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Long-term effectiveness of steroid injections and splinting in mild and moderate carpal tunnel syndrome

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Abstract To evaluate the long-term efficacy of non-surgical treatment methods for mild and moderate carpal tunnel syndrome, 120 patients with clinical symptoms and electrophysiologic evidence were included in a prospective, randomized and blinded trial: 60 patients were instructed to wear splints every night, 30 received injections of betamethasone 4 cm proximal to the carpal tunnel, and 30 received injections distal to the carpal tunnel. After approximately 1 year (mean, 11 months; range, 9–14), 108 patients were available for final evaluation. We assessed clinical symptom severity and performed detailed electrophysiologic examinations before and after treatment. Splinting provided symptomatic relief and improved sensory and motor nerve conduction velocities at the long-term follow-up when the splints were worn almost every night. Proximal and distal injections of steroids were ineffective on the basis of both clinical symptoms and electrophysiologic findings.

Key words Carpal tunnel syndrome • Splinting • Steroid injections • Therapy

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Introduction

There is no commonly accepted non-surgical treatment program for mild and moderate carpal tunnel syndrome (CTS) at this time. Although splinting and local steroid injections into, and more recently, proximal to the carpal tunnel have been reported to be effective non-surgical treatment options, long-term effectiveness of these methods remains controversial [1]. Some authors suggest that the relief of CTS symptoms is temporary after steroid injections [2]. Therefore it seems reasonable to carry out long-term follow-up studies after steroid injections applied for the treatment of CTS. Furthermore, a few reports described median nerve injury from local injections of steroids [3–5]. Unfortunately, most studies of non-surgical treatment methods for CTS had a short-term follow-up. Moreover, the majority of these studies was retrospective, incomparable or unblinded and in some papers the evaluation of treatment efficacy was made solely on the basis of clinical criteria [7–12].

The aim of this long-term, prospective, randomized and blinded study was to compare the detailed electrophysiologic and clinical outcomes of steroid injections and splinting, two common treatment options in mild and moderate CTS.

Patients and methods

The study enrolled consecutive patients who attended or were referred to the neurology, plastic and reconstructive surgery and orthopaedics outpatient clinics of Mersin University Hospital between December 1999 and May 2001. The patients gave informed consent to participate in the study. The Ethics Committee of Mersin Medical Faculty approved the study protocol and the study was conducted according to principles established in the Declaration of Helsinki.

A patient was considered as a candidate for the study when referred to the electroneuromyography (ENMG) laboratory for the evaluation of CTS with symptoms including nocturnal paresthesias, pain in the median nerve distribution during activity, or numbness in the median nerve distribution. The duration of complaints varied between 5 months and 30 years. Those who were found to have abnormal median sensory nerve conduction values were included in the study. All participants had a distal latency of the median nerve at least 0.4 ms longer than that of the ulnar nerve in a median-versus-ulnar digit IV antidromic sensory distal latency comparison study. We excluded from the study: patients with secondary CTS (i.e. those with diabetes mellitus, hypothyroidism, rheumatic disease, previous wrist trauma); patients with coincident cervical radiculopathy or ulnar-radial neuropathy; patients younger than 18 years; patients who had previous surgical treatment of CTS, used splints in the last 6 months or received steroid injections for CTS; patients with a median motor distal latency longer than 6 ms on ENMG examination; and pregnant women. Patients with a median nerve distal motor latency longer than the reference values underwent needle electromyography of the abductor pollicis brevis muscle (APB). Patients with fibrillation potentials, positive sharp waves or chronic neuropathic changes (decreased recruitment pattern, long duration or high amplitude of motor unit potentials) at needle electromyography and patients with both normal motor and normal sensory conduction values were also excluded. In those patients with bilateral symptoms, the hand with the most severe symptoms was chosen for treatment and evaluation.

A total of 120 patients were included in the study. Patients were randomly assigned to one of the 3 groups: splint group (60 patients), distal injection group (30 patients) and proximal injection group (30 patients). The patients underwent clinical assessment of symptoms, electrophysiological examination, and sensory and motor nerve conductions studies before and after treatment.

Two authors (HK and MA), blinded to the electrophysiologic findings and treatment methods of the patients throughout the study, assessed the patients using a structured questionnaire regarding possible symptoms of carpal tunnel syndrome: numbness, pain, paresthesia, swelling, sense of swelling, drying or/and color change in the related hand; numbness, pain, paresthesia of the forearm and arm; provocation of symptoms by housework, reading and driving; existence of night symptoms; awakening due to night symptoms; frequency of night symptoms; numb hand upon awakening in morning; and mean duration of any symptom throughout the day. The severity of each symptom was graded from 0 to 3 (0, no symptom; 1, mild; 2, moderate; 3, severe). The sum of all complaint scores gave a total neurologic symptom score (NSS) for each patient.

