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Research Article

Study of Demographic Determinants, Clinical Spectrum and Surgical Management of Diabetic Foot Ulceration: a Cross-Sectional Analysis

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ABSTRACT

Introduction: Diabetic foot ulceration (DFU) is a major complication of diabetes mellitus, contributing significantly to morbidity, infection risk, and lower limb amputations. Understanding its demographic determinants and clinical spectrum is essential for timely intervention and improved outcomes.

Aim: To evaluate the demographic risk factors, clinical characteristics, and surgical management modalities associated with DFU in patients attending a tertiary care teaching hospital in India.

Methods: A prospective, cross-sectional observational study was conducted from 2024 to 2025, involving 130 patients with type 2 diabetes mellitus—65 with DFU and 65 matched controls without DFU. Data on age, gender, diabetes duration, HbA1c levels, smoking history, ulcer type, duration, infection status, and management strategies were collected. Wagner grading was used to assess ulcer severity. Statistical analysis included chi-square testing for categorical associations.

Results: DFU was significantly associated with age ≥60 years (64.6%), male gender (70.8%), diabetes duration >10 years (60%), poor glycemic control (HbA1c >8% in 72.3%), and smoking history (40%). Neuropathic ulcers were most common (43.1%), with 50.8% persisting for 4–12 weeks. Infection was present in 47.7% and osteomyelitis in 27.7%. Management included glycemic optimization (93.8%), antibiotics (80%), surgical debridement (41.5%), and minor amputations (29.2%). No significant association was found between Wagner grade and infection status ($p = 0.81$).

Conclusion: DFU is strongly linked to advanced age, male gender, long-standing diabetes, poor glycemic control, and smoking. Multimodal management including early surgical intervention and metabolic optimization is essential. Wagner grading alone may not reliably predict infection risk, underscoring the need for comprehensive clinical assessment.

Keywords: Diabetic Foot Ulcer, Glycemic Control.

INTRODUCTION

Diabetic foot ulceration (DFU) is among the most debilitating and costly complications of diabetes mellitus, contributing substantially to patient morbidity, lower limb amputations, and healthcare burden worldwide. It is estimated that up to 25% of individuals with diabetes will develop a foot ulcer during their lifetime, with a significant proportion progressing to infection, osteomyelitis, or limb loss if not promptly and adequately managed[1,2]. In India, the rising prevalence of diabetes—projected to exceed 100 million cases by 2030—has been paralleled by an increase in DFU-related hospitalizations and amputations, particularly in resource-constrained settings[3].The pathogenesis of DFU is multifactorial, involving peripheral neuropathy, peripheral arterial disease, immunosuppression, and poor glycemic control. These factors often coexist and synergistically impair wound healing, predisposing patients to chronic, non-healing ulcers. Additionally, sociodemographic variables such as age, gender, duration of diabetes, and lifestyle factors like smoking have been implicated in modulating DFU risk and outcomes[4,5]. Despite advances in wound

care and surgical techniques, DFU continues to pose a clinical challenge due to delayed presentation, limited access to multidisciplinary care, and variability in management protocols. Surgical interventions—including debridement, amputations, and revascularization—remain cornerstones of treatment, yet their utilization patterns and outcomes vary widely across institutions. Furthermore, the role of clinical grading systems such as the Wagner classification in predicting infection risk and guiding treatment decisions warrants further exploration[6].In this context, the present study was undertaken to comprehensively evaluate the demographic determinants, clinical spectrum, and surgical management strategies associated with DFU in a tertiary care teaching hospital in India. By comparing DFU cases with non-ulcerated diabetic controls, the study aims to elucidate key risk factors, characterize ulcer phenotypes, and assess the effectiveness of various therapeutic modalities in real-world clinical practice.

Aim

To evaluate the demographic determinants, clinical characteristics, and surgical management modalities associated with diabetic foot ulceration (DFU) in patients attending a tertiary care teaching hospital in India.

Objectives

1. To identify demographic and clinical risk factors associated with the development of diabetic foot ulcers, including age, gender, duration of diabetes, glycemic control, and smoking history.
2. To characterize the clinical spectrum of DFU, including ulcer type, duration, infection status, and presence of osteomyelitis.
3. To assess the distribution and outcomes of surgical and supportive management strategies employed in DFU cases, such as debridement, amputation, skin grafting, antibiotic therapy, glycemic optimization, offloading, advanced wound care, and revascularization.
4. To analyze the relationship between Wagner grading and infection status in DFU patients and determine its statistical significance.

MATERIAL AND METHODS

Study Design and Setting

This was a prospective, cross-sectional observational study conducted in the Department of General Surgery at a tertiary care teaching hospital in India. The study was carried out over a one-year period from 2024 to 2025. Ethical clearance was obtained from the Institutional Ethics Committee prior to initiation of the study. Written informed consent was obtained from all participants.

