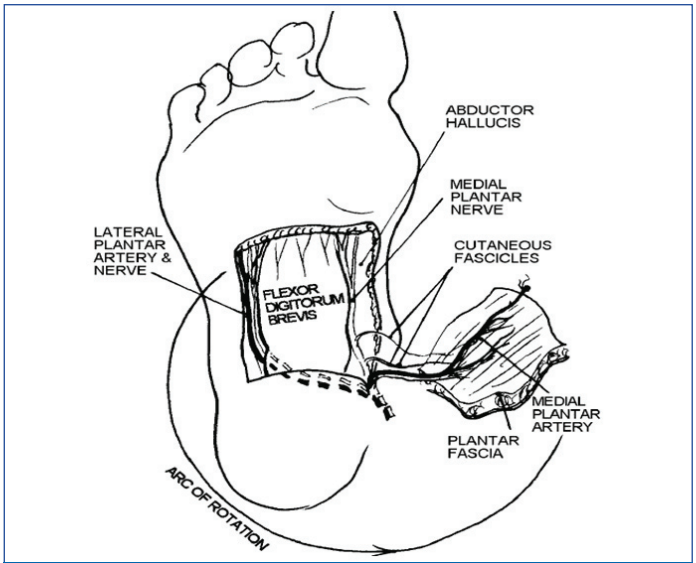
Surgical Technique

Flap planning [2]: Under pneumatic tourniquet control, defect is recreated by thoroughly cleaning and debriding trophic ulcer or by doing oncological excision of tumour on weight-bearing areas of sole. In planning the flap, the weight-bearing area was avoided and the flap was not extended above tuberosity of navicular bone [2]. A proximal incision up to posterior edge of sustentaculum tali was required for dissection of the pedicle. The lateral edge of abductor hallucis muscle marks the line, over which the flap was centred. It can be approximately marked out on the surface by a line drawn between the centre of the heel posteriorly and the medial sesamoid of the great toe. It corresponds to the medial edge of planta aponeurosis. Flap may be raised with dimensions up to 10x7 cm size [2].

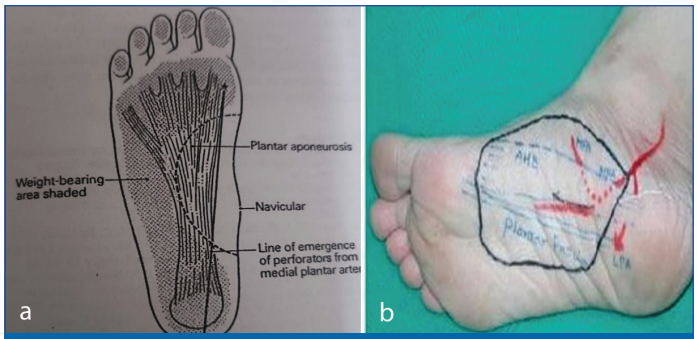
Flap elevation [2]: i) Proximally based flap- The flap was elevated from distal to proximal in a plane, superficial to abductor hallucis so as to include plantar fascia [Table/Fig-3,4a,b]. The septum between abductor hallucis and flexor digitorum brevis containing MPA and its fasciocutaneous perforators is removed in continuity with the flap. The distal branches of MPA are divided. Cutaneous branches

Patient	Size of flap (in cm)	Type of flap	Flap necrosis	Donor site closure	Revision surgeries	Donor site complications	Flap sensations	Follow-up details and outcome
1	6×5.5	PB	-	STG	-	-	+	After two months patient had functional recovery and cosmetically acceptable flap cover
2	6×5	DB	-	STG	-	-	-	Flap offered good cover without any functional problems
3	5×5	PB	-	STG	-	-	+	Offered good cover without any functional limitations
4	7×6	PB	-	STG	-	-	+	Flap offered cosmetically acceptable and functional foot
5	7×6	PB	-	STG	-	Partial graft loss treated conservatively	+	Full functional recovery with acceptable cosmetic appearance
6	10×7	PB	-	STG	-	Partial graft loss treated conservatively	+	No recurrence of ulcer and stable flap
7	6×5	PB	-	STG	-	-	+	Stable flap cover and acceptable cosmetic appearance
8	7×5	PB	-	STG	-	-	+	Stable flap cover and acceptable appearance
9	7×6	DB	Marginal necrosis (treated conservatively)	STG	-	-	-	Stable flap cover and acceptable cosmetic appearance
10	6×5	DB		STG	-	-	-	Stable flap cover and acceptable cosmetic appearance

[Table/Fig-2]: Details of postoperative and follow-up status.
PB: Proximally based; DB: Distally based; STG: Split thickness skin graft; + Present; - Absent



[Table/Fig-3]: Diagrammatic representation proximally based medial plantar flap.

