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DIAGNOSTIC ACCURACY OF CLINICAL SCORING SYSTEMS (NSS, NDS, AND TCSS) COMPARED TO ELECTROPHYSIOLOGICAL TESTING IN DIABETIC NEUROPATHY AMONG T2DM PATIENTS

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ABSTRAK

Neuropati diabetik merupakan salah satu komplikasi kronis yang paling umum terjadi pada pasien diabetes melitus dan dapat menurunkan kualitas hidup secara signifikan. Diagnosis dini menjadi kunci dalam penanganan, namun keterbatasan alat diagnostik seperti pemeriksaan elektrofisiologis di berbagai fasilitas kesehatan memerlukan metode alternatif yang lebih praktis dan efisien. Penelitian ini bertujuan untuk membandingkan akurasi tiga instrumen penilaian klinis, yaitu NSS (Neuropathy Symptom Score), NDS (Neuropathy Disability Score), dan TCSS (Toronto Clinical Scoring System) dalam menegakkan diagnosis neuropati diabetik pada pasien DM Tipe 2 di RS Dr. Mohammad Hoesin Palembang. Penelitian dilakukan dengan desain potong lintang, dan hasilnya menunjukkan bahwa TCSS memiliki akurasi tertinggi (90,3%) dibanding NDS (85,5%) dan NSS (85,4%). TCSS juga memiliki keseimbangan terbaik antara sensitivitas (95,4%) dan spesifisitas (77,8%). Ketiga instrumen ini dapat dijadikan alat skrining awal yang efektif, khususnya di layanan kesehatan dengan keterbatasan alat diagnostik.

ABSTRACT

Diagnostic Accuracy of Clinical Scoring Systems (NSS, NDS, AND TCSS) Compared To Electrophysiological Testing In Diabetic Neuropathy Among T2dm Patients. Diabetic neuropathy is one of the most common chronic complications in diabetes mellitus patients and can significantly impair quality of life. Early diagnosis is essential, but limited availability of diagnostic tools such as electrophysiological testing in many healthcare facilities calls for more practical and efficient alternatives. This study aimed to compare the diagnostic accuracy of three clinical scoring systems—NSS (Neuropathy Symptom Score), NDS (Neuropathy Disability Score), and TCSS (Toronto Clinical Scoring System)—in detecting diabetic neuropathy among Type 2 DM patients at Dr. Mohammad Hoesin Hospital, Palembang. A cross-sectional design was employed, and findings revealed that TCSS had the highest accuracy (90.3%) compared to NDS (85.5%) and NSS (85.4%). TCSS also demonstrated the best balance of sensitivity (95.4%) and specificity (77.8%). All three instruments can serve as effective early screening tools, especially in healthcare settings with limited access to electrophysiological diagnostic facilities.

INTRODUCTION

Diabetic neuropathy is a clinical symptom due to peripheral nerve damage, either somatic, autonomic, or both, caused by diabetes mellitus (DM) without any other cause. This chronic complication is one of the most common in people with DM, both type 1 and type 2.[1,2] In 1988, diabetes experts attempted to develop a diagnostic tool to detect diabetic neuropathy, which was later known as the San Antonio Consensus. In the consensus, several scoring systems were introduced, such as the Neuropathy Symptom Score (NSS), Neuropathy Deficit Score (NDS), and Toronto Clinical Scoring System (TCSS). These scoring systems have been tested diagnostically using electrodiagnosis, with Nerve Conduction Study (NCS) as the gold standard.[3,4]

Nerve conduction study (NCS) currently becomes the gold standard in diagnosing diabetic neuropathy because it has accurate and objective results in diagnosing and is a reliable indicator of DSPN (Distal Sensorimotor Polineuropathy) in epidemiological research and clinical trials.[5] However, nerve conduction examinations usually show normal results in cases of small fiber neuropathy or neuropathy with subtle sensory and motor nerve damage. Other diagnostic tools, such as skin biopsy and QST (Quantitative Sensory Threshold), can confirm small fiber neuropathy but require higher costs and invasive procedure.[6,7]

