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Local Flap Reconstruction in Plantar Soft-Tissue Defects of the Foot: Surgical Outcomes from a Prospective Observational Study

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ABSTRACT:

Background: Plantar soft-tissue defects of the foot resulting from trauma, diabetic foot ulcers, infections, and post-oncological resections present significant reconstructive challenges because of limited local tissue availability, weight-bearing requirements, and the need for durable coverage. Local flaps provide a reliable reconstructive option while preserving function and achieving acceptable aesthetic outcomes.

Aim: To evaluate the effectiveness and outcomes of local flap reconstruction in plantar soft-tissue defects of the foot.

Materials and Methods: A prospective observational study was conducted among 30 patients with plantar soft-tissue defects of the foot managed using local flap reconstruction between December 2024 and December 2025. Flap selection was based on defect size, location, and vascular anatomy. Advancement, rotation, transposition, interpolation, propeller, and intrinsic muscle flaps were used. Patients with extensive composite defects, critical limb ischemia, active osteomyelitis, or peripheral vascular disease were excluded. Outcomes assessed included flap viability, complications, functional recovery, and patient satisfaction.

Results: Complete flap survival was observed in 26 patients (86.7%). Partial flap necrosis occurred in 4 patients (13.3%), and wound infection developed in 3 patients (10.0%). No total flap loss occurred. All complications were managed conservatively with antibiotics, wound care, and debridement when necessary. Most patients achieved stable wound coverage and satisfactorily resumed weight-bearing activities.

Conclusion: Local flaps are a safe, effective, and dependable option for selected plantar soft-tissue defects of the foot. Careful patient selection and meticulous surgical planning yield high flap-survival rates, acceptable complication profiles, and satisfactory functional outcomes.

Natural Resources for Human Health
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INTRODUCTION

The foot possesses a unique anatomical structure characterized by limited soft-tissue coverage over bones, tendons, and joints. Plantar soft-tissue defects of the foot commonly arise following trauma, diabetic foot ulcers, infections, tumour excision, and chronic ulceration [1-3].

Reconstruction of foot defects remains challenging because of weight-bearing demands, exposure of vital structures, and the need to restore both function and appearance. Skin grafting has traditionally been used for coverage; however, grafts over weight-bearing areas are associated with hyperkeratosis, ulcer recurrence, and poor durability [3,4].

Local flaps offer several advantages, including preservation of regional vascularity, tissue similarity, shorter operative time, and avoidance of microsurgical expertise. Advancement, rotation, transposition, and propeller flaps can provide durable coverage with minimal donor-site morbidity [4-6].

The present study evaluates the clinical outcomes of local flap reconstruction in patients with soft-tissue defects of the plantar aspect of the foot [5,7].

MATERIALS AND METHODS

Study Design and Setting

This prospective observational study was conducted in the Department of Plastic Surgery at a tertiary-care centre in Puducherry. The study evaluated the clinical outcomes of plantar soft-tissue defect reconstruction using local flaps. It was conducted between December 2024 and December 2025. Institutional Ethics Committee approval was obtained before commencement, and written informed consent was obtained from all participants.

Study Population

A total of 30 patients presenting to the outpatient department with plantar soft-tissue defects of the foot were included. All patients underwent local flap reconstruction.

Inclusion and Exclusion Criteria

Patients with plantar soft-tissue defects requiring flap coverage after trauma, diabetic foot ulceration, infection, or post-surgical debridement were eligible. Patients with critical limb ischemia, extensive composite defects, active osteomyelitis, peripheral vascular disease, medical unfitness for surgery, or unwillingness to comply with postoperative follow-up were excluded.

Preoperative Evaluation

All patients underwent comprehensive preoperative evaluation, including a detailed medical history and clinical assessment of defect size, location, depth, and surrounding skin. Neurological assessment was performed to evaluate peripheral neuropathy. Lower-limb vascular status was assessed clinically, and arterial Doppler evaluation was performed when required to exclude significant ischemia. Serial debridement and infection control were completed before reconstruction.

Methodology

The defects involved the hindfoot, midfoot, and forefoot and were reconstructed using local flap techniques selected according to defect size, location, and characteristics [7,8]. Defect dimensions ranged from 2 × 2 cm to 5 × 4 cm (4-20 cm^2). All procedures were performed under regional anaesthesia and tourniquet control. The wound was completely debrided and thoroughly irrigated. The planned flap was harvested, transferred to the defect, and inset. The donor site was covered with a split-thickness skin graft when necessary. A non-adherent sterile dressing was applied, and the foot was immobilized postoperatively in a plaster-of-Paris cast. Surgical details are presented in Table 1.

