The Role of the Nine-Hole Peg Test and Neurophysiological Tests in the Classification of Carpal Tunnel Syndrome

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Abstract

Aim: The aim of this study was to investigate the effectiveness of the use of the nine-hole nail test and neurophysiological tests in the diagnosis and classification of carpal tunnel syndrome (CTS).

Methods: This study was planned as a prospective cross-sectional study. Age, gender, occupation, height (cm), weight (kg), body mass index (BMI-kg/m2) values of all patients included in the study were recorded. In addition to the nine-hole nail test, LANNS, DN4 model was applied to CTS patients. In addition, the duration of the patients' complaints (months), the classification of their clinical findings and electrophysiological staging were recorded. The sensory and muscle strength examination of the hand was evaluated with Phalen and Tinel tests. Nerve conduction study (NCS) was performed with Cadwell Sierra EMG in our Neurophysiology Laboratory and normal values from our Clinical Neurophysiology Laboratory were used.

Results: A positive (linear) moderate correlation was found between the BCTQ FSS value and the left nine-hole nail test, the defective nine-hole nail test, the BCTQ SSS, LANNS and DN 4 values (r=0.387; r=0.350; r=0.649; r=0.431; r=0.490, respectively). A positive (linear) moderate correlation was found between the LANNS value and the defective nine-hole wooden nail test and DN 4 values (r=0.395; r=0.666, respectively). A positive (linear) moderate correlation was found between the DN 4 value and the BCTQ SSS, the BCTQ FSS and LANNS values (r=0.599; r=0.490; r=0.666, respectively).

Conclusions: It is possible to say that the nine-hole nail test and BCTQ tests are effective and reliable tools in the clinical and functional evaluation of CTS.

Keywords: *Carpal tunnel syndrome; electrophysiology; BCTQ; Nine-hole nail test*

1. Introduction

Carpal tunnel syndrome (CTS) is characterized by compression of the median nerve within the carpal tunnel in the wrist. CTS is typically characterised by symptoms of pain, numbness, tingling and weakness in the hand and fingers. Sensory symptoms may include nocturnal pain that can radiate from the hand into the forearm, elbow and shoulder, and paresthesia or hypoesthesia in the areas innervated by the median nerve. Motor symptoms include clumsiness, weakness in the hand and fingers, and interference with daily activities[1,2]. The diagnosis of CTS is based on clinical assessment, neurophysiological testing and imaging.

Neurophysiological testing, which measures nerve conduction velocities, is also an important tool in assessing the severity of the disease[3].

The nine-hole peg test is a simple but effective technique used in the diagnosis of CTS. This test assesses motor function based on the movement of the fingers and hands. In the early stages of CTS, neurophysiological testing provides more accurate results, while the nine-hole peg test is a simpler and quicker alternative[4]. However, studies comparing these two tests are limited.

Our aim in this study is to compare the nine-hole peg test and neurophysiological tests in carpal tunnel syndrome.

2. Materials and Methods

2.1. Study design and data collection

The present study was meticulously designed as a prospective cross-sectional study. Ethical approval for the study was obtained from the Ethics Committee of Adana City Training and Research Hospital (Meeting date: 22/06/2022; Meeting number: 108;

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Decision number: 1997). Following the acquisition of ethical approval, patients were enrolled in the study from 25 July 2022 to 25 April 2023. All patients who approved informed consent were included in the study. The study was carried out in the Neurology Clinic and Neurophysiology Laboratory of Adana City Training and Research Hospital, Health Science University.

