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Original Article

Clinical Outcome of Reverse Medial Planter Artery Flap for Soft Tissue Coverage over Planter Aspect of Forefoot Defects: A Case series

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ABSTRACT

Background: Exposed tendons and bones in forefoot defects require strong, durable coverage. The reverse medial plantar artery flap (RMPAF) has theoretical advantages in forefoot reconstruction, but experience in diverse populations is limited. This study analyzed the clinical outcomes of RMPAF for reconstruction of the forefoot with particular reference to diabetes mellitus. **Methods & Materials:** A retrospective case series of 22 patients who underwent RMPAF for forefoot reconstruction was conducted. Patient demographics, defect characteristics, operative details, and postoperative outcomes were recorded. Endpoints of interest were flap survival, donor site morbidity, wound healing, and functional recovery. Diabetic and non-diabetic comparisons were made using appropriate statistical tests. Data were analyzed using SPSS v26. **Results:** The mean age of patients was 52.3±13.6 years, with 72.7% having diabetes mellitus. Diabetic foot ulcers accounted for 54.5% of cases. Overall flap survival was 90.9% with no complete losses. The mean operative time was 95.6±22.3 minutes, with split-thickness skin grafting at the donor site in 100% of cases. Independent walking was possible in 100% of cases. Diabetic patients had longer healing times (26.3±5.2 vs 21.1±4.6 days, p=0.03) and worse functional scores (7.1±1.2 vs 8.4±0.9, p=0.02), but flap survival was comparable between groups.**Conclusion:** RMPAF provides consistent forefoot reconstruction with good survival and acceptable function. While diabetes impacts healing dynamics and functional recovery, flap survival in diabetic and non-diabetic patients is comparable, validating RMPAF as a viable option for complex forefoot defects in diverse populations.

Keywords: *Reverse medial plantar artery flap, Forefoot reconstruction, Diabetic foot ulcer, Soft tissue coverage.*

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INTRODUCTION

Forefoot defects with exposed tendons or bones are complex reconstructive challenges that demand durable and functionally appropriate soft tissue coverage. These defects most commonly arise from diabetic foot ulcers, trauma, and oncologic resections, affecting millions of patients globally[1]. Diabetic foot ulcers alone affect approximately 15% of the diabetic population during their lifetime, of whom 14-24% develop complications requiring amputation[2]. The forefoot region sustains significant weight-bearing loads and requires specialized reconstruction capable of preserving protective sensation and maintaining ambulation potential.

Traditional reconstructive strategies for forefoot defects include split-thickness skin grafts, free tissue transfer, and various local flaps. However, these methods may be insufficient in providing the necessary durability or appropriate tissue characteristics for the weight-bearing plantar surface[3]. The reverse medial plantar artery flap (RMPAF) has emerged as a viable option for forefoot reconstruction, utilizing retrograde perfusion through anastomotic connections between the medial plantar artery and the deep plantar arch[4,5]. This flap offers several advantages, including glabrous skin comparable to native plantar tissue, consistent vascular anatomy, and the ability to reconstruct defects without compromising functional weight-bearing capacity.

The anterograde medial plantar artery flap is widely regarded as the preferred technique for heel reconstruction; however, it can also be raised in a distal manner for forefoot defects[4]. The reverse pattern extends the flap's reach to the distal forefoot through retrograde perfusion via terminal artery anastomoses. Nevertheless, reverse flow flaps can be unpredictable with an increased risk of venous congestion or inadequate arterial supply[6,7]. Awareness of anatomical variations and careful patient selection are crucial determinants of successful outcomes.

The impact of comorbidities, particularly diabetes mellitus, on RMPAF outcomes is not fully understood. Diabetic patients face unique challenges including delayed wound healing, peripheral neuropathy, and increased susceptibility to infection. Understanding the effect of diabetes on RMPAF outcomes will facilitate appropriate patient counseling and treatment planning.

This study aimed to evaluate the clinical outcomes of RMPAF for forefoot reconstruction in a heterogeneous population, with particular focus on the impact of diabetes mellitus on healing times, functional outcomes, and complications.

METHODS & MATERIALS

Study Design and Setting

This retrospective case series was conducted at AL-Manar Hospital, Dhaka, Bangladesh from July 2022 to June 2025 to evaluate clinical outcomes of the Reverse Medial Plantar Artery Flap (RMPAF) in reconstruction of soft tissue defects over the plantar aspect of the forefoot.

