Published in final edited form as:

J Hand Surg Am. 2009 September ; 34(7): 1188–1192. doi:10.1016/j.jhsa.2009.04.024.

Topographical Assessment of Symptom Resolution Following Open Carpal Tunnel Release

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Abstract

Purpose—Katz et al published the only standardized scoring system of hand diagrams for the diagnosis of carpal tunnel syndrome. The purpose of this study was to quantitatively evaluate alternative scoring of the hand diagram for detection of carpal tunnel syndrome.

Methods—In a prospective study of 1107 workers from diverse industries, 221 workers with hand symptoms completed hand diagrams and electrodiagnostic testing of the median nerve screening for carpal tunnel syndrome. Scoring algorithms for the hand diagrams included Katz rating, a “Median Nerve Digit Score” (0–2) with a maximum of two symptomatic digits of thumb, index, and long, and isolated digit scores (0–1) of thumb, index, or long. Intraclass correlation coefficients quantified inter-rater reliability. Sensitivity, specificity, and logistic regression analyses evaluated scoring systems performances ability to predict abnormal median nerve conduction.

Results—110 (50%) subjects illustrated symptoms within the median nerve distribution. All scoring systems demonstrated substantial inter-rater reliability (ICC range, 0.87–0.98). “Classic” or “Probable” Katz scores, “Median Nerve Digit Score” of 2, and positive long finger scores were significantly associated with abnormal median nerve distal sensory latency (DSL) and median-ulnar difference (MUD) ($p < 0.01$). Abnormal distal motor latency (DML) was significantly ($p < 0.001$) associated with the “Median Nerve Digit Score” of 2 and positive long finger scores. Increasing Katz scores from “Possible” to “Probable” and “Classic” were not associated with greater odds of electrodiagnostic abnormality. Positive long finger scores performed at least as well as the most rigorous scoring by Katz (sensitivity and odds ratio of abnormal nerve conduction).

Conclusions—Symptoms diagramed within the median nerve distribution are associated with abnormal nerve conduction among workers. The “Median Nerve Digit Score” and the long finger score offer increased ease of use compared to the Katz method while maintaining similar

performance characteristics. The long finger appears best suited for isolated digit scoring to predict abnormal median nerve conduction among in a working population.

Keywords

carpal tunnel; resolution; surgery; symptoms; topographical

Introduction

Hand symptom diagrams are one method of active surveillance for detecting carpal tunnel syndrome among workers. Popularized by Katz and colleagues following publication in 1990, such diagrams have been utilized in clinical practice, screening of newly hired workers, and longitudinal assessment of working populations.⁽¹⁻⁴⁾ The diagrams allow subjects to illustrate the location and quality of symptoms.

Clinicians and researchers score diagrams to predict the probability of carpal tunnel syndrome. Scoring of hand diagrams for carpal tunnel syndrome has traditionally relied on the system of Katz et al.^(1, 2) The Katz scoring algorithm accounts for symptoms within the median nerve distribution, with additional symptoms outside of the median nerve innervated digits diminishing the estimated probability of carpal tunnel syndrome. Scoring in this manner is positively associated with a clinical diagnosis of carpal tunnel syndrome in patients presenting with upper extremity paresthesias and is significantly associated ($p < .05$) with abnormal nerve conduction among active workers.^(1, 3)

The purpose of this investigation was to quantify the ability of alternative hand diagram scoring algorithms to predict positive provocative physical examination maneuvers and abnormal median nerve conduction at the wrist among active workers. Our hypothesis was that scoring based solely upon symptoms within median nerve innervated digits would perform as well as the Katz method in this working population. These alternative scoring systems were created based on the premise that symptoms outside of median nerve innervated digits should not diminish assigned scores. Symptoms outside the median nerve distribution occur commonly among individuals with carpal tunnel syndrome^(1, 5) and decrease the inter-rater reliability of scoring by Katz's method.⁽⁴⁾ Additionally, based upon literature suggesting the third digit as the most sensitive for detecting carpal tunnel syndrome, we hypothesized that the long finger score would maximize association of the diagram rating with abnormal median nerve conduction.⁽⁶⁾

