Original Research

Accuracy of Provocative Tests for Carpal Tunnel Syndrome

Dafang Zhang, MD, *, 1 Cassandra M. Chruscielski, BS, *, Philip Blazar, MD, *, 1 Brandon E. Earp, MD *, 1

* Department of Orthopaedic Surgery, Brigham and Women’s Hospital, Boston, MA
1 Harvard Medical School, Boston, MA

Accuracy of Provocative Tests for Carpal Tunnel Syndrome

Prior literature on the diagnostic accuracy of commonly used provocative tests for suspected carpal tunnel syndrome (CTS) is influenced by research biases. The objectives of this study were to measure and compare the diagnostic accuracy of 4 commonly used provocative tests for CTS using electrodiagnostic study as the reference standard.

Methods: We prospectively evaluated 85 hands in 55 patients with suspected CTS. Tinel sign, Phalen’s test, Durkan’s test, and Phdurkan test (a combination of wrist flexion and carpal compression) and subsequent electrodagnostic testing were performed on all patients. Sensitivity and specificity were calculated using electrodagnostic findings as the reference standard. McNemar test was used to compare differences in paired outcomes between provocative tests.

Results: Tinel sign had a sensitivity of 0.47 and specificity of 0.56. Phalen’s test had a sensitivity of 0.50 and specificity of 0.33. Durkan’s test had a sensitivity of 0.71 and specificity of 0.22. Phdurkan test had a sensitivity of 0.84 and specificity of 0.11. Median time to a positive Phdurkan test result was 3 seconds. McNemar tests showed significant differences (P < .05) in the proportions of positive results among all CTS provocative tests except between Tinel sign and Phalen’s test.

Conclusions: Commonly performed provocative tests for suspected CTS differ in sensitivity and specificity. As the examination maneuver becomes more provocative, the test becomes more sensitive and less specific for CTS.

Type of study/level of evidence: Diagnostic III.

The diagnosis of carpal tunnel syndrome (CTS) is established by history and physical examination, with or without the aid of diagnostic questionnaires, electrodagnostic studies, and ultrasound. 1–4 Sensitive and specific provocative tests are key components of the physical examination and are incorporated into diagnostic tools such as the CTS-6. 5 The most commonly used provocative tests for CTS are Tinel sign, Phalen’s test, and Durkan’s test.

Combined wrist flexion and direct manual compression of the carpal tunnel has been described as a diagnostic test for CTS. 6 Because this maneuver combines Phalen’s test and Durkan’s test, we refer to it as the Phdurkan test. The combination of wrist flexion and carpal compression may more readily provoke CTS symptoms than either maneuver in isolation.

Prior literature on the diagnostic accuracy of common provocative tests for suspected CTS is affected by research biases. The objectives of our study were to measure and compare the diagnostic accuracy of 4 commonly used provocative tests for CTS using electrodiagnostic study as the reference standard.

Methods: We prospectively evaluated 85 hands in 55 patients with suspected CTS. Tinel sign, Phalen’s test, Durkan’s test, and Phdurkan test (a combination of wrist flexion and carpal compression) and subsequent electrodagnostic testing were performed on all patients. Sensitivity and specificity were calculated using electrodagnostic findings as the reference standard. McNemar test was used to compare differences in paired outcomes between provocative tests.

Results: Tinel sign had a sensitivity of 0.47 and specificity of 0.56. Phalen’s test had a sensitivity of 0.50 and specificity of 0.33. Durkan’s test had a sensitivity of 0.71 and specificity of 0.22. Phdurkan test had a sensitivity of 0.84 and specificity of 0.11. Median time to a positive Phdurkan test result was 3 seconds. McNemar tests showed significant differences (P < .05) in the proportions of positive results among all CTS provocative tests except between Tinel sign and Phalen’s test.

Conclusions: Commonly performed provocative tests for suspected CTS differ in sensitivity and specificity. As the examination maneuver becomes more provocative, the test becomes more sensitive and less specific for CTS.

Type of study/level of evidence: Diagnostic III.

