



12-31-2016

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Recommended Citation

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DOI: [https://doi.org/10.6315/2016.44\(3\)01](https://doi.org/10.6315/2016.44(3)01)

Available at: <https://rps.researchcommons.org/journal/vol44/iss3/1>

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The Use of Ultrasonography to Assess Outcomes and Prognostic Indicators in Carpal Tunnel Syndrome: A Study in Patients Treated with Night Splinting

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The Use of Ultrasonography to Assess Outcomes and Prognostic Indicators in Carpal Tunnel Syndrome: A Study in Patients Treated with Night Splinting

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Background: Controversy exists regarding the use of ultrasonography (US) to assess outcome variables and prognostic indicators of carpal tunnel syndrome (CTS).

Objective: To investigate the value of US in evaluating outcomes and prognosis for CTS treated with night splinting.

Methods: Fifty-eight hands with mild to moderate CTS were prospectively enrolled; 42 diseased hands completed the study. Satisfaction rating, symptom severity score (SSS), functional status score (FSS), nerve conduction study (NCS) data, and US data were evaluated as outcome variables before and after 3 and 6 months of night splinting. On an intent-to-treat basis, a binary logistic regression analysis was used to determine prognostic indicators of subjective satisfaction and receiver operating characteristic (ROC) curves were plotted.

Results: After 6 months of splinting, 29 hands had good subjective outcomes and 13 had poor subjective outcomes. SSS, FSS, sensory conduction velocity (SCV) on NCS, and the cross-sectional area of the median nerve at the pisiform bone level (PCSA) on US improved significantly in hands with good satisfaction but not in hands with poor satisfaction. On an intent-to-treat basis, 29 hands were categorized as good or poor subjective outcomes respectively. According to regression model and the ROC curves, SCV and PCSA were independent prognostic indicators, and the optimal cut-off values of SCV and PCSA for good subjective outcome were $\geq 40\text{m/s}$ and $\leq 11.35\text{ mm}^2$ respectively.

Conclusions: US is an appropriate tool for assessing outcome variables and a prognostic indicator of night splinting for CTS. (Tw J Phys Med Rehabil 2016; 44(3): 123 - 134)

Key Words: carpal tunnel syndrome, ultrasonography, nerve conduction study, splint, prognostic indicator

INTRODUCTION

Carpal tunnel syndrome (CTS) is diagnosed by subjective symptoms and clinical manifestations and then confirmed by nerve conduction studies (NCSs).^[1]

Submitted date: 4 January 2017

Revised date: 10 April 2017

Accepted date: 18 April 2017

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doi: 10.6315/2016.44(3)01

Ultrasonography (US) has recently been introduced as a reliable and valid diagnostic tool for CTS.^[1-9] An increased cross-sectional area of the median nerve at the pisiform bone level (PCSA), which is the location considered to be the inlet of the carpal tunnel, is a key US finding in CTS.^[2,4,6] Moreover, various clinical studies have shown that US findings correlate with clinical symptoms as well as with NCS results.^[4-7,9,10]

Severe cases of CTS may require the operative release of the flexor retinaculum. Mild to moderate cases are often treated conservatively, via corticosteroid injection or wrist splinting.^[11-13] Traditional outcome variables for CTS treated with wrist splinting include quantification of subjective symptoms and NCSs.^[14-17] Prognostic indicators of wrist splinting for CTS include symptom duration, pre-treatment symptom severity, and pre-treatment NCSs.^[18-20] There is a growing interest in the application of the PCSA on US as a possible outcome variable and prognostic indicator of CTS following both surgical and non-surgical treatments, although controversy exists. Several studies have reported that the PCSA decreases after successful operative and non-operative treatments; thus, the PCSA may serve as an outcome variable.^[21-29] However, two studies did not find a difference in post-surgical PCSA reduction between patients with good subjective outcomes and those with poor outcomes.^[30,31] With respect to studies evaluating prognostic indicators, four studies demonstrated that smaller pre-treatment PCSAs predicted successful outcomes after treatment, including surgical decompression and local corticosteroid injections.^[23,32-34] To the best of our knowledge, only two publications have described the effectiveness of therapeutic splinting for CTS using US data.^[26,35] However, no research has evaluated if US data can predict prognosis after splinting. Additionally, studies have shown inconsistent results in patients with CTS treated with wrist splinting.^[26,35] The aim of our study was to investigate whether US parameters, specifically the PCSA, could serve as outcome variables and/or prognostic indicators of mild to moderate CTS treated with night splinting.

