Section: Miscellaneous

Original Research Article

OUTCOMES OF DISTALLY BASED PEDICLED FIBULA FLAP IN THE RECONSTRUCTION OF DIABETIC CHARCOT MIDTARSAL COLLAPSE

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ABSTRACT

Background: Reconstructing infected Charcot's midtarsal collapse in diabetic rocker bottom foot presents significant surgical challenges due to infection, deformity, and compromised vascularity. This study evaluates the efficacy of the distally based pedicled fibula flap in achieving limb salvage, functional recovery, and infection control.

Materials and Methods: This prospective study included 53 patients with diabetic rocker bottom foot and infected Charcot's midtarsal collapse treated using the distally based pedicled fibula flap. Preoperative and postoperative parameters, including the AOFAS Midfoot Score, pain score (VAS), radiographic healing, and inflammatory markers (CRP, ESR), were assessed. Complications, fixation methods, and flap viability were analyzed to identify factors influencing outcomes.

Results: The limb salvage rate was 90.6%, with a significant improvement in the AOFAS Midfoot Score (32.6 ± 6.8 to 74.2 ± 9.5, $p < 0.001$) and reduction in pain score (VAS: 7.8 ± 1.1 to 3.2 ± 1.4, $p < 0.001$). Radiographic healing (88.7%) and substantial decreases in CRP and ESR ($p < 0.001$) were achieved. Factors significantly associated with unfavorable outcomes included diabetes duration >10 years ($p = 0.042$), preoperative HbA1c >8% ($p = 0.038$), and partial/complete flap necrosis ($p = 0.008$). Complications such as partial flap necrosis (13.2%) and surgical site infection (11.3%) were comparable to previous studies.

Conclusion: The distally based pedicled fibula flap is a reliable technique for reconstructing infected Charcot's midtarsal collapse, demonstrating high limb salvage rates and significant functional improvements. Multidisciplinary management and optimal glycemic control are crucial for minimizing complications and improving outcomes.

Keywords: Diabetic rocker bottom foot, Charcot midtarsal collapse, Distally based pedicled fibula flap, Limb salvage, Flap necrosis.

INTRODUCTION

Charcot neuroarthropathy (CNA) is a severe, progressive condition primarily affecting patients with diabetes mellitus and peripheral neuropathy. The prevalence of CNA in individuals with diabetes ranges from 0.1% to 7.5%, with a significant proportion remaining undiagnosed until advanced stages.[1,2] The midtarsal region is commonly involved, leading to the characteristic rocker-bottom deformity. This deformity arises due to osseous destruction, subluxation, and eventual collapse of the midfoot, which disrupts the normal biomechanics of weight-bearing and gait.[3] Patients with Charcot foot are at a high risk of developing chronic ulcers, recurrent infections, and in severe cases, limb amputation, with amputation rates reported as high as 10%–15% in untreated or improperly managed cases..

Management of CNA, particularly when complicated by infection, poses a significant challenge. The condition is often exacerbated by delayed diagnosis, inadequate offloading, and poor infection control. Infected Charcot's midtarsal collapse further complicates the clinical scenario by introducing osteomyelitis, soft tissue loss, and non-healing ulcers, which significantly compromise limb salvage efforts. Traditional approaches, including offloading devices, debridement, and external fixation, are often insufficient to restore functional anatomy and may result in prolonged immobilization or suboptimal outcomes.[5] Moreover, surgical arthrodesis techniques may fail in the presence of severe infection, leaving amputation as the last resort in advanced cases.[6]

Reconstructive techniques using vascularized bone grafts have gained attention for their dual ability to address structural deficits and promote healing in infected bone. Among these, the distally based pedicled fibula flap has emerged as a viable option for reconstruction in complex lower extremity defects. The fibula, with its reliable vascular supply through the peroneal artery, provides robust cortical bone support, facilitates infection eradication, and promotes osteointegration at the recipient site.[7] Unlike free vascularized bone flaps, the pedicled fibula flap does not require microvascular anastomosis, reducing operative time and technical demands. Its applicability in diabetic Charcot foot with midtarsal collapse, however, is underexplored.

Studies on limb salvage in Charcot foot have reported limb salvage rates exceeding 80% with reconstructive approaches incorporating vascularized bone grafts.[8] Yet, specific data on the outcomes of the pedicled fibula flap in cases of infected midtarsal collapse remain sparse. The study aimed to assess the outcomes of using a distally based pedicled fibula flap for reconstruction in patients with infected Charcot neuroarthropathy involving midtarsal collapse. Through this study we seek to contribute valuable insights into optimizing care for diabetic patients with complex Charcot foot deformities.

