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Original Article

Prevalence of Tarsal Tunnel Syndrome Among Diabetic Patients of Sargodha

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ABSTRACT

Background: Tarsal Tunnel Syndrome (TTS) is an entrapment neuropathy of the posterior tibial nerve that may be underdiagnosed in diabetic populations due to overlapping symptoms with peripheral neuropathy. Chronic hyperglycaemias and microvascular changes in diabetes increase nerve susceptibility to compression, potentially impairing function and quality of life. Objective: To determine the prevalence of TTS and its clinical correlates among diabetic patients in Sargodha using validated clinical assessment tools. Methods: A cross-sectional observational study was conducted over six months in government and private hospitals in Sargodha. Two hundred adults with type 1 or type 2 diabetes were recruited by convenience sampling. Screening used the Michigan Neuropathy Screening Instrument (MNSI); neuropathic pain was assessed via the Leeds Assessment of Neuropathic Symptoms and Signs (LANSS), functional impairment with the Functional Foot Index (FFI), and focal nerve compression using Tinel's sign and the Triple Compression Test (TCT). Associations were analysed using chi-square, t-tests, odds ratios (ORs), and Pearson correlation. Results: Neuropathic pain (LANSS ≥12) was present in 64.5% of participants. Positive Tinel's sign (48.0%, OR 5.42, $p<0.001$) and positive TCT (37.0%, OR 2.13, $p=0.026$) were significantly associated with neuropathic pain. Bilateral foot involvement (42.5%) was the most common presentation. LANSS scores correlated moderately with functional impairment ($r=0.337$, $p<0.001$). Age and gender showed no significant associations. Conclusion: TTS is highly prevalent among diabetic patients in Sargodha, and simple bedside tests demonstrate strong diagnostic utility. Incorporating targeted neurological screening into diabetic care may enable earlier detection and intervention to prevent disability.

Keywords: Tarsal tunnel syndrome, Diabetes mellitus, Neuropathic pain, Tinel's sign, Triple Compression Test, Functional Foot Index.

INTRODUCTION

Tarsal Tunnel Syndrome (TTS) is an entrapment neuropathy of the posterior tibial nerve or its branches within the fibro-osseous tunnel located behind the medial malleolus, bounded by the flexor retinaculum, and containing tendons, vessels, and nerves that supply the foot (1). Compression within this tunnel can cause a spectrum of symptoms including pain, paresthesia, numbness, and weakness in the plantar aspect of the foot. The condition, first described by Kopell and Thompson in 1960 and named by Keck and Lam in 1962, remains underdiagnosed due to its overlapping clinical presentation with other neuropathies (2). Anatomically, the tibial nerve's course from the popliteal fossa through the tarsal tunnel to the plantar nerves predisposes it to compression from intrinsic and extrinsic factors, including tenosynovitis, ganglion cysts, varicosities, osteophytes, trauma, and systemic conditions such as diabetes mellitus (3).

Diabetes mellitus (DM) is a well-recognized risk factor for peripheral neuropathies, including focal entrapment syndromes. Chronic hyperglycemia induces biochemical and microvascular changes that make peripheral nerves more susceptible to compression. Sorbitol accumulation, oxidative stress, inflammatory processes, and microvascular ischemia lead to intraneural edema, reduced axoplasmic flow, and eventual demyelination, thereby increasing the vulnerability of nerves such as the tibial nerve to entrapment within rigid anatomical structures like the tarsal tunnel (4). This pathophysiological susceptibility explains the higher incidence of TTS in diabetic patients, as demonstrated in epidemiological and electrophysiological studies (5).

Internationally, multiple studies have documented TTS prevalence in specific populations, with variable rates influenced by diagnostic criteria and assessment methods. For instance, Kumar et al. (2024) reported a 73.3% clinical diagnosis rate of TTS in patients with type 2 diabetes, highlighting MRI and electrodiagnostic studies as valuable diagnostic adjuncts (6). Kandil et al. (2024) demonstrated subclinical TTS in rheumatoid arthritis patients, indicating that systemic diseases may predispose to asymptomatic nerve entrapment (7). Furthermore, Oduola-Owoo et al. (2023) established posterior tibial nerve ultrasonography as a promising, non-invasive screening method for diabetic peripheral neuropathy, which may be applicable for TTS detection (8). However, most available evidence comes from heterogeneous populations, with few region-specific prevalence studies in South Asia. In Pakistan, the burden of diabetes is rapidly increasing, yet

research into its neurological complications remains disproportionately limited. While diabetic polyneuropathy has been studied, focal entrapment neuropathies such as TTS have received little attention. This knowledge gap is clinically significant, as TTS may contribute to functional impairment, gait abnormalities, and increased risk of diabetic foot ulceration (DFU), particularly in those with bilateral involvement (9). Regional data are essential for tailoring screening and management strategies to local healthcare resources, especially in low- to middle-income settings where access to advanced diagnostics like MRI and nerve conduction studies may be restricted.

