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Clinical Evaluation of Biomechanical Changes in Patients With Diabetic Foot Disease: A Prospective Observational Study

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Abstract

Background: Diabetic foot disease is a major complication of diabetes mellitus and a leading cause of hospitalization, disability, and lower limb amputation. Although neuropathy and peripheral arterial disease are well recognized, combined assessment of multiple biomechanical abnormalities using simple bedside methods has received relatively less attention.

Objective: To prospectively evaluate biomechanical changes in diabetic foot disease using simple, cost-effective clinical methods and to determine their association with Wagner grading.

Methods: A prospective observational study was conducted in the Department of General Surgery, ESIC Medical College and Hospital, Hyderabad, over two years. Forty patients with Wagner grade 0-2 diabetic foot disease were evaluated. Neuropathy was assessed using the 10-g Semmes-Weinstein monofilament, 128-Hz tuning fork, ankle reflex, autonomic function, and proprioception. Vasculopathy was assessed by capillary refill time and dorsalis pedis pulse examination; musculoskeletal and dermatological abnormalities were also recorded. Associations with Wagner grade were analyzed using the chi-square test, with $p < 0.05$ considered significant.

Results: Mean age was 54.37 ± 5.12 years, and 62.5% were male. Wagner grade 1 was most common (47.5%), followed by grade 0 (35%) and grade 2 (17.5%). Loss of protective sensation occurred in 45% and was significantly associated with Wagner grade ($\chi^2 = 17.87$, $p < 0.001$). Impaired vibration perception occurred in 17.5% ($\chi^2 = 8.34$, df = 2, $p = 0.015$), absent ankle reflex in 12.5% ($\chi^2 = 18.03$, $p < 0.001$), and impaired proprioception in 30% ($\chi^2 = 9.09$, $p = 0.011$). Autonomic dysfunction was present in 62.5% but was not significantly associated with Wagner grade ($\chi^2 = 4.38$, $p = 0.112$). Peripheral pulse grading ($\chi^2 = 12.82$, $p = 0.012$), musculoskeletal deformities (55%; $\chi^2 = 15.47$, $p < 0.001$), and dermatological abnormalities (65%; $\chi^2 = 23.92$, $p < 0.001$) were significantly associated with disease severity.

Conclusion: Multiple neuropathic, vascular, musculoskeletal, and dermatological abnormalities increase with diabetic foot severity. Structured bedside biomechanical assessment using inexpensive clinical tools may help identify high-risk patients and support early preventive intervention.

Categories: General Surgery
Keywords: diabetic foot biomechanics, diabetic foot ulcer, monofilament test, peripheral neuropathy, peripheral vascular disease, wagner classification

Introduction

Diabetes mellitus is a major global public health problem with a growing burden of chronic complications [1]. According to the International Diabetes Federation, approximately 537 million adults were living with diabetes in 2021, with the number projected to increase substantially by 2045 [2]. India has one of the world's largest diabetic populations, creating a considerable healthcare burden.

Diabetic foot disease is among the most disabling complications of diabetes and contributes substantially to hospitalization, disability, and non-traumatic lower-limb amputation. Its development reflects interaction between peripheral neuropathy, peripheral arterial disease, foot deformity, repetitive mechanical stress, and impaired healing [3]. Peripheral neuropathy causes loss of protective sensation, motor imbalance, and structural deformity, while autonomic dysfunction contributes to reduced sweating, dry skin, and fissuring [4]. Vascular insufficiency further compromises tissue perfusion and healing.

Wagner's classification remains a simple and widely used method for grading diabetic foot disease and guiding treatment and prognosis [5]. Although diabetic foot research often focuses on ulcer characteristics, microbiology, vascular imaging, or outcomes, relatively few studies prospectively assess multiple biomechanical abnormalities together using simple bedside methods. Monofilament testing, vibration

perception, ankle reflexes, capillary refill, pulse examination, and assessment of deformity are inexpensive and readily available. A comprehensive assessment may therefore identify patients at increased risk before advanced ulceration develops [6].

