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Risk Factors And Surgical Outcomes Of Diabetic Foot Ulcer In Patients With Type 2 Diabetes- A Retrospective Study

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ABSTRACT

Introduction- Diabetic foot ulcers (DFUs) are a major complication of type 2 diabetes, leading to severe morbidity, infections, and amputations. Identifying risk factors and surgical outcomes is crucial for improving patient management. This retrospective study analyzes key predictors of DFU progression and evaluates surgical interventions to optimize treatment strategies and outcomes.

Material and method- This retrospective study analyzed medical records of patients with type 2 diabetes and DFUs treated at Maharshi Vishwamitra Autonomous State Medical College, Ghazipur. Data on demographics, comorbidities, ulcer characteristics, infection status, surgical interventions, and outcomes and its predictors were collected. Statistical analysis, including multivariate regression, was performed to identify significant risk factors influencing DFU progression and surgical outcomes.

Result- This study analyzed 980 patients with mean age of 54.8±10.7years and mean diabetes duration of 12.5±6.8years). Poor glycemic control was present in 68%, with neuropathy (76.5%), peripheral arterial disease i.e. PAD (48%), and CKD (36%) as major comorbidities. Infected ulcers were observed in 65%, osteomyelitis in 40%, and multidrug-resistant organisms in 22%. Surgical interventions included wound debridement (74%), minor amputations (32%), and major amputations (34%). Postoperative infections (28%) and delayed healing (39%) were common, with a 48% re-ulceration rate. Multivariate analysis identified osteomyelitis, PAD, and uncontrolled diabetes as significant predictors of poor outcomes.

Conclusion- Diabetic foot ulcers are associated with significant comorbidities, poor glycemic control, and high infection rates, leading to severe surgical outcomes. Early intervention, optimized diabetes management, and multidisciplinary care are crucial in reducing complications, improving limb salvage, and enhancing the overall prognosis for affected patients.

Keywords: *Diabetes, DFUs, outcomes, PAD, patients etc.*

1. INTRODUCTION

Diabetic foot ulcers (DFUs) are a serious complication of type 2 diabetes mellitus (T2DM), leading to increased patient morbidity, mortality, and healthcare costs.[1] These ulcers develop due to factors such as peripheral neuropathy, peripheral arterial disease (PAD), poor glycemic control, and infections.[2] If left untreated, DFUs can lead to severe complications like gangrene and lower limb amputations, significantly affecting quality of life.[3] The rising prevalence of diabetes has increased DFU incidence, necessitating an analysis of risk factors and surgical outcomes to improve patient care. Peripheral neuropathy, a primary cause of DFU development, results from prolonged hyperglycemia, leading to nerve damage and loss of sensation in the feet.[4] This prevents individuals from detecting minor injuries, which can worsen due to continued

pressure and secondary infections. PAD further exacerbates the problem by impairing blood circulation, restricting oxygen and nutrient delivery essential for healing.[5] Poor glycemic control weakens immune function, increasing susceptibility to infections that may progress to osteomyelitis or sepsis.[6] Additional DFU risk factors include foot deformities, callus formation, and inappropriate footwear, which create pressure points leading to ulceration.[7] A history of ulcers or amputations indicates a higher recurrence risk. Long-standing diabetes increases the likelihood of complications, further predisposing patients to DFUs. Socioeconomic factors such as limited healthcare access, lack of awareness, and poor self-care contribute to delayed diagnosis and inadequate management, particularly in low-resource settings.[8]

Severe or non-healing DFUs often require surgical interventions. Common procedures include wound debridement, minor amputations (toe or forefoot removal), and major amputations (below-knee or above-knee).[9] Success depends on ulcer severity, infection presence, vascular status, and patient health. Limb salvage is sometimes possible through reconstructive procedures like skin grafting or flap surgery. However, surgical interventions pose risks, including delayed healing, infections, and psychological distress.[10] Surgical outcomes vary based on factors such as patient age, comorbidities (hypertension, chronic kidney disease), and adherence to post-surgical care.[11] Patients with well-controlled diabetes and adequate vascular supply tend to have better outcomes than those with uncontrolled diabetes and severe PAD. A multidisciplinary approach involving endocrinologists, vascular surgeons, podiatrists, and wound care specialists has been shown to improve surgical outcomes and reduce amputation rates.[12] Beyond physical effects, DFUs and their surgical interventions have significant psychosocial and economic consequences with costs related to hospital stays, surgeries, wound care, and rehabilitation.[8] Despite advances in diabetes management and surgical techniques, DFUs remain a leading cause of lower limb amputations worldwide. Identifying key risk factors and analyzing surgical outcomes is essential for developing effective treatment strategies. This retrospective study assesses factors contributing to DFU development and evaluates surgical intervention outcomes in T2DM patients. By analyzing past cases, this research aims to provide insights into early identification of high-risk patients, optimizing treatment plans, and reducing diabetes-related complications and amputations. The findings will contribute to evidence-based clinical interventions to improve patient outcomes.

