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Ultrasound-Guided Hydrodissection with Corticosteroid Injection for Carpal Tunnel Syndrome

Karpal Tünel Sendromunda Kortikosteroid Enjeksiyonu ile Ultrason Kılavuzluğunda Hidrodiseksiyon

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ABSTRACT Objective: Corticosteroid injections are remarkably effective as a treatment for carpal tunnel syndrome (CTS) in the short term. This study aimed to determine the effects of ultrasound (US)-guided corticosteroid injection with or without hydrodissection on symptom severity, functional status, grip strength, quality of life, and the cross-sectional area (CSA) of the median nerve in CTS. **Material and Methods:** A prospective cohort of patients with CTS was retrospectively evaluated. A total of 28 patients were randomly selected who received US-guided triamcinolone injection with hydrodissection (3 mL) as the hydrodissection group and US-guided triamcinolone injection (1 mL) as the control group, from the data (case-control ratio 1:1). Outcome measures were the hand grip strength (HGS), CSA of the median nerve, Boston Carpal Tunnel Questionnaire (BCTQ), and Short Form 12. We recorded the assessments at baseline, 1 and 4 weeks after injections. **Results:** HGS significantly improved, CSA of the median nerve, Symptom Severity Scale, and Functional Status Scale (FSS) scores of BCTQ significantly decreased in both groups throughout the assessment points ($p<0.01$ for each variable). Percent changes in baseline and 1st-week results between groups showed improvement in the FSS score of BCTQ in the hydrodissection group (-47.46% vs. -13.97%, $p=0.016$) but this was not available after 4 weeks (-53.25% vs. -33.33%, $p=0.053$). **Conclusion:** Corticosteroid injection with hydrodissection did not provide an additional clinical effect except for an improvement in functional scores in 1st week.

Keywords: Carpal tunnel syndrome; ultrasound; hydrodissection; steroid injection

ÖZET Amaç: Kortikosteroid enjeksiyonları kısa vadede karpal tünel sendromunun (KTS) tedavisinde oldukça etkilidir. Bu çalışmada, KTS'de ultrason (US) kılavuzluğunda hidrodiseksiyonlu veya hidrodiseksiyonsuz kortikosteroid enjeksiyonunun semptom şiddeti, fonksiyonel durum, kavrama gücü, yaşam kalitesi ve medyan sinirin kesit alanı [cross-sectional area (CSA)] üzerine etkilerini belirlemek amaçlandı. **Gereç ve Yöntemler:** KTS'li hastaların prospektif bir kohortu retrospektif olarak değerlendirildi. Hidrodiseksiyon grubu olarak US kılavuzluğunda hidrodiseksiyonlu triamsinolon enjeksiyonu (3 mL) yapılan ve kontrol grubu olarak US kılavuzluğunda triamsinolon enjeksiyonu (1 mL) yapılan toplam 28 hasta verilerden rastgele seçildi (vaka-kontrol oranı 1:1). Sonuç ölçümleri; el kavrama kuvveti [hand grip strength (HGS)], medyan sinirin CSA'sı, Boston Karpal Tünel Anketi [Boston Carpal Tunnel Questionnaire (BCTQ)] ve Kısa Form 12 idi. Değerlendirmeler başlangıçta, enjeksiyonlardan 1 hafta ve 4 hafta sonra kaydedildi. **Bulgular:** Değerlendirme noktaları boyunca her iki grupta da HGS anlamlı olarak iyileşirken; medyan sinirin CSA'sı, BCTQ'nun Semptom Şiddet Ölçeği ve Fonksiyonel Durum Ölçeği [Functional Status Scale (FSS)] skorları anlamlı olarak azaldı (her değişken için $p<0,01$). Başlangıç ve 1. hafta sonuçlarındaki yüzde değişiklikler gruplar arasında karşılaştırıldığında, hidrodiseksiyon grubunda BCTQ'nun FSS skoru iyileşme gösterdi (-47.46% vs. -13.97%, $p=0.016$); fakat bu fark 4 hafta sonra mevcut değildi (-53.25% vs. -33.33%, $p=0.053$). **Sonuç:** Hidrodiseksiyonlu kortikosteroid enjeksiyonu 1. haftadaki fonksiyonel skorlarda iyileşme dışında ek bir klinik etki sağlamadı.

Anahtar Kelimeler: Karpal tünel sendromu; ultrason; hidrodiseksiyon; steroid enjeksiyonu

Carpal tunnel syndrome (CTS) is the most common and extensively investigated nerve entrapment syndrome.[1] The pathology is considered to be associated with entrapment, irritation, or compression of the median nerve in the carpal tunnel at the wrist: an anatomical area bounded volarly by the fibrous flexor

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retinaculum and dorsally by the carpal bones. Anything that causes an increase in the pressure within the compartment or a decrease in the volume of this compartment may cause or precipitate the symptoms of CTS.[2]

