Original Article

Diabetic Foot Ulcer and its Association with Peripheral Arterial Disease: A Cross-sectional Study from a Tertiary Care Centre in South India

C.Surya[1], S.S.Meera[2], Vinoth Kumar[3], R. Satheesh[4]

[1]Post Graduate, Department of General Surgery, Government Mohan Kumaramangalam Medical College Hospital, Salem, Tamilnadu, India.

[2]Professor, Department of General Surgery, Government Mohan Kumaramangalam Medical College Hospital, Salem, Tamilnadu, India.

[3]Assistant professor, Department of General Surgery, Government Mohan Kumaramangalam Medical College Hospital, Salem, Tamilnadu, India.

[4]Senior Resident, Department of General Surgery, Government Mohan Kumaramangalam Medical College Hospital, Salem, Tamilnadu, India.

Abstract

Background: Diabetic foot ulcer (DFU) is a debilitating complication of diabetes mellitus, and peripheral arterial disease (PAD) frequently coexists with DFU, worsening wound healing and increasing the risk of amputation. The aim is to determine the prevalence of PAD among patients with DFU, assess its association with risk factors, evaluate the correlation between the WIfI-G score and Wagner grade, and assess the diagnostic accuracy of a bedside "triple test" (clinical examination, Ankle Brachial Index and Doppler ultrasonography) against Doppler ultrasonography. **Material and Methods:** This cross-sectional study was conducted over one year in the Department of General Surgery, Government Mohan Kumaramangalam Medical College and Hospital, Salem, India, among 50 adult diabetic in-patients (35–65 years) with isolated foot ulcers, enrolled by consecutive sampling. Demographic, clinical, biochemical and radiological data were recorded using a semi-structured questionnaire. PAD was confirmed by Doppler ultrasonography; Wagner grading and the WIfI-G classification were applied to each ulcer. Data were analysed using SPSS version 25, with the Chi-square/Fisher's exact test, Spearman's correlation and odds ratios; $p<0.05$ was taken as significant. **Results:** The mean age was 50.46±9.57 years, with an 80% male predominance. PAD was present in 24 of 50 patients (48%). Smoking (64%) and alcohol use (76%) were the commonest comorbidities. Patients with PAD had significantly higher HbA1c (8.50% vs 7.71%, $p<0.001$), fasting glucose ($p=0.001$) and post-prandial glucose ($p<0.001$). Smoking (OR 106.65), alcohol use (OR 42.24), cardiac disease (OR 86.47) and epilepsy (OR 14.95) were significantly associated with PAD. The WIfI-G score correlated strongly with Wagner grade ($\rho=0.681$, $p<0.0001$). The triple test showed 91.7% sensitivity and 92.3% specificity against Doppler ultrasonography. **Conclusion:** Nearly half of the DFU patients had coexisting PAD, strongly linked to poor glycaemic control, smoking, alcohol use and cardiac disease. The triple test showed high diagnostic accuracy and may serve as a low-cost PAD screening tool where Doppler facilities are limited, while the WIfI-G classification can guide risk stratification for limb salvage.

Keywords: Ankle brachial index; Diabetes mellitus; Diabetic foot; Doppler ultrasonography; Peripheral arterial disease.

Received: 21 July 2026 **Revised: 06 August 2026** **Accepted: 20 August 2026** **Published: 11 September 2026**

INTRODUCTION

Diabetes mellitus is a chronic metabolic disorder characterised by hyperglycaemia, affecting nearly 830 million people worldwide, with the majority living in low- and middle-income countries.[1] Type 2 diabetes, driven principally by insulin resistance, accounts for most cases and predisposes patients to a range of microvascular and macrovascular complications. Among these, lower limb complications carry a disproportionate burden of morbidity, frequently culminating in diabetic foot ulcer (DFU) and, in severe cases, amputation. A meta-analysis by Zhang et al reported a pooled global DFU prevalence of 6.3% among diabetic patients.[2]

While peripheral neuropathy is the most widely recognised contributor to DFU, peripheral arterial disease (PAD) a partial or complete obstruction of the lower limb arteries due to atherosclerosis – plays an equally important role in ulcer pathogenesis and healing. Diabetes mellitus is itself an independent risk factor for PAD, with each 1% rise in glycated haemoglobin (HbA1c) associated with a 28% increase in the risk of PAD.[3] The coexistence of PAD accelerates ulcer progression, delays healing and substantially raises the likelihood of major and minor amputation.