Criteria for inclusion in the study;

1. Patients over 18 years old
2. Those who approved participation in the study
3. Patients with clinical findings consistent with carpal tunnel syndrome

Criteria for exclusion in the study:

1. Those under 18 years of age
2. Those who refused participation in the study
3. Patients with polyneuropathy or neurodegenerative diseases
4. Patients with diseases causing neuropathy, such as diabetes mellitus
5. Patients who had surgery for carpal tunnel syndrome
6. Patients undergoing treatment for neuropathic pain
7. Patients with clinical or electrodiagnostic findings consistent with ulnar or radial neuropathy

Data recorded for all patients included age, gender, occupation, weight (kg), height (cm), and body mass index (BMI, kg/m^2). In addition to the Nine-Hole Peg Test (NHPT)[5], the LANNS and DN4 models were applied to patients with CTS. The duration (in months) of their complaints, clinical classification, and electrophysiological staging were also recorded.

2.2. Clinical Evaluation

The clinical findings comprised the presence of nocturnal paresthesia in the first three fingers (Flick sign), paresthesia or pain with exercise or hand movements in the first three fingers, and weakness or atrophy in the hand muscles innervated by the median nerve. The evaluation of sensory and muscle strength in the hand was conducted using the Phalen and Tinel tests. The clinical classification is outlined below:

1. Only nocturnal paresthesia
2. Diurnal and nocturnal paresthesia
3. Loss of sensory
4. Atrophy or weakness in the thenar muscles innervated by the median nerve
5. Paralysis of the thenar muscles innervated by the median nerve

2.3. Neurophysiological Evaluation

Nerve conduction studies (NCS) were performed using the Cadwell Sierra EMG device (Cadwell Laboratories, Kennewick, Washington, USA) in the Neurophysiology Laboratory. Surface electrodes were utilised for the purposes of recording and stimulation. NCS was performed when the extremities were above 32°C. In cases where the extremities were cold, they were warmed up. The filter settings for sensory and motor NCS were set to 20 Hz-2 kHz and 20 Hz-10 kHz, respectively. For the purpose of sensory NCS, sensitivity and sweep rate were set to 10 µV/division and 1 ms/division, respectively. For motor NCS, the sensitivity and sweep rate were set to 2 mV/division and 5 ms/division, respectively. Bilateral median and ulnar sensory-motor NCS were performed on all patients. It is also noteworthy that all nerves were stimulated supramaximally. The recording for median and ulnar motor NCS was obtained from the abductor pollicis brevis (APB) and abductor digiti minimi (ADM) muscles, respectively. For the conduction of motor nerve studies, the distance between the stimulation point and the recording electrode at the wrist was set at 5 centimetres.

For median motor NCS, the stimulation sites were located at the wrist and elbow, while for ulnar motor NCS, the stimulation sites were positioned at the wrist, below the elbow, and above the elbow. In the case of median sensory NCS, antidromic recording was performed at the second finger-wrist segment, and orthodromic recordings were conducted at the second finger-wrist, palm-wrist, and wrist-elbow segments (mixed nerve). Ulnar sensory NCS was performed at the 5th finger-wrist segment using antidromic stimulation.

Neurophysiological classification was conducted in accordance with the established guidelines.

1. Mild CTS: SNCV of the median nerve at the 2nd finger-wrist segment was observed to be slowed, with a peak latency above 40.9 m/s and/or an onset latency above 44.6 m/s.
2. Moderate CTS: Slowing of sensory nerve conduction velocity (SNCV) at the 2nd finger-wrist segment and delayed distal median motor latency of more than 3.7 ms
3. Severe CTS: Absent distal median compound sensory action potential (CSAP) and delayed distal median motor latency of more than 3.7 ms
4. Very severe CTS: Absent distal median CSAP and compound muscle action potential (CMAP)

2.4. Nine Hole Peg Test Procedure

The Nine Hole Peg Test was used to demonstrate dexterity in the hand. This device is a setup consisting of a square platform and a storage box. There are 9 holes in the square area (12.7x2 cm) and 9 cylinders suitable for these holes. The diameter of the holes is 0.71 cm, the diameter of the cylinders is 0.64 cm, the length is 3.2 cm, the distance between the holes is 3.2 cm, the hole depth is 1.3 cm and the storage box size is 13x13 cm. Patients are asked to quickly take the 9 cylinders from the storage box, place them in the holes and then back in the storage box. The time is measured in seconds with a stopwatch[5].

