Original Article

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Changes of the six-item carpal tunnel syndrome (CTS) symptoms scale and the nerve electrophysiological findings after surgery for CTS with abnormal nerve electrophysiological findings

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Background: The aim of this study was to compare the Six-Item CTS Symptoms Scale (CTS-6) and nerve electrophysiological findings between pre- and the postoperative states of patients with carpal tunnel syndrome (CTS) who were treated by carpal tunnel release.
Methods: The preoperative and postoperative CTS-6 and nerve electrophysiological findings were evaluated in a total of 60 cases treated for CTS. Preoperative nerve electrophysiological study determined the presence of CTS and the postoperative analysis was performed at a mean 3.75 years after intervention. Poor prognostic factors and preoperative nerve electrophysiological findings influencing the recovery periods were evaluated.
Results: As compared with the preoperative score, the average CTS-6 at the latest follow-up improved from 3.21 ± 0.66 to 1.86 ± 0.72 ($P < 0.001$) in 53 out of 60 cases (88%). Likewise, the nerve electrophysiological findings based on Bland grade system improved significantly from 2.23 ± 1.16 to 1.86 ± 0.72 ($P < 0.001$). There were statistically significant differences seen between the improved values of CTS-6 and Bland grade ($P = 0.048$). The conduction velocity of the sensory nerve was improved from 36.58 ± 6.47 m/sec to 39.20 ± 1.10 m/sec ($P < 0.01$), and the distal latency of the motor nerve improved from 4.03 ± 1.40 to 3.67 ± 1.10 ($P = 0.038$). In electrophysiological findings, the recovery period of the isolated CTS was relatively shorter compared to CTS combined with cervical radiculopathy ($P = 0.049$).
Conclusion: The outcome of surgery for CTS was excellent in most cases. The CTS-6 was a very reliable, valuable and useful indicator for the treatment outcome. There was a statistically significant difference between the CTS-6 and Bland grade. Our data shows that for CTS patients with combined cervical radiculopathy, recovery period after CTS surgery may be negatively impacted.

Keywords: Carpal tunnel syndrome; Six-item CTS symptoms scale; Nerve electrophysiological findings; Carpal tunnel release

INTRODUCTION

Carpal tunnel syndrome (CTS) is a relatively common disease of the hand. Usually preservative treatment is performed but if ineffective, rotator cuff excision and decompression of the median nerve, termed as carpal tunnel release, results in a successful outcome. Between 70%–90% of patients show enhanced clinical condition after carpal tunnel release [1], but painful lesion, edema, decrease in hand strength, and surgery-related nerve injury may delay recovery. Previous studies have analyzed the extent of recovery and prognosis after carpel tunnel release, but factors influencing the recovery period have not been investigated. Wever and Rude [2] and Weber et al. [3] looked at 105 cases of carpal tunnel release and found improved clinical and functional outcome in all cases at an average follow-up period of 6 months. However, they noted that the actual duration

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for full resolution of symptoms took longer for most cases. Nerve electrophysiological examination not only enables diagnosis of CTS but also measures the severity of CTS, and gives an objective evaluation of recovery after treatment. For example, distal latency of motor and sensory nerves have been shown to be closely associated with recovery of clinical symptoms [4], but controversy regarding this issue exists [5]. The present report focuses on the comparison between the preoperative and postoperative values of the six-item CTS symptoms scale introduced by Atrochi et al. [6], and the nerve electrophysiological findings in CTS-diagnosed patients who underwent conservative carpal tunnel release, and determine whether factors influencing the recovery of clinical symptoms exist.

METHODS

From May 2007 until December 2012, 98 patients diagnosed with CTS received conventional open transverse carpal ligament release surgery for CTS from our clinic. Of these, 42 patients (60 cases of CTS) were subject to a retrospective study that had an average follow-up period of 3 years and 9 months (range, 1 year to 5 years 3 months), whilst the other 56 patients were unable to participate in the follow-up examinations. Of the 42 patients, 6 were male (7 cases) and 36 were female (53 cases) and had an average age at the time surgery of 56.1 years (range, 25 to 74 years). There were 18 bilateral cases and 24 unilateral cases of CTS. The primary diagnosis of CTS was made using the physical examinations such as Tinel sign and Phalen examination, as well as clinical symptoms of sensory defects, numbness, and pain around the nerve distribution of the hand. Also, the presence thenar muscle atropy was used as a diagnostic marker for CTS. Furthermore, diagnosis was made if nerve electrophysiological tests detected decrease in the velocity of nerve conduction or the electromyogram test detected denervation potential, in the form of fibrillation potential or positive sharp wave, in the symptomatic muscles innervated by the median nerve.

