ORIGINAL RESEARCH

# A Randomized Prospective Comparison of Ultrasound-Guided and Landmark-Guided Steroid Injections for Carpal Tunnel Syndrome

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**Purpose:** The aim of this study was to compare the clinical and electrodiagnostic efficacy of ultrasound (US)-guided versus landmark (LM)-guided steroid injections in patients with carpal tunnel syndrome (CTS).

**Methods:** This randomized clinical trial included 47 patients (60 affected hands) with moderate CTS (30 hands in each group). All clinically suspected patients with CTS who met the inclusion criteria confirmed by electrodiagnostic tests were enrolled. The subjects received 40 mg of methylprednisolone either with the US-guide or the LM-guided injection technique. They were evaluated using the Boston Carpal Tunnel Questionnaire (symptom/function/total) and 6 electrodiagnostic findings at the baseline and 12 weeks after injection.

**Results:** Symptom severity scores and functional status scores and electrodiagnostic parameters were significantly improved within each group at week 12 after treatment ($P < 0.05$), except for compound muscle action potential amplitude and motor nerve conduction velocity ($P > 0.05$). The improvement in symptom severity scores and functional status scores in the US-guided group was more than in the LM-guided group after 12 weeks, but there was no statistically significant difference ($P = 0.79$ and 0.64). The mean changes in electrodiagnostic parameters were also not different between groups except for the higher sensory nerve action potential amplitude in LM-guided group ($P = 0.003$).

**Conclusions:** Both US-guided and LM-guided steroid injections were effective in reducing the symptoms, improving the function and electrodiagnostic findings of CTS. Although there was better symptomatic improvement with US-guided injections and better increase in sensory nerve action potential amplitude with LM-guided injection, a significant difference was not generally observed between US-guided and LM-guided CTS injections.

**Key Words:** Carpal tunnel syndrome, Ultrasound, Guide, Injection, Corticosteroid.

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Carpal tunnel syndrome (CTS) is the most common focal peripheral neuropathy caused by compression of the median nerve at the wrist.[1] The CTS symptoms are paresthesia (which is commonly exacerbated at night), numbness, tingling, pain (more often nocturnal), and weakness in distribution of median nerve distal to carpal tunnel.[2,3] Nonsurgical treatment by steroid injection into the carpal tunnel is an effective and frequently used intervention for CTS.[4] In clinical practice, this intervention is mostly performed blindly using surface anatomic landmarks.[5]

A systematic review (Marshal et al.[6]) has shown that local corticosteroid injection for CTS provides greater clinical improvement in symptoms 1 month after injection compared with placebo, but significant symptom relief beyond 1 month has not been demonstrated. Local corticosteroid injection does not significantly improve clinical outcome compared with either anti-inflammatory treatment and splinting after 8 weeks or helium–neon laser treatment after 6 months. In addition, two local corticosteroid injections did not provide any significant added clinical benefit in comparison with one injection.

However, far too little attention has been paid to method of injection and this article will focus on examining the two different procedures of injection.

Although major complications of CTS steroid injection are uncommon, there are reports of direct needle insult to the median nerve or surrounding tissues.[7,8] To avoid blind injection complications and for providing safer, reliable, and more efficient needle tip placement during CTS injections, ultrasound (US) guidance can play a beneficial role. Currently, musculoskeletal US has gained popularity based on its dynamic real-time property and low-cost availability.[9] Ultrasound provides high-resolution scanning view of median nerve and surrounding vessels and tendons and assists in diagnosis as well as needle placement guidance.

Smith et al.[10] and others[11,12] provided some in-plane and out-plane methods for US-guided CTS injection performance. Technically, in-plane approach provides the advantage of longitudinal needle visualization with transverse imaging of the carpal tunnel.

The authors aimed to compare the efficacy of US-guided versus LM-guided corticosteroid injection for patients with CTS with attention to the primary outcome measure of clinical findings and secondary outcome measure of electrodiagnostic aspects.

