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Original Article

The effect of splint use on outcomes in ultrasound guided injection of carpal tunnel syndrome

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Abstract

Aim: Splint use is often recommended following wrist injection patients diagnosed with carpal tunnel syndrome (CTS), but there is not any data in the literature pertaining to the impact of splint treatment, used before injection, on the results of local injection treatment. The aim of this study to evaluate whether or not splint use starting before the injection would impact the local injection treatment outcomes.

Materials and methods: Fifty seven patients (57 hands) with CTS and underwent ultrasound-guided injection were included in the study, and patients were divided into two groups in terms of splint use. Median nerve cross-sectional area (MNCSA), pain/numbness by visual analogue scale (VAS), symptoms and functionality by Boston Carpal Tunnel Questionnaire (BCTQ) were investigated before injection and 15 days after injection.

Results: There was significant change over time in MNCSA, VAS, and BTCQ scores in groups. The patients not using splint group had significantly higher percentage change in VAS nighttime score.

Conclusion: Our findings has shown that using neutral wrist splint, starting before and continuing after injection treatment, did not increase the injection treatment efficacy and may actually have negative effect on improvement in VAS nighttime scores.

Keywords: Median nerve; sonography; splinting; steroid injection

INTRODUCTION

Carpal tunnel syndrome (CTS) is the most common entrapment neuropathy and occurs as a result of compression to the median nerve inside the carpal tunnel (1). Both conservative and surgical approaches are used in its treatment, while the conservative approach is first-line treatment in mild to moderate cases (2). Lifestyle changes, wrist splint, drugs such as oral nonsteroidal anti-inflammatory drugs (NSAIDs) or corticosteroids, local corticosteroid injections, and physical therapy modalities are frequently used treatment methods (3,4).

The use of wrist splint is common among patients diagnosed with CTS; the splint holds the wrist in a neutral position and is thought to be effective by reducing intraneural edema (5). Studies have shown that splint use reduces CTS symptoms and increases functionality (6,7). Splint use is also frequently combined with other conventional treatments (4,8-12). Local injection into the carpal tunnel is recommended in cases of mild to moderate severity and is a safe, easily applied method to improve symptoms (13). Steroid injection into the wrist due to CTS has been shown to be more effective than placebo in reducing both symptom severity as well as the rate of undergoing surgery one year later (14), while ultrasound-guided injection has been reported to be even more effective (15,16).

Although splint use is often recommended following wrist injection, there are reports that it does not clinically contribute to treatment compared to steroid injection alone (11,12). However, we did not encounter any data in the literature pertaining to the impact of splint treatment, used before injection, on the results of local injection treatment. Therefore, in this study, we examined the effect of static wrist splint use starting one month before injection and continuing after injection in patients with CTS undergoing ultrasound-guided injection. We aimed to evaluate whether or not splint use starting before the injection would impact the outcomes of local injection treatment.

MATERIALS and METHODS

This study was conducted with the approval of the Clinical Research Ethics Committee of our hospital. Patients

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diagnosed with CTS, who met inclusion-exclusion criteria, and underwent ultrasound guided injection at our hospital's Physical Therapy and Rehabilitation outpatient clinic between January 1 and December 31, 2018 were included in the study. The study was conducted in accordance with the principles of the Declaration of Helsinki.

The study's inclusion criteria were as follows: age of 18 and older, complaints of numbness and tingling in the median nerve innervation region with or without pain, symptoms lasting longer than twelve weeks, electrophysiological diagnosis of mild or moderate CTS, injection into one hand with the diagnosis of CTS, completion of the evaluations (attendance to evaluation before and 15 days after injection).

Exclusion criteria were as follows: complaints on both hands due to CTS, diagnosis of cervical radiculopathy, multiple entrapment neuropathy or polyneuropathy, weakness of thumb abduction or opposition, thenar atrophy, previous corticosteroid and/or local NSAID injections for CTS, regular use of oral corticosteroid or NSAID drugs, participation in physical therapy program for CTS within last six months, history of wrist-level trauma or arthritis flare, history of CTS-related surgery, diabetes, hypothyroidism or hyperthyroidism; wrist ultrasound showing bifid median nerve, persistent median artery, ganglion cyst, tenosynovitis, or tendinitis; existence of any rheumatic disease (such as rheumatoid arthritis, ankylosing spondylitis, systemic lupus erythematosus, vasculitis, systemic sclerosis, dermatomyositis), chronic renal failure, presence of malignancy, and pregnancy or breastfeeding.