In a subgroup of patients, the intraclass correlation coefficient was calculated for a total score of the NSS to assess the interrater agreement of the scale.

Electrophysiological examinations were performed on the chosen hand of each patient before and after the treatment, by the same author (SS) who was blinded to treatment methods and historical data throughout the study.

Sensory nerve conduction studies

Median antidromic sensory nerve conduction studies (MAMSV) of digits I, II and III, ulnar sensory nerve conduction study of digit V, and median-versus-ulnar digit IV antidromic sensory distal latency (MUSCD-IV) comparison study were done on the chosen hand of each participant. Ring electrodes were placed on the related digit with the active and reference electrodes 4 cm apart for recording. The stimulation was applied 10 cm proximal to the active recording electrode for digits I and V and 13 cm for digits II, III and IV. The ground electrode was between the active and the stimulating electrodes. Median nerve stimulation was applied over the median nerve between the tendons of palmaris longus and flexor carpi radialis muscles, whereas ulnar nerve stimulation was applied over the flexor carpi ulnaris tendon. For each patient, the mean antidromic median sensory conduction velocity (MAMSV) and the mean antidromic median sensory action potential amplitude (MAMSA) of the 3 digits (digits I, II and III) were calculated in meters/second (m/s) and microvolts (μV), respectively.

Motor nerve conduction studies

Median and ulnar motor nerve conduction and median second lumbrical-versus-ulnar interossei distal motor latency comparison studies were performed on the chosen hand of each participant. A Medelec Synergy 2.0 ENMG machine was used for electrophysiological examinations. Palmar skin temperature was maintained above 31°C.

- For the median motor nerve conduction study, the active surface recording electrode is placed over the belly of the APB. The reference electrode was placed on the distal phalanx of the thumb, and the ground was between the active and stimulating electrodes. Distal stimulation was applied over the median nerve between the tendons of palmaris longus and flexor carpi radialis muscles with the cathode 5 cm proximal to the active electrode. The proximal stimulation site was at the elbow crease on the ulnar side of the brachial artery.
- For the ulnar nerve motor conduction study, the active surface recording electrode was placed over the belly of the abductor digiti minimi muscle. The reference electrode was placed on the fifth digit and the ground was between the active and stimulating electrodes. Distal stimulation was applied just over the flexor carpi ulnaris tendon with the cathode 8 cm proximal to the active electrode. The proximal stimulation site was at the ulnar groove.
- For the median second lumbrical-versus-ulnar interossei distal motor latency (MUDML) comparison study, the recording electrode was placed slightly lateral to the midpoint of the third metacarpal. The reference electrode was placed distally over the metacarpal-phalangeal joint of digit II and the ground was between the active and stimulating electrodes. We stimulated the median and ulnar nerves at the wrist using identical distances from the active electrode as described by Preston and Logigian [12].

CTS treatments

Steroid injections were administered by one author (OD) who was blinded to the electrophysiologic and clinical findings. The injections, containing 3 mg betamethasone disodium phosphate and 3 mg betamethasone acetate suspension (Celestone Chronodose), mixed with 0.5 cc of a lidocain HCl solution (Aritmal ampul 2%, 5 cc), were given through a 26-gauge needle. In the proximal injection group, the injection site was the volar side of the forearm 4 cm proximal to the wrist crease between the tendons of the radial flexor muscle; the long palmar muscle and the needle was inserted with an angle of 10º–20º before injection of the solution as described by Dammers et al. [1]. In the distal injection group, the needle was inserted at the anterior wrist flexion crease just near to ulnar side of the palmaris longus tendon and angulated 45º distally as well as 45º radially. Patients were instructed to warn for stopping the insertion when they felt pain or pins and needles in the median distribution. After an appropriate needle placement, injection was undertaken. Participants were observed for 10 minutes to ensure that the solutions were given appropriately as indicated by numbness in the median nerve distribution due to the anaesthetic effect of lidocaine. All the patients were injected once.

Splinting was performed by placing a standard lightweight wrist splint with a metal strip extending across the wrist to the midpalm region. The splint was bent so the wrist would be in neutral position (0° to 5° extended). The patients were instructed to wear the splints every night and to mark each night that they had worn the splints on a calendar.

A nurse collected all the electrophysiologic and clinical data and kept them in a locker.