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This manuscript contributes to the ultrasound-guided musculoskeletal injection for a very common disease (Carpal tunnel syndrome). Sonographic-guided injections are becoming well known and getting so much attention in recent decade articles. This article has a potential of interest for researchers in the field of musculoskeletal disease, ultrasound guide or blind interventions, carpal tunnel syndrome, hand and upper limb pain, and paresthesia.

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## MATERIALS AND METHODS

### Design

This prospective randomized clinical trial compared US-guided and LM-guided injection of 40 mg of methylprednisolone into the carpal tunnel in patients with CTS. All participants gave their informed written consent, and the study protocol was approved by the ethics committee, which was in compliance with the Declaration of Helsinki. The trial was registered on the Iranian "Clinical trial Registry" with identification number "IRCT201408013217N9."

### Study Population

Forty-seven patients (60 median nerves) with primary moderate idiopathic CTS with a clinical and electrodiagnostic conformation of CTS were included in this study. Clinical diagnosis of CTS was based on Daniel Dumitru's Electrodiagnostic Medicine.[13,14] Patients with symptoms of paresthesia and numbness in the median nerve distribution area of the hand visiting physical medicine and rehabilitation clinics in Tabriz University of Medical Sciences during 16 months period from January 2014 until April 2015 underwent electrodiagnostic study for confirmation of CTS.

The clinical inclusion criteria for participants with CTS included: (1) hand numbness and tingling or pain in the distribution of the median nerve, (2) nocturnal worsening of the symptoms, (3) positive Tinel and/or Phalen sign, (4) the desire of the participant to have a corticosteroid injection.

Electrodiagnostic inclusion criteria for participants with CTS according to Stevens criteria[13] included:

1. Criteria of moderate CTS: (1) compound motor action potential (CMAP) latency >4.2 milliseconds, (2) median sensory nerve action potential (SNAP) latency >3.0 milliseconds, (3) median SNAP latency >3.0 + low-amplitude SNAP, and (4) SNAP nerve conduction velocity <40 m/sec.
2. Criteria of moderate to severe CTS and unwillingness of patients to surgery according to the above-mentioned criteria associated with the following: (1) low-amplitude CMAP <4 mV, (2) low-amplitude SNAP <12 μV, without any denervation potentials (Fib/PSW) in needle electromyography (EMG).

Exclusion criteria included (1) thenar atrophy, (2) prior carpal tunnel decompressive surgery, (3) previous corticosteroid injection of CTS in the preceding 6 months, (4) polyneuropathy as documented on nerve conduction studies, (5) the presence of infection or skin lesion at the site of injection, (6) severe CTS in EMG presenting with Fib/PSW in median innervated hand muscles, (7) low-amplitude median CMAP <2 mV, (8) active cervical radiculopathy confirmed with electrodiagnosis or MRI study, (9) history of wrist fracture, and (10) refusal of informed consent or inability to participate in follow-ups.

### Sample Size and Assignment

The trial was powered to detect an effect size of $d = 0.55$ as statistically significant in a 2-tailed test with $\alpha = 0.05$ and power of 0.80 with $N = 26$ per condition. Since it was possible that 15% of patients do not complete the study, 30 cases were included in each group. Using RANDLIST 1.2 software, random numbers were produced and according to sample size, patients were enrolled into the study and randomly assigned to US-guided or LM-guided injection groups.

To define patients who benefited from treatment or success rate, a study by Ozer et al.[15] was considered in this regard. The results of this study showed that nondiabetic patients required 1.45 and 1.6 points in symptom and function severity scores of the Boston questionnaire, to achieve the minimal clinically important difference, respectively. Accordingly, a minimal reduction of 1.45 points for symptom severity and 1.60 points for function severity scores of Boston measure on a rating scale of 1 to 5 was defined as clinically significant improvement perceived by patients in the present study.

### Injection Techniques

The LM-guided injection technique was conducted using the ulnar side (medial to palmaris longus tendon) approach. The participants were placed in a comfortable seated position facing the physician, with the forearm supinated and the wrist resting in a neutral position. After skin preparation and antisepsis, the 23-gauge needle was inserted to the proximal carpal tunnel at the distal wrist crease just medial to the palmaris longus tendon.