Materials and Methods

A prospective study of consecutive patients referred to a single hand surgeon for suspected CTS from December 2018 to June 2019 was performed with institutional review board approval. A total of 65 eligible patients (100 symptomatic hands) were identified with clinically suspected CTS after a history was taken by a fellowship-trained hand surgeon, with no prior confirmatory
electrodiagnostic study. All patients met the inclusion criteria of (1) age 18 years or greater, (2) ability to follow physical examination commands, and (3) full wrist range of motion to allow performance of provocative tests. For all patients, Tinel sign, Phalen’s test, Durkan’s test, and Phdurkan test were performed by the senior author (B.E.E.), a fellowship-trained, subspecialty-certified hand surgeon. Tinel sign at the carpal tunnel was performed by percussion over the median nerve just proximal to the wrist crease and recorded as positive if associated with radiating paresthesias distally in the median nerve distribution (Fig. 1A). Phalen’s test was performed by maximal wrist flexion held for up to 60 seconds according to the original description and recorded as positive if associated with reproduction of distal paresthesias in the median nerve distribution (Fig. 1B). Elbows were maintained in extension during Phalen’s tests to prevent provocation of concomitant ulnar neuropathy at the elbow. Durkan’s test was performed by manual compression of the carpal tunnel held for up to 30 seconds according to the original description and recorded as positive if associated with reproduction of distal paresthesias in the median nerve distribution (Fig. 1C). Phdurkan test was performed by manual compression of the carpal tunnel with the examiner’s index and middle fingers and flexion of the wrist with the examiner’s thumb, and recorded as positive if associated with reproduction of distal paresthesias in the median nerve distribution (Fig. 1D). Patients were allowed to return to the baseline level of symptoms between provocative tests. Phdurkan test was held for up to 60 seconds, and the length of time to onset of symptoms was recorded.

After the clinical encounter, all patients were referred for electrodiagnostic testing. Carpal tunnel syndrome was a suspected clinical diagnosis for all patients in the study after the clinical encounter. Of 65 patients, 10 did not complete the ordered electrodiagnostic studies and were excluded. A final cohort of 85 hands in 55 patients were included in the study.

Nerve conduction studies and electromyography were performed by independent neurophysiologists who were not provided with the results of the provocative maneuvers. All electrodiagnostic studies were performed at our institution in accordance with practice guidelines from the American Association of Electrodiagnostic Medicine. Severity of CTS was graded as normal, mild, moderate, or severe by the criteria of Werner and Andary. Electrodiagnostic evidence of mild, moderate, or severe CTS was used as the reference standard for the diagnosis of CTS. Sensitivities and specificities of the 4 common CTS provocative tests were calculated for the final cohort of 85 hands. Sensitivity was calculated as the proportion of positive provocative test results among all hands with electrodiagnostically confirmed CTS. Specificity was calculated as the proportion of negative provocative test results among all hands without electrodiagnostically confirmed CTS. Positive predictive value (PPV) was calculated as the proportion of electrodiagnostically confirmed CTS among all hands with positive provocative test results. Negative predictive value (NPV) was calculated as the proportion without electrodiagnostically confirmed CTS among all hands with negative provocative test results. Calculations of sensitivities, specificities, PPV, and NPV were then repeated for a subset of 55 hands, retaining only 1 hand/patient in bilateral cases, to test the assumption of independence. The excluded hand in bilateral cases was selected by a random number generator. McNemar test was used to compare differences.
in paired outcomes between provocative tests. The standard significance criterion of \( \alpha = 0.05 \) was employed.

**Results**

Mean age of the 55 patients was 59 years (SD, 13 years) and 39 were female; 25% had diabetes mellitus. We studied 43 left hands and 42 right hands. Nine hands had no electrodiagnostic evidence of CTS, 20 had mild CTS, 19 had moderate CTS, and 37 had severe CTS. Other concomitant compressive neuropathies included cubital tunnel syndrome (\( n = 5 \)), cervical radiculopathy (\( n = 1 \)), and generalized polyneuropathy (\( n = 1 \)).

Sensitivities, specificities, PPV, and NPV of the 4 common CTS provocative tests were calculated in the cohort of 85 hands. Tinel sign had a sensitivity of 0.47, specificity of 0.56, PPV of 0.90, and NPV of 0.11. Phalen’s test had a sensitivity of 0.50, specificity of 0.86, and NPV of 0.07. Durkan’s test had a sensitivity of 0.71, specificity of 0.22, PPV of 0.89, and NPV of 0.08. Phdurkan test had a sensitivity of 0.84, specificity of 0.11, PPV of 0.89, and NPV of 0.08 (Table 1, Fig. 2). Use of all 4 provocative tests together in parallel (a positive result in any of the 4 maneuvers was scored as a positive test for CTS) yielded a sensitivity of 0.88, specificity of 0, PPV of 0.88, and NPV of 0. Use of all 4 provocative tests together in series (positive results in all 4 maneuvers were required to be scored as a positive test for CTS) yielded a sensitivity of 0.32, a specificity of 0.78, a PPV of 0.92, and an NPV of 0.12. The percentage of true positive provocative test results was highest for all tests in the moderate electrodiagnostic stage of CTS (Fig. 3).

Sensitivities, specificities, PPV, and NPV were calculated in a subset of 55 hands, with no bilateral cases, to check the assumption of independence. Tinel sign had a sensitivity of 0.47, specificity of 0.66, PPV of 0.92, and NPV of 0.13. Phalen’s test had a sensitivity of 0.51, specificity of 0.33, PPV of 0.86, and NPV of 0.08. Durkan’s test had a sensitivity of 0.78, specificity of 0.33, PPV of 0.90, and NPV of 0.15. Phdurkan test had a sensitivity of 0.90, specificity of 0.17, PPV of 0.90, and NPV of 0.17.