This prospective observational study evaluated neuropathic, vasculopathy, musculoskeletal, and dermatological changes in patients with diabetic foot disease and examined their association with Wagner grading, with emphasis on the practical value of simple bedside assessment. In this study, the term "biomechanical changes" refers to clinically identifiable neurological, vascular, musculoskeletal, and dermatological abnormalities that may influence foot structure, mechanical loading, sensation, and tissue vulnerability. The study used bedside clinical assessments rather than quantitative biomechanical measurements.

Materials And Methods

Study design and setting

This was a prospective observational study conducted in the Department of General Surgery, ESIC Medical College and Hospital, Hyderabad, Telangana, India. The study included patients presenting with diabetic foot disease to the inpatient and outpatient departments. The study was conducted over a period of two years, from August 2022 to August 2024. Institutional Ethics Committee approval was obtained before commencement of the study, and written informed consent was obtained from all participants. A standardized clinical assessment protocol was followed for evaluation of biomechanical abnormalities.

Study population

A total of 40 patients with diabetic foot disease were recruited from the inpatient and outpatient departments of ESIC Medical College and Hospital. Patients were selected according to the predefined inclusion and exclusion criteria and evaluated using a standardized clinical examination protocol.

Inclusion criteria

Patients were included if they (1) had diabetic foot disease classified as Wagner grade 0, 1, or 2; (2) were between 30 and 70 years of age; and (3) provided written informed consent for participation in the study.

Exclusion criteria

Patients were excluded if they (1) did not satisfy the predefined inclusion criteria and (2) satisfied the inclusion criteria but did not provide consent for participation.

Data collection

A detailed clinical history was obtained from all participants, followed by physical examination of the lower limbs. Each participant underwent assessment for neurological, vascular, musculoskeletal, and dermatological abnormalities using a standardized clinical protocol. The findings were recorded systematically, and patients were classified according to Wagner's grading system.

Neurological assessment

10-g Semmes-Weinstein Monofilament Test

Protective sensation was assessed using a 10-g Semmes-Weinstein monofilament (Figure *1*). The filament was applied to the plantar aspect of the great toe, first metatarsal head, or third metatarsal head until it buckled. The response was recorded as positive when the patient perceived the stimulus and negative when the sensation was not perceived [7].



FIGURE 1: 10-g Semmes-Weinstein monofilament used for the assessment of protective sensation in the diabetic foot.

The monofilament is applied to standardized plantar sites, including the great toe and metatarsal heads, to assess perception of light pressure.

Vibration Perception

Vibration sensation was assessed using a 128-Hz tuning fork (Figure *2*). The tuning fork was struck with consistent force and applied to the dorsal aspect of the distal phalanx of the great toe, immediately proximal to the nail bed. The patient's ability to perceive the vibration over a period of five seconds was recorded. The sensation was demonstrated to the participant before assessment [8].

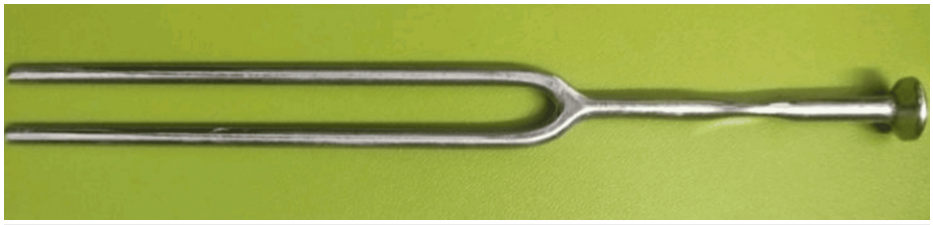


FIGURE 2: 128-Hz tuning fork used for the assessment of vibration perception.

The vibrating tuning fork is applied to the dorsal aspect of the distal phalanx of the great toe, proximal to the nail bed, to assess peripheral sensory function.