The US-guided injection technique was performed using the ulnar side approach. The patients were maintained a comfortable seated position with hands placed on a pillow, the forearm supinated and the wrist resting in a neutral position. In-plane ulnar approach was used for the US-guided CTS injection technique as precisely described by Smith et al.[10] Intervention was performed with a commercially available sonographic scanner (Sonix OP; Ultrasonix Medical Corporation, Richmond, Canada), 5.0 to 14-MHz linear transducer. The transducer was placed transversely along the distal wrist crease (transversely between the pisiform and the scaphoid bone) and perpendicular to the median nerve at carpal tunnel inlet (Fig. 1). The flexor retinaculum was visualized as the hyperechoic structure forming the carpal tunnel roof across the pisiform and scaphoid bones. The median nerve lies just below the flexor retinaculum (Fig. 1). The ulnar nerve and artery were detected just radial to the pisiform outside the carpal tunnel. Doppler imaging can be used to confirm the artery location if necessary.

The injection was performed under sterile conditions with an in-plane freehand technique. After skin preparation with an antiseptic, the proximal carpal tunnel was visualized with the same transducer. A sterile US transducer cover was used. Needle was inserted into the skin from the ulnar side of the proximal carpal tunnel at the level of the distal wrist crease. The needle passed to skin nearly parallel with the transducer footprint. It traverses superficially to the ulnar nerve and artery, penetrating the flexor retinaculum. Under real-time US, the needle is directed under the median nerve, after which the injected material is delivered. As the injected material is delivered, the median nerve is typically separated from the underlying tendons.

Ultrasonographic parameters of the median nerve mainly include two parameters: (1) cross-sectional area in transverse

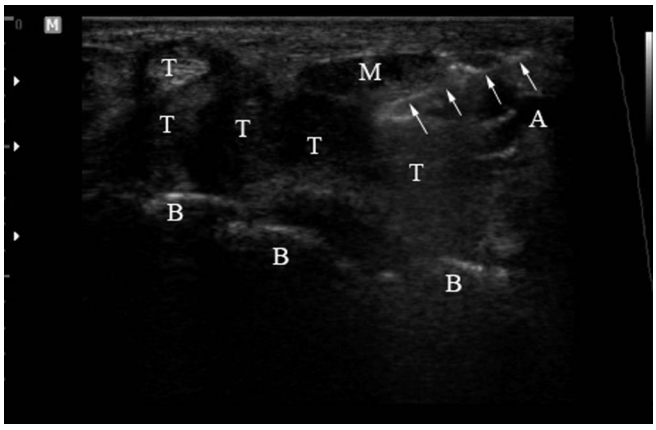


**FIG. 1.** Ultrasound-guided carpal tunnel syndrome (CTS) injection in transverse (short axis) view. M, median nerve; T, tendons; B, metacarpal bones; A, ulnar artery; White arrows, needle.

sections looking for nerve enlargement at the carpal inlet (distal hand crease) and continuous tracing of the hypoechoic rim and inside carpal tunnel, (2) flattening ratio (or swelling ratio), which was measured with different methods and name in articles. Both parameters were measured during the US-guided injection procedure.

Typical time involved in doing injection including prepping, localization, and injection lasted approximately 5 minutes in LM-guided injection and 7 minutes in US-guided injection on average. In both groups, 40 mg of methylprednisolone without local anesthetic were used. Standard cock-up hand splint at nights and 300 mg of vitamin B1 were administered for both groups during the study.