MATERIALS AND METHODS

Subjects presenting with CTS symptoms were

recruited from a medical center that is open to the public and receives patients referred from local hospitals and clinics. The screening process began with an interview to review demographic data and medical and surgical history. Patients underwent NCSs to confirm CTS or exclude other neuropathies and were assessed by US to identify any anatomic variations or space-occupying lesions in the carpal tunnel. Each patient was treated with night splinting for 6 months. Evaluations were carried out before night splinting (T0) and 3 months (T1) and 6 months (T2) after night splinting. This study was approved by the institutional review board of the medical center; written informed consent was also obtained. Information provided to patients before recruitment included the aim, procedures, and potential complications of the study, as well as the participants' rights.

Inclusion Criteria

Patients were included if they: (1) had two or more core symptoms suggestive of CTS (nocturnal paresthesia that awakened the patient from sleep; shaking the hand to relieve symptoms; pain and/or paresthesia evoked by hand grip; sensory symptoms in digits one, two, and three or part of the fourth digit; or any combination),^[36] (2) had experienced the symptoms for more than 1 month, and (3) were diagnosed with mild to moderate CTS based on the NCS (Padua's classification grade 2, 3, or 4; Appendix).^[37]

Exclusion Criteria

Exclusion criteria were as follows: (1) inability to express symptoms, function, or general satisfaction; (2) history of systemic diseases associated with peripheral neuropathy, such as diabetes mellitus, chronic renal failure, and hypothyroidism; (3) history of trauma or paralysis of the upper extremity; (4) previous carpal tunnel release surgery; (5) pregnancy; (6) ulnar neuropathy, cervical radiculopathy, polyneuropathy, or nerve anastomosis on the NCS; (7) severe CTS based on the NCS (Padua's classification grade 5 or 6 See Appendix),^[37] or (8) an anatomic variation or space-occupying lesion in the carpal tunnel on US.

Intervention

For patients meeting the inclusion criteria, volar

low-temperature thermoplastic customized splints were fabricated by an experienced occupational therapist. The splints maintained the wrist in the neutral position to minimize median nerve compression and intra-tunnel pressure while allowing the thumb and fingers to move freely.^[38,39] The patients were instructed to wear the splints while sleeping at night over a period of 6 months. Other treatments for CTS, such as physical modality, analgesics, corticosteroid injection, surgery, and alternative medicine, during the period of study were not allowed. Self-care for CTS at home such as activity modification and posture modulation was not forbidden. Participants who received different treatments dropped out from the study and were categorized as poor subjective satisfaction of splinting on an intent-to-treat basis. Patients who were not satisfied with outcomes after 6 months of night splinting were referred for other treatments, such as steroid injection or surgery.

Outcome Variables

1. General subjective satisfaction

Patients rated their general subjective satisfaction after 6 months of night splinting on a four-point transition scale: complete recovery, much improved, stationary, and much worse. Complete recovery and much improved were categorized as good subjective outcomes; stationary and much worse were categorized as poor subjective outcomes.

2. Symptom severity scale (SSS) and functional status scale (FSS) of CTS

Patients completed a self-administered questionnaire that included the SSS and FSS, which is a validated cross-cultural method for assessing the clinical symptoms and functional status in patients with CTS.^[40,41] In the SSS, symptoms are quantified on an 11-item scale. Each item is presented in a multiple-choice format. For FSS, the questionnaire contained eight multiple-choice items regarding subjective functional status. The score for each item ranged from one point (none or never) to five points (very severe). The mean scores of the SSS and FSS for each patient were recorded for later analysis.

3. Sensory conduction velocity, wrist to index finger (SCV), motor distal latency (MDL) of the median nerve,

and Padua's grade.^[37]

The NCS guidelines of the American Association of Electrodiagnostic Medicine for CTS were followed^[42] using the Viking IV Electrodiagnostic System (Nicolet Biomedical Inc., Madison, WI, USA). A licensed physiatrist, blinded to the patients' clinical and US data, performed the NCS. The temperature of the tested limbs was maintained at 32°C to 34°C. The motor response of the median nerve was recorded at the abductor pollicis brevis with stimulation at the wrist at a distance of 6 cm. The sensory response of the median nerve was recorded at the index finger with stimulation at the wrist at a distance of 13 cm, and the SCV was calculated as 13cm divided by the onset sensory latency. By recording the sensory response at the fourth digit following stimulation at a distance of 12 cm, the median-ulnar sensory latency difference was obtained. Additionally, routine ulnar motor and sensory studies, as well as electromyography, were performed to exclude other abnormalities. In the electrophysiological laboratory, CTS was diagnosed if any one criterion was met: MDL >4.1 ms; SCV <48m/s; or median-ulnar sensory latency difference in the fourth digit, >0.4 ms. These diagnostic criteria were derived from the data of 20 healthy subjects and defined as the mean plus two standard deviations.^[2] The severity of CTS was further graded by Padua's classification (See Appendix).^[37]