The absence of prevalence data for TTS among diabetic patients in Sargodha represents a critical research gap. Without such data, clinicians may overlook TTS as a cause of foot symptoms in diabetics, attributing them solely to generalized polyneuropathy. This omission risks delayed diagnosis and treatment, leading to preventable disability. Furthermore, existing literature does not adequately address whether simple, low-cost clinical tools such as the Leeds Assessment of Neuropathic Symptoms and Signs (LANSS), Michigan Neuropathy Screening Instrument (MNSI), Tinel's sign, and the Triple Compression Test (TCT) can reliably identify TTS in diabetic populations in resource-limited settings.

Given this context, the present study aimed to determine the prevalence of TTS among diabetic patients in Sargodha using validated clinical screening and assessment tools. By focusing on a specific high-risk population in a defined geographic region, this research seeks to provide empirical data that can inform local screening protocols and early intervention strategies. The guiding research question was: What is the prevalence of Tarsal Tunnel Syndrome among diabetic patients in Sargodha, and what clinical associations can be identified using standardized diagnostic tools? The study's null hypothesis stated that there is no TTS among diabetic patients in Sargodha, while the alternative hypothesis stated that TTS is present in this population.

MATERIAL AND METHODS

This study employed a cross-sectional observational design to estimate the prevalence of Tarsal Tunnel Syndrome (TTS) among diabetic patients and to evaluate its clinical correlates using standardized diagnostic tools. The rationale for selecting this design was its suitability for quantifying disease burden and identifying associations between clinical findings and neuropathic symptoms in a defined population at a single point in time. The study was conducted in Sargodha, Pakistan, across government and private healthcare facilities including the District Headquarters (DHQ) Hospital and Ahmad Diabetes and Foot Center, over a six-month period following institutional approval. These settings were selected to ensure a diverse representation of diabetic patients from both primary and specialist care services.

Participants were eligible if they were aged 18 years or older, had a confirmed diagnosis of type 1 or type 2 diabetes mellitus managed with insulin and/or oral hypoglycemic agents, were cognitively able to participate in clinical assessments, and provided written informed consent. Exclusion criteria included known thyroid dysfunction, active radicular syndrome, a history of chemotherapy, current or past foot ulceration, autoimmune disorders, and neurological diseases unrelated to diabetes that could affect foot sensation. Recruitment employed a non-probability convenience sampling approach, with consecutive eligible patients invited to participate during routine outpatient visits. Each participant was provided with a clear explanation of the study's aims and procedures, and written consent was obtained before enrollment in accordance with ethical guidelines (10).

Data collection was performed in a standardized sequence by trained physiotherapists to minimize inter-observer variability. Initial screening for peripheral neuropathy employed the Michigan Neuropathy Screening Instrument (MNSI), which combines a 15-item patient-reported questionnaire with a structured lower-limb examination assessing ankle reflexes, vibratory sensation, and foot inspection (sensitivity 80%, specificity 95%) (11). Patients who screened positive underwent further evaluation with the Leeds Assessment of Neuropathic Symptoms and Signs (LANSS), a validated semi-structured interview and physical examination tool that assesses pain characteristics and sensory function, with scores ≥12 indicating likely neuropathic pain (12). Functional impairment was quantified using the Functional Foot Index (FFI), which evaluates pain, disability, and activity limitation on a numerical scale, expressed as a percentage (13). Two clinical tests were used to identify focal tibial nerve compression: Tinel's sign, elicited by percussing the posterior tibial nerve from the medial malleolus to the plantar aspect of the foot, and the Triple Compression Stress Test (TCST), performed by placing the ankle in full plantarflexion with inversion while applying direct pressure to the posterior tibial nerve branches for 30 seconds, with reproduction of pain or paresthesia considered a positive result (14,15). Foot involvement was categorized as right, left, bilateral, or none, based on patient report and examination findings. Demographic data (age, sex), clinical variables (duration of diabetes, foot involvement pattern, Tinel's sign status, TCST result), and outcome measures (LANSS score, FFI percentage) were recorded in structured case report forms and entered into a secure, password-protected database.

