Prospective comparison of the six-item carpal tunnel symptoms scale and portable nerve conduction testing in measuring the outcomes of treatment of carpal tunnel syndrome with steroid injection

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Abstract

Background We prospectively studied patients clinically diagnosed with carpal tunnel syndrome (CTS) and treated with the injection of corticosteroid into their carpal tunnel in order to compare changes in the six-item CTS symptoms scale and portable nerve conduction study (NCS) parameters as outcome tools. Our pilot study was the first to assess the utility of the six-item CTS symptom scale (CTS-6) with steroid injections as a patient-directed outcome measure for the treatment of CTS.

Methods We enrolled patients who presented to our county hospital orthopedic surgery clinic from August 2012 through August 2013. The patients were clinically diagnosed with CTS. After completing the six-item CTS symptoms scale questionnaire, portable NCS was obtained. Each patient then received an injection of 1 ml of triamcinolone acetonide 40 mg/ml mixed with 1 ml of 1 % lidocaine into the carpal tunnel. Six weeks postinjection, each patient repeated a CTS-6 questionnaire and underwent a repeat portable NCS. The CTS-6 and NCS results were analyzed using the paired samples *t* test. A Pearson correlation was used to assess the correlation between the changes in the CTS-6 and the NCS measurements. Statistical significance was set at $P < 0.05$.

Results Thirty-two wrists in 20 patients were evaluated. There was a statistically significant difference between the CTS-6 scores before and after injection. There were also statistically significant changes in the five of the NCS parameters. None of

the correlations between the CTS-6 and the NCS parameters were statistically significant.

Conclusions The six-item CTS symptoms scale and portable NCS are both useful measures for evaluating the results of steroid injections. The CTS-6 is an effective tool because of its ease of use, low cost, correspondence with changes in NCS, and ability to monitor the outcome of steroid treatment for carpal tunnel syndrome.

Keywords Carpal tunnel syndrome · Nerve conduction studies · Outcome studies · Steroid injection · CTS-6 · County hospital

Introduction

Carpal tunnel syndrome (CTS) is the most common nerve compression problem with prevalence between 1.5 and 4.9 %. The diagnosis of CTS is difficult due to the variability of etiology and clinical presentation, the uncertain role of electrophysiologic studies, and the lack of a reference standard test [7, 31]. Steroid injections are an option for nonoperative management of carpal tunnel syndrome. While the short-term efficacy of steroid injections is well established, the duration of benefit is variable [5, 13, 15, 23, 28, 36, 38]. Steroid injections into the carpal tunnel produce improvement in nerve conduction studies (NCS) [1, 6, 8, 12, 22, 36].

There are a number of patient-rated outcome measures available to measure the treatment effect for CTS [14, 29, 37]. Few studies have combined outcome measures and the results of NCS with treatment with steroids [1, 12, 22, 24].

The six-item CTS symptom scale (CTS-6) is a brief measure of symptoms in CTS that has been used after the surgical treatment of CTS [3, 4]. The scale has not been tested in conjunction with steroid injection. Please note that this scale,

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developed by Atroshi and referred to as CTS-6, unfortunately shares the same abbreviated name with a CTS diagnostic tool developed by Graham [16, 17]. While the two systems share a name, they are not related.

In this pilot study, we prospectively studied patients clinically diagnosed with CTS and treated with the injection of corticosteroid into their carpal tunnel in order to compare the six-item CTS symptoms scale as an outcome tool with portable nerve conduction testing.

Materials and Methods

The study was approved by our institutional review board. We enrolled patients who presented to our county hospital orthopedic surgery clinic from August 2012 through August 2013. The patients were clinically diagnosed based on initial history and physical exam. Examination and treatment were performed by orthopedic surgery residents working with two different attending surgeons.

Patients with previous steroid injection or surgery for carpal tunnel syndrome were excluded from the study. Patients were enrolled on a voluntary basis without compensation. The NCS was done at no cost to the patient. All patients gave written consent.