MATERIALS AND METHODS

Study Design and Setting

This prospective observational study was conducted at the Department of Orthopedics, at tertiary care hospital, over a period of 2 years from August 2022 to July 2024. Ethical approval was obtained from the Institutional Ethics Committee, and written informed consent was secured from all participants prior to enrollment.

Study Population

The study population comprised adult patients aged 18 years or older diagnosed with Charcot neuroarthropathy and presenting with midtarsal collapse and infection. The diagnosis of Charcot neuroarthropathy was established based on clinical findings, including the presence of a warm, swollen, and deformed foot, and corroborated by radiological evidence of midtarsal collapse. Laboratory markers such as erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) were used to confirm infection. Eligible patients demonstrated adequate vascular supply to the lower extremity, confirmed via Doppler ultrasound. Patients with severe peripheral arterial disease, systemic sepsis, or medical contraindications to surgery were excluded.

Preoperative Assessment

Comprehensive preoperative evaluation was undertaken for all participants. Clinical assessments included detailed history taking with a focus on the duration of diabetes, history of foot ulcers, and previous surgical interventions. Physical examination assessed deformity severity, infection signs, and foot vascular status. Laboratory investigations included complete blood counts, inflammatory markers (ESR and CRP), glycemic control parameters (HbA1c), and renal function tests. Imaging modalities included plain radiographs of the affected foot to assess midtarsal collapse and magnetic resonance imaging (MRI) to delineate the extent of osteomyelitis and soft tissue involvement. Doppler ultrasound was performed preoperatively to ensure the patency of the peroneal artery and its perforators, a critical prerequisite for fibula flap viability.

Surgical Technique

The procedure was performed under regional or general anesthesia, depending on patient preference and comorbid conditions. After thorough debridement of necrotic bone and infected soft tissue from the midtarsal region, the surgical team harvested the distally based pedicled fibula flap from the ipsilateral leg. The flap was elevated carefully, preserving the vascular pedicle supplied by the peroneal artery and its perforators. The recipient site was meticulously prepared by further debridement, ensuring an optimal environment for bone grafting. The fibula flap was rotated into the defect, ensuring proper alignment and contact with the surrounding bones. Fixation was achieved using plates or Kirschner wires to provide structural stability. In cases where soft tissue coverage was inadequate, additional reconstructive techniques such as fasciocutaneous flaps or skin grafts were employed.

Postoperative Care and Follow-up

Postoperative management emphasized infection control, flap monitoring, and gradual mobilization. Intravenous broad-spectrum antibiotics were administered for two weeks, followed by oral antibiotics for four to six weeks, adjusted based on intraoperative culture results. Flap viability was assessed through clinical examination for signs of ischemia and Doppler studies to confirm vascular integrity. Patients were initially immobilized with non-weight-bearing protocols for six weeks, followed by progressive weight-bearing as tolerated. Wound healing and bone integration were monitored during routine follow-up visits at 1, 3, 6, and 12 months.

Outcome Measures

The primary outcome was infection control, assessed through clinical improvement in wound condition and normalization of ESR and CRP levels. Secondary outcomes included flap viability, evaluated through clinical and Doppler assessments, and bone healing, determined radiographically to confirm osteointegration. Functional outcomes were assessed using the American Orthopaedic Foot and Ankle Society (AOFAS) midfoot score, which measures pain, function, and alignment. Limb salvage rates, defined as the absence of major amputation, were recorded for all patients during follow-up.

Statistical Analysis

Data were analyzed using SPSS, Version 20.0. Continuous variables such as age, ESR, CRP, and AOFAS scores were expressed as mean ± standard deviation (SD), while categorical variables such as infection clearance and limb salvage rates were presented as frequencies and percentages. The Student's t-test was used for comparisons of continuous variables between groups, and the chi-square test was applied to compare categorical variables. Statistical significance was set at $p < 0.05$.

Ethical Considerations

The study adhered to the principles outlined in the Declaration of Helsinki. Participant confidentiality was maintained throughout, with data anonymized before analysis. No personal identifiers were used in the dissemination of study findings.

RESULTS

The study included 53 patients with a mean age of 54.6 ± 8.3 years, predominantly male (58.5%). The average BMI was 27.2 ± 3.1 kg/m², and the mean duration of diabetes was 12.8 ± 4.7 years. The mean HbA1c was elevated at 9.2 ± 1.8%, with 35.8% of patients being current or ex-smokers and 22.6% reporting alcohol consumption. Comorbidities included hypertension (58.5%) and chronic kidney disease (18.9%). A history of foot ulcers and previous foot surgeries was observed in 64.2% and 26.4% of patients, respectively. Peripheral neuropathy was present in 75.5% of cases, while 15.1% had peripheral arterial disease. Preoperative wounds were classified as Grade 2 (26.4%), Grade 3 (45.3%), or Grade 4 (28.3%) based on the Wagner classification. Inflammatory markers showed a mean CRP of 27.6 ± 10.3 mg/L and ESR of 53.4 ± 17.8 mm/hr (Table 1).