Study design

This study was conducted retrospectively. Medical records of all patients who underwent ultrasound-guided wrist injections were scanned by the researcher AM. Patients who were recommended to use wrist splints containing a metal bar that held the wrist in neutral position during the night due to CTS were called to the outpatient clinic for control after 1 month. Patients who accepted the ultrasound-guided wrist injection and continue to use splint after the injection during night were considered "patients using splint", while patients who had never used a splint for CTS or those who did not accept using a splint were considered "patients not using splint".

Administration of Injection: Injections were made using a 25-gauge needle with a 6-18 MHz superficial linear probe (Mindray, Shenzhen, China). Patients were in a seated position with their elbow flexed, forearm in supination, wrist neutralized and the injection site was cleaned with povidone-iodine solution. The ultrasound probe was held parallel to the distal wrist level, while the probe was held close to the ulnar edge, diagonally inserted between the ulnar artery and median nerve with the in-plane approach, and advancing under the median nerve, the injection was given inside the carpal tunnel. The injection contained 1 ml compound betamethasone (2 mg betamethasone sodium phosphate and 5 mg betamethasone dipropionate) with 1.5 ml of 0.5% lidocaine hydrochloride.

Evaluation criteria

Patients who were included in the study were screened according to age, sex, body mass index (BMI), duration of symptoms, dominant hand, injected hand, and CTS severity detected by EMG. At evaluations before injection and 15 days after injection, patients were evaluated by the researcher BK in terms of sonographic assessment of median nerve, degree of pain/numbness in wrist and fingers, severity of symptoms, and degree of functionality.

Sonographic assessment of median nerve: Ultrasound evaluation was performed using a 6-18 MHz superficial linear probe (Mindray, Shenzhen, China). All measurements were made using established frequency and depth settings. During examination, patients were facing the clinician in a seated position, with their elbow at 90 degrees flexion, forearm in supination, and fingers in semi-flexion position. Examination began by finding the median nerve in the axial plane of the wrist. With the probe at the pisiform and scaphoid bone level, median nerve cross-sectional area (MNCSA) was measured. The MNCSA was calculated using the manual method with tracing of a continuous line around the inner hyperechoic rim of the median nerve using electronic calipers. Units of square millimeters were used for all field measurements. All measurements were made three times each and the average of the three measurements was noted.

Pain/numbness evaluation: Severity of pain and numbness in patients was assessed using the visual analogue scale (VAS). A horizontal plane of 10-cm length was used in the VAS evaluation. Patients were explained that the value of 0 indicated no pain or numbness, while the value of 10 indicated the most severe pain and numbness the patient had ever experienced. For each evaluation, the average score of daytime and nighttime pain/numbness severity for the past three days was assessed.

Symptom severity and functionality: The Boston Carpal Tunnel Questionnaire (BCTQ), which was previously subjected to Turkish validity and reliability study, was used to evaluate the symptom severity and functionality of patients (17). BCTQ is a two-part questionnaire completed by the patients themselves, consisting of a symptom severity scale (SSS) and functional status scale (FSS). Each item in both sections contains five separate answers with a score of 1 to 5. The average score is obtained by dividing the total score by the number of questions and ranges from 1 to 5, with a high score indicating severe symptoms. Mean scores are calculated separately for symptom severity and functional status.

Electrophysiological Assessment: Patients have previously undergone electrodiagnostic study in our hospital's neurology department, as recommended by American Association of Electrodiagnostic Medicine, for

CTS diagnosis (18). Patients with mild or moderate degree CTS according to the neurophysiological classification system by Padua et al. (19) were included in our study.

Statistical analyses

Statistical analyses were performed with SPSS version 19.0 software (IBM Corporation, Armonk NY, USA). The distribution of the data was determined by Shapiro-Wilk tests. Continuous variables were expressed as mean ± standard deviation, categorical variables as frequency and percent. Categorical variables were compared using Yates Chi-square test or Fisher's exact test. Groups were compared using independent samples t-tests and Mann–Whitney U tests for parametric and non-parametric variables, respectively. A 2-way repeated measures Anova was used to measure the time, group and time x group interaction effect, and a value of $p<0.05$ was accepted as statistically significant.

After the study was completed, the post-hoc power analysis was performed using the G*Power version 3.1.9.2 software (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany). For the Repeated measures within-between interaction ANOVA from F-test family, the post-hoc power was calculated as 0.96 in the power analysis using VAS night score measure for 2 groups and 2 repeats.