Methods

This investigation was performed under IRB approval granted for the ongoing Predictors of Carpal Tunnel Syndrome (PrediCTS) Study, a prospective investigation of 1107 newly hired industrial workers initiated in July 2004. Workers were recruited from 11 companies or organizations in the St. Louis, Missouri area, representing healthcare, service, managerial, and construction trade industries. Subjects were excluded for a history of carpal tunnel syndrome, peripheral neuropathy, current pregnancy, or inability to undergo nerve conduction testing. All participants provided written informed consent prior to enrollment. Baseline and 36 month assessment included a detailed demographic/work factor

questionnaire, a hand symptom diagram,⁽¹⁾ physical examination (Tinel's test over median nerve at wrist, Phalen's test) and nerve conduction tests. Nerve conduction testing was performed with an automated device (NC-Stat, NEUROMetrix, Inc, Waltham, MA). Reliability and criterion validity of this device are previously established as comparable to other methods of nerve conduction testing.^(7, 8) Abnormal median nerve conduction findings were defined in this study as a sensory latency of >3.5 ms (DSL), motor latency of >4.5ms (DML), or paired transcarpal median-ulnar sensory difference of >0.5ms (MUD).

As part of the study questionnaire, subjects completed hand symptom diagrams (Figure 1). The hand diagram was only completed if the subject reported the presence of hand symptoms defined as a positive response to the question: "In the past year, have you had recurring (repeated) symptoms in your hands, wrists, or fingers more than 3 times or lasting more than one week?" Symptoms illustrated grouped pain, numbness, tingling, and burning without differentiation among these categories. A total of 221 subjects' with completed hand diagrams were available for analysis: 141 subjects who reported hand symptoms at baseline and a separate group of subjects (n=80) who reported hand symptoms at 36 months.

Hand diagrams were reviewed by three researchers (two physicians, one occupational therapist) independently. Each reviewer scored all diagrams twice, at least 1 month apart. Diagrams were randomized for each review. Scoring was performed according to the recommendations of Katz and Stirrat⁽¹⁾ with modification including additional explicit clarification⁽³⁾ to maximize inter-rater agreement.⁽⁴⁾ Diagrams scored by this "modified Katz" system were scored as "Unlikely (0)", "Possible (1)", "Probable (2)", or "Classic (3)" for carpal tunnel syndrome (Table 1). Alternative scoring systems included the "Median Nerve Digit Score" in which diagrams were scored based upon the number of digits (thumb, index, long) with distal volar shading. In this "Median Nerve Digit Score" the presence of any palm, wrist, or dorsal symptoms were inconsequential. A "long finger" rating was determined to be positive or negative based solely on the presence or absence of distal volar shading in the long finger. Any shading outside of that location did not impact the score. Hand diagrams were also scored similarly for distal volar shading in the index finger and the thumb respectively. In all alternative scoring systems, distal volar shading was defined as shading of the volar surface of the distal phalanx and/or greater than half of the volar surface of the middle phalanx. For thumb, this required volar shading over the distal phalanx.

Statistical Analysis

Descriptive statistics were produced to summarize subject demographic data as well as the prevalence of positive provocative physical examination maneuvers and abnormal nerve conduction. Only right hand diagrams were chosen for analysis. We excluded left hand diagrams based upon previously documented significant correlation ($p<.001$) between bilateral electrodiagnostic results that prohibits analysis as independent data points in a single data set.⁽³⁾ For some analyses, hand diagram scores for the Katz system were dichotomized as positive ("Classic" or "Probable") and negative ("Possible" or "Unlikely"). For the "Median Nerve Digit Score" system, a score of 2 (2 or more digits) was considered positive and scores of 0 or 1 digit were considered negative.

Inter-rater reliability among the three raters was assessed by intraclass correlation coefficient (ICC) using a two-way mixed model for absolute agreement. Kappa values quantified intra-rater reliability – assessing consistency in scoring for each rater between reviews.

Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated to show each scoring system's (Katz, "Median Nerve Digit Score", and long finger) dichotomous performance compared to abnormal median nerve test results defined as Median DSL >3.5ms or Median DML >4.5ms or MUD >0.5ms. Chi square tests were then conducted to compare all three scoring symptoms performance for each of these three measures. Additional chi-square tests were conducted for each scoring system separately to determine the association between patient age (dichotomized at >30 years), body mass index (dichotomized at >30), race (dichotomized Caucasian versus other), gender, positive Phalen's test, and positive Tinel's test over the carpal tunnel.

Logistic regression analysis determined the predictive value of each scoring system for abnormal nerve conduction parameters using the pre-determined cut-points. We specifically evaluated the predictive ability of each Katz score to test our hypothesis that the presence of symptoms outside of the median innervated digits does not impact the probability of median nerve dysfunction. For all analyses, significance values less than 0.05 were accepted as statistically significant. Analyses were completed using the statistical software package SAS 9.2 (SAS Institute, Cary, NC), SPSS Version 17.0 (SPSS Inc., Chicago IL) and Microsoft Excel 2007 (Microsoft, Seattle, WA). Less than 10 values were missing for each nerve conduction parameter. These missing data were excluded from analyses affected.

Results

Study group characteristics are shown in Table 2. One hundred and ten (50%) subjects completing hand diagrams illustrated symptoms within the median nerve distribution and 94 of these subjects (43%) had at least one abnormal nerve conduction parameter. Table 3 presents the distribution of hand diagram ratings for each of the scoring systems. The prevalence of symptoms meeting the definition of CTS was smallest for the Katz hand diagram (26.7%), and largest for the long finger definition (43%).

Intraclass correlation coefficients demonstrated substantial inter-rater reliability for all scoring systems (range: 0.87–0.98). Inter-rater reliability slightly improved when utilizing the long finger score (ICC: 0.98; 95%CI: 0.97–0.98) or "Median Nerve Digit Score" (ICC: 0.96; 95%CI: 0.95–0.97) versus the Katz scoring (ICC: 0.87; 95%CI: 0.84–0.90). Mean kappa values of intra-rater reliability were 0.86 for Katz scoring, 0.97 for the "Median Nerve Digit Score" system, and 0.97 for long finger scores. As inter-rater and intra-rater reliability were substantial for all scoring systems and all reviewers, scores from the first review by one physician were utilized for subsequent analyses.

Table 4 presents the sensitivity, specificity, PPV, and NPV of positive scores for each rating system relative to abnormal nerve conduction results. Chi square tests revealed greater sensitivity for all abnormal nerve conduction parameters using the long finger score ($p<0.01$) compared to all other hand diagram scoring systems. Smaller and statistically non-

significant differences ($p>0.05$) were demonstrated between the three scoring systems and specificity, PPV, and NPV of abnormal nerve conduction results. All scoring systems were significantly associated with a positive Phalen's test ($p<0.05$), but not with age, BMI, gender, race, or positive Tinel's test.

The odds ratio (OR) of abnormal nerve conduction values based on hand diagram scores are presented in Table 5. All scoring system parameters, except thumb, were found to be significant predictors of abnormal nerve conduction with the long finger providing the highest OR of 5.3 (95% CI: 2.9–9.7). Increasing Katz scores from "Possible" to "Probable" or "Classic" was not associated with greater odds of abnormal nerve conduction.

Discussion

Our findings indicate that the scoring of hand diagrams solely based on symptoms of one or two digits within the median nerve distribution in a population of working subjects can yield results that are similar to results obtained using the approach of Katz et al.⁽¹⁾ Such scoring maximizes inter- and intra-rater reliability, minimizes time required for scoring, and predicts abnormal nerve conduction parameters when screening for carpal tunnel syndrome similar to Katz's scoring method.

