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DIAGNOSTIC ACCURACY OF PROVOCATIVE TESTS FOR THE DETECTION OF CARPAL TUNNEL SYNDROME (CTS) BY TAKING THE ELECTRO-DIAGNOSTIC TEST AS A GOLD STANDARD IN CLINICALLY SUSPECTED PATIENTS

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Abstract

Background: *Screening for carpal tunnel syndrome has been made possible with the development of provocative tests. These procedures involve exerting pressure or stretching the median nerve in order to provoke symptoms.*

Objective: *The diagnostic accuracy of provocative tests for the detection of carpal tunnel syndrome (CTS) by taking the Electro-diagnostic Test as a gold standard in patients with clinically suspected CTS at Tertiary Care Hospital*

Material and Methods: *A cross-sectional study was carried, 218 patients between the ages of 18 and 80 years who had a clinical suspicion of carpal tunnel syndrome were included during the period 03-05-2024 to 30-11-2024. To verify the diagnosis, participants were subjected to electrodiagnostic testing. All provocative tests, including Phalen's test and Durkan's test were carried out in accordance with the protocols that were established initially. In order to determine the diagnostic accuracy of the provocative tests, sensitivity, specificity, and predictive values were determined.*

Results: *Within the sample, there were 138 males (63.3%) and 80 females (36.7%). The average age was 40.25±15.32 years. Tinel's signal had the best diagnostic accuracy (91.7%) with sensitivity and specificity of 94.7% and 87.4%, respectively. Phalen's test had the lowest diagnostic accuracy (65.13%), with sensitivity and specificity of 66.4% and 63.2%, respectively. The diagnosis accuracy of Phdurkan was found to be 70.18 percent, with some variance occurring depending on the demographics of patient and their clinical profile.*

Conclusion: *The most reliable diagnostic tool for identifying carpal tunnel syndrome (CTS) is Tinel's signal, followed by Durkan's test and Phalen's test.*

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INTRODUCTION

Carpal tunnel syndrome (CTS) is a common condition that affects the median nerve, which runs from the forearm to the hand and provides sensation and movement to the thumb and lateral two and half digits. [1] Carpal tunnel syndrome (CTS) is one of the most common diagnoses in hand that surgeons encounter, with a prevalence of approximately 4% in the general population. [2] The carpal tunnel syndrome (CTS) diagnosis is established by history and physical examination, with or without diagnostic questionnaires, electrodiagnostic studies, and ultrasound. [3, 4]

The main way to diagnose carpal tunnel syndrome is based on the patient's symptoms and physical examination. NCS/EMG can help exclude other causes of median nerve compression unrelated to the carpal tunnel[5]. Carpal tunnel syndrome can affect one or both hands. The cause of carpal tunnel syndrome is primarily unknown; however, some risk factors that are linked to it are diabetes, hypothyroidism, obesity, pregnancy, menopause, and smoking. [6]

Electrodiagnostic Test measures the electrical activity and function of the nerves and muscles, and it is considered the gold standard for diagnosing CTS. However, electrodiagnostic Test is invasive, expensive, and not widely available. [7] Some provocative tests have been developed to screen for CTS by applying pressure or stretching the median nerve and eliciting symptoms. These tests include Tinel's sign, Phalen's and Durkan's tests. [4, 8]

According to a systematic review by Graham et al.[10], the sensitivity and specificity of Tinel's sign ranged from 24% to 67% and from 77% to 96%, respectively. The sensitivity and specificity of Phalen's Test ranged from 24% to 80% and from 53% to 97%, respectively. The sensitivity and specificity of Durkan's Test ranged from 64% to 87% and 22% to 95%, respectively. The sensitivity and specificity of the Phdurkan test ranged from 82% to 91% and from 90% to 99%, respectively.

