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ORIGINAL ARTICLE

Clinical and Electrophysiological Detection of Diabetic Neuropathy in Individuals with Type 2 Diabetes Mellitus: A Comparative Pilot Study in Western Maharashtra

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Abstract

Background: Diabetic Peripheral Neuropathy (DPN) is the most common chronic complication of Type 2 Diabetes Mellitus (T2DM), and Indian studies report a prevalence ranging widely from about 9% to 78% depending on region and diagnostic method. Bedside clinical tests remain the first-line screening tools in resource-limited settings, but their concordance with Nerve Conduction Study (NCS), the electrophysiological reference standard, is uncertain and may vary by population. **Aim:** To compare the diagnostic performance of bedside clinical methods (vibration perception by tuning fork, Semmes-Weinstein monofilament testing, and ankle reflex) against NCS for detecting diabetic neuropathy in patients with T2DM in a Western Maharashtra population. **Materials and Methods:** This descriptive, cross-sectional pilot study enrolled 14 patients with T2DM. Each patient underwent a structured clinical neurological examination (vibration perception, monofilament testing, ankle reflex) and NCS (motor and sensory conduction of an upper- or lower-limb nerve). Findings from clinical examination were compared against NCS, which was used as the reference standard. Descriptive statistics were used given the small sample size. **Results:** The mean age was 52.1 ± 15.4 years and mean duration of diabetes was 9.1 ± 4.7 years; mean HbA1c was 9.3 ± 1.9%. NCS was abnormal in 11 of 14 patients (78.6%) — mixed pattern in 5, axonal in 4, and demyelinating in 2 — while 3 patients (21.4%) had entirely normal nerve conduction. In contrast, bedside clinical examination detected an abnormality in only 5 of 14 patients (35.7%). Using NCS as the reference standard,

Keywords: Clinical Examination, Diabetic Peripheral Neuropathy, Monofilament Test, Nerve Conduction Study, Pilot Study, Type 2 Diabetes Mellitus, Vibration Perception

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clinical examination showed a sensitivity of 45.5%, a specificity of 100%, and an overall concordance of 57.1%. Abnormal NCS was seen in 5 of 6 patients (83.3%) with diabetes duration ≥10 years and in 6 of 8 patients (75.0%) with shorter duration, suggesting a modest but non-absolute association between longer disease duration and electrophysiological neuropathy in this small cohort. **Conclusion:** In this small pilot cohort, bedside clinical tests substantially under-detected diabetic neuropathy compared with NCS, consistent with prior literature describing low sensitivity of clinical examination for subclinical DPN. These preliminary findings support incorporating NCS or more sensitive quantitative screening tools where feasible, and warrant confirmation in a larger, adequately powered study.

INTRODUCTION

Diabetic Peripheral Neuropathy (DPN) is the most common microvascular complication of diabetes mellitus and a leading cause of foot ulceration, amputation, and disability worldwide[1,3]. Global projections estimate that approximately 783 million adults will be living with diabetes by 2045, over 90% of whom will have Type 2 Diabetes Mellitus (T2DM), making the burden of its complications, including DPN, a growing public health concern[4,6]. Indian population-based studies report a wide range of DPN prevalence, from roughly 9% to 78% depending on the region, the diagnostic tool used, and the population studied, with several large cohorts reporting rates between 18% and 45%[7,9]. This variability partly reflects differences in the screening method: clinical criteria alone tend to underestimate the true burden of neuropathy compared with electrophysiological testing, and under-recognition of DPN in routine practice is well documented[10]. Nerve Conduction Study (NCS) is widely regarded as the electrodiagnostic reference standard for DPN, as it objectively measures the amplitude, latency, and velocity of motor and sensory nerve conduction, and can detect subclinical nerve dysfunction before symptoms or clinical signs appear[11,13]. However, NCS requires specialized equipment and trained personnel, and is not universally available at the primary or secondary care level, particularly in semi-urban and rural India[7,9].

