

8-1-2017

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### Recommended Citation

Tulipan, Jacob E; Lutsky, Kevin F F.; Maltenfort, Mitchell G.; Freedman, Mitchell K.; and Beredjiklian, Pedro, "Patient-Reported Disability Measures Do Not Correlate with Electrodiagnostic Severity in Carpal Tunnel Syndrome." (2017). *Department of Orthopaedic Surgery Faculty Papers*. Paper 102.

<https://jdc.jefferson.edu/orthofp/102>

# Patient-Reported Disability Measures Do Not Correlate with Electrodiagnostic Severity in Carpal Tunnel Syndrome

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**Background:** Electrophysiologic studies including electromyography and nerve conduction studies play a role in the evaluation of carpal tunnel syndrome (CTS), despite evidence that these studies do not correlate with CTS-specific symptom scores. There is a lack of evidence comparing electrophysiologic data with general measures of function.

**Methods:** Fifty patients presenting for CTS treatment over an 8-month period were analyzed retrospectively. All patients completed surveys including the Quick Disabilities of the Arm, Shoulder, and Hand questionnaire (DASH) and the Medical Outcomes Study 12-Item Short-Form Survey [(physical component summary 12, mental component summary (MCS-12)]. Electromyography and nerve conduction studies were performed on all patients and compared with outcome scores.

**Results:** Analysis demonstrated no relationship between DASH or MCS-12 and electrodiagnostic severity. No significant correlations were noted between DASH or MCS-12 and median motor or sensory latency. There was a moderate-weak correlation ( $\rho = 0.34$ ) between more severe electrophysiologic grade and better function based on physical component summary 12.

**Conclusions:** Electrodiagnostic severity grades do not correlate with patient-reported disability, including the DASH and MCS-12 surveys. There is a counterintuitive correlation between more-severe electrodiagnostic findings and decreased physical disability. These findings indicate that disability may not correlate with electrodiagnostic severity of median neuropathy in CTS. (*Plast Reconstr Surg Glob Open* 2017;5:e1440; doi: 10.1097/GOX.0000000000001440; Published online 11 August 2017.)

## INTRODUCTION

Although history and physical alone can be sufficient to diagnose carpal tunnel syndrome (CTS), electrophysiologic studies including electromyography and nerve conduction studies (EMG/NCS) continue to play an important role in the evaluation of this condition.<sup>1-3</sup> Electrodiagnostic findings have been compared with a number of specific symptom scoring tools, including the CTS Assessment Questionnaire,<sup>4,5</sup> CTS-6 scale,<sup>6</sup> and the McGill pain questionnaire.<sup>7</sup>

The 12-item Short Form Health Survey (SF-12) is a general measure of physical and mental health function used for monitoring of chronic conditions. We chose to use the SF-12 score because it is reflective of a more general assessment of the impact of a patient's condition on their overall health and well-being.<sup>8</sup> It allows calculation of a physical component summary (PCS-12) and mental component summary (MCS-12) to evaluate patient health along these axes.<sup>9</sup> Questions are more broadly focused on patients' experience of their general daily function. This instrument allows researchers to capture nonspecific symptoms and patient experience more broadly than more specific scores like DASH. Furthermore, it allows evaluation of the mental component of patient health, which plays a clear role in patient disability. The purpose of the present study was to assess the relationship between English-language patient-reported functional scores and EMG/NCS findings in patients with CTS. We hypothesize that electrodiagnostic findings in patients with CTS do not correlate with patient-reported functional disability as measured by validated outcome surveys.

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Received for publication April 19, 2017; accepted June 14, 2017.

Presented in E-Poster format at the ASSH annual meeting 2016, Austin, Tex.

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DOI: 10.1097/GOX.0000000000001440

**Disclosure:** The authors have no financial interest to declare in relation to the content of this article. The Article Processing Charge was paid for by the authors.

## METHODS

Our institutional review board approved this cross-sectional study protocol. We retrospectively analyzed patients with a diagnosis of CTS who presented for treatment to our group of fellowship-trained, orthopedic hand surgeons between April and December 2015. The study size was set at 50 patients based on a preliminary power analysis. The diagnosis was based on clinical history, physical examination, and EMG/NCS evaluation. Inclusion criteria consisted of EMG/NCS performed within 3 months of presentation. Patients with trauma-related onset of symptoms, previous surgery for CTS, patients with negative electrodiagnostic studies, and those with concomitant upper extremity compression neuropathies were excluded from the study.

