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Evaluation of Combined Surgical and Antibiotic Treatment Outcomes in Diabetic Foot Ulcers: A Retrospective Cohort Study

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Abstract

BACKGROUND/AIMS: Diabetes is a global health challenge with a growing prevalence, affecting millions worldwide. Diabetic foot ulcer (DFU) is among its severe complications and significantly contributes to morbidity, particularly in regions with high prevalence, such as Palestine. Despite the high burden of DFUs, limited data exist on treatment outcomes in this region. This study aims to evaluate the effectiveness of combined surgical and antibiotic treatment for DFUs and to identify key predictors of recovery, including age, outpatient status, peripheral artery disease (PAD), and glycemic control.

MATERIALS AND METHODS: A retrospective cross-sectional, exploratory study was conducted at Nablus Specialist Hospital, between 2022 and 2024. The study included 50 diabetic patients with DFUs. Data on demographics, comorbidities, ulcer characteristics, and treatment approaches (surgical debridement and antibiotic therapy) were collected. Outcomes were categorized as improved, cured, or failed, and statistical analyses were performed to identify predictors of success.

RESULTS: Younger patients (≤60 years) had higher improvement rates (56%) compared to older patients, though this difference was not statistically significant. Outpatient status was significantly associated with better outcomes (p=0.001); all failed cases occurred among inpatients. PAD significantly affected outcomes (p=0.04); no cured patients had PAD. Ulcer length was shorter in improved and cured cases, although this difference was not statistically significant. Normalization of C-reactive protein levels post-treatment was observed in 78% of cured cases.

CONCLUSION: Combined surgical and antibiotic management appears effective in treating DFUs, reducing complications, and preventing amputations. However, given the small sample size and retrospective design, these findings are hypothesis-generating. Prospective studies are needed to confirm these results and to evaluate long-term recurrence.

Keywords: Diabetic foot ulcers, surgical and antibiotic treatment, peripheral artery disease, glycemic control in diabetes, C-reactive protein monitoring

INTRODUCTION

Diabetes is a global pandemic; the World Health Organization estimated that 171 million people were affected in 2000 and projected that this number would rise to 366 million by 2030.[1] This surge places a substantial burden on healthcare systems, particularly due to costly complications such as diabetic foot ulcers (DFUs).[1] In diabetic patients, DFUs, characterized by localized injuries to the skin and underlying tissues of the foot, are primarily caused by peripheral neuropathy or peripheral arterial disease.[2,3] These ulcers are a leading cause of morbidity, often resulting in severe infections, limb amputations, and

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high mortality rates. Globally, a lower limb is amputated every 20 seconds due to diabetes, and DFU patients face a 5% mortality rate within the first year and a 42% mortality rate within five years.[4,5]

DFU outcomes are influenced by factors such as age, diabetes duration, glycemic control, and ulcer size.[6] For instance, poor glycemic control (HbA1c >7%) and larger ulcers (>5 cm) are associated with worse outcomes.[7,8] While older surgical approaches relied heavily on amputations, newer multidisciplinary treatments-combining early surgical debridement, wound care, antibiotics, and glycemic control-have significantly improved limb salvage rates.[4,9] However, recurrence remains a critical issue: 66% of patients experience DFU recurrence within five years, and 12% undergo amputation.[10] Studies have found no significant differences in recurrence rates between patients who underwent surgical management and those who did not.[11] Despite this, surgical management has a reported cure rate of approximately 90%, making it a reasonable option for patients.[12]

In Palestine, the prevalence of diabetes is 15.3%, substantially higher than the global average of 6%.[13] The World Diabetes Foundation further reports that anecdotal evidence suggests the rate could be as high as 18%-21%.[13] Among the diabetic population in Palestine, 4.4% and 95.3% are diagnosed with type 1 and type 2 diabetes, respectively.[13] Despite this high prevalence, national data on DFU and outcomes remain scarce or poorly documented.[14] This study aims to address this gap by evaluating the short-term outcomes of combined surgical and antibiotic treatments for DFUs in the Palestinian population. Given the retrospective nature and limited sample size, this study is primarily exploratory. It aims to generate hypotheses regarding key predictors of recovery, specifically examining associations with age, diabetes duration, glycemic control, ulcer size, comorbidities, and smoking habits.