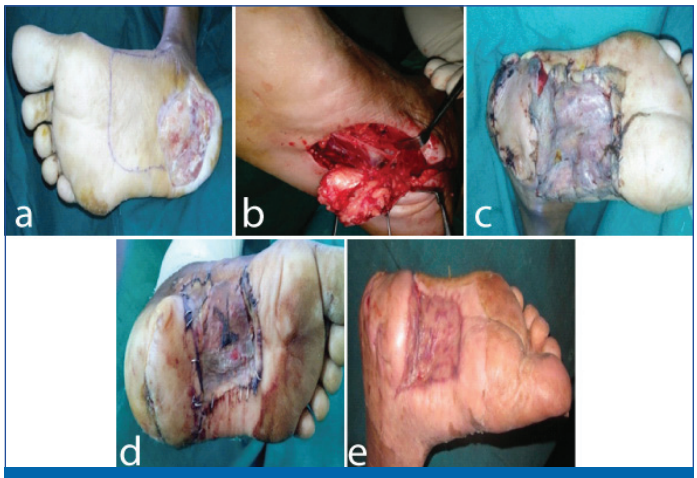


[Table/Fig-4]: a) Flap planning; b) Diagrammatic representation proximally based medial plantar flap [16].
Flap raised from non weight-bearing area marked by dotted line; A AHM: Abductor hallucis muscle; MPA: Mrdial plantar artery; LPA: Lateral plantar artery

innervating flap can be dissected from main stem of the medial plantar nerve and stripped proximally. As the neurovascular bundle is traced proximally, it passes beneath the abductor hallucis and it is necessary to divide the muscle to mobilise the pedicle all the way up to the point where posterior tibial artery divides. This gives arc of rotation, which allows flap to be brought over the desired weight-bearing area of the heel.

Distally based flap [2]- Distally based MPA flap dependent for its blood supply on the distal anastomoses of the MPA branches with the distal plantar arch branches supplied by lateral plantar artery and also penetrating branch through the first interosseous space from the dorsalis pedis artery can also be raised for forefoot defect reconstruction. The skin island is placed proximally in the donor area and flap elevation commences at the posterior margin of the skin island. The medial and lateral borders of skin islands are then incised and elevated with the MPA. The retrograde flow in MPA checked before this is finally divided and elevation of the anterior margin is completed.

After elevation of the flap, tourniquet is released and haemostasis is achieved. Resultant defect over the donor area is covered with split thickness skin graft. Limb is immobilised in dorsal splint for seven days. If graft take is good then partial weight-bearing is allowed after three weeks and full weight-bearing is allowed after six weeks.



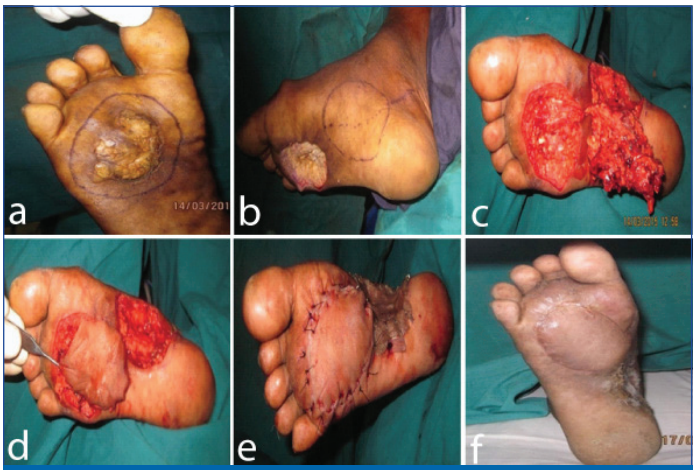
[Table/Fig-5]: a) Defect over heel with flap marking; b) Raised medial plantar flap with medial plantar nerve; c) Donor area covered with split thickness skin graft and defect with flap; d) Postoperative day 7; e) Postoperative two months.

DISCUSSION

According to the Gilles' principles of plastic surgery i.e., 'losses must be replaced in kind' [3], tissue should be replaced by like tissue. The medial plantar instep flap proximally based and distally based/ reverse flap provides glabrous, durable, and cosmetically acceptable

[Table/Fig-6]: a) Postinfective defect over forefoot; b) Postdebridement and flap marking; c) Flap raised showing medial plantar neurovascular bundle; d) Immediate postoperative- Flap inset with donor site STG; e) Postoperative two month.