All surgery was performed by one surgeon. In order to minimize complications from damage of palmar cutaneous braches of the ulnar nerve and median nerve in proximal portion, motor nerves branches of median nerve and also the superficial palmar arch in distal portion, a 3cm of skin incision was made from proximal transverse carpal ligament following the third interdigital web space to the adipose pads, before decompression of the median nerve. In most cases, transverse carpal ligament hyperplasia (97%) and median nerve atrophy (61%) were detected, but in no case was neurolysis required.

The pre- and postoperative values of CTS-6 [6] and the Bland grade system [7] that classifies results from the nerve electrophysiological findings from grade 0 to 6 were used to test whether a significant association between change in these values and clinical recovery existed. Postoperative values were taken around 4–6 months after surgery and spaced out by as much until the final follow-up. If preoperative CTS-6 could not be taken, clinical assessment was performed retrospectively using medical records, questionnaires, and interviews. Further, putative factors such as patient age, duration of disease contraction, presence of comorbid diseases, and presence of thenar muscle atropy were compared to the duration of recovery period required to test for a statistical association. The subjective values for recovery of clinical symptoms were resolution of numbness, pain, sensory deficit. Further, negative to positive results in provocative tests such as Phalen examination and Tinel sign, and nerve electrophysiological tests showing improvements in values of CTS to the level of the non-affected hand were defined as a successful recovery after carpal tunnel release.

The statistical analysis tool used to test the association between the changes of pre- and postoperative values with the period of symptom recovery was the Pearson correlation coefficient. The paired t-test was performed using SPSS ver. 18.0 (SPSS Inc., Chicago, IL, USA) and $P < 0.05$ with a confidence interval of 95% was determined as statistically significant.

RESULTS

The CTS-6 improved from a mean score of 3.21 ± 0.66 to 1.86 ± 0 postsurgery in 53 of 60 cases (88%), showing a statistically significant improvement ($P < 0.001$) (Table 1).

Table 1. Changes of the the six-item CTS symptoms scale and bland grade

Parameter	Before surgery	Latest follow-up	P-value[a)]
Six-item CTS symptoms scale	3.21 ± 0.66	1.86 ± 0.72	<0.001
Bland grade	2.23 ± 1.16	1.08 ± 1.12	<0.001

Values are presented as mean ± SD.
CTS, carpal tunnel syndrome.
[a)]Paired t-test.

Nerve electrophysiological findings evaluated using the Bland grade system showed a statistically significant enhancement from a preoperative value of 2.23 ± 1.16 to a postoperative value of 1.86 ± 0.72 (P < 0.001) (Table 1). The statistical significance between changes in the Bland grades and changes in the CTS-6 score was also seen (P = 0.048) (Table 2). However, the statistical significance between the improvement in distal latency of the motor nerve within the median nerve and the results of CTS-6 was not seen, and neither was it seen with improvements in the conduction velocity of the sensory nerve (P > 0.05) (Table 2). Nerve electrophysiological findings show conduction velocity of sensory nerves improved from 36.58 ± 6.47 m/sec to 39.20 ± 1.10 m/sec (P = 0.01), and similarly, distal latency of the motor nerves improved from 4.03 ± 1.40 to 3.67 ± 1.10 (P = 0.038) (Table 3). For the 6 patients whose conduction velocity of sensory nerves were not determined, in-between follow-ups between the surgery and final check-up showed a gradual increase in velocity.

Table 2. Correlations between the six-item CTS symptoms scale and nerve electrophysiological findings

Electrophysiological finding	No.	Pearson correlation coefficient	P-value[a)]
Bland grade	60	0.257	**0.048**
Motor DL (msec)	60	-0.044	0.755
Sensory NCV (m/sec)	54	0.129	0.327

CTS, carpal tunnel syndrome; DL, distal latency; NCV, nerve conduction velocity.
[a)]Pearson correlation coefficients.