Carpal Tunnel Syndrome is a prevalent condition, and its accurate diagnosis is crucial for appropriate patient management. Clinicians often use various physical examination tests like Tinel's sign, Phalen's Test, and Durkan's Test to aid in diagnosing CTS. However, the reliability and accuracy of these tests compared to electrodiagnostic tests (the gold standard) need to be established. Electrodiagnostic tests, while accurate, can be expensive and less accessible than physical examination tests. Determining the diagnostic accuracy of clinical tests can help streamline the diagnostic process and allocate resources more efficiently. Suppose Tinel's sign, Phalen's, Durkan, or Phdurkan tests have strong diagnostic accuracy compared to electrodiagnostic tests. In that case, this can enhance clinicians' confidence in using these tests for CTS diagnosis. This can lead to earlier and more cost-effective diagnoses. Furthermore, these tests for CTS are important as they can lead to more efficient and cost-effective diagnosis, improved patient care, and resource allocation. It can positively impact both clinical practice and the overall healthcare system. Finally, it would also improve the knowledge of clinicians practicing in our hospital and help develop a management plan for patients with clinically suspected CTS. If the clinical tests are reliable, then potentially reduce the need for expensive tests.

MATERIAL AND METHODS:

Following the acceptance of the study's outline by the College of Physicians and Surgeons Pakistan (CPSP) via letter : CPSP / RE U / PLS-2O 23' 79 2-7 74 dated 20-04-2024 and the institutional ethical and review committee, this cross-sectional study is currently being carried out at the Department of Plastic Surgery at Liaquat National Hospital in Karachi over the course of a period of six months. Wan Nor Arifin's sample size calculator was used to determine the total number of patients that were included in the study. The precision of the calculator was set at 10%, and the confidence interval was set at 95%. The method of sampling that is been utilised is known as non-probability consecutive sampling.

A total 218 participants enrolled during the period 03-05-2024 to 30-11-2024 in the study ranged in age from 18 to 80 years old and reported experiencing symptoms of carpal tunnel syndrome (CTS) for a period of at least three months. These symptoms included pain, numbness, or tingling. Before undergoing confirmatory electrodiagnostic testing, everyone was subjected to a clinical examination to establish a clinical suspicion of carpal tunnel syndrome (CTS). The criteria for inclusion are open to anybody of either gender being considered. Patients having a history of any surgical procedures in the upper extremity, ulnar neuropathy,

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or other neurological illnesses affecting the upper extremities are included in the exclusion criteria. These criteria are comprehensive and try to minimise the impact of confounding factors. There were also participants who were not allowed to participate if they had a previous history of carpal tunnel release surgery, recent trauma, or injuries to their wrists or hands.

To improve the reliability of the diagnostic process, all provocative tests were carried out by hand surgeons who had extensive experience and specialised training. The replication of distal paresthesia in the median nerve distribution during the various tests was a defining characteristic of the positive findings. Tinel's sign is performed by lightly tapping the median nerve at the wrist and producing a tingling sensation in the fingers. Phalen's Test is performed by holding the wrists in complete flexion for 60 seconds and inducing numbness or paresthesia in the median nerve distribution Figure 1. Durkan's Test is performed by applying direct pressure over the carpal tunnel for 30 seconds, causing pain or paresthesia in the hand Figure 2. Phdurkan Test

combines wrist flexion and carpal compression, increasing the pressure in the carpal tunnel.

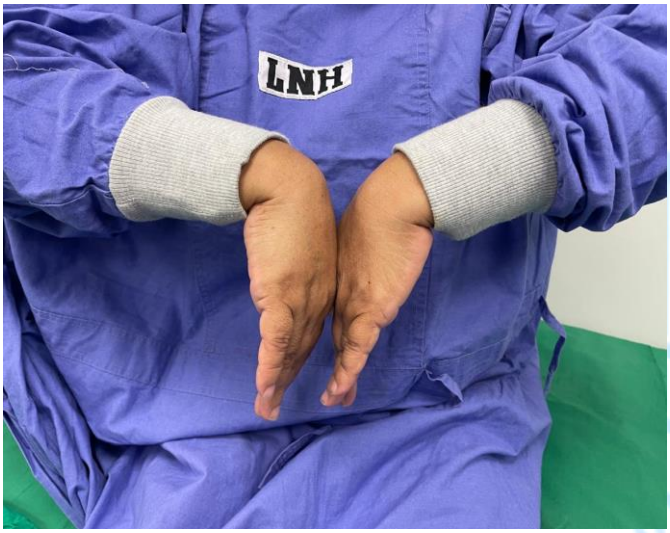

Figure 1 showing Phalen's test.