Study Population

The study included a total of 130 patients with type 2 diabetes mellitus (T2DM), divided into two groups:

A. Cases (n = 65): Patients with clinically diagnosed diabetic foot ulceration (DFU).
B. Controls (n = 65): Age- and sex-matched diabetic patients without any history or clinical evidence of foot ulceration.

Inclusion Criteria

1. Patients aged ≥18 years with a confirmed diagnosis of type 2 diabetes mellitus.
2. For the case group: Presence of diabetic foot ulceration, defined as a full-thickness skin lesion distal to the malleoli, of neuropathic, ischemic, or neuroischemic origin.
3. For the control group: Diabetic patients without current or prior history of foot ulceration.
4. Willingness to provide informed consent and comply with study procedures.

Exclusion Criteria

1. Patients with foot ulcers of non-diabetic etiology (e.g., traumatic, venous, or malignant ulcers).
2. Individuals with type 1 diabetes mellitus.
3. Patients with critical illness, terminal disease, or cognitive impairment precluding informed consent.
4. Patients with incomplete clinical records or lost to follow-up during the study period.

Data Collection

A structured proforma was used to collect demographic data (age, gender), clinical history (duration of diabetes, smoking status), glycemic control (HbA1c levels), and ulcer characteristics (type, duration, infection status, presence of osteomyelitis). Management modalities including surgical and supportive interventions were documented. Ulcers were graded using the Wagner classification system.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS version XX (or equivalent statistical software). Categorical variables were expressed as frequencies and percentages. Chi-square test was used to assess associations between categorical variables, including the relationship between Wagner grade and infection status. A p-value <0.05 was considered statistically significant.

Observation and Result

Table 1: Clinical History

Sr No	Variable	Cases (DFU) 65 (100 %)	Controls (No DFU) 65 (100 %)	Total 130(100 %)
1	Age a. ≥60 years b. <60 years	42 (64.6%) 23 (35.4%)	28 (43.1%) 37 (56.9%)	70 (53.8%) 60 (46.2%)
2	Gender a. Male b. Female	46 (70.8%) 19 (29.2%)	38 (58.5%) 27 (41.5%)	84 (64.6%) 46 (35.4%)
3	Duration of Diabetes a. >10 years b. ≤10 years	39 (60.0%) 26 (40.0%)	24 (36.9%) 41 (63.1%)	63 (48.5%) 67 (51.5%)
4	HbA1c a. Poor (>8%) b. Moderate (6.5–8%) c. Good (<6.5%)	47 (72.3%) 12 (18.5%) 6 (9.2%)	26 (40.0%) 24 (36.9%) 15 (23.1%)	73 (56.2%) 36 (27.7%) 21 (16.2%)
5	Smoking History a. Yes b. No	26 (40.0%) 39 (60.0%)	14 (21.5%) 51 (78.5%)	40 (30.8%) 90 (69.2%)

The comparative analysis between diabetic foot ulcer (DFU) cases and non-DFU controls revealed several significant demographic and clinical distinctions. Patients aged ≥60 years were disproportionately represented among DFU cases (64.6%) compared to controls (43.1%), suggesting age-related vulnerability. Male predominance was noted in both groups, but more pronounced in DFU cases (70.8% vs 58.5%), indicating potential gender-linked risk factors. Duration of diabetes emerged as a critical determinant: 60% of DFU cases had diabetes for over 10 years, whereas only 36.9% of controls fell into this category. Glycemic control, assessed via HbA1c levels, showed stark contrasts—72.3% of DFU patients had poor control (>8%), compared to 40% in controls. This underscores the role of chronic hyperglycemia in ulcer pathogenesis. Additionally, smoking history was more prevalent among DFU cases (40%) than controls (21.5%), reinforcing its role as a modifiable risk factor.

Table 2: Clinical Spectrum of DFU

Sr No	Clinical Feature	Frequency n=65	Percentage (100 %)
1	Ulcer Type a. Neuropathic b. Ischemic c. Neuroischemic	 28 15 22	 43.1 % 23.1 % 33.8 %
2	Ulcer Duration a. <4 weeks b. 4–12 weeks c. >12 weeks	 17 33 15	 26.2 % 50.8 % 23.1 %
3	Infection Status a. Infected b. Non-infected	 31 34	 47.7 % 52.3 %

4	Osteomyelitis a. Present b. Absent	 18 47	 27.7 % 72.3 %

Among the 65 DFU cases, neuropathic ulcers were the most common subtype (43.1%), followed by neuroischemic (33.8%) and ischemic ulcers (23.1%). This distribution reflects the multifactorial etiology of diabetic foot pathology, with neuropathy playing a dominant role. Ulcer chronicity was notable, with half of the cases (50.8%) presenting with ulcers lasting 4–12 weeks, and 23.1% persisting beyond 12 weeks. Infection was present in 47.7% of cases, while osteomyelitis was diagnosed in 27.7%, indicating a substantial burden of deep tissue involvement and potential for limb-threatening complications.

