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Original Research Article

Colour Doppler Findings in Patients with Diabetic Foot Attending Radiodiagnosis Department in a Tertiary Care Hospital: A Cross-Sectional Study

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Abstract: ***Background***: Peripheral arterial disease (PAD) is a common complication of diabetes mellitus and contributes to impaired wound healing and diabetic foot complications. Colour Doppler ultrasonography provides anatomical and haemodynamic information about lower-limb arteries, while the ankle–brachial index (ABI) is a commonly used screening tool. ***Aim*****:** To evaluate Colour Doppler findings in patients presenting with diabetic foot, assess the distribution and severity of lower-limb arterial disease, examine its association with Wagner grade, and compare Doppler findings with ABI. ***Materials and Methods*****:** This hospital-based cross-sectional observational study included 150 patients with diabetic foot attending the Department of Radiodiagnosis at a tertiary-care hospital. Bilateral lower-limb arterial assessment was performed using B-mode, colour-flow and spectral Doppler ultrasonography. Arterial stenosis, waveform patterns and haemodynamic parameters were evaluated. ABI findings were compared with Colour Doppler findings, and associations with clinical variables were analysed. ***Results*****:** The mean age was 57.3 ± 10.4 years, and 64% of participants were male. Colour Doppler identified PAD in 84 patients (56%). Distal arteries, particularly the dorsalis pedis and posterior tibial arteries, demonstrated substantial stenotic involvement. Dorsalis pedis artery stenosis increased significantly with Wagner grade. ***Conclusion*****:** Colour Doppler ultrasonography identified PAD in 56% of patients with diabetic foot, with substantial distal arterial involvement. It demonstrated significant associations between arterial stenosis and Wagner grade and may complement ABI in evaluating lower-limb arterial disease.

Keywords: Diabetic Foot, Peripheral Arterial Disease, Colour Doppler Ultrasonography, Ankle–Brachial Index, Wagner Grade.

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INTRODUCTION

Colour Doppler Assessment of Peripheral Arterial Disease in Diabetic Foot: Arterial Distribution, Association with Wagner Grade, and Agreement with Ankle–Brachial Index.

Diabetes mellitus is a chronic metabolic disorder associated with microvascular and macrovascular complications that contribute substantially to morbidity, disability, and healthcare expenditure. Among its important lower-extremity complications, diabetic foot disease represents a major clinical challenge because it may involve peripheral neuropathy, peripheral arterial disease (PAD), infection, ulceration, and tissue necrosis. Diabetic foot ulcers are associated with delayed healing, recurrent hospitalisation, and an increased risk of lower-limb amputation. Early recognition of the underlying vascular abnormalities is therefore essential for appropriate assessment and management [1].

Peripheral arterial disease is characterised by atherosclerotic narrowing or occlusion of arteries supplying the lower extremities, resulting in impaired tissue perfusion. In people with diabetes, PAD frequently coexists with neuropathy and infection, producing a complex clinical presentation. Neuropathy may reduce pain perception and mask the classical symptoms of limb ischaemia, while arterial calcification may interfere with conventional pressure-based assessments. Consequently, clinically palpable foot pulses or an apparently reassuring ankle–brachial index (ABI) may not reliably exclude significant arterial disease in every patient with diabetic foot ulceration [2, 3].

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The presence of PAD in patients with diabetic foot ulcers is clinically important because it is associated with impaired wound healing, increased likelihood of limb loss, and adverse cardiovascular outcomes. International guidelines recommend systematic assessment for PAD in people with diabetes, particularly those presenting with foot ulceration or gangrene. They also emphasise that no single bedside test is sufficient to exclude PAD reliably in all patients. Combining clinical examination with arterial Doppler waveforms and pressure measurements can improve assessment and help identify patients who require further vascular evaluation [2-4].