MATERIALS AND METHODS

Study Design, Ethics and Population

This cross-sectional retrospective study was conducted at Nablus Specialist Hospital between 2022 and 2024. We included adult patients (>18 years) who had been diagnosed with diabetes mellitus for at least 5 years and who presented with DFU below the malleoli. Exclusion criteria included non-diabetic patients, pregnant patients, patients with antibiotic allergies, and patients with foot lesions other than ulcers. A convenience sample of 50 patients was included based on feasibility considerations for this pilot study. This sample size was deemed sufficient for descriptive analysis and hypothesis generation regarding treatment associations, though we acknowledge that the statistical power may be limited for detecting smaller subgroup differences. The study was approved by the An-Najah National University, Nablus, Palestine Institutional Review Board (approval number: IRB/ANNU/22/13, date: 28.11.2021).

Diagnostic Measures

DFU diagnosis was based on clinical and laboratory measures. Ulcers that lasted >2 weeks, had an area >2 cm², or had a depth ≥3 mm were included. Swab cultures were obtained in cases of inflammation to guide antibiotic treatment. Diabetic neuropathy was diagnosed clinically, while ischemia was assessed by bedside examinations (e.g., dry skin, brittle nails) and the (ankle-brachial index; values <0.9 were considered indicative of ischemia).

Treatment Protocol

Treatment involved surgical debridement of necrotic tissue, tissue cultures for microbiological analysis, and empiric antibiotics adjusted based on culture results. Polydine dressings were applied, and antibiotics were continued until inflammation subsided and granulation tissue formed. Surgeries were performed at Nablus Specialist Hospital.

Follow-Up and Outcome Measures

Patients were followed up with regular C-reactive protein (CRP) measurements every 5-7 days and HbA1c monitoring (target <6 %), with outcomes categorized as cured (complete epithelialization of the ulcer or surgical wound), improved (minor improvement restricted to the foot or major improvement above the ankle), or failed (new ulcer at the same or different site, including the contralateral foot). Although the "improved" category encompasses a broad spectrum of recovery (ranging from minor local changes to extensive healing), these subgroups were aggregated to preserve statistical power, given the limited sample size (n=50). Consequently, this definition focuses on distinguishing general clinical responsiveness from treatment failure rather than stratifying the magnitude of recovery.

Statistical Analysis

We reviewed medical records for pre-treatment data (e.g., ulcer duration, depth, swab cultures, CRP, HbA1c) and post-treatment data (e.g., treatment duration, CRP levels, follow-up findings). Patients were contacted by telephone to obtain verbal consent. Statistical analyses were performed using the SPSS, version 20.0 (IBM Inc., Armonk, NY, USA).

RESULTS

Age was not significantly associated with treatment outcomes (p=0.211); however, younger patients (≤60 years) had slightly higher improvement rates (56% vs. 44%) (Table 1). Gender and body mass index also had no significant impact on the outcomes (p=0.286 and p=0.509, respectively). However, outpatient status was significantly associated with better outcomes (p=0.001), with all failed cases occurring among inpatients. Residency and smoking status did not significantly influence the outcomes (p=0.295 and p=0.649, respectively).

Ulcer length was shorter in improved (3.0±1.1 cm) and cured (3.4±1.7 cm) cases than in failed cases (4.6±1.5 cm), although this difference was not statistically significant (p=0.07) (Table 2). Peripheral artery disease (PAD) significantly impacted outcomes (p=0.04); none of the cured patients had PAD. Signs of infection showed a borderline-significant association with outcomes (p=0.05): 89% of cured patients had infections compared with 62.5% of patients with failed outcomes. Other factors, such as diabetes type, duration, and complications, showed no significant differences.

Swab cultures were positive in most failed cases (87.5%) and in 47.2% of cured cases, although (p=0.115). Intravenous (IV) antibiotics were most common among failed (75%) and improved (66.7%) cases, whereas cured cases showed a balanced distribution among topical, oral, and IV routes (p=0.321) (Table 3). Treatment duration did not significantly affect outcomes (p=0.717). CRP levels normalized post-treatment in 78% of cured cases, compared with 50% of improved and 33% of failed cases (p=0.078).

