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LOCO-REGIONAL RECONSTRUCTIVE OPTIONS FOR HEEL DEFECTS

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Abstract

BACKGROUND: *The main aim to reconstruction of heel defect is weight bearing capability and sensory recovery. From different options, the choice of flap used depends on site and size of defect, donor area availability.*

OBJECTIVE: *The objective of this article is to see the suitability of different loco-regional flaps for heel defects considering flap characteristics meeting the requirements of this critical weight bearing area.*

MATERIAL AND METHODS: *Study design used is case series in which 20 patients having heel defects are included from July 2022 to July 2023 in which different flaps (medial planter artery flap, reverse sural flap, local random pattern flap) are used for the reconstruction. The outcome would be seen in terms of flap survival, recovery of sensation, the durability of coverage and function. Selection criteria: Inclusive criteria included patients with all heel defects, both genders, all ages, ambulant patients, While, exclusive criteria excluded patients that are bed ridden patients, poor life expectancy / outcome. Sampling method was convenience sampling. Data analysis was done using SPSS version 20.*

RESULTS: *A total of 20 patients were taken in study 15 were males and 5 were female. Only 16 patients developed protective sensation, with a mean recovery time of 9.6 months (ranging from 8 to 14 months). Two cases of medial plantar artery flaps (used after tumor excision) and two cases of heel advancement flaps (used for posterior defects) demonstrated touch sensation at an average of 4.75 months (ranging from 11 to 12 months).The return of protective sensation and the mean AOFAS subjective score were notably higher in the non-neuropathic ulcer group.*

CONCLUSION: *One of the common causes of heel defects especially in children in spoke wheel injury. To cover this defect locoregional flaps can be used with a satisfactory outcome. Among them reverse sural artery flap is a reliable option to cover most of the heel defects along with MPA depending upon the site of defect.*

INTRODUCTION

Reconstruction of heel defects is really challenging as it needs coverage with a sensate and durable tissue. As heel is the weight bearing part of body and undergo repetitive trauma, heel defects are very common in our population[1]. One of the most common cause of heel defects in children is spoke wheel injury (occurring

due to foot entrapment in the rotating spokes of bicycle or motorbike vehicle.

Heel is a specialized tissue having a thick epidermis and dermis with perpendicular fibrous septa firmly anchoring the dermis/epidermis to planter aponeurosis to prevent shearing. Apart from this it contains fat loculi in between which acts as shock absorber[2][3].Defect in heel area can result from multiple factors like trauma, may include avulsion injury of heel including total loss or isolated posterior heel, associated with the exposed Achilles tendon or calcaneal bone fracture, trophic ulcer, tumor excision etc[4][5].The other factors that cause defects in the area of heel may include burns, trauma, excision tumor, and also trophic ulcers. Secondary amputation may be led by superadded infections[6][7].

While, anterior weight bearing part of the heel is most commonly involved in Neurogenic ulcers and tumors. On the other hand, Neurogenic ulcers in patients with several neuropathies such as syringomyelia, diabetic neuropathies, hanson's disease, traumatic nerve injuries, spina bifida and others. In these patients the protective sensation is lost and over pressure points they do not relieve pressure intermittently, so it caused the breakdown of the skin and ulceration because of repetitive trauma[8].

There are various tools to access the overall function of foot and among them American Orthopaedic Foot and Ankle Society(AOFAS) Ankle-Hindfoot clinical ratings scale to objectively and subjectively assess the foot function will be used here.

The AOFAS score takes into consideration pain(40 points), function(50) and alignment(10), higher the score, better the ankle function.

Reconstruction of heel is difficult due to poor vascularity, limited tissue mobility and need for robust coverage that is resistant to shear forces.Local flaps as skin grafts, cross-leg flap provide an effective solution for heel defect reconstruction, offering reliable coverage while preserving limb function[9]. However, coverage with a similar tissue is challenging because of limited availability of glabrous local tissue.

This article explores loco-regional reconstructive options for heel reconstruction.

