

SENSITIVITY AND SPECIFICITY OF SYMPTOMS AND PROVOCATIVE TESTS IN DIAGNOSING MEDIAN NERVE NEUROPATHY IN DOMINANT HANDS CONFIRMED BY NERVE CONDUCTION TESTING

Laura R. Kaufman, University of Utah
Matthew S. Thiese, University of Utah
Kurt T. Hegmann, University of Utah

Kurt.Hegmann@hsc.utah.edu

ABSTRACT

Population-based studies are needed to better define the effectiveness of commonly elicited symptoms and provocative testing in screening for and diagnosing median nerve neuropathy. This report details baseline sensitivity, specificity, and predictive value data of median nerve signs and symptoms from an ongoing prospective cohort study.

Workers (n=851) from both Wisconsin and Utah have been enrolled in a prospective cohort study of distal upper extremity musculoskeletal disorders. These workers are employees of 12 diverse plants. Plant processes include electric motor manufacturing, apparel manufacturing, airbag manufacturing, meat processing, electric generator manufacturing, assembly, small motor manufacturing, and electric light manufacturing. All subjects completed a questionnaire that included demographic characteristics, past medical history and psychosocial factors; a structured interview focusing on musculoskeletal symptoms consistent with disorders of the neck and upper limbs, including the location of tingling and/or numbness in the prior month; standardized and confirmatory physical examinations; and nerve conduction velocity measurement on both extremities, regardless of symptoms.

Data for this report were examined by right (n=715) or left (n=75) hand dominance or ambidexterity (n=43). The frequencies of numbness and tingling and abnormal nerve conduction studies (NCS) were similar comparing right hands or left hands. Sensitivity (13% positive Tinel's – 83% hand pain) and specificity (62% hand pain – 98% positive Tinel's combined with numbness and tingling) of symptoms and provocative testing increased slightly in dominant hands compared to all left or right hands. Positive predictive value for dominant hands improved: right hand 14% (hand pain) – 50% (positive Tinel's combined with numbness and tingling) and left hand 21% (hand pain) – 36% (positive Phalens's combined with numbness and tingling) compared with all right or left hands (13% positive Tinel's – 40% positive Phalens's combined with numbness and tingling).

The baseline findings from this population-based cohort study show poor

sensitivity, high specificity, and poor positive predictive value of symptoms and provocative testing in a large population. The sensitivity, specificity, and positive predictive value are increased somewhat when considering dominant hands only.

INTRODUCTION

Population-based studies are needed to better define the effectiveness of commonly elicited symptoms and provocative testing in screening for and diagnosing median nerve neuropathy. This report details baseline sensitivity, specificity, and predictive value data of median nerve signs and symptoms from baseline data of an ongoing prospective cohort study.

METHODS

Workers (n=851) from both Wisconsin and Utah have been enrolled in a prospective cohort study of distal upper extremity musculoskeletal disorders. These workers are employees of 12 diverse plants. Processes include electric motor manufacturing, apparel manufacturing, airbag manufacturing, meat processing, electric generator manufacturing, assembly, small motor manufacturing, electric light manufacturing, and office work. The health outcomes assessments were performed blinded to the occupational exposure status.

All subjects, regardless of the presence or absence of symptoms, completed all steps in the enrollment process including a questionnaire, anthropometric measurements, structured interview, standardized physical examination, second physical examination, and nerve conduction velocity study. The laptop-administered questionnaire, given under the direction of a research assistant, consisted of items including demographic characteristics, past medical history, and psychosocial factors.

A hand therapist or occupational medicine resident (“first examiner”) conducted a structured interview and the first of two consecutive standardized physical examinations. The structured interview included two pain diagrams, one for the hand/forearm and one for the upper extremities and upper torso. The purpose of the first physical examination was to archive all upper extremity-related symptoms and assess a long list of physical examination findings relevant for screening for application of *a priori* case definitions.

A board-certified occupational medicine physician (“second examiner”) conducted the second, confirmatory physical examination. The purposes of the second physical examination were to repeat positive findings for reproducibility and assess pertinent negative findings while attempting to determine diagnostic impressions in a manner more analogous to a clinical evaluation.

All first and second examiners had the option of performing additional physical examination maneuvers, if indicated, to confirm diagnostic impressions.

The location of tingling and/or numbness was recorded on a hand pain diagram that was administered by the first examiner for all subjects who noted any history of tingling/numbness in the arms or hands in the prior month. There were only two codes used, (1) an aggregate for pain (OOO) (including pain, burning, and aching) and (2) for tingling/numbness (XXX). The simplification from typical clinical hand pain diagrams to the use of only two codes, and the completion of those diagrams by examiners, was instituted to avoid coding errors. Diagrams were coded through the use of transparencies with segments of the hands and fingers, subdivided for purposes of data entry into 72 segments per hand. For purposes of this report, the data for tingling and/or numbness in the prior month were utilized to represent active symptoms of paraesthesias.