4. The cross-sectional area of the median nerve at the pisiform bone level (PCSA) and at the hook of the hamate bone level (HCSA) on US

A Sequoia 512 scanner (Siemens Medical Systems, Malvern, PA, USA) with an 8-15 MHz linear-array transducer was used. US was performed by another licensed physiatrist with 8 years of experience in US of the peripheral nerve who was blinded to the patients' clinical and NCS data. Patients were evaluated while seated upright with the elbow flexed, fingers semi-flexed, and wrist in the neutral position. The carpal tunnel was scanned in both longitudinal and transverse planes. A color Doppler study was performed if a vascular lesion was suspected on the B-mode image. The transverse image of the median nerve presents as an oval or ellipsoid hypoechoic reticular area with a hyperechoic rim.^[2,4] The

PCSA and HCSA were measured by directly tracing inside the hyperechoic rim. According to a pilot study for intra-rater reliability, the intraclass correlation coefficient of the PCSA and HCSA were calculated as 0.865 and 0.814, respectively.^[2]

Statistical Analyses

SPSS 12.0 (SPSS Inc., Chicago, IL, USA) was used for data entry and statistical analysis. Normality of numeric variables was tested using the Kolmogorov-Smirnov test. A two-sided paired t-test or Wilcoxon rank sum test was used to compare within-group outcome differences (T0 vs. T1, T1 vs. T2, and T0 vs. T2). Correlations between the SSS, FSS, NCS, and US variables were calculated using Pearson's correlation or Spearman's correlation if the variable was not normally distributed. A p-value <0.05 was considered significant.

On an intent-to-treat basis, patients who received a different treatment and subsequently dropped out of the study were categorized as having poor subjective outcome. To examine the relationship between subjective outcome (good or poor) and each of the potential prognostic indicators, a single variable analysis was performed using the chi-squared test for categorical variables and a two-sided independent t-test or Mann-Whitney U test for numeric variables. Variables related to the subjective outcome (defined as $p < 0.10$) were subsequently included in a binary logistic regression model with forward stepwise selection method, and the variables retained in the model were identified as independent prognostic indicators. For the convenience of clinical practice, the receiver operating characteristic (ROC) curves of the prognostic indicators were plotted and the optimal cut-off values were determined.

RESULTS

Of the 60 subjects (95 hands) screened, 16 patients (27 hands) were excluded because they met the exclusion criteria and 6 patients (10 hands) refused to participate. As a result, 38 patients (58 hands) were recruited. Ten patients (16 hands) subsequently dropped out. Thus, in total, 28 patients with 42 hands with CTS (22 right hands and 20 left hands) completed the study (Figure 1). The

baseline demographics of participants showed that there were 3 men and 25 women with mean age 44.2 ± 11.3 years old. In average, body height was 158.6 ± 6.1 cm, and body weight was 66.7 ± 15 Kg. Mean body mass index was 26.4 ± 5.3 . The clinical characteristics were: the median of symptom duration 7.5 months with the interquartile range 34 months; mean SSS 2.21 ± 0.77 ; the median of FSS 1.14 with the interquartile range 0.56; mean MDL 5.09 ± 1.17 ms; mean SCV 39.6 ± 8.7 m/s; the median of Padua's grade 4 with the interquartile range 0; and mean PCSA and HCSA 13.1 ± 4.3 and 11.7 ± 3.9 mm² respectively.

Twenty-four of 28 participants completed study performed self-care for CTS during the period of study. Of the 4 participants not perform self-care, finally two patients (4 hands) reported good subjective satisfaction and 2 patients (3 hands) report poor subjective satisfaction. Comparing the rates of reported good subjective outcome, there was no significant difference between who performed self-care and who did not perform self-care. Analysis of the characteristics such as demographics and baseline parameters of clinical severity, NCS, and US, yielded no significant differences between the patients completed the study and those dropped out.