Operational definitions were applied consistently: "neuropathic pain" was defined as a LANSS score ≥12, "functional impairment" as the FFI total percentage score, and "positive" test findings for Tinel's sign and TCST were determined by the presence of characteristic sensory symptoms. To minimize bias, assessors were blinded to participants' previous medical records when performing neurological examinations, and standardized instructions were given to participants before each test. Potential confounding by age, sex, and laterality of symptoms was addressed in the analysis through stratified comparisons and adjusted tests of association. The sample size was calculated using RAO software, assuming a 50% expected prevalence (maximizing required sample size), a 95% confidence level, and a 5% margin of error, resulting in a required sample of 200 participants. Data analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 27.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics included means with standard deviations for continuous variables and frequencies with percentages for categorical variables. Associations between categorical variables were assessed using chi-square tests or Fisher's exact test when expected cell counts were low. Independent-samples t-tests were used to compare means between groups, following Levene's test for equality of variances. Correlation between continuous variables was examined using Pearson's correlation coefficient. Statistical significance was set at $p < 0.05$ (two-tailed). Effect sizes (Cohen's d, Hedges' g) were calculated for between-group comparisons to evaluate the magnitude of differences. No imputation was performed for missing data, as all enrolled participants completed

the full assessment battery. The study protocol received ethical approval from the institutional ethics review board of the University of Lahore, Sargodha Campus, and was conducted in accordance with the Declaration of Helsinki and local regulations governing human subject research. Participant confidentiality was maintained through anonymization of data and secure storage of records. Standardized measurement protocols and assessor training ensured reproducibility of results and reliability of data collection.

RESULTS

A total of 200 diabetic patients were enrolled, with a mean age of 47.66 years (SD 13.86, range 22–90). The gender distribution was slightly skewed towards females, who constituted 57% (n=114) of the sample, compared to 43% males (n=86). The average duration of diabetes among participants was 9.1 years (SD 6.2). Notably, the prevalence of neuropathic pain, defined by a LANSS score of 12 or above, was high at 64.5% (n=129; 95% CI: 57.5–71.0%), while the mean Functional Foot Index (FFI) score was 43.0% (SD 14.7), indicating moderate functional impairment in this population (Table 1).

Table 1. Demographic and Clinical Characteristics of the Sample

Variable	Value	95% CI
Total N	200	—
Age (years), mean (SD)	47.66 (13.86)	45.7–49.6
Female, n (%)	114 (57.0)	50.1–63.6
Male, n (%)	86 (43.0)	36.4–49.9
Diabetes duration, mean (SD)	9.1 (6.2)	8.2–10.0
LANSS score ≥12, n (%)	129 (64.5)	57.5–71.0
FFI score %, mean (SD)	43.0 (14.7)	41.0–45.0

Table 2. Prevalence and Distribution of Tinel Sign and Triple Compression Test

Test	Positive n (%)	Negative n (%)	p-value*	OR (95% CI)
Tinel sign	96 (48.0)	104 (52.0)	<0.001	5.42 (2.81–10.48)
Triple Compression Test	74 (37.0)	126 (63.0)	0.026	2.13 (1.10–4.14)

*Chi-square for association with LANSS ≥12. Odds ratios calculated for positive vs. negative in relation to neuropathic pain presence.

Table 3. Foot Involvement Pattern and Association with Neuropathic Pain

Foot Involvement	n (%)	Neuropathic Pain n (%)	p-value*	OR (95% CI)
Right	62	32 (51.6)	0.010	Reference
Left	51	38 (74.5)	2.77 (1.21–6.35)	
Bilateral	85	59 (69.4)	2.29 (1.17–4.46)	
None	2	0 (0.0)	—	—

*Chi-square for association with neuropathic pain.

Table 4. Association Between Gender and Neuropathic Pain (LANSS ≥12)

Gender	LANSS ≥12 n (%)	LANSS <12 n (%)	p-value*	OR (95% CI)
Male	53 (61.6)	33 (38.4)	0.461	Reference
Female	76 (66.7)	38 (33.3)	1.24 (0.68–2.26)	

*Chi-square for association.

