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Original Article

Clinical and electrophysiological evaluation of neutral wrist nocturnal splinting in patients with carpal tunnel syndrome

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Abstract. [Purpose] To prospectively assess the effectiveness of neutral wrist nocturnal splinting in patients with carpal tunnel syndrome (CTS) by using clinical scores and nerve conduction studies (NCS). [Subjects and Methods] Forty-one patients enrolled in the study were clinically evaluated by a symptom severity scale (SSS) and functional status scale (FSS), and were electrophysiologically evaluated by conventional NCS; distal motor latency (DML), sensory conduction velocity (SCV), and difference in sensory latency between the median and ulnar nerves (ΔDSL) were measured. Subjects were treated with wrist splinting. Patients who showed no improvement in symptoms were treated with other conservative treatments, the remaining patients continued to wear splints. SSS, FSS, and NCS were evaluated after splinting as well. [Results] The follow-up was completed in 20 patients (31 wrists) with splinting. SSS and FSS decreased, the DML shortened and ΔDSL decreased significantly after splinting for 3.03 ± 1.16 months. There were significant correlations between SSS and DML, SCV of wrist digit 2, and SCV of wrist digit 4. No correlations were found between SSS and ΔDSL, and FSS and the parameters of NCS. [Conclusion] Neutral wrist nocturnal splinting is effective in at least short term for CTS patients. There is a weak correlation between clinical scores and NCS, which suggests that both approaches should be used to effectively assess the therapeutic effect of CTS treatment.

Key words: Carpal tunnel syndrome, Splinting, Evaluation

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INTRODUCTION

Carpal tunnel syndrome (CTS) is the most common entrapment neuropathy[1–3)], caused by compression and traction of the median nerve at the level of the carpal tunnel, which is a cylindrical, inelastic cavity, delimitated by the carpal bones and transverse carpal ligament[4, 5)].The compression results in impaired nerve conduction, paresthesia, and pain, which worsen at night and often wake the patient[6, 7)].

The treatment for CTS can be broadly divided into surgical and non-surgical approaches. According to the findings of several important randomized controlled trials, surgical treatment is superior to non-surgical treatment[8, 9)]. Carpal tunnel-release surgery is effective in 70–75% of patients, but is relatively invasive and can be accompanied by complications[10)]. Furthermore, recurrence after surgery, although uncommon, can be difficult to treat[11)]. Moreover, surgical decompression leaves 8% of patients in a worse condition than they were previously[12)], and persistent pain in the scar or proximal palm 5 years after carpal tunnel release has been reported in 6% of patients[13)].

Numerous non-surgical, less-invasive treatment options are available, including oral medication, splinting, exercise, corticosteroid injections, and mobilization interventions[14–17)]. Only a few complications result from non-surgical approaches in those with mild-to-moderate CTS. Thus, non-surgical treatment might be indicated for patients with CTS when surgery is not desired or for any other reason not immediately indicated[18)]. To the best of our knowledge, surgical decompression or carpal

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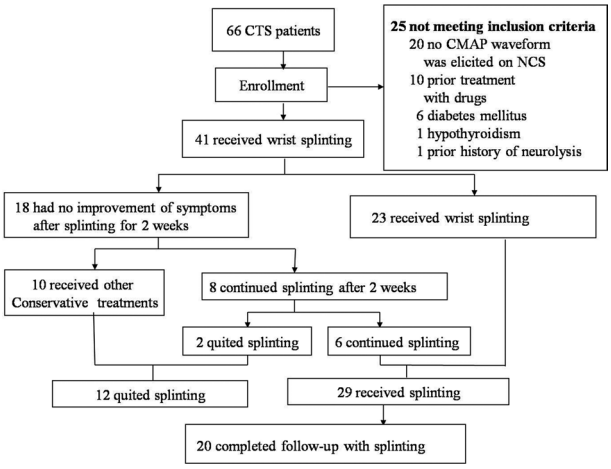

Fig. 1. Flow diagram

tunnel release is not performed widely in mainland China. However, there is currently limited evidence indicating any benefit from splinting, exercise, and mobilization[15, 16]. This study aimed at prospectively assessing the effectiveness of nocturnal splinting by using clinical scores and NCS.