Patient age and gender were recorded. All patients completed self-reported health and disability scores, including the Quick Disabilities of the Arm, Shoulder, and Hand questionnaire (DASH) and the Medical Outcomes Study 12-Item SF-12. Although the DASH scores are inversely proportional to functional status (a lower score reflects higher function), the SF-12 [physical (PCS-12) and mental (MCS-12) spheres] are directly proportional to function.

Electrodiagnostic studies were the reference standard for the diagnosis of CTS, consisted of nerve conduction studies and electromyography. The studies were performed by Physical Medicine and Rehabilitation specialists in our group according to the guidelines of the American Association of Neuromuscular and Electrodiagnostic Medicine.<sup>10,11</sup> All the electromyographers have agreed on the basic protocols used to assess CTS and are part of a laboratory, which is certified by the American Association of Neuromuscular and Electrodiagnostic Medicine. EMG and NCS were performed on all patients in conjunction with a history and physical. Temperature of the upper extremity was maintained at 32 degrees Celsius. Temperatures lower than 32 degrees can result in prolonged distal latency of motor and sensory studies and slowing of conduction velocities.<sup>12</sup>

NCS consisted of evaluation of median and ulnar motor and sensory nerves in the symptomatic upper extremity and compared findings with absolute normal values and relative values between the contralateral median nerve and ipsilateral ulnar nerve. Median and ulnar sensory nerve action potentials were obtained by stimulating the nerve in the forearm 14 cm proximal to the “active” electrode, which picks up the electrical impulse at the base of the index finger and the proximal interphalangeal joint of the small finger, respectively. Motor nerve action potentials were achieved by stimulating the median nerve 8 cm proximal to the “active” electrode, which is over the midpoint of the abductor pollicis brevis and the ulnar nerve 8 cm proximal to the abductor digiti minimi. Transcarpal studies are very sensitive studies that are used to diagnose subtle CTS in patients with convincing symptoms who did not have abnormal electrical findings with conventional motor and sensory studies. Transcarpal studies are mixed sensory-motor studies that involve stimulation over the midpalm and recording from the active electrode, which is 8 cm proximal to the midpalm the ulnar and median

nerves. The time that it takes to travel from the stimulating electrode to the active electrode is called the distal latency. The size of the electrical potential is called the amplitude.

Needle examination was routinely performed on a sampling of muscles that are innervated by the C5–T1 nerve roots, brachial plexus, and peripheral nerves of the upper extremity. Muscle screen standardly included biceps, pronator teres, triceps, abductor pollicis brevis, first dorsal interosseous, and if radiculopathy was suspected, the cervical paraspinal musculature was also evaluated. Each muscle was evaluated for spontaneous electrical potentials (positive waves, fibrillations). The degree of spontaneous activity was graded between 0 and 4. Submaximal and maximal contraction of the musculature were performed to evaluate patients for polyphasicity, size of the electrical potentials, and repetitive firing that are indicators of chronicity and severity of injury.

Distal sensory latencies greater than 3.6 ms and/or distal motor latencies greater than 4.4 ms were considered diagnostic for CTS.<sup>13</sup> For all patients, median nerve sensory and motor latencies, and electromyographic changes were recorded. In addition, the neuropathy was graded mild, moderate, or severe according to the criteria of Werner and Andary,<sup>14</sup> with evidence of sensory involvement considered “mild” CTS, sensory and motor involvement considered “moderate” CTS, and evidence of axonal changes (including needle EMG changes or severe signal amplitude loss) considered “severe” CTS.

Statistical analysis was performed using R (R foundation for Statistical computing, Vienna, Austria). A 2-sided Spearman rank analysis was used to correlate CTS electrodiagnostic severity with DASH and SF-12 outcomes. A post hoc power analysis of our sample demonstrated 80% power to detect a correlation of  $\rho = 0.39$ .  $\rho$  values of 0.30 are considered the minimum clinically significant correlation.<sup>15</sup> A linear regression was used to correlate nerve conduction latency with DASH and SF-12 scores.

