Original Article

# Changes in electrophysiological parameters after open carpal tunnel release

Mohammad A. Tahririan, Alireza Moghtaderi[1], Farzaneh Aran[2]

Department of Orthopedics, Medical University of Isfahan Kashani Hospital, [1]Physical Medicine and Rehabilitation at Isfahan University of Medical and Health Sciences, [2]General Physician Medical University of Isfahan, Iran

## Abstract

**Background:** Carpal tunnel syndrome (CTS) is the most frequent compressive mononeuropathy, affecting mostly females. Few studies have been performed to assess the electrophysiological parameters before and after carpal tunnel release. The purpose of our study was to evaluate these changes postoperatively and in the course of a 9-month period after operation in comparison with the preoperative values.

**Materials and Methods:** A case-series study was carried out and included 17 cases of moderate or severe electrophysiologically confirmed CTS, who underwent open carpal tunnel release (CTR) from December 2010 to May 2011. Severity grade was assigned following American Association of the Electrodiagnostic Medicine criteria of CTS. Distal motor and sensory latencies and sensory nerve conduction velocity of the median nerve across the carpal tunnel were evaluated and compared before, at 6, and 9 months after surgery.

**Results:** From the 17 evaluated hand with moderate, moderate to severe and severe CTS, severity improvement was reported in 82.3% 6 months and in 88.2% 9 months after surgery, but only 47% had satisfied or completely satisfied opinion about the results. Others, though still complaining of serious symptoms, had improved or normal NCS.

**Discussion:** Electrophysiological investigations outlined severity improvement after CTR. In the current study, the electrophysiological studies were not meaningful in determining outcome.

**Key Words:** Carpal tunnel syndrome, median nerve, nerve conduction studies, open carpal tunnel release

**Address for correspondence:**
Dr. Mohammad Ali Tahririan, Department of Orthopedics, Kashani Hospital, Medical University of Isfahan, Iran. E-mail: tahririan@med.mui.ac.ir
**Received:** 13.03.2012, **Accepted:** 28.05.2012

## INTRODUCTION

Carpal tunnel syndrome (CTS) is the most frequent compressive focal mononeuropathy, occurring in up to 10% of the population, characterized by paresthesia and pain over the skin territory of median nervre.[1-4]

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|---|---|
| Quick Response Code: | Website: www.advbiores.net |
| | DOI: 10.4103/2277-9175.100151 |

Although Provocative tests on physical examination such as the wrist flexion test (Phalen's sign) and the local percussion test over the median nerve (Tinel's sign) can be extremely helpful in supporting the diagnosis, Nerve conduction studies (NCS) as the most definite diagnostic tests for CTS with high degree of sensitivity and specificity, are performed to confirm the diagnosis, to determine the severity and exact site of nerve entrapment and to preclude alternative diagnoses that overlap with CTS in presentation.[1,5]

Decision making for surgery is mainly according to



**How to cite this article:** Tahririan MA, Moghtaderi A, Aran F. Changes in electrophysiological parameters after open carpal tunnel release. Adv Biomed Res 2012;1:46.

clinical findings in physical examination and degree of abnormalities on the NCS. In moderate to severe cases, surgical intervention for decompression of the median nerve by trans-section of the transverse carpal ligament (TCL) is the treatment of choice.[6]

There is still controversy in the literature concerning the correlation between the NCS and the outcome of surgical decompression of the median nerve.[7-10] The purpose of this study is to assess the changes in the electrophysiological parameters of the median nerve postoperatively and during a 9-month period in comparison with the preoperative values.

## MATERIALS AND METHODS

After obtaining ethics committee approval and informed written consent, 17 cases of moderate or severe electrophysiologically confirmed carpal tunnel syndrome (14 patients, 13 female, and 1 male), aged 28--78 years old, included in our study (from December 2010 to May 2011). All patients had been treated non surgically for at least 6 months.

These patients did not suffer from any medical condition that is known to affect the peripheral nerves, such as diabetes mellitus, double-crush syndrome, pregnancy, thyroid disease, connective tissue disease, malignancy, wrist fractures and hematoma, or other disorders resembling CTS like: cervical radiculopathy, brachial plexopathy, pronator teres syndrome and polyneuropathy, and were not on any drug that may cause a focal or generalized neuropathy, such as an antiepileptic drug, statin, chemotherapy and antiarrhythmic drug or consumption of corticostroids in the preceding 6 months. Patients suspected of any of the above were not included in this study. Patients with history of a prior carpal tunnel release or an inability to give informed consent or without their pre-op electrophysiological test for comparison were excluded as well.

