Journal of Cardiovascular Disease Research
ISSN: 0975-3583, 0976-2833 VOL 15, ISSUE 08, 2024

Feasibility of Various Loco-Regional Flaps in the Reconstruction of Weight Bearing Heel Pad Defects-An Observational Study

Dr. S. Sirisha [1], Dr. M. Naveen Kumar [2], Dr. P. Durga Prasada Rao [3], Dr. T. Mohana Rao [4]

[1] Associate Professor, Department of Plastic Surgery, Andhra Medical College, Visakhapatnam, Andhra Pradesh, India.
[2] Assistant Professor, Department of Plastic Surgery, Andhra Medical College, Visakhapatnam, Andhra Pradesh, India.
[3] Assistant Professor, Department of Plastic Surgery, Andhra Medical College, Visakhapatnam, Andhra Pradesh, India.
[4] Professor & HOD, Department of Plastic Surgery, Andhra Medical College, Visakhapatnam, Andhra Pradesh, India.

Corresponding Author
Dr. T. Mohana Rao, Professor & HOD, Department of Plastic Surgery, Andhra Medical College, Visakhapatnam, Andhra Pradesh, India.

Received: 10-06-2024 / Revised: 20-06-2024 / Accepted: 28-07-2024

ABSTRACT

INTRODUCTION
Reconstruction of weight bearing heel defects is challenging to plastic surgeons because of the paucity of local available soft tissue. Heel is a specialized tissue because of its importance in weight bearing. The main aim of reconstruction of weight bearing heel defects is to give a robust, stable, durable, sensate, flap cover with skin akin to glabrous skin of foot to withstand shearing forces while walking and for weight bearing. The various reconstructive options described for resurfacing weight bearing heel defects are skin grafts, local flaps, pedicled or islanded fasciocutaneous flaps, cross leg flaps, free tissue transfer.

AIM
This study is to evaluate the versatility and applicability of various loco-regional flaps in the reconstruction of weight bearing heel pad defects.

OBJECTIVES
Reconstruction of heel pad is difficult for plastic surgeons due to paucity of local available tissues to execute reconstruction.
1. To study the etiology of weight bearing heel defects.
2. To give stable, durable, soft tissue cushion, enabling normal weight bearing with a reasonable sensation.
3. To study the various complications of the flaps performed and their management.

METHODOLOGY
The present study was conducted in the Department of Plastic Surgery, King George Hospital, Vishakhapatnam from March 2024 to May 2024 for a period of 3 months. A total of 20 patients were included in the study.

Inclusion Criteria:

1. Patients of ages >10 years, <70 years with weight bearing heel defects of various etiology requiring flap cover.

Exclusion Criteria:

1. Patients with heel defects of weight bearing area requiring other wound resurfacing options ranging from skin grafts to free flaps.
2. Patients with comorbidities with hypertension, liver and renal diseases.
3. Patients with fractures around ankle joint and lower third of leg are excluded from the study.
4. Patients not giving informed consent for flap cover are excluded from the study.

RESULTS

The study was conducted on 20 patients with 15 male and 5 female patients with mean age 34.7. All the defects were weight bearing heel involving right heel in 16 cases and left heel in 4 cases. The size of the defect ranged between 4 cm to 20 cm. The defects involved right heel in 80 % cases and left heel in 20 % cases. The defects ranged from 4 x 2 cm to 16 x 20 cm. The flaps that we performed were pedicled distally based reverse sural artery neuro cutaneous artery flap in 8 cases , Islanded Reverse sural artery flaps in 3 cases, pedicled medial plantar artery flap in 5 cases, Islanded Medial plantar artery flaps in 3 cases, cross leg flap in 1 case . The etiology for various heel defects involving weight bearing area were trauma in 13 cases sustained due to road traffic accidents, burns in 2 cases, electric burn in 1 case, infective chronic ulcers in 2 cases associated with diabetes mellitus, 1 case of neuropathic ulcer with spinal cord injury and malignancy(malignant melanoma heel) in 1 case. 2 patients had associated calcaneal fracture in trauma cases. 1 case had associated avulsion injury of ipsilateral leg.

