

*Research Article*

## Surgical Outcome of Clinically Diagnosed Carpal Tunnel Syndrome in Patients with Negative Nerve Conduction Studies

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### Abstract

**Background:** Carpal tunnel syndrome (CTS) is the most common entrapment neuropathy. The diagnosis of CTS relies upon the characteristic signs and symptoms of median nerve compression aided by positive provocative tests and nerve conduction studies (NCS). However, NCS remain normal in 15% of patients with characteristic clinical features of CTS. **Objective:** is to assess the surgical outcome of carpal tunnel release in patient with signs and symptoms of carpal tunnel syndrome, despite having negative nerve conduction studies. **Patients and methods:** 38 patients suffering from clinical signs and symptoms CTS with negative NCS were surgically treated after failure of conservative treatment. **Results:** There was statistically significant improvement in the postoperative clinical status and functional status of the patients. **Conclusion:** although nerve conduction studies aid in the diagnosis of most cases of carpal tunnel, negative studies do not exclude the diagnosis in patients with clinical signs and symptoms; thus, the diagnosis of carpal tunnel syndrome remains a clinical one.

**Keywords:** Median nerve, Carpal tunnel, nerve, entrapment, neuropathy.

### Introduction

Carpal tunnel syndrome (CTS) is the most common entrapment neuropathy, accounting for 90% of all entrapment neuropathies and 10–20% of all neurosurgical procedures. It affects approximately 0.6% of the male population and 5.8% of the female population. CTS is caused by chronic compression of the median nerve by the transverse carpal ligament within the carpal tunnel at the wrist. Patients present with potentially disabling pain and paresthesia of the hand and forearm, and impaired pinch and grip activities.<sup>13, 21</sup>

The diagnosis of CTS relies upon the characteristic signs and symptoms of median nerve compression aided by positive provocative tests and nerve conduction studies (NCS). However, NCS remain normal in 15% of patients with characteristic clinical features of CTS. Several studies attempted the use of different imaging modalities as an alternative to NCS, to detect nerve compression in these clinically positive CTS patients with normal NCS.<sup>16,20,21</sup>

Ultrasonography and magnetic resonance imaging (MRI) has been proven as diagnostic tools, providing anatomical details of the Median nerve and its cross-sectional area, and its surroundings in a painless non invasive economic manner. But there is no consensus regards their application in the diagnosis of CTS or their utilization as alternative tools to NCS.<sup>12,19,21</sup>

### Study subjects

This study included 38 patients suffering from clinical signs and symptoms of CTS with negative NC studies; all patients failed to respond to prolonged medical and physical therapy for durations more than 6 months. The Patients were informed in details about their clinical condition and the two alternative approaches; either to continue with non operative measures, or to proceed with the operative alternative. Meanwhile, it was made clear that surgery does not guarantee a good surgical outcome.

The clinical diagnosis of CTS was based upon Harrington et al., criteria: Pain, or paraesthesia, or sensory loss in the median

nerve distribution and one of: Tinel's test positive, Phalen's test positive, nocturnal exacerbation of symptoms, motor loss with wasting of abductor pollicis brevis.<sup>10</sup>

The patients were considered to have negative NCS based of the criteria of Padua et al.,<sup>16</sup>, which outlined the severity of CTS as detected by NCS as follows:

1. Negative (normal findings on all tests)
2. Minimal (abnormal segmental or comparative tests only)
3. Mild (abnormal digit/wrist sensory NCV and normal distal motor latency)
4. Moderate (abnormal digit/wrist sensory NCV and abnormal distal motor latency)
5. Severe (absence of sensory response and abnormal distal motor latency)
6. Extreme (absence of motor and sensory response)

#### Exclusion criteria

- Prior history of trauma or surgery of the wrist,
- Presence of rheumatoid arthritis and the presence of space-occupying lesions at the wrist.
- Previous history of neurological disease or Diabetes

All patients were operated through a vertical palmer incision under local anesthesia; without tourniquet application. The clinical status and functional status of the patients were assessed before and six month after surgery utilizing the Levine-Katz self-assessment questionnaire (Appendix 1, 2).<sup>15</sup> The institutional review board and the local ethics committee reviewed and approved the protocol of the study and informed consent documents.

