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**Original Research Article**

# Incidence of peripheral arterial disease in diabetic foot

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## ABSTRACT

**Background:** Diabetic foot infections (DFIs) are a major cause of morbidity and lower-limb amputations in individuals with diabetes mellitus. Peripheral arterial disease (PAD) significantly increases the risk of non-healing ulcers and adverse outcomes, yet often remains underdiagnosed. This study aimed to determine the prevalence of PAD in patients with DFI and to evaluate its association with clinical profile and outcomes.
**Methods:** A hospital-based descriptive observational study was conducted among 100 adults with DFI. Clinical data were collected using a structured proforma. The severity of foot lesions was graded using the Wagner classification. Ankle–brachial pressure index (ABI) was measured for all participants, and arterial Doppler was performed when ABI was abnormal. Microbiological culture results and need for amputation were recorded. Statistical associations were assessed using Chi-square test.
**Results:** PAD was detected in 60% of patients, with moderate disease being most common. PAD prevalence was significantly higher in older individuals, those with longer diabetes duration, and patients with poor glycaemic control ($p<0.05$). Overall, amputation rate was 34% (34/100), with significantly higher rates in PAD patients (38.3%) vs non-PAD (27.5%) ($p<0.05$). Gram-negative organisms predominated in wound cultures, with Pseudomonas (24.0%) and Proteus (17.0%) as the most common isolates.
**Conclusions:** PAD is highly prevalent among hospitalized patients with DFI and is strongly associated with ulcer severity and poor clinical outcomes. Routine ABI-based vascular assessment is essential for early detection and timely intervention to improve limb salvage.

**Keywords:** Diabetes mellitus, Diabetic foot infection, Peripheral arterial disease, Ankle–brachial index, Amputation, Vascular assessment

## INTRODUCTION

Diabetes mellitus (DM) is a major global health concern, with a rapidly increasing prevalence worldwide. According to recent IDF estimates, the global diabetic population may reach 853 million by 2050, highlighting the escalating burden.[1] Diabetic foot complications remain one of the most serious consequences of long-standing diabetes, leading to substantial morbidity, healthcare costs, and reduced quality of life. The lifetime risk of developing a diabetic foot ulcer is estimated at 15-25%, and lower-limb amputation continues to be a frequent outcome when ulcers become infected or fail to heal.[2] Diabetic foot–related amputations are also associated with high 5-year mortality, comparable to many cancers.[3]

The pathogenesis of diabetic foot infection (DFI) is multifactorial, involving peripheral neuropathy, altered biomechanics, trauma, and impaired wound healing. Among these factors, peripheral arterial disease (PAD) plays a crucial role by compromising tissue perfusion and increasing the risk of non-healing ulcers, gangrene, and subsequent amputation.[4] Around half of diabetic foot

ulcers have coexisting PAD, making early identification essential for limb salvage.

However, PAD is often underdiagnosed in diabetics because neuropathy can mask classical symptoms such as claudication and rest pain. Additionally, medial arterial calcification may lead to falsely elevated vascular pressure measurements, particularly in long-standing diabetes. Therefore, objective vascular assessment is recommended as part of every diabetic foot evaluation.[5] Recent IWGDF and ADA guidelines emphasise mandatory vascular assessment at presentation for all diabetic foot ulcers.[6]

The ankle-brachial pressure index (ABI) is a simple, non-invasive bedside screening tool to detect PAD. An ABI value <0.90 suggests arterial occlusive disease, whereas values >1.30 indicate possible arterial calcification requiring further assessment. Arterial Doppler ultrasonography provides detailed evaluation of segmental disease, aiding clinical decision-making regarding revascularization.[7,8]

Despite its clinical importance, PAD often receives less attention during DFI management in routine practice, especially in resource-constrained settings. Limited regional data also hinder effective risk stratification and targeted interventions. In India, where the burden of diabetes continues to rise, there is a pressing need to assess the extent of PAD among patients presenting with DFIs to improve detection and outcomes.[5,9] There is particularly limited data from South Indian tertiary centres on PAD prevalence among DFI patients

This study aimed to determine the prevalence of PAD among patients with diabetic foot infections attending a tertiary care centre in Kerala, using ABI and arterial Doppler examination. The study also explored associated clinical characteristics and outcomes, with the goal of strengthening early vascular evaluation and reducing amputation risk.

This study also addresses a key evidence gap by providing institution-level data that may help standardise vascular screening protocols.

## METHODS

### *Study design and setting*

This was a hospital-based descriptive observational study conducted in the Department of General Surgery, Malabar Institute of Medical Sciences (MIMS)/Aster MIMS, Kozhikode. Patients with diabetic foot infections admitted to the surgical wards during the study period were included.

