



Original Article

Sensitivity of the Wound, Ischemia and Foot Infection (WIFI) Scoring System to Predict Amputation in Patients with Diabetic Foot Ulcers: A Prospective Observational Study from a Tertiary Care Centre

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ABSTRACT

Background: Diabetic foot ulcers (DFUs) are a major complication of diabetes mellitus and a leading cause of non-traumatic lower limb amputations worldwide. Accurate risk stratification is essential to guide treatment and prevent limb loss. The Wound, Ischemia, and foot Infection (WIFI) classification system developed by the Society for Vascular Surgery integrates three critical components influencing diabetic foot outcomes. This study aimed to estimate the sensitivity of the WIFI scoring system in predicting amputation among patients with diabetic foot ulcers in a tertiary healthcare setting. **Methods:** A prospective observational study was conducted among 115 patients presenting with diabetic foot ulcers at the Department of General Surgery, Government Medical College, Thiruvananthapuram. Participants meeting inclusion criteria were recruited consecutively. WIFI scoring was performed at presentation based on wound characteristics, ischemia (using ankle-brachial pressure index), and infection severity. Patients were followed for six months to determine outcomes, including the need for amputation. Data were analysed using SPSS version 27. Sensitivity, specificity, and receiver operating characteristic (ROC) curve analysis were performed. **Results:** The mean age of participants was 61.1 ± 8.7 years, with males comprising 65.2% of the sample. Overall, 65.2% of patients underwent some form of amputation. Higher grades of ischemia and infection were significantly associated with increased amputation risk ($p < 0.01$). Among patients with WIFI stage ≥ 3 , 63 out of 64 required amputation compared to 12 among those with stage < 3 . The WIFI system demonstrated a sensitivity of 84% and specificity of 97.5% in predicting amputation. ROC analysis showed excellent predictive ability with an area under the curve of 0.924 (95% CI: 0.869–0.979). **Conclusion:** The WIFI classification system is an effective and reliable tool for predicting amputation risk in patients with diabetic foot ulcers, facilitating early risk stratification and improved clinical decision-making.

Keywords: Diabetic foot ulcer, Wifi classification, amputation, ischemia, infection, risk prediction.

INTRODUCTION

Diabetes mellitus is a major public health problem worldwide, with a rapidly increasing prevalence, particularly in developing countries such as India. According to global estimates, India is home to more than 77 million adults living with

diabetes, with many more individuals remaining undiagnosed. Chronic hyperglycemia in diabetes leads to a variety of microvascular and macrovascular complications that significantly contribute to morbidity and mortality. Among these complications, diabetic foot ulcers (DFUs) represent one of the most serious and disabling conditions affecting individuals with diabetes.¹

Diabetic foot ulcers occur due to the complex interplay of peripheral neuropathy, peripheral arterial disease, and infection. Neuropathy leads to loss of protective sensation, abnormal foot biomechanics, and repeated trauma to the foot. Peripheral arterial disease reduces tissue perfusion and impairs wound healing, while infection further aggravates tissue destruction and increases the likelihood of limb loss.² Consequently, diabetic foot ulcers frequently progress to severe infections and gangrene, ultimately resulting in lower limb amputation if not managed appropriately.

Globally, diabetic foot ulcers are the leading cause of non-traumatic lower limb amputations. Approximately one in four individuals with diabetes is expected to develop a foot ulcer during their lifetime, and nearly 80% of diabetes-related amputations are preceded by foot ulcers.³ These complications significantly reduce quality of life, increase healthcare costs, and impose a substantial burden on healthcare systems.

Early risk assessment and stratification are therefore essential in the management of diabetic foot ulcers. Various classification systems have been developed to categorize the severity of diabetic foot disease and predict clinical outcomes. Traditional classification systems include the Wagner classification, University of Texas (UT) classification, Fontaine classification, and Rutherford classification.⁴⁻⁶ However, most of these systems focus on a single component such as wound depth or ischemia and do not comprehensively account for the multiple factors contributing to disease progression.