Loco-regional flaps that can be used for this purpose include v-y advancement flaps, random pattern, peroneal artery perforator flaps, reverse sural artery and medial planter artery flaps etc.

MATERIAL AND METHODS

A case series study design was used in this study. A total of 20 patients were taken as a sample size and patients having heel defects are included from the duration of July 2022 to July 2023 in which different flaps (medial planter artery flap, reverse sural flap, local random pattern flap) are used for the reconstruction, and the study was continued after informed consent from the patients involved in the study. The outcome was seen in terms of flap survival, recovery of sensation, the durability of coverage and of function. Selection criteria of the study included inclusion criteria and excluded exclusion criteria. Inclusive criteria included patients with all heel defects, both genders (male, female), all the ages, ambulant patients, While, exclusive criteria excluded patients who were bed ridden patients, patients with poor life expectancy / outcome. Patients data including defect size, location of the defect, age, sex, etiology were recorded. Debridement, daily dressing and antibiotic coverage prepare the wounds according to the wound swab culture report.Loco-regional flaps that can be used for this purpose include v-y advancement flaps, random pattern, peroneal artery perforator flaps, reverse sural artery and medial planter artery flaps etc to cover posterior heel region.

At the anterior heel region Medial Plantar Artery flaps were used to cover moderate size defects. To confirm the presence of Medial Plantar Artery handheld Doppler was used preoperatively. The concept of the medial plantar artery (MPA) islanded flap was first introduced by Harrison and Morgan [12], where they described elevating the flap along with the distal segment of the medial plantar artery after dividing it. In the current technique, however, all MPA flaps were raised using the superficial subcutaneous branch of the medial plantar artery, preserving the continuity of the main vessel. This approach was performed under spinal block anesthesia, utilizing tourniquet control and loop magnification for precision, as outlined in previous literature[13]. One of the key advantages of this method is that it avoids sacrificing the medial plantar artery, thereby maintaining its vascular integrity. When the plantar sensation was intact, the cutaneous nerve was included in the flap to preserve sensory function. Following flap dissection, a separate incision was made through the healthy skin bridging the donor and recipient sites to allow for smooth transposition of the flap. This was then carefully sutured into place after insetting. The donor site was managed using a split-thickness skin graft. Postoperatively, the ankle joint was immobilized with a dorsal splint until successful graft take-up was achieved.

Extended reverse sural artery (RSA) flaps were utilized to reconstruct full-thickness heel defects and were also employed for anterior heel coverage in cases where the medial plantar artery flap was not a viable option. For posterior heel wounds without avulsion and those extending to the region of the Achilles tendon, conventional islanded RSA flaps with a pedicle width of approximately 4 cm were used.The extended RSA flap was executed in two stages, following the technique described by [14], and performed under spinal anesthesia with the aid of a tourniquet. In the initial stage, the flap was outlined along the upper third of the calf, keeping its uppermost border within 4–5 cm below the popliteal crease. Elevation of the flap was carried out in a proximal-to-distal direction, deep to the fascia, including the short saphenous vein and the sural nerve within the dissection. The pivot point for flap rotation was located approximately 5 cm above the tip of the lateral malleolus, with the fasciocutaneous pedicle maintained at about 5 cm in width, spanning the area between the posterior border of the fibula and the midline of the Achilles tendon. Once the flap was raised, it was used as an interpositional flap to cover the defect. Donor sites were managed with a split-thickness skin graft. The ankle was immobilized using a dorsal splint until flap division. To prevent pressure on the pedicle, the patient was positioned in a contralateral decubitus posture. The second stage, which included division of the flap and final insetting, was performed three weeks later, after the delay phase, and the pedicle was then returned to the donor site.

Across all patients, weight-bearing was permitted four weeks after complete suture removal. Objective evaluation of the surgical outcomes included flap viability, sensory return, and the durability of soft tissue coverage.

