Electrophysiological and clinical comparison of local steroid injection by means of proximal versus distal approach in patients with mild and moderate carpal tunnel syndrome

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Background
Local corticosteroid injection is one of the treatment modalities for carpal tunnel syndrome. Symptomatic and electrophysiological improvement following local corticosteroid injection has been documented.

Objectives
The aim of the present study was to compare the effects of proximal and distal approaches of local steroid injection in patients with mild and moderate carpal tunnel syndrome on clinical scores and electrophysiological parameters at the end of 1 month following injection.

Patients and methods
A total of 30 patients were included and randomly assigned into one of the two groups based on the local steroid injection approach either by means of distal (group I) or by mean of proximal approach (group II). Clinical and electrophysiological examinations were carried out before and 1 month following the injection.

Results
There was a significant reduction in the pain and disability scores of the Boston Carpal Tunnel Questionnaire between the baseline and follow-up in both groups. Median motor nerve distal latency was statistically significantly reduced in both groups 1 month after the injection. Median motor conduction velocity and amplitude (amp) showed a statistically nonsignificant difference 1 month following the injection. Median sensory distal latency, amp, and conduction velocity showed statistically significant difference between the two groups. The average duration of the procedure in group I was 9.29 ± 0.76 s compared with 47.91 ± 9.66 s in group II. The average grade of pain expressed by the patients in group I was 1.97 ± 0.82 compared with 5.11 ± 0.67 in group II.

Conclusion
Local corticosteroid injection at the carpal tunnel using the distal approach is associated with favorable clinical and electrophysiological results similar to those reported using the proximal approach. The distal approach is much less time consuming and more comfortable compared with the proximal approach.

Keywords:
carpal tunnel syndrome, distal approach, local corticosteroid injection, proximal approach

Introduction
Carpal tunnel syndrome (CTS) is the most commonly diagnosed disabling condition of the upper extremities. It is the most commonly known and prevalent type of peripheral entrapment neuropathy that accounts for about 90% of all entrapment neuropathies [1]. Management of CTS includes splinting [2], local corticosteroid injection [3], or surgical decompression [4]. The main aim of these modalities is to reduce or eliminate the compression of the median nerve at the carpal tunnel.

Local steroid injections are widely used for diagnostic and therapeutic purposes in the management of CTS [5]. Usually, 15–40 mg of methylprednisolone acetate (depomedrol; Pfizer) is injected just ulnar to the tendon of the palmaris longus (PL) at a distance ranging from 0 to 4 cm proximal to the first crease of the wrist [6–8].

Corticosteroid injections can cause complications such as ischemia, skin depigmentation and atrophy, and trauma to superficial flexor muscle tendons of the hand. Median nerve injury is the most serious complication associated with local steroid injection for CTS [9,10].

Typically, the median nerve is just dorsal and radial to the PL tendon at the carpal tunnel level. If the

needle is inserted radial to the PL tendon, the median nerve can be injured. However, patients with CTS are more vulnerable to needle injury compared with healthy participants even if the needle is inserted at a correct position, because the median nerve is swollen and/or flattened around the wrist crease. Anatomic variation such as the presence of the median nerve in an abnormal location, a bifid median, and anomalous muscle also may affect the procedure [11–14].

Habib *et al.* [15] reported a novel approach for local steroid injection for the treatment of CTS with comparable favorable effects in terms of relief of numbness. In this approach, a 29-G needle is used to inject 12 mg of depomedrol 2–3 cm distal to the wrist crease between the thenar and hypothenar eminences, targeting the distal part of the carpal tunnel.

Repeated nerve conduction measurements after local steroid injection using the classic method showed improvement in different electrophysiological parameters. These studies were performed at different timepoints, including 0.5, 1.5, 2, 3, 4, 4.5 and/ or 6 months following the injection, and at every timepoint the nerve conduction parameters were better than those at baseline [7,8,16–18].

The main objective of this study was to investigate the effects of local steroid injection therapy with the novel method on clinical scores and electrophysiological parameters in comparison with the classic method at the end of 1 month.