2. MATERIAL AND METHOD

The present retrospective study was conducted at Maharshi Vishwamitra Autonomous State Medical College, Ghazipur, analyzing patient records over a defined period. Data were collected from medical records of patients diagnosed with DFUs and undergoing surgical interventions between August 2021 and August 2024. The study was conducted in accordance with the Declaration of Helsinki and adhered to institutional guidelines for research involving human subjects.[1] Patients included in this study were those diagnosed with T2DM and DFUs who had undergone surgical treatment. Inclusion criteria required patients to have a confirmed diagnosis of DFU, as per clinical and radiological assessments, and to have undergone surgical intervention, including wound debridement, minor amputations, or major amputations. Exclusion criteria included patients with incomplete medical records, those with DFUs due to non-diabetic causes, and patients who did not undergo surgical intervention. Patients with other severe comorbidities that significantly impacted wound healing, such as advanced malignancies, were also excluded. Relevant clinical data, including patient demographics (age, sex, and BMI), duration of diabetes, glycemic control status (HbA1c levels), presence of comorbidities (hypertension, chronic kidney disease, PAD), and ulcer characteristics (size, depth, infection severity, presence of osteomyelitis), were extracted from patient records. Additional variables, such as smoking status, history of previous DFUs, and previous amputations, were also noted.

Surgical details, including the type of procedure performed (debridement, minor amputation, or major amputation), duration of hospital stay, perioperative antibiotic use, and need for vascular interventions (such as angioplasty or bypass surgery), were documented. Postoperative complications, including wound infections, delayed healing, re-ulceration, and the need for revision surgeries, were recorded. Functional outcomes, such as mobility status after surgery and patient adherence to follow-up care, were also evaluated. The primary outcome measures included surgical success rates, wound healing time, postoperative complications (infection, delayed healing, re-ulceration), and amputation rates. Success was defined as complete wound healing without the need for further surgical intervention within six months. Healing time was recorded from the date of surgery to complete epithelialization of the wound. Secondary outcomes included duration of hospital stay, mortality rates, readmission rates due to DFU-related complications, and limb salvage success. Limb salvage was defined as the ability to preserve functional use of the affected limb without the need for major amputation. The psychological impact of DFU surgery on patients, assessed through documented mental health consultations, was also considered. Data were analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA), with descriptive statistics used to summarize patient characteristics and surgical outcomes. Categorical variables were expressed as frequencies and percentages, while continuous variables were presented as means and standard deviations. Comparative analysis was conducted using chi-square tests for categorical variables and t-tests or Mann-Whitney U tests for continuous variables. Multivariate logistic regression analysis was performed to identify independent predictors of poor surgical outcomes, adjusting for confounding variables such as age, glycemic control, and presence of PAD. A p-value < 0.05 was considered statistically significant.

3. RESULT

A total of 980 patients were included in this retrospective study. As clear from table 1, the mean age of the patients was 54.8±10.7 years, with mean diabetes duration of 12.5±6.8 years. The mean HbA1c level was 8.2±1.4%, indicating suboptimal glycemic control among the study population. The average hospital stay duration was 14.3±5.2 days, reflecting the prolonged inpatient care required for diabetic foot ulcer management.

Table 1- Patient Characteristics

Characteristics (n=980)	**Mean±SD**
Mean age (years)	54.8±10.7
Duration of diabetes (years)	12.5±6.8
Mean HbA1c (%)	8.2±1.4
Mean hospital stay (days)	14.3±5.2

As seen in figure 1, the study indicated higher prevalence of diabetic foot ulcers (DFUs) in males as among the 980 patients included in the study, 577 (58.87%) were male, and 403 (41.12%) were female.

