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Scratch Collapse Test for Carpal Tunnel Syndrome: A Systematic Review and Meta-analysis

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Background: Despite the fact that carpal tunnel syndrome (CTS) is the most common entrapment neuropathy, the diagnostic accuracy of clinical screening examinations for CTS is controversial. The scratch collapse test (SCT) is a novel test that may be of diagnostic advantage. The purpose of our study was to determine the diagnostic accuracy of the SCT for CTS.
Methods: A literature search was performed using PubMed (1966 to April 2018); Ovid MEDLINE (1966 to April 2018); EMBASE (1988 to April 2018); and Cochrane Central Register of Controlled Trials (The Cochrane Library, to April 2018). We examined the studies for the pooled sensitivity, specificity, and likelihood ratios of the SCT. This review has been registered with PROSPERO (CRD42018077115).
Results: The literature search generated 13 unique articles. Seven articles were included for full text screening and 3 articles met our inclusion criteria, all of which were level II evidence with low risk of bias (165 patients). Pooled sensitivities, specificities, positive likelihood ratio, and negative likelihood ratios were 0.32 [95% CI (0.24–0.41)], 0.62 [95% CI (0.45–0.78)], 0.75 [95% CI (0.33–1.67)], and 1.03 [95% CI (0.61–1.74)], respectively. The calculated area under the summary receiver operating characteristic (AUSROC) curve was 0.25, indicating a low diagnostic accuracy.
Conclusion: The SCT has poor sensitivity; however, it is moderately specific. Based on the current literature and their variable quality of the evidence, we conclude that the SCT is not an adequate screening test for detecting CTS. *(Plast Reconstr Surg Glob Open 2018;6:e1933; doi: 10.1097/GOX.0000000000001933; Published online 14 September 2018.)*

INTRODUCTION

The diagnostic accuracy of clinical screening examinations for carpal tunnel syndrome (CTS) is controversial. Despite it being the most common compression neuropathy, common clinical tests such as Tinel's sign, Phalen's manoeuvre, and Durkan's test have variable sensitivity and specificity.[1–5] Self-reported questionnaires, such as the 6-item carpal tunnel symptoms scale (CTS-6), have been reported to have higher diagnostic accuracy, but still remain insufficient to make a definitive diagnosis of CTS. Ultrasonography is another diagnostic tool that is gaining popularity and has demonstrated promising results, but it still remains in its nascent stage.[6–8] The current gold standard to diagnose CTS is the electromyography (EMG). However, up to 16–34% of affected patients can still be missed, creating false negatives.[9] In patients with suspected CTS and ambivalent test results, there remains a clinical equipoise on treatment.

The scratch collapse test (SCT) is a novel test that may be of diagnostic advantage to identify nerve compression when the diagnosis is unclear. Originally developed by Susan Mackinnon, it is performed by applying a stimulus over an area of nerve compression while the patient is exerting bilateral external shoulder rotation.[24] A positive test is noted if there is transient loss of muscle resistance resulting in the arm collapsing, thus, coining the term of this provocative test "the scratch collapse test." This concept can also be applied to other nerve compression syndromes. Mackinnon has demonstrated diagnostic utility for ulnar nerve entrapment in cubital syndrome[10,11] and peroneal nerve compression.[12] Since its inception, several refinements have been suggested by the creator, such as the addition of ethyl chloride spray to assist in detecting multiple levels of nerve compression, which are outlined in detail by Kahn et al.[13]

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Current theories postulate that the findings of the SCT are explained by the cutaneous silent period (CuSP).[14–16] The CuSP has been described since 1919 by Hoffman, who defined it as a transient decrease in EMG activity during voluntary contraction resulting from a noxious stimulus to a cutaneous nerve. Although the precise mechanism has not been elucidated, the work of Hoffman has been expanded to demonstrate that irritation to small diameter A-δ nerve fibers evoke a spinal inhibitory reflex and may explain the etiology underlying the phenomenon.[15]

The purpose of our study was to determine the diagnostic accuracy of the SCT in patients with CTS, using EMG as the reference standard, by summarizing the current literature.