Clinical scoring systems such as NSS, NDS, and TCSS can be used to establish diabetic neuropathy as well as determine the severity of it. In addition, this clinical score can be performed using simple equipment and without the need for experts. Each of these scores has both advantages and disadvantages. Neuropathy Symptom Score (NSS) is a clinical assessment based on the characteristics of the symptoms complained of by the patient, which can be done quickly in a few minutes, but the severity score is highly dependent on the subjectivity of the patient.[6–8] Neuropathy Deficit Score (NDS) has better objectivity because it relies on a standard physical examination in determining the severity of neuropathy.[9] On the other hand, TCSS combines subjective symptoms from patients and objective results from clinical examinations, making it a complete system, yet it requires some equipment and longer duration tests.[10,11] In general, NSS, NDS, and TCSS are commonly used in several studies to help diagnose diabetic neuropathy and determine the severity of neuropathy.[12–14] Despite their individual validation, no previous study has directly compared the diagnostic performance of NSS, NDS, and TCSS in the same population. Therefore, this study aims to determine the comparative accuracy of NSS, NDS, and TCSS scores in diagnosing diabetic neuropathy.

METHOD

This research used diagnostic tests to determine the diagnostic values of each NSS, NDS, and TCSS examination against electrophysiological examination (ENMG) in patients with diabetic neuropathy. The study was conducted at the outpatient polyclinic of RSMH Palembang and the ENMG laboratory of RSMH from November 2024 to February 2025. This study used a consecutive method wherein all subjects who met the inclusion and exclusion criteria were selected and then included in the study until the required number of samples was met. The inclusion criteria in this study were patients aged ≥ 18 years who had been diagnosed with diabetes mellitus based on medical records and were willing to participate in the study. The exclusion criteria were patients with clinical neuropathy suspected to be caused by diseases other than diabetes mellitus, such as morbus hansen neuropathy, MDR TB neuropathy, drug- or chemotherapy-induced neuropathy,

severe liver disease, or chronic alcohol. Stroke patients and patients who had amputation of the leg or arm, aphasia, or dementia were excluded from the study. The variables of this study consisted of predictor variables, namely the NSS score (Neuropathy Symptom Score), NDS (Neuropathy Deficit Score), and TCSS (Toronto Clinical Scoring System), while for the reference standard, the Electroneuromyography (ENMG) examination. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy were calculated for each score. Data analysis was carried out descriptively and presented in the form of narratives, tables, and diagrams or graphs. This study has been approved by the Health Research Ethics Commission of RSMH Palembang with a certificate of ethical feasibility No. DP.04.03/ D.XVIII.6.8/ ETIK/ 022/2025.

RESULTS

During the research, a total of 71 patients were recruited. However, 9 subjects were excluded—2 patients were unable to complete the ENMG examination and 7 had a history of chemotherapy. Among the 62 participants, 71% were diagnosed with neuropathy based on ENMG. Positive ENMG results indicated that 19.4% had severe neuropathy, 25.8% had moderately severe neuropathy, 14.5% had moderate neuropathy, and 11.3% had mild neuropathy (Table 1).

Table 1. Demographic Characteristics and Electrophysiological Findings of T2DM Patients

Variable	Total (n)	Percentage (%)
Age		
18 - 45 y.o.	8	12,9%
46 - 65 y.o.	46	74,2%
> 65 y.o.	8	12,9%
Sex		
Male	30	48,4%
Female	32	51,6%
Body Mass Index (BMI)		
Underweight	1	1,6%
Normal	21	33,9%
Overweight	16	25,8%
Obese I	14	22,6%
Obese II	10	16,1%
Duration of DM		
≥ 5 years	33	53,2%
< 5 years	29	46,8%
HbA1C		
≤ 7,0%	25	40,3%
> 7,0 %	37	59,7%
Dislipidemia		
Yes	49	79%
No	13	21%
Hypertension		

Yes	48	77,4%
No	14	22,6%
Cigarette		
Yes	21	33,9%
No	41	66,1%
Neuropathy Severity (ENMG-Based)		
Normal	18	29%
Mild	7	11,3%
Moderate	9	14,5%
Moderate - severe	16	25,8%
Severe	12	19,4%

Sensory nerve conduction studies revealed widespread nerve damage in all nerve fibers examined: the median, ulnar, sural, and peroneal nerves. Most sensory nerve fibers showed a decrease in amplitude: 33.9% in the sural nerve, 29% in the peroneal nerve, 24.2% in the ulnar nerve, and 19.4% in the median nerve. In more advanced cases, extensive damage was noted with absent SNAP responses in the sural and peroneal nerves (27.4% each) and absent SNAP responses in the median nerve in 14.5% of subjects (Table 2). A similar pattern was observed in motor nerve fibers (Table 3), with advanced damage in the upper extremities primarily affecting the median nerve, where 14.5% of subjects showed absent CMAP responses. In the lower extremities, 22.6% and 8.1% of subjects had absent CMAP responses in the peroneal and tibial nerves, respectively.