Outcome Variables

After 6 months of night splinting, the general subjective satisfaction was 1 (much worse) in six hands, 2 (stationary) in seven hands, 3 (much improved) in 17 hands, and 4 (completely recovered) in 12 hands. Thus, there were 13 hands with a poor subjective outcome and 29 hands with a good subjective outcome. A comparison of SSS, FSS, NCS, and US variables at the baseline and follow-up evaluations is shown in Table 1.

In patients with a good subjective outcome (much improved or completely recovered), the mean SSS score improved significantly from T0 to T1, T1 to T2, and T0 to T2. The median FSS scores improved from T0 to T1 and T0 to T2. SCV improved from T0 to T1 and T0 to T2. Padua's grade improved from T0 to T2. Moreover, PCSA improved from T1 to T2 and T0 to T2. However, no improvement was observed in any variable from baseline to the 6-month follow-up in patients with a poor subjective outcome (much worse or stationary). In total, SSS score, FSS score, SCV, Padua's grade, and PCSA improved from T0 to T2.

Correlations

The correlations among SSS, FSS, NCS, and US variables are shown in Table 2. There was a significant correlation between SSS and FSS ($r = 0.667$, $p < 0.001$), and SSS was significantly correlated with MDL, SCV, and PCSA (r 's ranged from -0.44 to 0.47 , all $p < 0.001$). There were moderate correlations between FSS and MDL and between FSS and SCV ($r = 0.33$ and -0.321 respectively, $p < 0.001$). Mild correlations were observed between SSS and HCSA, as well as between FSS and PCSA. Furthermore, moderate correlations were observed between NCS and US data (r 's ranged from -0.466 and 0.48 , $p < 0.001$).

Prognostic Indicators

On an intent-to-treat basis, there were 29 hands were categorized as good or poor subjective outcome

respectively. The single variable analysis revealed five potential prognostic indicators associated with a good subjective outcome (good general satisfaction): symptom duration, MDL, SCV, Padua's grade, PCSA, and HCSA. These variables were included in a binary logistic regression model with forward stepwise selection; only SCV and PCSA were retained in the final model. The odds ratios for SCV and PCSA were 1.14 (95% confidence interval [CI], 1.045–1.244), $p = 0.003$ and 0.773 (95% CI, 0.609–0.981), $p = 0.034$, respectively. According to the ROC curves, the areas under curve (AUC) of SCV and PCSA were 0.780 (95% CI, 0.660–0.901, $p < 0.001$) and 0.767 (95% CI, 0.647–0.887, $p < 0.001$). (Figure 2) The optimal cut-off values of SCV and PCSA to predict a good subjective outcome were ≥ 40 m/s and ≤ 11.35 mm² respectively. The actual rates of a good subjective outcome after 6 months of night splinting are shown in Table 3.

Table 1 Comparison of symptom, function, nerve conduction study, and ultrasonographic variables at the baseline and follow-up evaluations

Variables	Subjective Outcome	Evaluations			p		
		T0	T1	T2	T0 vs T1	T1 vs T2	T0 vs T2
SSS	Good	2.17 (0.79)	1.45 (0.43)	1.32 (0.45)	<0.001**	0.049*	<0.001**
	Poor	2.29 (0.76)	2.18 (0.77)	2.19 (0.56)	0.527	0.992	0.252
	All	2.21 (0.77)	1.66 (0.64)	1.57 (0.63)	<0.001**	0.079	<0.001**
FSS	Good	1.25 (0.63)	1 (0.25)	1 (0.14)	0.004**	0.245	<0.001**
	Poor	1.14 (0.41)	1 (0.39)	1.14 (0.31)	0.397	0.144	0.31
	All	1.14 (0.56)	1 (0.25)	1 (0.25)	0.015*	0.099	<0.001**
MDL (ms)	Good	4.6 (1)	4.5 (0.9)	4.4 (1.1)	0.059	0.406	0.063
	Poor	6 (1.2)	6.1 (1.3)	6.1 (1.4)	0.787	0.544	0.973
	All	5.1 (1.2)	5.0 (1.3)	4.9 (1.3)	0.393	0.181	0.176
SCV (m/s)	Good	43.6 (6.7)	45.4 (8.1)	45.8 (8.5)	0.041*	0.589	0.049*
	Poor	33.3 (5.8)	33.8 (6.8)	34.2 (6.6)	0.414	0.388	0.137
	All	39.6 (8.7)	41.8 (9.3)	42.3 (9.5)	0.027*	0.459	0.024*
Padua's Grade	Good	4 (2)	4 (2)	3 (2)	0.102	0.075	0.028*
	Poor	4 (0)	4 (0)	4 (0)	1	0.317	0.317
	All	4 (0)	4 (1)	4 (2)	0.25	0.118	0.017*
PCSA (mm ²)	Good	11.4 (2.9)	10.8 (3.2)	10.1 (2.6)	0.276	0.04*	0.017*
	Poor	14.9 (4.1)	14.1 (3.3)	14 (3.3)	0.474	0.657	0.444
	All	13.1 (4.3)	12.8 (3.5)	11.2 (3.3)	0.188	0.045*	0.017*
HCSA (mm ²)	Good	10.6 (3.1)	10.5 (2.8)	10.4 (3.5)	0.807	0.652	0.606
	Poor	12.4 (2.7)	12.3 (2.5)	12.6 (3.1)	0.789	0.342	0.167
	All	11.7 (3.9)	11 (2.8)	10.7 (3.4)	0.527	0.337	0.271