Ankle Reflex

The ankle reflex was assessed using a knee hammer (Figure *3*) with the foot dorsiflexed. The Achilles tendon was tapped, and the resulting plantar flexion response was recorded as present or absent [9].



FIGURE 3: Knee-jerk reflex hammer used for neurological examination.

The hammer is used to elicit tendon reflexes during clinical assessment of peripheral neurological function, including assessment of the ankle reflex.

Autonomic Function

Autonomic dysfunction was assessed based on the patient's history of sweating. Current sweating of the feet while wearing footwear was compared with the patient's previous sweating pattern and recorded as increased or decreased.

Proprioception

Knee joint proprioception was assessed without visual feedback. The participant's leg was guided to a

position between 0° and 45° using verbal cues. The participant was asked to memorize the position and subsequently reproduce the position voluntarily. Proprioceptive error was assessed according to deviation from the target position during target positioning, target memory, and target reproduction [10].

Vascular assessment

Capillary Refill Time Test

Capillary refill time was assessed by applying pressure to the great toe for up to 10 seconds until the toe became pale. Following release of pressure, the time required for the skin to return to a colour comparable with the surrounding tissue was recorded.

Dorsalis Pedis Pulse

The dorsalis pedis artery pulse was palpated over the anterior aspect of the foot, lateral to the extensor hallucis tendon, and documented according to the clinical grading used in the study.

Musculoskeletal assessment

The feet were examined for clinically apparent deformities, including hammer toe, claw toe, bunion, and prominent first metatarsal head. The presence of any of these deformities was recorded as a positive finding.

Dermatological assessment

The skin and nails of the feet were examined for skin colour changes, nail abnormalities such as brittleness or Beau's lines, and hair loss over the dorsal aspect of the toes. The presence of at least one of these findings was recorded as a positive dermatological abnormality.

Wagner classification

The severity of diabetic foot disease was classified according to Wagner's classification. Only patients belonging to Wagner grades 0, 1, and 2 were included in the study [11].

Sample size

A total of 40 patients with diabetic foot disease were included in the study. Patients fulfilling the predefined inclusion criteria and providing informed consent were recruited during the study period.

Statistical analysis

Data were summarized using descriptive statistics. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequency and percentage. The chi-square test was used to assess the association between categorical biomechanical findings and Wagner grade. A p-value < 0.05 was considered statistically significant. Associations between categorical biomechanical parameters and Wagner grade were assessed using Pearson's chi-square test of independence. Where expected cell frequencies were small, an exact test for contingency tables was used. A two-sided p-value < 0.05 was considered statistically significant.

Results

Patient characteristics and Wagner classification

A total of 40 patients with diabetic foot disease were included in the study. The mean age of the study population was 54.37 ± 5.12 years, with an age range of 35-67 years. The majority of patients belonged to the 51-60-year age group, comprising 24 (60.0%) patients, followed by 41-50 years in nine (22.5%) patients, 61-70 years in four (10.0%) patients, and 31-40 years in three (7.5%) patients. There were 25 (62.5%) males and 15 (37.5%) females.

According to Wagner's classification, 14 (35.0%) patients had grade 0 disease, 19 (47.5%) had grade 1 disease, and 7 (17.5%) had grade 2 disease. Thus, Wagner grade 1 constituted the largest proportion of the study population.

Neurological assessment

Loss of protective sensation assessed using the 10-g Semmes-Weinstein monofilament test was present in 18 (45.0%) patients, whereas protective sensation was preserved in 22 (55.0%) patients. A statistically significant association was observed between monofilament findings and Wagner grade ($\chi^2 = 21.29$, df = 2, $p < 0.001$). All seven patients with Wagner grade 2 disease demonstrated loss of protective sensation.

Vibration perception assessed using a 128-Hz tuning fork was impaired in 7 (17.5%) patients and preserved in 33 (82.5%). Vibration perception showed a statistically significant association with Wagner grade (χ^2 = 8.34, df = 2, p = 0.015).