Follow-up evaluation

At the end of 11 months (range, 9–14 months), contacts with one patient from the proximal injection group and one from the distal injection group were lost for follow-up. Another patient from the proximal injection group refused the electrophysiologic follow-up examination. These 3 patients were dropped from the final analysis. Of the 60 participants in the splint group, 9 wore the splints on average 1–5 nights per week and were excluded. Twenty-three from this group wore the splints less than 1 night per week and were considered to form a control group. The remaining 28 patients wore the splints 6–7 nights per week and they were taken as the properly used splint group. Thus, follow-up evaluation was performed on 28 patients from the proximal injection group, 29 from the distal injection group, 28 from the splint group and 23 from the control group. These 108 participants were re-evaluated by the same methods used at baseline and by the same physicians.

Statistical analysis

One-way ANOVA and Student-Newman-Keuls tests were used to compare the differences between the groups for NSS and electrophysiologic data at baseline. Paired T-test was used to compare the baseline and follow-up measures of NSSs and electrophysiologic findings of each group.

Results

A total of 120 patients with carpal tunnel syndrome (CTS) were randomized to receive betamethasone injected proximally or distally to the carpal tunnel or to undergo conservative treatment with splints. After 11 months (range, 9–14), a total of 108 patients was available for follow-up analysis (Table 1). Of the 60 patients instructed to wear their splints every night, 28 (46.6%) used the splints for an average of 6–7 days per week. A control group was formed by the subset of patients who did not comply with wearing the splint.

None of the patients in either steroid treatment group experienced serious complications due to the injections. Two patients from the distal injection group stated moderate pain lasting less than 24 hours after injection. One patient from the proximal injection group developed a small haematoma at the injection site, which disappeared in 10 hours. One patient from the control group developed an allergic reaction on the skin of her hand and was treated with topical steroids.

Intraclass correlation coefficient was calculated to be over 0.80 ($p<0.001$) for a total score of the NSS.

The average age of the 108 participants evaluated at follow-up was 46 years (SD=10; range, 23–71 years) there were no significant differences in age between the four study groups. Overall, 69 patients (64%) had bilateral CTS and 39 (36%) had unilateral CTS. The right hand was studied in 77 patients and left hand in 31 patients. Only 6 patients had CTS complaints lasting longer than 5 years.

No significant differences existed between the four groups for pre-treatment NSS (Table 2) and electrophysio-

Table 1 Characteristics of 108 of 120 patients included in the study and available for follow-up analysis

Group	Patients, n	Age, years[a]	Female, n (%)	CTS, n	
				Bilateral	Unilateral
Proximal injection	28	43.89 (10.54)	27 (96)	18	10
Distal injection	29	45.45 (11.60)	24 (83)	21	8
Splint	28	49.71 (9.75)	22 (79)	17	11
Control	23	46.00 (7.90)	19 (83)	13	10
Total	108	46.27 (10.24)	92 (85)	69	39

[a] Values are mean (SD)

Table 2 Electrophysiologic findings and neurologic symptom score (NSS) at baseline and follow-up, for 108 patients who completed the study, by treatment group. Values are mean (SD). Normal values determined in our laboratory

	MAMSV, m/s[a]	MUSCD-IV, m/s[b]	MUDML, ms[c]	NSS
Normal values	≥47.8	≤0.37	≤0.38	–
Control (n=23)				
Baseline	43.07 (6.10)	0.97 (0.45)	0.68 (0.52)	14.74 (4.48)
Follow-up	43.33 (5.84)	0.96 (0.45)	0.70 (0.52)	14.87 (4.47)
Proximal injection (n=28)				
Baseline	41.15 (5.25)	1.10 (0.46)	0.86 (0.47)	17.18 (4.64)
Follow-up	41.41 (5.06)	1.11 (0.44)	0.87 (0.45)	16.89 (5.24)
Distal injection (n=29)				
Baseline	42.52 (5.74)	0.96 (0.47)	0.74 (0.52)	15.90 (7.03)
Follow-up	42.42 (5.37)	1.02 (0.43)	0.74 (0.51)	14.72 (7.14)
Splint (n=28)				
Baseline	44.45 (4.70)	0.99 (0.37)	0.68 (0.40)	16.03 (4.44)
Follow-up	47.70 (4.45)	0.71 (0.27)	0.54 (0.32)	11.53 (4.99)

MAMSV, mean antidromic median sensory nerve conduction velocity of digits I, II and III; *MUSCD-IV*, median-versus-ulnar digit IV antidromic sensory distal latency difference; *MUDML*, median second lumbrical-versus-ulnar interossei distal motor latency difference; *NSS*, neurologic symptom score

logic data of all the conduction studies with the expection of a longer mean F wave latency in the proximal injection group compared to the control group and a lower MAMSA in the proximal injection group compared to the other 3 groups (data not shown). Significant improvement in NSS was observed at the follow-up examination for the split group ($p<0.001$). Although the mean NSS for the proximal and distal injection group was slightly lower at follow-up than that at baseline, no statistically significant difference was found between the baseline and follow-up NSSs for these group or for the control group (Table 2).