Table 2. Electrophysiological Characteristics of Sensory Nerves in T2DM Patients

	ENMG Findings								
	Latency (n (%))			Amplitude (n (%))			NCV (n (%))		
	Normal	Slowing	Absent	Normal	Decrease	Absent	Normal	Decrease	Absent
N. Medianus	32 (51,6%)	21 (33,9%)	9 (14,5%)	41 (66,1%)	12 (19,4%)	9 (14,5%)	52 (83,9%)	1 (1,6%)	9 (14,5%)
N. Ulnaris	53 (85,5%)	8 (12,9%)	1 (1,6%)	46 (74,2%)	15 (24,2%)	1 (1,6%)	60 (96,8%)	1 (1,6)	1 (1,6%)
N. Sural	42 (67,7%)	3 (4,8%)	17 (27,4%)	24 (38,7%)	21 (33,9%)	17 (27,4%)	44 (71%)	1 (1,6%)	17 (27,4%)
N. Peroneus	44 (71%)	1 (1,6%)	17 (27,4%)	27 (43,5%)	18 (29%)	17 (27,4%)	45 (72,6%)	0 (0%)	17 (27,4%)

Table 3. Electrophysiological Characteristics of Motor Nerves in T2DM Patients

	ENMG Findings								
	Latency (n (%))			Amplitude (n (%))			NCV (n (%))		
	Normal	Slowing	Absent	Normal	Decrease	Absent	Normal	Decrease	Absent
N. Medianus	54 (87,1%)	7 (11,3%)	1 (1,6%)	49 (79%)	12 (19,4%)	1 (1,6%)	56 (90,3%)	5 (8,1%)	1 (1,6%)
N. Ulnaris	62 (100%)	0 (0%)	0 (0%)	61 (98,4%)	1 (1,6%)	0 (0%)	60 (96,8%)	2 (3,2%)	0 (0%)
N. Tibialis	54 (87,1%)	3 (4,8%)	5 (8,1%)	50 (80,6%)	7 (11,3%)	5 (8,1%)	49 (79%)	8 (12,9%)	5 (8,1%)
N. Peroneus	44 (71%)	4 (6,5%)	14 (22,6%)	32 (51,6%)	16 (25,8%)	14 (22,6%)	39 (62,9%)	9 (14,5%)	14 (22,6%)

Statistical analysis revealed a significant correlation between all three scoring systems (NSS, NDS, and TCSS) and the electrophysiological findings for neuropathy, with a p-value of 0.000. Higher scores on the NSS, NDS, and TCSS were associated with greater severity of neuropathy as reflected by ENMG findings (Figure 1), indicating that these clinical scoring systems may serve as useful tools for diagnosing diabetic neuropathy.