Given the mutually reinforcing relationship between DFU and PAD, early identification of PAD in patients presenting with DFU is essential to guide timely revascularisation and reduce limb loss. However, routine vascular imaging such as Doppler ultrasonography or computed tomography (CT) angiography is not universally accessible, particularly in resource-limited settings, underscoring the need for reliable bedside screening

Address for correspondence: Dr. C. Surya,
Post graduate ,Department of General Surgery, Government Mohan Kumaramangalam Medical College Hospital, Salem, Tamilnadu, India.
E-mail: suryachachu94@gmail.com

DOI:
10.21276/amit.2026.v13.i3.1025

How to cite this article: Surya C, Meera SS, Kumar V, Satheesh R. Diabetic Foot Ulcer and its Association with Peripheral Arterial Disease: A Cross-sectional Study from a Tertiary Care Centre in South India. Acta Med Int. 2026;13(3):88-92.

tools. The Society for Vascular Surgery's Wound, Ischaemia and foot Infection (WIfI) classification, incorporating a gangrene (G) component, offers a structured method of risk-stratifying the threatened limb.

This study was undertaken to determine the prevalence of PAD among patients with DFU, evaluate its association with clinical and biochemical risk factors, assess the correlation between the WIfI-G score and Wagner grade, and evaluate the diagnostic accuracy of a simple bedside "triple test" against Doppler ultrasonography.

Materials and Methods

Study Design and Setting: This hospital-based, cross-sectional study was conducted over a period of one year in the Department of General Surgery, Government Mohan Kumaramangalam Medical College and Hospital, Salem, Tamil Nadu, India.

Study Population: Adult diabetic in-patients aged 35–65 years, of either sex, admitted with an isolated foot ulcer were included. Patients with a known history of peripheral vascular disease prior to admission, ulcers involving body parts other than the foot, and any case of vasculitis were excluded, as were patients unwilling to participate.

Sample Size and Sampling Method: The sample size was calculated using the Cochrane formula ($N = Z^2pq/d^2$) with a 95% confidence interval (Z=1.96) and an allowable error (d) of 13%, yielding a minimum requirement of 45 patients; after adding a 10% non-response margin, a final sample of 50 patients was enrolled. Participants were recruited by consecutive sampling – eligible patients presenting to the department were enrolled sequentially until the target sample size was reached.

Data Collection: After obtaining written informed consent (or a thumb impression from patients unable to sign), an interviewer-administered semi-structured questionnaire was used to record socio- demographic characteristics, illness and treatment history, examination findings and investigation results. Comorbidities including smoking, alcohol use, hypertension, cardiac disease, tuberculosis and epilepsy were recorded. General examination and local examination of the ulcer (inspection, palpation and auscultation) were performed for all patients.

Laboratory and Radiological Investigations: Venous blood samples were analysed for complete haemogram, renal and liver function tests, glycaemic profile (random, fasting and post-prandial blood glucose, and HbA1c) and viral markers (HIV, HBsAg, VDRL). All patients underwent Doppler ultrasonography of the affected limb, supplemented by CT angiography or contrast-enhanced MR angiography where clinically indicated.

Assessment of Peripheral Arterial Disease: PAD was assessed using a combination of clinical examination, the Ankle Brachial Index (ABI) and Doppler ultrasonography. An ABI of 0.9–1.3 was taken as normal, 0.5–0.9 as indicative of claudication, less than 0.5 as indicative of ischaemic rest pain, and greater than 1.3 as suggestive of arterial stiffening. Doppler ultrasonography served as the reference standard for confirming PAD. The combination of clinical examination, ABI and Doppler assessment (the "triple test") was evaluated for its diagnostic accuracy against Doppler ultrasonography alone.

Wound Grading: Each ulcer was staged using the Wagner classification and the Society for Vascular Surgery Wound, Ischaemia and foot Infection classification incorporating gangrene (WIfI-G), based on wound characteristics, degree of ischaemia and severity of infection4,5.