The location(s) of pain in the remainder of the upper extremity and upper torso was identified by subjects through the use of a sectioned, lettered body diagram during the structured interview.

Phalen's Test

All subjects underwent Phalen's testing as part of the standardized physical examination by the first examiner (or both if positive upon the first examination). This test was performed with passive, maximal wrist flexion for 60 seconds while the subject held the elbows flexed approximately 90 degrees. The duration of wrist flexion was timed. The wrist flexion was assisted by the examiner to assure passive wrist flexion (Phalen, 1957; Phalen, 1966; Phalen, 1970). Subjects were specifically queried regarding development and location of any symptoms after performing this procedure. Subjects were not specifically queried regarding the development of tingling/numbness, nor were they cued to expect symptoms in certain digits. A positive Phalen's result was defined as development of tingling and/or numbness within 60 seconds in at least 2 median nerve served digits (i.e., thumb, index, middle and/or ring fingers). For purposes of this study, a positive result found by either examiner was considered a positive result.

Tinel's Sign

All subjects also underwent Tinel's testing over the median nerve using a reflex hammer. The reflex hammer was held approximately 10 cm above the wrist and actively used to strike the target tissue. As there is some controversy regarding where to assess Tinel's, it was assessed in all subjects in each of 3 locations: (1) over the distal wrist crease at the entrance to the carpal canal, (2) over the carpal canal proper, and (3) at the exit of the carpal canal. Thus, each subject's wrist was struck approximately 9-12 times. Subjects were specifically queried for the development and location of symptoms after performing this procedure. To be considered positive, tingling/numbness was required in at least two median nerve served digits at any single location.

Nerve conduction studies (NCS) were completed on all subjects by either of two boarded physical medicine and rehabilitation physicians, blinded to other measures. Hand temperature was measured and those that were not at least 34 degrees were warmed with warming blankets. Nerve conduction study results were categorized as normal, mildly abnormal, and moderately/severely abnormal. Normal results were defined as having transcarpal deltas of <0.4 msec in comparing the median and ulnar nerves (motor ≤ 4.4 msec; sensory ≤ 3.7 msec).

Statistical Analyses

Nerve conduction studies were utilized as the gold standard for comparison with other signs such as Tinel's and Phalen's. For these analyses, signs (Tinel's and Phalen's) and symptoms (tingling and numbness, worsening with holding an object, or continuous symptoms) were examined alone and in the following combinations: positive Phalen's and median nerve tingling and numbness; positive Tinel's and median nerve tingling and numbness; positive median nerve tingling and numbness and exacerbation when holding an object; and positive median nerve tingling and numbness and continuous tingling and numbness.

RESULTS

Data for this report were examined by right (n=715) or left (n=75) hand dominance or ambidexterity (n=43). Eighteen people did not answer a hand preference. The frequencies of tingling and numbness and abnormal nerve conduction studies (NCS) were similar in both hands, regardless of hand dominance. Twenty-eight hands had indeterminate results (9 right, 19 left). (See Table 1 for the baseline characteristics by hand dominance.)

Table 1. Prevalence of nerve conduction study abnormalities, tingling/numbness, and positive Tinel's and Phalen's tests.

Hand dominance:	Right	Left	Ambidextrous
Positive NCS			
Right	28.4%	32.%	33.5%
Left	12.3%	14.%	19.5%
Tingling and numbness			
Right	37.5%	33.%	39.5%
Left	32.3%	33.%	32.6%
Positive Tinel's			
Right	14.8%	9.3%	18.6%
Left	14.1%	13.0%	14.0%
Positive Phalen's			
Right	18.9%	10.7%	20.9%
Left	17.9%	17.3%	18.6%

Sensitivities, specificities, and positive predictive value (PPV) were lower for mild NCS results than for moderate/severe results. The following results focus on identifying and predicting workers who had moderate/severe NCS results.

Sensitivity of symptoms and provocative testing (13% positive Tinel's-83% hand pain) increased slightly in dominant hands compared to all left or right hands (25% positive Tinel's - 76% numbness and tingling). Specificity increased slightly (62% hand pain – 98% positive Tinel's combined with numbness and tingling and 98% in continuous symptoms) when analyzing dominant hands compared to all left or right hands (53% hand pain - 97% continuous symptoms). Positive predictive value for dominant hands improved: right hand 14% (hand pain) – 50% (positive Tinel's combined with numbness and tingling) and left hand 21% (hand pain) – 36% (positive Phalen's combined with numbness and tingling) compared with all right or left hands (13% positive Tinel's - 40% positive Phalen's combined with numbness and tingling).