RESULTS

Ninety-six patients who underwent CTS injection were evaluated, and a total of 57 hands of 57 patients who met inclusion criteria were included in our study. The patients not using splint group consisted of 25 patients (Group 1), while the patients using splint group consisted of 32 patients (Group 2). There were no adverse side effects related to treatment in any of the patients. There was no significant difference among two groups for age, BMI, duration of symptoms, sex, dominant hand, injected hand, and CTS severity ($p>0.05$). Demographic and clinical data of the patients are presented in Table 1.

Table 1. Demographic and Clinical Characteristics of the Study Groups

		Group 1 (n=25)		Group 2 (n=32)		p
Age (year)		45.7±6.8		41.4±7.2		0.059†
BMI (kg/m²)		30.1±10.3		29.5±5.1		0.786*
Duration of symptoms (month)		43.2±21.8		38.9±25.9		0.062*
		n	%	n	%	
Sex	Female	21	84.0	30	93.8	0.388§
	Male	4	16.0	2	6.3	
Dominant hand	Right	23	92.0	32	100	0.188§
	Left	2	8.0	0	0	
Injected hand	Right	12	48.0	20	62.5	0.274‡
	Left	13	52.0	12	37.5	
CTS severity	Mild	13	52.0	10	31.3	0.113‡
	Moderate	12	48.0	22	68.8	

Data are presented as mean ± SD and number (percent) where applicable. *Independent samples t test, †Mann Whitney U test, ‡Yates' chi-square test, and §Fisher's exact test, Group 1: The patients not using splint, Group 2: The patients using splint

Table 2. Evaluation of the interaction effects of the groups and times on parameters

	Day 0		Day 15		Group		Time		Group-Time interaction	
	Group 1	Group 2	Group 1	Group 2	F	p	F	p	F	p
VAS daytime	5.9±2.3	5.8±1.7	1.9±1.3	1.9±2.0	0.002	0.965	158.835	<0.001	0.119	0.733
VAS nighttime	7.0±2.3	6.4±2.2	1.5±1.4	2.3±2.0	0.009	0.926	208.168	<0.001	2.634	0.118
MNCSA	14.9±4.7	13.4±2.8	12.7±3.9	12.3±3.5	0.812	0.377	55.380	<0.001	1.656	0.210
SSS	34.8±7.3	36.9±6.3	20.4±5.2	20.4±4.5	1.372	0.253	380.459	<0.001	1.851	0.186
FSS	20.1±76.8	24.4±5.8	13.3±4.7	14.8±4.4	6.988	0.014	125.376	<0.001	5.940	0.023

Data are presented as mean ± SD. p: Two way repeated measures for ANOVA, p value of <0.05 is considered statistically significant, F: Test statistics (analysis of variance with repeated measurements), VAS: Visual analogue scale, MNCSA: Median nerve cross-sectional area, SSS: Symptom severity scale, FSS: Functional status scale, Group 1: The patients not using splint, Group 2: The patients using splint

There was a significant group effect on FSS score (p<0.05). FSS score on day 0 was significantly lower in Group 1 compared to Group 2 (p=0.012). There was significant change over time in VAS daytime, VAS nighttime, MNCSA, SSS, and FSS values (p<0.05). Both groups had significant decrease in values over time. There was statistically significant effect of group and time interaction in FSS values (p<0.05), and this difference was due to the group effect on FSS score (Table 2).

The percent change was calculated by taking the difference between the baseline (day 0) and day 15 in both groups. Group 1 had significantly higher percentage change in VAS nighttime score (p<0.05) (Table 3). There was no significant change in other parameters (p>0.05).

Table 3. Percent Changes of the Parameters between Days 0 and 15

	Group 1	Group 2	p
VAS daytime	63.9±28.4	66.7±28.5	0.707
VAS nighttime	78.1±21.5	63.4±25.1	0.023
MNCSA	14.1±15.2	9.4±12.0	0.644
SSS	41.9±18.6	43.8±12.3	0.260
FSS	29.8±23.1	36.4±20.5	0.197

Data are presented as mean ± SD. p value of <0.05 is considered statistically significant; p values for independent samples t test, VAS: Visual analogue scale, MNCSA: Median nerve cross-sectional area, SSS: Symptom severity scale, FSS: Functional status scale. Group 1: The patients not using splint, Group 2: The patients using splint

DISCUSSION

This study was conducted in order to determine whether or not the use of static splint use starting one month before injection and continuous use after injection would have an effect on treatment outcomes in patients diagnosed with CTS undergoing ultrasound-guided injection treatment. Steroid and NSAID injection guided by ultrasonography imaging was shown to have short-term positive effect on pain/numbness, MNCSA, and symptom and functional scores. Our findings demonstrated that using neutral wrist splint during sleep, starting before and continuing after injection treatment, did not increase the efficacy of injection treatment and may actually have negative effect on improvement in VAS nighttime scores.