All 20 flaps survived. Of 11 cases of reverse sural artery flaps, 1 case had distal 1 cm marginal flap necrosis which was treated with excision and secondary suturing at the time of flap division. 1 case of cross leg flap had distal partial epidermal necrosis at the tip of the flap of 1 cm which was managed conservatively. 1 case of medial plantar artery had venous congestion which resolved after removal of distal stitches. RSA pedicled flaps, cross leg flap were divided after 3 weeks and inset given. All flaps settled well. Patients were able to bear weight and walk normally after 12 weeks.

CONCLUSION

Loco-regional flaps are one of the best options available to cover weight bearing heel pad defects which can be performed with little expertise. Medial plantar artery flap is best suitable for reconstruction of small to medium sized defects in the weight bearing heel with intact instep skin and posterior tibial vessels. It is sensate and has glabrous skin of foot. Distally based Reverse sural artery neuro cutaneous flaps are best suitable for large weight bearing heel pad defects & defects encroaching on to medial plantar artery territory, providing good bulk to heel pad. Cross leg fasciocutaneous flap is one of the options available if ipsilateral fasciocutaneous flaps are not possible because of ipsilateral injury to leg.

KEY WORDS

Heel Pad Defects, Reverse Sural Artery, Medial Plantar Artery, Weight Bearing Heel Defect, Cross leg.

INTRODUCTION

Reconstruction of weight bearing heel defects is challenging to plastic surgeons because of the paucity of local available soft tissue. Heel is a specialized tissue because of its importance in weight bearing. It has thick glabrous skin, vertical fibrous septa extending from calcaneum to plantar aponeurosis through the fat globules enabling heel to withstand shearing forces while walking. The various causes of heel defects are trauma, infection, chronic ulcers, diabetic ulcers, burns, electric burns, neuropathic ulcers, malignancy.

The main aim of reconstruction of weight bearing heel defects is to give a robust, stable, durable, sensate, flap cover with skin akin to glabrous skin of foot to withstand shearing forces while walking and for weight bearing. The various reconstructive options described for resurfacing weight bearing heel defects are skin grafts, local flaps, pedicled or islanded fasciocutaneous flaps, cross leg flaps, free tissue transfer. Each procedure has its own merits & demerits. Previously, various types of flaps have been proposed to repair wounds in the same area, with varying results [1, 2-5].

In this article, we present with various available loco-regional flaps for resurfacing weight bearing defects of heel. Various flaps used in the study are distally based Reverse sural artery neuro cutaneous flap, medial plantar artery flaps, cross leg fasciocutaneous flap.

METHODOLOGY

The present study was conducted in the department of plastic surgery, King George hospital, Vishakhapatnam from March 2024 to May 2024 for a period of 3 months. A total of 20 patients were included in the study.

Inclusion Criteria

Patients of ages >10 years, <70 years with weight bearing heel defects of various etiology requiring flap cover.

Exclusion Criteria

1. Patients with heel defects of weight bearing area requiring other wound resurfacing options ranging from skin grafts to free flaps.
2. Patients with comorbidities with hypertension, liver disease renal disease.
3. Patients with fractures around ankle joint and lower third of leg are excluded from the study.
4. Patients not giving informed consent for flap cover are excluded from the study.

Preoperative Assessment and Operative Technique

Preoperative evaluation included detailed history, general examination, local examination of the heel defect, vascularity of the limb assessed clinically. The wound is examined in detail in due respect of size of defect and x-ray of limb is taken to rule out fractures. The blood investigations are done like complete blood picture, blood sugar, Liver and kidney tests.

Surgery is performed under spinal Anaesthesia with a tourniquet placed on the thigh in a bloodless field. All wounds are thoroughly debrided and depending on the size, clinical patency of posterior tibial vessels, intactness of instep area, donor site morbidity, reverse sural artery flap or Medial plantar artery flap or cross leg flap are planned.

For Reverse sural artery flaps, patient is kept in prone position. The axis of the flap marked by drawing a line from midpoint of knee joint to mid-point of distance between lateral malleolus and tendoachilles. Planning in reverse is done to mark the flap with pivot point at 7 cm above lateral malleolus. Flap is harvested in sub facial plane exposing median raphe of

gastrocnemius and paratenon of tendoachilles up to the pivot point including and ligating short saphenous vein and sural nerve .The flap is inset into the defect with foot in plantar flexion and immobilized in the same position. The donor area is split skin grafted.

Distally based reverse sural artery flaps were done in 11 among 20 cases with large defects more than 8 x 6 cm. 8 flaps were pedicled distally based reverse sural artery flaps 3 were islanded.