[Table/Fig-7]: a) Melanoma over heel; b) Flap marking; c) Flap raised; d) Donor area covered with STG & flap inset; e) Three month follow-up.



[Table/Fig-8]: a) Squamous cell carcinoma on right fore foot; b) Marking of Flap after excision of defect; c) Flap raised; d) Flap Transposed; e) Flap inset with STG over donor area; f) Follow-up five months.

skin cover for heel and forefoot respectively [4]. Skin grafts are used to cover raw area over non weight-bearing areas of sole. Weight-bearing area of sole is covered with local or distant flap.

Evans GR and Robb GL developed a reconstructive options based on the location of the defect (heel and midplantar area, distal plantar area, and non weight-bearing sole) [5]. Defects of the non weight-bearing areas can be managed with skin grafts. Defects in the distal plantar area have been managed with local flaps including toe fillet flaps, medial plantar flaps, or V-Y flaps. Defects in the heel and midplantar area can be managed with local (V-Y flaps, medial plantar flaps, or island perforator flaps) and free flaps, such as various fasciocutaneous or muscle flaps, each having pros and cons of the procedure [6-8].

[Table/Fig-9]: a) Electric burns defect; b) Flap marking after debridement; c) Flap islanded; d) Medial Plantar artery in the centre of flap divided proximally; e) Flap inset with donor area STG; f) Follow-up six month postoperative.

[Table/Fig-10]: a) Operated case of right heel trophic ulcer postoperative day 5 after flap; b) Cosmetically acceptable heel follow-up four years.

After the description of the instep fasciocutaneous flap by Harrison DH and Morgan BD, the flap has been used successfully and has proved to provide ideal soft tissue coverage for the weight-bearing heel [9]. The uniqueness of this flap is that it replaces heel defects with skin of a similar texture and histologic features to that of the original tissue [10].

MPA flap for heel reconstruction is associated with very high flap survival rate (98.2%), low minor flap complications (9.4%), and low donor site complications (5.2%) [11,12]. However, in present series, we have partial necrosis was observed in two patients without any functional limitations in follow-up period. The results from this review are consistent with the largest study on the use of MPA or heel reconstruction by Schwarz RJ and Negrini JF with a flap survival rate of 98% [10]. One other flap that has been used for heel reconstruction is the reverse sural artery flap. A study has compared this flap to the MPA flap for heel reconstruction and has founded the MPA flap to have fewer associated complications [12]. Moreover, the donor tissue used in the sural artery flap does not provide the glabrous tissue that the instep provides. Another advantage of the MPA flap is the ability to transfer it as a sensate flap.

In present series of 10 cases, there was no recurrence of trophic ulcer, melanoma, squamous cell carcinoma in any case during the follow-up period. Besides the issues of durability, reverse sural pedicled flaps or free flaps such as anterolateral thigh flap or latissimus dorsi can be bulky for plantar reconstruction and additional debulking procedures are commonly needed. The donor site morbidity in the area was low. Apart from two cases of delayed wound healing, there were no short-term or long-term donor site complications. The donor site is invariably covered by split thickness skin graft and thus aesthetically less satisfactory.

In present series, three cases of melanoma and one case of squamous cell carcinoma underwent excision and reconstruction with MPA flap proximally based and distally based respectively. Immediate reconstruction of the foot after melanoma resection has

the potential to reduce the number of necessary operations, patient morbidity, and hospital costs [12]. There are few studies about the overall outcomes and oncologic safety after resection of melanoma tumours with immediate reconstruction [13-15]. In head and neck melanomas, studies have demonstrated a 2.6% to 2.8% recurrence rate, validating that this surgical method can be safely performed with low recurrence rates.

Benito-Ruiz J et al., noted no recurrent ulcers in either MPA flaps or reverse sural flaps, with 1 to 2 years of follow-up [16]. This flap can be used to cover large skin defects, up to 8cm diameter in this study, and will cover posterior heel defects and even forefoot defects. The island medial plantar flap (instep flap) and distally-based island medial plantar flap was used for proper reconstruction of the weight-bearing area [17]. Innervated MPA free flap from contralateral free flap is also used in postoncological reconsructions [17].

MPA based flap is single-stage procedure without sacrificing major vessels and tissues. It has a good arc of rotation, it is durable and good results can be achieved with proper planning and dissection of tissues.

CONCLUSION(S)

The MPA proximally and distally based flap is a good tissue cover for small to medium size defects on the heel and weight-bearing area of the forefoot respectively. It can cover diabetic foot postdebridement, postelectric burns, postoncological resection defects. It has good survival rate with negligible complications. It is sensate and replaces specialised sole tissue with similar tissue.

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