To address this limitation, the Society for Vascular Surgery proposed the Wound, Ischemia, and foot Infection (WIFI) classification system.⁷ This system integrates three major pathophysiological components influencing limb prognosis: wound characteristics, degree of ischemia, and severity of infection. Each component is graded from 0 to 3 based on severity, and the combined scores categorize patients into four clinical stages corresponding to increasing risk of amputation.

The WIFI classification has gained increasing attention as a comprehensive tool for assessing threatened limbs and guiding clinical decision-making. Previous studies have demonstrated its usefulness in predicting wound healing, need for revascularization, and risk of amputation.⁸ However, limited data are available regarding its predictive performance in the Indian population, where the burden of diabetic foot disease is high.

Therefore, the present study was conducted to estimate the sensitivity of the WIFI scoring system in predicting amputation among patients with diabetic foot ulcers presenting to a tertiary care centre.

MATERIALS AND METHODS

Study Design

This study was conducted as a prospective observational study aimed at evaluating the effectiveness of the Wound, Ischemia, and Foot Infection (WIFI) classification system in predicting the risk of amputation among patients presenting with diabetic foot ulcers. The WIFI scoring system, proposed by the Society for Vascular Surgery, is a validated tool used to stratify patients with threatened lower limbs based on wound severity, degree of ischemia, and presence of infection. The present study sought to determine the sensitivity of the WIFI classification in predicting limb outcomes and to examine the association between individual WIFI components and the likelihood of amputation.

Study Setting

The study was conducted in the Department of General Surgery at Government Medical College, Thiruvananthapuram, a tertiary care teaching hospital in Kerala, India. The hospital serves as a major referral center for patients with diabetic foot complications from both urban and rural regions of the state. The institution provides multidisciplinary management for diabetic foot conditions, including surgical care, vascular evaluation, infection management, and rehabilitation services. The availability of specialized surgical units and diagnostic facilities made it a suitable setting for conducting the present study.

Study Population

The study population consisted of adult patients diagnosed with diabetic foot ulcers who presented to the surgical outpatient department or were admitted to the surgical wards of the hospital during the study period. Patients were assessed for eligibility based on predefined inclusion and exclusion criteria. Eligible patients were enrolled consecutively until the

required sample size was achieved. All participants included in the study had a confirmed diagnosis of diabetes mellitus and presented with clinically identifiable foot ulcers attributable to diabetic complications.

Study Period

The study was conducted over a period of one year following approval from the Institutional Ethics Committee. During this period, patients presenting with diabetic foot ulcers were evaluated and enrolled in the study after obtaining informed consent. Participants were followed up for a defined duration to assess clinical outcomes, particularly the occurrence of limb amputation.

Sample Size Determination

The sample size required for the study was calculated using the standard formula for estimating proportions in observational studies, $N = 4pq/d^2$. In this formula, p represents the expected sensitivity of the WIfI classification system based on previous literature, q represents the complement of p , and d represents the allowable error. Based on findings from a previous study conducted at Christian Medical College, Vellore, the expected sensitivity of the WIfI scoring system in predicting amputation was estimated to be approximately 82%. Accordingly, the value of q was calculated as 18, and the allowable error was set at 8%. Using these values, the calculated sample size was 92.2. Considering the expected proportion of amputations among diabetic foot ulcer patients to be approximately 80%, the sample size was adjusted to ensure adequate representation of the outcome variable. After adjustment, the minimum required sample size was calculated as 115 patients, and this number of participants was included in the study.

Sampling Technique

A consecutive sampling technique was employed for patient recruitment. All eligible patients presenting to the surgical outpatient department or admitted to the surgical wards with diabetic foot ulcers during the study period were screened for eligibility. Patients who satisfied the inclusion criteria and provided informed consent were consecutively enrolled until the required sample size of 115 participants was reached.

Inclusion and Exclusion Criteria

Patients aged 18 years or older with a confirmed diagnosis of diabetes mellitus and presenting with diabetic foot ulcers were included in the study. Both patients attending the outpatient department and those admitted to the surgical wards were considered eligible for inclusion, provided they were willing to participate and gave written informed consent.