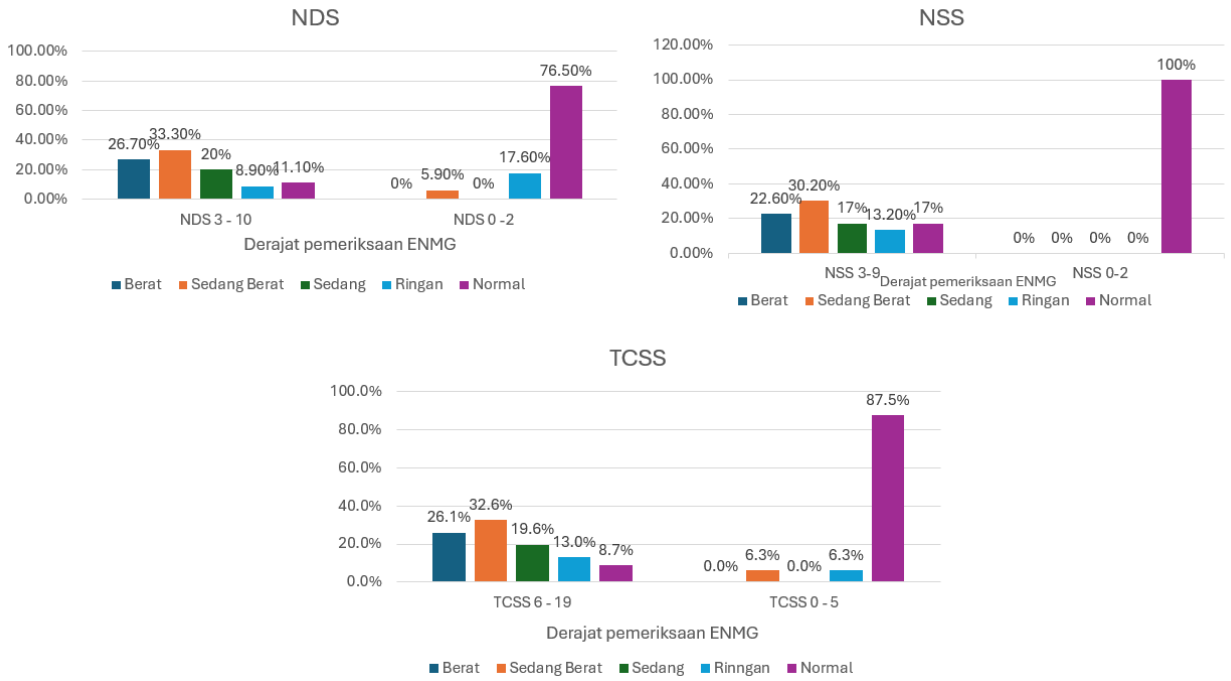

Figure 1. Evaluation of NSS, NDS, and TCSS Scores According to Neuropathy Severity Based on ENMG Findings

Among the three scores, TCSS demonstrated the highest diagnostic accuracy (90.3%), followed by NDS (85.5%) and NSS (85.4%) (Table 4). In terms of sensitivity, NSS had the highest value (100%) but the lowest specificity (50%). TCSS showed a more balanced profile between sensitivity and specificity (Figure 2). These findings suggest that the combination of subjective symptoms and objective clinical findings incorporated in the TCSS provides the best diagnostic value among the three scoring systems.

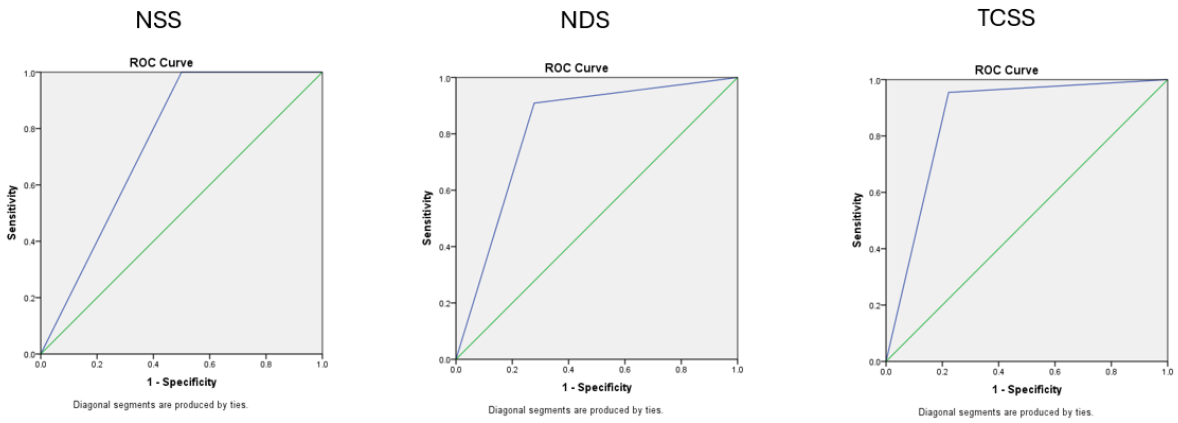

Figure 2 NSS, NDSS, and TCSS ROC (*Receiver Operating Charactristic*) Curve

Table 4. Comparison of the Diagnostic Values of NSS, NDS, and TCSS

	NSS	NDS	TCSS
Sensitivity	100%	90,9%	95,4%
Specificity	50%	72,2%	77,8%
PPV	83%	88,9%	91,3%
NPV	100%	76,5%	87,5%
Lr +	2	3,27	4,30
Lr -	0	0,13	0,006
Accuracy	85,4%	85,5%	90,3%
AUC	0,750 (Cl 95% 0,594 – 0,906)	0,816 (Cl 95% 0,682 – 0,949)	0,866 (Cl 95% 0,746 – 0,987)