## Data Collection and Assessments of Outcome Measures

### Clinical Evaluation

At the baseline and at the end of the 3-month follow-up period, patients were asked to complete the Boston Carpal Tunnel Questionnaire (BCTQ) and underwent an electrodiagnostic study to evaluate the efficacy of the treatment. The BCTQ, a self-administered disease-specific outcome instrument, was used to assess the severity of symptoms and the functional status. The questionnaire consists of 2 multi-item scales: the Symptom Severity Scale (SSS) and the Functional Status Scale (FSS). The SSS evaluates symptoms like pain, numbness, weakness, paresthesia, or clumsiness and overall functional status using 11 questions. The FSS evaluates difficulties with daily activities like writing, buttoning clothes, holding a book while reading, gripping a telephone handle, opening jars, household chores, carrying grocery bags, and bathing/dressing using eight questions. The SSS consisted of responses numbered 1 (no symptoms) to 5 (most severe). The FSS consisted of responses numbered 1 (performance with no difficulty) to 5 (unable to perform due to symptoms). The overall SSS and FSS scores are calculated as the mean of the scores.[16]

### Electrodiagnostic Examination

Electrodiagnostic data, including distal latency and amplitude of CMAP and SNAP of the median nerve and needle EMG were also derived from electrodiagnostic study reports and recorded on the patient's data form. The electrodiagnostic procedure was carried out (using Viking Nicolet Instrument; Natus Medical Incorporated, San Carlos, CA) according to standardized protocols, as described by Dumitru et al.[17] and Eslamian et al.[1] All the above processes were performed by an expert physiatrist and final data were recorded in a checklist, individually.

One of the treating physiatrists who was carrying out US-guided injection, performed the Nerve conduction study of patients in this group, another treating physician who was performing LM-guided injection, performed Nerve conduction study of that patient group. These procedures were conducted in different electrodiagnostic centers of university hospitals with similar instruments. A resident of physical medicine and rehabilitation, who was unaware of group typing administered the BCTQ and completed the questionnaires for all patients of both groups.

## Statistical Analysis

Statistical analyses were carried out using the Statistical Package for Social Sciences, version 16.0 (SPSS, Chicago, IL). Quantitative data were presented as mean ± SE, while qualitative data were demonstrated as frequency and percent. Linear mixed-effects model (MIXED) was used to compare the mean of continuous outcomes between 2 groups at baseline and after 12 weeks. A $P < 0.05$ was considered statistically significant.

# RESULTS

Sixty hands with median nerve entrapment neuropathy (CTS) of 47 patients (43 women, 4 men) were enrolled into the study and divided into 2 therapeutic groups (Fig. 2).

In the US-guided group, there were 27 patients, of which 24 patients presented with only 1 hand involvement, while both hands were treated for the remaining 3 patients. In the LM-guided group, 10 patients had both injected hands; contributing 20 hands and 10 patients had only 1 hand treated.

Of the 47 patients (60 injected hands), 2 hands in the US-guided group and 5 hands in the LM-guided group were placed in moderate to severe CTS grading and others had moderate CTS.

Demographics and electrophysiologic findings including DML (distal motor latency), CMAP amplitude, DSL (distal sensory latency), and SNAP amplitude of the patients are presented in Table 1. At the baseline, both groups were found to be similar without any statistically significant difference with respect to age, sex, and electrophysiologic findings. However, SSS and CMAP velocity were different between the 2 groups ($P < 0.05$), because the former was worse in LM-guided group and motor velocity was higher in this group.

Table 2 shows electrodiagnostic and functional findings before and after intervention in US-guided and LM-guided injection groups in comparing baseline with after treatment.

All functional parameters including the BCTQ total, SSS, and FSS demonstrated statistically significant improvement in