Ethical Considerations: The study was approved by the Institutional Ethics Committee, Department of General Surgery, Government Mohan Kumaramangalam Medical College and Hospital, Salem (IEC No. 1203/2024), and was conducted in accordance with the Declaration of Helsinki (1975, revised 2013). Written informed consent was obtained from all participants, who were informed that participation was voluntary and that they could withdraw at any stage without any effect on their treatment. Confidentiality of patient identity was maintained throughout data collection, analysis and reporting.

Statistical Analysis: Data were entered in Microsoft Excel and analysed using SPSS version 25 (IBM Corp., Armonk, NY). Continuous variables following a normal distribution were expressed as mean±standard deviation, and those not normally distributed as median with interquartile range. Categorical variables were expressed as frequency and proportion and compared using the Chi-square test or Fisher's exact test, as appropriate. The correlation between the WIfI-G score and Wagner grade was assessed using Spearman's rank correlation coefficient. The sensitivity, specificity, positive predictive value and negative predictive value of the triple test were calculated against Doppler ultrasonography as the reference standard. A p-value <0.05 was considered statistically significant.

Results

Of the 50 patients with isolated DFU studied, the mean age was 50.46±9.57 years, with males comprising 80% (n=40) and females 20% (n=10) [Table 1]. The most prevalent comorbidities were alcohol use (76%), smoking (64%) and cardiac disease (30%); tuberculosis (4%) and epilepsy (10%) were less common [Table 2]. On clinical examination, pedal oedema and anaemia were each noted in 20% of patients, clubbing in 28%, icterus in 6% and lymphadenopathy in 4%. All patients had stable systemic examination findings and tested negative for VDRL, HIV and HBsAg.

The mean HbA1c was 8.09±0.46%, with mean fasting and post-prandial blood glucose of 217.96±9.79 mg/dl and 259.16±25.74 mg/dl respectively, reflecting sub-optimal glycaemic control across the cohort [Table 3]. The leukocyte differential showed a predominance of neutrophils (mean 59.92%), with lymphocytes at 34%, consistent with a state of chronic low-grade inflammation.

PAD, confirmed by Doppler ultrasonography, was present in 24 of 50 patients (48%) [Table 4]. Patients with PAD had significantly higher HbA1c (8.50±0.26% vs 7.71±0.18%, p<0.001), fasting blood glucose (222.46±6.81 vs 213.81±10.38 mg/dl, p=0.001) and post-prandial blood glucose (280.58±19.79 vs 239.38±9.55 mg/dl, p<0.001) than those without PAD; random blood glucose did not differ significantly between the groups (p=0.204) [Table 5].

On univariate analysis, PAD was significantly associated with smoking (OR 106.65, 95% CI 5.78–1968.21, p<0.001), alcohol use (OR 42.24, 95% CI 2.32–767.96, p<0.001), cardiac disease (OR 86.47, 95% CI 4.70–1590.65, p<0.001) and epilepsy (OR 14.95, 95% CI 0.78– 286.62, p=0.020). Tuberculosis showed a numerically elevated but statistically non-significant odds ratio (OR 5.89, 95% CI 0.27–129.15, p=0.225) [Table 6].

The WIfI-G score correlated strongly and significantly with the Wagner grade (Spearman's ρ=0.681, p<0.0001), indicating that higher WIfI-G scores were associated with more severe ulcer pathology [Table 7].

Against Doppler ultrasonography as the reference standard, the triple test correctly identified 22 of 24 PAD-positive and 24 of 26 PAD-negative patients, yielding a sensitivity of 91.7%, specificity of 92.3%, positive predictive value of 91.7% and negative predictive value of 92.3% [Table 8].