Ankle reflexes were absent in 5 (12.5%) patients and preserved in 35 (87.5%). A statistically significant association was observed between ankle reflex status and Wagner grade (χ^2 = 26.94, df = 2, p < 0.001).

Autonomic function was assessed based on sweating abnormalities. Abnormal or reduced sweating was observed in 25 (62.5%) patients, while sweating was considered intact in 15 (37.5%). The association between autonomic dysfunction and Wagner grade was not statistically significant (χ^2 = 2.55, df = 2, p = 0.280).

Proprioceptive assessment demonstrated an error in 12 (30.0%) patients, while 28 (70.0%) demonstrated no appreciable error. A statistically significant association was observed between proprioceptive findings and Wagner grade (χ^2 = 22.46, df = 2, p < 0.001).

Vascular assessment

Capillary refill time was ⩽3 seconds in 35 (87.5%) patients, whereas five (12.5%) patients demonstrated delayed capillary refill (>3 seconds). The association between CRTT and Wagner grade was statistically significant (χ^2 = 6.04, df = 2, p = 0.049).

Dorsalis pedis pulse examination demonstrated absent pulses (Grade 0) in 6 (15.0%) patients, diminished pulses (grade 1) in 21 (52.5%) patients, and normal pulses (grade 2) in 13 (32.5%) patients. Although diminished or absent pulses were common in the study population, the association between dorsalis pedis pulse grade and Wagner grade was not statistically significant (χ^2 = 5.13, df = 4, p = 0.275).

Musculoskeletal and dermatological assessment

Musculoskeletal deformities, including hammer toe (Figure *4*), claw toe (Figure *5*), bunion/hallux valgus (Figure *6*), and prominent metatarsal heads (Figure *7*), were identified in 22 (55.0%) patients, while 18 (45.0%) had no documented deformity. A statistically significant association was observed between musculoskeletal deformities and Wagner grade (χ^2 = 26.33, df = 2, p < 0.001).



FIGURE 4: Clinical photograph illustrating hammer toe deformity.

The affected toe demonstrates flexion deformity at the interphalangeal joint, producing an abnormal resting position of the digit.



FIGURE 5: Clinical photograph illustrating claw toe deformity.

The toes demonstrate characteristic flexion deformities with abnormal positioning of the interphalangeal joints, consistent with clawing.



FIGURE 6: Clinical photograph illustrating hallux valgus deformity.

The great toe is deviated laterally toward the lesser toes, with prominence of the first metatarsal head at the medial aspect of the forefoot.



FIGURE 7: Clinical photograph illustrating a prominent first metatarsal head.

The plantar aspect of the foot demonstrates increased prominence of the first metatarsal head, representing a structural foot abnormality that may alter mechanical loading.

Dermatological abnormalities, including skin colour changes, nail abnormalities, and hair loss over the dorsum of the foot, were present in 26 (65.0%) patients, while 14 (35.0%) had no such changes. Dermatological changes showed a statistically significant association with Wagner grade ($\chi^2 = 24.60$, df = 2, $p < 0.001$).

Overall findings

Overall, significant associations with Wagner grade were observed for loss of protective sensation, impaired vibration perception, absent ankle reflexes, proprioceptive abnormalities, delayed CRTT, musculoskeletal deformities, and dermatological changes. In contrast, autonomic dysfunction and dorsalis pedis pulse grade did not demonstrate statistically significant associations with Wagner grade. Table *1* presents the demographic and clinical characteristics, Table *2* presents the biomechanical parameters, and Table *3* presents the Dorsalis pedis pulse grade.

Characteristic	n (%)
Total patients	40 (100)
Age 31-40	3 (7.5)
Age 41-50	9 (22.5)
Age 51-60	24 (60.0)
Age 61-70	4 (10.0)
Mean age	54.37 +/- 5.12
Male	25 (62.5)
Female	15 (37.5)
Wagner Grade 0	14 (35.0)
Wagner Grade 1	19 (47.5)
Wagner Grade 2	7 (17.5)

TABLE 1: Demographic and clinical characteristics.