2.5. Statistical Analysis

The statistical analysis of the data was conducted utilising SPSS (Statistical Package for the Social Sciences) version 25.0. Categorical variables were summarised as frequencies and percentages, while continuous variables were summarised as medians. The Shapiro-Wilk test was employed to ascertain the normal distribution of the parameters in the study. The chi-square test was used to compare categorical variables. For non-normally distributed parameters, the Mann-Whitney U test was applied. The relationships between continuous measurements were determined by employing the Spearman's rho correlation test. A p value below 0.05 was considered statistically significant.

3. Results

The mean age of the patients was 46.1 ± 9.7 years (median: 46 years). Five of the patients (10.9%) were male and 41 (89.1%) were female. The distribution of CTS across the body was found to be uneven, with 29 (63%) cases affecting the right side and 17 (37%) cases affecting the left side. The distribution of electrophysiological classes was as follows: 14 (30.4%) mild, 26 (56.5%) moderate, and 6 (13%) severe.

In clinical classification, 5 (10.9%) patients had only nocturnal paresthesia, 30 (65.2%) had both nocturnal and diurnal paresthesia, 10 (21.7%) had sensory loss, and 1 (2.2%) had atrophy or weakness in the thenar muscles innervated by the median nerve.

Furthermore, 20 (43.5%) patients exhibited abnormal LANNS findings, while 35 (76.1%) patients demonstrated abnormal DN4 findings (see Table 1 for details). A statistically significant difference was observed in the rate of abnormal DN4 findings, with higher incidences observed on the left side compared to the right ($p=0.004$). Furthermore, an analysis of the mean LANNS values revealed that they were higher on the left side compared to the right ($p=0.012$). No statistically significant differences were observed between the other parameters and groups ($p>0.05$) (Table 2).

Table 1

Analysis of demographic, clinical and applied tests of patients

	Number (n)	Percentage (%)
Gender		
Male	5	10.9
Female	41	89.1
Working status		
Yes	13	28.3
No	33	71.7
Side		
Right	29	63
Left	17	37
Electrophysiological classification		
Mild	14	30.4
Moderate	26	56.5
Sever	6	13.0
Clinic classification		
Only nocturnal paresthesia	5	10.9
Nocturnal and diurnal paresthesia	30	65.2
Loss of sensation	10	21.7
Atrophy or weakness of thenar muscles with median innervation	1	2.2
LANNS		
Abnormal	20	43.5
Normal	26	56.5
DN 4		
Abnormal	35	76.1
Normal	11	23.9
	Average±SD	Med (Min-Max)
Age (years)	46.1±9.7	46 (24-65)
Complaint period (months)	16.0±27.2	6 (0.25-120)
nine-hole peg test right	22.5±3.3	22.1 (17.8-31.0)
nine-hole peg test left	23.1±3.5	22.8 (18.1-38)
nine-hole peg test that is broken	23.5±3.4	23.4 (18.5-38)
Median nerve motor latency	4.75±1.3	4.34 (63.28-8.75)
Median nerve motor action potential	11.1±4.9	10.5 (2.3-24.8)
Median nerve sensory velocity	28.3±11.6	32.9 (0-38.9)
Median nerve sensory action potential	22.9±16.7	18.8 (0-73.9)
BCTQ SSS	30.9±8.2	30.5 (15-49)
BCTQ FDS	20.8±6.9	20.5 (8-34)
LANNS	12.2±4.6	11 (5-24)
DN 4	5.52±1.6	6 (2-9)

A weak positive linear correlation was identified between BCTQ SSS and Nine-Hole Peg Test (right) values (r=0.038). Moderate positive correlations were found between the impaired Nine-Hole Peg Test and BCTQ FDS, LANNS, and DN4 values (r=0.359; r=0.649; r=0.587; r=0.599).