Patients and methods

The methodology of this prospective clinical study was approved by the research ethical committee of Ain Shams Faculty of Medicine, and all patients provided written informed consent before participation.

All patients referred to the Physical Medicine, Rheumatology and Rehabilitation outpatient clinic of Ain Shams University Hospitals with a presumptive clinical diagnosis of CTS were subjected to electrophysiological studies.

Electrophysiological tests were carried out for all patients using (Schwarzer topas basic EMG system, Germany) an electrophysiological instrument. Surface electrodes were used for recording. Precautions were taken to keep the hands warm at around 32–33°C. Orthodromic technique of stimulation was used to record sensory parameters at the wrist, with the median nerve being stimulated at the second digit and the ulnar nerve at the fifth digit. Midpalm stimulation was also carried out for both nerves at 8 cm

from the recording site at the wrist. Sensory parameters recorded included peak latencies, amplitude of sensory nerve action potentials, and conduction velocities (CVs) from both stimulating sites.

Motor recording was carried out using the abductor pollicis brevis muscle for the median nerve and the abductor digiti minimi for the ulnar nerve. Stimulation was carried out distally at the wrist and proximally at the elbow. Motor parameters included distal motor latencies, compound muscle action potential amplitude (amp), and motor CV.

Electrophysiological diagnosis of CTS was made as per the recommendations of the American Association of Electro diagnostic Medicine in 2002 [19].

Electrophysiological grading was carried out for all patients as per a scale given by Bland [20]. This study documented the distribution of patients on a scale based on the nerve conduction study findings, which were independent of the exact normal values. The author demonstrated a highly significant linear relationship between the neurophysiological grading and a numerical scale derived from the clinical history. The scale is as follows:

(1) Normal (grade 0): no neurophysiological abnormality.
(2) Very mild (grade 1): CTS demonstrable only with most sensitive tests (e.g. inching, combined sensory index, palm/wrist median/ulnar comparison).
(3) Mild (grade 2): sensory nerve CV slow on finger/wrist measurement, with normal terminal motor latency.
(4) Moderate (grade 3): sensory potentials preserved with motor slowing, with motor terminal latency greater than 4.5 ms and less than 6.5 ms.
(5) Severe (grade 4): sensory potentials absent but motor response preserved, with distal motor latency to abductor pollicis brevis (ABP) greater than 4.5 ms and less than 6.5 ms.
(6) Very severe (grade 5): terminal motor latency to ABP greater than 6.5 ms.
(7) Extremely severe (grade 6): sensory and motor potentials effectively unrecordable (surface motor potential from ABP <0.2 mV amplitude) [20].

All patients diagnosed as having CTS on electrophysiology of mild-to-moderate CTS (defined as grade 3 or less) and who were willing to take local steroid injection were included in the study.

Exclusion criteria were as follows: thenar atrophy and weakness; presence of contraindication for corticosteroid injection (hypersensitivity to corticosteroid, local skin infection); prior treatment for CTS during the last

6 months with steroid injection or surgery; traumatic or neoplastic origin of symptoms; current pregnancy or less than 3 months of postpartum; evidence of diffuse peripheral neuropathy or cervical radiculopathy; grade 4, 5, or 6 CTS; and unwillingness to undergo local steroid injection.

A total of 49 patients were screened and 30 patients were selected. Nine patients did not have CTS, whereas two reported previous history of local steroid injection and eight had severe bilateral CTS and hence were excluded. A total of 30 mild-to-moderate CTS patients were enrolled in this study.

Before steroid injection, patients were asked to subjectively quantify the degree of one parameter for which they were most symptomatic on a visual analogue scale (VAS) of 100. The parameters included pain, tingling, numbness, or functional impairment.

Symptom severity was assessed with the symptom severity score (SSS) and functional status score (FSS), which are both parts of the Boston Carpal Tunnel Questionnaire (BCTQ). The BCTQ is a patient self-reported outcome measure for CTS and has been tested for validity, reliability, and responsiveness [21].

The SSS has 11 questions, the FSS has eight questions, and both use a five-point scale. Each scale generates a final score (sum of individual item scores divided by number of items), which ranges from 1 to 5. Higher SSS and FSS correlate with more severe symptoms and functional impairment, respectively.