Colour Doppler ultrasonography is a non-invasive imaging technique that provides information about arterial anatomy and haemodynamics. B-mode imaging demonstrates arterial wall changes and atherosclerotic plaques, while colour-flow and spectral Doppler assessment help identify stenosis, altered blood-flow velocities, and waveform abnormalities. Evaluation of the common femoral, superficial femoral, popliteal, anterior tibial, posterior tibial, peroneal, and dorsalis pedis arteries enables assessment of the distribution and extent of lower-limb arterial disease. Detailed evaluation of below-knee and pedal arteries is particularly relevant in diabetic foot disease, where distal arterial involvement may influence the feasibility of revascularisation and wound management [2-5]

The ABI remains a commonly used non-invasive screening measure, but its interpretation in diabetes requires caution because medial arterial calcification can produce falsely elevated or apparently normal values. Therefore, comparison of ABI findings with Colour Doppler assessment may help demonstrate the limitations of relying on ABI alone in selected patients [4-6]. The Wagner grading system provides a clinical classification of diabetic foot lesions according to their depth and severity, offering a framework for examining whether the extent of arterial abnormalities varies across different grades of foot disease [7, 8].

Against this background, the present cross-sectional study evaluates Colour Doppler findings in patients with diabetic foot attending a tertiary care hospital. It assesses the prevalence, anatomical distribution, and severity of lower-limb arterial disease; examines the relationship between Doppler parameters and Wagner grade; explores associations with diabetes duration and diabetic retinopathy; and evaluates agreement between ABI and Colour Doppler findings. The study aims to contribute clinically relevant information about the pattern of arterial involvement in this patient population and the role of Colour Doppler in its vascular assessment.

OBJECTIVES

1. To assess the prevalence, distribution, and severity of lower limb peripheral arterial disease in patients with diabetic foot using Colour Doppler ultrasonography.
2. To evaluate the arterial segment-wise distribution of stenosis, atherosclerotic plaques, and Doppler waveform abnormalities, with particular attention to distal lower limb arteries.
3. To determine the association between Colour Doppler haemodynamic parameters—including stenosis, peak systolic velocity, resistive index, pulsatility index, and waveform patterns—and the Wagner grade of diabetic foot.

METHODOLOGY

The present study was a hospital-based, cross-sectional observational study conducted in the Department of Radiodiagnosis of a tertiary care teaching hospital over a total period of 18 months. The study included 150 patients diagnosed with diabetic foot who were referred for Colour Doppler ultrasonographic evaluation of the lower-limb arteries. Purposive sampling was employed, and eligible patients attending the department on designated Mondays during the 12-month data-collection period were enrolled after obtaining written informed consent. Patients aged 18 years or older with type 1 or type 2 diabetes mellitus and diabetic foot were included. Patients with systemic conditions independently affecting peripheral arterial haemodynamics, previous lower-limb revascularisation in the limb being evaluated, pregnancy, or inability or unwillingness to provide consent were excluded. Demographic details, diabetes duration, comorbidities, clinical findings, and Wagner grade were recorded using a structured proforma. Bilateral lower-limb arterial assessment was performed using B-mode, colour-flow, and spectral Doppler ultrasonography, evaluating the common femoral, proximal and distal superficial femoral, popliteal, anterior tibial, posterior tibial, peroneal, and dorsalis pedis arteries. Arterial stenosis, plaques, waveform patterns, peak systolic velocity, resistive index, pulsatility index, and intima-media thickness were assessed. Peripheral arterial disease was defined as at least 50% arterial diameter stenosis or a peak systolic velocity ratio of at least 2.0. The ankle–brachial index was also measured and interpreted according to the study protocol. Data were analysed to determine the prevalence and distribution of arterial disease and its associations with Wagner grade, diabetes duration, retinopathy, and ABI findings.

RESULTS AND OBSERVATIONS

Colour Doppler Assessment of Peripheral Arterial Disease in Diabetic Foot: Arterial Distribution, Association with Wagner Grade, and Agreement with Ankle–Brachial Index.

The present hospital-based cross-sectional observational study included 150 patients with diabetic foot referred to the Department of Radiodiagnosis of a tertiary care teaching hospital. Bilateral lower-limb

arterial assessment was performed using B-mode, colour-flow, and spectral Doppler ultrasonography. The results are presented in tables and figures describing the demographic profile, prevalence and distribution of peripheral arterial disease (PAD), association with Wagner grade, and agreement between the ankle–brachial index (ABI) and Colour Doppler findings.