All the data were collected by one physician. The patients were asked to estimate their general impression of procedure and improvement on a scale from 1 (completely satisfied) to 5 (completely dissatisfied). This included the actual clinical situation, diagnostic, and surgical measurements, and relationship between patient and physician.

Electrophysiological evaluations of all subjects were conducted by the same investigator with a Medelek electrophysiologic measurement system and by using standard techniques of supra-maximal cutaneous stimulation and surface electrode recording. Skin temperature was maintained at >32°C during the conduction studies.

The following parameters were analyzed: (1) distal motor latency to the abductor pollicis brevis muscle (APB) of the median nerve (DML); (2) Median nerve distal sensory latency of digit 3-to-wrist segment (DSL); and (3) Median sensory nerve conduction velocity of digit 3-to-wrist segment (SCV).

The NCS were performed as classically described in the literature. The distal motor latency was recorded with surface electrodes from the abductor pollicis brevis. The sensory responses were obtained at digit III for the median nerve. The normative value in our study for median motor distal latency was <4.2 ms, median sensory distal latency <3.6 ms and sensory nerve conduction velocity >48 m/s. Values more than or less than 2 SD from the mean were considered abnormal.

Results obtained are compared to age-dependent normal values, as well as to other nerves of the same hand or the contralateral hand.

Neurophysiological tests graded the CTS into the mild, moderate, and severe categories, according to the American Association of the Electrodiagnostic Medicine (AAEM) criteria: (1) Mild CTS: prolonged distal sensory latency with ± decreased sensory amplitude; (2) moderate CTS: abnormal median sensory latency with prolongation of the distal motor latency; (3) severe CTS: prolonged motor and sensory distal peak latencies either with a low or absent SNAP or CMAP. In the patients with bilateral CTS, the neurophysiological grade in the more severity affected hand was noted.[3,11]

Carpal tunnel decompression was performed by a group of surgeons who use the same surgical technique. Short incisions of the palm are performed just beyond the wrist fold. The transverse carpal ligament is sectioned in a proximal to distal direction along the ulnar side, and the division is extended subcutaneously, proximally, and distally, until complete release of the median nerve is achieved. The epineurium is left intact.

Comparison of the distal motor latencies (DML), distal sensory latencies (DSL), and sensory conduction velocities (SCV) was performed preoperatively and at 6 and 9 months postoperatively using the repeated measure analysis of variance. All analyses were conducted using SPSS v.16 and a one-tailed $P$ value $< 0.05$ was considered statistically significant.

## RESULTS

The majority of our cases were female (94.1%) and the average body mass index was in the overweight range

(mean ± SD, 27.72 ± 12.2 kg/m$^2$).

The mean ages at presentation were 54.47 ± 12.2 years, with the youngest patient at 28 years and oldest at 78 years. Seventy percent of the patients were between 40 and 60 years of age [Figure 1].

Using the repeated measure analysis of variance, demonstrated significant differences in the mean severity before (5.41 ± 0.87) and 6 (3.59 ± 1.54) and 9 months (2.82 ± 1.67) after CTR ($P < 0.001$) [Figure 2].

From the 17 hands were evaluated preoperatively, we had 4 (23.5%) with moderate, 2 (11.8%) with moderate to severe and 11 (64.7%) with severe CTS. Only 10 hands (58.8%) at 6 months and 6 hands (35.2%) at 9 months remained in this three degrees of severity that confirm our previous finding [Table 1].

At 6 months after surgery, 8 cases (47%) were completely satisfied[5] and satisfied.[3] Although this percentage remained unchanged at the end of the study; of those, seven cases were completely satisfied with the results, respectively, suggesting improvement in their general impression with the decreasing severity of CTS [Figures 3 and 4].

Significant differences were seen in comparison between satisfaction and severity at 6 ($P = 0/011$) and 9 ($P = 0/022$) months after surgery.[Tables 3 and 4] .

Notably patients were resolved electrophysiologically (none CTS group), had unsatisfactory opinion about the results because of developing symptoms again after a period of time and happening trigger finger (in one hand) [Tables 2 and 3].