Combining positive Tinel's or Phalen's with median root distribution numbness and tingling improved PPV in all hands, with the most improvement in the ambidextrous (14% numbness and tingling to 75% positive Phalen's combined with numbness and tingling). Combining positive Tinel's or Phalen's with median root distribution numbness and tingling did not improve sensitivity when looking at all hands, dominant or non-dominant. The sensitivity of positive Phalen's (50% right, 61% left) and Tinel's (35% right, 31% left) improved in both hands when an abnormal NCS was defined as abnormal only in the median nerve distribution when comparing all hands.

Subjects who had tingling and numbness were also considered (341 in right, 273 in left). In this group, 94 hands had mild NCS (22% right, 9.6% left) and 108 had moderate or severe NCS (20% right, 15% left). Phalen's had better sensitivity (49%-62%) than Tinel's (30%-39%). Sensitivity improved slightly when considering moderate/severe NCS results. Specificity ranged from 62%-77%. Positive predictive value worsened when considering moderate/severe NCS results (27%-68% abnormal NCS vs. 19%-38% for moderate/severe NCS).

DISCUSSION AND CONCLUSIONS

The baseline findings from this population based cohort study show poor sensitivity, high specificity, and poor positive predictive value of Tinel's and Phalen's in a large population. A combination of symptoms or signs that resulted in a reliable test combination for purposes of screening for median neuropathies was not found.

The sensitivity, specificity, and positive predictive value are increased somewhat when considering dominant hands only. This was quite unexpected since traditional teaching is that the test will have the same sensitivity and specificity regardless of the population screened since those attributes are supposedly related to the test, not the prevalence. This is in contrast with the positive and negative predictive values. However, these results found significantly different sensitivities and specificities for the right and left hands. There is uncertainty about the meaning of these findings. Random variability seems an unlikely explanation in such a large sample.

Prior Literature Synthesis

Phalen's and Tinel's signs have been used for many years for the purpose of diagnosing carpal tunnel syndrome (Phalen, 1957; Phalen, 1966; Phalen, 1970; Tetro, 1998). They also have been

relied upon for surveillance and research studies into the epidemiology of carpal tunnel syndrome (NIOSH, 1997).

Some prior clinical reports have suggested that both Phalen's and Tinel's have utility in the diagnosis of carpal tunnel syndrome. Reported sensitivities for Phalen's have ranged from 44% to 88% (Tetro, 1998; Durkan, 1991; Williams, 1992). Reported sensitivities for Tinel's have ranged from 56% to 100% (Tetro, 1998; Durkan, 1991). Yet, other reports of the positive predictive value for Phalen's (16-53%) and Tinel's (29%) were rather poor, assuming only 5% disease prevalence (Tetro, 1998), far below that of our population-based estimate. Prior reported studies evaluating this question did not include population-based ascertainment of nerve conduction study abnormalities, but were apparently clinical studies. Methods problems in prior studies include: lack of discussion regarding blinding (Durkan, 1991; Gellman, 1986; Tetro, 1998; DeKrom, 1990), lack of unequivocal case definitions (Tetro, 1998; Gellman, 1986; Durkan, 1991), lack of discussion of standardization of examinations (Gellman, 1986; Tetro, 1998; DeKrom, 1990; Durkan, 1991), lack of descriptions of the location(s) struck with a reflex hammer (Gellman, 1986; Tetro, 1998; Durkan, 1991), lack of clear descriptions of required symptoms into which digit(s) to call a Tinel's or Phalen's positive test (Gellman, 1986; Tetro, 1998; DeKrom, 1990; Durkan, 1991; Williams, 1992), lack of uniform and blinded electrodiagnostic studies (Tetro, 1998; Durkan, 1991), use of questionable control populations or lack of descriptions of controls (Tetro, 1998; Durkan, 1991), small sample sizes under 100 (Durkan, 1991; Gellman, 1986; Tetro, 1998; DeKrom, 1990; Williams, 1992), selective exclusion of those who lacked NCS abnormalities but had tingling and numbness (Tetro, 1998), exclusion of controls with tingling or numbness (Tetro, 1998), lack of nerve conduction testing in some or all potential controls (Gellman, 1986; Tetro, 1998; DeKrom, 1990), lack of an objective measure for the gold standard (Tetro, 1998; Williams, 1992), and apparent lack of standardization of force application. One study even reported using two completely different methods to assess one supposed test (manual compression vs. manometer compression) (Durkan, 1991). Thus, a rigorous assessment of the value of these commonly used clinical tools was needed.