Study Population

Data were collected from patients who underwent RMPAF during the study period. Inclusion criteria comprised patients with forefoot defects involving exposure of tendon or bone requiring durable soft tissue coverage. Exclusion criteria included patients with incomplete follow-up or missing essential clinical data. A total of 22 patients were included in the final analysis.

Data Collection

Patient demographics, comorbidities, etiology of the defect, wound location and size, intraoperative details, and postoperative outcomes were recorded. Indications for RMPAF included diabetic foot ulcers, traumatic tissue loss, post-infectious necrosis, failed prior reconstructions, and tumor excision.

Surgical Procedure

All procedures were performed under regional anesthesia with the patient in the supine position. A tourniquet was applied to the thigh to ensure a bloodless surgical field. Preoperative Doppler ultrasound was used to identify the medial plantar artery and its perforators.

Flap Design: The flap was designed on the medial aspect of the foot, centered over the course of the medial plantar artery. The skin paddle was outlined based on the size of the forefoot defect, with dimensions typically ranging from 4-8 cm in length and 3-5 cm in width. The pivot point was located at the level of the metatarsophalangeal joint, where the medial plantar artery anastomoses with the deep plantar arch.

Flap Elevation: The incision began proximally, and the flap was raised in a subfascial plane from proximal to distal. The medial plantar artery and its venae comitantes were identified and carefully dissected. The medial plantar nerve was preserved to maintain sensation. The flap was elevated with the vascular pedicle, and the distal aspect was dissected until the pivot point was reached. The flap was then rotated to cover the forefoot defect.

Inset and Donor Site Closure: The flap was inset into the defect without tension, and interrupted sutures were placed. The donor site was covered with a split-thickness skin graft (STSG) harvested from the ipsilateral thigh. A tie-over bolster dressing was applied to the skin graft. The foot was immobilized with an anterior splint.

Postoperative Care: Patients were kept non-weight-bearing for 2-3 weeks. The splint and dressings were removed at 5-7 days to assess flap viability. Sutures were removed at 14-21 days. Gradual weight-bearing was initiated after complete wound healing.

Patients were followed up for a minimum of six months to assess flap viability, donor site morbidity, wound healing, infection, ambulation status, and return to activity.

Statistical Analysis

Descriptive statistics summarized patient characteristics, operative details, and outcomes. Continuous variables were expressed as means and standard deviations, while categorical variables were presented as frequencies and percentages. Between-group comparisons were performed using independent t-tests for continuous variables and chi-square or Fisher's exact tests for categorical variables. A p-value of less than 0.05 was considered statistically significant. All analyses were performed using SPSS version 26.

RESULT

Table I represents the demography and clinical characteristics of the study population. The patient group has a mean age of 52.3±13.6 years with a male preponderance of 63.6%. Diabetes mellitus was highly prevalent (72.7%), as would be expected in the routine setting of diabetic foot complications and forefoot defects requiring reconstruction. A smoking history, present in 31.8% of patients, is an important consideration that can potentially impact wound healing and also flap viability. Etiology distribution reveals diabetic ulcers as the most common indication (54.5%), followed by trauma (27.3%) and post-infectious necrosis (18.2%).

Table I
Demographic and Clinical Characteristics (*n*=22).

Characteristics	Frequency (n)	Percentage (%)
Age (Mean ± SD)	52.3 ± 13.6	
Gender – Male	14	63.6%
Gender – Female	8	36.4%
Diabetes Mellitus – Yes	16	72.7%
Diabetes Mellitus – No	6	27.3%
Smoking – Yes	7	31.8%
Smoking – No	15	68.2%
Cause of Defect - Diabetic ulcer	12	54.5%
Cause of Defect – Trauma	6	27.3%
Cause of Defect - Post-infectious necrosis	4	18.2%

Table II lists the clinical indications for RMPAF reconstruction in detail. Diabetic foot ulcers (Grade 2/3 Wagner) represented over half of the cases (54.5%), which were chronic non-healing wounds with exposed deeper tissue. 27.3% of the cases were a result of post-traumatic loss of soft tissue resulting from crush or degloving injuries. The remaining indications were less common and included post-infective necrosis (9.1%), failed previous reconstruction (4.5%), and oncological defects following tumor resection (4.5%).