Patients were excluded if they were below 18 years of age, had stump ulcers following previous amputations, or had ulcers resulting from traumatic injuries or malignant conditions. Patients who declined to provide consent for participation were also excluded from the study.

Data Collection Procedure

Data collection was carried out using a structured and predesigned proforma specifically developed for the purpose of the study. After obtaining informed consent, participants were interviewed and examined by the investigator to collect relevant demographic and clinical information. The demographic details included age and gender of the participants. Clinical information such as duration of diabetes mellitus, presence of comorbid conditions including hypertension and coronary artery disease, and history of smoking was recorded.

A detailed clinical examination of the affected foot was performed to assess the characteristics of the ulcer, including its size, depth, presence of necrosis, and surrounding tissue involvement. Signs of infection such as erythema, purulent discharge, swelling, and systemic manifestations were also evaluated. Vascular status of the lower limb was assessed through clinical examination and measurement of the Ankle Brachial Pressure Index (ABPI) using Doppler ultrasonography. This assessment provided an objective evaluation of peripheral arterial perfusion and helped in grading the ischemia component of the WIfI classification.

WIfI Classification Assessment

The WIfI classification system was used to evaluate the severity of limb threat in patients with diabetic foot ulcers. This classification consists of three major components: Wound (W), Ischemia (I), and Foot Infection (FI). Each of these components is graded on a scale from 0 to 3, where grade 0 indicates minimal or no disease severity and grade 3 indicates the most severe presentation. The wound component assesses the extent and depth of the ulcer and the degree of tissue loss. The ischemia component evaluates the level of arterial insufficiency, primarily based on objective vascular measurements such as ABPI. The foot infection component assesses the severity of infection based on clinical signs and systemic involvement.

The scores assigned to each component were combined to determine the overall Wifl clinical stage, which ranges from stage 1 to stage 4. These stages correspond to increasing levels of risk for limb amputation and guide clinical decision-making regarding limb salvage and revascularization strategies.

Follow-up and Outcome Assessment

All patients enrolled in the study were followed up for a period of six months to monitor clinical outcomes. Follow-up assessments were conducted through scheduled outpatient visits and, when necessary, telephonic communication with the patients or their caregivers. The primary outcome measured in the study was the occurrence of amputation during the follow-up period.

Amputation procedures were categorized based on the level of limb removal. Minor amputations included toe disarticulation, ray amputation, and transmetatarsal amputation, while major amputations included procedures performed above the ankle, such as below-knee amputation or above-knee amputation. Patients who did not require amputation during the follow-up period were categorized as cases of limb salvage.

Statistical Analysis

The collected data were entered into Microsoft Excel and subsequently analyzed using the Statistical Package for the Social Sciences (SPSS) version 27. Descriptive statistical methods were used to summarize demographic and clinical characteristics of the study population. Continuous variables were expressed as mean values with standard deviation, while categorical variables were expressed as frequencies and percentages.

The diagnostic performance of the Wifl classification system in predicting amputation was evaluated by calculating sensitivity, specificity, and corresponding 95% confidence intervals. The association between the individual components of the Wifl score and the risk of amputation was also examined. Appropriate statistical tests were applied to determine the significance of these associations.

Ethical Considerations

Ethical approval for the study was obtained from the Institutional Ethics Committee of Government Medical College, Thiruvananthapuram prior to the initiation of the research. All procedures performed in the study were conducted in accordance with the ethical standards of the institutional research committee and the principles outlined in the Declaration of Helsinki.

Participants were informed about the objectives, procedures, potential benefits, and possible risks associated with the study through a detailed participant information sheet. Written informed consent was obtained from each participant before enrollment. Confidentiality of patient information was strictly maintained, and all collected data were used solely for academic and research purposes. Participation in the study was entirely voluntary, and patients were free to withdraw from the study at any time without affecting their medical care.

RESULTS

Demographic Characteristics

A total of 115 patients with diabetic foot ulcers were included in the study. The mean age of participants was 61.1 ± 8.7 years. The highest proportion of patients (45.2%) belonged to the age group of 50–59 years, followed by 33% in the 60–69 year age group. Males constituted 65.2% of the study population, while females accounted for 34.8%.