DML ranged from 4.4 to 6.9 ms. DSL ranged from 3.49 to 8.65 ms and SCV ranged from 12.3 to 40.29 m/s. The changes in these parameters at 6 and 9 months postoperatively are detailed in Table 4.

The process of improvement in each parameters was statistically significant at both time points using repeated measure analysis of variance. Electrophysiologic measures revealed the absence of sensory responses in one hand at 6 months and in two hands (belonging to one patient) at 9 months after the operation. Comparison and statistical evaluation of these parameters during the study period are detailed in Table 5.

## DISCUSSION

A higher predominance of female patients with a ratio of 16:1, the average BMI in the overweight range and the mean age at the time of presentation

**Table 1: Frequency distribution of severity over the time**

| Time | Severity frequency (%) | | | | | |
|---|---|---|---|---|---|---|
| | None (%) | Mild (%) | Mild to Mod (%) | Moderate (%) | Mod. to severe (%) | Severe (%) |
| Pre-op | 0 | 0 | 0 | 4 (23.5) | 2 (11.8) | 11 (64.7) |
| After 6m | 2 (11.8) | 2 (11.8) | 3 (17.6) | 7 (41.1) | 0 | 3 (17.6) |
| After 9m | 3 (17.6) | 8 (47) | 0 | 3 (17.6) | 1 (5.9) | 2 (11.8) |