Table 1: Age and sex distribution of the study population (n = 150)

Age group (years)	Male, n (%)	Female, n (%)	Total, n (%)
≤40	5 (3.3)	3 (2.0)	8 (5.3)
41–50	21 (14.0)	10 (6.7)	31 (20.7)
51–60	32 (21.3)	21 (14.0)	53 (35.3)
61–70	32 (21.3)	15 (10.0)	47 (31.3)
>70	6 (4.0)	5 (3.3)	11 (7.3)
Total	96 (64.0)	54 (36.0)	150 (100.0)

Mean Age: 57.3 ± 10.4 years; median age: 58 years. Reported age-group comparison by sex: $\chi^2 = 1.27$, $p = 0.86$.

Observation:

The largest age group was 51–60 years (35.3%), followed by 61–70 years (31.3%). Together, these groups accounted for 66.6% of the study population. Males constituted 64% of participants, while females constituted 36%. The age-group distribution did not differ significantly by sex (\(p=0.86\)).

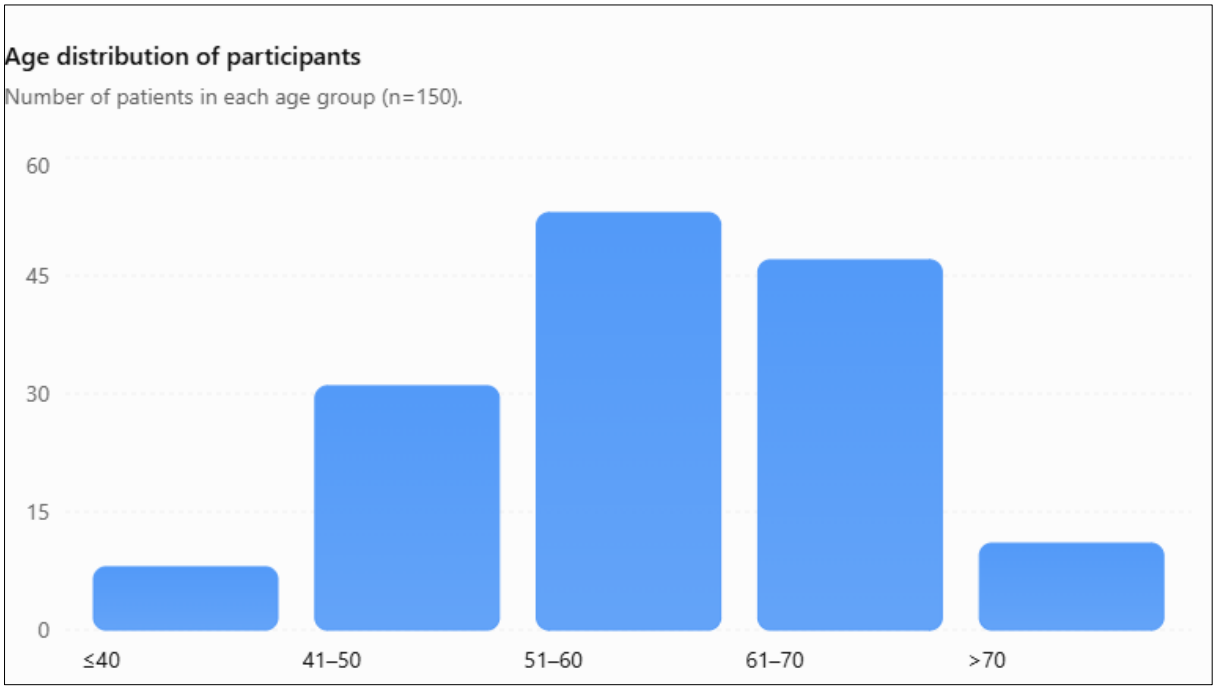


Figure 1: Age distribution of the study population

Age distribution of participants
Number of patients in each age group (n=150).

Table 2: Prevalence of Colour Doppler-detected peripheral arterial disease (n = 150)

Colour Doppler finding	Number of patients	Percentage
PAD present	84	56.0%
PAD absent	66	44.0%
Total	150	100.0%

95% confidence interval for PAD prevalence: 48.1–63.9%.

Observation:

Colour Doppler detected PAD in 84 patients (56%), while 66 patients (44%) were classified as having no PAD. Among the patients with PAD, 85.7% had bilateral involvement. These findings indicate a substantial burden of arterial disease in this hospital-based diabetic foot population.