Case 1 distally based Reverse sural artery flap for a post traumatic heel pad defect

<table>
<tr><td>  </td><td>  </td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td colspan="2">1 cm distal marginal necrosis of flap</td></tr>
</table>

	Well settled flap

CASE 2 Islanded Reverse sural artery flap for a traumatic heel pad defect

	
Well settled flap	

Medial plantar artery flaps were harvested under tourniquet with lower limb flexed at knee with foot elevated. Confirming the clinical patency of posterior tibial vessels, the fasciocutaneous flap raised by making an incision parallel to abductor hallucis muscle raising superficial to flexor hallucis muscle including the medial plantar vascular pedicle between them. The abductor hallucis muscle was divided proximally to mobilize pedicle and the flap sutured to heel defect after securing hemostasis. The donor area split skin grafted.

Of the 20 cases, 5 pedicled medial plantar artery flaps and 3 islanded medial plantar flaps performed for small to medium sized defects ranging from 4 x 3 cm to 8 x 6 cm. 5 were post traumatic defects, 1 post infective defect, 1 neuropathic heel pad defect, 1 was a case of biopsy proved malignant melanoma of 3 x 3 cm lesion over heel pad. Wide local excision of lesion with 2 cm margin done, sent for histopathological examination and defect resurfaced

with islanded MPA flap. Groin nodes were negative. Patient is being followed up regularly. All flaps settled well. 1 case had venous congestion which settled conservatively. Donor area settled well.

Case 3 Pedicled Medial Plantar Artery Flap


Neuropathic heel pad defect


Well settled flap

CASE 4 Islanded medial plantar artery flap for posttraumatic defect


Well settled flap

CASE 5 Islanded Medial plantar artery flap

	
Malignant melanoma of heel pad	**Islanded instep flap**

Distally based posterior tibial artery cross leg flap based on opposite leg posterior tibial vessels was performed in prone position in 1 case with weight large weight bearing heel defect with post traumatic avulsion injury of ipsilateral leg. With an exploratory incision the perforator was identified. Planning in reverse done keeping in view bridge segment along the axis of posterior tibial vessels .The base of fasciocutaneous flap raised, could then be sufficiently narrowed which helps to avoid kinking of the pedicle and attain better range of rotation of flap. With 9 cm perforator as pivot point, flap marked, raised, inset into defect. Donor area split, skin grafted. Limbs immobilized with Plaster of Paris cast with legs crossed for 3 weeks. Regular physiotherapy was done. Flap was divided after 3 weeks,

CASE 6

		
Cross leg flap		

RESULTS

The study included 15 males & 5 females with mean age 34.7, involving right heel in 16 cases, & left heel in 4 cases. The etiology of the heel defects were trauma in 13 cases, burns in 2 cases, electric contact burn in 1 case, chronic ulcers in 2 cases who were diabetic, malignancy (malignant melanoma) in 1 case and neuropathic ulcer in 1 case. The defect size ranged from 4 cm to 20 cm. The flaps used were distally based Reverse sural artery neuro cutaneous flap in 8 cases, islanded RSA flap in 3 cases, pedicled MPA flap in 5 cases, islanded MPA flap in 3 cases , cross leg faciocutaneous flap in 1 case .

The weight wearing heel defects were thoroughly debrided, flaps planned and executed. pedicled distally based Reverse sural artery neuro cutaneous flaps were performed in 8 cases & Islanded RSA flaps were done in 3 cases to resurface weight bearing large heel defects. Donor areas were split skin grafted.

Pedicled medial plantar artery flaps were done for 5 cases and 3 islanded MPA flaps were done to cover weight bearing heel defects. Cross leg flap was done in 1 case of posttraumatic defect of heel pad as the same limb had circumferential raw area of leg which was grafted.

Pedicled flap division was done after 3 weeks for pedicled flaps. All 20 flaps survived. Among 11 RSA flaps, 1 case of RSA flap had distal 1 cm flap marginal necrosis which was managed with excision and secondary suturing at the time of flap division. Donor areas of RSA flaps healed well except for 1 case of where small area of donor area healed with conservative management. 50% of cases of RSA flap complained of paraesthesias along lateral border of foot.