The original scoring system of the self-administered hand diagram for the diagnosis of carpal tunnel syndrome by Katz and Stirrat⁽¹⁾ considers symptoms within and outside of the median nerve distribution. The presence of symptoms outside of the thumb, index, and long digits downgrades the estimated probability of carpal tunnel syndrome. In Katz's series of patients evaluated for upper extremity paresthesia (88% prevalence of clinically diagnosed carpal tunnel syndrome), 42 of 75 patients with carpal tunnel syndrome were rated as "Probable" or "Possible" compared to 32 patients with "Classic" diagrams (1 patient had "Unlikely" diagram). This suggests that the predominance of carpal tunnel syndrome patients presented with extra-median nerve symptoms and is consistent with the 55% prevalence reported by Stevens et al.⁽⁹⁾ The series by Katz and Stirrat as well as another by Elfar et al.⁽⁵⁾ document that patients with clinically diagnosed carpal tunnel syndrome nearly universally diagram symptoms in the median nerve innervated digits along with a preponderance of extra-median symptoms. In a similar fashion, our study found symptoms outside of the median nerve distribution were common among workers with abnormal median nerve conduction values. The odds of having abnormal median nerve conduction remained nearly identical for hand diagrams scored as "Possible", "Probable", and "Classic" according to Katz criteria. Thus, in our population sample of active workers, scoring based on the presence of extra-median symptoms (used to differentiate these ratings) failed to improve the diagram's performance in predicting nerve conduction abnormalities in this population.

The sensitivity and specificity of hand diagram scores in predicting median nerve conduction abnormalities in a cohort of workers was lower than that reported by Katz (sensitivity:80%, specificity:90%).⁽¹⁾ This discrepancy is likely attributable to the populations from which study cohorts were drawn. Existing literature demonstrates greater predictive ability of hand diagrams for the clinical diagnosis of carpal tunnel syndrome and

nerve conduction abnormalities in clinic based studies.^(1, 10, 11) It is likely that those seeking medical care are different from active workers who are symptomatic yet may not be seeking treatment. Those presenting to medical professionals with upper extremity paresthesia might be more likely to have a higher prevalence of electrodiagnostic abnormalities and more advanced degrees of nerve compression. Differences in the prevalence of electrodiagnostic abnormalities do not directly affect estimates of sensitivity and specificity but do alter the positive predictive values which would require normalization of disease prevalence for comparison between studies. Alternatively, the act of seeking care may bias physicians scoring the hand diagrams.⁽⁴⁾ Potentially the result of several factors, hand diagrams have demonstrated poorer predictive performance in population studies.^(12–14)

There is no consensus digit identified as the most sensitive for detecting carpal tunnel syndrome. Although the index finger is commonly utilized to record median sensory data, different investigators have supported isolated testing of the thumb,⁽¹⁵⁾ long,^(6, 16, 17) and ring fingers^(18, 19) as the most sensitive digital location. Comparing the predictive ability of single digit scoring on the hand diagram in our study showed that the long finger outperformed the index and thumb in its association with abnormal nerve conduction measurements. The specificity of these digits was similar but the long finger demonstrated superior sensitivity. This is in accord with the findings of Elfar et al⁽⁶⁾ who found that the long finger was subjectively the “worst” digit among patients with clinical and electrodiagnostically diagnosed carpal tunnel syndrome. Although our population cannot be assumed to have carpal tunnel syndrome, it appears that those workers with abnormal median nerve conduction parameters were more likely to diagram symptoms in the long finger than the index or thumb. Thus, the long finger with greater sensitivity appears particularly well suited to serve as a single digit for evaluation during a first stage screening for carpal tunnel syndrome in population studies.

The high inter- and intra-rater reliabilities documented in this study are consistent with prior investigations.^(1, 3, 4) This suggests that the scoring of hand diagrams in subsequent investigations can be reasonably performed once by a single experienced investigator. Multiple blinded ratings and duplicative ratings by additional investigators are expected to minimally impact hand diagram scores. Dale et al suggested that rater disagreement likely was related to consideration of extra-median nerve symptoms.⁽⁴⁾ Our data demonstrated improved reliability when only scoring symptoms within the thumb, index, and long fingers. However, reliability measures are also expected to improve when classification or grading algorithms are simpler with fewer number of potential categories.