Clinical Characteristics

The majority of patients presented with foot ulcers (84.3%), while 65.2% had blackish discoloration of the foot. Paresthesia or numbness was reported by 86.1% of patients.

Regarding comorbidities, hypertension was present in 73% of patients and dyslipidemia in 48.7%. A history of cerebrovascular accident was reported in 8%, coronary artery disease in 4.4%, and chronic kidney disease in 2.7%.

More than half of the patients (53.9%) had diabetes for more than 10 years, indicating the chronic nature of disease among the study population. Smoking history was present in 40.9% of participants.

Table 1: Demographic and Clinical Characteristics of Study Participants (n = 115)

| Variable | Category | Frequency (n) | Percentage (%) |
|----------------|--------------------------------|---------------|----------------|
| Age | Mean age | 61 years | — |
| Peak age group | 50–59 years | — | |
| Gender | Male | 75 | 65.2 |
| | Female | 40 | 34.8 |
| Smoking Status | Smoker | 47 | 40.9 |
| | Non-smoker | 68 | 59.1 |
| Comorbidities | Hypertension | 84 | 73.0 |
| | Dyslipidemia | 56 | 48.7 |
| | Cerebrovascular accident (CVA) | 9 | 8.0 |
| | Coronary artery disease (CAD) | 5 | 4.4 |
| | Chronic kidney disease (CKD) | 3 | 2.7 |

Distribution of Wifi Components

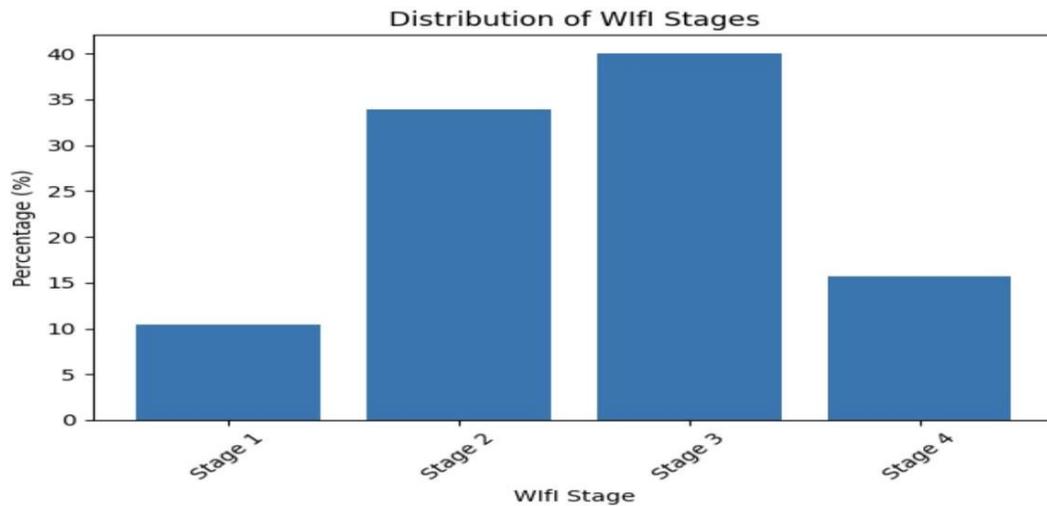
The distribution of the individual components of the Wound, Ischemia, and foot Infection (Wifi) classification system among the study participants showed varying degrees of severity. With respect to the wound component, the majority of patients presented with Grade 1 wounds, accounting for 80.9% of the study population. Grade 2 wounds were observed in 16.5% of the participants, while only 2.6% of patients had Grade 3 wounds, indicating that severe tissue loss was relatively uncommon in the study group.