2 patients with RSA flaps complained of bulkiness of flap for which flap thinning was advised. All flaps settled well and were able to bear weight after 12 weeks. They were asked to wear proper foot wear and be on regular follow up.

All cases of 8 Medial plantar artery flaps survived. 1 case of medial plantar artery flap had venous congestion which settled after suture removal of distal suture and conservative management. 1 case had hypertrophic scar of donor area which was managed with scar massages. All cases were able to bear weight after 8 weeks with proper foot wear and flaps are being followed regularly for follow up and sensation.

1 case of cross leg flap had distal venous congestion, superficial epidermal loss of distal 1 cm of flap which healed with conservative dressings. Flap division was done after 3 weeks. Flap settled well, patient is able to bear weight after 12 weeks and is on follow up.
All flaps were stable and patients could bear weight after 8-12 weeks.

Male Female

Male	15
female	5
Table 1- Sex distribution of heel defects.	

RT /Left

Right heel	16
Left heel	4
Table 2- Side of heel defect	

FLAPS

Pedicled Reverse Sural Artery Flaps	8
Islanded Reverse Sural Artery Flaps	3
Pedicled Medial Plantar Artery Flaps	5
Islanded Medial Plantar Artery Flaps	3
Cross Leg Flap	1
Table 3- Flaps used to cover weight bearing heel defects	

Etiology

Trauma	13
Burns	2
Electric burn	1
Chronic ulcers	2
Neuropathic Ulcer Malignancy1	11

Table 4- Etiology of weight bearing heel defects.

Heel Reconstruction

Serial no.	**Etiology of heel defect**	**Size of defect**	**Age / sex**	**Associated injury**	**Flap performed**	**Size of flap**	**Flap delay or division**	**Complications management**
1.	Trauma	6 x 8 cm	20y/M	Calcaneal fracture	Pedicled RSA flap	12x 8cm	Division after 3 weeks	nil
2.	Trauma	16 x 20 c m	31y/M	-	Pedicled RSA flap	20x12c m	Division 3 weeks	nil
3.	Trauma	12 x 8 cm	22y/M	nil	Islanded RSA flap	12x8cm	-	-
4.	Trauma	7 x 4 cm	35y/F	-	Islanded medial plantar artery flap	8x4 cm	-	-
5.	Trauma	4 x 5 cm	30y/M	-	Pedicled medial plantar artery flap	6x5 cm	-	-
6.	Trauma	10 x 6 cm	28y/M	Calcaneal fracture	Islanded RSA flap	10x6cm	-	-
7.	Trauma	7 x 5 cm	24y/M	-	Pedicled medial plantar artery flap	9x7 cm	-	-
8.	Trauma	8 x 6 cm	20y/M	-	Islanded medial plantar artery flap	8x6 cm	-	-
9.	Trauma	12 x 10 cm	25y/F	-	Islanded RSA flap	13x 11cm	-	-
10.	Trauma	9 x 7 cm	28y/M	nil	Crossleg flap	16x9cm	Division 3 weeks	Venous congestion, suerficial epidermal necrosis
11.	Trauma	10 x 13 cm	50y/F	**nil**	Pedicled RSA flap	16x 12 cm	Division 3 weeks	1. Venous congestion, marginal necrosis 2. Excision

								and suturing
12.	Trauma	8 x 7 cm	34y/F	**nil**	Pedicled RSA flap	10x8 cm	Division 3 weeks	-
13.	Trauma	9 x 6 cm	33y/M	**nil**	Pedicled RSA flap	12x8 cm	-	-
14.	Burns	5 x 6 cm	27y/M	nil	Pedicled medial plantar artery flap	8x6 cm	-	-
15.	Burns	14 x 7 cm	36y/M	**nil**	Pedicled RSA flap	18x8 cm	Division 3 weeks	-
16.	Electric burn	12 x 5 cm	60y/M	-	Pedicled RSA flap	17x5 cm	Division 3 weeks	-
17.	Infective	7 x 4 cm	56y/F	-	Pedicled medial plantar artery flap	8 x 5 cm	-	
18.	Infective	8 x 8 cm	60y/M	-	Pedicled RSA flap	14x8cm	-	-
19.	Neuropathy	4 x 3 cm	30y/M	-	Pedicled medial plantar artery flap	7x4 cm	-	Venous congestion
20.	Malignancy (malignant melanoma)	8 x 6 cm	45y/M	-	Islanded medial plantar artery flap	8x6 cm	-	-

Table 5 – Details of reconstruction of weight bearing heel defects.

