ISSN 0973-2063 (online) 0973-8894 (print)
Bioinformation 22(10): 7065-7068 (2026)
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BIOINFORMATION
Discovery at the interface of physical and biological sciences
BIOMEDICAL INFORMATICS
www.bioinformation.net
Volume 22(10)
Research Article

Received October 1, 2026; Revised October 31, 2026; Accepted October 31, 2026, Published October 31, 2026
DOI: 10.6026/973206300227065

SJIF 2026 (Scientific Journal Impact Factor for 2026) = 8.478
2022 Impact Factor (2023 Clarivate Inc. release) is 1.9

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Citation: Jain *et al.* Bioinformation 22(10): 7065-7068 (2026)

Risk factors and outcomes of diabetic foot ulcers requiring surgical management

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ISSN 0973-2063 (online) 0973-8894 (print)
Bioinformation 22(10): 7065-7068 (2026)
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Abstract:
Diabetic foot ulcer is a major complication of diabetes mellitus that is associated with infection, prolonged hospitalization, limb loss and increased healthcare burden, particularly in patients requiring surgical intervention. Therefore, it is of interest to evaluate the risk factors associated with diabetic foot ulcers requiring surgical management and to assess their clinical outcomes. A hospital-based prospective observational study was conducted among 120 patients with diabetic foot ulcers requiring surgical treatment and demographic, clinical, laboratory and operative data were analyzed using appropriate statistical methods. Poor glycemic control, peripheral neuropathy, peripheral arterial disease, smoking and longer duration of diabetes were identified as the major risk factors, while surgical debridement was the most commonly performed procedure and successful limb salvage was achieved in most patients. Early identification of high-risk patients and timely surgical management, combined with multidisciplinary care and optimal glycemic control, can improve clinical outcomes and reduce the risk of major amputation.

Keywords: Diabetic foot ulcer (DFU), diabetes mellitus (DM), surgical management, peripheral neuropathy, limb salvage, amputation

Background:
Diabetes mellitus is a major global health burden, with diabetic foot ulcer (DFU) being a serious complication associated with infection, hospitalization, disability and lower extremity amputation **[1]**. International guidelines emphasize early prevention and management of diabetic foot disease to reduce limb loss and improve quality of life **[2]**. DFU development is multifactorial, with peripheral neuropathy, peripheral arterial disease, poor glycemic control, foot deformity, chronic kidney disease, smoking and previous ulceration being important risk factors **[3, 4].** Early wound assessment, infection control, vascular evaluation, pressure off-loading and multidisciplinary care are essential for preventing disease progression **[5].** Despite advances in treatment, severe DFUs may require debridement, drainage or amputation because of extensive tissue damage or uncontrolled infection **[6].** Therefore, it is of interest to evaluate the major risk factors associated with DFUs requiring surgical management and to assess their clinical outcomes in patients treated at a tertiary care hospital.

Materials and Methods:
This hospital-based prospective observational study was conducted in the Department of General Surgery at a tertiary care teaching hospital over a period of 18 months from January 2024 to June 2025. A total of 120 consecutive adult patients diagnosed with diabetic foot ulcers requiring surgical management were enrolled using a consecutive sampling technique. The study included patients admitted for operative interventions such as surgical debridement, incision and drainage, minor amputation, or major amputation. Demographic characteristics, duration of diabetes, glycemic status, comorbidities, ulcer characteristics, microbiological findings and surgical procedures performed, post-operative complications, duration of hospital stay and treatment outcomes were recorded using a structured case record form.

Inclusion criteria:
[1] Patients aged ≥18 years with diagnosed diabetes mellitus.
[2] Patients presenting with diabetic foot ulcers requiring surgical management.
[3] Patients willing to provide informed written consent.
[4] Patients admitted for operative treatment and post-operative follow-up.

Exclusion criteria:
[1] Foot ulcers of non-diabetic etiology (traumatic, malignant, or venous ulcers).
[2] Patients managed conservatively without surgical intervention.
[3] Patients with incomplete clinical records or lost to follow-up.
[4] Patients with severe systemic illness precluding surgical management.

