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Comparative study between blind and ultrasound-guided steroid injection for carpal tunnel syndrome

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Abstract

Background Carpal tunnel syndrome is the most common entrapment neuropathy. Local injections of corticosteroids have proven to be an effective treatment option. Injections are either blind (non-guided) or guided by ultrasound. The current study aimed to compare the efficiency of both approaches and determine which one yields better results.

Method This study involved 30 patients (8 males, 22 females, aged 36–58 years, mean age 48.3 years) with 30 affected hands with mild or moderate carpal tunnel syndrome. Patients were randomly divided into two equal groups. Steroid injections were performed blindly in group 1 and ultrasound-guided in group 2. A mixture of 2 ml of triamcinolone and lidocaine was administered at both groups. Follow-up (using the Boston Carpal Tunnel Questionnaire and ultrasound assessment) was performed 4 weeks after the injection.

Results The symptom severity scale, functional status scale, cross-sectional area, and flattening ratio were significantly reduced in both groups at 4 weeks after the procedure. The ultrasound-guided group showed a statistically significant improvement compared to the blindly injected group.

Conclusions Local steroid injection is an effective method in the management of both idiopathic and secondary carpal tunnel syndrome. Although clinical and sonographic improvement was achieved with blind and guided steroid injections, better results were obtained when ultrasound was used.

Keywords Carpal tunnel syndrome, Boston carpal tunnel questionnaire, Corticosteroid injection, Blind, Ultrasound

Background

Carpal tunnel syndrome (CTS) is a chronic disabling disease and is the most frequent entrapment neuropathy caused by compression of the median nerve [1, 2]. It is highly prevalent in women, with a peak age incidence of 45–60 years [3].

Various therapeutic options are offered, either conservative with lifestyle modification, wrist splinting, and analgesics, or with local steroid injection in mild-to-moderate cases. Surgery is usually reserved for more advanced conditions [4]. Steroid injections proved to be effective in reducing median nerve inflammation and edema with the aim of reducing and carpal tunnel pressure and to improve the associated symptoms and signs, as well as functional status [5].

Local steroid injection is usually carried out blindly (palpation-guided) through known anatomical landmark of the wrist. Although considered a reliable procedure, it bears a potential risk of soft tissue injury or relative

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inadequacy if the injectate was not precisely placed at the target point [6].

The usage of ultrasound to guide the injection has recently built up acceptance as it provides a higher safety level, confirms proper needle placement, and ensures successful injection through an accurate scan of the median nerve and surrounding soft tissue structures within the carpal tunnel [7].

This study intends to analyze the efficiency of both methods and to show which one offers a better outcome.

Methods

Patients

This prospective study was carried out on consecutive patients with clinical symptoms and electrophysiological changes attributed to mild or moderate carpal tunnel syndrome (either idiopathic or secondary) not responding to medical treatment for three months or more, referred to our university hospital for a steroid injection, from December 2020 to February 2022.

We excluded patients presenting with cervical radiculopathy, severe carpal tunnel syndrome (CTS), and those with a previous history of fracture or deformity of the wrist or hand or with previous wrist decompression surgery.

We ended up with 30 participants with 30 affected hands that were eligible for local steroid injection and were randomized into two equal groups. A mixture of local steroid (triamcinolone) and anesthetic (lidocaine) was injected blindly (landmark-guided) in group 1 and guided by ultrasound in group 2.

The local ethics committee had approved the research protocol before the beginning of the study. Informed written consent was obtained from all participants.

Steroid injection procedure

All patients were in the supine position, and the symptomatic wrist was draped under strict aseptic conditions. Group 1 injections were carried out by a single rheumatologist with 12 years of experience in performing blind steroid injections. A 21G needle was inserted just proximal to the distal wrist crease, medial to the palmaris longus tendon. In group 2, a single radiologist with 3 years of experience in ultrasound-guided procedures had injected the steroid mixture with the in-plane ulnar approach, previously described by Smith et al. [8] using an ultrasound machine (ACUSON X 300, Siemens Healthineers AG, Erlangen, Germany) with a 10 MHz linear transducer. The ultrasound transducer was placed transversely proximal to the distal wrist crease. The bony boundaries of the carpal tunnel inlet (scaphoid and pisiform) and the flexor retinaculum (seen as a thick hyper-echoic band) were first identified. The median nerve was identified as an oval-shaped hypoechoic structure of honeycomb appearance, just below the flexor retinaculum. A 21G needle was inserted—under sonographic guidance—at the ulnar side of the transducer. It passed through the flexor retinaculum and addressed the proximal part of the carpal tunnel to reach the medial aspect of the median nerve where the steroid mixture was injected (Fig. 1).