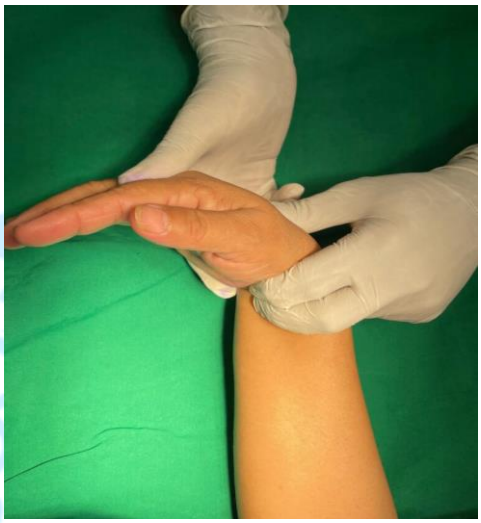

Figure 2 showing Durkan's test.

Electrodiagnostic testing, which may take anywhere from thirty to sixty minutes, involves the implantation of electrodes, the monitoring of muscle activity, and the interpretation of the results by experienced doctors. By using an organised strategy, one may verify that the gathering of data is in accordance with the rigorous criteria of clinical research. Comorbidities, demographic information, and the outcomes of provocative and electrodiagnostic testing are all meticulously documented in a methodical manner. The presence of comorbid conditions such as diabetes mellitus, hypertension, ischaemic heart disease, obesity, and smoking status was documented.

SPSS Version 22 was used to carry out the data analysis. In the case of regularly distributed data, continuous variables like age, weight, height, and body mass index (BMI) are reported as mean plus standard deviation, whereas in the case of non-normally distributed data, the median interquartile range (IQR) is used. To summarize categorical information, such as gender, comorbidities, and test findings, frequencies and percentages are used. A comprehensive evaluation of diagnostic accuracy was conducted by calculating the sensitivity, specificity, positive predictive value, and negative predictive value for every provocative test. This was accomplished by use a 2×2 contingency table, with the electrodiagnostic test serving as the gold standard. The identification of possible impact modifiers was accomplished using stratification based on age, gender, and comorbidities. Following the stratification process, the diagnostic accuracy was evaluated once again by calculating the sensitivity, specificity, positive predictive value, and negative predictive value for every provocative test. This was done by using a 2×2 contingency table, with the electrodiagnostic test serving as the gold standard.

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RESULTS

The statistics shown in **Table-1** demonstrate a composition that is mostly male, with 63.3% of the participants being male and 36.7% being female. There is a plurality of participants who are younger than 40 years old (56.4%), while 43.6% of them are older than 40 years old. The average age of the participants is 40.25 years. Taking into consideration the physical characteristics, the average height is 174.72 centimetres, and the average weight is 72.77 kilograms. This results in a mean body mass index (BMI) of 23.77 kilograms per square metre, which is within the acceptable range for weight. However, 27.1% of people are obese, which indicates that there is a subpopulation of people who have a high body mass index. Both diabetes mellitus and hypertension are frequent in the clinical setting, with each condition affecting 58.3 percent of the patients. In addition, 45.9% of persons have been found to have ischaemic heart disease, which indicates that there is a significant burden of cardiovascular disorders within the cohort. In terms of lifestyle variables, smoking is seen in 27.1% of the participants, however the bulk of the participants, which accounts for 72.9% of the total, are non-smokers, indicating that smoking is not a substantial risk factor in this community.