Natural Resources for Human Health
eISSN: 2583-1194

Table 1. Case Series with Surgical Details (n = 30)

No.	Age/Sex	Type of wound	Area involved	Defect size	Flap performed	Complications
1	49/M	Diabetic foot ulcer	Hindfoot	2 × 2 cm	Rotational flap	Nil
2	45/M	Diabetic foot ulcer	Hindfoot	4 × 4 cm	Interpolation flap (medial plantar artery flap)	Nil
3	55/M	Diabetic foot ulcer	Hindfoot	3 × 3 cm	Transposition flap	Nil
4	57/F	Diabetic foot ulcer	Midfoot	2 × 4 cm	V-Y advancement flap	Nil
5	52/M	Diabetic foot ulcer	Midfoot	2 × 4 cm	Rotational flap	Nil
6	48/F	Diabetic foot ulcer	Forefoot	3 × 4 cm	Transposition flap	Wound infection
7	62/M	Diabetic foot ulcer	Forefoot (great toe)	2 × 4 cm	Interpolation flap (first dorsal metatarsal artery flap)	Nil
8	64/F	Post-surgical excision defect	Forefoot	4 × 3 cm	Interpolation flap (reverse medial plantar artery flap)	Nil
9	50/M	Diabetic foot ulcer	Midfoot	2 × 2 cm	Advancement flap	Nil
10	40/M	Diabetic foot ulcer	Hindfoot	3 × 3 cm	Transposition flap	Partial flap necrosis
11	47/M	Diabetic foot ulcer	Midfoot	4 × 4 cm	Propeller flap	Partial flap necrosis
12	43/M	Diabetic foot ulcer	Midfoot	2 × 2 cm	Rotational flap	Nil
13	51/M	Diabetic foot ulcer	Hindfoot	4 × 3 cm	Intrinsic muscle flap	Nil
14	41/M	Diabetic foot ulcer	Midfoot	2 × 2 cm	Advancement flap	Wound infection
15	45/M	Diabetic foot ulcer	Hindfoot	5 × 4 cm	Interpolation flap (medial plantar artery flap)	Nil
16	58/F	Diabetic foot ulcer	Midfoot	2 × 4 cm	Rotational flap	Nil
17	44/M	Diabetic foot ulcer	Hindfoot	3 × 4 cm	Transposition flap	Nil
18	27/M	Post-traumatic defect	Forefoot	2 × 4 cm	Advancement flap	Nil
19	33/M	Post-traumatic defect	Hindfoot	4 × 4 cm	Rotational flap	Wound infection
20	35/F	Post-traumatic defect	Midfoot	2 × 2 cm	Advancement flap	Nil

No.	Age/Sex	Type of wound	Area involved	Defect size	Flap performed	Complications
21	40/M	Post-traumatic defect	Hindfoot	3 × 3 cm	Intrinsic muscle flap	Nil
22	42/M	Post-traumatic defect	Forefoot	2 × 2 cm	Advancement flap	Nil
23	43/M	Post-traumatic defect	Hindfoot	4 × 4 cm	Interpolation flap (medial plantar artery flap)	Partial flap necrosis
24	59/F	Post-infective defect	Forefoot	2 × 4 cm	Advancement flap	Nil
25	48/M	Post-infective defect	Hindfoot	5 × 4 cm	Interpolation flap (medial plantar artery flap)	Nil
26	44/F	Post-infective defect	Midfoot	2 × 2 cm	Advancement flap	Nil
27	60/F	Post-infective defect	Midfoot	2 × 4 cm	Advancement flap	Nil
28	54/M	Post-infective defect	Forefoot	2 × 4 cm	Advancement flap	Nil
29	62/F	Post-surgical excision defect	Midfoot	3 × 4 cm	Propeller flap	Nil
30	58/M	Post-surgical excision defect	Midfoot	3 × 3 cm	Intrinsic muscle flap	Partial flap necrosis

Case Series

Case 1. Hindfoot plantar soft-tissue defect reconstructed with a rotational flap: (A) preoperative appearance; (B) flap marking; (C) postoperative appearance.