Functional outcomes such as limitations in physical activity, walking distance and surfaces, and pain levels were assessed using the subjective component of the American Orthopaedic Foot and Ankle Society (AOFAS) hindfoot clinical rating scale (Table 1).[10,15,16]To evaluate sensory recovery at the flap site, the Semmes-Weinstein monofilament test was used with three different monofilament sizes: size 6.65 (300 g) to assess deep sensation, size 4.31 (2 g) for protective sensation, and size 3.61 (0.4 g) to test for normal touch sensitivity.[10,17] Additionally, soft tissue breakdown was monitored clinically to determine the long-term durability of the reconstruction.

Ankle–hindfoot scale

Parameter	Points
Pain (40 points)	
None	40
Mild	30
Moderate	20
Severe	0
Function (50 points)	
Activity limitations	
None	10
Limitations on recreational activities	7
Some limitations on daily and recreational activities	4
Severe limitations on daily and recreational activities	0
Maximum continuous walking distance	
600m or more	5
400 m to less than 600m	4
100 m to less than 400m	2
Less than 100m	0
Walking surfaces	
No difficulty on any surface	5
Some difficulty on uneven terrain, stairs, inclines	3
Severe difficulty or inability to walk on uneven terrain, stairs, inclines	0
Gait abnormality	
None or slight	8
Obvious (walking possible but gait abnormality obvious)	4
Marked (walking difficult and gait abnormality obvious)	0
Sagittal motion (flexion plus extension)	
Normal or mild restriction (30° or more)	8
Moderate restriction (15°–29°)	4
Severe restriction (less than 15°)	0
Hindfoot motion (inversion plus eversion)	
Normal or mild restriction (75%–100% normal)	6
Moderate restriction (25%–74% normal)	3
Severe restriction (less than 25% normal)	0
Ankle-hindfoot stability (anterior drawer, varus-valgus stress)	
Stable	8
Unstable	0
Alignment (10 points)	
Good, plantigrade foot, well aligned	10
Fair, plantigrade foot, mild to moderate degree of malalignment	5
Poor, nonplantigrade foot, severe malalignment	0

Sampling technique in sampling method was convenience sampling technique which was used. Data analysis was done using SPSS version 20.For quantitative variables like age, mean and SD were calculated. For qualitative variables like gender, frequency and percentage were calculated. Data was stratified age, gender. Chi-Square test was used post-stratification. P-Value of equal or less than 0.05 was considered significant.

RESULTS

A comprehensive analysis was conducted on 20 patients with heel defects. Of these, 15 were male and 5 were female, resulting in a male-to-female ratio of 3:1. The average age of the participants was 45.37 years, with ages spanning from 1 to 60 years. The most prevalent cause of heel defects was traumatic injury, accounting for 51.3% (11 cases), followed by neuropathic ulcers (29%, 5 cases), burn injuries (6.9%, 3 cases), and malignancy (4%, 1 case). Osteomyelitis of the calcaneus was noted in 4 of the defects.

Table 1 : Etiology and Location of Defect

Etiology of Defect	
Neuropathic	5 (29%)
Trauma	11 (51.3%)
Thermal	5 (8.5%)
Malignancy	3 (6.9%)
Contact	1 (4%)
Location of the Defect	
Anterior	8 (40%)
Posterior	4 (20%)
Complete	8 (40%)

Various flap types were used for heel defect coverage, and their outcomes were evaluated. Among the 16 extended reverse sural artery (RSA) flaps, 12 were used for covering complete heel defects, while 4 were employed for anterior heel defects. Of the 6 islanded RSA flaps, 2 were applied to isolated posterior heel defects, and 4 were used for posterior defects extending to the Achilles tendon region. Additionally, 6 local flaps were performed, with 4 addressing anterior defects and 2 heel advancement flaps utilized for posterior defects. Both free latissimus dorsi (LD) muscle flaps and cross-leg flaps were used for the reconstruction of complete heel defects.