METHODS

Search Strategy and Study Selection

The review was reported in concordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidance (Fig. 1). A literature search was performed using PubMed (1966 to April 2018); Ovid MEDLINE (1966 to April 2018); EMBASE (1988 to April 2018); and Cochrane Central Register of Controlled Trials (The Cochrane Library, to April 2018) databases by 2 independent reviewers (M.H. and A.K.). The original search terms included "scratch collapse test" and "carpal tunnel syndrome" or "median nerve entrapment"; however, articles were missed with these search terms; therefore, the authors performed a broader search using only "scratch collapse test" to ensure articles were not overlooked. We included all full text articles, which evaluated the use of the SCT to diagnose CTS in patients of all ages. Electrodiagnostic studies were used as the reference standard for the diagnosis of CTS. Articles were excluded if they used the SCT for other nerve entrapment syndromes, were not primary research articles, or the data could not be extracted. Our outcomes of interest were sensitivity, specificity, and likelihood ratios of the SCT, when applicable. The language of publication was restricted to English and French. This review has been registered with PROSPERO (CRD42018077115).

Data Extraction and Quality Assessment

Data from the included articles were independently extracted in duplicate by 2 reviewers (M.H. and A.K.) using a predefined, standardized data collection instrument. Any disagreements were resolved by discussion to reach a consensus. Extracted data included the true positive, false positive, true negative, and false negative rates for the SCT in diagnosing EMG-confirmed CTS.

Two reviewers (M.H. and A.K.) independently assessed the studies for risk of bias and applicability of the study methodology. For each article, the Quality Assessment Tool for Diagnostic Accuracy Studies tool was used to assess the risk of bias and concerns regarding applicability

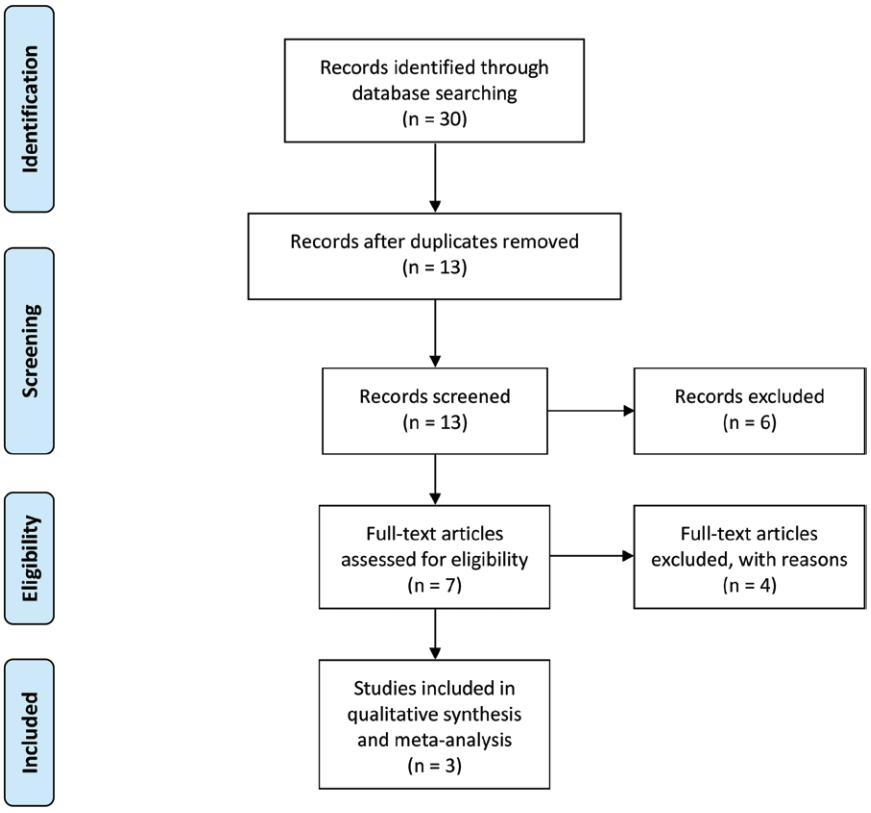

Fig. 1. Flowchart of study inclusion using Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines.

of the studies in 4 key domains: (1) patient selection; (2) index test; (3) reference standard; and (4) flow and timing. For each domain, a rating of low, high, or unclear was given for both risk of bias and concerns regarding applicability. Disagreement between reviewers were resolved through consensus.