The patients completed the six-item CTS symptoms scale questionnaire and underwent a physical exam (Fig. 1). After the questionnaire was completed, portable NCS was obtained using the Advance NCS/EMG System (NeuroMetrix, Waltham, MA). Each patient then received an injection of 1 ml of triamcinolone acetonide 40 mg/ml mixed with 1 ml of 1 % lidocaine into the carpal canal by the method described by Green [11, 18]. Six weeks postinjection, each patient repeated a CTS-6 questionnaire and underwent a repeat portable NCS.

The CTS-6 was scored with each of the six items receiving a score from 1 (no symptoms) to 5 (most severe symptoms) and the aggregate score being an average of all six items [3]. The data from the portable NCS were obtained on a printout

followed by a formal reading done on the electronically submitted data at the NeuroMetrix central reading facility. Measurements were obtained for distal motor latency (DML), compound motor action potential amplitude (CMAP), median-ulnar motor conduction differences (MUDM), distal sensory latency, sensory nerve action potential amplitude (SNAP), median-ulnar sensory conduction difference, and conduction velocity. The portable NCS system reported a categorical diagnosis (normal, mild CTS, moderate CTS, severe CTS) that was scored 1–4.

Statistical Analysis

The CTS-6 and NCS results were analyzed using the paired samples *t* test. A Pearson correlation was used to assess the correlation between the changes in the CTS-6 and the NCS measurements. Statistical significance was set at $P < 0.05$. Design stage analysis for the correlation between the CTS-6 and NCS parameters at 90 % power showed a requirement for 62 patients. After performing the power analysis, the decision was made to complete the study as a pilot project.

Results

Thirteen of 20 patients completed the study for a total of 20 wrists. The average age of the patients completing the study was 58 years (range 45–82). There were nine women and four men. The average duration of symptoms was 39 months (range 3–120). Seven of the patients had diabetes mellitus.

Seven patients were excluded from the study. Two patients did not return for follow-up. Four patients returned for follow-up several weeks after their planned 6-week postinjection follow-up visit. One patient withdrew from the study at the 6-week follow-up visit and requested surgery.

Postinjection follow-up averaged 3.7 months (range 1.5–7 months). There were no steroid-related complications.

Fig. 1 CTS-6 form

The following questions refer to your symptoms for a typical 24-hour period during the past two weeks. Please mark one answer to each symptom.

How severe are the following symptoms in your hand?

	None	Mild	Moderate	Severe	Very Severe
Pain at night	☐	☐	☐	☐	☐
Pain during daytime	☐	☐	☐	☐	☐
Numbness or tingling at night	☐	☐	☐	☐	☐
Numbness or tingling during the day	☐	☐	☐	☐	☐

How often did the following symptoms in your hand wake you at night?

	Never	Once	2 or 3 times	4 or 5 times	More than 5 times
Pain	☐	☐	☐	☐	☐
Numbness or tingling	☐	☐	☐	☐	☐

Of the 13 patients who completed the study, 10 experienced improvement in their CTS-6 scores. Of the three who did not improve, cervical stenosis was subsequently diagnosed in two of the patients. Nine patients reported subjective improvements in their symptoms at their last clinic visit.

At least one of the sensory NCS parameters was unable to be measured in 8 out of 20 wrists. The motor nerve parameter differences were measured in all 20 wrists. Overall, 30 of 280 (11 %) individual parameters could not be measured. For four wrists, the sensory waveform could not be identified by the machine either pre- or posttreatment, and there were no sensory parameters recorded. In the other four wrists, the sensory parameters were incompletely measured.

There was a statistically significant difference between the CTS-6 scores before and after injection. There were also statistically significant changes in the DML, MUDM, DSL, and MUDS (Table 1). Six of the 20 wrists (3 of the 13 patients) were designated “normal” on the NCS read by the NeuroMetrix before and after the injection. Two of these patients had cervical disk disease and did not have improvement on their CTS-6.

Fifteen of 20 wrists had improvement in their CTS-6 scores, with an average improvement of 0.7. Nine wrists showed improvement greater than the minimal important difference of 0.9 [3]. Excluding the two patients with cervical disk disease, 10 of 11 patients had improvements in their CTS-6 scores greater than 0.9.