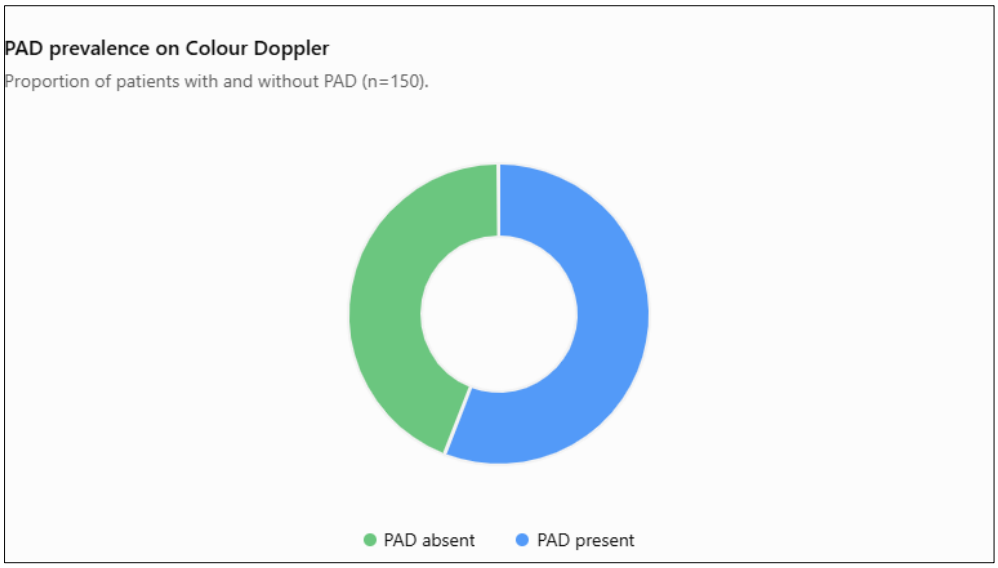


Figure 2: Distribution of patients according to Colour Doppler-detected PAD

PAD prevalence on Colour Doppler
Proportion of patients with and without PAD (n=150).
PAD absent
PAD present

Table 3: Segment-wise distribution of arterial stenosis on Colour Doppler

Arterial segment	Right: any stenosis, n (%)	Left: any stenosis, n (%)	Right: stenosis ≥50%, n (%)	Left: stenosis ≥50%, n (%)
Common femoral artery	21 (14.0)	28 (18.7)	3 (2.0)	11 (7.3)
Superficial femoral artery, proximal	40 (26.7)	45 (30.0)	18 (12.0)	21 (14.0)
Superficial femoral artery, distal	66 (44.0)	66 (44.0)	21 (14.0)	33 (22.0)
Popliteal artery	53 (35.3)	43 (28.7)	18 (12.0)	12 (8.0)
Anterior tibial artery	72 (48.0)	83 (55.3)	26 (17.3)	36 (24.0)
Posterior tibial artery	97 (64.7)	88 (58.7)	34 (22.7)	36 (24.0)
Peroneal artery	66 (44.0)	59 (39.3)	28 (18.7)	28 (18.7)
Dorsalis pedis artery	105 (70.0)	98 (65.3)	40 (26.7)	42 (28.0)

Any stenosis includes both the less-than-50% and ≥50% categories. Percentages use 150 observations per side and arterial segment. Values are calculated from the dissertation's segment-wise stenosis table.

Observation:

The dorsalis pedis artery showed the highest frequency of any stenosis on both the right (70.0%) and left (65.3%). The posterior tibial artery was the next most frequently affected segment. The common femoral artery showed the lowest frequency of stenosis. Stenosis of at least 50% was present in 26.7% of right and 28.0% of left dorsalis pedis artery assessments. This distribution suggests greater distal arterial involvement in the study population.

Table 4: Association between dorsalis pedis artery Doppler parameters and Wagner grade

Wagner grade	Mean PSV (cm/s)	Mean PI	Mean DPA stenosis (%)
Grade 0	43.9 ± 9.8	5.6 ± 2.7	10.3 ± 15.7
Grade 1	53.7 ± 19.3	4.5 ± 2.6	29.5 ± 22.1
Grade 2	59.6 ± 18.0	4.4 ± 2.5	32.6 ± 24.8
Grade 3	69.2 ± 32.7	4.9 ± 2.9	40.9 ± 27.1
Grade 4	72.8 ± 24.7	2.8 ± 2.2	47.9 ± 24.3
Grade 5	58.0 ± 31.6	3.5 ± 1.8	45.2 ± 22.9

| Overall p-value | 0.001 | 0.042 | **PSV = peak systolic velocity; PI = pulsatility index; DPA = dorsalis pedis artery. Resistive index was not significantly associated with Wagner grade (p = 0.369). Values are reproduced from the dissertation's reported results.