Thereafter, patients were randomly assigned into one of the two groups based on local steroid injection approach.

Novel (distal or palmar) approach
An injection of 12 mg of methylprednisolone acetate (depomedrol; Pfizer) was administered with 0.2 ml of 2% lidocaine about 2–3 cm distal to the middle of the wrist crease between the thenar and hypothenar muscles using a 1 ml insulin syringe with a needle size of 29 G×½ inch [15].

The patient's hand was in a midextended position, and the angle of introduction between the syringe and the axis of the forearm was about 35°, directing the needle toward the carpal tunnel. The needle was totally inserted (Fig. 1).

Conventional (proximal approach)
An injection of 40 mg of methylprednisolone acetate (1 ml of depomedrol; Pfizer) was administered with

0.5 ml of 2% lidocaine using a 25 G × 1 inch needle. The site of injection was 2–3 cm proximal to the first crease of the wrist just medial to the PL tendon, with the needle angled at 45° toward the palm and directed slightly medially.

The patient was asked to press the tip of the thumb to the tip of the little finger and to flex the wrist: the prominent tendon in about the midline of the wrist is the PL tendon.

The patient's wrist was slightly dorsiflexed and the needle was inserted about 15–20 cm at an angle of 30–45° with the forearm in the direction of the middle finger. The patient was asked to report parasthesia, in which case the needle was removed and repositioned. No resistance should be felt when injecting, neither pain nor parasthesia. Four patients from group II reported minor transient subcutaneous hematomas.

VAS was used to assess the amount of pain expressed by the patient during the procedures [22]. Moreover, the duration of both procedures from the time of inspection for the site of injection when the syringe was ready until the time of pulling out of the syringe after the injection was measured in each patient.

At 1 month after the injection, patients were reviewed. During this period, patients were not allowed to use any other form of therapy such as splints or drugs. Patients were asked to quantify the degree of improvement on VAS, SSS, and FSS.

Electrophysiological studies were repeated and the change in the following parameters was analyzed: distal motor latency, amplitude of compound muscle action potential (CMAP), motor CV, sensory peak

Figure 1

Local corticosteroid injection using distal (palmar) approach in the treatment of carpal tunnel syndrome.

latency, amplitude of sensory nerve action potential, and sensory CV.

Statistical analysis was performed using the paired *t*-test to look for a significant difference in the electrophysiological values of each parameter at baseline, which were compared with those at 1 month after a local steroid injection. A *P*-value less than 0.05 was considered as significant. The independent *t*-test was used to compare the mean pain level during the procedure and the mean duration of the procedure in both groups. The independent *t*-test was also used to compare preclinical and postclinical scores and electrophysiological studies between the two groups. SPSS program version 21 for Windows (IBM, New York, USA) was used for analysis.

Results
A total of 24 of the 30 patients had bilateral CTS, whereas three had CTS on the right hand and three had CTS on the left hand.

The baseline characteristics of patients in both groups are given in Table 1. There was no significant difference between the demographics of the patients in the two groups. Pain and tingling were the most common symptom at presentation, as shown in Table 2. The change of symptoms in both patient groups usually occurred 1–3 days after injection.

The average duration of the procedure in group I was 9.29 ± 0.76 s compared with 47.91 ± 9.66 s in group II (*P* = 0.000).

The average grade of pain expressed by the patients in group I was 1.97 ± 0.82 compared with 5.11 ± 0.67 in group II (*P* = 0.000).

As regards VAS, in group I, preinjection average pain severity was 7.27 ± 0.86 and postinjection average

pain severity was 3.59 ± 0.94 (*P* = 0.000). In group II, preinjection average pain severity was 7.41 ± 0.88 and postinjection average pain severity was 3.99 ± 1.06 (*P* = 0.000) (Table 3).

There was no significant difference between the two groups in both preinjection and postinjection VAS scores (Table 4).