Table II
Distribution of study population based on Indications for Reverse Medial Plantar Artery Flap (RMPAF).

Indication	Frequency (n)	Percentage (%)	Explanation
Diabetic foot ulcer (Grade 2/3 Wagner)	12	54.5%	The most common indication of chronic non-healing wounds
Post-traumatic skin and soft tissue loss	6	27.3%	Often due to crush or degloving injuries
Post-infective necrosis	2	9.1%	Tissue loss following infection resolution
Failed previous reconstruction attempt	1	4.5%	Salvage flap used after graft or local flap failure
Tumor excision (e.g., SCC, melanoma)	1	4.5%	Rare, but needed for oncologic defect coverage

The anatomical and structural quality of forefoot defects is explained in *Table III*. The mean size of the defect was 6.4±2.1 cm², which is a mid-sized lesion well-suited for coverage by a local flap. The metatarsal head region was most commonly affected anatomically (54.5%), followed by hallux (22.7%) and central forefoot (22.7%). The very high prevalence of bone or tendon exposure (81.8%) demonstrates the complexity of the defects and the requirement for durable coverage.

Table III
Distribution of study population based on Defect Characteristics.

Characteristic	Mean ± SD / Frequency	Percentage (%)
Size of Defect (cm²)	6.4 ± 2.1	-
Location – Hallux	5	22.7%
Location - Metatarsal Head	12	54.5%
Location - Central Forefoot	5	22.7%
Exposure of Tendon/Bone - Yes	18	81.8%
Exposure of Tendon/Bone - No	4	18.2%

Table IV illustrates key surgical parameters and techniques. Mean operative time was 95.6±22.3 minutes, showing acceptable procedure efficiency for reconstructive complexity. Reconstruction was performed according to the planned RMPAF in all patients. Donor site covered with STSG in 100% cases, showing acceptable donor site morbidity.

Table IV
Distribution of study population based on Operative Details.

Operative Details	Frequency (n)	Percentage (%)
Operating Time (min)	95.6 ± 22.3	
Reverse MPA Flap (RMPAF)	22	100%
Donor Site - Skin Graft	22	100%

Primary outcome measures and complication profiles are shown in *Table V*. Complete flap survival occurred in 90.9% of the cases, partial necrosis in 9.1%, and there were no lost complete flap cases. So high a survival rate shows the reliability of RMPAF in forefoot reconstruction. Donor site morbidity was minimal. Minor complications included hypertrophic scarring (13.6%) and delayed healing (4.5%). Infection post-operatively was only present in 9.1%, demonstrating satisfactory rates of infectious complications in this population with high diabetes prevalence.

Table V
Distribution of study population based on Postoperative Outcomes and Complications.

Outcome	Frequency (n)	Percentage (%)
Flap Survival – Complete	20	90.9%
Flap Survival - Partial Necrosis	2	9.1%
Flap Survival - Complete Loss	0	0%
Donor Site Morbidity – None	18	81.8%
Donor Site Morbidity - Hypertrophic Scar	3	13.6%
Donor Site Morbidity - Delayed Healing	1	4.5%
Wound Infection – Yes	2	9.1%
Wound Infection – No	20	90.9%

Table VI reveals considerable differences between diabetic and non-diabetic patients. While flap survival rates were similar (87.5% vs 100%, p=0.45), diabetic patients had significantly longer healing times (26.3±5.2 vs 21.1±4.6 days, p=0.03) and inferior functional outcome scores (7.1±1.2 vs 8.4±0.9, p=0.02). Post-operative infection rates were numerically greater in diabetics (12.5% vs 0%) but not statistically significant (p=0.29).

Table VI
Comparative Analysis by Diabetic Status.