Bedside clinical tests-vibration perception using a 128 Hz tuning fork, the Semmes-Weinstein monofilament test, and assessment of ankle reflexes-are therefore commonly used as first-line screening tools because they are inexpensive, quick, and require no specialized equipment[7,9]. Previous comparative studies have reported that the sensitivity of clinical neurological examination for detecting electrophysiologically confirmed neuropathy is often considerably lower than its specificity-for example, one study reported a sensitivity of only 40% against 100% specificity for neurological examination, while another Indian study comparing vibration testing with NCS reported high sensitivity for vibration testing but poor specificity, and near-perfect specificity but low sensitivity for NCV[15,16].

This suggests the two approaches may be complementary rather than interchangeable, and that reliance on clinical examination alone risks missing a substantial proportion of patients with electrophysiologically confirmed neuropathy[15,16].

A related dissertation from this region-a prospective study correlating glycaemic variability, HbA1c, and NCS in 93 patients with T2DM at a

tertiary centre in Kolhapur, Maharashtra- similarly used NCS as an objective marker of diabetic neuropathy and highlighted its value in characterizing nerve dysfunction independent of symptom reporting, underscoring the relevance of electrophysiological assessment in this population[17].

Given the practical importance of choosing appropriate screening strategies in settings where NCS access is limited, this pilot study was undertaken to directly compare bedside clinical methods against NCS in patients with T2DM attending a tertiary care centre in Western Maharashtra, with the aim of informing the design of a larger, adequately powered comparative study[17].

Aim and Objectives

Aim: To detect diabetic neuropathy in patients with type 2 diabetes mellitus using bedside clinical methods and nerve conduction study, and to compare the two approaches.

Objectives:

- To assess diabetic neuropathy using bedside clinical methods — vibration perception (tuning fork test), Semmes-Weinstein monofilament test, and ankle reflex — in patients with T2DM.
- To assess diabetic neuropathy using nerve conduction study (motor and sensory conduction) in the same patients.
- To compare the diagnostic yield and concordance of clinical methods against nerve conduction study.
- To examine the relationship between duration of diabetes, glycaemic control (HbA1c), and the presence of neuropathy on nerve conduction study.

MATERIALS AND METHODS

Study Design and Setting

This was a descriptive, cross-sectional pilot study conducted in the Department of Neuro-Physiotherapy in collaboration with the Department of Medicine, [Vikhe Patil Medical College & Hospital, Ahilyanagar, Maharashtra, India — confirm exact institutional name], following institutional ethics committee approval [approval number to be inserted]. This pilot study, comprising 14 patients, was undertaken to test the study protocol and generate preliminary data ahead of a larger, adequately powered comparative study.

Study Population

Fourteen patients with a confirmed diagnosis of type 2 diabetes mellitus, attending the outpatient/inpatient services of the department during the study period, were enrolled after written informed consent.

Inclusion Criteria

Patients of either sex, diagnosed with T2DM, willing to give written informed consent and undergo both clinical examination and nerve conduction study.

Exclusion Criteria

Peripheral neuropathy attributable to causes other than T2DM (e.g., chronic alcohol use, vitamin B12 deficiency, severe renal impairment, HIV infection, post-herpetic neuralgia, Guillain-Barré syndrome), and patients unwilling to provide consent.

Clinical Examination

A structured history and general and neurological examination were recorded for each patient. Neuropathy screening comprised: (i) vibration perception using a 128 Hz tuning fork applied over the bony prominence of the great toe/malleolus; (ii) touch/pressure sensation using a 10 g Semmes-Weinstein monofilament applied at standard plantar sites; and (iii) deep tendon (ankle) reflex assessment. Each modality was graded as normal or reduced/absent.

Nerve Conduction Study

NCS was performed using a standard electrodiagnostic (EMG/NCS) machine, recording motor distal latency, amplitude, and conduction velocity, and sensory latency, amplitude, and conduction velocity for a representative peripheral nerve (peroneal, ulnar, median, or radial, as clinically indicated) in each patient. Findings were classified as normal, axonal, demyelinating, or mixed

(axonal and demyelinating) pattern of neuropathy based on standard electrodiagnostic criteria.

Figure 1.Nerve Conduction Velocity Study.

Other Assessments

Anthropometric measurements (BMI), blood pressure, fasting and postprandial blood glucose, HbA1c, lipid profile, renal and liver function tests, and screening for diabetic retinopathy, nephropathy, and peripheral vascular disease were recorded as part of the standard workup.