Table 3. Changes of nerve conduction parameter

Parameter	Before surgery	Latest follow-up	P-value[a)]
Motor DL (msec)	4.03 ± 1.40	3.67 ± 1.10	0.038
Sensory NCV (m/sec)	36.58 ± 6.47	39.20 ± 6.74	0.010

Values are presented as mean ± SD.
DL, distal latency; NCV, nerve conduction velocity.
[a)]paired t-test.

Sex, presence of thenar muscle atropy, and diabetes were not shown to influence the period taken for clinical symptoms to resolve (P > 0.05) (Table 4). However, according to nerve electrophysiological findings, the carpel tunnel syndrome, if diagnosed isolated showed a statistically significant quicker recovery was seen than when it was combined with cervical radiculopathy (P = 0.049) (Table 4). Patient age, duration of symptoms, preoperative CTS-6 symptom index, preoperative nerve electrophysiological findings of conduction velocity of sensory nerves and distal latency of motor nerves showed no statistical correlation to the recovery period after carpel tunnel release (P > 0.05) (Table 5). However, higher the preoperative Bland grade, the longer it took for the clinical symptoms to disappear (P = 0.02) (Table 5).

DISCUSSION

The typical symptoms of CTS are pain, sensory deficit, rigidness, thenar muscle weakness, and numbness within median nerve distribution of the hands, and further it is shown to be more prevalent in females than males [8]. Diagnosis is made by taking provocative

Table 4. Associations between categorical preoperative predictor variables and recovery periods

Preoperative predict variable	No.	Mean ± SD	P-value[a)]
Sex			0.328
Male	7	6.86 ± 4.22	
Female	53	11.55 ± 12.40	
Thenar atrophy			0.733
Absent	47	11.28 ± 11.23	
Present	13	10.00 ± 14.22	
Cervical radiculopathy			**0.049**
Absent	43	9.12 ± 11.02	
Present	17	15.76 ± 12.75	
Diabetic mellitus			0.46
Absent	42	11.12 ± 11.24	
Present	18	10.72 ± 13.41	

[a)]Independent T-test.

Table 5. Correlations between continuous preoperative predictor variables and recovery periods

Preoperative predictor variable	No.	Pearson correlation coefficient	P-value[a)]
Duration of symptom	60	−0.138	0.291
Age	60	0.165	0.209
Preoperative six-item CTS symptoms Scale	60	−0.158	0.227
Preoperative sensory NCV (m/sec)	54	0.217	0.119
Preoperative motor DL (msec)	60	−0.246	0.059
Preoperative bland grade	60	−0.300	**0.020**

CTS, carpal tunnel syndrome; NCV, nerve conduction velocity; DL, distal latency.
[a)]Pearson correlation coefficients

tests such as Tinel sign and Phalen tests on the wrist, and electrophysiological findings tests such as electromyography and nerve conduction tests [9]. If only trivial symptoms exist, indicative of an early stage of disease, conservative method, for example, drug therapy, wrist splinting and steroidal treatment, is undertaken [8,10]. If the patient is unresponsive to this treatment and no clinical improvements are seen, or there is recurrence of disease, alterations in sensory nerve, or nerve atrophy surgical intervention should be considered [11]. In this study intraoperative findings in almost all cases were hypertrophy of the rotator cuff and subsequent decompression of the median nerve, however no periphery tissue adhesion was seen or any that required of neurolysis.

Various questionnaires are able to assess CTS patients, such as Boston carpal tunnel questionnaire [12], Michigan hand outcome [13], Disability of arm shoulder and hand [14], patient evaluation measure [15], clinical rating scale [16], upper extremity functional scale [17], and the six-item CTS symptoms scale [6] etc. The present study used the six-item CTS symptoms Scale, a well establish clinical tool to evaluate pre- and postoperative clinical symptoms. For our study, a statistically significant increase from a preoperative average of 3.21 ± 0.66 to a postoperative average of 1.86 ± 0.72 was seen ($P < 0.001$). With regards to the Boston questionnaire, several studies looking at the association between this assessment method and nerve electrophysiological findings exist [18–20]. In contrast, not much is known of the relationship between the CTS-6 and nerve electrophysiological findings. Our report determined the pre- and postoperative values of the Bland grade [7], which classifies the nerve electrophysiological findings from grade 0 to 7 of CTS patients and the CTS-6 score, and found a statistical significant correlation between the two ($P = 0.048$). This may be because the main symptoms of CTS (numbness of the hands, sensory deficit, and tingling sensation etc.) are closely related to the peripheral neuropathy [21], on which this scale is based. However, Kemble [4] saw that even if postoperative improvement of symptoms were seen, nerve conduction velocity may not be recovered to its normal level, which may be because the decreased diameter of nerve fibers cannot be restored to its normal level. This study also looked at improvements in neurotransmission through factors, such as distal latency of the motor nerve within the median nerve and the conduction velocity of sensory nerve, and its correlation to CTS-6, but did not see a statistically significant difference ($P > 0.05$). Although according to the the Bland grade [7], nerve electrophysiological findings may show a difference in the clinical symptoms, subtle changes in sensory nerve conduction velocity and distal latency of motor nerves may not be detected by broad intra-Bland grades. To see such visible changes using this indicator would require more time for symptoms recovery, and intra-patient subjectivity may influence the results also.

