Effects of Corticosteroid Injection on Nerve Conduction Testing for the Diagnosis of Carpal Tunnel Syndrome

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Abstract

We conducted a study to determine the change in nerve conduction testing after steroid injection in patients with carpal tunnel syndrome (CTS). One hundred forty-five patients with suspected CTS were targeted for this study. Twenty-seven patients underwent testing before and after injection. Repeat studies were performed 4 to 6 weeks after injection. All data from the electrodiagnostic studies were entered into a database and used for comparison.

Before injection, mean (SD) distal motor latency (DML) was 5.01 (0.9) ms, and mean (SD) peak sensory latency (PSL) was 5.01 (0.88) ms. After injection, mean (SD) DML was 4.82 (0.7) ms, and mean (SD) PSL was 4.69 (0.66) ms. Mean (SD) difference between preinjection and postinjection DML was 0.187 (0.45) ms, and mean difference between preinjection and postinjection PSL was 0.319 (0.48) ms. Both differences were statistically significant (paired *t* test).

Our study results showed a statistical difference between testing done before and after steroid injection. These results indicate that injections given before electrodiagnostic testing alter results and may affect patient management.

Carpal tunnel syndrome (CTS) is the most common entrapment neuropathy of the upper extremity. In 1913, Marie and Foix[1] discussed an autopsy of a patient with severe atrophy of the thenar musculature and no history of trauma. They found a neuroma of the median nerve just proximal to the transverse carpal ligament and were the first to recommend transecting the transverse carpal ligament to prevent paralysis of the thenar muscles. Cannon and Love[2] reported the first CTS case series, which consisted of 38 patients with median nerve palsy, 9 of which were treated with sectioning of the transverse carpal ligament.

In most patients with CTS, the diagnosis can be made from the history and the physical examination findings. Clinical symptoms often include paresthesia in the thumb and index and long fingers. The Tinel sign, the Phalen test, and the carpal compression test are provocatively used during physical examination to diagnose CTS. When the diagnosis is suspected, nerve conduction studies are performed to confirm and establish the severity of the disease. For diagnosed moderate or severe disease, surgery remains the treatment of choice.[3] Several studies[4-8] have shown short-term symptomatic relief with use of less invasive modalities, such as wrist splinting, oral steroids or anti-inflammatories, or injectable corticosteroids.

The effects of steroid injections for CTS treatment have been reported in several studies, dating back to the original experience of Phalen and Kendrick,[9] who found that 3 or 4 injections at weekly intervals led to symptom improvement. Dammers and colleagues[10] conducted the first randomized, double-blind, placebo-controlled trial suggesting a single corticosteroid injection may result in long-term improvement in clinical symptoms. Girlanda and colleagues[11] found the maximal effect of injected corticosteroids occurred 1 month after injection.

The differential diagnosis for patients with possible CTS includes but is not limited to possible cervical spine dysfunction and median nerve entrapment proximal to the carpal tunnel and distal to the axial skeleton. A dilemma for surgeons is the patient who has clinical evidence of CTS but seeks corticosteroid injection immediately, before confirmatory electrodiagnostic studies. In such a case, cortisone injections made before electrodiagnostic testing may alter the results and lead to management changes that otherwise would not have been considered.

We conducted a study to determine if the potential change in nerve conduction testing after steroid injection is statistically significant.

Materials and Methods

Between August 2010 and May 2011, 145 patients with electrodiagnostically proven CTS received a steroid injection into the carpal tunnel. The decision to perform nerve testing before injection was not a part of this study. Each patient either presented to the practice already having had nerve testing done, or decided in consultation with the physician to have the testing done to confirm CTS or rule out other diagnoses (this was

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before the patient was approached for the study).

After we obtained institutional review board approval for the study, and after patients made their unbiased decisions to receive a corticosteroid injection, we approached them about participating in the study. Patients who agreed to participate underwent repeat nerve testing 4 to 6 weeks after injection. Their complaints included CTS symptoms with physical findings of either a positive carpal Tinel sign or a positive carpal compression test and with electrodiagnostic evidence of CTS. Before injection, patients were treated conservatively with wrist splinting and behavior modification. Those who had their electrodiagnostic studies performed at an outside facility were excluded. We did this in order to have all testing performed by the same examiner using the same equipment and technique. Also excluded were 2 patients with diabetes or thyroid disease, 30 with testing done more than 6 months earlier, 28 with absent latencies on testing, 24 with injections received within the preceding 6 months, 23 who refused repeat testing, 3 with normal latencies, and 6 lost to follow-up. Twenty-seven (6 male, 21 female) patients (31 wrists) remained.