DISCUSSIONS

Based on this study, 74.2% of patients with type 2 diabetes mellitus (T2DM) were aged between 46 and 65 years, with a female predominance of 51.6%. Similar findings were reported by Rohmatulloh et al., where 93.1% of T2DM patients were aged ≥45 years, and 60.9% were female.[15] In this study, 72% of T2DM patients were found to have neuropathy based on electrophysiological examination. This result is consistent with the study by Widianti et al. (2024), which reported a 74% prevalence of diabetic neuropathy among T2DM patients.[16] Comparable findings were also observed in a study by Rahmi et al. in Padang, with a diabetic neuropathy prevalence of 75% in T2DM patients.[17] Diabetic neuropathy is one of the most common complications of T2DM. It results from microvascular complications leading to endothelial dysfunction in the small blood vessels (vasa nervorum) that supply the nerves, causing reduced blood flow and oxygenation. This hypoxia contributes to peripheral nerve damage, leading to impaired axonal transport and subsequent axonal atrophy and degeneration, particularly in distal regions (Wallerian degeneration).[18,19]

In this study, most sensory nerve fibers exhibited amplitude reduction: 33.9% in the sural nerve, 29% in the peroneal nerve, 24.2% in the ulnar nerve, and 19.4% in the median nerve. In more advanced stages, complete fiber damage was observed, with absent SNAP responses in the sural and peroneal nerves (27.4% each), and 14.5% absence in the median nerve. Previous study by Sepat

et al. involving patients with T2DM aged 40–80 years showed significant reductions in amplitude and conduction velocity of the median sensory nerve in diabetic compared to non-diabetic individuals. The amplitude of the median sensory nerve in T2DM patients was significantly lower (mean 5.856 ± 3.50 μV) compared to non-DM controls (mean 11.86 ± 4.09 μV), with a p-value <0.0001.[20] Nerve Conduction Velocity (NCV) was also significantly reduced (mean 45.34 ± 17.36 m/s in T2DM vs. 57.26 ± 10.26 m/s in non-DM; $p < 0.0001$). Similar findings were noted in the ulnar nerve, with reductions in amplitude, prolonged latency, and reduced NCV (means: 5.246 ± 3.231 μV, 2.373 ± 1.14 ms, and 42.04 ± 18.06 m/s, respectively).[20] Prashant et al. (2024) also demonstrated decreased sural nerve amplitudes in diabetic neuropathy patients, with a mean of 4.68 μV (95% CI: 3.11–6.25), along with reduced NCV (mean 42.12 m/s; 95% CI: 39.87–44.36).[18]

Abnormalities in nerve conduction reflect damage to large myelinated fibers, which typically affect the lower limbs more than the upper limbs, consistent with the length-dependent pattern of large-fiber degeneration.[18,19,21] In diabetic neuropathy, early damage generally occurs in small-diameter sensory fibers, particularly Aδ fibers (1–5 μm), which mediate tactile, pain, and thermal sensations.[21,22] The sural sensory nerve, with its small diameter and superficial distal anatomical location (serving the lateral lower leg, lateral heel, ankle, and dorsolateral foot), is highly sensitive in detecting early-stage diabetic neuropathy on electrophysiological studies.[18,21] In contrast, damage to motor fibers indicates more advanced neuropathy, as motor Aβ fibers are larger (4–12 μm). Early diabetic neuropathy typically begins with distal sensory axonal degeneration, often accompanied by damage to cell bodies and dorsal root ganglia. Microvascular changes in diabetic conditions, such as endoneurial capillary abnormalities and vascular reactivity impairment, lead to ischemia and endothelial dysfunction, contributing to oxidative stress, altered signal transduction pathways, reduced release of vasoactive substances, and decreased smooth muscle sensitivity.[23]

The degree of nerve fiber damage observed on electrophysiological studies correlates closely with the clinical symptoms and signs. Clinical scoring systems, which systematically assess symptoms and physical examination findings, have been shown to significantly correlate with axonal and myelin damage in both sensory and motor fibers.