The correlations between the CTS-6 and the NCS parameters are listed in Table 2. None of the correlations were statistically significant. The highest correlations with the CTS-6 were with the MUDM and the NCS summary diagnosis.

Post hoc analysis was repeated excluding the two patients with cervical disease. The only noteworthy change was the correlation between the change in the CTS-6 and the change in NCS diagnosis improved to 0.497 ($P=0.052$).

Table 1 Paired sample results

Postinjection-preinjection			
Test	Mean	<i>P</i> value	
CTS-6	−0.92	0.003 ^a	
DML	−0.44	0.001 ^a	
CMAP	−0.067	0.792	
MUDM	−0.5	0.001 ^a	
DSL	−0.36	0.013 ^a	
SNAP	1.1	0.665	
MUDS	−0.23	0.031 ^a	
CV	3.79	0.282	
Diagnosis	0.2	0.33	

Abbreviations, see text

^a Significant

Discussion

In patients with clinically diagnosed CTS treated with steroid injection, our study showed that the CTS-6 symptoms scale and portable NCS can be useful outcome measures. Significant improvements were seen in the scores of the CTS-6 symptoms scale and in the results of the NCS. We did not, though, find a statistically significant correlation between the improvement in patients' CTS-6 scores and improvement of their NCS. The lack of correlation is not surprising, as the Boston Carpal Tunnel Questionnaire has also not been shown to correlate with the results of NCS [19]. In this pilot study, correlations were highest with the CTS-6 compared to the MUDM and the NCS diagnosis.

Steroids are a well-established treatment option for the nonoperative management of CTS [5, 13, 15, 23, 28, 36, 38]. Multiple studies have shown their efficacy in the short run, with the benefits apparent at 4 weeks [34]. The duration of the improvements is variable. Studies have also shown that treatment with steroid injection produces improvement in NCS parameters. The improvement in the NCS parameters that we demonstrated after steroid injections in our study confirms the results of previous studies [1, 6, 8, 12, 22, 36].

There are a number of choices for injectable steroids, and all have potential side effects [20, 26, 39]. Triamcinolone was available in our institution. Side effects were not seen in our study group.

The CTS-6 was shown to be a sensitive and useful measure of outcomes. Six of our patients with normal NCS diagnosis improved their scores. In two of our patients, lack of improvement on the CTS-6 led to further diagnostic workup and the discovery of cervical spine disease. Reviewing the charts showed that one of these patients should have been excluded from the study. In both patients, the normal CTS-6 and NCS results, along with a better history of exam, helped lead to the diagnoses of cervical stenosis.

Table 2 Correlation between CTS-6 and NCS

Postinjection-preinjection		
CTS-6		
	Pearson correlation	<i>P</i> value
DML	0.26	0.27
CMAP	0.18	0.50
MUDM	0.42	0.07
DSL	−0.13	0.70
SNAP	0.08	0.78
MUDS	0.20	0.56
CV	0.00	0.990
Diagnosis	0.40	0.08

Abbreviations, see text

There are multiple diagnostic and outcome measures available to assess treatment effects for CTS, including the Short Form 36 (SF-36), Disability of the Arm, Shoulder, and Hand (DASH), QuickDASH, Boston Carpal Tunnel Questionnaire (BQ), Michigan Hand Outcomes Questionnaire (MHQ), global symptom score, Kamath questionnaire, CTS severity scale, and patient-related wrist evaluation [33, 37].

The SF-36 assesses general health and is not specific to hand problems. The DASH is a 30-item questionnaire that measures all regions of the upper extremity disability and has been used to assess CTS. The QuickDASH has 11 items. Both the DASH and QuickDASH have been shown to have good reliability, responsiveness, and validity [37]. The MHQ assesses disability with 37 questions along six different domains. These tests have been shown to be reliable and valid [10]. The MHQ questionnaire is more specific than the DASH, but not as specific for CTS as the BQ.

Specific to CTS, the BQ uses 11 questions to measure symptom severity and 8 questions for function [27]. It is reliable and responsive in the postoperative period [30]. The BQ has not been shown to correlate with NCS [19].