Sl. No.	Complications	RSA Flap	MPA flap	Crossleg flap
1	Venous congestion	1	1	1
2	Marginal necrosis	1	-	-
3	Flap loss	-	-	-
4	hematoma	-	-	-
5	Bulky flap	2	-	-
6	Graft loss donor area	Minimal loss 1 case	-	-
7	Donor site hypertrophic scar	-	1	-
8	Paraesthesia along lateral border of foot	Yes (50%)	-	-

Table 6- Table showing complications of flaps used.

DISCUSSION

The heel is important for weight distribution when walking and running and it also helps to absorb shock. The sole of foot is covered by a layer of subcutaneous connective tissue up to 2 cm thickness under the heel which contains septa firmly attached to both periosteum of calcaneum to plantar aponeurosis The sole of foot is highly vascular with abundant blood vessels further stabilizing the septa.

Reconstruction of weight bearing heel defects with the aim to restore stable, durable, reliable cover, enabling the patient to walk normally and wear foot wear has always been

challenging for the plastic surgeons. This is because of the paucity of local tissue availability to match the special characteristics of the heel.

Various options have been used for resurfacing weight bearing heel defects like split thickness skin grafting, Reverse sural artery flap, instep artery flap, lateral supramalleolar flap , Lateral calcaneal artery flap, Flexor digitorum brevis flap, cross leg flap and different free flaps like gracilis muscle flap, radial forearm flap, Anterolateral thigh flap, Lattissimus dorsi flap.

Skin grafts [6], are the simplest option used in resurfacing weight bearing heel defects. They are split skin grafting, full thickness skin grafting, dermal auto grafts or dermal substitutes. They are relatively simple, no donor site morbidity, and rapid recovery. However they are thin, insensate , prone for loss because of repeated wear and tear and sheering forces while walking and do not provide a stable soft tissue cover.

Loco-regional flaps harvested from foot \leg based on the fasciocutaneous perforators from ipsilateral \contralateral leg are important armamentarium in the reconstruction of weight bearing heel defects. The various flap options are myocutaneous flap [7], local flaps like transposition, rotation, v-y [8] flap, Reverse sural artery flap [9], medial plantar artery flap [10], cross leg flaps and free flaps [11].

Loco-regional flaps are easily available in the vicinity of the defect, most of the times available in isolated heel injury, there is no need to sacrifice major vessels, the donor area is split skin grafted and easily hidden under clothing.

There is no need for microscope, is always an option where there are no microsurgical equipment. They always give a stable cover and cushion over weight bearing heel to give stable durable cover restoring normal weight bearing and walking.

In 1 case due to ipsilateral lower leg soft tissue avulsion of skin, we did a cross leg flap based on faciocutaneous perforators from posterior tibial vessels from opposite leg and this option is reserved for exceptional case, though immobilization and positioning of patient is difficult.

The Reverse sural artery neuro cutaneous flap is indicated in heel defects reconstruction especially large defects and those encroaching on to the vascular territory of instep flap. A large flap can be harvested on a long malleable pedicle from posterior aspect of leg which provides good cushion to the heel. It gives a durable, well vascularized cover to the weight bearing heel.

Understanding the arterial and venous anatomy of distally based sural artery flap is the key to maximizing its reliability and safety [12]. Reverse sural Artery flap is a fasciocutaneous paddle from calf based on the vascular network around the sural nerve, short saphenous vein, and sural nerve in communication with the lowest two perforators of peroneal artery. The reverse flow described by Masquelet et al [13] is based on the anastomosis between sural artery and a perforator from the peroneal artery, either directly or through the interlacing vascular network behind the lateral malleolus .The septocutaneous perforators of peroneal artery emerge between flexor hallucis longus and soleus at one side and peroneus brevis on the other side starting 5- 7 cm above tip of lateral malleolus [14] and extending proximally 13 cm above the lateral malleolus.

The advantages of RSA flap are it is relatively simple and easy to perform, versatile with wide arc of rotation, needs very little expertise, safe, reliable with axial pattern vascular supply. There is no sacrifice of the principal vascular axis with anatomic constancy of the neurovascular axis. The cut paddle of RSA flap is large and can cover over 180 cm^2. The length of pedicle conferring a rotational arch that defines its performance. The donor site morbidity is minimal and long term complications are few. The primary complication of this neuro cutaneous flap is venous drainage and compression of pedicle because of tunneling is one cause. The other disadvantage is flap necrosis in 15 % cases.