Mod. - Moderate; Pre-op - Preoperation

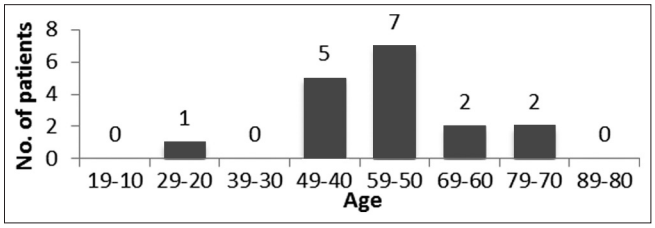


**Figure 1:** Age distribution of patients

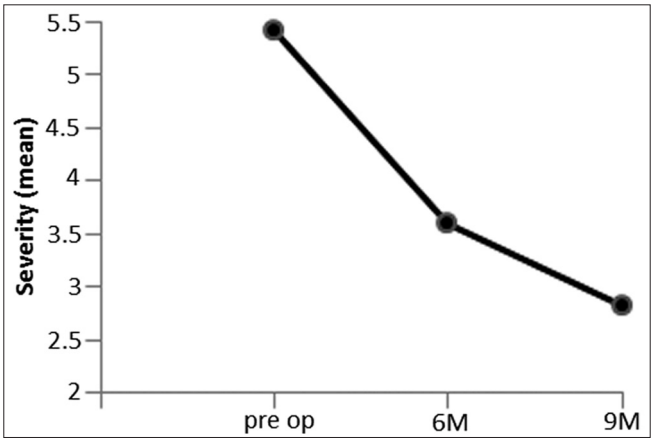


**Figure 2:** Mean severity differences over the time

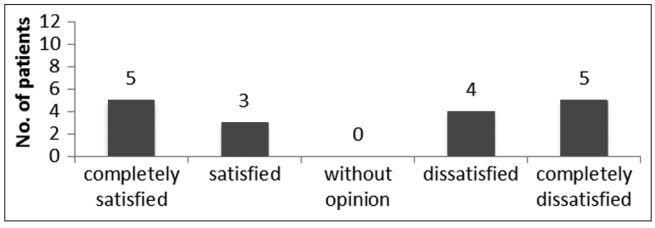


**Figure 3:** Distribution of patients satisfaction 6 months after surgery

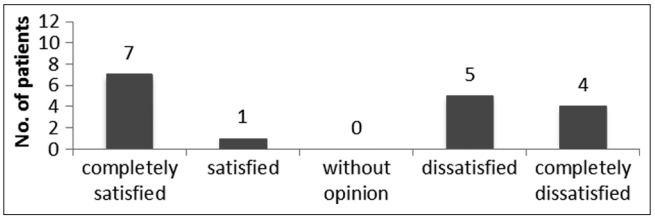


**Figure 4:** Distribution of patients satisfaction 9 months after surgery

**Table 2: Comparison between satisfaction and severity 6m after surgery**

| Severity | Satisfaction frequency (%) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Completely satisfied (%) | Satisfied (%) | Without opinion (%) | Dissatisfied (%) | Completely dissatisfied (%) | Total (%) | |
| None | 0 | 0 | 0 | 2 (100) | 0 | 2 (100) | $P = 0.011$ |
| Mild | 1 (50) | 0 | 0 | 0 | 1 (50) | 2 (100) | |
| Mild to Mod. | 3 (100) | 0 | 0 | 0 | 0 | 3 (100) | |
| Moderate | 1 (14.3) | 3 (42.9) | 0 | 2 (28.6) | 1 (14.3) | 7 (100) | |
| Mod. To Severe | 0 | 0 | 0 | 0 | 0 | 0 | |
| Severe | 0 | 0 | 0 | 0 | 3 (100) | 3 (100) | |
| Total | 5 (29.4) | 3 (17.6) | 0 | 4 (23.5) | 5 (29.4) | 17 (100) | |

Mod. - Moderate

**Table 3: Comparison between satisfaction and severity 9m after surgery**

| Severity | Satisfaction frequency (%) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Completely satisfied (%) | Satisfied (%) | Without opinion (%) | Dissatisfied (%) | Completely dissatisfied (%) | Total (%) | |
| None | 0 | 0 | 0 | 2 (66.7) | 1 (33.3) | 3 (100) | $P = 0.022$ |
| Mild | 7 (87.5) | 1 (12.5) | 0 | 0 | 0 | 8 (100) | |
| Mild to Mod. | 0 | 0 | 0 | 0 | 0 | 0 | |
| Moderate | 0 | 0 | 0 | 2 (66.7) | 1 (33.3) | 3 (100) | |
| Mod. To Severe | 0 | 0 | 0 | 1 (100) | 0 | 1 (100) | |
| Severe | 0 | 0 | 0 | 0 | 2 (100) | 2 (100) | |
| Total | 7 (41.2) | 1 (5.9) | 0 | 5 (29.4) | 4 (23.5) | 17 (100) | |

Mod. - Moderate

**Table 4: Electrophysiologic parameters of the median nerve before and after surgery**

| NCS preoperation | | | NCS 6m postoperation | | | NCS 9m postoperation | | |
|---|---|---|---|---|---|---|---|---|
| DML | DSL | SCV | DML | DSL | SCV | DML | DSL | SCV |
| 4.85 | 5.15 | 25 | 3.8 | 4 | 35.9 | 3.7 | 3.8 | 37.7 |
| 4.65 | 4.65 | 26.9 | 4.30 | 4.20 | 31.8 | 4.20 | 3.85 | 37.8 |
| 5.25 | 5.20 | 23.3 | 4.30 | 4 | 35 | 4.20 | 3.80 | 36.8 |
| 6.9 | 8.65 | 12.3 | 5.50 | 4.40 | 31 | 4.85 | 4.10 | 33.3 |
| 6.60 | 8.50 | 12.3 | 4.85 | 4.55 | 31.8 | 4.05 | 4 | 37.8 |
| 5.45 | 6.50 | 22.6 | 3.75 | 4.20 | 35 | 3.65 | 4 | 36.8 |
| 4.45 | 4.55 | 32.9 | 3.65 | 4 | 38.9 | 3.60 | 3.80 | 38.9 |
| 6.60 | 8.50 | 12.3 | 4.55 | 3.95 | 33.3 | 4.30 | 4.20 | 33.3 |
| 4.95 | 5.2 | 21.6 | 4.6 | 4.75 | 25.5 | 4.25 | 5.45 | 29.9 |
| 4.4 | 4.35 | 32.9 | 3.60 | 3.80 | 38.9 | 3.15 | 3.60 | 46.7 |
| 6.60 | 8.5 | 12.3 | 4.70 | 4.65 | 31.1 | 5.05 | 4.60 | 33.3 |
| 5.2 | 5.05 | 29.4 | 4.85 | 4.60 | 33.3 | 4.05 | 4.05 | 39.3 |
| 5.94 | 3.54 | 40.29 | 3.35 | 3.30 | 50 | 3.35 | 3 | 53.8 |
| 5.46 | 3.49 | 40.18 | 3.65 | 3.30 | 60.9 | 3.60 | 3.10 | 66.7 |
| 4.65 | 5 | 27.2 | 4.30 | 4.55 | 31.1 | 4.2 | 4.2 | 37.1 |
| 4.90 | 4.50 | 30.4 | 5.45 | 6.50 | 22.6 | 5.05 | Absent | Absent |
| 5.60 | 4.60 | 29.8 | 5.80 | Absent | Absent | 7.95 | Absent | Absent |