In both groups, a total of 2 ml consisting of 1 ml triamcinolone acetonide (40 mg/ml) and 1 ml lidocaine 1% (10 mg/ml) was administered to both groups. All patients received no treatment or physical therapy after injection.

Outcome measurements and follow-up

Clinical severity assessment and sonographic examinations were performed before injection (as a baseline) and at 4 weeks thereafter in both groups by another radiologist with 14 years of experience in musculoskeletal ultrasound examinations and who was blinded to the injection technique.

Clinical severity was assessed using the Boston Carpal Tunnel Questionnaire (BCTQ), suggested by Levine et al. [9] composed of two scales: the Symptom Severity Scale (SSS) and the Functional Status Scale (FSS). The SSS consisted of 11 questions. Each was scored from 1 to 5 points, with 1 being normal status and 5 being the most severe. The FSS comprised 8 questions on a 5-step grading. Grade 1 stands for "no difficulty" and grade 5 stands for "cannot perform the activity at all."

Ultrasonographic evaluation included measurement of the median nerve cross-sectional area (CSA) and flattening ratio (FR) at the distal wrist crease within the carpal tunnel inlet. Cross-sectional area (CSA) was used to confirm the diagnosis of CTS when equal to or exceeding 10 mm^2 [10]. The flattening ratio (FR) was determined by dividing the transverse diameter by the anteroposterior

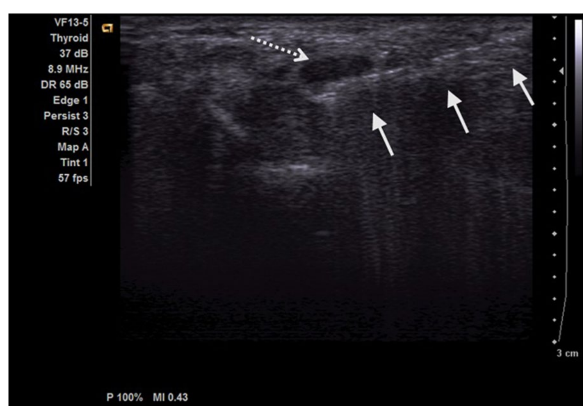

Fig. 1 Ultrasound image at the level of proximal carpal tunnel, shows a needle (white arrow), targeting the posterior aspect to the median nerve (dashed arrow) to deliver steroids

diameter of the median nerve and was used to monitor the favorable response to steroid injection if decreased [11].

The exact scores of SSS, FSS, CSA, and FR were registered. Their mean scores and mean reductions (at 4 weeks compared to pre-injection status) were calculated.

Statistical analysis

Analysis of data was performed with IBM SPSS software package (Armonk, NY: IBM Corp, version 20). Qualitative data were expressed in numbers and percentages. Quantitative data were reported as a minimum and maximum range, mean, standard deviation, median, and interquartile range.

The two groups were compared using the chi-square test for categorical variables, the Student's t test for normally distributed quantitative variables, and the Mann–Whitney test for abnormally distributed quantitative variables. Fisher's exact or Monte Carlo corrections were applied when more than 20% of cells were expected to be below 5. A paired t test was applied to compare two consecutive periods of normally distributed quantitative variables. The significance of results was determined at the 5% level.

Results

The current study included 30 patients with 30 symptomatic hands with mild ($n=13$) and moderate ($n=17$) carpal tunnel syndrome (CTS). Eight (26.7%) were males and 22 (73.3%) were females. The age ranged from 36 to 58 years (mean age 48.3 years). CTS was idiopathic in 25 patients (83.3%) and secondary in 5 patients (16.7%); to diabetes mellitus ($n=2$), rheumatoid arthritis ($n=2$), and pregnancy ($n=1$). There was no significant difference between patients treated with either technique with respect to demographics, electrophysiological data, or etiology of CTS (Table 1).

After injection, 5 of 15 (33.3%) patients in Group 1 experienced increased paresthesia and tingling (compared to the pre-injection conditions), which resolved spontaneously after 2 days. No complications were recorded in Group 2. Clinical success was achieved in all patients with idiopathic and secondary CTS and was expressed in terms of symptom relief and functional improvement. Mean values for SSS and FSS decreased significantly in both groups ($p<0.001$ for each) (Table 2).