Observation:

Mean DPA stenosis increased from 10.3% in Wagner Grade 0 to 47.9% in Grade 4, with a statistically significant difference across grades (\(p<0.001\)). PSV and PI also differed significantly across Wagner grades (\(p=0.001\) and \(p=0.042\), respectively). These findings indicate an association between selected arterial Doppler parameters and clinical grade of diabetic foot disease. The study design does not establish that the Doppler abnormalities caused the more severe clinical grades.

Table 5: Agreement between ABI and Colour Doppler findings (n = 150)

ABI category	Colour Doppler PAD present, n	Colour Doppler PAD absent, n	Total
ABI ≤0.90	76	34	110
ABI >0.90	8	32	40
Total	84	66	150

Diagnostic performance of ABI using Colour Doppler as the reference standard

Parameter	Result
Sensitivity	90.5%
Specificity	48.5%
Positive predictive value	69.1%
Negative predictive value	80.0%
Overall accuracy	72.0%
Cohen's kappa	0.407

Observation:

Of 110 patients with an ABI of 0.90 or below, 76 had PAD detected by Colour Doppler. Among 40 patients with an ABI above 0.90, eight (20%) were nevertheless found to have PAD on Colour Doppler. ABI showed high sensitivity but limited specificity, with an overall accuracy of 72% and moderate agreement with Colour Doppler (\(\kappa=0.407\)). These results suggest that ABI alone may not identify all patients with arterial disease in this study population. Since Colour Doppler was used as the reference standard, these findings describe agreement with Colour Doppler rather than accuracy against angiography.

DISCUSSION

The present study evaluated Colour Doppler findings in 150 patients with diabetic foot and demonstrated a substantial burden of peripheral arterial disease (PAD), detected in 56% of participants. The predominance of males (64%) and the mean age of 57.3 ± 10.4 years indicate that diabetic foot vascular complications were common in middle-aged and older adults in this hospital-based population. The high prevalence of hypertension and diabetic retinopathy further highlights the burden of associated comorbidities. These findings reinforce the importance of systematic vascular assessment in diabetic foot, as emphasised in international guidelines [9, 10].

Distal arteries, particularly the dorsalis pedis artery (DPA), showed the greatest frequency of stenosis, while the posterior tibial artery (PTA) was also substantially affected. This pattern is clinically relevant because impaired blood supply to the foot may complicate ulcer healing and influence decisions regarding further vascular assessment. The significant association between DPA stenosis and Wagner grade (\(p<0.001\)), together with significant differences in peak systolic velocity and pulsatility index, suggests that selected Doppler parameters vary with clinical severity. However, the cross-sectional design does not establish causality or prove that these parameters predict subsequent limb outcomes [11].

ABI demonstrated high sensitivity (90.5%) but limited specificity (48.5%) compared with Colour Doppler. Notably, 8 of 40 patients with ABI values above 0.90 had PAD detected on Colour Doppler. This finding supports caution when interpreting ABI in diabetic patients, in whom arterial calcification can affect pressure measurements. Current guidance recommends combining clinical assessment with Doppler waveform analysis and other vascular tests when PAD is suspected [9, 10].

The association between diabetes duration and PAD severity was modest but statistically significant (\(r=0.284,\ p<0.001\)), while retinopathy was associated with higher odds of PAD. These results should be interpreted in view of the single-centre setting, purposive sampling, and absence of angiographic validation. Overall, Colour Doppler provided detailed information about arterial distribution and haemodynamics and complemented ABI in the assessment of diabetic foot vascular disease.

CONCLUSION

The present study demonstrated that peripheral arterial disease (PAD) was detected by Colour Doppler ultrasonography in 56% of patients presenting with diabetic foot. Distal lower-limb arteries, particularly the dorsalis pedis and posterior tibial arteries, showed considerable stenotic involvement, highlighting the

importance of detailed arterial assessment in this patient population.

A significant association was observed between dorsalis pedis artery stenosis and Wagner grade.

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