The majority of flaps successfully survived, with the exception of one local rotation flap and one extended RSA flap, both of which experienced marginal necrosis. The tip necrosis of the rotation flap was treated with debridement and subsequent secondary suturing, while the marginal necrosis of the extended RSA flap was managed through secondary healing. Most of the flaps remained healthy during the average follow-up period of 15 months (ranging from 12 to 20 months), except in four cases of extended sural flaps and two cases of medial plantar artery flaps, where ulceration occurred at the flap margins. These ulcers were treated with regular dressings.All patients regained deep sensation, with an average recovery time of 5.8 months (ranging from 3 to 8 months).

Table 2 : Neuropathic and Non-Neuropathic Heel Defect

Group	Delayed Ulceration	Protective Sensation Return	Mean AOFAS Score and Range
Neuropathic	2(22%)	3(32.2%)	40 ± 11.8
Non-Neuropathic	2(11.4%)	23(76.4%)	45.3 ± 7.5
P-Value	0.220	0.004	0.03

However, only 16 patients developed protective sensation, with a mean recovery time of 9.6 months (ranging from 8 to 14 months). Two cases of medial plantar artery flaps (used after tumor excision) and two cases of heel advancement flaps (used for posterior defects) demonstrated touch sensation at an average of 4.75 months (ranging from 11 to 12 months).The return of protective sensation and the mean AOFAS subjective score were notably higher in the non-neuropathic ulcer group.

DISCUSSION

The primary goal of heel defect reconstruction is to restore durable tissue that can support daily activities and endure the pressure of regular footwear [10]. Heel defects can be classified as anterior, posterior, or complete, depending on their location. Isolated anterior heel defects, particularly in weight-bearing areas, often result from neuropathies, tumor excision, or burn injuries [8][10]. Chronic anterior heel defects are frequently associated with osteomyelitis of the calcaneus and a foul-smelling discharge, which requires appropriate management during treatment.

For reconstructing defects in the anterior weight-bearing area of the heel, medial plantar artery and local flaps are preferred due to their thick epidermis and dermis, which closely resemble the skin of the heel [6][10][8]. Local flaps such as V-Y advancement, transposition, and rotation are typically limited to covering small anterior heel defects [8][11][12]. The medial plantar artery islanded flap is ideal for moderate-sized anterior defects, offering the best match in terms of durability and cosmetic appearance. In cases where trauma affects the instep or the course of the medial plantar artery, other regional options like distally based fascio-cutaneous flaps from the leg or free flaps may be used to reconstruct the weight-bearing region of the heel.

In our study, the majority of anterior heel defects were of neuropathic origin, with the remaining cases resulting from tumor excision and burn injuries. Small anterior heel defects were primarily covered using local suprafascial flaps such as rotation and V-Y advancement flaps. For moderate-sized defects, we preferred to use medial plantar artery (MPA) islanded flaps based on the superficial branch of the medial plantar artery, whenever feasible. In cases where the MPA flap was not viable, we opted for an extended reverse sural artery (RSA) flap with fasciocutaneous pedicle exteriorization to reconstruct anterior heel defects.

Although this technique involves a two-stage procedure, its main advantage over a single-stage sural flap is that it preserves the contour of the posterior heel, avoiding unnecessary scarring in the Achilles tendon area. This is particularly beneficial as scarring in this region can sometimes cause discomfort while walking and is also less cosmetically appealing.

Defects in the posterior, non-weight-bearing area of the heel, which may result from prolonged immobilization or traumatic avulsion injuries, do not require coverage with thick, glabrous plantar skin. These defects are often associated with calcaneus fractures or injuries to the Achilles tendon region [10][5]. When the wound is superficial, skin grafting is typically indicated. For deeper defects, especially those exposing the calcaneus or Achilles tendon, reverse sural artery (RSA) and lateral calcaneal artery flaps are commonly used, as reported in several studies [4][5][13]. In our cases, we successfully closed posterior heel defects resulting from avulsion injuries through debridement and advancement of the avulsed heel flap. For posterior heel defects without avulsion or those extending into the Achilles tendon region, islanded RSA flaps were used. In this study, conventional RSA flaps were employed for small-sized posterior defects, as the distance between the defect and the pivot point was minimal. This allowed the skin paddle to easily cover the defect in a single stage, since it lies along the suprafascial path of the sural nerve.