Treatment recommendations for CTS are based on the severity of the disease, ranging from conservative management to surgical intervention. Even though conservative management is beneficial for most subjects with mild and moderate CTS, a Cochrane review recommends only limited or short-term effects of such treatments.[3] Local corticosteroid injections are often used for the treatment of CTS. The rationale for using this therapy is the capability of corticosteroids to reduce edema, enhancing the spatial relationship between the carpal tunnel and tendons and the median nerve.[4] Steroid injections are noted to be remarkably effective as a treatment for CTS in the short term.[5]

A relatively new technique to fight entrapment of the median nerve is ultrasound (US)-guided hydrodissection.[6-8] The potential benefit of hydrodissection in CTS depends on the theory that entrapment of the nerve is aggravated by median nerve fixation to surrounding tissues just as the transverse carpal ligament. Hydrodissection uses a US-guided injection of sterile saline to establish a perineural fluid plane between the surrounding tissues and the nerve, thereby improving the mobility of the nerve.[9]

To the best knowledge of the authors, there were two studies in the literature comparing the effect of US-guided steroid injection with or without hydrodissection, which found no further improvement in the hydrodissected group.[10,11] To fill the gap and consolidate scarce data for CTS, we hypothesized that hydrodissection with corticosteroid injection would yield superior clinical and sonographic results compared to corticosteroid injection alone in the short-term. Therefore, we aimed to compare the effects of US-guided corticosteroid injection with or without hydrodissection on symptom severity, functional status, grip strength, quality of life, and the cross-sectional area (CSA) of the median nerve in CTS.

MATERIAL AND METHODS

PARTICIPANTS AND STUDY DESIGN

A prospective cohort of patients with CTS admitted to a tertiary rehabilitation hospital between December 2018 and July 2020 was retrospectively evaluated. Patients were included if they accomplished the following criteria: (1) aged between 18-65, (2) clinically diagnosed with CTS, (3) electrophysiologically confirmed mild-to-moderate CTS, (4) having typical CTS symptoms for at least 3 months, (5) not benefiting from splinting and resting. Exclusion criteria were as follows: (1) electrophysiologically diagnosed with severe CTS, (2) surgery history for CTS, (3) presence of metabolic, endocrine, and neoplastic disorders (4) presence of other neurological disorders (such as plexopathy, proximal ulnar or median neuropathy cervical radiculopathy, polyneuropathy, and mononeuritis multiplex). Written informed consent was collected from all patients. Our study was performed according to the principles of the Declaration of Helsinki. The Ethics Committee of Ankara Numune Training and Research Hospital approved the study protocol (approval number: E-19-2476, approval date: February 7, 2019). ClinicalTrials.gov database registration (NCT04848324) was performed.

Demographic and clinical features of the subjects including age, education, body mass index, occupation, comorbidities, dominant hand, duration of symptoms, and CTS severity determined by electrophysiological study (mild or moderate) were noted.

From the data (case-control ratio 1:1), we randomly selected patients with CTS who received US-guided hydrodissection corticosteroid injection (hydrodissection group, 14 patients with 14 hands) and US-guided corticosteroid injection (control group, 14 patients with 14 hands). In the case of bilateral CTS, the hand with more severe symptoms was included. Outcome measurements were recorded at baseline, 1 and 4 weeks after injection.

INTERVENTION

The US-guided injection was performed with a 5-12 MHz linear transducer (Logic e portable; GE Health-

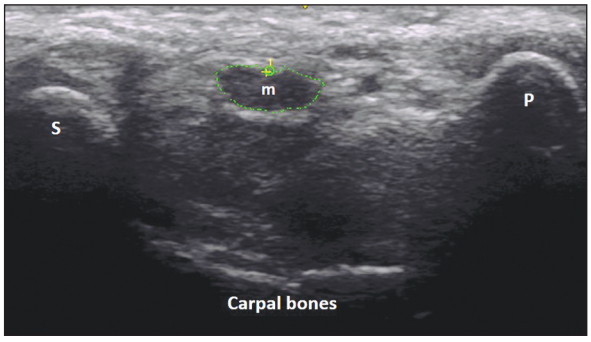

FIGURE 1: Axial ultrasound image over the volar wrist illustrates the cross-sectional area (dashed line) of the hypoechoic and swollen median nerve (m). S: Scaphoid bone; P: Pisiform bone.

care, China) by the same physiatrist. The median nerve was examined at the scaphoid-pisiform level of the inlet of the carpal tunnel (Figure 1). The hydrodissection was achieved by a total volume of 3 mL [1 mL of triamcinolone (40 mg) and 2 mL of saline] by using a 27-G needle in the hydrodissection group based on a study identifying median nerve hydrodissection with this volume.[12] Half of the total volume (1.5 mL) was delivered by the in-plane ulnar approach and the other half (1.5 mL) via the in-plane median approach to create a fluid plane along the nerve (Figure 2). In the control group, 1 mL of triamcinolone (40 mg) was delivered by using a 27-G needle with an in-plane ulnar approach. Participants were monitored for 30-min after injection for possible side effects.