A hindfoot diabetic neuropathic ulcer was debrided. A rotational flap was planned, harvested, transferred to the defect, and inset. A non-adherent sterile dressing was applied, and the foot was immobilized postoperatively in a POP cast.

Case 2. Hindfoot plantar soft-tissue defect reconstructed with an interpolation flap (medial plantar artery flap): (A) preoperative appearance; (B) flap marking; (C) postoperative appearance with split-thickness skin graft.

A hindfoot diabetic neuropathic ulcer was debrided, and a medial plantar artery flap was planned, harvested, transferred, and inset. The donor site was covered with a skin graft. A non-adherent sterile dressing was applied, and the foot was immobilized in a POP cast.

Case 3. Hindfoot plantar soft-tissue defect reconstructed with a transposition flap: (A) preoperative appearance; (B) after debridement; (C) flap harvested; (D) postoperative appearance with split-thickness skin-graft cover.

A hindfoot diabetic neuropathic ulcer was debrided. Because medial post-surgical scarring was present, a transposition flap was planned, harvested, transferred, and inset. The donor site was covered with a skin graft, and the foot was immobilized postoperatively in a POP cast.

Natural Resources for Human Health
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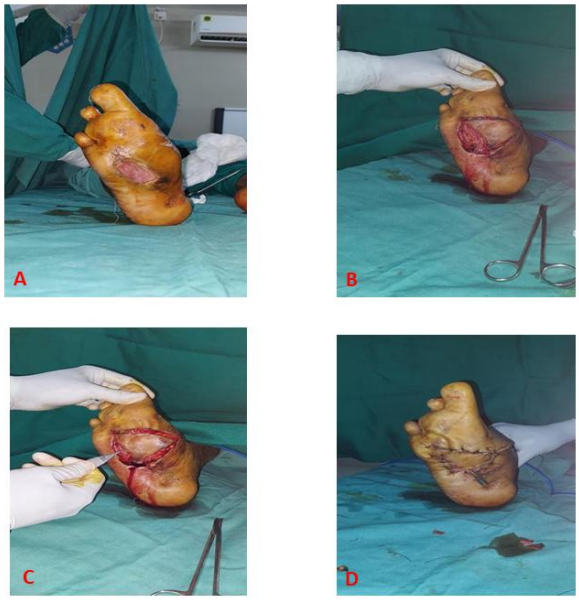

Case 4. Midfoot plantar soft-tissue defect reconstructed with a V-Y advancement flap: (A) preoperative appearance; (B) intraoperative appearance; (C) flap harvested; (D) postoperative appearance.

A midfoot diabetic ulcer was debrided, and a V-Y advancement flap was planned, harvested, transferred to the defect, and inset. The foot was immobilized postoperatively in a POP cast.

Case 5. Midfoot plantar soft-tissue defect reconstructed with a rotational flap: (A) preoperative appearance; (B) flap marking; (C) flap harvested; (D) postoperative appearance.

A midfoot diabetic neuropathic ulcer was debrided, and a rotational flap was planned, harvested, transferred to the defect, and inset. The foot was immobilized postoperatively in a POP cast.

Natural Resources for Human Health
eISSN: 2583-1194

Case 6. Forefoot plantar soft-tissue defect reconstructed with a transposition flap: (A) intraoperative appearance; (C) postoperative appearance.

A forefoot diabetic ulcer was debrided, and a transposition flap was planned, harvested, transferred to the defect, and inset. The foot was immobilized postoperatively in a POP cast.

Case 7. Great-toe plantar soft-tissue defect reconstructed with an interpolation flap (first dorsal metatarsal artery flap): (A) preoperative appearance; (B) flap marking; (C) flap harvested; (D) postoperative appearance.

A diabetic neuropathic ulcer of the great toe was debrided. A first dorsal metatarsal artery flap was planned, harvested, transferred to the defect, and inset. The foot was immobilized postoperatively in a POP cast.

Natural Resources for Human Health
eISSN: 2583-1194

Case 8. Forefoot plantar soft-tissue defect reconstructed with a reverse medial plantar artery flap: (A) post-excision defect with flap marking; (B) flap harvested; (C) postoperative appearance; (D) follow-up appearance.

A post-surgical forefoot defect was reconstructed with a reverse medial plantar artery flap. The flap was harvested, transferred to the defect, and inset; the donor site was covered with a skin graft. The foot was immobilized postoperatively in a POP cast.