There are several limitations inherent to this study. Only, active workers without medically diagnosed nerve compression were enrolled in this study. Therefore, hand diagrams could not be evaluated against a true “gold standard” of subjects clinically diagnosed with, and subsequently successfully treated for carpal tunnel syndrome. We instead have inferred accuracy in screening for carpal tunnel syndrome based upon comparisons to nerve conduction testing and provocative physical examination maneuvers. Some patients will have nerve conduction results that fail to coincide with their clinical presentation. Our results are not presumed to be generalizable to either patients with carpal tunnel syndrome or those seeking medical care for upper extremity nerve complaints. When determining

inter-rater reliability among individuals who routinely score such diagrams, we expect that our results represent a best case scenario and that there may be more discordant scores produced when raters are less experienced.

Hand diagram scores suggestive of carpal tunnel syndrome are associated with abnormal median nerve conduction velocities among active workers. Scoring of hand diagrams in the general population without consideration of symptoms outside of the median nerve distribution maintains the performance characteristics of the Katz scoring system while increasing the ease of use. We believe that the use of simpler scoring algorithms will aid in epidemiologic studies where notable time and effort are required to collect and score hand diagrams.

References

1. Katz JN, Stirrat CR. A self-administered hand diagram for the diagnosis of carpal tunnel syndrome. *J Hand Surg Am.* 1990; 15:360–363. [PubMed: 2324471]
2. Katz JN, Stirrat CR, Larson MG, Fossel AH, Eaton HM, Liang MH. A self-administered hand symptom diagram for the diagnosis and epidemiologic study of carpal tunnel syndrome. *J Rheumatol.* 1990; 17:1495–1498. [PubMed: 2273490]
3. Franzblau A, Werner R, Albers J, Grant C, Olinski D, Johnston E. Workplace surveillance for carpal tunnel syndrome using hand diagrams. *Journal of Occupational Rehabilitation.* 1994; 4:185–198. [PubMed: 24234506]
4. Dale AM, Strickland J, Symanzik J, Franzblau A, Evanoff B. Reliability of hand diagrams for the epidemiologic case definition of carpal tunnel syndrome. *J Occup Rehabil.* 2008; 18:233–248. [PubMed: 18521726]
5. Elfar JC, Calfee RP, Stern PJ. Topographical assessment of symptom resolution following open carpal tunnel release. *J Hand Surg Am.* 2009; 34:1188–1192. [PubMed: 19643551]
6. Elfar JC, Yaseen Z, Stern PJ, Kieffhaber TR. Individual finger sensibility in carpal tunnel syndrome. *J Hand Surg Am.* 2010; 35:1807–1812. [PubMed: 21050964]
7. Kong X, Gozani SN, Hayes MT, Weinberg DH. NC-stat sensory nerve conduction studies in the median and ulnar nerves of symptomatic patients. *Clin Neurophysiol.* 2006; 117:405–413. [PubMed: 16403673]
8. Armstrong TN, Dale AM, Al-Lozi MT, Franzblau A, Evanoff BA. Median and ulnar nerve conduction studies at the wrist: criterion validity of the NC-stat automated device. *J Occup Environ Med.* 2008; 50:758–764. [PubMed: 18617831]
9. Stevens JC, Smith BE, Weaver AL, Bosch EP, Deen HG Jr, Wilkens JA. Symptoms of 100 patients with electromyographically verified carpal tunnel syndrome. *Muscle Nerve.* 1999; 22:1448–1456. [PubMed: 10487914]
10. Szabo RM, Slater RR Jr, Farver TB, Stanton DB, Sharman WK. The value of diagnostic testing in carpal tunnel syndrome. *J Hand Surg Am.* 1999; 24:704–714. [PubMed: 10447161]
11. Katz JN, Lew RA, Bessette L, Punnett L, Fossel AH, Mooney N, et al. Prevalence and predictors of long-term work disability due to carpal tunnel syndrome. *Am J Ind Med.* 1998; 33:543–550. [PubMed: 9582945]
12. Homan MM, Franzblau A, Werner RA, Albers JW, Armstrong TJ, Bromberg MB. Agreement between symptom surveys, physical examination procedures and electrodiagnostic findings for the carpal tunnel syndrome. *Scand J Work Environ Health.* 1999; 25:115–124. [PubMed: 10360466]
13. Ferry S, Silman AJ, Pritchard T, Keenan J, Croft P. The association between different patterns of hand symptoms and objective evidence of median nerve compression: a community-based survey. *Arthritis Rheum.* 1998; 41:720–724. [PubMed: 9550482]
14. Walker-Bone KE, Palmer KT, Reading I, Cooper C. Criteria for assessing pain and nonarticular soft-tissue rheumatic disorders of the neck and upper limb. *Semin Arthritis Rheum.* 2003; 33:168–184. [PubMed: 14671727]