T0: Baseline (before splinting); T1: 3-month after splinting; T2: 6-month after splinting; SSS: symptom severity scale; FSS: functional status scale; MDL: motor distal latency of the median nerve; SCV: sensory conduction velocity of the median nerve, wrist to index finger; PCSA: cross-sectional area of the median nerve at the pisiform bone level; HCSA: cross-sectional area of median nerve at the hook of the hamate bone level.

The values are the mean (standard deviation), except median (interquartile range) for FSS and Padua's grade because they are not normal-distributed.

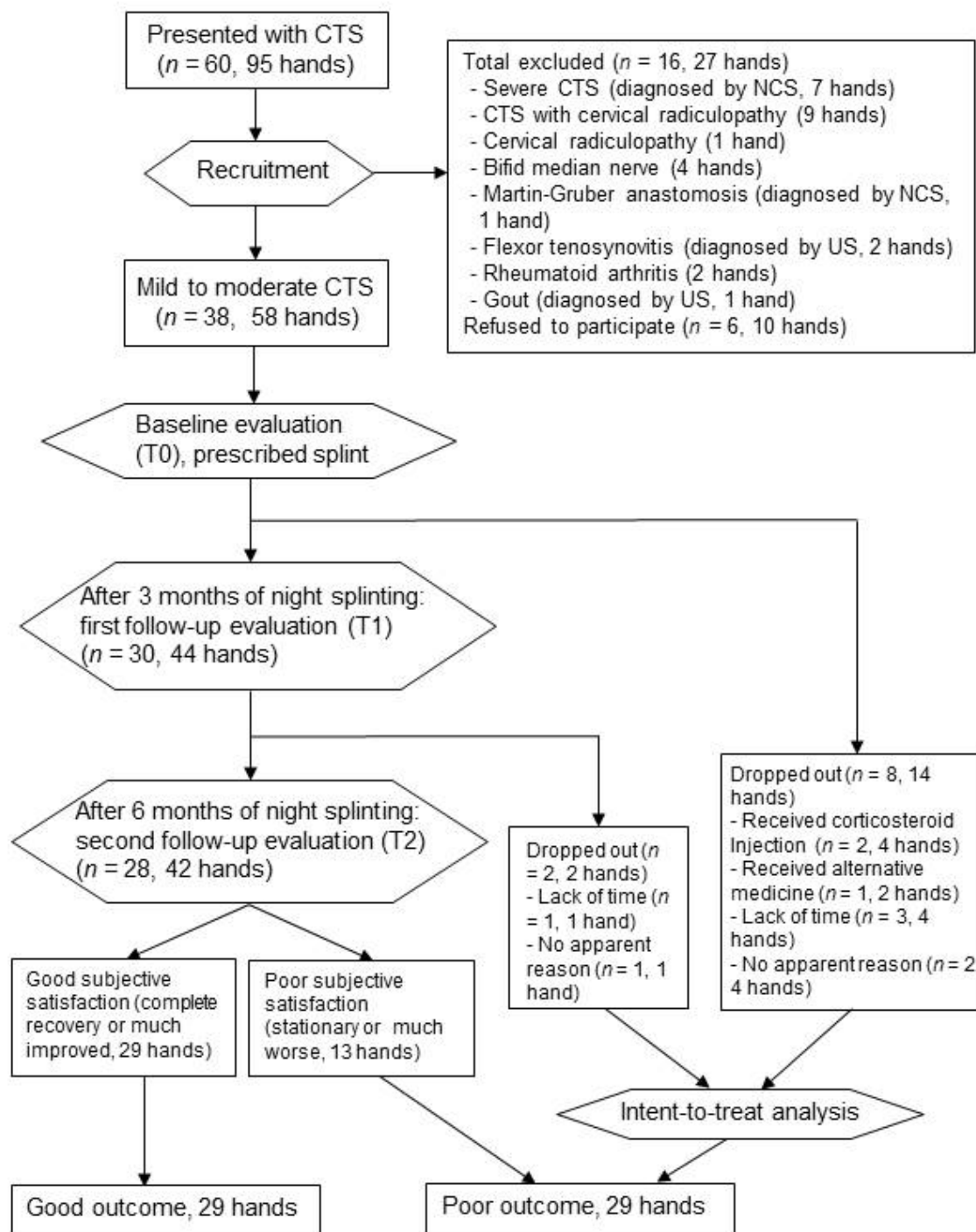


Figure 1. Flow of participants. CTS, carpal tunnel syndrome; NCS, nerve conduction study; US, ultrasonography.

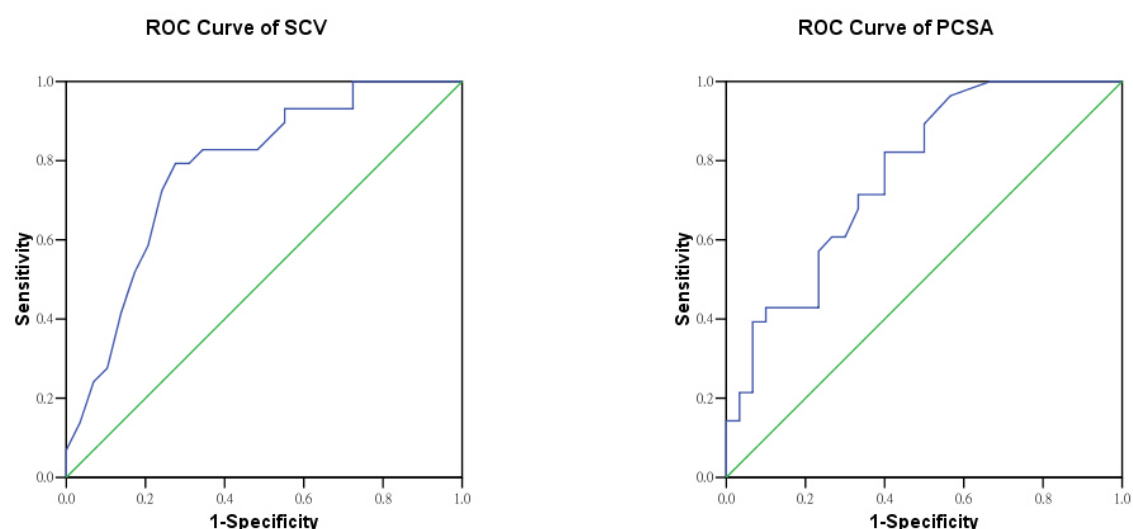


Figure 2. Receiver operating characteristic (ROC) curves of the sensory conduction velocity (SCV) and the cross-sectional area of the median nerve at the pisiform bone level (PCSA).

Table 2. Correlation coefficients for symptom, function, nerve conduction study, and ultrasonography variables

	SSS	FSS	MDL	SCV	PCSA	HCSA
SSS	1					
FSS	*0.667	1				
MDL	*0.47	*0.33	1			
SCV	*-0.44	*-0.321	*-0.849	1		
PCSA	*0.461	*0.223	*0.48	*-0.466	1	
HCSA	*0.222	0.126	*0.395	*-0.389	*0.651	1

* $p < 0.01$. SSS: symptom severity scale; FSS: functional status scale; MDL: motor distal latency of the median nerve; SCV: sensory conduction velocity of the median nerve, wrist to index finger; PCSA: cross-sectional area of the median nerve at the pisiform bone level; HCSA: cross-sectional area of median nerve at the hook of the hamate bone level.