Biomechanical parameters	Wagner Grade 0, n (%)	Wagner Grade 1, n (%)	Wagner Grade 2, n (%)	χ^2	df	p-value
Loss of protective sensation	0 (0.0)	11 (57.9)	7 (100.0)	21.29	2	<0.001
Impaired vibration perception	4 (28.6)	0 (0.0)	3 (42.9)	8.34	2	0.015
Absent ankle reflex	0 (0.0)	0 (0.0)	5 (71.4)	26.94	2	<0.001
Abnormal sweating/autonomic dysfunction	7 (50.0)	12 (63.2)	6 (85.7)	2.55	2	0.28
Proprioceptive error	0 (0.0)	5 (26.3)	7 (100.0)	22.46	2	<0.001
Delayed CRTT (>3 s)	4 (28.6)	0 (0.0)	1 (14.3)	6.04	2	0.049
Musculoskeletal deformity	0 (0.0)	16 (84.2)	6 (85.7)	26.33	2	<0.001
Dermatological changes	2 (14.3)	17 (89.5)	7 (100.0)	24.6	2	<0.001

TABLE 2: Biomechanical parameters.

Values are expressed as n (%). Percentages in each Wagner grade column are calculated using the number of patients within that Wagner grade as the denominator. Associations between categorical biomechanical parameters and Wagner grade were assessed using Pearson's chi-square test of independence. A p-value <0.05 was considered statistically significant. For dorsalis pedis pulse, Grade 0 = absent, Grade 1 = diminished, and Grade 2 = normal.

CRTT: capillary refill time test; df: degrees of freedom

Dorsalis pedis pulse grade	Wagner Grade 0, n (%)	Wagner Grade 1, n (%)	Wagner Grade 2, n (%)	χ^2	df	p-value
Grade 0 - Absent	4 (28.6)	1 (5.3)	1 (14.3)	5.13	4	0.275
Grade 1 - Diminished	5 (35.7)	11 (57.9)	5 (71.4)			
Grade 2 - Normal	5 (35.7)	7 (36.8)	1 (14.3)			
Total	14 (100)	19 (100)	7 (100)			

TABLE 3: Dorsalis pedis pulse grade.

Values are expressed as n (%). Percentages are calculated within each Wagner grade. The χ^2 value, degrees of freedom, and p-value represent the single overall Pearson's chi-square test of association across the complete 3 × 3 contingency table (dorsalis pedis pulse Grade 0/1/2 × Wagner Grade 0/1/2). Grade 0 = absent pulse; Grade 1 = diminished pulse; Grade 2 = normal pulse. A p-value < 0.05 was considered statistically significant.

Discussion

Diabetic foot disease is a multifactorial complication of diabetes mellitus in which peripheral neuropathy, vascular impairment, musculoskeletal abnormalities, and changes in skin and nail integrity interact to increase the risk of tissue breakdown and ulceration. The present study evaluated these biomechanical components using simple bedside clinical methods and examined their association with Wagner grade among 40 patients with diabetic foot disease. The majority of patients belonged to the 51-60-year age group, and Wagner grade 1 constituted the largest proportion of cases.

Neurological abnormalities

Peripheral neuropathy is an important contributor to diabetic foot pathology because loss of protective sensation allows repetitive mechanical trauma to occur without adequate pain perception. In the present study, 18 (45.0%) patients had loss of protective sensation on 10-g monofilament testing. A statistically significant association was observed between monofilament findings and Wagner grade ($\chi^2 = 21.29$, df = 2, $p < 0.001$), with all patients classified as Wagner grade 2 demonstrating loss of protective sensation. This finding supports the clinical importance of bedside sensory assessment in patients with diabetic foot disease.