Statistical Analysis

Given the small sample size (n=14), data were summarized descriptively as mean ± standard deviation for continuous variables and as frequency (percentage) for categorical variables. Clinical examination findings were compared against NCS (used as the reference standard) to derive sensitivity, specificity, and overall concordance. No formal inferential hypothesis testing was performed because the sample size was insufficient to yield statistically reliable p-values; findings are presented as descriptive/exploratory and hypothesis-generating.

RESULTS

A total of 14 patients with T2DM were included in this pilot study (Table 1). The mean age was 52.1 ± 15.4 years (range 30–75), and males predominated (64.3%). The mean duration of diabetes was 9.1 ± 4.7 years, and mean HbA1c was 9.3 ± 1.9%, indicating overall suboptimal glycaemic control across the cohort, although HbA1c ranged widely from 5.33% to 11.98%, reflecting heterogeneity in glycaemic control.

Table 1. Baseline demographic and clinical characteristics (n=14).

Parameter	Value
Age (years), mean ± SD (range)	52.1 ± 15.4 (30–75)
Sex, n (%) — Male / Female	9 (64.3%) / 5 (35.7%)
Duration of diabetes (years), mean ± SD (range)	9.1 ± 4.7 (2–16)
HbA1c (%), mean ± SD	9.3 ± 1.9
Fasting blood glucose (mg/dL), mean ± SD	139.2 ± 36.5
Postprandial blood glucose (mg/dL), mean ± SD	207.9 ± 73.9
BMI (kg/m^2), mean ± SD	20.8 ± 1.6

On nerve conduction study, 11 of the 14 patients (78.6%) had an abnormal pattern: mixed axonal-demyelinating in 5 (35.7%), axonal in 4 (28.6%), and demyelinating in 2 (14.3%). Three patients (21.4%) had entirely normal nerve conduction (Table 2).

Table 2. Distribution of nerve conduction study findings (n=14).

NCS Pattern	Number of Patients	Percentage
Normal	3	21.4%
Axonal	4	28.6%
Demyelinating	2	14.3%
Mixed (axonal + demyelinating)	5	35.7%
Total abnormal NCS	11	78.6%

On bedside clinical examination, findings were again less frequently abnormal than on NCS, though the gap narrowed somewhat with the larger sample. Vibration perception was reduced in 5 patients (35.7%), ankle reflex was reduced in 4 patients (28.6%), and the monofilament test was abnormal in 2 patients (14.3%). Overall, a composite clinical abnormality (any one test positive) was found in 5 of 14 patients (35.7%) (Table 3).

Table 3. Findings on individual bedside clinical tests (n=14).

Clinical Test	Abnormal, n (%)	Normal, n (%)
Vibration perception (tuning fork)	5 (35.7%)	9 (64.3%)
Monofilament test	2 (14.3%)	12 (85.7%)
Ankle reflex	4 (28.6%)	10 (71.4%)
Any clinical test abnormal (composite)	5 (35.7%)	9 (64.3%)

When clinical examination was compared against NCS as the reference standard, clinical examination correctly identified 5 of the 11 NCS-abnormal patients (true positives) and missed 6 (false negatives); it correctly classified all 3 NCS-normal patients as normal (true negatives), with no false positives (Table 4). This yielded a sensitivity of 45.5%, a specificity of 100.0%, and an overall concordance of 57.1% between clinical examination and NCS (Table 5).

Table 4. Clinical examination findings cross-tabulated against NCS.

	NCS abnormal (n=11)	NCS normal (n=3)	Total
Clinical exam abnormal	5 (True positive)	0 (False positive)	5
Clinical exam normal	6 (False negative)	3 (True negative)	9

Table 5. Diagnostic performance of composite clinical examination versus NCS (reference standard).

Diagnostic parameter	Value
Sensitivity	45.5% (5/11)
Specificity	100.0% (3/3)
Overall concordance/accuracy	57.1% (8/14)

Abnormal NCS was present in 5 of 6 patients (83.3%) with diabetes duration ≥10 years, compared with 6 of 8 patients (75.0%) with shorter duration — a modest difference that, unlike in the initial smaller cohort, did not show a clean cut-off effect, suggesting duration alone is an imperfect predictor of electrophysiological neuropathy in this population. Sensory conduction data could not be obtained for one patient (sensory testing was not performed for this patient) and this case was analysed using motor conduction findings alone.