As regards electrophysiological parameters, median nerve motor distal latencies showed a statistically significant difference in both groups 1 month following the injection (*P* < 0.05). Median nerve motor CV and CMAP amplitude showed a statistically nonsignificant difference in both groups following injection.

After the injection, median nerve sensory peak latency, amplitude, and CV showed significant statistical difference in both groups (*P* < 0.05) (Tables 5 and 6).

There was no significant difference between the two groups in preinjection and postinjection electrophysiological parameters (Table 7).

Evaluation of clinical outcome at 1 month revealed that SSS and FSS reduced significantly in both study groups from their baseline figures (*P* < 0.05) (Table 8).

There was no significant difference between the two groups in preinjection or postinjection SSS and FSS (Table 9).

Discussion
Several studies had shown that local corticosteroid injections can be used for the treatment of mild or moderate CTS. It may be used only before surgery in severe cases [3,23].

In our study, patients with mild and moderate CTS received local corticosteroid injection using two

Table 1 Baseline characteristics

Parameters	Group I	Group II	*P*-value
Total number (patients, hands)	(15 patients, 27 hands)	(15 patients, 27 hands)	
♀ : ♂	2 : 1	3 : 2	1.000
Age (years)	52.49 ± 5.17	50.93 ± 4.60	0.390
Right : left	5 : 4	4 : 5	0.724
Mean duration in months (SD)	17.87 ± 4.64	17.24 ± 4.53	0.711
Grade of CTS			0.726
Grade 1	0	0	
Grade 2	7	5	
Grade 3	20	22	
Symptom severity score	2.60 ± 0.39	2.47 ± 0.38	0.375
Functional severity score	2.46 ± 0.27	2.41 ± 0.30	0.613

CTS, carpal tunnel syndrome.

different approaches: the novel (distal or palmar) approach or the conventional (proximal) approach.

At 1 month following local corticosteroid injection, our patients reported symptomatic and functional improvement as documented by improvement in SSS and functional disability scale of the BCTQ.

Our study also showed that there was a significant improvement in distal motor latency of the median nerve and in all sensory parameters recorded, which included peak latency, amplitude of sensory nerve

action potential, and sensory CV. However, amplitude of compound muscle action potential and motor CV did not show a significant improvement.

The mechanism behind the electrophysiological improvement following steroid injection is believed to be the result of pressure release. The similar improvement in electrophysiological parameters following surgery supports this notion.

Many injection sites have been recommended [6,24–29], but there is no consensus about the safest site for carpal tunnel injection. An ulnar approach between the PL and the flexor carpi radialis, or just medial to the PL tendon has been commonly performed [24,25,30].

Considering median nerve swelling around the inlet of the carpal tunnel in patients with CTS, the median nerve might be injured during carpal tunnel injection.

Racasan and Dubert [31] reported their clinical experience of a painful electrical sensation during injection in 12 out of 32 patients and a permanent sensory deficit in three of those 12. Several cases with median nerve or ulnar artery injury have been reported after carpal tunnel injection [9,32–34].

Other approaches were recommended to reduce the risk of carpal tunnel steroid injection [13,27,29]. Among them, recent studies demonstrated that a technique through the flexor carpi radials tendon was more accurate and safer compared with other approaches [27,29]. However, it might be painful and increase the risk for tendon tear or rupture.

In the present study, local steroid injection was administered to half of our patients using the novel

Table 2 Symptom frequency at presentation

Symptom at presentation	Group I (n = 27 hands) [n (%)]	Group II (n = 27 hands) [n (%)]
Pain	27 (100)	27 (100)
Tingling	10 (37)	8 (29.6)
Numbness	6 (22.2)	7 (25.9)
Nocturnal awakening	4 (14.8)	3 (11.1)
Functional compromise	2 (7.41)	4 (14.8)

Table 3 Preinjection and postinjection values for pain severity on visual analogue scale scores

Number of hands (n = 54)	Preinjection (mean ± SD)	Postinjection (mean ± SD)	P-value
Group I (n = 27 hands)	7.27 ± 0.86	3.59 ± 0.94	0.000
Group II (n = 27 hands)	7.41 ± 0.88	3.99 ± 1.06	0.000

Table 4 Comparison between preinjection and postinjection visual analogue scale scores in both groups (mean ± SD)

VAS scores	Group I (mean ± SD)	Group II (mean ± SD)	P-value
VAS score (pre)	7.27 ± 0.86	7.41 ± 0.88	0.664
VAS score (post)	3.59 ± 0.94	3.99 ± 1.06	0.275

VAS, visual analogue scale.