#### Statistical analysis

The Data was collected and entered for statistical analysis using Statistical Package

for Social Sciences (SPSS/version 21) software. Arithmetic mean, standard deviation, Chi square test were used for categorized parameters. For comparison between pre and post operative numerical parametric data the t-test was used. The level of significance was 0.05.

#### Results

The study included 34 females and 4 males, with a mean age of 49.5 years (range: 32-62 years). The mean duration of symptoms prior to surgery was 10.18 months (range: 8 – 21 months), while the mean postoperative follow-up was 8.3 months (range: 6 to 16 months). The preoperative Harrington Et al., criteria are summarized in table 1.

There was significant reduction in the postoperative symptom severity scale of Levine-Katz self-assessment questionnaire in comparison with the preoperative score (table 2); where, there was a reduction of the preoperative score from a mean of  $26.05 \pm 4.42$  (range: 18-40) to a mean postoperative score of  $13.00 \pm 6.74$  (range: 11-53).

A similar significant reduction was observed in the postoperative functional status score of Levine-Katz self-assessment questionnaire in comparison with the preoperative score (table 3); where, there was a reduction of the preoperative score from a mean of  $15.45 \pm 4.46$  (range: 8-27) to a mean postoperative score of  $10.03 \pm 5.20$  (range: 8-40).

A patient developed complex regional pain syndrome, resulting in marked worsening of his symptom severity and functional status, about fifty percent of the patient still had some sort of weakness of their hand grip or their ability to open jars.

**Table (1): Distribution of the studied patients regarding Harrington et al., criteria**

Harrington <i>et al.</i> , criteria	No.	%
Pain or Paresthesia or Sensory loss	38	100.0
Tinnel sign	25	65.78
Phalen test	18	47.36
Nocturnal pain	20	52.63
Motor	24	63.15

**Table (2): Comparison between pre and post operative Symptom severity scale.**

	Pre operative		Postoperative		p-value
	No.	%	No.	%	
<b>1. How severe is the hand or wrist pain that you have at night?</b>					
1 I do not have hand or wrist pain at night	17	44.7	37	97.4	0.001*
2 Mild pain	2	5.3	0	0.0	
3 Moderate pain	9	23.7	0	0.0	
4 Severe pain	7	18.4	0	0.0	
5 Very severe pain	3	7.9	1	2.6	
<b>2. How often did hand or wrist pain wake you up during a typical night in the past 2 weeks?</b>					
1 .Never	17	44.7	37	97.4	0.002*
2 . Once	5	13.2	0	0.0	
3 . Two or three times	11	28.9	0	0.0	
4 . Four or 5 times	5	13.2	0	0.0	
5 . More than 5 times	0	0.0	1	2.6	
<b>3. Do you typically have pain in your hand or wrist during the daytime?</b>					
1 . I never have pain during the day	0	0.0	36	94.7	0.003*
2 . I have mild pain during the day	7	18.4	1	2.6	
3 . I have moderate pain during the day	16	42.1	0	0.0	
4 . I have severe pain during the day	14	36.8	0	0.0	
5 . I have very severe pain during the day	1	2.6	1	2.6	
<b>4. How often do you have hand or wrist pain during the daytime?</b>					
1 . Never	1	2.6	1	94.7	0.003*
2 . Once or twice a day	12	31.6	0	2.6	
3 . Three to 5 times a day	19	50.0	0	0.0	
4 . More than 5 times a day	6	15.8	1	0.0	
5 . Pain is constant	0	0.0	36	2.6	
<b>5. How long, on average, does an episode of pain last during the daytime?</b>					
1 . I never get pain during the day	1	2.6	36	94.7	0.004*
2 . Less than 10 minutes	17	44.7	1	2.6	
3 . 10 - 60 minutes	15	39.5	0	0.0	
4 . More than 60 minutes	5	13.2	0	0.0	
5 . Pain is constant throughout the day	0	0.0	1	2.6	
<b>6. Do you have numbness (loss or sensation) in your hand?</b>					
1 . No	3	7.9	33	86.8	0.001*
2 . I have mild numbness	18	47.4	4	10.5	
3 . I have moderate numbness	14	36.8	0	0.0	
4 . I have severe numbness	3	7.9	0	0.0	
5 . I have very severe numbness	0	0.0	1	2.6	

Table (2): Comparison between pre and post operative Symptom severity scale. "cont."