Median time to a positive Phdurkan test result was 3 seconds (interquartile range, 2–6 seconds). McNemar tests showed significant differences in the proportions of positive results among all CTS provocative tests (\( P < .05 \)) except between Tinel sign and Phalen’s tests (\( P = .6 \)). Post hoc power analysis showed that a

| Table 1 | Contingency Table for Provocative Tests |
|---------|---------------------------------------|
| Result  | Electrodiagnostic Study Result        |
|         | Positive | Negative |
| Tinel’s | Positive | 36 | 4 |
|         | Negative | 40 | 5 |
| Phalen’s test | Positive | 38 | 6 |
| Phalen’s test | Negative | 38 | 3 |
| Durkan’s test | Positive | 54 | 7 |
| Durkan’s test | Negative | 22 | 2 |
| Phdurkan test | Positive | 64 | 8 |
| Phdurkan test | Negative | 12 | 1 |

Figure 2. Sensitivity, specificity, PPV, and NPV of common provocative tests for CTS.
sample size of 85 had 80% power to detect a 0.30 difference in proportion of positive versus negative results.

Discussion

The diagnostic accuracies of common CTS provocative tests in this study were more modest than previously reported. Sensitivities ranged from 0.47 to 0.84, and specificities ranged from 0.11 to 0.56. The large differences in specificities from prior reports in the literature likely result from the use of a cohort with suspected CTS rather than asymptomatic volunteers. Furthermore, as the examination maneuver becomes more provocative (from Tinel sign to Phalen's test, Durkan's test, and Phdurkan test), the sensitivity of the test increases and the specificity of the test decreases. No single provocative test is optimal, and the use of multiple provocative tests in clinical practice is helpful. Use of all 4 provocative tests together in parallel optimizes sensitivity, whereas use of all 4 provocative tests together in series optimizes specificity.

Previously reported sensitivities of common CTS provocative tests ranged from 0.33 to 0.86, and specificities ranged from 0.83 to 0.99. A number of important research biases affected the results and interpretation of such prior studies on provocative tests for CTS. Because authors often compared a cohort with electrodiagnostically confirmed CTS with an asymptomatic control cohort, without enrolling patients with intermediate probabilities of disease, results were susceptible to spectrum bias. Moreover, the asymptomatic control cohort did not always undergo electrodiagnostic studies; therefore, a different reference standard was applied to each group, making results susceptible to verification bias. Finally, because interpretation of the provocative test often followed knowledge of the reference standard test results, results were susceptible to test review bias. The current study was designed to avoid these study biases. All patients prospectively enrolled in the study had CTS suspected after a history was taken by a fellowship-trained hand surgeon. Provocative tests were performed without knowledge of the reference standard results, and the same reference standard was applied afterward.

The median nerve compression with wrist flexion (Phdurkan) test was previously described by Tetro et al and was found to have a sensitivity of 0.82 and a specificity of 0.99 for CTS. We found for Phdurkan test a sensitivity of 0.84 and a specificity of 0.11 for the diagnosis of CTS. Although we agree with Tetro et al that Phdurkan test is sensitive for CTS, our results show it is not specific in the population of patients who present for evaluation of suspected CTS. Phdurkan test was positive in nearly 90% of patients with normal electrodiagnostic studies in our study. The combination of carpal compression and wrist flexion may also decrease the space of the carpal tunnel, making Phdurkan test the most provocative examination maneuver and the most likely to elicit false-positive results. Because Phdurkan test is so provocative, median time to onset of symptoms is only 3 seconds and was never more than 30 seconds in our study cohort. Because of its high sensitivity and rapid onset of symptoms, Phdurkan test can be a useful screening tool for hand surgeons in the office.
The accuracy of provocative tests for CTS in various electrodiagnostic stages of CTS has not been described. We found that all provocative tests are most likely to detect CTS in the moderate electrodiagnostic stage. A potential rationale for this finding is that the median nerve may be less irritable in milder stages. Conversely, in advanced stages, axonal loss may make it more difficult to elicit symptoms upon examination, or patients may not be able to report a change from baseline symptoms with provocative maneuvers.