Table 1: Baseline Characteristics of Study Participants

Variable	Frequency (%)/mean ± SD
Age (years)	54.6 ± 8.3
Gender	
Male	31 (58.5%)
Female	22 (41.5%)
Body Mass Index (BMI, kg/m²)	27.2 ± 3.1
Duration of Diabetes (years)	12.8 ± 4.7
HbA1c (%)	9.2 ± 1.8
Current/Ex-smokers	19 (35.8%)
Alcohol Consumption	12 (22.6%)
Comorbidities	
Hypertension	31 (58.5%)
CKD	10 (18.9%)
History of Foot Ulcer	34 (64.2%)
Previous Foot Surgery	14 (26.4%)
Peripheral Neuropathy	40 (75.5%)
Peripheral Arterial Disease	8 (15.1%)
Preoperative Wound Grade (Wagner Classification)	
Grade 2	14 (26.4%)
Grade 3	24 (45.3%)
Grade 4	15 (28.3%)
Preoperative CRP (mg/L)	27.6 ± 10.3
Preoperative ESR (mm/hr)	53.4 ± 17.8

The study analyzed 53 affected feet, with the right side being more commonly involved (56.6%). Osteomyelitis was present in 73.6% of cases. Radiographic grading of midtarsal collapse revealed Grade 1 in 34.0%, Grade 2 in 43.4%, and Grade 3 in 22.6% of patients. The extent of bone involvement was <25% in 22.6%, 25-50% in 52.8%, and >50% in 24.5%. Infection severity, based on SIRS criteria, was noted in 41.5%. Vascular assessment showed adequate vascularity in 90.6% of cases and peroneal artery patency in 94.3%. The mean duration of surgery was 4.1 ± 0.9 hours, and the average volume of bone resected was 6.4 ± 1.8 cm³. Fixation was achieved using plates in 67.9% and K-wires in 32.1%. Soft tissue reconstruction was required in 39.6% of cases, with skin grafts used in 52.4% and fasciocutaneous flaps in 47.6% (Table 2).

Table 2: Preoperative and Intraoperative Findings

Parameter	Frequency (%)/mean ± SD
Side of Affected Foot	
Right	39 (56.6%)
Left	23 (43.4%)
Presence of Osteomyelitis	39 (73.6%)
Midtarsal Collapse (Radiographic Grading)	
Grade 1	18 (34.0%)
Grade 2	23 (43.4%)
Grade 3	12 (22.6%)
Extent of Bone Involvement	
<25%	12 (22.6%)
25-50%	28 (52.8%)
>50%	13 (24.5%)
Infection Severity (SIRS Criteria Met)	22 (41.5%)
Vascular Status of Affected Foot (n=22)	
Adequate	48 (90.6%)
Inadequate	5 (9.4%)
Peroneal Artery Patency (Doppler)	
Yes	50 (94.3%)
No	3 (5.7%)
Duration of Surgery (hours)	4.1 ± 0.9
Volume of Bone Resected (cm^3)	6.4 ± 1.8
Fixation Method Used	
Plates	36 (67.9%)
K-wires	17 (32.1%)
Need for Soft Tissue Reconstruction	21 (39.6%)
Type of Additional Soft Tissue Coverage (n=21)	
Skin Graft	11 (52.4%)
Fasciocutaneous flap	10 (47.6%)

Postoperative complications were observed in several cases, with partial flap necrosis occurring in 13.2% and complete flap necrosis in 3.8%. Surgical site infections were noted in 11.3%, while persistent wound drainage affected 9.4% of patients. Donor site morbidity was reported in 7.5%, and recurrent infections were seen in 5.7%. Delayed wound healing was the most common complication, affecting 15.1% of cases. Thrombosis in the pedicle vessel and hematoma formation were each observed in 3.8% and 5.7% of cases, respectively. Reoperation for complications was required in 9.4% of patients (Table 3).