Table 5 Preinjection and postinjection nerve conduction studies in group I (mean ± SD)

Group I (n = 27 hands)	Preinjection (mean ± SD)	Postinjection (mean ± SD)	P-value
Median motor DL (ms)	4.76 ± 0.46	3.85 ± 0.23	0.000
Median motor amp (mV)	7.57 ± 2.80	7.58 ± 2.83	0.145
Median motor CV (m/s)	54.80 ± 3.74	54.84 ± 3.73	0.626
Median sensory peak latency (ms)	4.50 ± 0.36	3.73 ± 0.41	0.000
Median SNAP amplitude (μV)	7.28 ± 0.79	8.55 ± 0.65	0.001
Median sensory CV (between 2nd digit and wrist) (m/s)	43.72 ± 1.45	46.36 ± 1.56	0.000

CV, conduction velocity; DL, distal latency; SNAP, sensory nerve action potential.

Table 6 Preinjection and postinjection nerve conduction studies in group II (mean ± SD)

Group II (n = 27 hands)	Preinjection (mean ± SD)	Postinjection (mean ± SD)	P-value
Median motor DL (ms)	4.80 ± 0.57	3.93 ± 0.19	0.000
Median motor amp (mV)	7.61 ± 2.58	7.64 ± 2.61	0.119
Median motor CV (m/s)	54.79 ± 2.15	54.80 ± 2.15	0.106
Median sensory peak latency (ms)	4.64 ± 0.35	3.81 ± 0.37	0.000
Median SNAP amplitude (μV)	7.41 ± 0.86	9.06 ± 0.81	0.000
Median sensory CV (between 2nd digit and wrist) (m/s)	43.99 ± 1.31	46.33 ± 3.33	0.029

CV, conduction velocity; DL, distal latency; SNAP, sensory nerve action potential.

Table 7 Comparison between preinjection and postinjection nerve conduction studies in both groups (mean ± SD)

Electrophysiological parameters	Group I (mean ± SD)	Group II (mean ± SD)	P-value
Median motor DL (ms) (pre)	4.76 ± 0.46	4.80 ± 0.57	0.848
Median motor DL (ms) (post)	3.85 ± 0.23	3.93 ± 0.19	0.263
Median motor amp (mV) (pre)	7.57 ± 2.80	7.61 ± 2.58	0.965
Median motor amp (mV) (post)	7.58 ± 2.83	7.64 ± 2.61	0.949
Median motor CV (m/s) (pre)	54.80 ± 3.74	54.79 ± 2.15	0.994
Median motor CV (m/s) (post)	54.84 ± 3.73	54.80 ± 2.15	0.970
Median sensory peak latency (ms) (pre)	4.50 ± 0.36	4.64 ± 0.40	0.287
Median sensory peak latency (ms) (post)	3.73 ± 0.41	3.81 ± 0.37	0.578
Median SNAP amplitude (μV) (pre)	7.28 ± 0.79	7.41 ± 0.86	0.678
Median SNAP amplitude (μV) (post)	8.55 ± 0.65	9.06 ± 0.81	0.069
Median sensory CV (m/s) (pre)	43.72 ± 1.45	43.99 ± 1.31	0.601
Median sensory CV (m/s) (post)	46.36 ± 1.56	46.33 ± 3.33	0.972

CV, conduction velocity; DL, distal latency; SNAP, sensory nerve action potential.