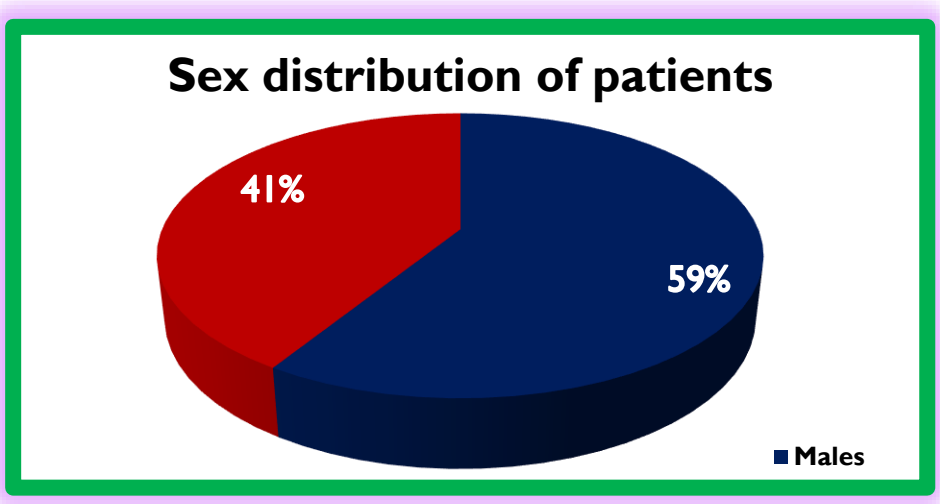

Figure 1- Sex distribution of patients

Among the study population, 42% (n=412) had a history of previous DFUs as depicted in table 2. Poor glycemic control (HbA1c >7.5%) was observed in 68% (n=666) of patients. Comorbid conditions were highly prevalent, with hypertension in 72% (n=706), peripheral arterial disease (PAD) in 48% (n=470), chronic kidney disease (CKD) in 36% (n=353), and dyslipidemia in 54% (n=529). Additionally, 28% (n=275) of patients were active smokers. The readmission rate was 29% (n=284), indicating the chronic and recurrent nature of DFUs. The one-year mortality rate was 22% (n=216), with sepsis and cardiovascular complications being the leading causes of death.

Table 2- Distribution of patients based on different variables.

Variable	**n**	**%**
History of previous DFUs (%)	412	42
Uncontrolled diabetes (HbA1c > 7.5%)	666	68
Hypertension	706	72

Peripheral arterial disease (PAD)	470	48
Chronic kidney disease (CKD)	353	36
Dyslipidemia	529	54
Active smokers	275	28
Readmission rate	284	29
Mortality rate within 1 Year	216	22
Leading causes of death	Sepsis, Cardiovascular complications	

Figure 2 clearly shows that the duration of diabetes varied among the patients, with the highest proportion (30.6%) having diabetes for 11-15 years. A significant number of patients (25.5%) had diabetes for 5-10 years, while 20.4% had diabetes for 16-20 years. Patients with a longer duration of diabetes (>20 years, 11.2%) were more likely to have complications, including peripheral arterial disease (PAD) and chronic kidney disease (CKD), contributing to poor wound healing and increased risk of amputation.