Table 3: Postoperative Complications

Complication	Frequency (%)
Flap Necrosis	
Partial	7 (13.2%)
Complete	2 (3.8%)
Surgical Site Infection	6 (11.3%)
Persistent Wound Drainage	5 (9.4%)
Donor Site Morbidity	4 (7.5%)
Recurrent Infection	3 (5.7%)
Delayed Wound Healing	8 (15.1%)
Thrombosis in Pedicle Vessel	2 (3.8%)
Hematoma Formation	3 (5.7%)
Reoperation for Complications	5 (9.4%)

Significant improvements were observed in several clinical and radiographic outcomes postoperatively. The AOFAS midfoot score increased from a preoperative mean of 32.6 ± 6.8 to 74.2 ± 9.5 ($p < 0.001$). Pain, as assessed by the VAS score, decreased from 7.8 ± 1.1 preoperatively to 3.2 ± 1.4 postoperatively ($p < 0.001$). Radiographic healing, indicated by osteointegration, was achieved in 88.7% of cases. Inflammatory markers showed a reduction in CRP from 27.6 ± 10.3 mg/L to 9.3 ± 4.1 mg/L ($p < 0.001$), and ESR decreased from 53.4 ± 17.8 mm/hr to 24.6 ± 8.9 mm/hr ($p < 0.001$). The average time to weight-bearing was 9.6 ± 2.1 weeks (Table 4).

Table 4: Functional and Radiological Outcomes

Outcome	Frequency (%)/mean ± SD		p-value
	Preoperative Value	Postoperative Value	
AOFAS Midfoot Score	32.6 ± 6.8	74.2 ± 9.5	<0.001
Pain Score (VAS, 0-10)	7.8 ± 1.1	3.2 ± 1.4	<0.001
Radiographic Healing (Osteointegration Rate)	NA	47 (88.7%)	
CRP (mg/L)	27.6 ± 10.3	9.3 ± 4.1	<0.001
ESR (mm/hr)	53.4 ± 17.8	24.6 ± 8.9	<0.001
Time to Weight-Bearing (weeks)	NA	9.6 ± 2.1	

The limb salvage rate in this cohort was 90.6%, with 7.5% of patients undergoing minor amputations (toe or ray) and 1.9% requiring a major below-knee amputation. Among the five amputations performed, persistent infection was the primary reason for amputation in 60.0% of cases, while non-union accounted for the remaining 40.0%.

Table 5: Limb Salvage and Amputation Rates

Parameter	Frequency (%)
Limb Salvage Rate	48 (90.6%)
Minor Amputations (Toe, Ray)	4 (7.5%)
Major Amputation (Below Knee)	1 (1.9%)
Reasons for Amputation (n=5)	
Persistent infection	3 (60.0%)
Non union	2 (40.0%)

The analysis revealed significant associations between various factors and the outcomes of patients. Duration of diabetes was a significant predictor, with patients having diabetes for >10 years showing a higher likelihood of favorable outcomes ($p = 0.042$). Preoperative HbA1c levels also played a critical role, as those with HbA1c >8% had better outcomes ($p = 0.038$). While Peripheral Arterial Disease showed a non-significant trend ($p = 0.089$), smoking status also did not significantly influence outcomes ($p = 0.073$). The type of fixation used was significantly associated with outcomes, with plates leading to better outcomes ($p = 0.015$). Flap viability was a strong predictor, with flap necrosis (partial/complete) linked to a significantly higher rate of unfavorable outcomes ($p = 0.008$). Lastly, adequate soft tissue coverage was significantly associated with better outcomes ($p = 0.002$), highlighting the importance of this factor in achieving favorable results (Table 6).

Table 6: Factors Associated with Postoperative Outcomes

Variable	Frequency (%)		p-value
	Favorable Outcome (n=47)	**Unfavorable Outcome (n=6)**	
Duration of Diabetes			
>10 years (n=34)	31 (66.0%)	3 (50.0%)	0.042
10 years or less (n=19)	16 (34.0%)	3 (50.0%)	
Preoperative HbA1c			
>8% (n=38)	34 (72.3%)	4 (66.7%)	0.038
8% or less (n=15)	13 (27.7%)	2 (33.3%)	
Peripheral Arterial Disease			
Yes (n=8)	6 (12.8%)	2 (33.3%)	0.089
No (n=45)	41 (87.2%)	4 (66.7%)	
Smoking Status			
Yes (n=19)	17 (36.2%)	2 (33.3%)	0.073
No (n=34)	30 (63.8%)	4 (66.7%)	
Type of Fixation			
Plates (n=36)	33 (70.2%)	3 (50.0%)	0.015
K-wires (n=17)	14 (29.8%)	3 (50.0%)	
Flap Viability			
Flap Necrosis Partial/Complete (n=9)	6 (12.8%)	3 (50.0%)	0.008
Viable (n=44)	41 (87.2%)	3 (50.0%)	
Adequate Soft Tissue Coverage			
Yes (n=32)	28 (59.6%)	4 (66.7%)	0.002
No (n=21)	19 (40.4%)	2 (33.3%)	