Postoperative Protocol

All patients were monitored in hospital for approximately 2-3 weeks after surgery. Standard postoperative care included sterile wound dressing, regular monitoring of flap vascularity and viability, appropriate antibiotic therapy when indicated, and heparin prophylaxis in patients at high risk for venous thromboembolism.

Flaps were assessed on alternate postoperative days for colour, temperature, capillary refill, tissue turgor, and evidence of vascular compromise or necrosis. Patients maintained strict non-weight-bearing on the operated foot for approximately 2-4 weeks, depending on flap type, wound condition, and clinical progress.

Progressive weight-bearing and mobilization were initiated after 5-6 weeks once satisfactory wound healing and flap integration had been confirmed. Subsequent visits assessed flap viability, wound healing, functional recovery, return to weight-bearing, and postoperative complications.

Follow-up Protocol

All patients were followed for 3-6 months after surgery. The first follow-up visit was scheduled at 2 weeks postoperatively, followed by monthly visits for up to 6 months.

At each visit, the surgical wound was assessed for dehiscence, surgical-site infection, and adequacy of healing. Flap viability was evaluated for partial or complete necrosis, venous congestion, and flap integrity.

Functional outcomes, including the patient's ability to resume weight-bearing, ambulation, and routine daily activities, were documented. Postoperative complications, secondary interventions, and overall recovery were recorded throughout follow-up.

Outcome Measures

The primary outcome was flap survival. Secondary outcomes included wound infection, flap necrosis, functional recovery, and long-term wound resolution. These parameters were evaluated throughout follow-up to determine procedural effectiveness.

Management of Complications

Partial flap necrosis and wound infection were managed conservatively with debridement, culture-directed antibiotics, and regular wound dressing. Areas of partial flap necrosis healed secondarily with complete epithelialization.

RESULTS

Patient Characteristics

A total of 30 patients with plantar soft-tissue defects of the foot underwent local flap reconstruction during the study period. Defects were secondary to diabetic foot ulcers, traumatic wounds, post-infective defects, and post-surgical excision wounds (Tables 2-4).

Table 2. Clinical Characteristics of Foot Defects (n = 30)

Etiology of defect	Number (%)
Diabetic foot ulcer	16 (53.3)
Traumatic wound	6 (20.0)
Post-infective defect	5 (16.7)
Post-surgical excision defect	3 (10.0)
Total	30 (100)

Table 3. Types of Local Flaps Utilized

Flap type	Number (%)
Advancement flap	10 (33.3)
Rotational flap	5 (16.7)
Transposition flap	4 (13.3)
Propeller flap	2 (6.7)
Intrinsic muscle flap	3 (10.0)
Medial plantar artery flap	5 (16.7)
First dorsal metatarsal artery flap	1 (3.3)
Total	30 (100)

Table 4. Postoperative Outcomes Following Local Flap Reconstruction

Outcome	Number (%)
Complete flap survival	26 (86.7)
Partial flap necrosis	4 (13.3)
Total flap loss	0
Wound infection	3 (10.0)
Major revision surgery	0
Successful limb salvage	30 (100)

Diabetic foot ulcers constituted the largest proportion of cases (53.3%), followed by traumatic wounds (20.0%), post-infective defects (16.7%), and post-surgical excision defects (10.0%) (Figure 9).

Complete flap survival was achieved in 26 patients (86.7%). Partial flap necrosis occurred in 4 patients (13.3%), and wound infection occurred in 3 patients (10.0%). No total flap loss or major revision surgery was recorded. All complications were successfully managed conservatively.

The limb-salvage rate was 100%, with all patients achieving stable soft-tissue coverage and satisfactory functional recovery at final follow-up. Most patients resumed weight-bearing and demonstrated satisfactory ambulatory function (Figures 10 and 11).

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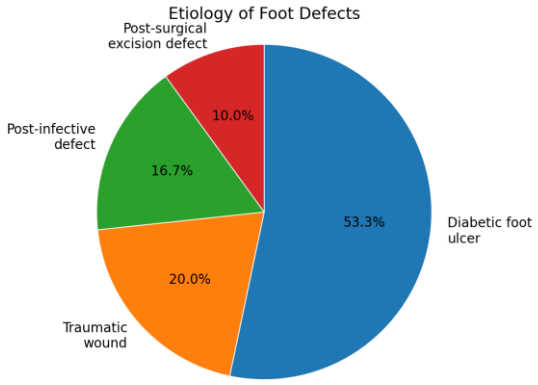

Figure 9. Etiology of foot defects.