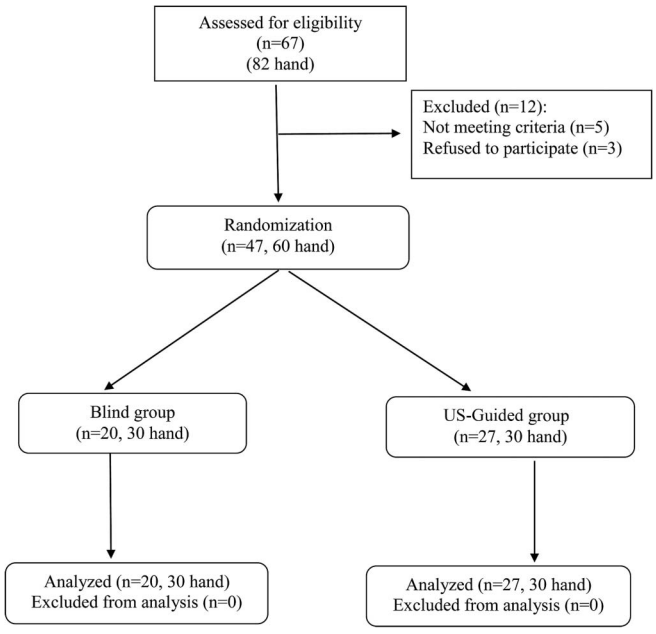


**FIG. 2.** A flow diagram of the study protocol.

both groups. The electrodiagnostic findings before and after treatment showed statistically significant improvement of DML, DSL, and sensory nerve conduction velocity in both groups and SNAP amplitude in LM-guided injection group. Although there were no statistically significant improvement with respect to CMAP amplitude and CMAP nerve conduction velocity in both groups (Table 2).

In comparing the amount of clinical and electrodiagnostic improvement (mean changes) between US-guided and LM-guided CTS injection groups, no statistically significant difference was observed, except for the amount of SNAP amplitude increase in LM-guided group (Table 3).

It should be noted that the average median nerve cross-sectional area was 12.18 ± 0.9 $mm^2$ at the baseline in US-guided group and decreased to 10.22 ± 1.4 $mm^2$ after treatment in this group ($P \leq 0.001$).

In addition, median nerve swelling ratio was 1.18 ± 0.2 at the baseline in US-guided group and changed to 1.02 ± 0.3 $mm^2$ after treatment in the same group ($P = 0.63$). These parameters were evaluated only in US-guided group and were not calculated in LM-guided group.

Approximately half of the participants in LM-guided group and 46% of patients in US-guided group achieved successful therapy response (minimal clinically important difference) in the SSS of the BCTQ at week 12. In contrast, 30% to 33% of participants achieved a success rate regarding the FSS at the end of study in US-guided and LM-guided groups, respectively.

Pearson $\chi^2$ test showed that there was no statistically significant difference between groups regarding symptoms and functional improvement percentage ($P = 0.796$, 0.781).

The groups were similar in terms of adverse major side effects and none was reported in both groups. Some patients reported transient pain during injection procedure in both groups, which were resolved after therapy. One diabetic patient in LM-guided group suffered from wrist flexors tendonitis and that was treated using anti-inflammatory drugs within a week. Apart from that, no side effects including infection, exacerbation of inflammation, or sustained pain related to injection process were seen in the present study.

## DISCUSSION

This study compared US-guided versus LM-guided corticosteroid injection in patients with CTS. Marked clinical and electrodiagnostic improvement occurred for both groups following corticosteroid injection, which is similar to the findings of Grassi et al.[18] and Ustün et al.[8] Grassi et al.[18] reported short-term and mid-term (6 weeks) clinical improvement after US-guided injection in a CTS case secondary to tenosynovitis in a patient with rheumatoid arthritis. Ustün et al.[8] evaluated 46 affected median nerves with CTS for US-guided and blind injections. They evaluated participants with BCTQ and 2 electrodiagnostic