Enhancement in distal latency of the motor nerve within the median nerve and the conduction velocity of sensory nerve was found at 6 months follow-up, after a symptomatic wrist had undergone carpal tunnel release, according to nerve electrophysiological findings by Senda et al. [22] and Reale et al. [23]. The current study also found that a significant improvement was seen in terms of distal latency of the motor nerve within the median nerve ($P < 0.001$) and the conduction velocity of sensory nerve ($P < 0.001$). Even in 6 cases where preoperative conduction velocity of sensory nerve was near zero, postoperative improvements were seen. Results improved for individuals upon long-term follow-up even when their preoperative nerve electrophysiological values were poor, indicating symptom resolution could take a long time in some individuals.

Poor prognoses in patients with CTS are age, smoking, alcohol consumption, comorbidity, duration of disease contraction, nocturnal pain, and compensatory psychology. Further, delayed nerve conduction tests is also being studied as one prognostic factor [24]. In this study, recovery of symptoms after the surgery was delayed due to the combined cervical radiculopathy, and it is thought that despite resolution of symptoms resulting from median nerve decompression, persistence of cervical radiculopathy that had similar symptoms to CTS, perceived symptoms of CTS did not recover. Pauda et al. [25] found a functional link between the nerve electrophysiological findings and clinical signs of CTS, but no correlation in terms of the actual relief of clinical symptoms of the patient. This, they proposed, was due to the eventual increase in the intensity of pain as the disease proceeded. So, even at an early stage, changes in the nerve electrophysiological findings may be seen, but this may not be reflected by patients' symptoms. The authors concluded that such findings were not useful to predict prognosis after surgery.

In this study, although we found an association between the nerve electrophysiological findings as classified using the bland grade and the period required for symptom

recovery (P = 0.048), the preoperative distal latency of the motor nerve within the median nerve and the conduction velocity of sensory nerve showed no apparent relationship (P > 0.05). Presence of thenar muscle atrophy after the operation has been shown to exert a negative influence on recovery [26]. Yet, other studies give contradicting results that state otherwise, and this was thought that subjectivity of mild atrophy was difficult to rely [27]. In our study, 7 cases showed no improvement of the postoperative CTS-6. Of these, 2 cases had combined cervical radiculopathy, and 2 cases had a severe preoperative symptom of sensory deficit having a visual analog scale of greater than 8, only resolving partially after the operation. Further, of the 13 cases of combined thenar muscle atrophy, 3 cases were of severe atrophy and their condition worsened after the operation and at the same time did not see an improvement in the CTS-6 scale. However, the rest 10 cases (77%) showed mild muscle atrophy and showed postoperative enhancement of CTS-6 value, and for these cases muscle atrophy was not associated with recovery time (P > 0.05).

The current study looked at the known poor prognosis factors influencing the recovery period of patients that underwent treatment for CTS. However, we found no correlation between the recovery period and having such factors. Follow-up studies showed that delay in recovery from carpal tunnel release might otherwise occur due to loss of pinch strength, grip strength, scar pain from skin incision, neuroma, and sensory deficit that arose from surgical intervention.

In conclusion, the six-item CTS symptoms scale questionnaire can be used along with other questionnaires to usefully determine the clinical improvements after surgical treatment of patients with carpal tunnel syndrome. Combined cervical radiculopathy may have a negative impact on surgical outcomes of carpal tunnel release and recovery thereafter. Further, during surgical intervention, care must be taken so that complications do not arise from the accidental damage of palmar cutaneous braches of the ulnar nerve and median nerve in proximal portion, motor nerves branches of median nerve and the superficial palmar arch in distal portion.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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