### *Study duration*

The study was carried out over 13 months from October 2021 to December 2022

### *Study population*

Adults (≥18 years) with a known diagnosis of diabetes mellitus presenting with clinical features of diabetic foot infection were recruited consecutively after obtaining informed consent.

### *Inclusion criteria*

The study included adults with a confirmed diagnosis of diabetes mellitus who presented with an infected foot ulcer or gangrene and who were willing to participate after providing informed consent.

### *Exclusion criteria*

Patients with non-infected diabetic foot ulcers were not enrolled. Individuals who were critically ill and therefore unable to provide consent were excluded.

### *Data collection and clinical evaluation*

Patient demographics, comorbidities, glycaemic control parameters and infection characteristics were recorded using a structured proforma. Diabetic foot severity was graded using the Wagner classification.

### *Assessment for peripheral arterial disease*

All participants underwent ankle–brachial pressure index (ABI) measurement using a handheld Doppler. ABI ≤0.90 was taken as diagnostic of peripheral arterial disease (PAD), while ABI >1.30 was interpreted as suggestive of arterial wall calcification. Patients with ABI abnormalities were further evaluated using arterial Doppler ultrasonography to determine the level and severity of arterial obstruction.

### *Microbiological evaluation*

Deep tissue or swab samples from the infected site, obtained after wound irrigation, were cultured using standard microbiological methods to identify bacterial isolates.

### *Management and outcomes*

Patients received standard care including infection control, wound debridement, off-loading, and appropriate antibiotic therapy. Indications for minor or major amputation were documented. Clinical outcomes, including need for amputation and healing status, were recorded at discharge.

### *Sample size*

A total of 100 eligible patients were included in the final analysis.

### *Statistical analysis*

Data were entered in Microsoft Excel and analysed using standard statistical methods. Categorical variables were expressed as proportions and percentages, and continuous variables as mean and standard deviation. Associations between PAD and clinical variables were assessed using Chi-square test, with $p<0.05$ considered statistically significant.

### *Ethical considerations*

The study was approved by the Institutional Ethics Committee of MIMS Kozhikode. Written informed consent was obtained from all participants prior to enrolment.

## RESULTS

A total of 100 patients with diabetic foot infections were included in the study.

Demographic data is presented in Table 1.

**Table 1: Demographic data.**

| Characteristics | Range |
|---|---|
| **Age (years)** | 67.5±9.3 |
| **Gender (%)** | |
| Male | 74 |
| Female | 36 |
| **Duration of diabetes (%)** | |
| ≤10 | 44 |
| 10-20 | 51 |
| 20-30 | 4 |
| >30 | 1 |
| **Distribution of comorbidities** | |
| Hypertension | 53 |
| Coronary artery disease | 38 |
| Chronic kidney disease | 23 |
| Cerebrovascular accident | 7 |
| Hypothyroidism | 6 |

The median duration of diabetes was 12.5 years (IQR 6-16). Poor glycaemic control was observed in the majority, with Median HbA1c for PAD group=9.7 (IQR 8.6-11.9), non-PAD=8.2 (IQR 7.3-9.6). Based on Wagner classification, grade IV (32%) is the most frequent followed by grade II (31%) and then grade III (25%) (Table 2).

Peripheral arterial disease was identified in 56% of patients: 52 % of the individuals had ABI between 0.4 and 0.9 and 4 % had ABI values less than 0.4 indicating severe PAD. 4 individuals had an ABI of >1.3 whose Doppler studies showed calcifications with significant stenosis indicating PAD (Figure 1). Arterial Doppler showed predominantly tibial arterial involvement, with infrapopliteal occlusions more common than proximal disease. The presence of PAD was significantly associated with older age ($p<0.05$), longer duration of diabetes ($p<0.05$), higher Wagner grade ($p<0.05$), and elevated HbA1c levels ($p<0.05$). No statistically significant difference was observed with respect to sex.

Gram-negative organisms were most frequently isolated, with *Pseudomonas* (24.0%), *Proteus* (17.0%) being the predominant pathogens.

Overall, amputation was required in 34 patients (34%), of which 6 underwent major amputation. The amputation rate was significantly higher among patients with PAD compared to those without PAD ($p<0.05$).