The 10-g monofilament is a simple and inexpensive method for identifying loss of protective sensation and can be particularly useful in routine outpatient and resource-limited settings. Loss of protective sensation increases the likelihood that repetitive pressure, friction, or minor trauma will remain unnoticed, potentially contributing to callus formation and tissue injury. The marked occurrence of sensory loss among patients with higher Wagner grades in the present study suggests an important relationship between neuropathic impairment and the clinical severity of diabetic foot disease.

Vibration perception was impaired in seven (17.5%) patients, while 33 (82.5%) patients retained vibration perception. Vibration abnormality was significantly associated with Wagner grade ($\chi^2 = 8.34$, df = 2, $p = 0.015$). Although the proportion with impaired vibration was smaller than that with loss of protective sensation, the significant association indicates that vibration assessment may provide additional information regarding neurological involvement.

Ankle reflexes were absent in five (12.5%) patients and preserved in 35 (87.5%) patients. A significant association was observed between ankle reflex status and Wagner grade ($\chi^2 = 26.94$, df = 2, $p < 0.001$). The relatively low overall frequency of absent reflexes compared with sensory abnormalities may indicate that different components of peripheral neurological dysfunction are not affected uniformly. Nevertheless, the greater occurrence of absent reflexes among patients with higher Wagner grades supports their inclusion as part of a comprehensive neurological examination.

Proprioceptive abnormalities were identified in 12 (30.0%) patients, and proprioceptive findings were also significantly associated with Wagner grade ($\chi^2 = 22.46$, df = 2, $p < 0.001$). Impaired proprioception may influence gait, balance, and the distribution of mechanical loads across the foot. Thus, proprioceptive assessment may complement conventional sensory testing when evaluating the biomechanical consequences of diabetic neuropathy.

Autonomic dysfunction

Abnormal sweating was observed in 25 (62.5%) patients, making it one of the more frequent abnormalities identified in the study. However, the association between autonomic dysfunction and Wagner grade was not statistically significant ($\chi^2 = 2.55$, df = 2, $p = 0.280$). Therefore, although autonomic abnormalities were common in the study population, the present data do not establish a statistically significant relationship

between sweating abnormalities and Wagner grade.

Reduced sweating may contribute to dryness and increased susceptibility to fissuring, but the absence of statistical significance in the present study indicates that autonomic dysfunction should not be interpreted as a marker of increasing Wagner grade on the basis of these data alone.

Vascular abnormalities

Vascular status was evaluated using capillary refill time and dorsalis pedis pulse examination. Delayed CRTT (>3 seconds) was identified in five (12.5%) patients and demonstrated a statistically significant association with Wagner grade ($\chi^2 = 6.04$, df = 2, $p = 0.049$). This finding suggests that capillary refill assessment may provide useful bedside information regarding peripheral perfusion in patients with diabetic foot disease. Peripheral arterial disease is an important component of diabetic foot disease and may adversely affect tissue perfusion and wound healing [12].

In contrast, dorsalis pedis pulse examination demonstrated absent pulses in 6 (15.0%) patients, diminished pulses in 21 (52.5%) patients, and normal pulses in 13 (32.5%) patients. Despite the relatively high frequency of diminished or absent pulses, the association between pulse grade and Wagner grade was not statistically significant ($\chi^2 = 5.13$, df = 4, $p = 0.275$). Therefore, the present study does not support the conclusion that dorsalis pedis pulse abnormality independently increased with Wagner grade.

This difference between CRTT and pulse findings highlights the importance of interpreting individual bedside vascular parameters separately rather than considering all vascular abnormalities as equivalent indicators of disease severity. More comprehensive vascular assessment using ankle-brachial index, Doppler examination, or other objective vascular investigations would be useful in future studies [13].

Musculoskeletal abnormalities

Musculoskeletal deformities were present in 22 (55.0%) patients, including abnormalities such as hammer toes, claw toes, bunion/hallux valgus, and prominent metatarsal heads. A statistically significant association was observed between musculoskeletal deformity and Wagner grade ($\chi^2 = 26.33$, df = 2, $p < 0.001$).