For the reconstruction of complete heel defects involving both the weight-bearing and non-weight-bearing areas, local fasciocutaneous flaps are often insufficient in size to cover the entire defect. As a result, alternative options such as reverse sural artery (RSA) flaps, distally based fasciocutaneous flaps, free fasciocutaneous or muscle flaps, cross-leg flaps, or a combination of two loco-regional flaps must be considered. Large heel defects are typically treated with free flaps, though these require specialized expertise and the necessary infrastructure for microsurgery. Conventional RSA flaps have a limited role in covering large and distal foot defects due to their defined territory and unpredictable outcomes [14][15]. Several modifications of the reverse sural

flap, such as flap delay, skin extension over the pedicle, and venous supercharging, have been described to reduce the risks of venous congestion and flap necrosis, as well as to increase the flap's coverage area [16][15][17]. These modifications have made the sural flap a reliable alternative to free tissue transfer for covering large foot defects, and in patients with comorbidities, it may even be the preferred choice.

We prefer the extended reverse sural artery (RSA) flap as the first choice for reconstructing complete heel defects due to its simplicity, safety, and relatively quick procedure, which does not require additional microsurgical techniques. The extended RSA flap can be performed in a single stage by splitting the area between the pivot point and the defect, or in two stages by exteriorizing the pedicle over the intervening area. Including skin over the pedicle offers several benefits, including enhanced blood supply and protection for the pedicle against traction and twisting [16][18][19]. We did not observe any venous congestion or significant flap necrosis using this technique, even when the flap extended to the midsole region. Although this technique requires a second surgery for pedicle division, extra wound care at the pedicle site, and donor site morbidity at the calf, it is generally well accepted by patients. In the two-stage flap procedure, during flap division and inset, the de-epithelialized portion of the pedicle can be used to fill any partial bony cavities, such as in cases of calcaneal osteomyelitis. Other techniques mentioned in the literature for filling partial bony cavities with soft tissue after calcaneal debridement include musculocutaneous sural artery flaps and combined muscle and skin flaps from the calf [20][21].

In all the patients, no skeletal abnormalities of the foot were observed. Delayed ulceration was noted in 2 out of 8 (25%) medial plantar artery (MPA) flaps and 4 out of 16 (25%) extended reverse sural artery (RSA) flaps in our study. Schwarz and Negrini reported delayed ulceration in 7 out of 50 (14%) MPA flaps used for heel reconstruction. Yucel et al. observed ulcer recurrence in 1 out of 20 cases when using free tissue transfer for sole and heel reconstruction. In a study focused on heel pad reconstruction, all seven cases showed successful flap survival with no ulcer formation during follow-up. J.-X. Gu and colleagues didn't report delayed ulceration in 11 MPA flap reconstructions, though none of these cases had a neuropathic cause. Benito-Ruiz and his team also didn't find recurrent ulcers in either MPA or reverse sural flaps used for heel soft tissue reconstruction after 1 to 2 years of follow-up. Other studies using reverse sural flaps for heel defects did not mention any recurrence of ulceration during follow-up either.

Regarding functional outcomes, we found no significant difference between the various flap techniques or between free and pedicled flaps in reconstructing the weight-bearing part of the sole. In our study, the highest mean AOFAS subjective score was seen with the islanded RSA flap used in posterior traumatic defects (54.66 out of 60 points), followed by local flaps for small anterior and posterior defects, which scored an average of 51.33 out of 60 points. The MPA flap, primarily used for neuropathic ulcers in our study, had a lower average score of 40.5 out of 60, compared to 57.3 out of 60 reported in other studies.

CONCLUSION

One of the common causes of heel defects especially in children in spoke wheel injury. To cover this defect locoregional flaps can be used with a satisfactory outcome. Among them reverse sural artery flap is a reliable option to cover most of the heel defects along with MPA depending upon the site of defect.

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