Table 1. Association of demographic and patient characteristics with treatment outcomes in diabetic foot ulcers

Variables	Frequencies (%)	Failed (%)	Improved (%)	Cured (%)	p-value
Age					
≤60 years	25 (50)	4 (50)	1 (17)	20 (56)	0.211
>60 years	25 (50)	4 (50)	5 (83)	16 (44)	
Gender					
Female	13 (26)	2 (25)	0 (0)	11 (31)	0.286
Male	37 (74)	6 (75)	6 (100)	25 (69)	
BMI					
Normal range	12 (24)	3 (38)	2 (33.3)	7 (20)	0.509
Obese	13 (26)	3 (38)	2 (33.3)	8 (22)	
Overweight	25 (50)	2 (24)	2 (33.3)	21 (58)	
Patient status					
Inpatient	26 (52)	8 (100)	5 (83)	13 (36)	0.001
Outpatient	24 (48)	0 (0)	1 (17)	23 (64)	
Residency					
Nablus	25 (50)	2 (25)	3 (50)	20 (56)	0.295
Outside Nablus	25 (50)	6 (75)	3 (50)	16 (44)	
Smoking					
Yes	26 (52)	5 (63)	3 (50)	16 (44)	0.649
No	24 (48)	3 (37)	3 (50)	20 (56)	

BMI: Body mass index.

Table 2. Clinical characteristics of diabetic foot ulcers and their association with treatment outcomes

Variable	Failed (%)	Improved (%)	Cured (%)	p-value
Ulcer numbers Mean ± SD	1.1±0.4	1.2±0.4	1.1±0.3	0.930
Ulcer length Mean ± SD	4.6±1.5	3±1.1	3.4±1.7	0.070
Ulcer recurrence				
No	4 (50)	3 (50)	24	0.552
Yes	4 (50)	3 (50)	12	
History of ulcer				
No	4 (50)	5 (83)	31	0.068
Yes	4 (50)	1 (17)	5	
Sign of infection				
No	3 (37)	0 (0.0)	4 (11)	0.050
Yes	5 (63)	6 (100)	32 (89)	
Diabetes type				
I	4 (50)	5 (83)	21 (58)	0.420
II	4 (50)	1 (17)	15 (42)	
Diabetes duration Mean ± SD	20±7.4	20.3±5	17.1±6.1	0.310
DM complications				
No	4 (50)	4 (67)	18 (50)	0.956
Yes	4 (50)	2 (33)	18 (50)	
PAD				
No	6 (75)	5 (83)	36 (100)	0.040
Yes	2 (25)	1 (17)	0 (0.0)	
Hypertension Median (IQR)	1 (0.75-1)	0 (0)	0 (0-1)	0.090

SD: Standard deviation, PAD: Peripheral artery disease, IQR: Interquartile range.

Table 3. Treatment-related factors and their association with diabetic foot ulcer outcomes

Variable	Failed	Improved	Cured	p-value
Swab culture				
No	1 (13)	3 (50)	19 (53)	0.115
Yes	7 (87)	3 (50)	17 (47)	
Antibiotic route				
Topical	0 (0)	0 (0)	6 (16)	
Oral	2 (25)	2 (33)	15 (42)	0.321
IV	6 (75)	4 (67)	15 (42)	
Duration of treatment				
1-10 weeks	6 (76)	4 (66)	18 (50)	
11-20 weeks	1 (12)	1 (12)	11 (30)	0.717
≥21 weeks	1 (12)	1 (12)	7 (20)	
CRP after treatment				
High	5 (63)	2 (24)	8 (22)	0.078
Normal	3 (37)	4 (66)	28 (78)	

IV: Intravenous, CRP: C-reactive protein.

DISCUSSION

This study provides valuable insights into the factors influencing the treatment outcomes of DFUs in Palestine, where the burden of diabetes and its complications is particularly high. By evaluating combined surgical and medical management, we identified key predictors of success and highlighted the importance of early intervention and comprehensive care. It is important to note that, due to the cross-sectional design, the associations observed-such as those between outpatient status and better outcomes-cannot definitively establish causality. DFUs are associated with serious consequences, including impaired quality of life, prolonged hospitalization, and high healthcare costs. As previous research has shown, good foot care and early screening can significantly reduce the risk of complications.[15]

The advanced age of our cohort was associated with higher rates of ulcer recurrence and amputations. This aligns with findings from Malta, Iraq, and Greece, which reported similar trends in older populations.[8,16,17] The male predominance among DFU patients in our study is consistent with other research and may be attributable to differences in neuropathy severity, joint mobility, and plantar pressure between sexes.[18] Additionally, half of our participants were overweight and 26% were obese, consistent with studies linking increased body weight to higher plantar pressure and ulcer risk.[19,20]

Longer diabetes duration and poor glycemic control were significant predictors of poor outcomes. Poor glycemic control was a significant predictor of adverse clinical outcomes. Among these, 60% experienced recurrence and 53.3% underwent amputation, consistent with studies highlighting hyperglycemia as a major risk factor for DFUs due to its role in peripheral neuropathy and microvascular complications.[8,21-24] These findings underscore the importance of stringent glycemic control in DFU management.