Table 3. Rates of good subjective outcome after six months of night splinting according to baseline SCV and PCSA

SCV	PCSA	Rate of Good Subjective Outcome
≥ 40 m/s	$\leq 11.35 \text{ mm}^2$	93.3% (14/15)
≥ 40 m/s	$> 11.35 \text{ mm}^2$	56.3% (9/16)
< 40 m/s	$\leq 11.35 \text{ mm}^2$	37.5% (3/8)
< 40 m/s	$> 11.35 \text{ mm}^2$	15.8% (3/19)

SCV: sensory conduction velocity of the median nerve, wrist to index finger; PCSA: cross-sectional area of the median nerve at the pisiform bone level.

DISCUSSION

In the present study, we found that symptoms, functional status, SCV on NCS, and PCSA on US improved in patients with CTS who reported good satisfaction after 6 months of night splinting but not in those who reported poor satisfaction. In all patients who completed study, symptoms, functional status, NCS and US improved after 6 months of night splinting, too. This may be related to the fact that most of the patients who completed study reported good subjective satisfaction (29/42). Moreover, we observed that SCV on NCS and PCSA on US were prognostic indicators for good outcomes in patients with CTS treated with night splinting. The utility of prognosis prediction was similar in SCV and PCSA because of their overlapped 95% CI of AUCs. ANCS is an electrophysiologic examination used for diagnosis and treatment guidance in CTS.^[43] Our results agree with those of previously published studies evaluating clinical symptoms and NCS improvement after at least 3 months of night splinting in patients with CTS.^[14-17]

US is a noninvasive and convenient imaging modality that can reveal morphologic changes in the median nerve. The pathophysiology of CTS is thought to be an increase in intracarpal tunnel pressure, resulting in the breakdown of the blood flow barrier and subsequent subperineurial edema, followed by increased thickening of the epineurium and perineurium.^[44] The US characteristic of CTS, namely the hypoechoic swelling of the median nerve, representing edematous thickening of the epineurium and perineurium connective tissue,^[45] is consistent with this pathophysiology. As a result, US could be used as a supplementary laboratory test to diagnose CTS, especially in patients experiencing discomfort with NCS testing. Many previous studies have also measured PCSA on US before and after surgical or non-surgical treatment for CTS, but did not obtain consistent results.^[21-27,30] Soyupek et al. compared three conservative treatments for CTS with US: (1) wrist splinting, (2) phonophoresis with corticosteroid, and (3) phonophoresis with non-steroidal anti-inflammatory drugs. They found a reduction in PCSA after 3 months of phonophoresis with corticosteroid, but not after the other

two treatments.^[26] However, in the present study, we found a significant reduction in PCSA and increases in SCV on NCS after therapeutic splinting due to a different splinting regimen and a longer follow-up duration (3 months in Soyupek's study vs. 6 months in the present study). In Soyupek's study, patients were instructed to wear the splint 24 hours per day in the first 15 days, and wear the splint when symptomatic in the following periods.^[26] In a recent publication regarding the effectiveness of radial shockwave therapy for CTS, Wu et al. reported significant improvements in SSS, FSS, NCS, and PCSA in control groups (those patients received sham shockwave therapy plus night splinting) after a 3-month treatment.^[35] The present study also demonstrated the utility of NCS and PCSA for assessing outcome measures after therapeutic splinting for CTS. PCSA is the measurement of the swollen median nerve at the inlet of the carpal tunnel and is the key characteristic of CTS on US.^[2,4,6] It is not surprising that PCSA was an outcome variable and a prognostic indicator in our study. However, HCSEA, representing the degree of swelling of median nerve at the outlet of the carpal tunnel, was considered to be a minor or insignificant ultrasonographic finding of CTS.^[6,8,9] This may interpret that HCSEA neither improved after treatment nor predicted prognosis in the present study.

In many studies, short-term (3 month) efficacy of night splinting to treat mild to moderate CTS was proved.^[14-16,29] In Premoselli's, Ucan's, as well as the present study, significant improvements of SSS, FSS, and NCS variables were noted at 6-month evaluation compared to at baseline.^[14,16] Most improvements of these outcomes developed from baseline to the 3-month evaluation (from T0 to T1), and few or even no improvements developed from the 3-month evaluation to the 6-month evaluation (from T1 to T2). However, in the present study, most improvement in PCSA developed from T1 to T2, not from T0 to T1. Long-term efficacy of night splinting to treat CTS is needed to further investigate because of the discrepancy of changes in symptom, neurophysiology on NCS, and morphology on US.