Foot deformities can alter the normal distribution of mechanical forces across weight-bearing areas. In patients with neuropathy, these changes may be particularly important because abnormal pressure may remain unrecognized in the absence of protective sensation [14]. Appropriate offloading is an important component of management when excessive mechanical loading contributes to diabetic foot ulceration [15]. The significant association observed in this study supports the importance of incorporating structural foot examination into routine diabetic foot assessment rather than focusing solely on the presence of an ulcer.

Dermatological abnormalities

Dermatological changes were observed in 26 (65.0%) patients, including skin colour changes, nail abnormalities, and hair loss over the dorsum of the foot. These abnormalities were significantly associated with Wagner grade ($\chi^2 = 24.60$, df = 2, $p < 0.001$).

Dermatological findings may reflect the cumulative effects of chronic neuropathic and vascular abnormalities and may also indicate impaired tissue integrity. In clinical practice, recognition of such changes may prompt more detailed neurological and vascular evaluation. However, because the present study was observational and assessed associations rather than temporal progression, these findings should not be interpreted as demonstrating that dermatological abnormalities directly cause progression of Wagner grade.

Interpretation

The findings of this study demonstrate that diabetic foot disease involves abnormalities across multiple functional domains rather than a single isolated pathological process. Significant associations with Wagner grade were observed for loss of protective sensation, impaired vibration perception, absent ankle reflexes, proprioceptive abnormalities, delayed CRTT, musculoskeletal deformities, and dermatological changes. In contrast, autonomic dysfunction and dorsalis pedis pulse grade were not significantly associated with Wagner grade.

The particularly strong associations observed for sensory and structural abnormalities emphasize the importance of a systematic bedside assessment. Monofilament testing, vibration assessment, ankle reflex examination, proprioception testing, vascular examination, and evaluation of foot architecture and skin integrity can collectively provide a broader clinical assessment than examination of the ulcer alone.

The principal practical implication of the study is that many of these assessments require minimal equipment and can be performed during routine clinical examination. Such an approach may be especially

useful in primary-care and resource-constrained settings where advanced biomechanical or vascular investigations may not be immediately available. However, bedside findings should complement, rather than replace, objective investigations when clinically indicated.

The present study has certain limitations that should be considered when interpreting these findings. The sample size was relatively small (n = 40), and the study was conducted at a single tertiary-care hospital, which limits the generalizability of the results. Only Wagner grades 0-2 were included, preventing assessment of biomechanical findings across more advanced grades of diabetic foot disease. In addition, the study relied predominantly on clinical bedside assessments and did not incorporate objective investigations such as plantar pressure measurement, gait analysis, ankle-brachial index, Doppler vascular assessment, or nerve conduction studies. The observational design also permits identification of associations but does not establish causal relationships or determine whether the observed abnormalities predict future ulcer progression. Larger, multicentre prospective studies incorporating quantitative biomechanical and vascular assessments are therefore warranted.

Conclusions

Diabetic foot disease is characterized by interacting neuropathic, vascular, musculoskeletal, and dermatological abnormalities. In this study, loss of protective sensation, absent ankle reflexes, proprioceptive impairment, musculoskeletal deformities, and dermatological abnormalities were significantly associated with Wagner grade, whereas vibration impairment and capillary refill time did not demonstrate a consistent progressive relationship. Dorsalis pedis pulse findings and autonomic dysfunction were not significantly associated with Wagner grade. A structured bedside clinical assessment using inexpensive tools may facilitate the identification of existing foot abnormalities and guide appropriate clinical evaluation and foot-care measures, particularly in resource-limited settings. However, these findings should be interpreted cautiously, as the study does not establish predictive value for future ulceration or demonstrate the effectiveness of preventive interventions.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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Supervision: Prasanth Gurijala

Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. Institutional Ethics Committee, ESIC Medical College and Hospital and ESIC Superspeciality Hospital issued approval ESICMC/SNR/IEC-S0150/07-2022. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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