There are many other clinical tests utilized to screen for carpal tunnel syndrome (DeKrom, 1990; Tetro, 1998). The carpal tunnel compression test has been reported as having good operant characteristics, e.g., with a sensitivity of 82% and specificity of 99% (Tetro, 1998). However, the usefulness of this maneuver has been reported in small clinic-based studies and has not apparently been assessed in large populations. Standardization of the amount of force applied over the median nerve is also not reported (Tetro, 1998). The same appears true of all other screening tests (2-point discrimination, carpal tunnel compression test with a manometer, carpal tunnel compression test with digital pressure, abductor pollicis brevis strength testing, Flick sign, thenar wasting, reverse Phalen's, tourniquet test, Luthy's sign, hypalgesia, hyperpathia), which must undergo similar rigorous testing prior to implied widespread acceptance of accuracy.

Strengths and Limitations

Strengths of the study discussed in this report include the large sample size, assessment of symptoms in all individuals, standardization of physical examinations, qualified examiners, blinding of nerve conduction studies, and specific case definitions. Limitations of this study include a limited number of individuals with severe nerve conduction studies and the lack of a

clearly standardized level of force to apply a Tinel's sign with a reflex hammer, despite the attempt to utilize the same amount of force primarily through gravity and a standardized technique. The number of strikes with a reflex hammer (potentially up to 18-24 per wrist if repeated by the second examiner), should have raised the sensitivity of the test. It is unclear whether some other maneuvers may have produced better results, such as active flexion for Phalen's, although that is not the original method (Phalen, 1957; Phalen, 1966; Phalen, 1970). There is a possibility that the results would have been different in another population, however, the number of workers in so many different employment settings limits that possibility, and in theory the test characteristics should remain the same despite changes in prevalence.

SUMMARY

The use of either Phalen's or Tinel's signs for either surveillance or diagnosis of carpal tunnel syndrome appears unsupportable. Utilizing these signs for their negative predictive value is supportable, but requires the examiner to ignore any positive findings as having significant potential to be misleading. There are differences in the sensitivity and specificity between the right and left hands that were not explained by the data.

REFERENCES

National Institute for Occupational Safety and Health. Musculoskeletal disorders and workplace factors: A critical review of epidemiologic evidence for work-related musculoskeletal disorders of the neck, upper extremity, and low back (second printing). Cincinnati, OH: US Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, 1997. DHHS (NIOSH) Publication No. 97-141

DeKrom MCT, Knipschild PG, Kester ADM, Spaans F. Efficacy of provocative tests for diagnosis of carpal tunnel syndrome. *Lancet*. 1990;335:393-5.

Durkan JA. A new diagnostic test for carpal tunnel syndrome. *J Bone Joint Surg*. 1991;73A:535-8.

Franzblau A, Werner R, Valle J, Johnston E. Workplace surveillance for carpal tunnel syndrome: a comparison of methods. *J Occup Rehab*. 1993;3:1-14.

Gellman H, Gelberman RH, Tan AM, Botte MJ. Carpal tunnel syndrome: an evaluation of the provocative diagnostic tests. *J Bone Joint Surg*. 1986;68A:735-7.

Golding DN, Rose DM, Selvarajah K. Clinical tests for carpal tunnel syndrome: an evaluation. *Br J Rheumatol*. 1986;25:388-90.

Phalen GS, Kendrick I. Compression neuropathy of the median nerve in the carpal tunnel. *JAMA*. 1957;164:524-30.

Phalen GS. Reflections on 21 years' experience with the carpal tunnel syndrome. *JAMA*. 1970;212:1365-7.

Phalen GS. The carpal tunnel syndrome. Seventeen years experience in diagnosis and treatment of six hundred and fifty-four hands. *J Bone Joint Surg* 1966;48A:211-28.

Pryse-Phillips WE. Validation of diagnostic sign in carpal tunnel syndrome. *J Neurol Neurosurg Psychiatry*. 1984;47:870-2.

Seror P. Phalen's test in the diagnosis of carpal tunnel syndrome. *J Hand Surg*. 1988;13B:383-5.

Tetro AM, Evanoff BA, Hollstien SB, Gelberman RH. A new provocative test of carpal tunnel syndrome. *J Bone Joint Surg*. 1998;80B(3):493-8.

Williams TM, MacKinnon SE, Novak CB, McCabe S, Kelly L. Verification of the pressure provocative test in carpal tunnel syndrome. *Ann Plast Surg*. 1992;29:8-11.