Statistical Analysis

We calculated pooled estimates of sensitivity, specificity, positive and negative likelihood ratios by the DerSimonian-Laird random-effects model. Each study was weighted by the inverse variance with 95% confidence intervals (CI). Statistical heterogeneity was analyzed by means of the I^2 statistic and an I^2 value greater than 50% indicated substantial heterogeneity.

The diagnostic performance of each test was assessed by constructing summary receiver operator characteristic (SROC) curves to summarize study results by the use of Moses' constant for linear regression models. In this method, the true-positive and false-positive rates of each study were logarithmically transformed and calculated in a regression model. The SROC model is described by the equation: $D = a + bS$, where D is the log of the diagnostic odds ratio and S is a measure of the diagnostic threshold. Estimation of the variables a and b was done using a least-squares method, weighted by inverse variance. The regression line was back-transformed to the ROC space. Analyses were performed using Microsoft Excel (2013) and MetaDiSc Version 1.4 for Windows (Hospital Ramón y Cajal, Madrid, Spain).

RESULTS

The literature search generated 13 unique articles. In total, 7 articles were included for full text screening. We identified 3 articles that met our inclusion criteria, all of which were level II evidence, according to the American Society of Plastic Surgeons Rating Levels of Evidence and Grading Recommendations, with low risk of bias (Tables 1, 2). In total, 165 patients were included in the meta-analysis. Pooled sensitivities, specificities, positive likelihood ratio, and negative likelihood ratios were 0.32 [95% CI (0.24–0.41)], 0.62 [95% CI (0.45–0.78)], 0.75 [95% CI (0.33–1.67)], and 1.03 [95% CI (0.61–1.74)], respectively (Fig. 2). The I^2 values were nonheterogeneous for sensitivity (0%) and substantially heterogeneous for the specificity (74%), positive likelihood ratio (51.5%), and negative likelihood ratios (74.4%); however, due to the small sample size, it was not feasible to explore the cause of heterogeneity. The calculated area under the curve was 0.25, indicating a low diagnostic accuracy (Fig. 3).

DISCUSSION

Our results demonstrate that the SCT is not a useful diagnostic tool for the assessment of CTS. By extension, the utility of the SCT in identifying other nerve compression syndromes is dubious. The mechanism of action is postulated to result from the CuSP; however, results from studies examining the CuSP for CTS is ambivalent. Aurora et al.[20] originally demonstrated that the cutaneous silent period was prolonged in patients with CTS, while the CuSP was absent in severe CTS. Kofler et al.,[21] Koo et al.,[22] and Svilpauskatie et al.,[23] have performed similar studies examining the CuSP with conflicting results. For instance, Koo et al.[22] reproduced the exact opposite results from the study by Aurora et al.[20] Koo et al.[22] found that the mean CuSP duration in CTS patients was not significantly different from the control group in their cohort, and all the patients had a CuSP regardless of the severity of their CTS. Moreover, the studies applied nociceptive stimuli to the D2 and D5 of the hand with miraculous and disputable inhibitory effects to the abductor pollicis brevis muscle. Aurora et al.[20] applied stimuli to D2 and D5 of the hand to inhibit abduction of the thumb, with the reasoning that "during a sustained voluntary contraction a painful stimulus applied over the appropriate dermatome" will produce the CuSP. It is unclear how stimulation of a dermatome on the fifth digit would affect the motor potential of the abductor pol-

Table 1. Characteristics of All Included Studies

Reference	Study Design	Patient Number (n)	Sensitivity (95% CI)	Specificity (95% CI)	Positive Likelihood Ratio (95% CI)	Negative Likelihood Ratio (95% CI)
Blok et al.[17]	Prospective study	37	0.32 (0.17–0.51)	1.00 (0.54–1.00)	4.59 (0.30–69.50)	0.72 (0.53–0.99)
Makanji et al.[18]	Prospective study	88	0.34 (0.23–0.47)	0.61 (0.39–0.80)	0.86 (0.47–1.60)	1.09 (0.75–1.57)
Simon et al.[19]	Prospective study	40	0.28 (0.14–0.47)	0.38 (0.09–0.76)	0.45 (0.21–0.97)	1.92 (0.76–4.81)