Compared to baseline, in the splint group at follow-up there was a significant reduction ($p<0.001$) in median-versus-ulnar digit IV antidromic sensory distal latency difference (MUSCD-IV), median second lumbrical-versus-ulnar interossei distal motor latency (MUDML) difference and median nerve motor distal latency (data not shown). There was also a significant increase in MAMSV for the splint group between baseline and follow-up examinations ($p<0.001$). Significant reduction in F wave latency and increased F wave persistency (data not shown) were also found for the splint group at follow-up compared to baseline ($p=0.044$ and $p=0.047$, respectively). The two parameters that were expected to improve but did not show statistically significant differences between baseline and follow-up values in the splint group were median nerve compound action potential and median nerve sensory action potential amplitudes (data not shown). None of the parameters of any other group showed statistically significant difference at the follow-up study when compared with those at baseline.

Discussion

To our knowledge, this study is the only long-term, prospective, randomised and blinded study comparing the detailed electrophysiologic and clinical outcomes of steroid injections and splinting with a large group of patients. Almost all previous studies with short-term follow-up reported improvement with steroid injections and splinting in carpal tunnel syndrome [1, 7, 10, 12].

In CTS, the most sensitive diagnostic tests are sensory and motor nerve conduction studies. In mild and moderate CTS, an effective therapy should improve sensory and motor nerve conduction velocities and distal latencies of the median nerve. Any study that compares pre- and post-treatment electrophysiologic values should provide detailed measurements of conduction studies and a detailed questionnaire to increase the reliability of the study. It has been postulated that, according to the anatomic location of their funiculus, ring and middle finger branches are more severely affected than the thumb and index finger among the four digital branches of the median nerve in CTS [13–15]. For this reason, besides performing extensive electrophysiologic evaluation including sensitive tests for carpal tunnel syndrome, we calculated the mean sensory velocities and action potential amplitudes of the 3 digits innervated by the median nerve (digits I, II and III).

In some studies, total and partial relief of complaints of each patient and the percentage of such patients in study groups were taken as a criterion for effectiveness of treatment. We did not use such a criterion because as far as we know no standardization has been achieved in any 2 studies on the subject. Therefore, we made comparisons on the basis of mean values of each group.

Splinting provided symptomatic relief and improved sensory and motor conduction velocities in our patients in the long-term follow-up when the splints were worn almost every night. We found that both injection methods, distal and proximal, made no long-term benefit for relief of complaints nor for electrophysiologic findings. We did not observe any harmful effect of injections, but there are a few reports among hundreds indicating permanent median nerve injury due to steroid injections and stating that repetitive injections should be avoided [3, 4]. There are conflicting results in the literature about the long-term efficacy of steroid injections, and recurrence rates range between 8% and 100% [7]. Unfortunately most of these studies were retrospective, incomparable or unblinded and in most of them the evaluation of efficacy of these treatments was made solely on the basis of clinical criteria. Girlanda and co-workers [2] suggested a possible several-month honeymoon period of symptoms for local steroid injections. They found a clear-cut short-term (at weeks 1, 2, 4 and 8) efficacy of steroid treatment when compared with placebo, but no long-term (6 and 18 months) efficacy. Ozdogan and Yazici [11] reported similar results to Girlanda et al. [2] and stated that the benefit of steroid treatment was transient for most cases. In contrast, Giannini et al. [8] reported that the recovery of function of the median nerve continued for a long period and explained this discrepancy by patient selection and the usage of a long-acting steroid agent (triamcinolone acetonide). Dammers and co-workers [1] stated that by using the proximal injection method, 63% of their patients improved at the end of one year, which also contradicts with our results. The contradicting results can be due to different methods used to evaluate the outcomes. Dammers et al. [1] did not include electrophysiologic examination in their study and based the success of the treatment on a single question on patient satisfaction.

There can be some short-term beneficial effects of steroid injections in mild and moderate CTS; and even if there were in our study, we demonstrated that these benefits do not last one year. On the other hand, when properly used, splinting provided symptomatic relief and improved sensory and motor nerve conduction velocities in the long-term. Long-lasting effectiveness of steroid injections is still a dilemma.

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