Evaluation of the ischemia component demonstrated a broader distribution across the different grades. Grade 2 ischemia was the most frequently observed category, affecting 35.7% of patients. This was followed by Grade 0 ischemia, seen in 33% of participants, indicating that a substantial proportion of patients had no significant arterial insufficiency. Grade 1 ischemia was identified in 26.1% of cases, while Grade 3 ischemia, representing severe ischemic compromise, was present in 5.2% of the study population. The mean ankle-brachial pressure index (ABPI) among participants was 0.68 ± 0.19 , reflecting an overall moderate level of peripheral arterial disease in the cohort.

Assessment of the foot infection component revealed that Grade 2 infection was the most common presentation, accounting for 40.0% of patients. Grade 1 infection was observed in 34.8% of cases, while Grade 3 infection, indicating severe infection, was present in 13.9% of the participants. A smaller proportion of patients, 11.3%, had Grade 0 infection, indicating the absence of clinically significant infection at the time of evaluation.

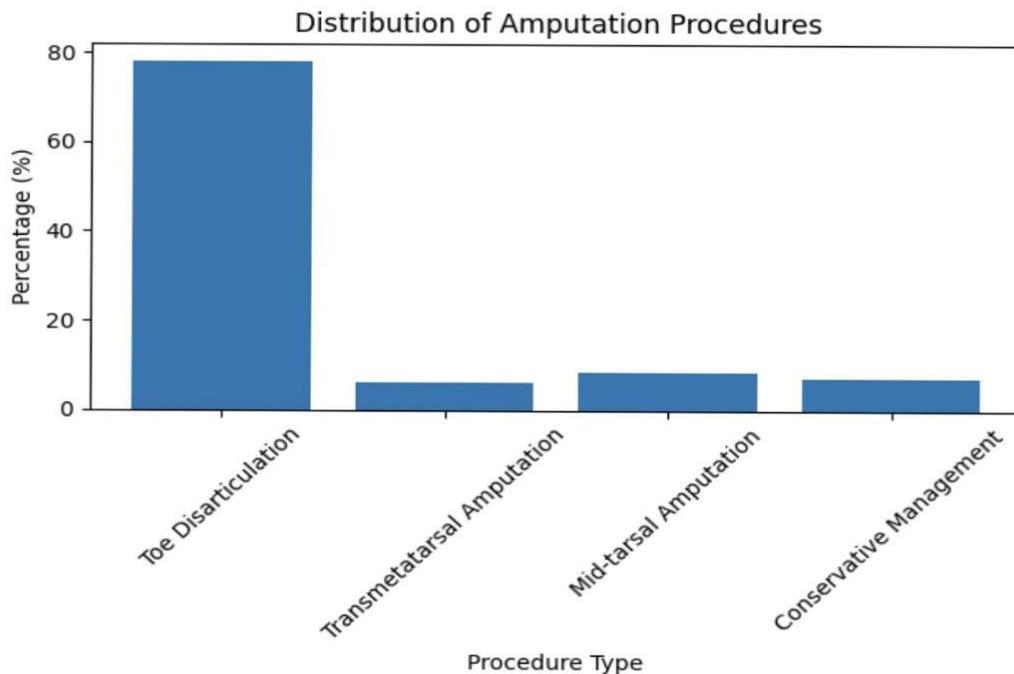
Distribution of Wifi Stages

Based on the combined assessment of wound severity, degree of ischemia, and infection status, the overall Wifi staging of patients was determined. The most common stage observed was Stage 3, which included 40% of the participants, indicating a moderately high risk of limb loss. Stage 2 was the second most frequent category, accounting for 33.9% of the study population. Stage 4, which represents the highest risk of amputation, was observed in 15.7% of patients. In contrast, Stage 1, representing the lowest risk category, comprised 10.4% of the participants.