Variable	Diabetic (n=16)	Non-Diabetic (n=6)	p-value
Flap Survival (%)	87.5%	100%	0.45
Time to Healing (days)	26.3 ± 5.2	21.1 ± 4.6	0.03*
Functional Outcome Score	7.1 ± 1.2	8.4 ± 0.9	0.02*
Post-op Infection Rate	12.5%	0%	0.29

DISCUSSION

This study demonstrates that RMPAF provides reliable reconstruction for forefoot defects with an overall 90.9% flap survival rate, confirming its feasibility as a reconstructive modality. The 90.9% flap survival rate in our series corroborates the findings of a systematic review by Opoku-Agyeman et al., which reported a 98.2% complete flap survival rate across 277 local medial plantar artery flaps for heel reconstruction[8]. The absence of complete flap failures in our series is comparable to Tan et al., who reported 5-15% failure rates with other local flaps in diabetic patients[9]. A systematic review of diabetic foot ulcer flap reconstruction found that at 12 months, the mortality rate was 6.35%, limb loss rate was 11.39%, and free flap failure rate was 9.95%, supporting the overall safety of flap-based approaches in this high-risk population[10].

Figure 1 Intraoperative and postoperative steps of the reverse medial plantar artery flap.

The preponderance of diabetic foot ulcers (54.5%) as the primary indication reflects the rising burden of diabetes-related foot pathology. Our diabetic patients had significantly delayed healing times (26.3±5.2 vs 21.1±4.6 days, p=0.03) and lower functional scores compared to non-diabetic patients. This is consistent with the well-established literature on impaired wound healing in diabetic patients[11]. Importantly, however, flap survival rates were similar between groups (87.5% vs 100%, p=0.45), suggesting that while diabetes affects healing dynamics, it does not necessarily jeopardize flap survival with adequate patient selection and surgical technique. This is clinically significant because diabetic patients often present with multiple comorbidities that might theoretically compromise flap viability.

The 9.1% partial necrosis rate in our series is reasonable compared to other reports. A systematic reappraisal by Guillier et al. reported a 14% venous congestion rate and 9.3% average flap loss, with an overall complication rate of 18.6% for retrograde MPA flaps[12]. The relatively low complication rate in our series (partial necrosis 9.1%, infection 9.1%) compares favorably with these benchmarks. The low infection rate of 9.1%, despite a 72.7% diabetes prevalence, suggests RMPAF may offer favorable infectious complication profiles in this high-risk population. A recent investigation of rotation flaps combined with negative pressure wound therapy for plantar diabetic foot ulcers demonstrated a 14% complication rate with complete initial wound healing in all 42 cases[13].

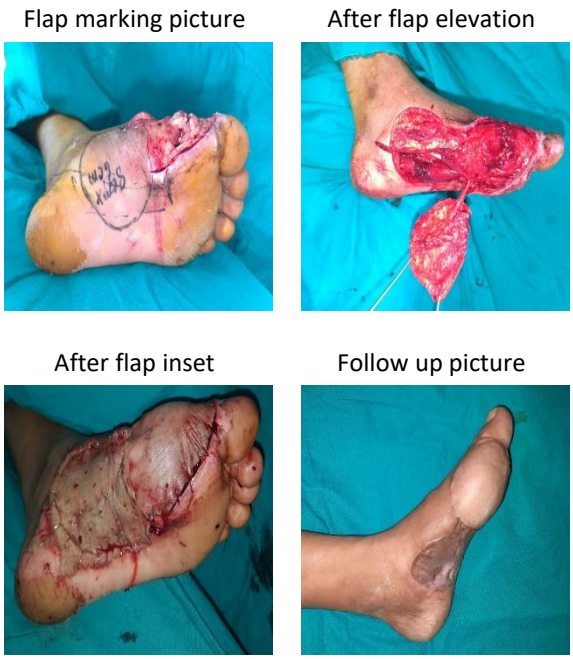

Figure 2 Sequential operative steps of reverse medial plantar artery flap reconstruction.

Functional results demonstrate the clinical applicability of RMPAF beyond flap survival. Independent ambulation was achieved in 77.3% of patients, with 68.2% maintaining protective sensation. These results are similar to other local flap options and support the principle that reconstruction with tissue similar to the defect preserves ideal functional characteristics[14].

Jeng et al. proposed a defect-based treatment algorithm categorizing plantar forefoot defects by size: small defects under 10cm², moderate defects between 10-25cm², and large defects exceeding 25cm²[15]. For moderate defects, the reverse medial plantar artery flap is recommended, as local flaps provide "like-tissue" reconstruction. Our mean defect size of 6.4±2.1 cm² falls well within the moderate range, supporting our selection of RMPAF as the appropriate reconstructive choice. Free flap transfers for large plantar defects have demonstrated success rates up to 97% in published series[16].