Table 3: Surgical and Supportive Management

Sr No	Management Modality	Frequency n=65	Percentage (100 %)
1	Surgical Debridement	27	41.5 %
2	Minor Amputation	19	29.2 %
3	Major Amputation	8	12.3 %
4	Skin Grafting	6	9.2 %
5	Antibiotic Therapy	52	80.0 %
6	Glycemic Optimization	61	93.8 %
7	Offloading (TCC/Orthotics)	38	58.5
8	Advanced Wound Dressings	44	67.7
9	Revascularization (Endovascular/Open)	11	16.9

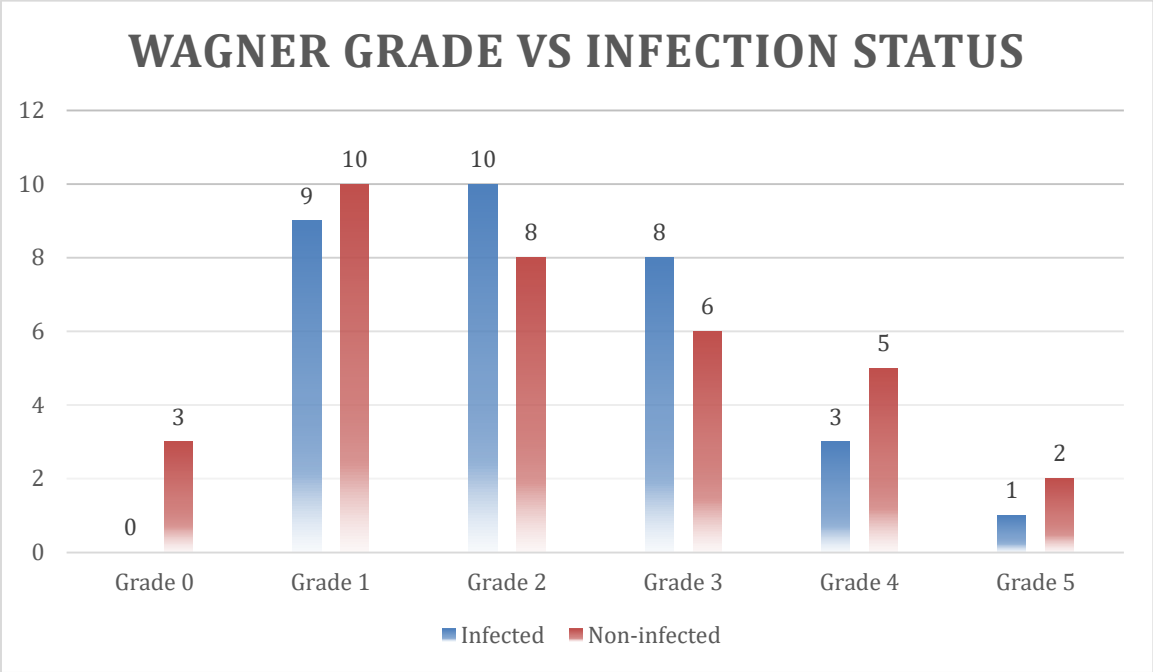
Management strategies were diverse and multimodal. Glycemic optimization was nearly universal (93.8%), reflecting its foundational role in DFU care. Antibiotic therapy was administered in 80% of cases, consistent with the high infection rate. Advanced wound dressings (67.7%) and offloading techniques (58.5%) were commonly employed, highlighting adherence to standard wound care protocols.Surgical interventions were frequent: debridement was performed in 41.5% of cases, minor amputations in 29.2%, and major amputations in 12.3%. Skin grafting was used in 9.2% of cases. Revascularization procedures, either endovascular or open, were undertaken in 16.9% of patients, indicating the presence of significant ischemia in a subset.