**Table 2: Wagner grade.**

| Wagner grade | N | % |
|---|---|---|
| **Grade I** | 10 | 10 |
| **Grade II** | 31 | 31 |
| **Grade III** | 25 | 25 |
| **Grade IV** | 32 | 32 |
| **Grade V** | 2 | 2 |

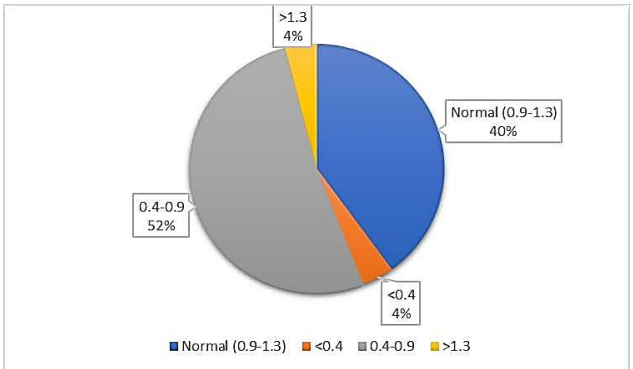


**Figure 1: Distribution of ABI among the participants.**

## DISCUSSION

The prevalence of PAD in our study (60%) is comparable to findings from other tertiary care settings, where reported rates range from 30% to 60% among diabetic foot ulcer patients.[10,11] In addition, a recent systematic review and meta-analysis from India reported a lower pooled prevalence of approximately 18%, highlighting the variability across different populations and study settings.[12] This finding reflects the significant contribution of ischemia to chronic non-healing ulcers in diabetes and aligns with the well-recognized trend that PAD is more frequent when neuropathy and infection coexist. The majority of affected patients were above 60 years of age, which supports the hypothesis that vascular complications typically manifest late after diabetes onset due to cumulative endothelial injury over time. This finding is similar to many studies where the prevalence of PAD increases with age.[13,14]

A clear male preponderance was observed, similar to earlier regional and international studies, and this pattern may be attributable to greater exposure to modifiable risk factors such as smoking among men.[15] However, it is important to note that some studies have reported a predominantly female distribution, with up to 59% of participants being women, indicating that gender patterns may vary depending on the study population and setting.[16,17] Long duration of diabetes, systemic hypertension and coronary artery disease were all more common in the PAD group. These findings similar to multiple studies strengthen the pathophysiological basis linking chronic hyperglycemia and atherosclerosis to impaired lower-limb perfusion.[14,18]

Most patients presented with advanced Wagner grades (II–IV) rather than early, superficial lesions. This supports two important interpretations: first, ulcer detection and care-seeking may be delayed in the community; second, patients often reach surgical departments only once ulcers become limb-threatening. Ulcers with higher Wagner grades showed significantly lower ABPI values, reinforcing the link between worsening ischemia and ulcer severity.

In our study, abnormal ABI values (<0.9) were observed in 40% of cases. Other Indian studies have reported lower PAD prevalence based on ABI, including about 16% in one study and 18.6% in another, with additional participants classified as borderline or non-compressible.[16,17,19] These findings highlight the variable but significant burden of PAD among patients with diabetic foot ulcers. Posterior tibial artery disease was the most frequent Doppler finding, followed by anterior tibial involvement, and is in accordance with studies.[20]

Microbiological evaluation revealed predominantly gram-negative organisms, with *Pseudomonas aeruginosa* as the leading pathogen. This pattern corresponds to longer duration of ulceration, recurrent dressings, and frequent exposure to healthcare environments. Such infections are often more resistant and may contribute to delayed wound healing.

PAD was strongly associated with a poorer prognosis in terms of treatment outcomes. Amputation was necessary in 38% of PAD patients compared with 27.5% in those without PAD, confirming that reduction in blood flow is a major determinant of tissue viability. Although angiography and angioplasty were advised for all PAD cases, only a minority underwent revascularization, primarily due to cost constraints and extensive disease patterns. This highlights the challenges faced in implementing limb salvage strategies in resource-limited settings.

Overall, the study underscores the importance of routine vascular assessment in every patient with diabetic foot ulceration. Early ABPI screening at the primary care level could improve identification of at-risk individuals and foster timely referral for advanced evaluation and revascularization when indicated. Preventing the progression to severe ischemia has the potential to significantly reduce the need for amputations and improve functional outcomes.

### *Strengths and limitations*

The strengths of this study include the use of both ABI and Doppler for PAD documentation and the prospective evaluation of clinical outcomes. However, being a single-centre study with a relatively small sample size, the results may not be fully generalizable. Long-term follow-up after discharge was not performed, preventing assessment of complete healing rates and late complications.

## CONCLUSION

Peripheral arterial disease was present in more than half of patients with diabetic foot infections, with 56% showing abnormal ABI values. Most cases demonstrated moderate arterial compromise (ABI 0.4–0.9), while 4% had severe ischemia (ABI <0.4). A small subset with ABI >1.3 showed arterial calcification with significant stenosis on Doppler evaluation. Arterial Doppler findings indicated that PAD in this population predominantly involved the tibial arteries, with infrapopliteal occlusions more frequent than proximal disease.

### *Implications for practice and future research*

Routine vascular screening should be prioritized in all diabetic foot infection cases. Community-based risk stratification studies and implementation-focused research on referral pathways may help reduce late presentations and improve limb salvage rates. Larger multicentre studies are recommended to validate these findings and evaluate long-term outcomes following vascular interventions.

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