Group 2 achieved better clinical improvement, which is expressed in a significant reduction in the mean difference of SSS and FSS (at 4 weeks compared to pre-injection status) of 14.13 and 8.07, respectively, compared to 7.60 and 4.87 in group 1. This difference was statistically significant ($p=0.001$ and $p=0.011$ for the SSS and FSS, respectively) (Table 2).

Sonographic improvement (in terms of CSA and FR reduction) was observed in all patients with either idiopathic or secondary CTS. Mean CSA decreased from 12.67 in groups 1 and 2 before the procedure to a mean of 11.20 and 9.80 after 4 weeks in groups 1 and 2, respectively. Likewise, the mean FR decreased from 2.80 and 2.59 to a mean of 2.51 and 2.07 after 4 weeks in groups

Table 1 Comparison between the two studied groups according to demographic, clinical, and electrophysiological parameters

	Blind ($n=15$)	Ultrasound ($n=15$)	Test of sig	p
Age (years)	48.13 ± 4.76	48.47 ± 6.59	$t=0.159$	0.875
Sex				
Male	4 (26.7%)	4 (26.7%)	$\chi^2=0.0$	$^{FE}p=1.000$
Female	11 (73.3%)	11 (73.3%)		
UL affected				
Right	8 (53.3%)	8 (53.3%)	$\chi^2=0.0$	1
Left	7 (46.7%)	7 (46.7%)		
NCS				
Mild	6 (40%)	7 (46.7%)	$\chi^2=0.136$	0.713
Moderate	9 (60%)	8 (53.3%)		
Type of CTS				
1ry idiopathic	13 (86.7%)	12 (80%)	$\chi^2=0.240$	$^{FE}p=1.000$
2ry	2 (13.3%)	3 (20%)		
DM	1 (50%)	1 (33.3%)		
RA	1 (50%)	1 (33.3%)		
Pregnancy	0 (0%)	1 (33.3%)		

IQR: Interquartile range; SD: Standard deviation; t: Student's t test; χ^2: Chi-square test; MC: Monte Carlo; FE: Fisher's exact test

p: *p* value for comparing between the studied groups

Table 2 Comparison between the two studied groups according to SSS and FSS

		Blind ($n = 15$)	Ultrasound ($n = 15$)	Test of sig	p
SSS	Before	26.67 ± 5.27	25.93 ± 6.71	t = 0.333	0.742
	After 4 weeks	19.07 ± 3.67	11.80 ± 1.57	t = 7.046*	< 0.001*
	p_1	< 0.001*	< 0.001*		
	Reduction of SSS	7.60 ± 2.50	14.13 ± 5.29	U = 31.50*	0.001*
FSS	Before	19.40 ± 4.24	18.27 ± 5.23	t = 0.652	0.52
	After 4 weeks	14.53 ± 2.92	10.20 ± 2.08	t = 4.679*	< 0.001*
	p_1	< 0.001*	< 0.001*		
	Reduction of FSS	4.87 ± 1.68	8.07 ± 3.77	U = 52.0*	0.011*

IQR: Interquartile range; SD: Standard deviation; t: Student's t test; U: Mann–Whitney test

p: p value for comparing between the studied groups

p_1: p value for paired t test for comparing between before and after in each group

*Statistically significant at $p \leq 0.05$

1 and 2, respectively. This decrease in CSA and FR was statistically significant in both groups ($p < 0.001$, respectively) (Table 3), (Figs. 2, 3, and 4).

Better mean reductions were recorded in group 2, reaching 2.87 and 0.51 for CSA and FR, respectively, compared with 1.47 and 0.29 for group 1, despite the sonographic improvement in mean scores for both groups. This difference was statistically significant ($p = 0.001$, $p = 0.002$ for CSA and FR respectively) (Table 3).

Discussion

Local steroid injections have proven to be an effective treatment option for patients with CTS. The injection is usually performed blindly by palpating anatomical landmarks [12]. More recently, the use of ultrasound to guide injections has emerged and gained popularity.

In this study, 30 affected hands with mild or moderate CTS were treated with local corticosteroid injection, either blindly or guided by ultrasound. Significant improvements in clinical and ultrasonographic parameters were observed in both groups at 4 weeks after procedure, with significantly improved results under ultrasound guidance.