**TABLE 1.** Demographics and Electrodiagnostic Findings of Participants at the Baseline

| | US Guided, Mean ± SE | LM Guided, Mean ± SE | *P* |
|---|---|---|---|
| Age, yrs, mean ± SE | 54.52 ± 2.05 | 49.33 ± 1.82 | 0.07 |
| Women, n (%) | 25 (86.2) | 20 (100.0) | 0.13 |
| History of diabetes mellitus, n (%) | 5 (16.7) | 4 (13.3) | >0.999 |
| BCTQ symptom | 3.03 ± 0.13 | 3.39 ± 0.11 | 0.038 |
| BCTQ function | 2.60 ± 0.13 | 2.68 ± 0.11 | 0.986 |
| BCTQ total | 2.86 ± 0.12 | 3.08 ± 0.10 | 0.170 |
| DML, msec | 5.27 ± 0.22 | 5.30 ± 0.2 | 0.922 |
| CMAP amplitude, mV | 9.28 ± 0.68 | 8.47 ± 0.73 | 0.415 |
| MNCV, msec | 54.34 ± 0.96 | 65.55 ± 3.92 | 0.007 |
| DSL, msec | 4.20 ± 0.21 | 4.26 ± 0.23 | 0.852 |
| SNAP amplitude, μV | 17.20 ± 1.6 | 15.86 ± 0.18 | 0.580 |
| SNCV, m/sec | 35.09 ± 1.29 | 34.81 ± 1.30 | 0.875 |

BCTQ, Boston Carpal Tunnel Questionnaire; CMAP, compound muscle action potential; DML, distal motor latency; DSL, distal sensory latency; LM, landmark; MNCV, motor nerve conduction velocity; SNAP, sensory nerve action potential; SNCV, sensory nerve conduction velocity; US, ultrasound.

**TABLE 2.** Clinical and Functional Evaluations of the Patients in Each Groups at Baseline and After Treatment

| | US Guided, Mean ± SE | *P** | LM Guided, Mean ± SE | *P** |
|---|---|---|---|---|
| BCTQ symptom | | | | |
| Baseline | 3.03 ± 0.13 | <0.001 | 3.39 ± 0.11 | <0.001 |
| At week 12 | 1.63 ± 0.10 | | 1.95 ± 0.15 | |
| BCTQ function | | | | |
| Baseline | 2.68 ± 0.13 | <0.001 | 2.68 ± 0.11 | <0.001 |
| At week 12 | 1.54 ± 0.97 | | 1.61 ± 0.12 | |
| BCTQ total | | | | |
| Baseline | 2.86 ± 0.12 | <0.001 | 3.08 ± 0.10 | <0.001 |
| At week 12 | 1.58 ± 0.09 | | 1.80 ± 0.13 | |
| DML, msec | | | | |
| Baseline | 5.27 ± 0.22 | 0.001 | 5.30 ± 0.21 | <0.001 |
| At week 12 | 4.75 ± 0.11 | | 4.64 ± 0.16 | |
| CMAP amplitude, mV | | | | |
| Baseline | 9.28 ± 0.68 | 0.172 | 8.47 ± 0.73 | 0.068 |
| At week 12 | 9.85 ± 0.72 | | 9.25 ± 0.73 | |
| MNCV, msec | | | | |
| Baseline | 54.34 ± 0.96 | 0.895 | 65.55 ± 3.92 | 0.199 |
| At week 12 | 54.20 ± 0.88 | | 66.96 ± 4.59 | |
| DSL, msec | | | | |
| Baseline | 4.20 ± 0.21 | 0.002 | 4.26 ± 0.23 | <0.001 |
| At week 12 | 3.67 ± 0.9 | | 3.60 ± 0.14 | |
| SNAP amplitude, μV | | | | |
| Baseline | 17.20 ± 1.64 | 0.194 | 15.86 ± 0.18 | <0.001 |
| At week 12 | 18.56 ± 1.09 | | 21.79 ± 1.93 | |
| SNCV, m/sec | | | | |
| Baseline | 35.09 ± 1.29 | <0.001 | 34.81 ± 1.30 | <0.001 |
| At week 12 | 38.86 ± 1.00 | | 40.77 ± 1.22 | |

*$P < 0.05$.

BCTQ, Boston Carpal Tunnel Questionnaire; CMAP, compound muscle action potential; DML, distal motor latency; DSL, distal sensory latency; LM, landmark; MNCV, motor nerve conduction velocity; SNAP, sensory nerve action potential; SNCV, sensory nerve conduction velocity; US, ultrasound.

parameters in 6 and 12 weeks after intervention and reported significant improvement in both groups.