15. Kothari MJ, Rutkove SB, Caress JB, Hinchey J, Logigian EL, Preston DC. Comparison of digital sensory studies in patients with carpal tunnel syndrome. *Muscle Nerve*. 1995; 18:1272–1276. [PubMed: 7565924]
16. Padua L, Lo Monaco M, Valente EM, Tonali PA. A useful electrophysiologic parameter for diagnosis of carpal tunnel syndrome. *Muscle Nerve*. 1996; 19:48–53. [PubMed: 8538669]
17. Macdonell RA, Schwartz MS, Swash M. Carpal tunnel syndrome: which finger should be tested? An analysis of sensory conduction in digital branches of the median nerve. *Muscle Nerve*. 1990; 13:601–606. [PubMed: 2388658]
18. Terzis S, Paschalis C, Metallinos IC, Papapetropoulos T. Early diagnosis of carpal tunnel syndrome: comparison of sensory conduction studies of four fingers. *Muscle Nerve*. 1998; 21:1543–1545. [PubMed: 9771684]
19. Valls J, Llanas JM. Orthodromic study of the sensory fibers innervating the fourth finger. *Muscle Nerve*. 1988; 11:546–552. [PubMed: 3386663]

	RIGHT WRIST	LEFT WRIST	RIGHT HAND	LEFT HAND	RIGHT FINGERS	LEFT FINGERS
Burning/ Pain	O	O	O	O	O	O
Tightness/ Stiffness	O	O	O	O	O	O
Soreness/ Cramping/ Aching	O	O	O	O	O	O
Numbness/ Tingling	O	O	O	O	O	O

Please show on the diagram below where you have experienced numbness, tingling, burning, or pain by shading in the problem area.

Figure 1.

Hand Diagram

Please describe the location and type of symptoms you are having by marking the responses below, where appropriate. Mark as many responses as necessary. *For example, if you are experiencing stiffness and cramping in your right fingers, mark those two responses under “right fingers.”*

Table 1

Preoperative Complaints

Symptom	Zone 1		Zone 2		Zone 3		Zone 4		Zone 5	
	#	%	#	%	#	%	#	%	#	%
Pain	28	70	6	15	13	33	5	13	9	23
Numbness	40	100	19	48	7	18	0	0	5	13
Tingling	37	93	19	48	10	25	1	3	7	18
Strange (Electric/Burning)	15	38	3	8	3	8	1	3	2	5
Total Complaints	120		47		33		7		23	

Table 2

Postoperative Complaints

Symptom	Zone 1		Zone 2		Zone 3		Zone 4		Zone 5	
	#	%	#	%	#	%	#	%	#	%
Pain	5	13	0	0	1	3	1	3	0	0
Numbness	5	13	1	3	0	0	0	0	0	0
Tingling	5	13	1	3	0	0	0	0	0	0
Strange (Electric/Burning)	1	3	0	0	0	0	0	0	0	0
Total Complaints	16		2		1		1		0	

Table 3

Probability of resolution of each symptom type by zone after surgery.

Symptom	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
Pain	0.82	1.00	0.92	0.80	1.00
Numbness	0.88	0.95	1.00	n/a	1.00
Tingling	0.86	0.95	1.00	1.00	1.00
Strange	0.93	1.00	1.00	1.00	1.00