Controversial results were shown in previous series examining the performance of steroid injections when administered blindly or with ultrasound guidance. Two large meta-analyses of 448 and 469 patients showed the effectiveness of applying ultrasound with better outcomes and improved severity and functional status [13, 14]. Conversely, in a series of 60 hands in 47 patients, the benefit of ultrasound was not significant, despite satisfactory results in both groups [15]. This disparity could be attributed to the different designs, the type and dose of injectates, the etiology of the CTS between groups, and the experience of operators administering drugs using both techniques.

Introduction of ultrasound provided additional benefits in a study of 46 affected median nerves, with shorter time to achieve symptom relief (4 days post-injection) and sustained efficacy up to 12 weeks [16].

Table 3 Comparison between the two studied groups according to CSA and FR

		Blind ($n = 15$)	Ultrasound ($n = 15$)	Test of sig	p
CSA	Before	12.67 ± 1.84	12.67 ± 1.99	t = 0.00	1
	After 4 weeks	11.20 ± 1.74	9.80 ± 1.42	t = 2.411*	0.023*
	p_1	< 0.001*	< 0.001*		
	Reduction of CSA	1.47 ± 0.52	2.87 ± 1.19	U = 36.0*	0.001*
FR	Before	2.80 ± 0.43	2.59 ± 0.44	t = 1.341	0.191
	After 4 weeks	2.51 ± 0.41	2.07 ± 0.37	t = 3.058*	0.005*
	p_1	< 0.001*	< 0.001*		
	Reduction of FR	0.29 ± 0.09	0.51 ± 0.23	U = 39.0*	0.002*

IQR: Interquartile range; SD: Standard deviation; t: Student's t test; U: Mann–Whitney test

p: p value for comparing between the studied groups

p_1: p value for Paired t test for comparing between before and after in each group

*Statistically significant at $p \leq 0.05$

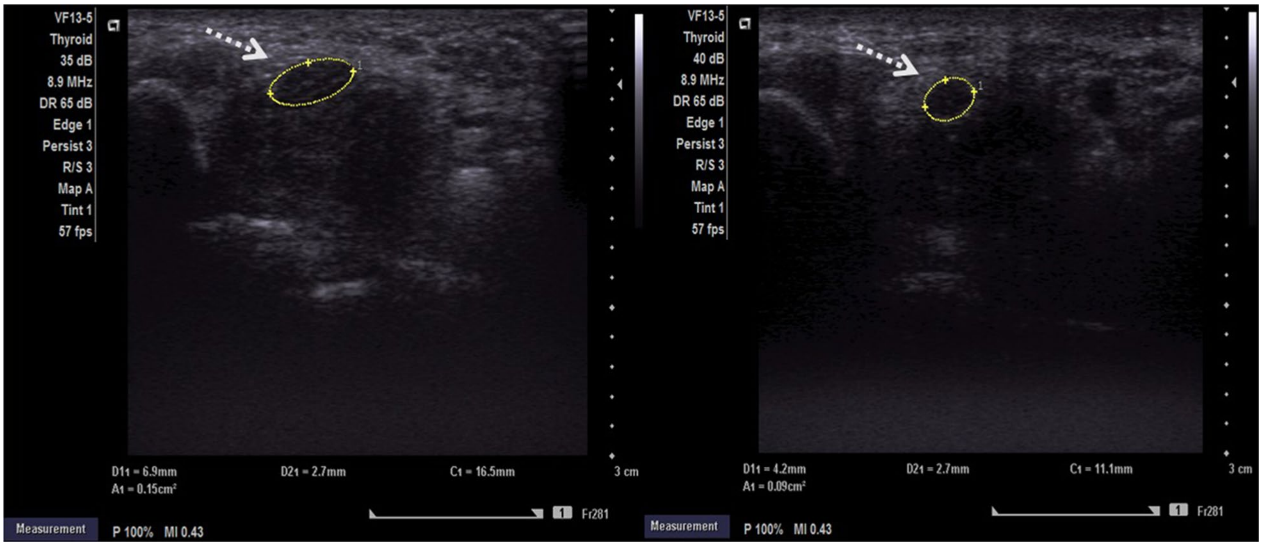

Fig. 2 Ultrasound image of the median nerve (dashed arrow) of a 52-year-old patient with moderate CTS treated with ultrasound-guided injection. Before injection. CSA and FR were 15 mm^2 and 2.55 (left image), which improved to 9 mm^2 and 1.55, respectively, 4 weeks after injection (right image)