The other drawbacks of RSA flap are anesthesia of external border of foot because of sacrifice of sural nerve, scar at donor site, bulky flap which requires flap thinning and it is

insensate.

Various flaps used in the study are, Pedicled distally based reverse sural artery neuro cutaneous flaps done in 8 cases, Islanded RSA flap in 3 cases. No delays were done. Out of 20 cases, 8 cases of pedicled RSA and 3 cases of islanded distally based reverse sural artery neuro cutaneous flaps were performed for weight bearing heel defects. 8 cases were male, 3 cases were females. Road traffic accidents with heel pad avulsion were 8 cases with 2 cases had associated calcaneal fractures, electric burn defect 2 and chronic ulcer 1, post burn defect. Out of 11 flaps, associated calcaneal fracture was seen in 2 cases. The dimensions of the flap ranged from 8 to 20 cm in length and 4 to 12 cm in width. 1 case had venous congestion and distal 1 cm flap necrosis which was managed by excision and suturing. Presence of valves in short saphenous vein prevents retrograde blood flow leading to continuous ingress to the flap without egress. The incidence of partial or complete necrosis reported in various studies by Yilmaz et al is 12 %,[15] Hasgawa et al 5%,[16] Rajiaac et al 14 %,[17] Touam et al 5%,[18] and Fraccalvieert et al 17%.[19] In our study the complication rate is 18.18%.

In our study large flap with lengthy pedicled had higher incidence of venous congestion. Baumeister et al reported higher complication in chronic wound. Donor site healed well except 1 case which had a small raw area which healed conservatively. 50% of patients complained of pareasthesia. Flap division was done after 3 weeks. Patient was ambulant after 12 weeks.

Medial plantar artery flap transfers non- weight bearing medial plantar glabrous skin of the foot to the heel. The flap provides pliable, vascularized sensate tissue for weight bearing. This faciocutaneous flap is based on superficial branch of medial plantar artery [20] pedicle found between abductor hallucis and flexor digitorum brevis muscles along with venae commitantes. The medial plantar nerve is routinely dissected along with the flap for an immediate sensate flap without the need for nerve cooptation. The donor area is split skin grafted. 6 males and 3 female patients were included in the study to cover weight bearing heel defects. The mean age was 28.2 years. The average flap size was 8 x 4.5 cm. 4 cases were traumatic, 1 case of burn defect [1], diabetic chronic ulcer, 1 case of malignant melanoma heel, 1 neuropathic ulcer over heel [5]. Pedicled instep flaps and 3 islanded instep flaps were successfully performed for weight bearing heel defects. In our study, 1 case had venous congestion which settled conservatively. All flaps settled well. Graft settled well. Hypertrophic scar was there in 1 patient in the donor area, which was managed with scar message for 3 months. Patient was allowed partial weight bearing after 6 weeks, full weight bearing after 8 weeks. These results are close to the study conducted by Opoku-Agyeman [20] which reports high flap survival rate (98%), low minor complications (9.4%) and low donor site complications (5.2%).

Rashid et al. [21] compared medial plantar artery flap with sural artery flap for heel reconstruction and found that instep flap is was associated with earlier weight-bearing and lesser complications than sural artery flap. Patients returned to work at 8 weeks while it took 12 weeks with sural artery flap. The advantage being instep skin is glabrous and similar to the heel skin as compared to any other flap. A similar results of study by Siddique et al [21] who studied instep island flaps for 14 years, was found in our study with good contour of heel with glabrous skin with minimum donor site morbidity.

Both the regional fasciocutaneous flaps, Reverse sural flap and medial plantar artery flap can resurface heel defects up to 338 cm^2 and 90 cm^2 respectively.

Cross leg flap was described first by Hamilton in 1854 and later has been used to cover defects of leg and foot defects in almost all possible locations [22]. In cases of severe poly-trauma, patient may not be fit to undergo prolonged surgery and cross-leg flap provides a simpler means of providing wound cover. This flap is an alternative to free flap where microsurgical facilities are not available. There are many varieties of cross leg flaps depending on the location of defect and availability of the vascular pedicle. Posterior tibial artery

perforator flap cross leg can be raised as distally based [22-25], superior based flap based on the PTA perforators located in the middle one-third of the leg [26] and whole leg CL flap based on the septocutaneous perforators of the PTA emerging between the soleus and flexor digitorum longus muscles. Lu et al described the use of cross-leg flap as the first choice flap in preference to free flap in their series of 56 patients with lower extremity trauma [27].