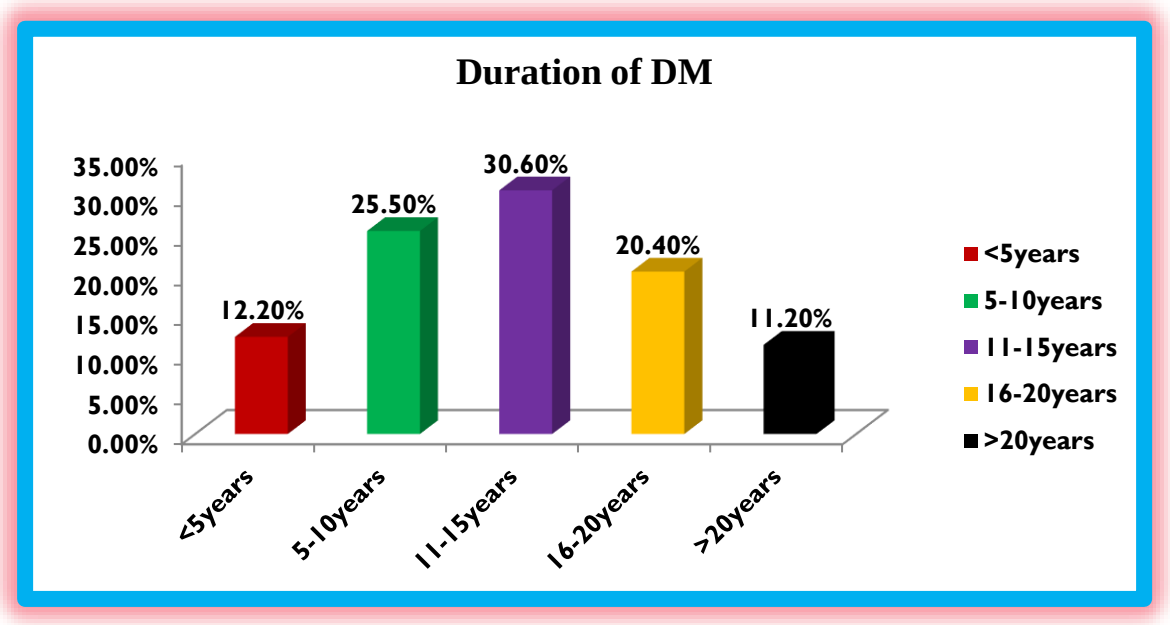

Figure 2- Duration of DM among patients with DFU

Figure 3 shows co-morbidities among DFU patients, neuropathy was the most prevalent co-morbidity, affecting 76.5% (n=750) of cases. Hypertension was present in 66.3% (n=650) of patients, followed by dyslipidemia in 49.0% (n=480) and retinopathy in 51.0% (n=500). Peripheral artery disease (PAD) was observed in 42.9% (n=420) of cases, significantly impacting circulation and wound healing. Chronic kidney disease (CKD) was found in 30.6% (n=300) of patients, while coronary artery disease (CAD) affected 28.6% (n=280), both contributing to overall disease burden. Obesity (BMI >30) was noted in 25.5% (n=250) of patients, indicating a potential link between metabolic syndrome and DFU progression. Stroke history was reported in 12.2% (n=120) of patients, while chronic heart failure (CHF) was diagnosed in 10.2% (n=100), highlighting the cardiovascular risks associated with diabetic complications.