DISCUSSION

This pilot study found a persistent gap between the detection of diabetic neuropathy by bedside clinical methods and by Nerve Conduction Study: while NCS identified abnormal nerve conduction in nearly 4 of every 5 patients, routine clinical examination flagged only about 1 in 3. This translated into a low sensitivity (45.5%) but perfect These findings are consistent with the broader literature on this topic. A study evaluating the validity of neurological examination for diagnosing DPN reported a similarly low sensitivity of 40% alongside 100% specificity, and concluded that a combination of clinical signs and electrophysiology, as recommended by the American Academy of Neurology, offers the most accurate diagnosis specificity (100%) for clinical examination against NCS as the reference standard in this small sample[15]. These findings are consistent with the broader literature on this topic. A study evaluating the validity of neurological examination for diagnosing DPN reported a similarly low sensitivity of 40% alongside 100% specificity, and concluded that a combination of clinical signs and electrophysiology, as recommended by the American Academy of Neurology, offers the most accurate diagnosis[15]. Another Indian study comparing vibratory quantitative sensory testing with NCS in Kolkata found that vibration testing had relatively higher sensitivity but poor specificity, whereas NCV showed the opposite pattern — near-complete specificity but low sensitivity — leading the authors to conclude that these modalities are complementary rather than interchangeable[3]. Our results, in which vibration perception was the only clinical test to detect any abnormality while the monofilament test was normal in every patient despite predominantly abnormal NCS, echo this pattern of clinical under-detection[15].

The consistently high specificity of clinical examination across studies, including ours, suggests that a positive bedside finding is a reliable indicator of true neuropathy[1,3]. However, the low sensitivity means a

normal bedside examination cannot be used to rule out neuropathy, particularly in its early or subclinical stages — a concern given that NCS is known to detect nerve dysfunction before clinical signs or symptoms emerge[4]. This has direct practical implications for physiotherapy and primary-care screening programmes that rely solely on bedside testing: a substantial proportion of patients with electrophysiologically confirmed neuropathy may be missed and denied timely intervention such as foot-care education, gait and balance training, or referral for further evaluation[2,4].

The modest trend toward more frequent abnormal NCS in patients with longer diabetes duration (≥10 years) is broadly consistent with established knowledge that neuropathy risk rises with disease duration and cumulative glycaemic exposure, and with a related dissertation from this region that examined nerve conduction alongside glycaemic variability and HbA1c in a larger cohort of patients with T2DM — although in our expanded cohort this relationship was no longer clear-cut, with abnormal NCS also common among patients with shorter disease duration, underscoring that duration is only one of several contributors to nerve dysfunction[15, 7] Given that Indian prevalence estimates for DPN vary widely (roughly 9–78%) depending partly on the diagnostic method used, our findings reinforce the argument that studies and screening programmes should be explicit about which diagnostic standard — clinical or electrophysiological — is being applied, since this choice materially affects reported prevalence[6,7].

This study has important limitations. Foremost, the sample size of 14 patients remains small; the resulting sensitivity, specificity, and concordance estimates carry wide confidence intervals and are presented as preliminary, hypothesis-generating findings rather than definitive diagnostic accuracy estimates[1]. NCS was performed on a single representative nerve per patient rather than a standardized multi-nerve protocol, which may under- or overestimate the true burden of neuropathy in individual patients[1]. The cross-sectional, single-centre design limits generalizability, and formal inter-rater reliability of clinical examination was not assessed[1]. These limitations should be addressed in a larger, adequately powered, multi-nerve, multi-centre comparative study, which this pilot was designed to inform.

CONCLUSION

In this pilot study of 14 patients with type 2 diabetes mellitus, bedside clinical methods substantially under-detected diabetic neuropathy compared with nerve conduction study, demonstrating moderate sensitivity but high specificity[1]. These preliminary findings indicate that clinical examination alone may not be adequate to exclude diabetic neuropathy and support the wider use of nerve conduction study or other more sensitive screening tools where feasible[1]. A larger, adequately powered comparative study is warranted to confirm these observations and refine screening recommendations for diabetic neuropathy in Western Maharashtra[1].

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Conflict of Interest

The authors declare no conflict of interest.

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