Nerve Conduction Studies

Nerve conduction studies were performed by Dr. Cowan following the CTS protocol defined by the American Association of Electrodiagnostic Medicine.[12] Before testing, skin temperature was measured; hands cooler than 32°C were warmed. Sensory and motor nerve conduction tests were studied using surface electrodes for stimulation and recording. Latencies were measured from stimulus onset to initial negative response, and amplitudes were measured from baseline to negative peak. Sensory nerve action potentials (SNAPs) were recorded antidromically 14 cm from the ring-shaped recording electrodes placed around the proximal (recording, cathode) and distal (reference, anode) interphalangeal joints. The ground electrode was attached to the distal region of the wrist. Median nerve sensory conduction velocity was measured from the wrist to the middle finger. Compound muscle action potential (CMAP) was recorded from the thenar eminence with the active recording electrode placed over the abductor pollicis brevis muscle belly. The reference electrode was placed over the abductor pollicis brevis tendon. Median nerve distal motor latency (DML) was measured with stimulation and recording cathodes 7 cm apart. Median motor conduction velocity was measured in the forearm. Supramaximal stimulation was delivered to the elbow and wrist. Patient cases were divided into 3 groups based on severity of electrodiagnostic findings[13]:

- ***Mild.*** Prolonged (relative or absolute) SNAP or mixed nerve action potential (NAP) distal latency (orthodromic, antidromic, or palmar) plus or minus SNAP amplitude below the lower limit of normal.
- ***Moderate.*** Abnormal median sensory latencies (as above) and relative or absolute prolongation of median DML.
- ***Severe.*** Prolonged median motor and sensory distal latencies, absent SNAP or mixed NAP, or low amplitude or absent thenar CMAP. Needle examination often reveals fibrillations, reduced recruitment, and motor unit potential changes.

Patients who had evidence of CTS, met inclusion criteria, and chose a corticosteroid injection for temporary relief of symptoms were approached to participate in the study. Patients who agreed to participate underwent repeat nerve conduction testing 4 to 6 weeks after injection.

Corticosteroid Injection

Corticosteroid injections were standardized to all physicians participating in the study. A mixed solution of 1 mL mepivicaine and 1 mL containing 3 mg betamethasone sodium phosphate and 3 mg betamethasone acetate was injected into the carpal tunnel using a 25-gauge needle. The injection site was proximal to the wrist crease ulnar to the palmaris longus tendon or, if the palmaris longus tendon was absent, half the distance from the flexor carpi ulnaris tendon to the flexor carpi radialis tendon. Patients were instructed to report any paresthesias of the fingers during injection in order to avoid intraneural injection. They were instructed to continue splinting and behavior modification after injection.

Data Collection and Analysis

All study patient data—including age, sex, injected wrist, disease severity, injection date, splint use, and anti-inflammatory use—were entered into a database for analysis. Data from nerve conduction studies done before and after corticosteroid injections were used for comparison and statistical analysis using paired t test to detect any significant statistical difference in nerve conduction velocity.

Results

The **Table** lists the collected data. Mean age was 53 years (range, 35-79 years). At initial testing, 8 cases were classified mild, 20 moderate, and 3 severe (in the severe cases, patients were injected at their request to relieve symptoms and were not approached to participate in the study until after their decision was made). Twenty-three patients had either improvement or no change after injection, 3 had worsened DML and peak sensory latency (PSL), 6 had worsened DML only, and 5 had worsened PSL only. Power analysis showed that, with about 31 patients per group, there should be a 100% chance (statistical power) of detecting a mean difference in DML and PSL that is greater than or equal to 0.07 (units). This analysis assumes that a paired t test is performed with a 2-sided type I error rate of 5%. Before injection, mean (SD) distal motor latency (DML) was 5.01 (0.9) ms, and mean (SD) peak sensory latency (PSL) was 5.01 (0.88) ms. After injection, mean (SD) DML was 4.82 (0.7) ms, and mean (SD) PSL was 4.69 (0.66) ms. Mean (SD) difference between preinjection and postinjection DML was 0.187 (0.45) ms ($t = 2.3$, $P = .029$), and mean difference between preinjection and postinjection PSL was 0.319 (0.48) ms ($t = 3.7$, $P = .001$).