NSS (Neuropathy Symptom Score), with its high sensitivity, is effective in detecting true positive neuropathy cases and is useful as a screening tool. However, it has a high rate of false positives (50%), leading to potential overdiagnosis. A similar study by Zamroni et al. reported that NSS had high sensitivity (84.25%) but lower specificity (66.5%) due to its reliance on subjective patient-reported symptoms, which are influenced by individual perception.[24]

NDS (Neuropathy Disability Score), which assesses reflexes and sensory perception, demonstrated high sensitivity (90.9%) and better specificity (72.2%) compared to NSS, indicating improved objectivity due to its reliance on clinical observation rather than subjective symptoms. This is consistent with findings by Zamroni et al., who reported sensitivity and specificity of 85.7% and 83.3%, respectively, when compared to nerve conduction studies.[24] The overall diagnostic accuracy of NDS in this study was 85.5%, making it a reliable tool for distinguishing patients with and without diabetic neuropathy. A positive NDS result can support the diagnosis and initiation of treatment, while a negative result can reasonably exclude the condition, although further testing may still be warranted in high-risk or atypical cases.

Among the three scoring systems, TCSS (Toronto Clinical Scoring System) had the highest diagnostic accuracy in this study (90.3%), with the highest sensitivity (95.4%) and good specificity (77.8%). Compared to NSS and NDS, TCSS showed superior performance in terms of sensitivity, specificity, and likelihood ratios, making it the most reliable tool for diagnosing diabetic neuropathy.

TCSS combines both subjective symptoms and objective neurological findings, offering a comprehensive scoring system. This finding is consistent with a study by Purbasari et al., which reported TCSS sensitivity and specificity of 77.2% and 75.6%, respectively. A previous study by Destriyanah et al. also found that most patients with diabetic neuropathy had TCSS scores indicating mild to moderate severity, which was confirmed by electrophysiological testing.[11,25–27]

The use of clinical scoring systems such as NSS, NDS, and TCSS provides a practical alternative for diagnosing diabetic neuropathy, especially in areas with limited access to electrophysiological testing. NSS is the simplest scoring system and requires no specialized training. Although it is advantageous for rapid and easy assessment, NSS alone is not sufficiently reliable for diagnosis due to its high false positive rate and low specificity. Therefore, it is crucial to use it in conjunction with more objective scoring systems such as NDS and TCSS. For clinical assessment of diabetic neuropathy, NDS and TCSS can serve as reliable diagnostic tools, particularly in resource-limited settings.

Although this study employed appropriate methodology, it has several limitations. An imbalance between positive and negative cases may affect diagnostic metrics, particularly predictive values, limiting generalizability to populations with different prevalences. Selection bias may have occurred due to single-center recruitment. Additionally, the absence of small fiber neuropathy tests (e.g., skin biopsy, CCM) may underestimate early or subtle cases. Reference bias is also possible due to the lack of comparison with other diagnostic modalities such as biomarkers or advanced techniques like Single Fiber EMG (SFEMG), skin biopsy, or CCM (*Corneal Confocal Microscopy*). Furthermore, electrophysiological testing has a false-negative rate of 5–10%, as neuropathic symptoms may precede detectable changes in nerve conduction or structural damage in sensory fibers. Clinical scoring systems can be used as initial tools to assess diabetic neuropathy in symptomatic or suspected patients. These findings support the integration of TCSS and NDS into clinical pathways for early diabetic neuropathy detection in primary care settings. Thus, patients suspected of having diabetic neuropathy may first undergo clinical scoring assessments (NSS, NDS, and TCSS), followed by electrophysiological evaluation to determine nerve fiber function.

CONCLUSSIONS

All three clinical scoring systems exhibit adequate diagnostic accuracy, with the Toronto Clinical Scoring System (TCSS) demonstrating the highest accuracy at 90.3%. TCSS and NDS provide high diagnostic accuracy and can serve as reliable clinical tools in the absence of electrophysiological testing. Although the Neuropathy Symptom Score (NSS) shows high sensitivity, it is more appropriately utilized as an initial screening instrument.

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