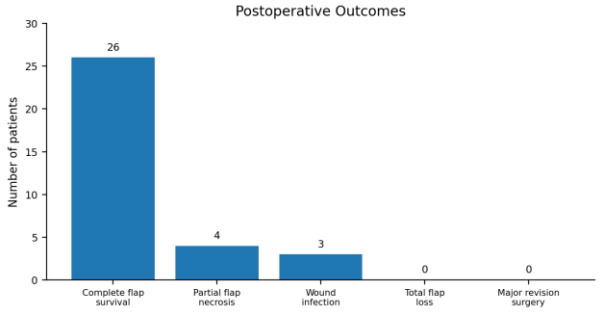

Figure 10. Postoperative outcomes.

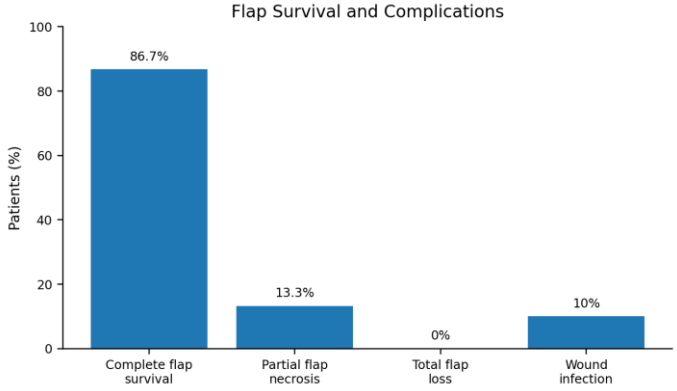

Figure 11. Flap survival and complication profile.

DISCUSSION

Soft-tissue reconstruction of the foot remains a demanding surgical challenge because of its specialized weight-bearing function and limited availability of local tissue [4,5,7].

Skin grafting is the simplest reconstructive option and is appropriate for superficial wounds with a healthy, well-vascularized recipient bed. It offers technical simplicity, shorter operative time, minimal donor-site morbidity, and rapid wound coverage. However, skin grafts cannot survive over exposed bone without periosteum, tendon without paratenon, cartilage without perichondrium, or major neurovascular structures. They are also associated with secondary contracture, inferior contour, reduced durability, pigment mismatch, and poor cosmetic outcomes, particularly in functionally important regions [3,4]. Consequently, skin grafting is generally unsuitable for deep composite defects or weight-bearing areas that require durable soft-tissue padding.

Free flaps represent the highest level of the reconstructive ladder and are recommended for large, complex, or composite defects when local tissue is insufficient. Microsurgical free-tissue transfer can provide well-vascularized skin, fascia, muscle, or bone according to reconstructive need and is especially useful in defects with exposed critical structures, extensive tissue loss, prior radiation, infection, or failed local reconstruction. Although free flaps provide durable coverage and superior functional restoration, they are associated with donor-site morbidity, prolonged operating time, a need for microsurgical expertise, and specialist postoperative monitoring [9-11]. Flap failure caused by vascular thrombosis remains a recognized complication even in experienced centres.

Local flaps can be performed under regional anaesthesia in relatively short procedures, which is advantageous for patients with systemic disease. Nearby tissue provides a close match and may reduce donor-site morbidity. Regional flaps, including

the medial plantar artery flap, provide durable glabrous skin without excessive bulk and can cover larger defects than smaller random local flaps [4,5].

Local flaps offer superior durability and contour matching compared with skin grafts in plantar and weight-bearing areas and may reduce recurrent ulceration. Preservation of regional vascular axes and avoidance of microsurgery further support their use in selected defects [5,7].

In the present study, complete flap survival was achieved in 86.7% of patients. Complications were manageable and did not result in total flap loss [1,12]. These findings are consistent with previous reports describing durable coverage, low donor-site morbidity, and satisfactory functional outcomes after local flap reconstruction [13].

Appropriate patient selection, meticulous flap design, preservation of vascularity, and strict postoperative off-loading remain essential for successful outcomes [5,7].

CONCLUSION

Local flap reconstruction is a reliable and effective technique for selected plantar soft-tissue defects of the foot. Flap selection based on defect characteristics provides durable coverage, high flap-survival rates, preservation of function, acceptable aesthetic outcomes, and manageable complications. Careful patient selection and meticulous surgical planning are critical to success.

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