DML - Distal motor latency in milliseconds; DSL - Distal sensory latency in milliseconds; SCV - Sensory conduction velocity in meters/second

**Table 5: Comparison of electrophysiologic parameters before and after surgery onthe carpal tunnel**

| Parameters | Time of measurements (Mean ± SD) | | | |
|---|---|---|---|---|
| | Preoperation | 6m Postoperation | 9m Postoperation | *P* value |
| DML | 5.44 ± 0.82 | 4.41 ± 0.73 | 4.31 ± 1.09 | <0.001 |
| DSL | 5.79 ± 1.86 | 4.15 ± 0.45 | 3.97 ± 0.58 | 0.001 |
| SCV | 24.76 ± 9.57 | 36.23 ± 8.73 | 39.68 ± 9.5 | <0.001 |

DML - Distal motor latency in milliseconds; DSL - Distal sensory latency in milliseconds; SCV - Sensory conduction velocity in meters/second

(54.47) seen in our study, are similar to those of other studies and follows a normal distribution discussed in text books.[2,3]

Electrophysiological investigations reported severity improvement in 82.3% (14 cases) 6 months and in 88.2% (15 cases) 9 months after surgery. This is in accordance with the literature, where good outcomes are reported in 85% of cases underwent surgical treatment.[2,12]

Only 47% (eight cases) had satisfied or completely satisfied opinion about the results. Others, though still complaining of serious symptoms, had improved or normal NCS. We agree with Choi *et al.*, who suggest that the process causing symptoms of CTS may not be identical to process causing nerve conduction slowing.[9] Therefore, symptom improvement does not correlate with electrophysiologic grades, which are based on nerve conduction.

This study showed significant improvement in the DML, DSL, and SCV 6 months postoperatively.

Few studies in the literature have looked at the time and pattern of improvement in the electrophysiologic parameters after carpal tunnel release.

El-Hajj *et al.* (2010) examined 18 patients and showed significant improvement in all the studied variables (DML, M-amp, S-amp, and SCV), except the distal sensory latency, 18 weeks after surgery, wheras the DSL improved only at 42 weeks postoperatively.[13]

Ginanneschi *et al.* (2008) found in their recent series of 16 hands that 1 months after carpal tunnel release, SCV and DML improved but M-amp was still reduced. However, all parameters had significantly improved at 6 months postoperatively.[14] This pattern of improvement in conduction velocities with decreased M-amp was also reported in other studies (Mondelli *et al.*, 2000).[15]

In their large series, Prick *et al.* (2003) studied the changes in latencies in the median nerve 6 and 12 months postoperatively and found that both DSL and DML improved at 6 and 12 months, respectively; however, there was still some slowing in both latencies at 12 months in 80% of cases.[16]

Shurr *et al.* were among the first to study the electrophysiologic changes after carpal tunnel release, and they found that the MCV and SCV were significantly improved as early as 2 weeks postoperatively but the DSL and DML did not improve before 3 and 6 months, respectively.[17] The reason is that the CTS compression is in the distal part of the median nerve at the carpal tunnel rather than the proximal part in the forearm.

In their series of 50 patients, Naidu *et al.* (2003) showed that the DML and S-amp showed significant improvement at 6 months but the DSL and SCV remained slow.[18]

Because it is difficult to evaluate subjective symptoms and physical findings after carpal tunnel release, the only objective way to determine and quantitate objectively the improvement after decompression is by NCS. This is of utmost importance in patients who claim no clinical improvement after surgery or who develop symptoms again after a period of time after decompression.

NCS performed postoperatively are also important to determine inadequate decompression of the MN or recurrence of entrapment over time. The latencies after release, improve but, do not return to normal in most cases, and one can diagnose the recurrence of MN entrapment only by comparing pre- and postoperative NCS.

There are some limitations in our study. First, our study did not cover a large number of patients. Second, the preoperative symptoms were not recorded according to the severity of electrodiagnostic studies to be compared postoperatively. Third, our patients were mostly women, and these may not represent the general population with carpal tunnel syndrome.

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**Source of Support:** Nil, **Conflict of Interest:** None declared.