	Pre operative		Post operative		p-value
	No.	%	No.	%	
<b>7. Do you have weakness in your hand or wrist?</b>					0.002*
1 . No weakness	14	36.8	29	76.3	
2 . Mild weakness	3	7.9	8	21.1	
3 . Moderate weakness	14	36.8	0	0.0	
4 . Severe weakness	7	18.4	0	0.0	
5 . Very severe weakness	0	0.0	1	2.6	
<b>8. Do you have tingling sensations in your hand?</b>					0.003*
1 . No tingling	16	42.1	34	89.5	
2 . Mild tingling	18	47.4	2	5.3	
3 . Moderate tingling	4	10.5	1	2.6	
4 . Severe tingling	0	0.0	0	0.0	
5 . Very severe tingling	0	0.0	1	2.6	
<b>9. How severe is numbness (loss of sensation) or tingling at night?</b>					0.001*
1 . I have no numbness or tingling at night	17	44.7	37	97.4	
2 . Mild	6	15.8	0	0.0	
3 . Moderate	13	34.2	0	0.0	
4 . Severe	2	5.3	0	0.0	
5 . Very severe	0	0.0	1	2.6	
<b>10. How often did hand numbness or tingling wake you up during a typical night during the past 2 weeks?</b>					0.004*
1 . Never	21	55.3	37	97.4	
2 . Once	7	18.4	0	0.0	
3 . Two or 3 times	9	23.7	0	0.0	
4 . Four or 5 times	1	2.6	0	0.0	
5 . More than 5 times	0	0.0	1	2.6	
<b>11. Do you have difficulty with the grasping and use of small objects, such as keys or pens?</b>					0.003*
1 . No difficulty	7	18.4	21	55.3	
2 . Mild difficulty	5	13.2	15	39.5	
3 . Moderate difficulty	19	50.0	1	2.6	
4 . Severe difficulty	6	15.8	0	0.0	
5 . Very severe difficulty	1	2.6	1	2.6	
<b>Total score</b>					0.001*
Range	18-40		11-53		
Mean±S.D.	26.05±4.42		13.00±6.74		

**Table (3): Comparison between pre and post operative functional status outcome.**

	Pre operative		Post operative		p-value
	No.	%	No.	%	
<b>Writing</b>					
1 I do not have hard or wrist pain at night	16	42.1	33	86.8	0.008*
2 Mild pain	11	28.9	4	10.5	
3 Moderate pain	9	23.7	0	0.0	
4 Severe pain	2	5.3	0	0.0	
5 Very severe pain	0	0.0	1	2.6	
<b>Buttoning</b>					
1 I do not have hard or wrist pain at night	31	81.6	37	97.4	0.141 N.S.
2 Mild pain	4	10.5	0	0.0	
3 Moderate pain	3	7.9	0	0.0	
4 Severe pain	0	0.0	0	0.0	
5 Very severe pain	0	0.0	1	2.6	
<b>Holding book</b>					
past 2 weeks?					
1 .Never	14	36.8	37	97.4	0.001*
2 . Once	18	47.4	0	0.0	
3 . Two or three times	5	13.2	0	0.0	
4 . Four or 5 times	1	2.6	0	0.0	
5 . More than 5 times	0	0.0	1	2.6	
<b>Gripping phone</b>					
1 . I never have pain during the day	2	5.3	32	84.2	0.001*
2 . I have mild pain during the day	20	52.6	5	13.2	
3 . I have moderate pain during the day	13	34.2	0	0.0	
4 . I have severe pain during the day	3	7.9	0	0.0	
5 . I have very severe pain during the day	0	0.0	1	2.6	
<b>Open jars</b>					
1 . Never	3	7.9	18	47.4	0.001*
2 . Once or twice a day	11	28.9	18	47.4	
3 . Three to 5 times a day	14	36.8	1	2.6	
4 . More than 5 times a day	8	21.1	0	0.0	
5 . Pain is constant	2	5.3	1	2.6	
<b>House chores</b>					
1 . I never get pain during the day	13	34.2	31	81.6	0.001*
2 . Less than 10 minutes	16	42.1	6	15.8	
3 . 10 - 60 minutes	6	15.8	0	0.0	
4 . More than 60 minutes	3	7.9	0	0.0	
5 . Pain is constant throughout the day	0	0.0	1	2.6	