A moderate positive correlation was identified between BCTQ FDS values and impaired Nine-Hole Peg Test values, BCTQ SSS, LANNS, and DN4 on the left side (r=0.387; r=0.350; r=0.649; r=0.431; r=0.490). A moderate positive correlation was identified between LANNS values and impaired Nine-Hole Peg Test and DN4 values (r=0.395; r=0.666). Furthermore, a moderate positive correlation was identified between DN4 values and BCTQ SSS, BCTQ FDS, and LANNS values (r=0.599; r=0.490; r=0.666) (Table 3).

4. Discussion

The findings of this study provide important insights into the clinical and electrophysiological characteristics of CTS patients and the relationships between various tests used in diagnosing the disease. The mean age of the patients and the predominance of females support the hypothesis that CTS is more prevalent in middle-aged individuals, especially women[6]. The high proportion of female patients in this study lends further support to the relationship between gender and CTS.

The electrophysiological classification results indicate that the majority of patients have moderate (56.5%) and mild (30.4%) CTS, suggesting that CTS often does not manifest prominent symptoms until it reaches the moderate stage. However, as symptoms progress, there is an attendant increase in neurophysiological impairments[7]. The clinical findings indicate that 65.2% of patients experienced both diurnal and nocturnal paresthesia, suggesting that symptoms become persistent throughout the day as the disease progresses. While the rate of atrophy or weakness in the thenar muscles due to median nerve damage was low, it is possible that this finding may become more prominent in the later stages of the disease[8].

The LANNS and DN4 tests results indicate that these tests can be valuable diagnostic tools in the assessment of CTS. Specifically, the DN4 test may offer more information about nerve damage, thus making it a useful clinical tool in evaluating CTS[9].

Table 2

Demographic, clinical and test results of the patients according to the right and left upper extremities

	Right (number=29) Percentage (%)	Left (number=17) Percentage (%)	p
Gender			
Male	3 (10.3)	2 (11.8)	0.891
Female	26 (89.7)	15 (88.2)	
Working status			
Yes	9 (31)	4 (23.5)	0.585
No	20 (69)	13 (76.5)	
Electrophysiological classification			
Mild	7 (24.1)	7 (41.2)	0.476
Moderate	18 (62.1)	8 (47.1)	
Sever	4 (13.8)	2 (11.8)	
Clinic classification			
Only nocturnal paresthesia	3 (10.3)	2 (11.8)	0.500
Nocturnal and diurnal paresthesia	17 (58.6)	13 (76.5)	
Loss of sensation	8 (27.6)	2 (11.8)	
Atrophy or weakness of thenar muscles with median innervation	1 (3.4)	-	
LANNS			
Abnormal	10 (34.5)	10 (58.8)	0.109
Normal	19 (65.5)	7 (41.2)	
DN 4			
Abnormal	18 (62.1)	17 (100)	0.004*
Normal	11 (37.9)	-	
	Average±SD	Average±SD	p
Age (years)	44.8±9.8	48.2±9.3	0.194
Complaint period (months)	14.6±24.2	18.4±32.3	0.398
Nine-hole peg test right	23.1±3.1	21.5±3.5	0.074
Nine-hole peg test left	22.4±3.1	24.2±3.9	0.148
Nine-hole peg test that is broken	23.1±3.1	24.2±3.9	0.546
Median nerve motor latency	4.87±1.4	4.56±1.2	0.432
Median nerve motor action potential	11.1±5.7	11.2±3.3	0.419
Median nerve sensory velocity	27.9±12.0	28.8±11.3	0.802
Median nerve sensory action potential	19.2±13.5	29.4±19.8	0.083
BCTQ SSS	30.3±9.3	31.8±5.9	0.419
BCTQ FDS	19.2±7.3	23.4±5.4	0.058
LANNS	10.9±4.3	14.2±4.4	0.012*
DN 4	5.27±1.8	5.94±0.7	0.156