Several factors have been reported to be prognostic indicators for splinting for CTS, such as symptom severity, symptom duration, and NCS data.^[18-20] Olliviere

et al. reported that SSS and FSS (particularly SSS) were predictive of outcomes following conservative treatment for CTS, including steroid injection, splinting, and tendon gliding exercise.^[20] However, SSS and FSS were not identified as independent prognostic indicators in our study, probably due to the different treatment protocol, statistical methods, and baseline FSS scores (the baseline FSS in Olliviere's study and our study were 2.15 and 1.14 respectively). Gerristen et al. identified two prognostic indicators for splinting success for CTS, namely shorter symptom duration (≤ 1 year) and less severe paresthesia at night ($\leq 6/10$).^[18] In the present study, we did not measure paresthesia at night with an ordinal scale. On the other hand, symptom duration was indeed a potential prognostic indicator in the single variable analysis, but it was not retained in the final multiple logistic regression model. This discrepancy maybe related to the shorter symptom duration in our series (median 6.5 months vs. 12 months). To the best of our knowledge, no researchers have evaluated if US data can predict the prognosis for CTS treated with splinting. In our study, PCSA on US was identified as a prognostic indicator of splinting for CTS in addition to SCV on NCS.

Our study is not without a few limitations. First, the small sample size may limit its generalizability. Second, the dropout rate was 0.28 (16 of 58 hands); however, our analysis revealed no significant differences in demographic and baseline data between patients who completed the study and those who dropped out. Third, we did not recruit a non-interventional control group due to ethical considerations. Forth, we enrolled patients with symptoms of CTS at least 1 month. Acute CTS may get some spontaneous improvement after activity modification and posture modulation. This may overestimate the result of the present study.

In conclusion, PCSA on US is an outcome variable and a prognostic indicator for mild to moderate CTS treated with night splinting.

APPENDIX

Padua's grade for nerve conduction studies for carpal tunnel syndrome.^[37]

Grade 1: Normal motor and sensory conduction studies and cross-wrist conduction velocity of the

median nerve, as well as a normal median-ulnar comparison study.

- Grade 2: Normal motor and sensory conduction studies but prolonged cross-wrist conduction velocity of the median nerve and/or an abnormal median-ulnar comparison study.
- Grade 3: Normal motor conduction study but prolonged sensory distal latency of the median nerve.
- Grade 4: Prolonged motor distal latency and sensory distal latency of the median nerve.
- Grade 5: Prolonged motor distal latency and absence of a sensory response in the median nerve.
- Grade 6: Absence of both motor and sensory responses in the median nerve.

ACKNOWLEDGEMENTS

The authors thank Dr. Shum-Man Cheung for recruitment of participants.

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超音波作為腕隧道症候群成效及預後因子：以夜間 副木治療之研究

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背景：超音波作為腕隧道症候群的預後因子仍有爭議。

目的：針對輕度到中度腕隧道症候群夜間穿戴副木治療的個案，探討超音波是否能作為成效及預後的指標。

方法：本研究納入 58 隻輕度到中度腕隧道症候群的手，42 隻手完成研究。在治療前、夜間副木治療三、六個月接受療效評量(主觀滿意度、症狀嚴重度評分 symptom severity score (SSS)、功能狀態評量 functional status score (FSS)、神經傳導檢查及超音波評估)。根據意向分析，使用二項回歸分析找出主觀滿意度的預後因子並畫出接受者操作特徵(receiver operating characteristic, ROC)曲線。

結果：經過六個月副木治療，主觀滿意度好的有 29 隻手，主觀滿意度差的有 13 隻手。主觀滿意度好的其 SSS, FSS, 感覺傳導速度, 及超音波上正中神經在豌豆骨旁的截面積(the cross-sectional area of the median nerve at the pisiform bone level, PCSA)皆有顯著進步，但主觀滿意度差的都無進步。根據意向分析，各有 29 隻手分屬治療成功或失敗。依據回歸模式及 ROC 曲線，感覺傳導速度與 PCSA 是獨立預後因子；對於治療成功，其最佳切點值分別是 ≥ 40 m/s 及 ≤ 11.35 mm²。

結論：輕度到中度腕隧道症候群夜間穿戴副木的個案，超音波能作為成效及預後的指標。(台灣復健醫誌 2016; 44(3): 123 - 134)

關鍵詞：腕隧道症候群(carpal tunnel syndrome)、超音波(ultrasonography)、神經傳導檢查(nerve conduction study)、副木(splint)、預後因子(prognostic indicator)