## RESULTS

One hundred five consecutive patients were evaluated for inclusion in this study, and a total of 50 met inclusion criteria. There were 34 women and 16 men included in the study with an average age of 58.6 years (range, 26–86 years). Based on electrophysiologist’s rating, there were 18 patients with electrophysiologically severe CTS (36%), 23 with moderate CTS (46%), and 9 with mild CTS (18%).

The average DASH and SF-12 scores are reported in Table 1. Spearman’s rank analysis demonstrated no statistically significant correlation between DASH and electrodiagnostic severity ( $\rho = -0.18$ ;  $P = 0.08$ ). There was no significant correlation between MCS-12 and electrodiagnostic median neuropathy severity ( $\rho = 0.149$ ;  $P = 0.18$ ). A statistically significant correlation was noted between the PCS-12 value and electrodiagnostic severity ( $\rho = 0.34$ ;  $P = 0.002$ ). Pearson’s correlation coefficient measured 0.096 for the relationship between PCS-12 and patient age, demonstrating a minimal effect of age on PCS-12 in our sample (Fig. 1).

**Table 1. Correlation between Disability Scores and Electrodiagnostic Severity**

Survey	Mild	Moderate	Severe	Spearman Rank Coefficient Rho	P
DASH	50.07	30.49	34.5	-0.179	0.08
PCS-12	30.22	40.25	41.48	0.335	0.002*
MCS-12	46.7	53.48	55.06	0.149	0.18

\*P < 0.05

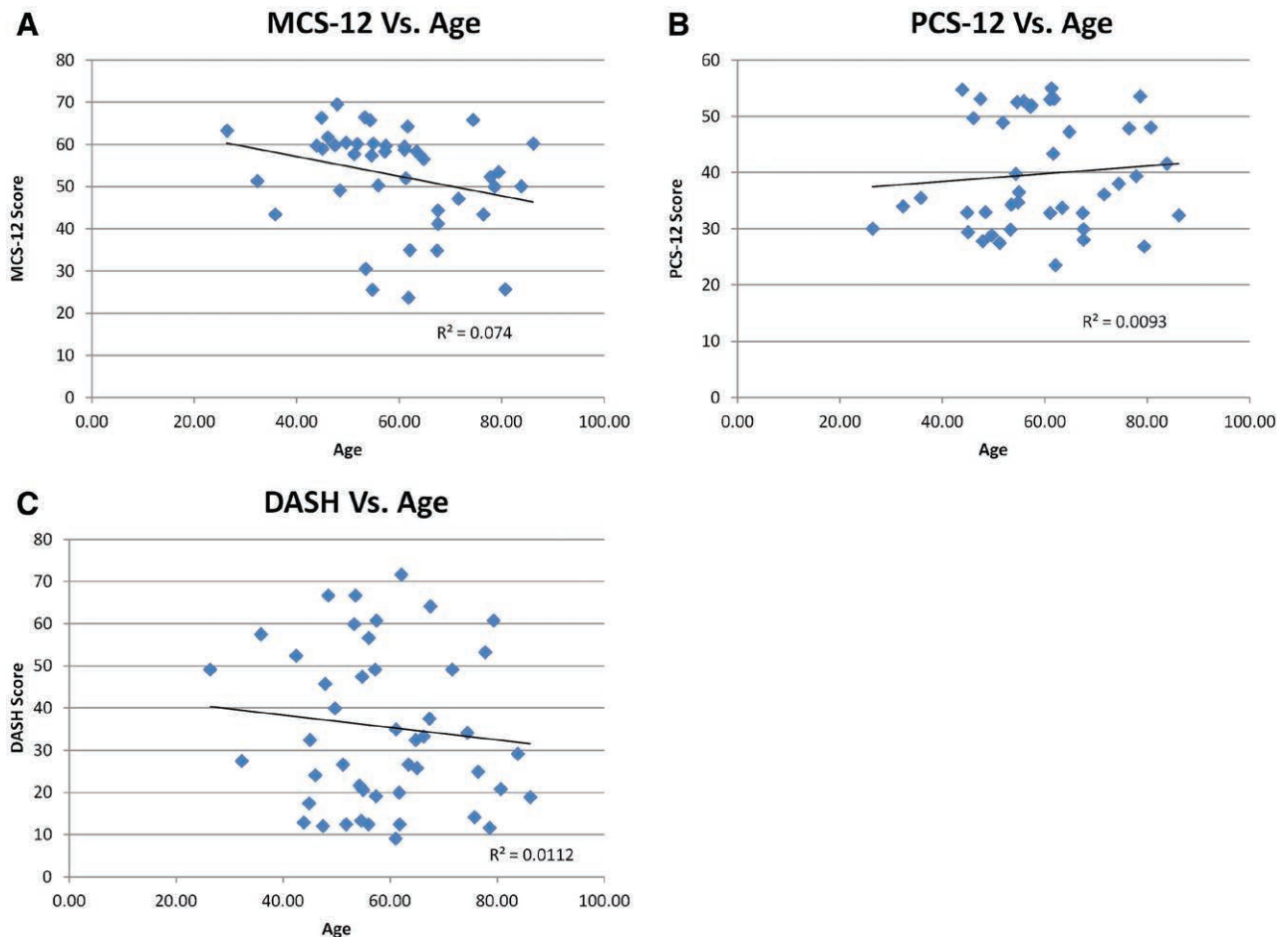
No statistically significant correlations were noted between DASH, PCS-12, or MCS-12 and median motor or sensory latency at the wrist (Table 2; Fig. 2).