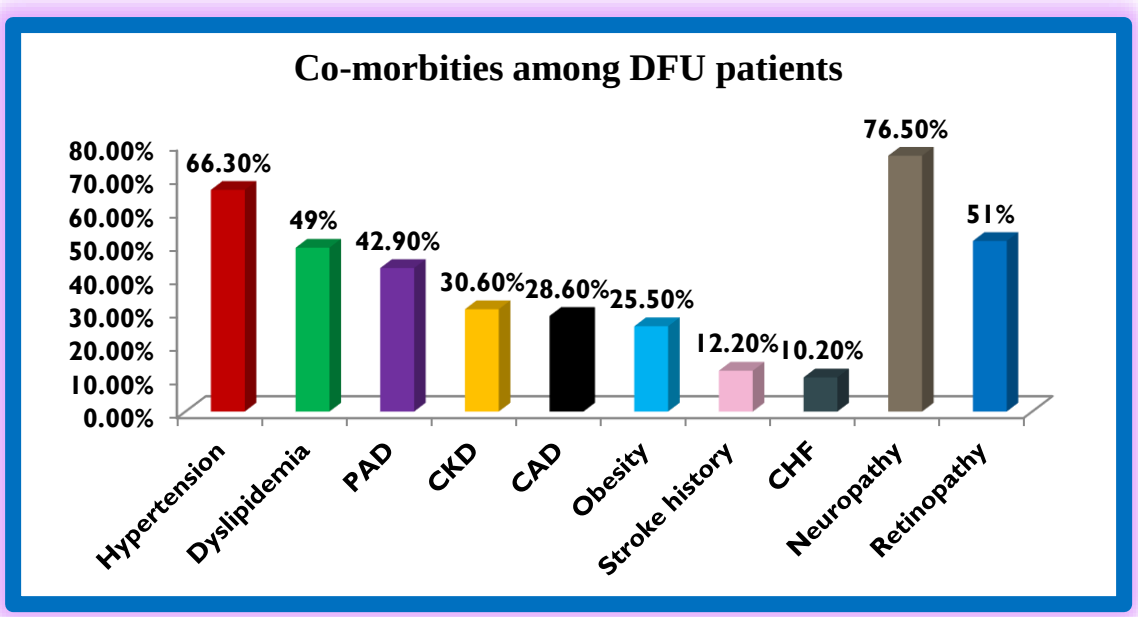

Figure 3- Co-morbidities among patients with diabetic foot ulcers

In present study, the most common ulcer location observed was the plantar surface, accounting for 56% (n=549) of cases, followed by ulcers on the toes in 34% (n=333) of patients as depicted in table 3. Based on the Wagner grading system, 10% (n=98) of ulcers were classified as Grade 1, while 22% (n=216) were Grade 2. More severe ulcers were common, with 38% (n=372) classified as Grade 3 and 30% (n=294) as Grade ≥4, indicating a high proportion of advanced foot ulcers requiring extensive management. Infection was present in 65% (n=637) of patients, emphasizing the significant role of infections in DFU progression. Osteomyelitis, a serious bone infection, was diagnosed in 40% (n=392) of patients. Additionally, multidrug-resistant organisms (MDROs) were detected in 22% (n=216) of cases, posing challenges for effective antimicrobial treatment. The most frequently isolated pathogens were Staphylococcus aureus and Pseudomonas aeruginosa, both of which are known to contribute to severe infections and delayed wound healing.

Table 3- Ulcer characteristics and infection status.

Ulcer & infection status		**n**	**%**
Ulcer location	**Plantar surface**	549	56
	Toes	333	34
Wagner grade	**Grade1**	98	10
	Grade2	216	22
	Grade3	372	38
	Grade≥4	294	30
Presence of infection		637	65
Osteomyelitis		392	40
Multidrug-resistant organisms (MDROs)		216	22
Common pathogens		Staphylococcus aureus, Pseudomonas aeruginosa	

Table 4 shows the surgical intervention & its outcomes along with functional and psychological outcomes of DFUs. Among the 980 patients, wound debridement was the most common surgical intervention, performed in 74% (n=725) of cases. Minor amputations were required in 32% (n=314) of patients, while major amputations were performed in 34% (n=333).

Postoperative infections occurred in 28% (n=275) of patients, contributing to delayed wound healing in 39% (n=382) of cases. Re-ulceration within six months was noted in 48% (n=470) of patients, highlighting the recurrent nature of DFUs. Despite these challenges, limb salvage was successfully achieved in 62% (n=608) of patients. However, 24% (n=235) required revision surgeries, indicating the complexity of wound management. As far as functional and psychological outcomes are concerned, independent ambulation after minor amputation was observed in 68% (n=666) of patients, demonstrating the potential for functional recovery. Among patients who underwent major amputations, 58% (n=568) adapted to prosthetic use. Psychological distress was reported in 47% (n=461) of patients, and 52% (n=509) experienced a reduced quality of life, emphasizing the significant impact of DFUs on mental and social well-being.

Table 4- Distribution of patients based on different outcomes.

Outcomes		**n**	**%**
Surgical interventions and its outcomes	**Wound debridement**	725	74
	Minor amputations	314	32
	Major amputations	333	34
	Postoperative infections	275	28
	Delayed wound healing	382	39
	Re-ulceration within 6months	470	48
	Limb salvage success	608	62
	Need for revision surgeries	235	24
Functional and psychological outcomes	**Independent ambulation after minor amputation**	666	68
	Prosthetic use after major amputation	568	58
	Psychological distress	461	47
	Reduced quality of life	509	52

A multivariate analysis identified several significant predictors associated with adverse outcomes in patients with diabetic foot ulcers (DFUs) as shown in table 5. Uncontrolled diabetes (HbA1c >7.5%) was associated with a 2.1 times higher risk of complications (OR=2.1, $p<0.05$). Peripheral arterial disease (PAD) significantly increased the likelihood of poor outcomes, with an odds ratio of 2.8 ($p<0.01$). Osteomyelitis was found to be the strongest predictor, with a 3.2 times higher risk of complications (OR=3.2, $p<0.01$). Additionally, active smoking was associated with a 1.9 times higher risk (OR=1.9, $p<0.05$), highlighting its detrimental impact on wound healing and overall prognosis.