Amputation Outcomes

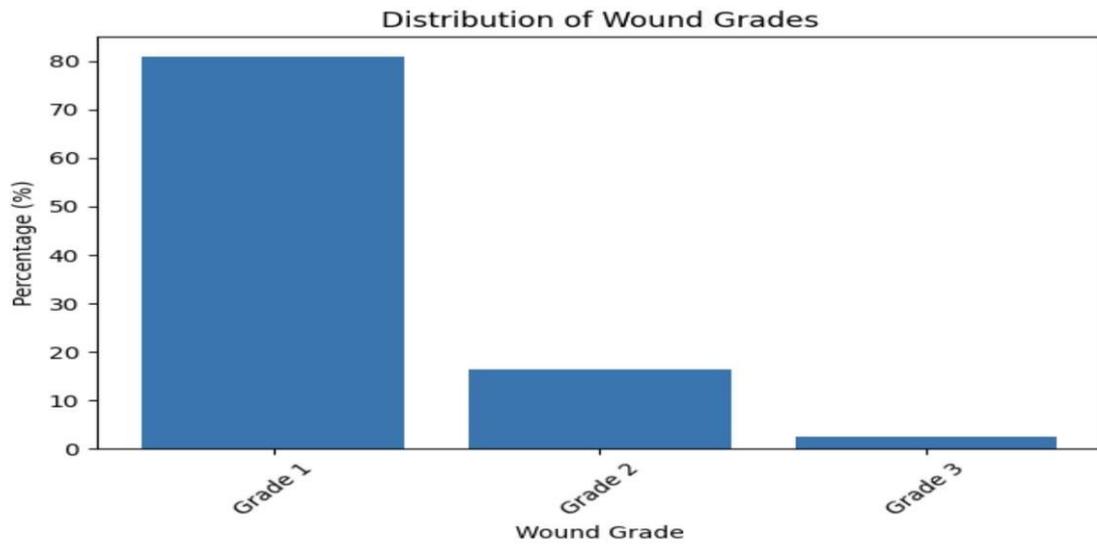
Among the 115 patients included in the study, 75 patients (65.2%) underwent some form of amputation, while 40 patients (34.8%) were managed without amputation during the follow-up period. The majority of amputations performed were minor amputations, with toe disarticulation being the most common procedure, accounting for 78% of the cases. Other procedures included transmetatarsal amputation, which was performed in 6.1% of patients, and mid-tarsal amputation, carried out in 8.5% of cases. A small proportion of patients, 7.3%, were managed through conservative treatment, which included wound care, infection control, and supportive medical management without surgical amputation.



Association Between Wifi Components and Amputation

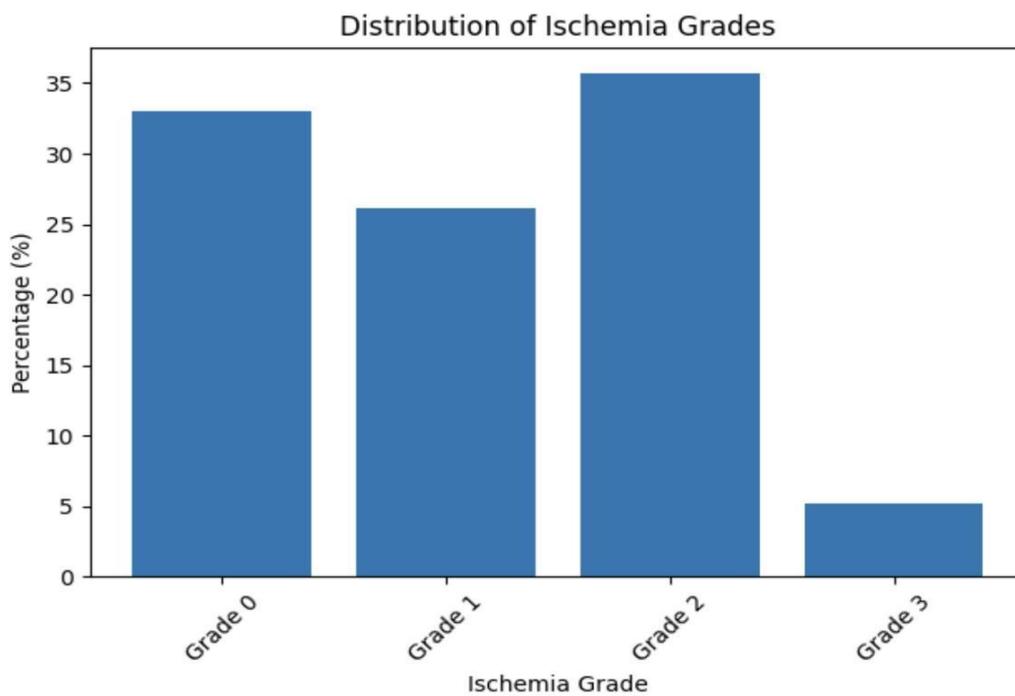
Wound Grade

Higher wound grades showed increased rates of amputation. However, this association did not reach statistical significance ($p = 0.078$).