Statistical analysis:
Data were analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. The Chi-square test and Student's t-test were used for comparison between groups as appropriate. A p-value of <0.05 was considered statistically significant.

Results:
A total of 120 patients with diabetic foot ulcers requiring surgical management were included in the study. Most patients were aged 60–69 years (38.3%), with a male predominance (65%). Nearly half (49.1%) had diabetes for more than 10 years and poor glycaemic control (HbA1c ≥7%) was observed in 80% of the study population **(Table 1).** Peripheral neuropathy was the most common risk factor (73.3%), followed by peripheral arterial disease (43.3%) and smoking (36.7%), indicating that neurovascular impairment played a major role in ulcer development **(Table 2).** Wagner Grade III ulcers were the most common presentation, followed by Grade IV ulcers, suggesting that most patients presented with advanced disease requiring surgical intervention **(Figure 1).** Surgical debridement was the

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most frequently performed procedure (45%). Overall, limb salvage was achieved in 104 (86.7%) patients, whereas 16 (13.3%) required major amputation. Post-operative wound-related complications were observed in 14 (11.7%) patients during follow-up **(Table 3).** Nearly half of the patients (48.3%) required hospitalization for 8–14 days, reflecting the need for continued wound care and postoperative monitoring after surgical management **(Figure 2).** Poor glycemic control, peripheral neuropathy, peripheral arterial disease, smoking, longer duration of diabetes and chronic kidney disease were significantly associated with an increased risk of major amputation ($p<0.05$). Peripheral arterial disease demonstrated the strongest association with unfavorable surgical outcomes **(Table 4).**

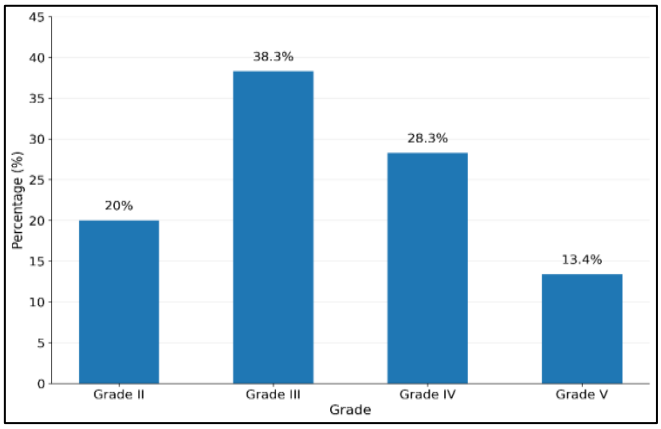


Figure 1: Distribution of wagner grade of diabetic foot ulcers

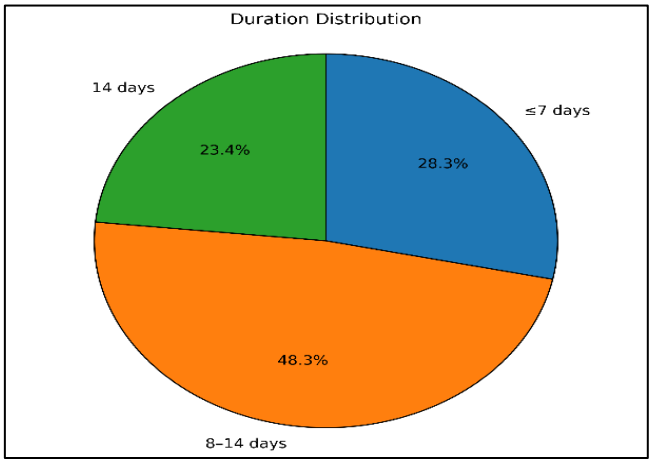


Figure 2: Duration of hospital stay following surgical management

Table 1: Baseline demographic and clinical characteristics of the study participants (n = 120)

Variable		Frequency (n)	Percentage (%)
Age Group (years)	<50	18	15%
	50-59	34	28.3%
	60-69	46	38.3%
	≥70	22	18.4%
Gender	Male	78	65%
	Female	42	35%
Duration of Diabetes	<5 years	20	16.7%
	5-10 years	41	34.2%
	>10 years	59	49.1%
HbA1c	<7%	24	20%
	≥7%	96	80%