### DISCUSSION

The purpose of this study was to assess the relationship between severity of electrodiagnostic findings and validated instruments measuring function and disability in patients presenting to hand surgeons for management of CTS. Based on our data, it appears that electrodiagnostic severity, based on an electrical grading system or on measured median nerve latency, does not correlate with patient-derived measures of disability in patients with CTS. In other words, it appears that dysfunction in these pa-

tients does not correlate to the electrophysiologic degree of nerve compression, but may rather be dependent on other factors. Depression, anxiety, catastrophization, and misinterpretation of pain have been shown to correlate with patient distress and could account for the variability in reported dysfunction that is not explained by electrophysiologic parameters.<sup>16-18</sup> Furthermore, disability secondary to CTS may be more likely with certain vocations, a variable not assessed in this study.

Previous studies have failed to link objective findings to symptom severity scales in patients with CTS. Levine et al.<sup>5</sup> developed a carpal-tunnel-specific questionnaire based on the frequency and severity of classic carpal tunnel symptoms such as tingling, numbness, weakness, and sleep disturbance as well as ability to complete daily activities. This scale was found to be reproducible and consistent but correlated poorly with objective measures of sensory neuropathy such as Semmes-Weinstein monofilament testing.<sup>5</sup> The authors did not correlate their findings with EMG/NCS results. Makanji et al.<sup>6</sup> compared motor and sensory latencies to score on the CTS-6 and Levine questionnaires, among other pain scales. The CTS-6 scale showed limited correlation with motor and sensory latencies, whereas the Levine scale did not. In



**Fig. 1.** Correlation between outcome scores and age. A, Short-Form 12 Health Survey Mental Component versus age. B, Short-Form 12 Health Survey Physical Component versus age. C, Disabilities of the arm, shoulder, and hand survey versus age.



**Table 2. Correlation between Disability Scores and Latency**

Electrodiagnostic Parameters	Versus DASH		Versus MCS-12		Versus PCS-12	
	Rho	P	Rho	P	Rho	P
Median sensory latency	-0.06	0.679	0.23	0.098	0.15	0.285
Median motor latency	-0.039	0.74	0.24	0.052	0.24	0.052