This study had limitations. First, we chose electrodiagnostic studies as the reference standard for the diagnosis of CTS. Although electrodiagnostic studies have been traditionally used as the reference standard, some authors advocated for diagnostic aids such as the CTS-6 or ultrasound as alternative standards. Electrodiagnostic studies have been associated with notable false-positive and false-negative rates in epidemiological studies in the general population, but further studies focusing on their accuracy in the select population with suspected CTS are needed. Second, because more than one provocative test was performed on each patient, there is the possibility of confirmation bias. We would expect confirmation bias to regress our findings toward the mean and make it more difficult to detect a difference in diagnostic value among tests; nonetheless, we were able to detect significant differences among diagnostic tests. Third, 10 of 65 recruited patients did not complete the ordered electrodiagnostic studies. It is possible that these patients were less symptomatic, and a greater proportion of them may have had normal electrodiagnostic studies, which may have influenced our results. We were unable to analyze outcomes of these 10 patients who did not complete electrodiagnostic studies. Fourth, we did not record patients who were evaluated for CTS and were thought not to be symptomatic enough to undergo electrodiagnostic testing. Fifth, using hands rather than patients as the unit of data analysis allows for the possibility of interdependency of data. However, repeat analysis using patients as the unit of data analysis showed similar results in sensitivities and specificities. Sixth, predictive values are not entirely intrinsic to the test, but also depend on the population prevalence of the disease. Indeed, predictive values will vary depending on the prevalence of disease. An alternative method could have calculated predictive values based on the prevalence in the general population. We elected not to do so because the prevalence of CTS in patients with suspected disease is unknown. As such, the PPV and NPV presented in this study should be interpreted with caution. Finally, all provocative tests were performed by a single attending hand surgeon, and we are unable to comment on intraobserver or interobserver reliability.

Commonly performed provocative tests for suspected CTS differ in sensitivity and specificity. Future studies may focus on the accuracy of provocative tests with different diagnostic standards, such as ultrasound. As the examination maneuver becomes more provocative, the test becomes more sensitive and less specific for CTS. In the population of patients who present to a hand surgeon for evaluation for CTS, a single negative provocative test result has poor accuracy, and use of multiple provocative tests is helpful. The Phldurkan test can be a useful screening test for CTS owing to its high sensitivity and rapid onset of symptoms, but it results in many false positives.

References

1. American Academy of Orthopaedic Surgeons. Management of carpal tunnel syndrome: evidence-based clinical practice guideline. Available at: www.aaos.org/ctsguideline. Accessed April 12, 2020.
2. Fowler JR, Cipolli W, Hansan T. A comparison of three diagnostic tests for carpal tunnel syndrome using latent class analysis. J Bone Joint Surg Am. 2015;97(23):1958–1961.
3. Graham B. The value added by electrodiagnostic testing in the diagnosis of carpal tunnel syndrome. J Bone Joint Surg Am. 2008;90(12):2587–2593.
4. Wiesler ER, Chloros GD, Cartwright MS, Smith BP, Rushing J, Walker FO. The use of diagnostic ultrasound in carpal tunnel syndrome. J Hand Surg Am. 2006;31(5):726–732.
5. Graham B, Regehr G, Naglie G, Wright JC. Development and validation of diagnostic criteria for carpal tunnel syndrome. J Hand Surg Am. 2006;31(6):919–924.
6. Tetro AM, Evanoff BA, Hollstien SB, Gelberman RH. A new provocative test for carpal tunnel syndrome: assessment of wrist flexion and nerve compression. J Bone Joint Surg Br. 1998;80(3):493–498.
7. Boyer K, Wies J, Turkelson CM. Effects of bias on the results of diagnostic studies of carpal tunnel syndrome. J Hand Surg Am. 2009;34(6):1006–1013.
8. Phalen GS, Kendrick JI. Compression neuropathy of the median nerve in the carpal tunnel. J Am Med Assoc. 1957;164(5):524–530.
9. Durkan JA. A new diagnostic test for carpal tunnel syndrome. J Bone Joint Surg Am. 1991;73(4):535–538.
10. American Association of Electrodiagnostic Medicine, American Academy of Neurology, and American Academy of Physical Medicine and Rehabilitation. Practice parameter for electrodiagnostic studies in carpal tunnel syndrome: summary statement. Muscle Nerve. 2002;25(6):918–922.
11. Werner RA, Andary M. Electrodiagnostic evaluation of carpal tunnel syndrome. Muscle Nerve. 2011;44(4):597–607.
12. González del Pino J, Delgado-Martínez AD, González I, Lovic A. Value of the carpal compression test in the diagnosis of carpal tunnel syndrome. J Hand Surg Br. 1997;22(1):38–41.
13. Mondelli M, Passero S, Giannini F. Provocative tests in different stages of carpal tunnel syndrome. Clin Neurol Neurosurg. 2001;103(1):178–183.
14. Kuhlman KA, Hennessey WJ. Sensitivity and specificity of carpal tunnel syndrome signs. Am J Phys Med Rehabil. 1997;76(6):451–457.
15. Atroschi I, Gummesson C, Johnson R, Ornstein E, Ranstam J, Rosén I. Prevalence of carpal tunnel syndrome in a general population. JAMA. 1999;282(2):153–158.