Discussion

In 1956, Dawson[14] examined electrical excitability at the wrist, and the relative conduction velocity between the wrist and the elbow, of sensory and motor fibers in the median and ulnar nerves. The same year, Simpson[15] conducted some of the earli-

est studies of electrodiagnostic findings for the carpal tunnel; ischemic sections of the median nerve in CTS demonstrated slowed conduction, which returned to normal after decompression. Phalen and Kendrick[9] were the first to use steroid injections in CTS management. In 1962, Goodman and Foster[16] reported on the results of 23 patients and on the effects of

Table. **Results Data for Study Patients**

				Before Injection		After Injection		Change In:	
Age, y	Sex	Severity	Hand	DML, ms	PSL, ms	DML, ms	PSL, ms	DML, ms	PSL, ms
59	F	Moderate	R	5.3	6.8	4.5	4.9	0.8	1.9
50	F	Moderate	R	5.1	5.3	4.5	4.9	0.6	0.4
54	M	Moderate	L	5.4	5.6	5.4	5.6	0	0
65	M	Mild	L	4.5	4.2	4.5	4.1	0	0.1
53	M	Moderate	L	5	4.8	4.6	4.7	0.4	0.1
66	F	Moderate	R	4.4	4.5	4.4	4.4	0	0.1
35	F	Mild	L	4.3	3.9	4	3.6	0.3	0.3
70	F	Severe	L	6.4	6.6	5.3	5.3	1.1	1.3
67	F	Moderate	L	4.9	4.6	4.7	4.7	0.2	–0.1
79	M	Moderate	L	4.9	6.1	5.2	5.4	–0.3	0.7
63	M	Moderate	R	5.1	4.7	4.5	4.2	0.6	0.5
38	F	Mild	R	4.3	4	5.5	4.6	–1.2	–0.6
38	F	Moderate	L	5.3	5.2	5.3	5.4	0	–0.2
56	F	Moderate	R	4.5	4.4	4.5	4.4	0	0
57	F	Severe	R	8.1	6.4	7.3	5.9	0.8	0.5
55	F	Mild	R	4.3	4.5	4.7	4.8	–0.4	–0.3
49	F	Moderate	R	4.7	4.5	4.5	4.3	0.2	0.2
63	F	Mild	L	4.3	4.2	4.3	3.7	0	0.5
69	F	Moderate	L	4.8	4.8	5	4.7	–0.2	0.1
53	F	Severe	L	7.1	6.4	6.6	6	0.5	0.4
47	F	Mild	R	3.6	3.7	3.9	3.6	–0.3	0.1
35	M	Mild	L	4.3	3.8	4.2	3.6	0.1	0.2
48	F	Moderate	R	5	6.4	4.5	5.4	0.5	1
48	F	Moderate	L	5.1	5.3	4.7	4.8	0.4	0.5
48	F	Moderate	R	5.3	5	5	4.8	0.3	0.2
43	F	Moderate	R	5.1	5.2	4.9	5	0.2	0.2
43	F	Moderate	L	4.8	4.7	4.8	4.6	0	0.1
51	F	Mild	L	3.9	4.2	4.2	4.3	–0.3	–0.1
42	F	Moderate	R	6.0	6.0	5.1	5.5	0.9	0.5
52	F	Moderate	R	4.8	4.8	4.5	4	0.3	0.8
52	F	Moderate	L	4.7	4.7	4.4	4.2	0.3	0.5
Mean				5.00967742	5.00967742	4.82258065	4.69032258	0.18709677	0.31935484
SD				0.89901978	0.88368729	0.69986174	0.66098655	0.45294734	0.47987454

Abbreviations: DML, distal motor latency; PSL, peak sensory latency.

treatment with local corticosteroid injection on median nerve conduction: symptom relief, and improved abnormalities of nerve conduction that relapsed 9 to 15 months after injection.