**Table (3): Comparison between pre and post operative functional status outcome .”cont.”**

	Pre operative		Post operative		p-value
	No.	%	No.	%	
<b>Carry grocery</b>					0.0041*
1 . No	9	23.7	27	71.1	
2 . I have mild numbness	17	44.7	10	26.3	
3 . I have moderate numbness	11	28.9	0	0.0	
4 . I have severe numbness	1	2.6	0	0.0	
5 . I have very severe numbness	0	0.0	1	2.6	
<b>Bath dress</b>					0.411 N.S.
1 . No weakness	35	92.1	37	97.4	
2 . Mild weakness	3	7.9	0	0.0	
3 . Moderate weakness	0	0.0	0	0.0	
4 . Severe weakness	0	0.0	0	0.0	
5 . Very severe weakness	0	0.0	1	2.6	
<b>Total score</b>					0.002*
Range	8-27		8-40		
Mean±S.D.	15.45±4.46		10.03±5.20		

### Discussion

There is much debate as regard NCS between the Association of Neuromuscular and Electrodiagnostic Medicine (ANEM) and the American Association of Orthopedic Surgeons (AAOS); where the ANEM considers NCS to be the gold standard for the diagnosis of CTS in various clinical practice guidelines, while the AAOS claims that there is limited evidence to support the capacity of a hand-held NCS technique to diagnose CTS.<sup>9</sup>

Although many electrodiagnostic techniques are able to improve NCS sensitivity, false negative results still remain in an estimated 10–25% of patients with clinical signs and symptoms of CTS.<sup>1</sup> Several studies consider NCS as complementary or even unnecessary for the diagnosis and outcome assessment of CTS, as they found either no or only a limited relationship between them and the patient's clinical status or satisfaction after surgery.<sup>3,6,8</sup>

The present study concurs with the findings of these studies, as there was significant patient improvement despite the pre-operative negative NCS.

Kitsis et al.,<sup>14</sup> attributed this discrepancy to a rise in the carpal tunnel pressure beyond the normal range of 3 to 5 mmHg, to pressures between 20–30 mmHg, which are

sufficient enough to cause epineurial edema, block of axonal transport and reduction of the epineurial blood flow of the median nerve. These changes may cause symptoms without disturbing the electrical function of the nerve. It was found that pressures exceeding 30–40mmHg were required before electrophysiological abnormalities can be detected<sup>7</sup>; while, complete intraneural ischemia and motor and sensory block occur at about 60 mmHg.<sup>18</sup>

Borire et al., had symptomatic patients with negative NCS, but had carpal tunnel pressures ranging between 20–30 mmHg (pressures as previously mentioned, that might cause symptoms in the absence of alterations in NCS parameters) and demonstrated nerve enlargement by US. They concluded that normal NCS findings do not exclude CTS, and that US may be a useful tool in the detection of CTS in this cases.<sup>1</sup>

Conventional NCS assess only large motor and sensory (A $\beta$ )- nerve fibers (involved with proprioception and light touch sensation) and do not assess small myelinated (A $\delta$ ) and unmyelinated (C) nerve fibers (involved with temperature and pain sensations), the two later nerve fibers have been implicated with different stages of the disease. The assessment of these small nerve fibers requires specific techniques, like quantitative sensory testing or laser

evoked potentials to investigate temperature and pain sensations, which are less commonly available and performed than conventional NCS.<sup>4,19</sup>