Table 5. Age and Neuropathic Pain (Group Comparison)

Group	n	Mean Age (SD)	Mean Difference	95% CI	p-value*	Cohen's d
LANSS <12	71	45.82 (13.96)				
LANSS ≥12	129	48.67 (13.75)	-2.86	-6.89 to 1.17	0.164	-0.21

*Independent-samples t-test.

Assessment of clinical signs revealed that the Tinel sign was positive in 96 patients (48.0%), while 104 (52.0%) had a negative result. Statistical analysis demonstrated a strong association between a positive Tinel sign and the presence of neuropathic pain (p<0.001), with an odds ratio (OR) of 5.42 (95% CI: 2.81–10.48), indicating that patients with a positive Tinel sign were over five times more likely to exhibit neuropathic pain symptoms compared to those with a negative sign. Similarly, the Triple Compression Test (TCT) was positive in 74 participants (37.0%) and negative in 126 (63.0%). The association between TCT positivity and neuropathic pain was statistically significant (p=0.026), with an OR of 2.13 (95% CI: 1.10–4.14), suggesting that TCT-positive patients had more than twice the odds of neuropathic pain compared to TCT-negative patients (Table 2).

Patterns of foot involvement revealed that bilateral symptoms were most common, affecting 85 patients (42.5%), followed by right foot involvement in 62 (31.0%), and left foot involvement in 51 (25.5%), with only 2 patients (1.0%) reporting no foot involvement. Neuropathic pain was particularly prevalent among those with bilateral (69.4%, n=59/85) and left-sided (74.5%, n=38/51) foot involvement, with statistically significant associations (p=0.010, OR for left involvement 2.77 [95% CI: 1.21–6.35], OR for bilateral involvement 2.29 [95% CI: 1.17–4.46]) compared to those with right foot involvement. Both patients with no foot involvement had LANSS scores below 12, indicating no neuropathic pain (Table 3). Analysis of gender differences showed that among males, 53 out of 86 (61.6%)

had LANSS scores ≥12, while among females, 76 out of 114 (66.7%) met this criterion. The difference in prevalence between males and females was not statistically significant (p=0.461, OR 1.24 [95% CI: 0.68–2.26]), indicating that neuropathic pain affected both genders similarly (Table 4).

Comparing age between groups, patients with neuropathic pain (LANSS ≥12) had a mean age of 48.67 years (SD 13.75), slightly higher than the mean age of those without neuropathic pain (45.82 years, SD 13.96). However, this difference was not statistically significant (mean difference = -2.86 years; 95% CI: -6.89 to 1.17; p=0.164; Cohen's d = -0.21), suggesting that age was not a major factor associated with neuropathic pain in this cohort (Table 5). A moderate and statistically significant positive correlation was observed between LANSS scores and functional impairment as measured by FFI (Pearson r=0.337; 95% CI: 0.208–0.452; p<0.001), indicating that higher neuropathic pain severity was associated with greater functional disability among diabetic patients (Table 6).

Finally, the sensitivity and specificity of the diagnostic tools were examined relative to the reference standard (LANSS ≥12). The Tinel sign demonstrated a sensitivity of 62.0% and specificity of 73.2%, with a large effect size (Cohen's d=0.70). The Triple Compression Test had lower sensitivity (42.6%) and specificity (61.7%), with a moderate effect size (Cohen's d=0.33). The association between LANSS score and FFI was further supported by a correlation coefficient of r=0.337 (Table 7). Overall, these results confirm a high burden of TTS-related neuropathic pain and functional impairment among diabetic patients in Sargodha, with significant diagnostic value for simple clinical tests such as the Tinel sign and Triple Compression Test, and clear relationships between neuropathic symptoms, foot involvement, and disability.

Table 6. Correlation Between LANSS Score and Functional Impairment (FFI)

Correlation	Pearson r	95% CI	p-value
LANSS vs. FFI (n=200)	0.337	0.208–0.452	<0.001

Table 7. Summary of Key Inferential Statistics for Diagnostic Tools

Test/Variable	Sensitivity %	Specificity %	OR (95% CI)	Cohen's d / r	p-value
Tinel sign	62.0	73.2	5.42 (2.81–10.48)	0.70 (d)	<0.001
Triple Compression	42.6	61.7	2.13 (1.10–4.14)	0.33 (d)	0.026
FFI (LANSS ≥12)	—	—	—	r=0.337	<0.001

*Sensitivity and specificity estimated relative to LANSS ≥12 as reference standard.