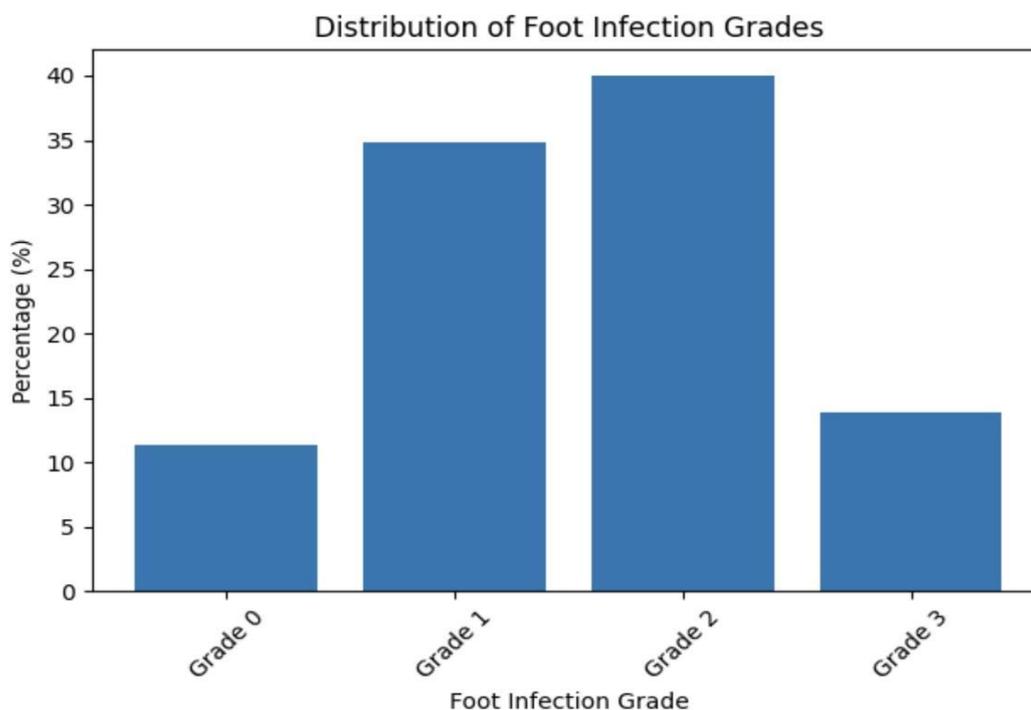
Ischemia Grade

Amputation rates increased progressively with ischemia severity, ranging from 39.5% in Grade 0 to 100% in Grade 3. This association was statistically significant ($p < 0.01$).



Infection Grade

Similarly, increasing severity of foot infection was strongly associated with amputation risk. Amputation rates ranged from 15.4% in Grade 0 to 93.8% in Grade 3 ($p < 0.01$).



Diagnostic Accuracy of Wifl Scoring

Among patients with Wifl stage ≥ 3 , 63 out of 64 underwent amputation, whereas only 12 of 51 patients with stage < 3 required amputation.

The diagnostic performance of the Wifl classification was as follows:

- Sensitivity: 84%
- Specificity: 97.5%

ROC curve analysis demonstrated excellent predictive performance with an area under the curve of 0.924 (95% CI: 0.869–0.979, $p < 0.01$).

DISCUSSION

Diabetic foot ulcers represent a major cause of morbidity among individuals with diabetes and frequently lead to lower limb amputations. Accurate risk stratification is essential for timely intervention and limb salvage. The present study evaluated the predictive performance of the Wifl classification system in assessing amputation risk among patients with diabetic foot ulcers.