We desired a concise, straightforward, and efficient questionnaire for our patient population. The CTS-6 uses only six questions and was derived from the BQ. Using factor analysis and item response theory, items were removed or merged by Atroshi and the layout was changed. Testing showed it to be reliable and valid, with strong correlation to the QuickDASH and agreement with the BQ. The CTS-6 has also been shown to be highly responsive to symptoms. A score change of 0.9 indicated a minimal clinically important difference, and the effect size, 2, was high [3, 4]. An effect size of 0.2 is considered to be small, 0.5 is moderate, and 0.8 or greater is large [25]. Ten of our patients (nine wrists) showed a clinically important difference.

Demirci et al. compared open carpal tunnel release to steroid injection in 90 patients with electrodiagnostically proven carpal tunnel syndrome [12]. They followed patients symptomatically and with electrodiagnostics and the Boston Questionnaire at 3 and 6 months. There were statistically significant improvements in both the Boston Questionnaire and the NCS.

Armstrong et al. compared steroid injection to placebo injection for the treatment of carpal tunnel syndrome in 81 patients [1]. Similar to our findings, those patients who received the steroid injection experienced statistically significant improvement in their symptoms as measured by the Carpal Tunnel Study Functional Status and Symptom Severity Questionnaire as well as median sensory distal latency when compared to the placebo group at 2 weeks. However, they do not comment on whether the change in the median sensory distal latency from baseline is significant nor the strength of its correlation with the improvement in patients' symptoms measured by the questionnaire.

Heybeli et al. studied 44 patients with carpal tunnel syndrome comparing the improvement in clinical symptoms by the Boston Questionnaire and NCS at 3 and 6 months after surgical release [21]. However, their article analyzes surgical release rather than steroid injection. They did not find a correlation between the improvement in the Boston Questionnaire and NCS data, although both showed improvement at 3 and 6 months.

Hui et al. showed improvements in the global symptom score and NCS with both steroid injection and surgical release [12].

The value of portable NCS testing units is well established [2, 35]. During the study period, our county facility did not have formal electrophysiologic testing availability for most of our patients. We found that using the portable NCS unit in our clinic was feasible and relatively simple and could be administered by residents and nursing staff. The portable NCS testing only took about 15 to 20 min to administer. However, there were limitations. For example, we were unable to measure all the sensory parameters in eight wrists. The automated nature of the portable unit did not allow for easy recalibration or retesting of those missing parameters. The formal reading from the company was not available until the next day. In our study, the most consistent parameter was the median-ulnar difference. The median-ulnar difference acts as an internal control for differences in skin temperature and other factors and was therefore felt to be a useful measure in our portable setting [32].

Limitations of our study include the difficulties in obtaining all the NCS parameters on each patient, our small sample size and high dropout rate, and the lack of strict initial diagnostic criteria for CTS.

Our study did show that the CTS-6 is a useful scale for its ease of use, its ability to monitor the outcome of steroid treatment, its low cost, and its correspondence with changes in NCS. The size of the changes in the scores was large compared with the minimal important difference of 0.9. The test is short and is easily adopted in a county hospital setting.

Our pilot study was the first to assess the utility of the CTS-6 with steroid injections as an outcome measure for CTS. Previously, the CTS-6 was used with surgical treatment. Patient-reported outcomes are not routinely reported in the hand surgery literature [9]. Further studies are needed to compare the CTS-6 with other patient-reported scales. In our study, the changes in the CTS-6 and the NCS both were significant. Further evaluation with a larger patient sample size would be needed to establish whether the CTS-6 and portable NCS are equivalent outcome measures.

The six-item CTS symptoms scale and portable nerve conduction studies are both useful measures for evaluating the results of steroid injections. Due to the low cost and ease of use, the CTS-6 may be the measure of choice.

Conflict of Interest John R. Craw, Dane J. Church, and Richard L. Hutchison declare that they have no conflict of interest.

Statement of Human and Animal Rights All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008 (5). The study was approved by our institutional review board.

Statement of Informed Consent A waiver of informed consent was obtained.

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