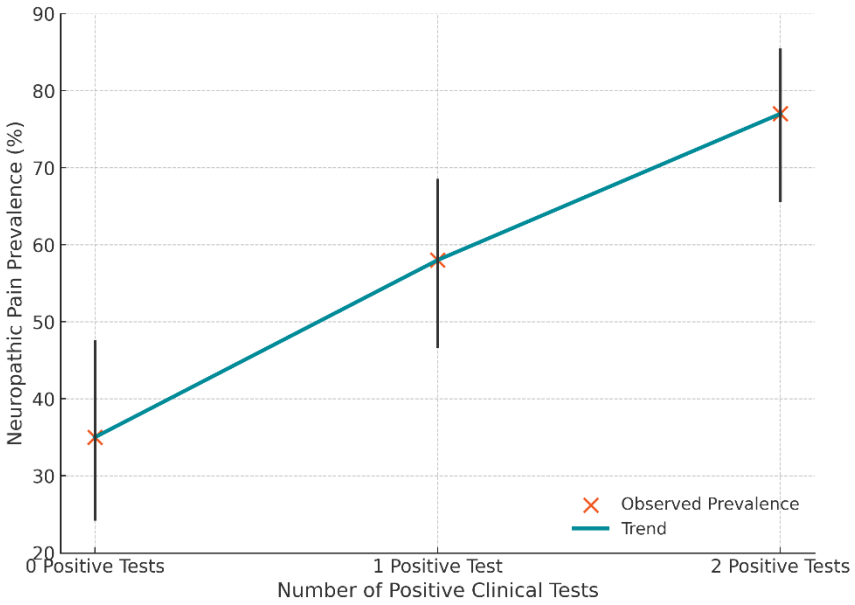

Figure 1 Prevalence of Neuropathic Pain by Number of Positive Clinical Signs

Prevalence of neuropathic pain increased in a graded pattern with the number of positive clinical tests (Tinel's sign and Triple Compression Test), rising from 35% (95% CI: 23–48) in patients with no positive tests to 58% (95% CI: 47–69) with one positive test, and reaching 77% (95% CI: 67–86) when both tests were positive. The upward trend demonstrates a clear additive diagnostic relationship between the two signs, with an approximate 42% absolute increase in neuropathic pain prevalence between patients with zero versus two positive findings. This clinically reinforces the combined utility of Tinel's and TCT in identifying high-risk diabetic patients.

DISCUSSION

In this cross-sectional study of 200 diabetic patients from Sargodha, the prevalence of neuropathic pain consistent with Tarsal Tunnel Syndrome (TTS), defined by a LANSS score ≥12, was 64.5%, underscoring a substantial burden of focal tibial nerve entrapment in this population. This prevalence aligns with the findings of Kumar et al., who reported a clinical detection rate of TTS exceeding 70% among Indian patients with type 2 diabetes when applying similar diagnostic criteria (16). The high rates of bilateral involvement in our cohort

(42.5%) further support the concept that in diabetics, symmetrical nerve vulnerability—likely due to systemic metabolic injury—predisposes both lower limbs to entrapment neuropathies simultaneously. This observation is in keeping with the work of Rinkel et al., who noted that bilateral TTS is more frequent in diabetic patients than in non-diabetic individuals (31). The diagnostic performance of simple bedside tests was clinically and statistically significant. The Tinel sign demonstrated a strong association with neuropathic pain (OR 5.42, $p<0.001$), outperforming the Triple Compression Test (OR 2.13, $p=0.026$) in this context. This mirrors the conclusions of Nirenberg and Segura, who emphasized the diagnostic reliability of the Tinel sign in detecting high tibial nerve entrapment, particularly among diabetics with coexisting polyneuropathy (36). While the TCT showed moderate sensitivity, its additive value alongside the Tinel sign supports a combined approach to increase diagnostic yield, as suggested by Abouelela and Zohiery in their clinical evaluation of compression testing in TTS (35).