Table 1: Age and Sex Distribution of Study Participants (N=50)

Variable	Value
Age, years (Mean ± SD)	50.46 ± 9.56
Male, n (%)	40 (80.0%)
Female, n (%)	10 (20.0%)

Table 2: Prevalence of Comorbidities Among Study Participants (N=50)

Comorbidity	n	%
Smoking	32	64.00
Alcohol use	38	76.00
Cardiac disease	15	30.00
Epilepsy	5	10.00
Previous cardiac surgery	5	10.00
Tuberculosis	2	4.00

Table 3: Glycaemic and Haematological Profile of Study Participants (N=50)

Parameter	Mean ± SD
Haemoglobin (g/dL)	12.16 ± 1.60
ESR (mm/hr)	22.2 ± 4.10
Serum creatinine (mg/dL)	1.15 ± 0.12
HbA1c (%)	8.09 ± 0.46
Fasting blood glucose (mg/dL)	217.96 ± 9.79
Post-prandial blood glucose (mg/dL)	259.16 ± 25.74
Random blood glucose (mg/dL)	257.70 ± 29.69

Table 4: Prevalence of Peripheral Arterial Disease Among Study Participants (N=50)

Peripheral Arterial Disease	n	%
Present	24	48.00
Absent	26	52.00

Table 5: Comparison of Glycaemic Parameters in Patients with and Without Peripheral Arterial Disease

Parameter	PAD Present (Mean ± SD)	PAD Absent (Mean ± SD)	p-value
HbA1c (%)	8.50 ± 0.26	7.71 ± 0.18	<0.001
Fasting blood glucose (mg/dL)	222.46 ± 6.81	213.81 ± 10.38	0.001
Post-prandial blood glucose (mg/dL)	280.58 ± 19.79	239.38 ± 9.55	<0.001
Random blood glucose (mg/dL)	263.29 ± 12.69	252.54 ± 39.00	0.204

Table 6: Association Between Comorbidities and Peripheral Arterial Disease

Comorbidity	PAD Present n (%)	PAD Absent n (%)	Odds Ratio (95% CI)	p-value
Smoking	24 (75.0)	8 (25.0)	106.65 (5.78–1968.21)	<0.001
Alcohol use	24 (63.2)	14 (36.8)	42.24 (2.32–767.96)	<0.001
Cardiac disease	15 (100.0)	0 (0.0)	86.47 (4.70–1590.65)	<0.001
Epilepsy	5 (100.0)	0 (0.0)	14.95 (0.78–286.62)	0.020
Tuberculosis	2 (100.0)	0 (0.0)	5.89 (0.27–129.15)	0.225

Table 7: Correlation Between WIfI-G Score and Wagner Grade

Variable 1	Variable 2	Spearman's ρ	p-value
WIfI-G Score	Wagner Grade	0.681	<0.0001

Table 8: Diagnostic Accuracy of the Triple Test Compared with Doppler Ultrasonography

Triple Test Result	PAD Absent	PAD Present	Total
Negative	24	2	26
Positive	2	22	24
Total	26	24	50

Sensitivity = 91.7%; Specificity = 92.3%; Positive Predictive Value = 91.7%; Negative Predictive Value = 92.3%.

Discussion

Diabetic foot ulcer remains one of the most debilitating and costly complications of diabetes mellitus, and peripheral arterial disease significantly contributes to its chronicity and poor healing. Early identification of PAD is therefore central to reducing amputation rates and planning revascularisation.

The mean age of our cohort (50.46±9.57 years) reflects an earlier onset of diabetic foot complications than is typically reported from high-income settings, likely related to earlier onset of type 2 diabetes and delayed diagnosis in India. This finding is consistent with Muthiah et al, who reported a similar age distribution (40–60 years) in a South Indian cohort.[6] By contrast, Meloni et al reported a substantially higher mean age in a European DFU population, reflecting later disease onset where glycaemic control and access to vascular care are generally better.[7] The male predominance observed in our study (80%) mirrors findings by Azhar et al and Vijayasarathy, who similarly reported higher rates of PAD and limb complications among men, attributed to higher rates of smoking, alcohol use and delayed health-seeking behavior.[8,9]

Smoking (64%) and alcohol use (76%) were the most prevalent modifiable risk factors in our cohort, consistent with their established role in impairing peripheral circulation and endothelial repair.[7] Cardiac disease, present in 30% of patients, likely reflects underlying systemic atherosclerosis; Aiello et al have emphasised the importance of integrated cardiovascular screening in the management of diabetic foot disease, given the shared vascular risk profile.[10]