SUBJECTS AND METHODS

Of the 66 consecutive outpatients to our neurological clinic, 41 patients who met the inclusion criteria were finally enrolled (Fig. 1). All individuals provided informed consent to participate in this study, and the local ethics committee of the hospital approved this study. The inclusion criteria of the Report of the Quality Standards Subcommittee of the American Academy of Neurology were implemented[19], whereby all the patients must meet at least one of the first 2 items and one of the remaining 5 items below to be included in the study:[19, 20] (1) numbness in the median nerve territory or the whole hand; (2) pain or hypesthesiain the hand; (3) awakened from sleep by numbness or pain mid-night or early in the morning; (4) numbness relieved by shaking the hand and aggravated by flexing the wrist, or numbness becoming more severe in winter than in summer; (5) weakness of the hand; (6) atrophy of the thenar muscle; and (7) positive Phalen or Tinel sign.

In this study, patients with the following conditions were excluded: (1) clinical or/and electrophysiological findings suggesting ulnar nerve lesion, cervical radiculopathy, polyneuropathy, systematic diseases (e.g., diabetes mellitus, hypothyroidism, and rheumatoid arthritis), and stroke[20]; (2) CTS caused by wrist trauma or deformity[20]; (3) prior treatment for CTS through any approach, either surgical or non-surgical; and (4) severe weakness or atrophy of the hand, and no response of compound muscle action potentials (CMAP) elicited from the muscle of the abductor pollicis brevis (mAPB) on NCS. The follow-up was completed in 20 patients with splinting (Fig. 1).

This study had a prospective design recommended by American Association of Neuromuscular and Electrodiagnostic Medicine (AANEM)[21]. All the subjects enrolled in this study underwent electrophysiological detection after oral informed consent was obtained. Electrophysiological detections were completed on Keypoint 4 (Detec, Denmark) by one examiner. The limb temperature was maintained at ≥32 °C. While NCS was performed, surface electrodes were used for stimulating or recording. While recording CMAP, the median and ulnar nerves were both stimulated at the wrist. While recording the sensory nerve action potentials (SNAP), the median and ulnar nerves were also stimulated at the wrist, and ring electrodes were placed at digits 2 and 5, respectively. In addition, for comparing the difference in distal sensory latency (ΔDSL), the median and ulnar nerves were stimulated at the wrist, recording the SNAP at digit 4. The following parameters were analyzed: the distal motor latency (DML) from the wrist to mAPB or abductor digiti minimi; the sensory conduction velocity (SCV) from the wrist to digits 2, 5, and 4; and the ΔDSL. Needle electromyographic detection was performed to observe abnormal spontaneous activities only when the amplitude of the CMAP of mAPB reduced.

Considering Stevens (AANEM) and our previous study[20, 22], the following electrodiagnostic criteria for CTS were used in this study: (1) SCV (wristdigit 2) <40.0 m/s or SCV (wristdigit 4) <43.5 m/s; DML (wrist to mAPB) ≥3.7 ms (distance 5.5–6.5 cm); or ΔDSL ≥0.4 ms; and (2) normal sensory or motor conduction in the ipsilateral ulnar nerve.