Table 3

Results of patients' nine-hole nail test results according to BCTQ, LANNS and DN4

Parameters	BCTQ SSS		BCTQ FDS		LANNS		DN 4	
	r	p	r	p	r	p	r	p
Nine-hole peg test right	0.038*	0.022	0.125	0.407	0.256	0.085	0.084	0.579
Nine-hole peg test left	0.207	0.167	0.387**	0.008	0.167	0.269	0.101	0.503
Nine-hole peg test that is broken	0.359*	0.014	0.350*	0.017	0.395**	0.007	0.203	0.175
Median nerve motor latency	0.187	0.213	0.127	0.399	-0.027	0.858	-0.067	0.657
Median nerve motor action potential	-0.118	0.434	-0.024	0.875	0.089	0.557	-0.037	0.809
Median nerve sensory velocity	-0.255	0.087	-0.102	0.501	-0.027	0.859	-0.003	0.983
Median nerve sensory action potential	-0.154	0.307	-0.087	0.564	0.111	0.461	0.032	0.834
BCTQ SSS			0.649**	<0.001			0.599**	<0.001
BCTQ FDS	0.649**	<0.001					0.490**	0.001
LANNS	0.587**	<0.001	0.431**	0.003			0.666**	<0.001
DN 4	0.599**	<0.001	0.490**	0.001	0.666**	<0.001		

The higher rate of abnormal DN4 findings on the left side and the higher LANNS values in the left hand suggest that neurological impairments may be more pronounced on the left side, indicating possible differences between the left and right sides in terms of neurophysiological effects[10].

The present analysis sought to explore the relationship between BCTQ and the Nine-Hole Peg Test, with the objective of determining the existence of any correlation between the two tests. The results of the analysis revealed that there was a weak to moderate positive correlation between the two tests. Of particular note are the medium correlations observed between impaired Nine-Hole Peg Test results and BCTQ FDS, LANNS, and DN4. This finding suggests that combining clinical findings with electrophysiological tests may facilitate more precise classification of CTS[11]. Furthermore, stronger relationships with BCTQ SSS, FDS, and DN4 imply that these tests are essential in evaluating the impact of CTS on daily living activities. The Nine-Hole Peg Test is a simple yet effective tool for monitoring CTS in clinical settings, as its results correlate with other diagnostic tests.

This study has some limitations. These include the relatively small sample size and the reliance on data from a single healthcare centre. Furthermore, the evaluation of factors such as the patients' treatment processes and the continuity of their symptoms was not undertaken, which may limit the generalizability of the findings. Consequently, subsequent studies encompassing larger patient populations and incorporating long-term follow-up will be instrumental in substantiating the validity of these findings.

5. Conclusion

The findings of this study highlight the relationships between various tests used in the clinical and neurophysiological evaluation of CTS and their importance in disease management. The Nine-Hole Peg Test and BCTQ tests have been demonstrated to be effective and reliable tools in the clinical and functional assessment of CTS. Furthermore, neuropathic pain tests such as LANSS and DN4 have the potential to inform treatment strategies for CTS patients.

Statement of ethics

This study was approved by the Adana City Training and Research Hospital Clinical Research Ethics Committee (Meeting number: 108; meeting date: 23.06.2022; decision number: 1997).

genAI

Artificial intelligence (AI)-assisted technologies (such as Large Language Models [LLMs], chatbots, or image creators) were not used in the production of this article.

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Conflict of interest statement

The authors declare that they have no conflict of interest.

Availability of data and materials

This Data and materials are available to the researchers

Author contributions

EBS, ME: conceptualization, methodology, investigation, and writing – original draft. EBS, ME, ZA, HF: resources, formal analysis, and writing – review and editing. EBS, ME, SB, DO, ZA, HF: conceptualization, methodology, and writing – review and editing. All authors read and approved the final version of the manuscript.

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