Table 4: Wagner Grade vs Infection Status

Sr No	Wagner Grade	Infected (n, %)	Non-Infected (n, %)	Total (n, %)	Chi-square	p-value
1	Grade 0	0 (0.0%)	3 (8.8%)	3 (4.6%)	2.27	0.81 (NS)
2	Grade 1	9 (29.0%)	10 (29.4%)	19 (29.2%)		
3	Grade 2	10 (32.3%)	8 (23.5%)	18 (27.7%)		
4	Grade 3	8 (25.8%)	6 (17.6%)	14 (21.5%)		
5	Grade 4	3 (9.7%)	5 (14.7%)	8 (12.3%)		
6	Grade 5	1 (3.2%)	2 (5.9%)	3 (4.6%)		
Total		31 (47.7%)	34 (52.3%)	65 (100%)		

The distribution of Wagner grades among infected and non-infected ulcers did not show statistically significant variation (Chi-square = 2.27, p = 0.81). Grade 1 and Grade 2 ulcers were the most prevalent across both infected and non-infected groups. Interestingly, Grade 0 ulcers were exclusively non-infected, while higher grades (Grade 4 and 5) showed mixed infection status. This suggests that while Wagner grading reflects ulcer severity, it may not reliably predict infection status in isolation.

Graph 1: Wagner Grade vs Infection Status



DISCUSSION

This cross-sectional study highlights the multifactorial nature of diabetic foot ulceration (DFU), underscoring the interplay between demographic risk factors, glycemic control, and clinical outcomes. The predominance of DFU among elderly males with long-standing diabetes and poor glycemic control aligns with global epidemiological trends and reinforces the need for early risk stratification and preventive strategies.In the present study, patients aged ≥60 years constituted 64.6% of DFU cases, significantly higher than in the control group. This finding is consistent with the observations of Lavery et al., who reported age-related decline in peripheral nerve function and microvascular integrity as key contributors to ulcer susceptibility[7]. Similarly, the male predominance (70.8%) among DFU cases mirrors findings from studies in India and abroad, where occupational exposure, footwear practices, and delayed health-seeking behavior among men have been implicated[8,9]. Duration of diabetes >10 years was significantly associated with DFU (60% vs 36.9% in controls), corroborating the findings of the EURODIALE study, which identified chronic hyperglycemia as a major determinant of peripheral neuropathy and impaired wound healing[10]. Poor glycemic control (HbA1c >8%) was observed in 72.3% of DFU cases, reinforcing the role of sustained hyperglycemia in promoting advanced glycation end-products (AGEs), oxidative stress, and impaired leukocyte function—all of which compromise tissue repair and immune defense[11,12].

Smoking history was more prevalent among DFU patients (40%) compared to controls (21.5%), echoing the findings of Reiber et al., who demonstrated that smoking exacerbates peripheral arterial disease and impairs capillary perfusion, thereby increasing the risk of ischemic ulcers[13].Clinically, neuropathic ulcers were the most common subtype (43.1%), followed by neuroischemic (33.8%) and ischemic ulcers (23.1%). This distribution is in line with the findings of Boulton et al., who emphasized the central role of peripheral neuropathy in the pathogenesis of diabetic foot lesions[14]. The high proportion of ulcers persisting beyond four weeks (73.9%) reflects delayed presentation and suboptimal early intervention, a pattern frequently reported in low-resource settings[15].Infection was present in 47.7% of cases, and osteomyelitis in 27.7%, consistent with global estimates that suggest nearly half of all DFUs are complicated by infection[16]. Despite this, the association between Wagner grade and infection status was not statistically significant (p = 0.81),

suggesting that infection may occur across all ulcer grades and that clinical vigilance is warranted even in lower-grade lesions. Similar findings were reported by Oyibo et al., who noted that infection risk is influenced more by ulcer chronicity and depth than by Wagner grade alone[17].

Management patterns in this study reflect a multimodal approach, with glycemic optimization (93.8%) and antibiotic therapy (80%) forming the cornerstone of treatment. Surgical debridement (41.5%) and minor amputations (29.2%) were frequently employed, comparable to the amputation rates reported in Indian tertiary centers[18]. The relatively low rate of major amputations (12.3%) may reflect timely intervention and the availability of limb-salvage strategies such as advanced wound dressings (67.7%) and revascularization procedures (16.9%).The observed outcomes underscore the importance of integrated care pathways involving endocrinologists, surgeons, podiatrists, and wound care specialists. Mechanistically, the convergence of neuropathy, ischemia, and immunosuppression in diabetes creates a permissive environment for ulcer formation and progression. Hyperglycemia impairs neutrophil chemotaxis and phagocytosis, while microvascular dysfunction limits oxygen delivery, collectively delaying granulation and epithelialization[19].

CONCLUSION

This study reinforces the multifactorial etiology of diabetic foot ulceration, with age, male gender, prolonged diabetes duration, poor glycemic control, and smoking emerging as significant risk factors. Neuropathic and neuroischemic ulcers dominate the clinical spectrum, often complicated by infection and osteomyelitis. The findings highlight the importance of early detection, aggressive glycemic management, and timely surgical intervention to prevent progression and limb loss. While Wagner grading remains a useful tool for ulcer classification, its predictive value for infection status appears limited, suggesting the need for integrated clinical and microbiological evaluation in DFU care pathways

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