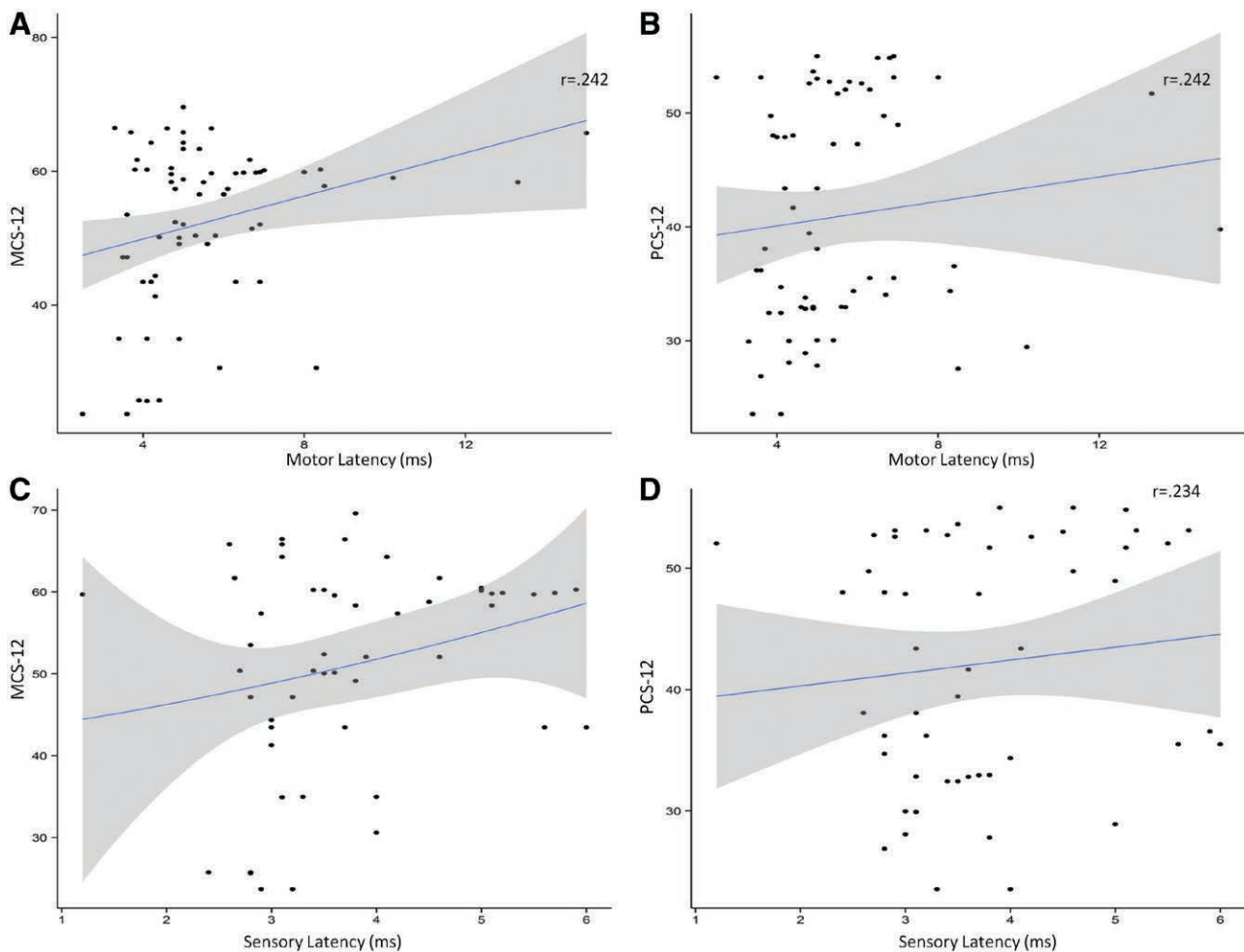
\**P* < 0.05. Rho = 0.30 is considered the minimum clinically significant correlation.<sup>19</sup>

addition, the authors found no significant difference in Levine scale scores and CTS-6—derived probability in patients categorized as having mild, moderate, or severe CTS. In a 2015 study,<sup>19</sup> CTS-6 scores were found to be significantly higher in patients with electrodiagnostically severe disease versus those with electrodiagnostically moderate disease (3.1 versus 2.7). This study, however, did not specifically examine objective measures such as latency values and used a different (and older) set of electrodiagnostic criteria than the American Association of Neuromuscular and Electrodiagnostic Medicine<sup>14</sup> criteria used in this study.