Table 2. QUADAS-2 Results for the Risk of Bias

Study	Risk of Bias				Applicability Concerns		
	Patient Selection	Index Test	Reference Standard	Flow and Timing	Patient Selection	Index Test	Reference Standard
Blok et al.[17]	☺	☺	☺	☹	☺	☺	☺
Makanji et al.[18]	☺	?	☺	?	☺	☺	☺
Simon et al.[19]	☺	☺	☺	☺	☺	☺	☺

☺ Low risk ☹ High risk ? Unclear risk.
QUADAS-2, Quality Assessment Tool for Diagnostic Accuracy Studies.

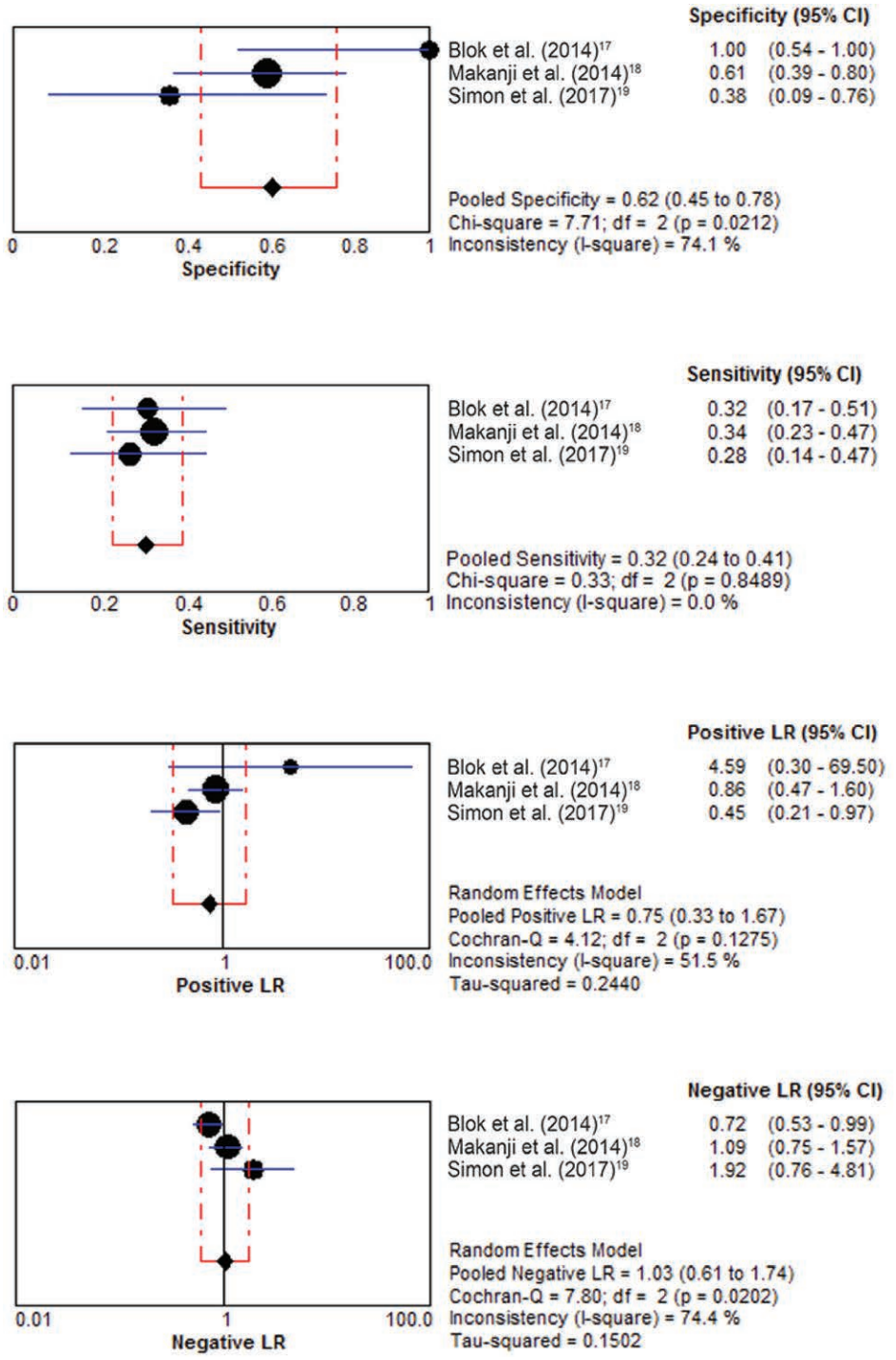

Fig. 2. Pooled estimates of sensitivity, specificity, and likelihood ratios for the diagnostic accuracy of the SCT for CTS.

licis brevis of the thumb as they are based off of 2 different peripheral nerves, the ulnar and median nerve, respectively. Uncini et al.[14] demonstrated in their study that the CuSP phenomenon can affect completely unrelated different nerve roots. For example, they produced the CuSP in the opponens pollicis, abductor digiti minimi, flexor carpi ulnaris, extensor carpi radialis, biceps brachialis, tibialis anterior, gastrocnemius lateralis, orbicularis oculi, and masseter simply from finger stimuli alone.