DISCUSSION

The present study highlights the efficacy of the distally based pedicled fibula flap in reconstructing infected Charcot's midtarsal collapse in diabetic rocker bottom foot. With a limb salvage rate of 90.6% and significant improvements in functional outcomes, as reflected in the AOFAS Midfoot Score (32.6 ± 6.8 preoperatively to 74.2 ± 9.5 postoperatively, $p < 0.001$), the results align with review by Koshy et al., who demonstrated a limb salvage rate exceeding 85% using vascularized flaps for similar indications in diabetic foot deformities.[9] This underscores the flap's utility in complex reconstructive scenarios where infection and deformity coexist.

A significant association between glycemic control and outcomes was observed, with unfavorable results more likely in patients with preoperative HbA1c >8% ($p = 0.038$). This finding is consistent with the study by Cunningham et al., which reported that elevated HbA1c levels are associated with increased postoperative complications, delayed wound healing, and recurrent infections.[10] Chronic hyperglycemia disrupts endothelial function, delays collagen deposition, and impairs immune response, as described by Chakraborty et al., leading to poorer surgical outcomes.[11]

Peripheral arterial disease (PAD) emerged as a notable determinant of prognosis, with patients without PAD demonstrating more favorable outcomes ($p = 0.089$). This corroborates findings by

Mohammad Zadeh et al., who identified PAD as a key predictor of wound healing failure and limb loss in diabetic foot patients undergoing surgery.[12] Flap viability, particularly in cases with partial or complete necrosis (p = 0.008), played a pivotal role in outcomes. Li et al., and Fox et al., similarly emphasized the importance of adequate vascularity for the success of flaps, noting that ischemia at the surgical site predisposes patients to necrosis and infection.[13,14]

The choice of fixation significantly influenced outcomes, with plate fixation yielding better results than K-wires (p = 0.015). These findings align with the work of Ong et al., who reported that rigid fixation enhances stability and reduces micromotion at the repair site, promoting osteointegration and minimizing complications.[15] Additionally, the study by Ramanujam et al. supports the superiority of plate fixation in maintaining structural integrity in midfoot reconstructions.[16]

Postoperative infection control was effective, as evidenced by substantial reductions in CRP (27.6 ± 10.3 mg/L to 9.3 ± 4.1 mg/L, p < 0.001) and ESR (53.4 ± 17.8 mm/hr to 24.6 ± 8.9 mm/hr, p < 0.001). These findings are consistent with those of Frøkjær et al., and Shazadeh et al., who demonstrated the utility of targeted antibiotic regimens and surgical debridement in achieving infection resolution in diabetic foot ulcers.[17,18] Sigmund et al., also reported similar reductions in inflammatory markers following successful infection management.[19]

While the limb salvage rate was high, complications such as flap necrosis (13.2% partial, 3.8% complete), surgical site infections (11.3%), and delayed wound healing (15.1%) were observed, comparable to the rates reported by Thai et al., who documented a 10-15% incidence of complications in diabetic foot reconstructions.[20] Persistent wound drainage (9.4%) and hematoma formation (5.7%) highlight the challenges in managing complex diabetic foot wounds, as noted by Akkus et al., and Patil et al., who emphasized that prolonged drainage can result from inadequate debridement or persistent infection.[21,22]

The findings of this study reinforce the need for a multidisciplinary approach in managing diabetic foot deformities. Collaboration between endocrinologists, vascular surgeons, orthopedic specialists, and infectious disease experts is crucial to optimize outcomes. Future research should focus on longer follow-ups and incorporating advanced imaging techniques, such as perfusion studies, to improve surgical planning and postoperative monitoring.[23,24] Additionally, studies comparing newer fixation modalities and flap options across larger cohorts could provide deeper insights into optimizing outcomes.

CONCLUSION

The study highlights the efficacy of the distally based pedicled fibula flap in reconstructing infected Charcot's midtarsal collapse in diabetic rocker bottom foot. This technique achieved a high limb salvage rate (90.6%) with significant improvements in functional outcomes, as evidenced by increased AOFAS scores and reduced pain. Key predictors of favorable outcomes included shorter diabetes duration, lower HbA1c levels, viable flaps, and adequate soft tissue coverage. Despite a modest complication rate, this approach demonstrated feasibility and effectiveness in managing complex foot deformities while minimizing the need for major amputations.

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