The anti-inflammatory mechanism of steroid injection acts by reducing edema in CTS treatment (20). Although studies have shown the effectiveness of CTS treatment, the data on duration of action is unclear. While Atroshi et al. (14) demonstrated steroid injection was effective up to 10 weeks; another study did not obtain data that it was effective past one month (21). Steroid together with NSAID solution in CTS injection has also been reported. Armstrong et al. (22) found that steroid and lidocaine combination was more effective than lidocaine injection alone, while Karadas et al. (23) reported that procaine injection was as effective as steroid injection and that its effect lasted up to six months. In our study, we combine betamethasone and lidocaine, believing it would be more effective. Consistent with the literature, local steroid and NSAID injection was found to have positive effect on pain/numbness, MNCSA, and symptom severity and functionality.

Expanded median nerve may be observed due to many causes such as inflammation, fibrosis, and endoneural edema in CTS. MNCSA at pisiform-scaphoid bone level has been reported to be the most sensitive and specific sonographic parameter to determine this expansion (24). Cartwright et al. (25) reported significant decrease in distal wrist MNCSA measurement one week after steroid injection into the wrist for CTS, while another study reported significant decrease in MNCSA at scaphoid-pisiform bone level two weeks after steroid injection (26). Although both groups in our study displayed significant decrease in MNCSA two weeks after injection, the splint treatment in addition to steroid injection had no additional contribution in MNCSA in this period.

Wrist splint is one of the most commonly used methods in CTS treatment (5). Manente et al. (6) conducted a randomized controlled study on wrist splint treatment for four weeks and reported that it provided symptomatic and functional improvement. Another study (7) reported that full-time splint use provided greater electrophysiological improvement compared to nighttime splint use alone. The effectiveness of splint use together with other conventional treatment methods in CTS has also been investigated; however, the data that treatment will be more effective when splint use is combined with other treatment methods is not fully clear. Graham et al. (11) reported that splint use following steroid injection did not contribute to treatment. Another study (12) which also evaluated splint use after steroid injection found that there was no difference at the sixth-week assessment between the group that was only applied steroid injection compared to the group that received splint treatment in addition to steroid injection, however the group in which both treatments were applied had statistically greater improvement in symptom severity and functionality at the twelfth-week assessment, although this improvement was not found clinically significant. The same study also reported that local steroid injection provided significant improvement in CTS but this therapeutic effect wore off after six weeks. Therefore, we believe that the outcomes of the twelfth-week assessment in this study only show the effect of splint use, independent from injection treatment. Unlike the aforementioned study, we compared patients who began splint use four weeks before injection and continued use after injection, and median nerve was evaluated with ultrasound. As a result of our study, we obtained data showing that splint use may have negative short-term effects on VAS nighttime. In our study, patients using splint only used the wrist splint at night and the same group had less improvement in VAS nighttime parameter compared to the group not using splint. This finding suggests that restricting wrist movement at night after injection may reduce venous return in the wrist region and may also reduce the anti-inflammatory effect of steroid and NSAID injection, and this situation

may increase nighttime pain by slowing the decrease of intraneural pressure throughout the night.

LIMITATIONS

The most important limitation of our study was that short-term outcomes were evaluated. Therefore, we did not obtain data on the long-term effect of neutral wrist splint use together with injection treatment. Other major limitations of our study were that study groups were formed according to whether or not patients accepted splint use and that our study was retrospective in design. At the same time, measurement of MNCSA only at the pisiform-scaphoid bone level was also a limitation.

CONCLUSION

The results of our study are indicative that nighttime wrist splint use starting before and continuing after ultrasound-guided steroid and NSAID injection did not increase the effectiveness of injection treatment in CTS, and that splint use may even have negative effects on improvement of VAS nighttime score. In order to determine the effects of splint use starting before steroid injection in CTS treatment, there is a need for further randomized studies with larger patient samples which include patient groups with only splint use.

Conflict of interest : The authors declare that they have no competing interest.

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Ethical approval: This study was conducted with the approval of the Clinical Research Ethics Committee of Taksim Training and Research Hospital. (Number: 7.8.2019/100).

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