Table 8 Changes in clinical scores in both groups following intervention

Scores	Local steroid injection novel method			Local steroid injection conventional method		
	Before intervention (n = 27)	After intervention (n = 27)	P-value	Before intervention (n = 27)	After intervention (n = 27)	P-value
Symptom severity score	2.60 ± 0.39	1.42 ± 0.24	0.000	2.47 ± 0.38	1.35 ± 0.26	0.000
Functional severity score	2.46 ± 0.27	1.27 ± 0.30	0.000	2.41 ± 0.30	1.16 ± 0.14	0.000

Table 9 Comparison between preinjection and postinjection nerve clinical scores in both groups (mean ± SD)

BCTQ scores	Group I (mean ± SD)	Group II (mean ± SD)	P-value
Symptom severity score (pre)	2.60 ± 0.39	2.47 ± 0.38	0.375
Symptom severity score (post)	1.42 ± 0.24	1.35 ± 0.26	0.430
Functional severity score (pre)	2.46 ± 0.27	2.41 ± 0.30	0.613
Functional severity score (post)	1.27 ± 0.30	1.16 ± 0.14	0.225

BCTQ, Boston Carpal Tunnel Questionnaire.

or distal approach, and the conventional or proximal approach was administered to the other half. The average duration of the novel approach procedure was significantly shorter than that for the conventional approach procedure. Moreover, the average grade of pain expressed by patients in group I (distal approach) was lesser than that expressed by patients in group II (proximal approach) as measured by means of VAS.

In the novel approach, the median nerve is less likely to be damaged as it is located at a deeper and lower level compared with the injection site. None of the patients injected using the novel approach developed nerve damage. Other advantages of the novel approach over the conventional approach are its simplicity, quickness, and convenience for both the patient and the doctor. Another advantage is that much lower doses of depomedrol are required.

Habib et al. [15] compared favorable response rate, time duration, and pain level of local steroid injection using a novel approach for the treatment of patients with CTS versus a classic approach. The favorable

response rates were 100, 81, 71, and 57% in the classic approach group and 100, 71, 67, and 57% in the novel approach group after 1, 3, 6, and 12 weeks, respectively, with no significant difference between the two groups (P = 0.468). The average duration of the procedure in the classic approach group was 26.71 ± 32.83 s compared with 8.48 ± 1.12 in the novel approach group (P = 0.065).

Kamanli and colleagues conducted a study on 19 bilateral CTS patients assigned randomly into one of two groups based on the local steroid injection (proximal vs. distal approach). Clinical and nerve conduction study examinations were carried out at 3 weeks and 3 months after the injection. In addition, severity of pain and disability were assessed using the BCTQ and the Health Assessment Questionnaire at baseline and at 3 weeks and 3 months after the injection. There were significant reductions in pain and disability scores between baseline and the follow-up periods. There was no significant difference between groups. There was a significant improvement in patient's global assessment in patients from the distal injection group [35].

Badarny et al. [36] used the novel method for local injection and showed efficacy on symptoms of the patients and electrophysiological findings (including improvement in median distal sensory and motor latencies in 61 and 75% of 25 hands, respectively). The rate response of their electrophysiological studies is similar to results of previous ones using the classic approach [17,37].

Ozdemir and colleagues investigated the effects of local corticosteroid injection therapy using the novel method on subjective patient complaint and electrophysiological investigations of patients with mild CTS at the end of 3 months. A significant improvement was found in the mean pain severity measured with VAS. Median motor distal latency was statistically significant 3 months after injection, whereas median motor CV was statistically nonsignificant. After the injection, median sensory distal latency, amplitude and CV were statistically significant. They found greater improvement in the nondominant hand compared with the other. This was probably attributed to the pressure effect on the median nerve due to more profound use of the dominant hand the 3 months following injection. This observation supports the use of splints in neutral position and hand rest, in addition to local injection [38].

The limitations of our study are limited number of studied patients, short-term follow-up, and subjective functional assessment. Further studies can be planned to include larger patient groups, extended periods of follow-up, and the use of objective assessment tools such as ultrasound.

Conclusion
Local corticosteroid injection using the distal (palmar) approach for the treatment of CTS is easy, more comfortable, and less time consuming compared with the proximal approach. It gives clinical and electrophysiological improvement response comparable to those using the classic (proximal) approach, with elimination of the risk of median nerve injury.

Conflicts of interest
There are no conflicts of interest.

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