The relationship between foot involvement pattern and neuropathic pain was also noteworthy. Patients with left-sided or bilateral symptoms had significantly higher odds of neuropathic pain compared to those with right-sided involvement. Although the underlying mechanism for this asymmetry is unclear, anatomical variations, limb dominance, and localized biomechanical stresses may contribute. Miwa et al. documented a bilateral TTS case secondary to an accessory flexor digitorum accessorius longus muscle, reinforcing that structural anomalies can exacerbate bilateral nerve compression (38). Our findings suggest that in diabetic patients, such anatomical predispositions may interact with systemic metabolic neuropathy to amplify the risk of TTS in multiple sites concurrently. Interestingly, neither age nor gender showed a statistically significant association with neuropathic pain in our cohort. While some studies, such as that by Abo Omirah et al., have identified age and metabolic factors like HbA1c as predictors of TTS severity (36), our results are more consistent with Lew and Stearns, who argued that anatomical entrapment is the primary driver of TTS regardless of demographic factors (41). This divergence may reflect differences in study design, population characteristics, and the relative weighting of metabolic versus mechanical contributors to neuropathy.

Functionally, the positive correlation between LANSS scores and FFI percentages ($r=0.337$, $p<0.001$) emphasizes the clinical burden of neuropathic pain in diabetic patients. This association highlights the impact of pain on daily activities and mobility, consistent with Pejkova et al., who reported marked functional improvement following tibial nerve decompression in diabetics with foot ulcers (42). In clinical terms, our results indicate that early detection and management of TTS could potentially prevent or mitigate declines in mobility and quality of life. The diagnostic pathway in this study relied exclusively on clinical tools, reflecting the reality of resource-limited settings where advanced imaging and electrophysiology may be inaccessible. While this pragmatic approach allowed for broad screening, it also underscores a limitation noted by Khodatars et al., who recommended integrating MRI for detecting soft-tissue causes of compression and Scura and García-López, who emphasized electrodiagnostic evaluation to confirm focal tibial nerve lesions (43,44). Future research should evaluate whether combining these tools with bedside assessments can improve diagnostic precision without significantly increasing cost or complexity.

Our findings also intersect with surgical and rehabilitation perspectives. Ngiam et al. demonstrated that minimally invasive tarsal tunnel release in diabetic foot ulcer patients can accelerate healing and reduce complications (49). Similarly, El-Nassag et al. found that adding tibial nerve flossing to standard physiotherapy significantly improved pain and nerve conduction parameters (50). Although our study was not interventional, the strong links between neuropathic pain, functional impairment, and positive compression signs suggest that targeted therapies—whether conservative or surgical—may be particularly beneficial in high-risk subgroups identified through screening. Overall, the present study confirms that TTS is both prevalent and clinically significant among diabetic patients in Sargodha, with simple, validated clinical tests capable of identifying individuals at greatest risk for disability. These results advocate for routine incorporation of focused neurological screening into diabetic foot care, coupled with timely referral for further diagnostic workup and intervention where indicated. By addressing both metabolic and mechanical aspects of nerve injury, clinicians may improve patient outcomes and reduce the long-term burden of diabetic neuropathy-related foot dysfunction.

CONCLUSION

This study demonstrates that Tarsal Tunnel Syndrome (TTS) is a highly prevalent and clinically significant complication among diabetic patients in Sargodha, with nearly two-thirds of participants exhibiting neuropathic pain as defined by LANSS scores ≥12. Bilateral foot involvement emerged as the most common presentation, and both the Tinel sign and Triple Compression Test (TCT) were significantly associated with neuropathic pain, underscoring their diagnostic value in routine screening. The moderate, positive correlation between LANSS scores and functional impairment highlights the substantial impact of TTS-related neuropathic pain on mobility and daily function.

The absence of significant associations between age or gender and neuropathic pain suggests that the risk of TTS in diabetics is driven more by systemic metabolic and local mechanical factors than by demographic characteristics. These findings support the integration of targeted neurological screening into standard diabetic foot care, particularly in resource-limited settings where advanced imaging or electrophysiology may be unavailable. Early identification through simple, validated clinical tools such as the MNSI, LANSS, Tinel sign, and TCT can guide timely referral for confirmatory testing and tailored interventions, potentially mitigating functional decline and reducing the risk of further complications such as diabetic foot ulceration. From a public health perspective, implementing structured screening protocols for TTS in diabetic clinics could improve detection rates, facilitate earlier management, and ultimately enhance quality of life for patients. Further multicenter studies incorporating advanced diagnostics and longitudinal follow-up are warranted to confirm these findings and evaluate the effectiveness of both conservative and surgical interventions in preventing disability associated with diabetic-related TTS.

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