Table 5- Predictors of poor surgical outcomes

Predictor	**Odds Ratio (OR)**	**p-value**
Uncontrolled diabetes (HbA1c > 7.5%)	2.1	<0.05
Peripheral arterial disease (PAD)	2.8	<0.01
Osteomyelitis	3.2	<0.01
Active smoking	1.9	<0.05

4. DISCUSSION

The present retrospective study analyzed the risk factors and surgical outcomes of diabetic foot ulcers (DFUs) in patients with type 2 diabetes. Our findings highlight the high burden of comorbidities, poor glycemic control, and the significant impact of infection on DFU progression and outcomes. The mean age of patients in our study (54.8±10.7 years) was consistent with previous studies, which report DFUs predominantly in middle-aged individuals.[2] The mean duration of

diabetes (12.5±6.8 years) aligns with findings from prior research, which suggests that prolonged diabetes duration is a key risk factor for DFUs and poor healing outcomes.[12] Additionally, our study found a high prevalence of poor glycemic control (HbA1c >7.5% in 68% of patients), similar to previous reports indicating that elevated HbA1c levels contribute to impaired wound healing and increased infection risk.[13] Comorbid conditions such as hypertension (72%), PAD (48%), CKD (36%), and dyslipidemia (54%) were highly prevalent in our cohort, mirroring earlier findings that underscore the role of these factors in DFU development and progression.[4] Neuropathy was the most common comorbidity (76.5%), supporting previous research indicating that sensory impairment significantly increases the risk of ulceration and subsequent complications.[14] Our study found that the most common ulcer location was the plantar surface (56%), followed by the toes (34%), in agreement with research indicating that pressure points on the foot are the most frequent sites of ulceration.[15] The severity of ulcers was also high, with 38% classified as Wagner Grade 3 and 30% as Grade ≥4, indicating a substantial proportion of advanced ulcers requiring aggressive management. This distribution aligns with previous studies that report similar rates of advanced ulcers.[12] Infection played a crucial role in DFU outcomes, with 65% of patients presenting with infected ulcers. Osteomyelitis was diagnosed in 40% of cases, a finding comparable to other studies that report osteomyelitis in approximately 30–50% of severe DFUs.[8] Additionally, multidrug-resistant organisms (MDROs) were detected in 22% of cases, complicating treatment strategies. The predominant pathogens isolated—Staphylococcus aureus and Pseudomonas aeruginosa—are consistent with previous literature identifying these as the most common bacteria responsible for DFU infections.[8] Wound debridement was the most frequently performed procedure (74%), followed by minor amputations (32%) and major amputations (34%). These rates are comparable to earlier studies that report amputation rates ranging from 30–40% in DFU patients.[2] Despite surgical intervention, postoperative infections (28%) and delayed wound healing (39%) remained common, underscoring the complexity of managing DFUs. The re-ulceration rate within six months was 48%, reflecting the chronic and recurrent nature of DFUs, as also observed in prior studies.[16] Functional and psychological outcomes were also significant concerns. Independent ambulation after minor amputation was observed in 68% of patients, while 58% of major amputation cases adapted to prosthetic use. Psychological distress was reported in 47% of patients, and reduced quality of life was noted in 52%, emphasizing the profound impact of DFUs on mental and social well-being, as previously highlighted by Goodridge et al.[17] Multivariate analysis identified uncontrolled diabetes (HbA1c >7.5%), PAD, osteomyelitis, and active smoking as significant predictors of poor outcomes. These findings align with existing literature indicating that poor glycemic control, vascular disease, and infection substantially increase the risk of complications and amputations in DFU patients.[4,12] Osteomyelitis was the strongest predictor of adverse outcomes (OR=3.2, $p<0.01$), consistent with previous studies that associate bone infection with a high likelihood of limb loss.[8]

5. CONCLUSION

This retrospective study highlights the significant risk factors associated DFUs in patients with type 2 diabetes and their impact on surgical outcomes. Peripheral neuropathy, PAD, poor glycemic control, and prolonged diabetes duration emerged as key contributors to DFU development and progression. The high prevalence of multidrug-resistant infections further complicates management, highlighting the need for targeted antimicrobial strategies. Our findings indicate that patients with multiple comorbidities are more likely to experience poor post-surgical outcomes, including a higher risk of infection, delayed wound healing, and increased rates of amputation. Given the substantial rates of re-ulceration and diminished quality of life among affected individuals, early intervention through optimized glycemic control, regular foot care, and multidisciplinary treatment approaches is crucial in reducing DFU-related morbidity. Early identification and management of these risk factors, along with timely surgical intervention and comprehensive wound care strategies, are essential in improving patient prognosis and reducing the burden of DFUs. Future prospective studies are needed to validate these findings and explore more preventative strategies and multidisciplinary approaches to DFU management to reduce complications and improve the quality of life in affected patients.

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