Braun et al., had performed surgical release of the carpal tunnel in their study population which was divided into three groups; a group with positive NCS, a second group having normal NCS and a third that had not undergone NCS. At their final assessment, all three groups had comparable improvement in their clinical outcome (80% of the first group, 80% of the second group and 87% of the third group of patients).<sup>2</sup>

Heybeli et al., found that neither did the symptom severity and functional status scales correlation with postoperative improvement in distal motor and sensory conduction Nor did the postoperative improvements in the functional status scale and symptom severity scale scores correlate with the severity of the preoperative electrophysiological scores.<sup>5,11</sup>

### Conclusion

Although nerve conduction remains an important diagnostic tool in the armamentarium of CTS diagnosis, the diagnosis of CTS remains a clinical one. The surgical option should be offered to clinically positive patient even if their NCS are negative, but only after ample periods of conservative measures and after excluding other pathologies that might contribute to complaint.

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## Appendix 1 Symptom severity scale

### 1. How severe is the hand or wrist pain that you have at night?

- 1 ± I do not have hand or wrist pain at night
- 2 ± Mild pain
- 3 ± Moderate pain
- 4 ± Severe pain
- 5 ± Very severe pain

### 2. How often did hand or wrist pain wake you up during a typical night in the past 2 weeks?

- 1 . Never
- 2 . Once
- 3 . Two or three times
- 4 . Four or 5 times
- 5 . More than 5 times

### 3. Do you typically have pain in your hand or wrist during the daytime?

- 1 . I never have pain during the day
- 2 . I have mild pain during the day
- 3 . I have moderate pain during the day
- 4 . I have severe pain during the day
- 5 . I have very severe pain during the day

### 4. How often do you have hand or wrist pain during the daytime?

- 1 . Never
- 2 . Once or twice a day
- 3 . Three to 5 times a day
- 4 . More than 5 times a day
- 5 . Pain is constant



**5. How long, on average, does an episode of pain last during the daytime?**

- 1 . I never get pain during the day
- 2 . Less than 10 minutes
- 3 . 10 - 60 minutes
- 4 . More than 60 minutes
- 5 . Pain is constant throughout the day

**6. Do you have numbness (loss or sensation) in your hand?**

- 1 . No
- 2 . I have mild numbness
- 3 . I have moderate numbness
- 4 . I have severe numbness
- 5 . I have very severe numbness

**7. Do you have weakness in your hand or wrist?**

- 1 . No weakness
- 2 . Mild weakness
- 3 . Moderate weakness
- 4 . Severe weakness
- 5 . Very severe weakness

**8. Do you have tingling sensations in your hand?**

- 1 . No tingling
- 2 . Mild tingling
- 3 . Moderate tingling
- 4 . Severe tingling
- 5 . Very severe tingling

**9. How severe is numbness (loss of sensation) or tingling at night?**

- 1 . I have no numbness or tingling at night
- 2 . Mild
- 3 . Moderate
- 4 . Severe
- 5 . Very severe

**10. How often did hand numbness or tingling wake you up during a typical night during the past 2 weeks?**

- 1 . Never
- 2 . Once
- 3 . Two or 3 times
- 4 . Four or 5 times
- 5 . More than 5 times

**11. Do you have difficulty with the grasping and use of small objects, such as keys or pens?**

- 1 . No difficulty
- 2 . Mild difficulty
- 3 . Moderate difficulty
- 4 . Severe difficulty
- 5 . Very severe difficulty

(From Levine et al., (1993) with permission.)

**Appendix 2 Functional status scale**

On a typical day during the past 2 weeks, have hand and wrist symptoms caused you to have any difficulty doing the activities listed below? Please circle one number that best describes your ability to do the activity

Activity	No difficulty	Mild difficulty	Moderate difficulty	Severe symptoms	Cannot do at all due to hand
Writing	1	2	3	4	5
Buttoning of clothes	1	2	3	4	5
Holding a book while reading	1	2	3	4	5
Gripping of a telephone receiver	1	2	3	4	5
Opening of jars	1	2	3	4	5
Household chores	1	2	3	4	5
Carrying of grocery bags	1	2	3	4	5
Bathing and dressing	1	2	3	4	5