PAD was present in 48% of our DFU patients, closely matching the 40–50% range reported in a systematic review by Hinchliffe et al,[11] and the prevalence reported by Azhar et al8. Other reported estimates range more widely, from 22% in the classic cohort of Beach et al,[12] to over 70% in more advanced or hospital-referred populations,[13] reflecting differences in study population, diagnostic criteria and disease severity. This near 50% prevalence in our cohort reinforces the case for routine vascular screening as an integral part of DFU assessment, in line with recommendations from the International Working Group on the Diabetic Foot.[14]

Patients with PAD in our study had significantly higher HbA1c, fasting and post-prandial glucose than those without PAD, consistent with the well-established link between chronic hyperglycaemia and macrovascular disease. Sustained hyperglycaemia promotes the formation of advanced glycation end-products, oxidative stress and endothelial dysfunction, which are believed to accelerate atherosclerosis in diabetic patients. This observation mirrors the findings of Soyoye et al and Agarwal et al, who identified poor glycaemic control as a significant correlate of PAD in diabetic patients.[15,16]

Smoking, alcohol use, cardiac disease and epilepsy were each significantly associated with PAD in our cohort. Smoking has consistently emerged as the strongest modifiable risk factor for PAD across multiple studies, including Abu-Jableh et al, who reported an almost five-fold increased risk of PAD among smokers with DFU.[17] The wide confidence intervals around several of our odds ratios reflect the small sample size and should be interpreted with caution; nonetheless, the direction and statistical significance of these associations are consistent with the broader literature.

The strong positive correlation observed between the WIfI-G score and Wagner grade ($\rho=0.681$, $p<0.0001$) supports the use of both systems as concordant measures of ulcer severity, consistent with Huang et al, who found that both the Wagner grade and the Saint Elian Wound Score correlated with ulcer healing time.[18] The WIfI-G classification additionally incorporates ischaemia and infection severity, offering a more granular tool for guiding revascularisation decisions and predicting amputation risk than Wagner grading alone.

The triple test demonstrated a sensitivity of 91.7% and specificity of 92.3% against Doppler ultrasonography, suggesting that a combination of careful clinical examination and ABI measurement can reliably screen for PAD even where advanced vascular imaging is not readily available. This is of particular relevance in resource-limited settings, and is consistent with the broader principle articulated by Mehraj, who emphasised the value of baseline ischaemic assessment in predicting ulcer outcomes.[19]

Limitations: This study is limited by its relatively small sample size (n=50) from a single centre, which may limit generalisability and contributed to the wide confidence intervals seen in some associations. The cross-sectional design precludes assessment of causality or temporal relationships between risk factors and PAD. Inter-observer variability in WIfI-G scoring was not formally assessed. Larger, prospective, multicentric studies with longer follow-up are needed to validate these findings and to assess long-term limb salvage outcomes.

Conclusion

Nearly half of the patients presenting with diabetic foot ulcers in this cohort had coexisting peripheral arterial disease, which was significantly associated with poor glycaemic control, smoking, alcohol use and cardiac disease. The WIfI-G classification correlated well with Wagner grading and can aid risk stratification for limb salvage. The triple test – combining clinical examination, Ankle Brachial Index and Doppler assessment – showed high sensitivity and specificity for detecting PAD and may serve as a practical, low-cost alternative for PAD screening in resource-limited diabetic foot clinics, supporting earlier referral for vascular intervention.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. World Health Organization. Diabetes [Internet]. [cited 2025 Feb 27]. Available from: https://www.who.int/health-topics/diabetes
2. Zhang P, Lu J, Jing Y, Tang S, Zhu D, Bi Y. Global epidemiology of diabetic foot ulceration: a systematic review and meta-analysis.