In both provocative and electrodiagnostic tests, the data that were shown in **Table-2** revealed a considerable prevalence of good outcomes. The Tinel's signal was seen in 61.9% of the subjects, while the Phalen's test and the Durkan's test both gave positive findings in 54.6% and 59.2% of the instances, respectively. These findings were in close agreement with the results of the PHDurkan test, which had a positive rate of 59.6%. The fact that provocative tests are consistent with one another shows that there is a significant clinical trend within the cohort. The findings of electrodiagnostic evaluations provided further support for these observations, with sixty-one percent of the subjects displaying good outcomes. The diagnostic significance of these approaches for assessing the condition among the individuals who participated in this research is shown by the fact that the results of provocative and electrodiagnostic tests are consistently in agreement with one another.

Table-1: Descriptive statistics of demographic and clinical profile of study population

Gender[a]	
Male	138(63.3)
Female	80(36.7)
Age(years)[b]	
	40.25±15.32
≤40 years	123(56.4)
>40 years	95(43.6)
Body mass index[b]	
Height(cm)	174.72±10.53
Weight(kg)	72.77±12.60
BMI (kg/m^2)	23.77±3.40
Obesity[a]	
Yes	59(27.1)
No	159(72.9)
Diabetes Mellitus[a]	
Yes	127(58.3)
No	91(41.7)
Hypertension[a]	
Yes	127(58.3)
No	91(41.7)
Ischemic Heart Disease[a]	
Yes	100(45.9)

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No	118(54.1)
Smoking[a]	
Yes	59(27.1)
No	159(72.9)

Table-2: Frequency distribution of outcome of provocative tests and electrodiagnostic test

PROVOCATIVE TESTS[a]	
TINEL'S SIGNAL	
Present	135(61.9)
Absent	83(38.1)
PHALEN'S TEST	
Present	119(54.6)
Absent	99(45.4)
DURKAN'S TEST	
Present	129(59.2)
Absent	89(40.8)
PHDURKAN	
Present	130(59.6)
Absent	88(40.4)
ELECTRODIAGNOSTIC TEST[a]	
Present	131(60.1)
Absent	87(39.9)

There is a significant amount of variation in the diagnostic performance of provocative tests about sensitivity, specificity, and accuracy, as described in **Table 3**. The signal produced by Tinel exhibits the best diagnostic accuracy, which is 91.7%. Additionally, it has exceptional sensitivity (94.7%) and specificity (87.4%), which makes it a very dependable test. The test developed by Durkan also demonstrates excellent performance, with an accuracy of 77.98%, sensitivity of 80.9%, and specificity of 73.6%, which further substantiates the diagnostic utility of the test. With a sensitivity of 74.8 percent and a specificity of 63.2 percent, PHDurkan has a modest level of accuracy, clocking in at 70.18%. This indicates that it may be most successful when used in conjunction with other tests. Phalen's test, on the other hand, has a significantly lower accuracy of 65.13%, with intermediate sensitivity of 66.4 percent and specificity of 63.2 percent, which indicates that it has limits in discriminating between real positives and true negatives. Tinel's signal emerges as the most precise instrument in clinical assessment, as seen by the alignment of these tests in their predictive values, which underlines the collective diagnostic importance of these tests.

Table-3: Sensitivity, Specificity, and Diagnostic Accuracy of Provocative Tests

Cutt off values	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Diagnostic Accuracy (%)
TINEL'S SIGNAL	94.7	87.4	91.9	91.6	91.7
PHALEN'S TEST	66.4	63.2	73.1	55.6	65.13
DURKAN'S TEST	80.9	73.6	82.2	71.9	77.98
PHDURKAN	74.8	63.2	75.4	62.5	70.18

PPV= Positive Predictive Values NPV= Negative Predictive Values

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DISCUSSION

Carpal tunnel syndrome is often diagnosed on a clinical basis; after the collection of a history that is suggestive of the illness, standard provocative simple tests such as Phalen's and Tinel's tests are typically used to determine the identification of the ailment. It is common practice to do electrodiagnostic investigations prior to making a choice about surgical intervention (22). In most cases, a thorough history and physical examination are all that is required to arrive at a definitive clinical diagnosis of carpal tunnel syndrome (CTS) and to arrive at early therapy recommendations. Electrodiagnostic investigations, on the other hand, can validate the clinical perception of CTS, which has the effect of providing reassurance to both the patient and the clinician (23). In clinical practice, electrodiagnosis is the gold standard for verifying a diagnosis of carpal tunnel syndrome (3). Physical examination has traditionally been employed as the first stage in the diagnostic process for CTS.