Symptom severity scale (SSS) and functional status scale (FSS) were used to evaluate the patients at each hospital visit[23]. SSS consists of 11 questions with multiple-choice responses, which includes 6 critical domains for the evaluation of CTS: pain, paresthesia, numbness, weakness, nocturnal symptoms, and over-all functional status. FSS consists of 8 functional activities, including writing, buttoning of clothes, household chores, and bathing and dressing. Each question was scored 1 point (mildest/no difficulty with the activity) to 5 points (most severe/unable to perform the activity). The overall score was calculated as the mean of the scores for all the individual items. Items that were left unanswered and if not applicable, they

Table 1. Clinical data of the subjects

	All 41 patients	20 patients with splinting
Age (years)	20–72 (50.2 ± 12.0)	26–72 (52.5 ± 12.6)
Illness duration (years)	1.1 ± 1.7	1.5 ± 2.3
Male/Female (wrists)	4 (5)/37 (59)	1 (1)/19 (30)
Bilateral hands affected (cases)	24	11
Right hand affected (cases)	11	4
Left hand affected (cases)	6 (4 left-handed)	5 (4 left-handed)
Numbness (or pain) at night (cases)	21	6
Tinel sign (wrists)	18	11
Phalen sign (wrists)	20	14

Table 2. Comparison of clinical scores and NCS findings of splinting in 20 patients (31 wrists)

Parameters	Before splinting	After splinting
Clinical scores		
SSS	1.77 ± 0.38	1.55 ± 0.38***
FSS	1.53 ± 0.31	1.40 ± 0.27***
Parameters of NCS		
DML (ms)	4.53 ± 1.25	4.14 ± 0.76*
SCV of wrist digit 2 (m/s)	42.02 ± 8.29	42.12 ± 7.58
SCV of wrist digit 4 (m/s)	38.20 ± 6.72	38.51 ± 6.42
ΔDSL (ms)	1.24 ± 0.61	0.97 ± 0.60**

NCS: nerve conduction studies; SSS: symptom severity scale; FSS: functional status scale; DML: distal motor latency; SCV: sensory conduction velocity; ΔDSL: sensory latency difference between median and ulnar nerve
*p<0.05, **p<0.01, ***p<0.001

Table 3. Correlation of clinical scores with NCS findings in 20 patients treated by splinting

	DML	SCV of wristdigit2	SCV of wristdigit4	ΔDSL
SSS	0.420*	−0.425*	−0.519*	0.189
FSS	0.192	−0.175	−0.319	−0.124

Values represent correlation coefficients
*p<0.05

were not included in the calculation of the overall score[23].

All the subjects were instructed to make stereoplasm splints of approximately 9–12 cm × 5–7 cm size by themselves and bring them to us for assessment. Subsequently, they were asked to wear each splint on the dorsal and palmar surface of the hand, centered at the distal wrist crease, immobilizing the wrist in the neutral posture at bedtime, keeping the fingers relatively free.The wrists were fixed to ensure that they were neither too tight nor too loose. Meanwhile, the subjects were instructed to avoid flexing their wrists during any daytime activities such as washing clothes, riding a bicycle, working on a computer, and carrying heavy grocery bags. The patients were asked to strictly follow the above mentioned guidelines. The follow-up was completed in 20 patients (31 wrists) with splinting. Clinical scores and NCS were evaluated after 3.03 ± 1.16 months.

All statistical analyses were performed using statistical package for social sciences (SPSS) for version 17.0 (SPSS China, Shanghai). The data were presented as mean ± standard error of mean. One-sample t-test was used to compare the values with known population means, and paired-sample t-test was used to compare paired measurement data. In bivariate correlations, data of normality was analyzed by Person correlations, else by Spearman correlations. The Shapiro-Wilk test was used to test the normality of the measurement data. Values of $p<0.05$ were considered statistically significant; * represents $p<0.05$, ** $p<0.01$ and *** $p<0.001$.

RESULTS

Of the 41 patients who met the inclusion criteria, 90% were female, and the mean age of all patients was approximately 50 years old. The clinical data are presented in Table 1.