[14] Clearly, there is a body of literature demonstrating that noxious stimulation of cutaneous nerves can induce a silent period across various nerve roots and peripheral nerves that seem to contradict fundamental anatomical constraints. However, even though the CuSP may be a testable and reproducible phenomenon using EMG, it does not seem clinically transferable. A normal CuSP is approximately 50 ms, with

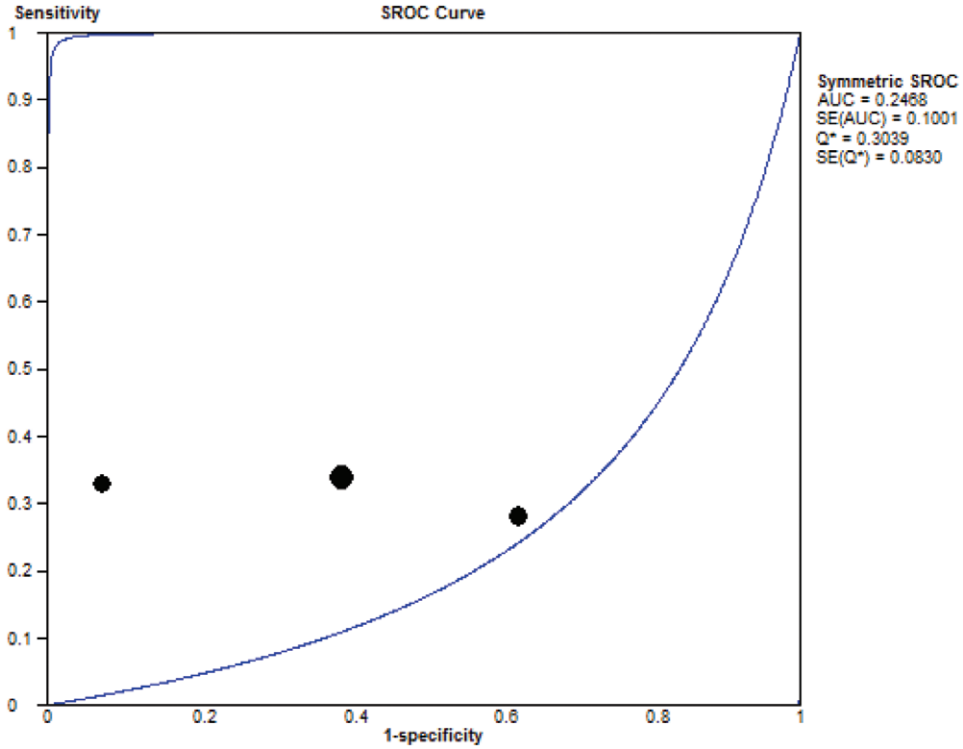

Fig. 3. SROC curve representing the diagnostic accuracy of the SCT for CTS. Solid circles represent each study included in the meta-analysis. The size of each solid circle indicates the size of each study. The regression SROC curve summarizes the overall diagnostic accuracy.

a prolonged CuSP often reported around 100 ms. A loss of voluntary muscle contraction for 100 ms would not be perceivable by a human examiner. Additionally, the time to administer the noxious stimulus and then apply resistance in the SCT would take longer than 100 ms, precluding the CuSP from being an adequate explanation for its mechanism of action.