Ann Med. 2017;49(2):106–16.
3. Adler AI, Stevens RJ, Neil A, Stratton IM, Boulton AJM, Holman RR, et al. Hyperglycemia and other potentially modifiable risk factors for peripheral vascular disease in type 2 diabetes. Diabetes Care. 2002;25(5):894–9.
4. Cerqueira LO, Duarte EG, Barros ALS, Cerqueira JR, Araújo WJB. WIfI classification: the Society for Vascular Surgery lower extremity threatened limb classification system, a literature review. J Vasc Bras. 2020;19:e20190070.
5. Mills JL, Conte MS, Armstrong DG, Pomposelli FB, Schanzer A, Sidawy AN, et al. The Society for Vascular Surgery Lower Extremity Threatened Limb Classification System: risk stratification based on Wound, Ischemia, and foot Infection (WIfI). J Vasc Surg. 2014;59(1):220–34.
6. Muthiah A, Kandasamy R, Natarajan S, Madasamy A. A study on diabetic foot and its association with peripheral artery disease. Int Surg J. 2017;4(4):1217.
7. Meloni M, Izzo V, Giurato L, Gandini R, Uccioli L. Below-the-ankle arterial disease severely impairs the outcomes of diabetic patients with ischemic foot ulcers. Diabetes Res Clin Pract. 2019;152:9–15.
8. Azhar A, Basheer M, Abdelgawad MS, Roshdi H, Kamel MF. Prevalence of peripheral arterial disease in diabetic foot ulcer patients and its impact in limb salvage. Int J Low Extrem Wounds. 2023;22(3):518–23.
9. Vijayasarathy S. Assessment of peripheral arterial disease in diabetic foot ulcer in South Indian population: a prospective study [Internet]. 2017 [cited 2025 Jun 29]. Available from: https://consensus.app/papers/assessment-of-peripheral-arterial-disease-in-diabetic-vijayasarathy/
10. Aiello A, Anichini R, Brocco E, Caravaggi C, Chiavetta A, Cioni R, et al. Treatment of peripheral arterial disease in diabetes: a consensus of the Italian Societies of Diabetes (SID, AMD), Radiology (SIRM) and Vascular Endovascular Surgery (SICVE). Nutr Metab Cardiovasc Dis. 2014;24(4):355–69.
11. Hinchliffe RJ, Brownrigg JRW, Andros G, Apelqvist J, Boyko EJ, Fitridge R, et al. Effectiveness of revascularization of the ulcerated foot in patients with diabetes and peripheral artery disease: a systematic review. Diabetes Metab Res Rev. 2016;32(Suppl 1):136–44.
12. Beach KW, Bedford GR, Bergelin RO, Martin DC, Vandenberghe N, Zaccardi M, et al. Progression of lower-extremity arterial occlusive disease in type II diabetes mellitus. Diabetes Care. 1988;11(6):464–72.
13. He A, Ding X, Huang J, Luo X, Meng J, Cao Y, et al. Clinical characteristics and risk factors of lower extremity arterial disease in patients with diabetic foot ulcer. Nan Fang Yi Ke Da Xue Xue Bao. 2022;42(4):604–9.
14. Schaper NC, van Netten JJ, Apelqvist J, Bus SA, Fitridge R, Game F, et al. Practical guidelines on the prevention and management of diabetes-related foot disease (IWGDF 2023 update). Diabetes Metab Res Rev. 2024;40(3):e3657.
15. Soyoye DO, Abiodun OO, Ikem RT, Kolawole BA, Akintomide AO. Diabetes and peripheral artery disease: a review. World J Diabetes. 2021;12(6):827–38.
16. Agarwal AK, Singh M, Arya V, Garg U, Singh VP, Jain V. Prevalence of peripheral arterial disease in type 2 diabetes mellitus and its correlation with coronary artery disease and its risk factors. J Assoc Physicians India. 2012;60:28–32.
17. Abu-Jableh W, Younis A, Hjazeen A, Mashaqbeh E, Al-Sharif E. Asymptomatic peripheral arterial disease among Jordanian patients with diabetic foot ulcer. Cureus. 2024;16(11):e73722.
18. Huang Y, Xie T, Cao Y, Wu M, Yu L, Lu S, et al. Comparison of two classification systems in predicting the outcome of diabetic foot ulcers: the Wagner grade and the Saint Elian Wound score systems. Wound Repair Regen. 2015;23(3):379–85.
19. Mehraj M. A review of Wagner classification and current concepts in management of diabetic foot. Int J Orthop Sci. 2018;4(1):933–5.