In the present study, no statistically significant difference was found between US-guided and LM-guided injection techniques in 3-month follow-up with regard to both functional (BCTQ) and six electrodiagnostic outcome measures. In contrast, Ustün et al. reported a significant difference only in the BCTQ symptom subscale (SSS) after 12 weeks between 2 groups in favor of US-guided group. They found no statistically significant difference in 6 weeks for all BCTQ subscales and in 12 weeks for FSS, but they concluded that US-guided CTS injection may be more effective than blind.[8]

Although the present study had a larger sample size and showed better results in US-guided group versus LM-guided CTS injection, no significant difference was found between both groups. Some previous studies made their conclusions about significant difference after measuring only one outcome without electrodiagnostic evaluation. We evaluated six electrodiagnostic variables including motor and sensory amplitudes, latencies, and velocities in each group. All parameters were not different statistically, except SNAP amplitude was higher in LM-guide group than US-guide group. One reason could be related to this fact that baseline SNAP amplitude in LM-guided group was lower than US-guided group (15.85 ± 9.67 vs. 17.20 ± 9.01 μV), so the amount of changes were greater in this group compared with the baseline values (5.93 ± 1.23 vs. 1.36 ± 0.78 μV, respectively).

Also, the proficiency of the specialist conducting LM-guided injections could be a determinant factor in having less or more efficient results in the blinded CTS injection group. Present findings highlight the need for more studies in this field.

Differences between groups regarding SSS at the baseline could be a confounding factor that can affect the results but since mean changes from baseline to 3 months after treatment were evaluated between groups, this form of analysis can overcome this discrepancy.

However, CMAP velocity was somewhat higher in LM-guided group. The reason is related to 3 cases of Martin-Gruber anastomosis in LM-guided group. But again mean changes of nerve conduction velocities between groups showed no evidence of considerable difference regarding this parameter.

Makhlof et al. showed that sonographic needle guidance injection of the carpal tunnel relative to conventional anatomic landmark palpation-guided methods, resulted in 77.1% reduction in injection pain, a 63.3% reduction in pain scores at outcome, 93.5% increase in the responder rate, and 71.0% increase in therapeutic duration. However, despite improved outcomes, the cost per patient per year was significantly increased for an outpatient in a physician's office and was neutral for a hospital outpatient.[19]

**TABLE 3.** Comparison of US-Guided and LM-Guided carpal tunnel syndrome Injection in the Improvement Amount (Mean Changes) of Clinical and Electrodiagnostic Parameters

| Variable | US Guided, Mean ± SD | LM Guided, Mean ± SD | US Guided vs. LM Guided, *P* |
|---|---|---|---|
| BCTQ symptom | | | |
| Point changes | 1.44 ± 0.11 | 1.40 ± 0.08 | 0.798 |
| Percentage changes | 46 | 43 | |
| BCTQ function | | | |
| Point changes | 1.19 ± 0.10 | 1.07 ± 0.11 | 0.645 |
| Percentage changes | 41 | 39 | |
| BCTQ total | | | |
| Point changes | 1.28 ± 0.11 | 1.23 ± 0.08 | 0.299 |
| Percentage changes | 49 | 48 | |
| DML, msec | | | |
| Point changes | 0.52 ± 0.17 | 0.66 ± 0.13 | 0.516 |
| Percentage changes | 10 | 12 | |
| CMAP amplitude, mV | | | |
| Point changes | 0.56 ± 0.30 | 0.78 ± 0.48 | 0.698 |
| Percentage changes | 6 | 9 | |
| MNCV, m/sec | | | |
| Point changes | 0.14 ± 0.38 | 1.41 ± 1.48 | 0.316 |
| Percentage changes | 0.2 | 2 | |
| DSL, msec | | | |
| Point changes | 0.53 ± 0.17 | 0.66 ± 0.15 | 0.558 |
| Percentage changes | 12 | 15 | |
| SNAP amplitude, μV | | | |
| Point changes | 1.36 ± 0.78 | 5.93 ± 1.23 | 0.003 |
| Percentage changes | 8 | 36 | |
| SNCV, m/sec | | | |
| Point changes | 3.77 ± 0.88 | 5.96 ± 0.83 | 0.075 |
| Percentage changes | 11 | 17 | |