In 20 patients (31 wrists) with CTS treated by splinting, SSS (1.77 ± 0.38, 1.55 ± 0.38; t=5.956, p=0.000) and FSS (1.53 ± 0.31, 1.40 ± 0.27; t=5.452, p=0.000) decreased. In addition, DML (4.53 ± 1.25, 4.14 ± 0.76; t=2.431, p=0.021) shortened and ΔDSL (1.24 ± 0.61, 0.97 ± 0.60; t=2.978, p=0.006) decreased significantly after splinting (Table 2). There was no improvement in the clinical scores in 9 patients (14 wrists, 45.8%) after splinting. There were significant correlations between SSS and DML (r=0.420, p=0.019), SCV of wrist digit 2 (r=−0.425, p=0.017), and SCV of wrist digit 4 (r= −0.519, p=0.003). No correlations were noted between SSS and ΔDSL (p>0.05), and between FSS and all the parameters of NCS (p>0.05) (Table 3).

DISCUSSION

In this study, 90% of patients with CTS were female, and the mean age was approximately 50 years, which is consistent with the epidemiological data[3]. Studies have shown that females with the highest body mass index (BMI) are more likely to develop CTS[24, 25]. A BMI ≥30 kg/m^2 almost doubled the risk of CTS, and when BMI was assessed as a continuous variable, the hazard ratio increased approximately linearly with increasing BMI[24].

Splinting is the most common method among the non-surgical treatments available for CTS[7]. In this study, a self-administered questionnaire was used to assess the severity of symptoms and functional status in CTS, as questionnaires are reproducible, internally consistent, valid, and responsive to clinical change[23]. The questionnaire for clinical evaluation was subjective, but it can be semi-quantitative. We recommend that the questionnaire should be used at least in the clinical research on CTS, so that the outcome of each researcher is relatively comparable. In this study, both SSS and FSS were ≤3 points, which suggested that the condition in most patients was not severe. In a previous study, 89% of patients with severe CTS experienced recurrence of the symptoms within 1 year after conservative treatment, whereas only 60% of patients with mild CTS experienced recurrence[26]. Therefore, the conservative approach is more successful in patients with mild nerve lesion than with severe CTS. Conservative management with splinting should be initiated in patients with CTS with only mild symptoms[12].

Splinting is an acceptable method for patients in the early phases of CTS, as it is simple and inexpensive and can be used at home. In this study, SSS and FSS decreased significantly, DML shortened, and ΔDSL decreased. Moreover, 54.2% of patients with CTS were effective after neutral wrist nocturnal splinting. Neutral wrist splinting can reduce the pressure on the median nerve and increase blood flow, especially when the wrist is held in a flexion position at night[27]. In a review assessing the effectiveness of conservative therapy for CTS, it was reported that splinting is an effective therapy especially when used for the whole day[28].

No improvement was noted in the clinical scores of almost half the patients in this study. This could be because the splints made by the patients may not have immobilized the wrist. Additionally, patients' low compliance for the complex course of splinting may have influenced the therapeutic effect, although we emphasized that the patients should follow our guidelines strictly.

This study showed that the DML shortened and the ΔDSL decreased after splinting. Splinting reduces latency, suggesting that the intervention may alter the underlying pathophysiological course of CTS[4]. Moreover, there was no correlation between SSS and ΔDSL, and between FSS and the parameters of NCS. Thus, there was a weak correlation between the clinical scores and NCS, which is consistent with the findings of a previous study[29]. Therefore, the use of both clinical scores and NCS may allow us to evaluate the therapeutic effect of splinting on CTS through different aspects.

Overall, conservative approaches such as splinting have a negligible incidence of serious complications and should be used more widely[12]. Providing patients the facts about their conditions and any therapeutic approach that might benefit them may be a good strategy. Nevertheless, patients with CTS who do not show satisfactory improvement with non-surgical treatment should be offered surgery[30].

The therapeutic effect of combination splinting and other conservative treatments on CTS were not compared, and the number of patients enrolled in this study was small, which were the main limitations in this study. Moreover, patients made the splints by themselves, which may cause a variation in the therapeutic effect among individuals, although the splints that they made were checked.

In conclusion, neutral wrist nocturnal splinting is effective in at least the short term in patients with CTS. There is a weak correlation between the clinical scores and NCS, which suggests that both approaches should be used to assess the therapeutic effect of treatment on CTS.

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