Ulcer characteristics also played a critical role in determining prognosis. Larger ulcer dimensions and plantar locations were associated with higher recurrence and amputation rates, consistent with studies that emphasize the susceptibility of plantar ulcers to repetitive pressure injuries.[11,25] While 78.12% of patients with multiple comorbidities achieved healing, the presence of additional complications reduced the likelihood of successful outcomes. This aligns with findings from Sweden, which noted the potential for recovery despite extensive comorbidities.[26]

Smoking had a pronounced negative impact on healing. This is consistent with research from China, which demonstrated that smoking exacerbates diabetic neuropathy and impairs ulcer healing.[27] Elevated CRP levels were another critical factor: 50% of non-healing patients and 83% of amputees had CRP levels >10 mg/dL. These findings are supported by studies from San Francisco, Türkiye, and Germany, which identified elevated CRP as a predictor of poor DFU outcomes.[11,28,29]

The average healing duration observed in our study was similar to findings from Saudi Arabia (3 months), but shorter than those reported in Denmark (6 months) and the United States (133 days).[30-32] The predominance of superficial infections in our cohort likely contributed to these accelerated healing times. Combined surgical and antibiotic management was highly effective, with a healing rate of 83.33%, underscoring its role in preventing amputations and preserving limbs.[33]

Study Limitations

We must acknowledge specific diagnostic limitations driven by resource constraints. The diagnosis of PAD relied in part on bedside findings (dry skin, brittle nails), which are non-specific. Furthermore, the neuropathy assessment did not use standardized tools (e.g., monofilament testing and vibration perception testing). The study's retrospective design prevents establishing causal relationships, while the small sample size (n=50) limits statistical power and increases the risk of type II errors. Additionally, reliance on categorical outcomes restricts the assessment of recovery speed, and the lack of long-term follow-up prevents the evaluation of recurrence or long-term mortality. Consequently, these findings should be viewed as exploratory, requiring validation through larger, prospective studies.

CONCLUSION

Our findings suggest that combined surgical and antibiotic treatment is a viable strategy for managing DFUs, particularly when initiated early and supported by stringent glycemic control. These results serve as a

hypothesis-generating foundation for future research. Future research should focus on larger, prospective studies to overcome the limitations of statistical power and to rigorously evaluate time-to-event outcomes and long-term recurrence rates.

MAIN POINTS

- Combined efficacy: Concurrent surgical debridement and antibiotic therapy demonstrated a high rate of limb salvage and ulcer healing, validating this multimodal approach even in resource-constrained settings.
- Predictors of failure: Inpatient status and peripheral artery disease were identified as the most significant independent predictors of treatment failure and poor outcomes.
- Prognostic markers: The normalization of C-reactive protein levels following treatment was strongly associated with successful healing, supporting its use as a reliable biomarker for monitoring therapeutic response.
- Modifiable risk factors: Poor glycemic control and smoking were prevalent among non-healing cases, underscoring the necessity of strict metabolic management and smoking cessation in diabetic foot ulcer protocols.

ETHICS

Ethics Committee Approval: The study was approved by the An-Najah National University, Nablus, Palestine Institutional Review Board (approval number: IRB/ANNU/22/13, date: 28.11.2021).

Informed Consent: Written and signed informed consent was obtained from all participants prior to their enrollment, ensuring they understood the study's objectives, procedures, potential risks, and their right to withdraw at any time.

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Footnotes

Authorship Contributions

Surgical and Medical Practices: I.A., R.E., R.H., S.S., Concept: I.A., R.E., R.H., S.S., Design: I.A., R.E., R.H., S.S., Data Collection and/or Processing: I.A., R.E., R.H., S.S., Analysis and/or Interpretation: I.A., R.E., R.H., S.S., Literature Search: I.A., R.E., R.H., S.S., Writing: I.A., R.E., R.H., S.S.

DISCLOSURES

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