In 1 case, we performed Cross-leg flap to cover large heel defect a post traumatic avulsion injury with ipsilateral avulsion of lower leg skin where all local flap options are not available. We performed a cross leg posterior tibial artery flap artery flap. Postoperatively, distal venous congestion was seen which resulted in superficial epidermal necrosis of distal 1 cm which settled conservatively. It does carry significant morbidity as it is a staged procedure and as the patient is immobilized with both legs attached with each other by the flap, for more than 3 weeks [28], flap division was done after 4 weeks and inset given. Flap settled well. Patient started weight bearing after 14 weeks.

Most of the flaps in the study are post traumatic weight bearing heel defects. Depending on the size, vascular pedicle availability, and also status of ipsilateral lower limb skin [23] and patency of posterior tibial artery and medial plantar artery, we performed 3 types of flaps to cover weight bearing heel defects, medial plantar artery sensate flap, distally based reverse sural artery flap, cross leg flap.

In cases with intact posterior tibial artery and medial plantar artery, intact instep area we performed medial plantar artery flap to cover small to moderate heel defects (3 to 8 cm). The flaps settled well with minimum donor site morbidity, maintaining good contour of heel with early return of sensation, allowing normal weight bearing and restoring normal gait. In cases with large heel defects requiring large skin paddles to resurface heel pad defects and those defects encroaching on to the medial plantar artery vascular territory with intact skin of calf, distally based reverse sural artery flaps were performed. The flaps provide bulk to heel, enabling normal weight bearing and gait, however the disadvantages being bulk of flap, unable to wear proper foot wear, frequent growth of hair which requires trimming.

Cross leg fasciocutaneous flap is still an option when ipsilateral loco-regional options are not available, and there are no facilities to conduct microvascular free flaps. Flap survival was comparable with other series in all these three types of flaps [29].

CONCLUSION

In our study, we have used distally based reverse sural artery flaps, Medial plantar artery flap, and distally based cross leg posterior tibial artery perforator flap, in weight bearing heel pad defects reconstruction. Medial plantar artery flap is best suitable for small to moderate heel pad defects, provide sensate glabrous skin, non-bulky and helps in early weight bearing restoring normal gait. The distally based reverse sural artery flap are best for moderate to large heel pad defects, gives good bulk to weight bearing heel enabling weight bearing though insensate. Cross leg flap still a good choice when other ipsilateral loco-regional options are not available. All types of these flaps showed good to excellent recovery. For long-term results, these patients should wear proper footwear and to be followed up regularly.

REFERENCES

[1] Baumeister S, Germann G.Soft tissue coverage of the extremely traumatised foot and ankle. Foot Ankle Clin 2001;6(4):867-903.
[2] Liang W, Tan BK. Use of cross-leg distally based surak artery flap for the reconstruction of complex lower extremity defects. Arch Plast Surg 2019;46(3):255-61.
[3] Gang RK. Reconstruction of soft tissue defect of of the posterior heel with lateral