The mean age of participants in this study was 61.1 years, which is consistent with previous studies reporting higher prevalence of diabetic foot complications among older individuals with long-standing diabetes. Similar age distributions have been reported in studies conducted by Cull et al. and Zhan et al., indicating that diabetic foot complications are more common in the sixth decade of life.^{9,10} Male predominance was observed in the present study, with 65.2% of participants being male. This finding is consistent with previous studies suggesting higher rates of diabetic foot ulcers among men, possibly due to increased exposure to trauma, occupational risk factors, and higher prevalence of smoking.¹¹ The majority of patients in the current study had long-standing diabetes, with more than half having a disease duration exceeding 10 years. Chronic hyperglycemia contributes to progressive neuropathy and peripheral arterial disease, which significantly increase the risk of foot ulceration and impaired wound healing.¹² Evaluation of the individual components of the Wifl scoring system demonstrated important associations with amputation outcomes. Although higher wound grades were associated with increased amputation rates, the relationship was not statistically significant in the present study. This finding suggests that wound characteristics alone may not be sufficient to predict amputation risk without considering other factors such as ischemia and infection.

In contrast, ischemia demonstrated a strong and statistically significant association with amputation risk. Amputation rates increased progressively with higher ischemia grades, reaching 100% in patients with grade 3 ischemia. This observation

highlights the critical role of impaired perfusion in determining limb prognosis. Previous studies have similarly reported ischemia as one of the most important predictors of limb loss in patients with diabetic foot ulcers.¹³ Foot infection severity also showed a strong association with amputation risk in the present study. Patients with severe infection had significantly higher amputation rates compared to those with mild or no infection. Severe infections can rapidly progress to deep tissue destruction, osteomyelitis, and systemic sepsis, thereby necessitating surgical intervention. Effective early management of infection is therefore essential in preventing limb loss.¹⁴ The overall diagnostic accuracy of the WIfI classification system in predicting amputation was found to be high in this study. With a sensitivity of 84% and specificity of 97.5%, the system demonstrated excellent ability to identify patients at high risk of limb loss. The ROC curve analysis further confirmed its strong predictive performance with an area under the curve of 0.924.

These findings are consistent with previous studies evaluating the clinical utility of the WIfI classification system. Cull et al. reported that amputation risk increased progressively with higher WIfI stages, with one-year amputation rates of 3%, 10%, 23%, and 40% for stages 1 to 4 respectively.⁹ Similarly, Zhan et al. observed that the majority of major amputations occurred among patients classified in stage 4 of the WIfI system, further confirming its predictive value.¹⁰ Another study by Williams et al. compared the WIfI system with the SINBAD classification and found that WIfI stages were significantly associated with amputation risk at one year, whereas SINBAD severity scores did not demonstrate similar predictive performance.¹⁵

Van Haelst et al. also reported that WIfI staging correlated strongly with clinical outcomes including wound healing, amputation rates, and mortality among patients with chronic limb-threatening ischemia.¹⁶ The findings of the present study further support the usefulness of the WIfI classification as a comprehensive tool for risk stratification in diabetic foot ulcers. By integrating wound characteristics, ischemia, and infection severity, the system provides a more holistic assessment of limb threat compared with traditional classification systems.

Early identification of patients at high risk for amputation allows clinicians to implement aggressive management strategies, including revascularization procedures, infection control, and surgical debridement. Such interventions can significantly improve limb salvage rates and reduce the burden of diabetic foot complications.

CONCLUSION

The present study demonstrated that the WIfI classification system is an effective and reliable tool for predicting the risk of amputation in patients with diabetic foot ulcers. Increasing severity of ischemia and infection were strongly associated with higher amputation rates. The WIfI scoring system showed excellent diagnostic performance with high sensitivity and specificity. Early application of this classification in clinical practice can assist clinicians in identifying high-risk patients, guiding treatment decisions, and improving limb salvage outcomes. Incorporating the WIfI scoring system into routine evaluation of diabetic foot ulcers may therefore enhance patient management and reduce the burden of diabetes-related amputations.

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