Table 2: Distribution of major risk factors among patients with diabetic foot ulcers

Risk Factor	Frequency (n)	Percentage (%)
Peripheral neuropathy	88	73.3%
Peripheral arterial disease	52	43.3%
Smoking	44	36.7%
Chronic kidney disease	26	21.7%
Previous foot ulcer	30	25%
Foot deformity	22	18.3%

Table 3: Surgical procedures performed and clinical outcomes

Variable		Frequency (n)	Percentage (%)
Surgical Procedure	Debridement	54	45%
	Incision and drainage	18	15%
	Minor amputation	32	26.7%
	Major amputation	16	13.3%
Clinical Outcome	Limb salvaged	104	86.7%
	Major amputation	16	13.3%
Postoperative Complications	Wound-related complications	14	11.7%

Table 4: Association of clinical risk factors with major amputation among patients with diabetic foot ulcers

Variable	Major Amputation (n=16)	Limb Salvage (n=104)	p-value
HbA1c ≥7%	15	81	0.028
Peripheral neuropathy	15	73	0.041
Peripheral arterial disease	12	40	0.006
Smoking	10	34	0.033
Duration of diabetes >10 years	13	46	0.021
Chronic kidney disease	7	19	0.017

Discussion:

Diabetic foot ulcer remains one of the most serious complications of diabetes mellitus because it is associated with prolonged hospitalization, repeated surgical procedures, increased healthcare costs and a high risk of lower limb amputation. In the present study, the majority of patients were elderly males with a long duration of diabetes and poor glycemic control, findings that are consistent with recent studies demonstrating that advancing age, male sex and chronic hyperglycemia increase the risk of severe diabetic foot disease requiring surgical intervention **[6].** Poor glycemic control was observed in most of our patients and showed a significant association with major amputation. Persistent hyperglycemia impairs leukocyte function, delays collagen synthesis and compromises wound healing, thereby increasing susceptibility to infection and tissue necrosis. Similar observations have been reported in recent clinical studies and international recommendations, which emphasize optimization of glycemic status as a key component of diabetic foot management **[7, 8]**. Peripheral neuropathy was the most frequent risk factor identified in the present study, followed by peripheral arterial disease and smoking. Neuropathy predisposes patients to repetitive unnoticed trauma, whereas peripheral arterial disease reduces tissue perfusion and delays healing. The coexistence of

these conditions substantially increases the likelihood of ulcer progression and limb loss. Comparable findings have been documented in contemporary studies evaluating predictors of adverse outcomes in diabetic foot ulcers **[9, 10].** Surgical debridement was the most commonly performed procedure, while successful limb salvage was achieved in most patients (86.7%). Nevertheless, a proportion of patients required major amputation because of advanced infection, extensive tissue necrosis, or critical limb ischemia. These findings support current evidence that early diagnosis, timely surgical intervention, appropriate antimicrobial therapy, vascular assessment and multidisciplinary care significantly improve clinical outcomes and reduce the need for major amputation **[11, 12]**. The present study highlights the importance of recognizing modifiable risk factors at an early stage and implementing comprehensive diabetic foot care. Patient education, regular foot examination, smoking cessation, strict glycemic control and prompt referral for surgical evaluation may substantially reduce disease progression and improve limb salvage rates. Although this was a single-center study with a relatively modest sample size, the findings provide clinically relevant evidence regarding the risk factors and outcomes of diabetic foot ulcers requiring surgical management and may help guide future preventive and therapeutic strategies **[13].**

Conclusion:

Diabetic foot ulcers requiring surgical management are associated with multiple risk factors, particularly poor glycemic control, peripheral neuropathy, peripheral arterial disease, smoking and longer diabetes duration. Early diagnosis, timely surgical intervention, effective wound care and metabolic optimization can improve healing and limb salvage. A multidisciplinary approach incorporating risk-factor modification, patient education and regular foot surveillance is essential to reduce complications and major amputations.

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