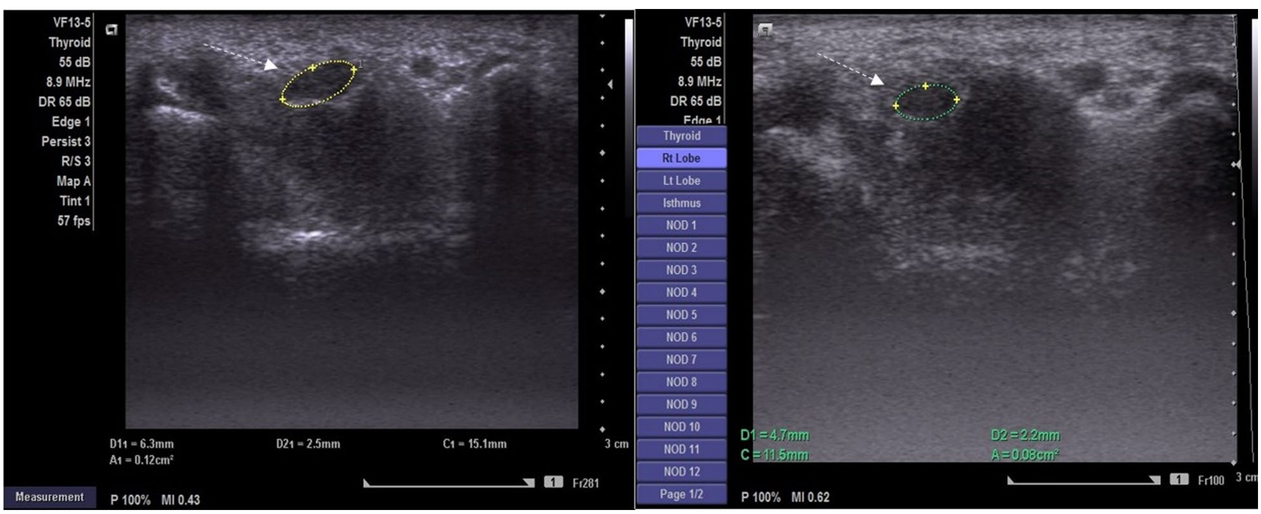

Fig. 3 Ultrasound image of the median nerve (dashed arrows) of a 45-year-old patient with mild CTS managed with ultrasound-guided injection. CSA and FR measured 12 mm^2 and 2.52 before injection (left image) and improved to 8 mm^2 and 2.13, respectively, at 4 weeks after injection (right image)

Evers et al. [17] evaluated the long-term outcome of local steroid injections (mean 7.2 years) in 689 hands. They observed a significant treatment-free survival rate in the ultrasound-guided treatment group. Re-treatment was required in 72% of patients compared with 55% of blindly and with ultrasound guidance, respectively. Using ultrasound reduced the risk of failure by 55%.

Cartwright et al. [18] examined 29 affected median nerves after steroid injection. They reported improved clinical and electrophysiological changes and a significant reduction in CSA 1 week after injection and suggested that reversible neuro-edema and congestion, rather than neuro-demyelination, may underlie the symptoms of CTS.

As in another series, normalization of FR was also observed in our study, 2 weeks after surgical release, even before improvement in nerve conduction studies [19].

Of note, improvement in other ultrasonographic signs indicative of successful injection has been reported, including decreased vascularity and increased median