The exact effect of corticosteroids on CTS continues to be debated. It is thought that the anti-inflammatory effects lead to decreased edema and therefore decreased pressure within the carpal tunnel. In 1994, Neuberger and colleagues[17] found that Schwann cells of peripheral nerves expressed glucocorticoid receptors and that glucocorticoids enhanced the potency of Schwann cell proliferation. In 1998, Chan and colleagues[18] showed that glucocorticoids enhanced the rate of myelin formation. More recently, Morisaki and colleagues[19] reported that Schwann cells in vivo expressed glucocorticoid receptors in intact and injured sciatic nerves; they also found that glucocorticoids had a crucial role in myelination processes and that their effects were most prominent at a physiologic level. In 2009, Milo and colleagues[20] studied patients for 6 months after local injection. At 1 month, there was a statistically significant decrease in DML. This decrease was also seen at 3 months, but numbness and tingling had already returned by then. At 6 months, DML returned to baseline. There were no improvements in sensory parameters or amplitude—which indicates improvement in the demyelinating component of the damage to motor fibers but not to sensory fibers. This may be why the effects of corticosteroids are more successful in improving DML.

Use of steroid injections in CTS treatment has been closely examined for years. More recent data have shown a good correlation between injection and improvement in nerve testing. Before examining the effects of injection, we must first understand treatment undertaken with more conservative methods. In a study by Karsidag and colleagues,[21] electrodiagnostic data demonstrated long-term CTS progress with use of only wrist splinting. There was no statistically significant change in nerve conduction testing of mild CTS, but statistically significant improvements in motor and sensory parameters, except median sensory amplitude, were found in the testing of patients with moderate CTS. Hardoim and colleagues[22] in 2009 actually found that 34.3% of patients with CTS showed electrophysiologic improvement, even without treatment, in long-term follow-up. Incidentally, less improvement was seen in patients absent median SNAPs, in elderly patients, and in males. However, investigators continue to study postinjection clinical, functional, and electrodiagnostic outcomes. In 2004, Armstrong and colleagues[23] conducted a randomized, double-blind placebo-controlled trial of steroid injection for CTS treatment. At 2 weeks, there were measurable improvements in median nerve motor conduction abnormalities (70% response rate on first injection). Over time, though, patients became refractory to repeat injections. In addition, in 2004 Hagebeuk and de Weerd[24] found a lasting improvement in nerve conduction parameters after steroid injection, with improvement starting as early as 1 month and remaining at final follow-up (6 months). Lee and colleagues,[25] on the other hand, studied the effectiveness of steroid injection in treating moderate and severe CTS. In the moderate group, all electrodiagnostic parameters improved by 4 weeks but were diminished by 2 months. In the severe group, DML was the only electrodiagnostic parameter that showed statistically significant improvement at 4 weeks and 2 months.

Although both clinical and electrophysiologic findings associated with CTS are improved with corticosteroid injection, there is no direct correlation between these findings.[26] In other words, a larger decrease in clinical symptoms is not directly measured by an improvement in nerve conduction findings. Hardoim and colleagues[22] found the electrophysiologic parameters of nerve testing in CTS can oscillate over the years of the disease and are not related to the clinical symptoms. Thus, it is difficult to effectively correlate clinical findings with prognosis.

Our results showed a statistically significant change in 2 of the objective parameters used in making decisions about CTS management after steroid injection. The use of steroid injections has an impact because even small differences can lead to a change in severity grading, from mild to moderate or from moderate to severe.

Study limitations included limited population size, lack of severity grading at repeat testing, lack of serial follow-up to determine when injection effects wear off and no longer impact nerve testing results, lack of clinical response or functional correlation, and lack of correlation of severity/chronicity to improvement with steroid use. The clinical significance of the statistically significant numerical change in conduction time induced by steroid injection still remains controversial. These areas would benefit from further research. This study concentrated only on the electrodiagnostic response—the basis for severity grading—as clinical response has no bearing on the grading scale. There is no consensus regarding correlation between clinical and electrodiagnostic response. Experienced hand surgeons all have different treatment plans, which are based on severity grading and clinical examination. There is overlap between mild and moderate disease and between moderate and severe disease, but the final grading is a significant factor in the treatment recommendation offered to patients. If even a small change in conduction velocity leads to worsened grading, then that will affect most decisions regarding treatment. Regardless, disease severity should not deter use of a steroid injection to relieve symptoms, if requested by the patient.

Although it is unfortunate that we cannot consistently predict the level of effectiveness of injections, we can still provide patients with options, recommendations, and data from studies such as this one, and this information will assist them in making educated decisions. Taking into account our collected data and analysis, we recommend that nerve testing be performed before steroid injections. This practice allows for accurate grading of disease severity and ultimately for more consistent guidance in managing CTS.

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