The body of literature on the scratch collapse has previously shown promising results in identifying CTS and other nerve compression syndromes; however, there are concerns regarding confirmation bias. The test interpretation is subjective, which can allow the observer to falsely perceive positive results if they are not blinded. Positive results of the SCT were only seen in a small number of studies by few researchers. The original study by Cheng et al.[24] reported sensitivity and specificity of 69% and 99%; however, their study was not included in our analysis as we were unable to extract the data. Since its publication, Mackinnon has published several other articles with similar results using the SCT for cubital tunnel syndrome,[10] multilevel ulnar nerve compression detection,[11] and peroneal nerve compression.[12] Several other authors have also reported positive findings with the SCT. Sollero and Maranhão-Filho[25] demonstrated a positive SCT in EMG-confirmed CTS when other clinical examinations were unremarkable. Pinder and Ng[26] similarly reported a positive SCT with EMG-confirmed long thoracic nerve compression. Both these studies, however, were case reports on a single patient. Hagert[27] and Hagert and Hagert[28] have also performed studies to demonstrate the clinical utility of the SCT in proximal median nerve entrapment. However, none of the studies examined the efficacy of the SCT, as the data on the sensitivity and specificity were not published or collected. Hagert only used the SCT as one of 3 criteria to operate on suspected proximal median nerve entrapment; the study did not examine the diagnostic accuracy of the SCT. Jiménez and Delgado[29] are the only other authors besides Mackinnon who has demonstrated positive results with the SCT. They demonstrated a 100% sensitivity and specificity with the SCT for diagnosis of proximal median nerve entrapment on 3 consecutive visits before their operation and a negative SCT 5–7 days after their operation. Conversely, our results demonstrate the studies that compared the SCT to a reference standard, the EMG, unlike in proximal nerve entrapment where there is no diagnostic standard. Therefore, we conclude that the SCT would not be a diagnostically useful test for CTS. Furthermore, its diagnostic utility in other nerve compression syndromes is suspicious as there are no other studies, besides that of Jiménez and Delgado[29] and the creator of the SCT, that have reported positive findings with the test.

Risk of Bias

The study by Blok et al.[17] received a rating of low concerns regarding applicability for all domains and low risk of bias for all domains except for a rating of unclear for "flow and timing," because not all patients received the reference standard diagnostic test. The study by Makanji et al.[18] received a rating of low concerns regarding applicability for all domains, but had unclear risk of bias for "index test" and

"flow and timing." It was not clarified whether the index test (SCT) results were interpreted without knowledge of the reference test results and why 7 patients never underwent EMG testing and had to be excluded. The study by Simon et al.[19] received a rating of low concerns regarding applicability and low risk of bias for all domains.

Limitations

Limitations of our review are the heterogeneity in the methodology and data reported by the authors. For example, there was variability in who performed the SCT, ranging from staff physicians, residents, or allied health professionals. However, they were all prospective studies with similar methodology, and the SCT was always compared with a known diagnostic standard, the EMG. Therefore, the heterogeneity of the studies should not invalidate our findings. Another limitation of our review is the low number of studies included in the meta-analysis, which may simply have led to heterogeneity in the results due to inadequate power. If more studies are included in future reviews, it is possible that the results may be different than ours and have greater statistical significance.

CONCLUSIONS

We demonstrated that the SCT has poor sensitivity (pooled value of 0.32 with no heterogeneity) and moderate specificity (pooled value of 0.61 with significant heterogeneity). Additionally, the current body of literature exhibits a heap of contradictory information regarding the accuracy and underlying pathophysiology of the SCT with regard to CTS. This ambiguity, along with our statistical findings, allow us to conclude that the SCT is an inappropriate screening test to detect for CTS.

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