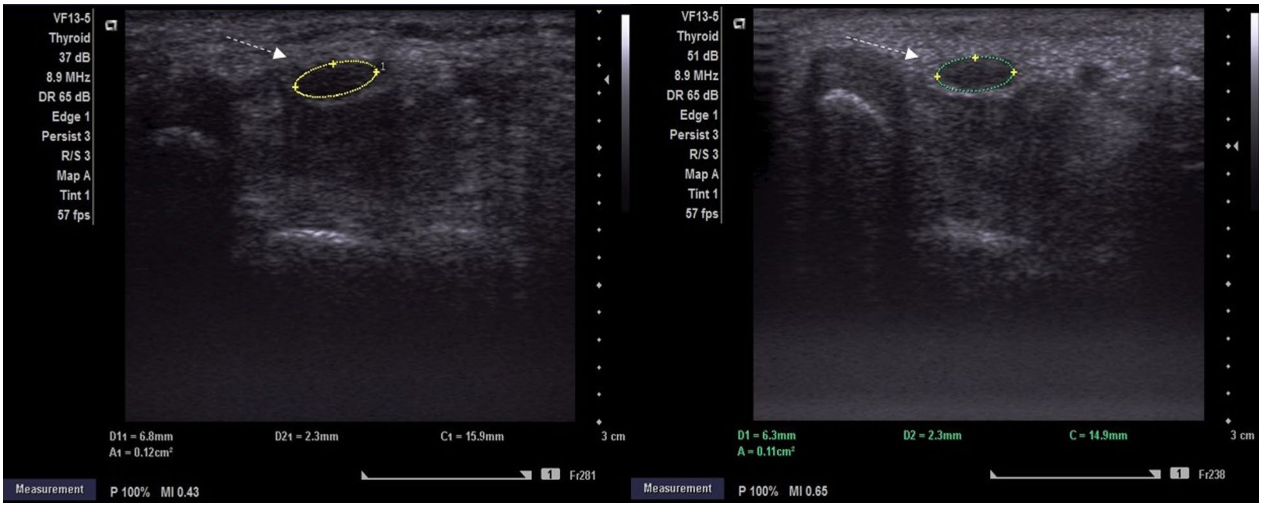

Fig. 4 Ultrasound image of the median nerve (dashed arrows) of a 49-year-old patient with mild CTS treated with blind (non-guided) steroid injection. Median nerve CSA and FR before (left image) and 4 weeks after steroid injection (right image). Ultrasonographic improvement was recorded as a slight decrease in CSA (11 mm^2 vs. 12 mm^2) and FR (2.73 vs.2.95)

nerve mobility [18] with diminished palmar bowing of the flexor retinaculum and increased transverse sliding distance of the median nerve [20]

With ultrasound guidance, the needle can be placed in-plane or out-of-plane. In our study, we chose the in-plane ulnar approach because it matches well with our experience with other ultrasound-guided procedures. Lee et al. [21] analyzed the results obtained after steroid injections in 75 hands with ultrasound guidance (in-plane and out-of-plane ulnar approaches) and blindly. They reported significantly better clinical and ultrasonographic results in the ultrasound-guided in-plane group at 4 and 12 weeks after injection. This approach allows for good recognition of the various structures of the carpal tunnel, visualization of the entire needle, proper placement of the needle tip, and delivery of steroids into the perineural space without nerve injury [8].

Local steroid injections within 1 cm of the median nerve have been shown to pose a risk of injury [22]. Our needle was placed as close to the nerve as possible, and there were no side effects in the ultrasound-guided group. The virtue of ultrasound use in reducing the risk of nerve injury had been demonstrated previously in various reports [23, 24]. On the contrary, in our study, 33.3% of the blind group experienced transient nerve irritation. In a study of 102 patients, median nerve irritation (expressed as numbness in the fingers) was more pronounced with blind injections (observed in 14% of patients with blind injections versus 2% with ultrasound-guided injection) [25].

To our knowledge, secondary cases of CTS were not included in previous serious. In our study, we enrolled five secondary cases to be injected blindly and under ultrasound guidance and showed significant clinical and sonographic improvement at both groups. Ultrasonography adds diagnostic value in identifying the underlying etiology of secondary CTS. Validating these data requires another larger series.

The current study has some limitations. First, the relatively small sample size compromised our results. Second, we did not integrate our results with post-injection electrophysiological changes, as we relied primarily on ultrasonography. Third, data were lacking for long-term follow-up. Finally, two different operators with different specialties performed the injections.

Conclusions

Local steroid injection is an effective treatment for idiopathic and secondary carpal tunnel syndrome (CTS). Significant clinical and sonographic improvements were obtained with blind and ultrasound-guided steroid injections, whereas significantly superior results were obtained with ultrasound.

Abbreviations

CTS	Carpal tunnel syndrome
BCTQ	Boston carpal tunnel questionnaire
SSS	Symptom severity scale
FSS	Functional status scale.
CSA	Cross-sectional area.
FR	Flattening ratio

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Not applicable.

Author contributions
AR designed the work, acquisition and analysis and interpretation of data. SH designed the work and substantively revised it. RE designed the work and data analysis. AA designed the work, acquisition and analysis and substantively revised it. All authors have read and approved the manuscript.

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Availability of data and materials
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study was approved by the Research Ethics Committee of the Faculty of Medicine at Alexandria University in Egypt (IRB NO: 00012098, FWA NO: 00018699) on 21/1/2021 with serial number 0106690. All patients included in this study gave written informed consent to participate in this research.

Consent for publication
All patients included in this research gave written informed consent to publish the data contained within this study.

Competing interests
The authors declare that they have no competing interests.

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