Our study comprehensively evaluated the diagnostic accuracy of provocative tests for carpal tunnel syndrome (CTS), comparing their performance against electrodiagnostic standards. Among the tests, Tinel's signal emerged as the most reliable, with a diagnostic accuracy of 91.7%, demonstrating consistently high sensitivity and specificity across subgroups. Durkan's test showed moderate reliability (77.98%), performing well in males and individuals with diabetes. PHDurkan exhibited comparable accuracy (70.18%) but varied across subgroups, showing slightly better performance in males. Phalen's test, with the lowest diagnostic accuracy (65.13%), demonstrated limited reliability, particularly in females. These findings underscore Tinel's signal as the most effective test, while Durkan's and PHDurkan offer viable alternatives in specific patient populations, emphasizing the need for subgroup-based test selection in CTS diagnosis.

When comparing the findings, Tinel's signal clearly outperformed the other tests in terms of sensitivity, specificity, and diagnostic accuracy, demonstrating its utility as a primary diagnostic tool for CTS. Durkan's test ranked second, offering moderate reliability, while Phalen's test showed the least consistency and accuracy. These findings highlight the importance of selecting the appropriate diagnostic test based on patient characteristics and the clinical context to ensure accurate detection of CTS. Tinel's sign was shown to have a greater Specificity when compared to Phalen's test, according to Zhang et al. (25).

Several investigations have indicated the opposite, with Phalen's test having a larger Sn/Sp ratio in comparison to Tinel's sign (26,27). The sensitivities in another investigation (28), which varied from 0.47 to 0.84, and the specificities, which ranged from 0.11 to 0.56, were comparable. The huge disparities in specificities compared to previous results in the literature are most likely the consequence of using a sample of individuals who were suspected of having CTS rather than volunteers who were asymptomatic themselves. A further point to consider is that as the examination manoeuvre gets more provocative (from the Tinel sign to Phalen's test, Durkan's test, and Phdurkan test), the sensitivity of the test rises while the specificity of the test drops. In clinical practice, it is beneficial to employ numerous provocative tests since there is no one provocative test that has shown to be the most effective. When all four provocative tests are used together in parallel, the sensitivity of the test is maximised, whereas the specificity of the test is maximised when all four provocative tests are used together in series. In previous studies, the sensitivities of popular provocative tests for CTS were reported to vary from 0.33 to 0.86, while the specificities were reported to range from 0.83 to 0.99 (29-31).

According to the findings and interpretations of such earlier studies on provocative tests for CTS, a number of significant research biases were responsible for the findings (32). Since the authors often compared a group with electrodiagnostically confirmed CTS with an asymptomatic control cohort, without recruiting individuals with intermediate probabilities of illness, the findings were subject to spectrum bias (28).

Our research had a few shortcomings that needed to be addressed. First, it was research that focused on a single individual. The second limitation of the study was that it had a rather limited sample size. To make this score relevant to a wider range of situations, it is necessary to conduct more research with larger sample sizes.

CONCLUSION

Among the provocative tests that were evaluated for the purpose of diagnosing carpal tunnel syndrome (CTS), Tinel's signal was found to have the highest diagnostic accuracy, sensitivity, and specificity. This finding establishes Tinel's signal as the most reliable tool for

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detecting CTS when compared to the electrodiagnostic test that is the gold standard. The test developed by Durkan also shown a reasonable level of accuracy, notably in men and patients who were diagnosed with diabetes mellitus. On the other hand, the test developed by Phalen had the lowest diagnostic accuracy and high variability between subpopulations. The results of this study indicate the superiority of Tinel's signal, especially in persons who have comorbidities such as diabetes and hypertension. Additionally, these findings highlight the significance of adapting diagnostic techniques depending on patient demographics and clinical features to maximise the identification of CTS.

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