calcaneal artery island flap. Plast Reconstr Surg 1987;79(3):415-421.
[4] Tee R, Jeng SF, Chen CC. The medial sural artery perforator pedicled propellar flap for coverage of middle -third leg defects. J Plast Reconstr Aesthet Surg 2019;72(12):1971- 8.
[5] Roblin P, Heay CM.Heel reconstruction with a medial plantar V-Y flsp.Plast Reconstr Surg 2007;119(3):927-32.
[6] Singh K, Kundu ZS, Singh B, et al. Heel defect reconstruction using local vascularised flaps:results and clinical outcomes in 16 patients.J Foot Ankle Surg (Asia-Pacific) 2018;4(3):16-20.
[7] Saltz RH Ochberg J, Givens KS. Muscle and musculocutaneous flaps of the foot.Clin Plast Surg 1991;18(3):627-38.
[8] Masquelet AC, Romana MC, Wolf G. Skin island flaps supplied by vascular axis of the sensitive superficial nerves: anatomic study and clinical experience in the leg. Plast Reconstr Surg 1992;89(6):1115-21.
[9] El-Shazly M, Yassin O, Kamal A. Soft tissue defects of the heel: a surgical reconstruction algorithm based on a retrospective cohort study. J Foot Ankle Surg 2008;47(2):145-52.
[10] Opoku-Agyeman JL, Allen A, Humenansky K. The use of local medial plantar artery flap for heel reconstruction: a systematic review. Cureus 2020;12(8):e9880.
[11] Ring A, Kirchhoff P, Goertz O, et al. Reconstruction of soft-tissue defects at the foot and ankle after oncological resection. Front Surg 2016;3:15.
[12] Follmar KE, Baccarani A, Baumeister SP, Levin LS, Erdmann D.The distally based sural flap. Plast Reconstr Surg 2007;119(6):138e-48
[13] Masquelet AC, Romana MC, Wolf G. Skin island flaps supplied by vascular axis of the zsensitive superficial nerves:Anatomic study and clinical experience in the leg. Plast Reconstr Surg 1992;89;1115-21.
[14] Jeng SF, Wei FC, Kuo YR. Salvage of the distal foot using the distally – based sural island flap.Ann Plast Surg 1999;43:499-505.
[15] Yilmaz M, Karatas O, Barutcu A. The distally based superficial sural artery island flap: Clinical experience and modifications. Plast Reconst Surg 1998;102:2358.
[16] Hasegawa M. The distally based superficial sural artery flap. Past Reconstr Surg 93:1012,1994.
[17] Rajajic N, Ganf RK, Darweesh M, Abdul Fetah N, Kojic S. Reconstruction of soft tissue defects around knee with use of lateral sural fasciocutaneous artery island flap. Eur J Plast Surg 1999;22(1):12-6.
[18] Touam C, Rostoucher P, Bhatia A, Oberlin C. Comparative study of two series of distally based fasciocutaneous flaps for coverage of the lower one- fourth of the leg, the ankle, and the foot. Plast Reconst Surg 2001;107(2);383-92.
[19] Fraccalvieri M, Verna G, Dolcet M, Fava R, Rivarossa A, Robotti E, Bruschi S, The distally- based superficial sural flap ; our experience in reconstructing the lower leg and foor. Ann Plast Surg 2000;45:132-9.
[20] Opoku-Agyeman JL, Allen A, Humenansky K. The use of local medial plantar artery flap for heel reconstruction: a systematic review. Cureus 2020;12(8):e9880.
[21] Rashid M, Hussain SS, Illahi I. A comparison of two fasciocutaneous flaps in the reconstruction of the weight-bearing heel. J Coll Physicians Surg Pak 2003;13(4):216-8.
[22] Sharma RK, Kola G. Cross leg posterior tibial artery fasciocutaneous island flap for reconstruction of lower leg defects. Br J Plast Surg 1992;45(01):62-5.
[23] Georgescu AV, Irina C, Ileana M. Cross-leg tibial posterior perforator flap. Microsurgery 2007;27(5):379-83.
[24] Demiralp CÖ, Akkaya H, Duman Y, Armangil M, Demirseren ME. Reconstruction of traumatic lower extremity soft tissue defects with the combination of ipsilateral and contralateral perforator flaps. Int J Low Extrem Wounds 2012;11(4):304-6.

[25] Giraldo F, García MD, De Grado J, González C, Rus JA. The injured foot: Cutaneous coverage with a distally based posterior tibial cross leg flap. Br J Plast Surg 1996;49(2):115-8.
[26] Percival N J, Sykes P J, Earley M J. Free flap surgery: the Welsh Regional Unit experience. Br J Plast Surg 1989;42(04):435-40.
[27] Lu L, Liu A, Zhu L, Zhang J, Zhu X, Jiang H. Cross-leg flaps: our preferred alternative to free flaps in the treatment of complex traumatic lower extremity wounds. J Am Coll Surg 2013;217(03):461-71.
[28] Siddiqi MA, Hafeez K, Cheema TA, et al. The medial plantar artery flap: a series of cases over 14 years. J Foot Ankle Surg 2012;51(6):790-4.
[29] Kalam MA, Faruqee SR, Rahman SA, Uddin HN. Reconstruction of heel: options and strategies. Bangladesh J Plast Surg 2010;1(1):14-8.