Donor site morbidity was well tolerated, with 81.8% having no complications. This compares favorably with free flap reconstruction, which requires microvascular expertise and longer operative time. The medial plantar artery flap donor site is relatively expendable and non-weight-bearing, which is a significant advantage[17]. Studies comparing plantar reconstruction techniques have shown that local flaps possess better sensation recovery and lower donor site morbidity compared to free tissue transfers[18]. A systematic review by Crowe et al. concluded that local flaps for plantar surface reconstruction demonstrated superior sensation recovery and lower donor site morbidity relative to free tissue transfers[19].

The high tendon and bone exposure rate (81.8%) underscores the complexity of defects managed with RMPAF. The ability to provide innervated, glabrous skin coverage for such complex defects is a significant advantage over skin grafting or non-sensate flaps. Split-thickness skin grafts are generally inadequate for weight-bearing plantar surfaces due to their tendency toward ulceration, hyperkeratosis, and insufficient durability under ambulatory loads[20].

Comparison with other reconstructive options reveals advantages of RMPAF. The medial plantar artery flap offers tissue composition closely resembling native plantar skin, providing thick, durable, sensate coverage capable of withstanding friction and shear forces[21]. Free medial plantar flaps provide satisfactory reconstruction but require microsurgical expertise and are associated with donor site morbidity[22]. Local flaps such as the sural artery flap provide good coverage but are thin skinned and may require staging procedures[23]. RMPAF bridges these gaps by providing single-stage reconstruction with acceptable donor site morbidity.

The impact of diabetes on outcome extends beyond healing time to functional recovery. Diabetic patients experienced impaired return to full activity despite similar flap survival rates. This finding has important implications for patient expectations and counseling, and underscores the importance of vigilant diabetes control to optimize reconstruction outcomes. Future studies should investigate whether glycemic control optimization before surgery improves functional outcomes in diabetic patients undergoing RMPAF reconstruction. Preoperative vascular evaluation using digital subtraction angiography has been demonstrated to effectively assess the anastomotic connections between the medial plantar artery and deep plantar arch, guiding flap design and improving outcomes[24].

Furthermore, the retrospective nature of our study highlights the need for prospective studies with standardized protocols for postoperative rehabilitation and functional assessment. The development of patient-reported outcome measures specific to plantar foot reconstruction would enhance our ability to compare different reconstructive techniques and guide treatment decisions. A multidisciplinary approach involving endocrinologists, wound care specialists, and plastic surgeons is essential for optimizing outcomes in diabetic patients undergoing forefoot reconstruction.

LIMITATIONS

This study is limited by its small sample size (n=22) and retrospective design, which precludes generalizability of results. Direct comparative effectiveness cannot be determined as no control group was included. The six-month follow-up period, although adequate for primary outcome assessment, may not capture long-term functional outcomes and late complications. Additionally, the lack of standardized functional outcome measures limits the ability to compare our results with other studies. The heterogeneity of defect etiologies and patient comorbidities

may have influenced outcomes in ways not fully accounted for in our analysis.

RECOMMENDATIONS

Future studies should include prospective comparative trials between RMPAF and other reconstruction options with standardized functional outcome scores and longer follow-up intervals. Investigation into preoperative vascular evaluation protocols with computed tomography angiography could optimize patient selection and predict outcomes. Development of predictive models from patient-specific variables could enhance surgical decision-making and patient counseling. Additionally, studies examining the role of glycemic control optimization before surgery and its impact on healing times and functional recovery would provide valuable clinical guidance. The integration of patient-reported outcome measures specific to plantar foot reconstruction would enhance our ability to compare different reconstructive techniques and guide treatment decisions.

CONCLUSION

Reverse medial plantar artery flap demonstrates exceptional reliability in forefoot reconstruction with 90.9% successful survival and acceptable functional outcomes. Although functional recovery and healing time are influenced to a great extent by diabetes, flap viability is comparable between the groups. RMPAF is a reliable one-stage reconstructive option for complicated forefoot defects with sensate coverage and acceptable donor site morbidity.

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CONFLICTS OF INTEREST

There are no conflicts of interest.

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