BCTQ, Boston carpal tunnel questionnaire; CMAP, compound muscle action potential; DML, distal motor latency; DSL, distal sensory latency; LM, landmark; MNCV, motor nerve conduction velocity; SNAP, sensory nerve action potential; SNCV, sensory nerve conduction velocity; US, ultrasound.

In contrast, the overall improvement percentages in our study are lower compared with Makhlof's study; 46% to 43% reduction for symptom severity score and 41% to 39% reduction for function status score in US-guided and LM-guided groups, respectively.

Regarding the different results mentioned above, there are few points to be noted:

1. Intracarpal injection in Makhlof's study was conducted using a 2-step technique including 3 mL of 1% lidocaine and then 80 mg (2 mL) of triamcinolone acetonide, while injected material in the present study was only 40 mg (1 mL) of methylprednisolone without lidocaine. Although some previous review articles concluded that there is no consensus on dose or type of corticosteroid injected, so that methylprednisolone, triamcinolone, and β-methasone are commonly used (Carlson et al.[20]); however one reason of discrepancy may be related to different techniques, dose, and potency of injected steroids.
2. Outcome measures in two studies are different from each other, since procedural pain, pain at outcome, responders rate, therapeutic duration, and total cost were determined in the above study. This study did not evaluate injection pain or other mentioned indexes and instead of "pain severity," focus was mostly on symptoms and functions severity as well as median nerve conduction studies using electrodiagnosis. So, it is estimated that improvement of all symptoms and function are lower than only pain intensity.
3. The frequency and duration of follow-up in Makhlof's study was more and longer than ours (at week 2 and month 6). Therefore, it is valuable if the persistency of results lasted 6 months; however, if results are indicative of the first 2 weeks after treatment, this may be related to short-term effects rather than long-lasting effects.

Recent evidences regarding US study of the median nerve at the distal wrist crease[21] demonstrated significant changes in nerve cross-sectional area, mobility, and vascularity following steroid injection for CTS. In addition, authors showed that at 6 months, mobility and vascularity values stopped improving and began returning toward the baseline, similar to the symptom score and sensory velocity, which suggests these parameters may be sensitive than electrodiagnostic findings for the assessment of CTS and also confirm our hypothesis that the effects of injection are greater in the short-term and in most cases attenuate over time.

Lee et al.,[22] evaluated blind, in-plane ulnar and out-plane ulnar approaches of US-guided injections with 15 participants in each group and all groups had significant improvements with 40 mg triamcinolone injection, but US-guided technique showed

significant improvement at 4 weeks in the in-plane ulnar approach group compared with the out-plane ulnar approach and blind injection.

As shown in our study, the in-plane ulnar approach has some advantages especially in decreasing the possibility of nerve insult, facilitating an accurate near nerve injection, and the important advantage appears to be in viewing nerve, vessel, and visible needle.

Nonetheless, the present study does have some limitations such as the lack of long-term follow-up beyond 3 months and short-term evaluations and nonhomogeneous baseline variables in both groups. However, including electrodiagnostic parameters and larger sample size was precisely proven. With respect to the findings of present study, it is recommended that additional researches with longer follow-up, different in-plane US approaches, and determination of diagnostic US parameters such as median cross-section and nerve vascularity as outcome variables to be conducted to achieve more accurate results.

## CONCLUSIONS

Both US-guided using ulnar side in-plane approach and LM-guided steroid injections were effective in reducing the symptoms, improving the function and electrodiagnostic findings of CTS. Although there was better symptomatic improvement with US-guided injections and better increase in SNAP amplitude with LM-guided injection, a significant difference was not generally observed between US-guided and LM-guided CTS injections.

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