Chan et al.<sup>4</sup> evaluated the correlation between electrodiagnostic studies and the CTS Assessment Questionnaire functional status scale. The authors found no statistically significant relationships between the electrodiagnostic findings and functional status and symptom severity.<sup>4</sup>

Although our study reaches a similar conclusion, the outcome measures used in our study (DASH, SF-12) are general measures of extremity function and disability. As such, this study differs from previous ones in the generality of the outcome scores—that is, it does not examine symptoms specifically related to CTS. Patients with CTS can struggle to define their symptomatology, and the description of these symptoms varies by patient, culture, and location.<sup>20,21</sup>

Electrodiagnostic findings have also been compared with scores on the DASH. Bakhsh et al.,<sup>22</sup> in a 2012 study, found no correlation between DASH scores and individual electrodiagnostic parameters. The authors did not provide any electromyographic data, and as such the correlation of DASH score with nerve conduction parameters is of limited value relative to the categorization of CTS severity.<sup>22</sup> In a similar study, Itsubo et al.<sup>23</sup> demonstrated a weak correla-



**Fig. 2.** Correlation between mental and physical SF-12 components and nerve conduction latency. A, Median motor latency in ms versus Short-Form 12 Health Survey Mental Component. B, Median motor latency in ms versus Short-Form 12 Health Survey Physical Component. C, Median sensory latency in ms versus Short-Form 12 Health Survey Mental Component. D, Median sensory latency in ms versus Short-Form 12 Health Survey Physical Component. Shaded areas represent 95% confidence band.

tion (correlation coefficient, 0.36) between electrophysiologic grade (mild/moderate/severe) and the Japanese QuickDASH but failed to find any correlation between QuickDASH and specific electrophysiologic parameters. The authors used median nerve latency and velocity to categorize CTS severity, a significant limitation of this study.

The SF-12 was evaluated for use in CTS by Bessette et al. in a 1998 study,<sup>24</sup> but no attempt was made to elucidate the relationship between SF-12 score and preoperative CTS electrodiagnostic severity. A 2006 study comparing open and endoscopic carpal tunnel release also measured SF-12 pre- and postoperatively but again did not attempt to correlate disease severity and SF-12 score.<sup>25</sup>

We found a statistically significant correlation between electrodiagnostic severity based on electrodiagnostic grading and PCS-12. The positive correlation ( $r = 0.34$ ) indicates that the patients presenting with electrodiagnostic evidence of more severe pathology reported less physical disability (higher PCS-12), which is counterintuitive and supports the notion that the electrical grading system is not useful to predict disability. We cannot definitively explain the correlation between less severe electrophysiologic grade and higher reported disability. It may be that patients with newer onset symptoms (and therefore milder grade) have not compensated for this condition in the same way as patients with more severe (and presumably longer duration of) symptoms. There may also be a self-selection bias in that those patients who experience their disability more strongly may present earlier in the disease course. Finally, since the strength of this correlation was moderate-low and the results of this finding are counterintuitive, this lends further support to our overall conclusions that electrophysiologic measures do not correspond well to patient-reported disability scores.

Nerve conduction studies evaluate large nerve fibers responsible for motor and proprioceptive function, rather than the small c fibers responsible for pain transmission and paresthesias. Patients may thus experience symptomatology due to dysfunction of these small fibers, which is not detected by nerve conduction studies. None of this is factored into the grading system, which is why grading systems can be controversial in the evaluation of CTS.<sup>26–28</sup> Linear regression analysis confirmed the lack of correlation between median motor and sensory latency and disability, supporting our findings that patient-rated dysfunction appear to be unrelated to electrodiagnostic findings.

Limitations of this study include a small patient cohort and the retrospective nature of this study. Although a post hoc power analysis demonstrated an ability to detect a rho value of 0.38 or greater, there is a possibility that a weaker but statistically significant correlation exists. Although it is possible that this limitation could be improved by including a greater number of patients, it is likely that such a weak correlation would have limited clinical value. Second, the study also fails to account for symptom duration. Patients with longer symptom duration may report higher or lower levels of disability. Given the often-insidious onset of CTS symptoms, exact time of disease onset is difficult to determine. Furthermore, it is difficult to separate longer-duration CTS from worsening CTS. Further studies obtaining longitudinal data will be required to evaluate the effect of symptom duration

on patient disability. Third, bias may have been introduced by patient awareness of electrophysiologic test results. Our clinical protocol did not specifically address electrophysiologist discussion and interpretation of the results with the patient. As a result, patients may have known of their diagnosis of “mild, moderate, or severe” CTS at the time they filled out their surveys, potentially affecting their responses.

Based on the results of this study, it appears that the severity of electrodiagnostic studies does not correlate with patient function using validated patient outcome measures generalized for the upper extremity in CTS. Further studies evaluating the factors accounting for patients’ perceived disability could improve treatment and outcomes for this common clinical condition.

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