OUTCOME MEASUREMENTS

Boston Carpal Tunnel Questionnaire

The Boston Carpal Tunnel Questionnaire (BCTQ), which examines symptom severity and overall functional status of patients, consists of two subscales [Symptom Severity Scale (SSS) and Functional Status Scale (FSS)], which were filled out by the patient him/herself.[13] Both subscales of BCTQ are scored between 1 and 5, and higher scores illustrate a greater degree of disability. The Turkish validity of the questionnaire was demonstrated.[14]

Hand Grip Strength

Standard Jamar Dynamometer was used to measure hand grip strength (HGS). The patients were placed in a sitting position with the forearm in a neutral position and the elbow in 90° flexion. Three consecutive measurements were performed, and the mean value was noted. Studies have shown that the Jamar dynamometer has high validity and reliability and is considered to be the gold standard for evaluating HGS.[15,16]

CSA of the Median Nerve

CSA of the median nerve was measured at the scaphoid-pisiform level using the US since the median nerve swelling is a reliable measure for the follow-up of the post-injection period at this level. Three measurements were performed for analysis and the mean value was recorded.

Short Form 12

Quality of life was evaluated with the Turkish version of Short Form 12 (SF-12). The physical component score and mental component score are obtained from SF-12. Higher scores indicate better outcomes.

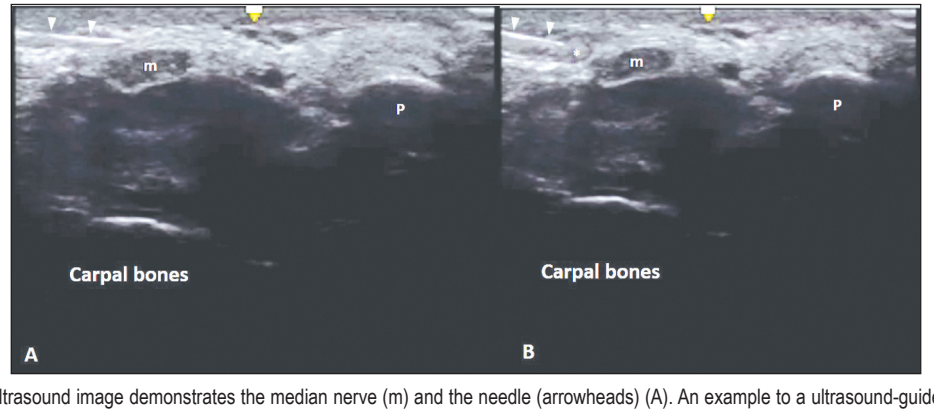

FIGURE 2: Axial ultrasound image demonstrates the median nerve (m) and the needle (arrowheads) (A). An example to a ultrasound-guided hydrodissection consisting of 3 mL corticosteroid and saline solution (asterisk) (B). P: Pisiform bone.

STATISTICAL ANALYSIS

Data analysis was performed using IBM SPSS ver. 25.0 (IBM Corp., Armonk, NY, USA) To determine whether the variables were normally distributed, analytical (Kolmogorov-Smirnov, skewness, and kurtosis) and visual (histogram, probability plots) methods were used. mean±standard deviation, percentage (%), and the median or interquartile range were used for the expression of the data of descriptive analysis. Student-t test and Mann-Whitney U test were used for comparison of continuous data between two groups. Categorical variables were compared using the chi-square test or Fischer's exact test when appropriate. To assess the effectiveness of each treatment modality at 1-week and 4-week periods, the median percentage changes were compared between the two groups for each time point (Week 1-Week 0; Week 4-Week 0). For this efficacy analysis, $p<0.025$ was considered as the border of statistical significance (Bonferroni correction). Additionally, to assess the efficacy of each treatment modality, changes in different scores within the same group were compared by the Friedman test. For the analyses other than the effectiveness analysis mentioned above, a 5% Type-I error level was used to conclude statistical significance. The sample size was identified using the G*power (V3.1) program (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany; http://www.gpower.hhu.de/). Based on an effect size of 1.28, 95% power, 5% alpha level, and a t-test model, a minimum sample size of 11 subjects was calculated for each group. Our sample size was chosen as 28 participants to replace any missing data.[10]

RESULTS

A total of 28 patients [17 (60.7%) female] were analyzed. No adverse effects related to the intervention were reported in either group. Figure 3 illustrates the flow chart of the study.

Patients' demographic and clinical characteristics were comparable and given in Table 1. Although the difference was not statistically significant, the duration of symptoms ($p=0.11$) and FSS score of BCTQ ($p=0.08$) were higher in the hydrodissection group.

HGS significantly improved, CSA of the median nerve, SSS, and FSS scores of BCTQ significantly decreased in both groups throughout the assessment points ($p<0.01$ for each variable).

In terms of percentage changes of baseline and 1st-week outcome measures between groups (Table 2), improvement in the FSS score of BCTQ was statistically significant in the hydrodissection group (-47.46% vs. -13.97%, $p=0.016$) while after 4 weeks (Table 3), this was no longer present (-53.25% vs.-33.33%, $p=0.053$) (Figure 4).

DISCUSSION

In this study, we aimed to illustrate whether hydrodissection with corticosteroid injection would show superior results compared to corticosteroid injection alone. It was found that corticosteroid injec-

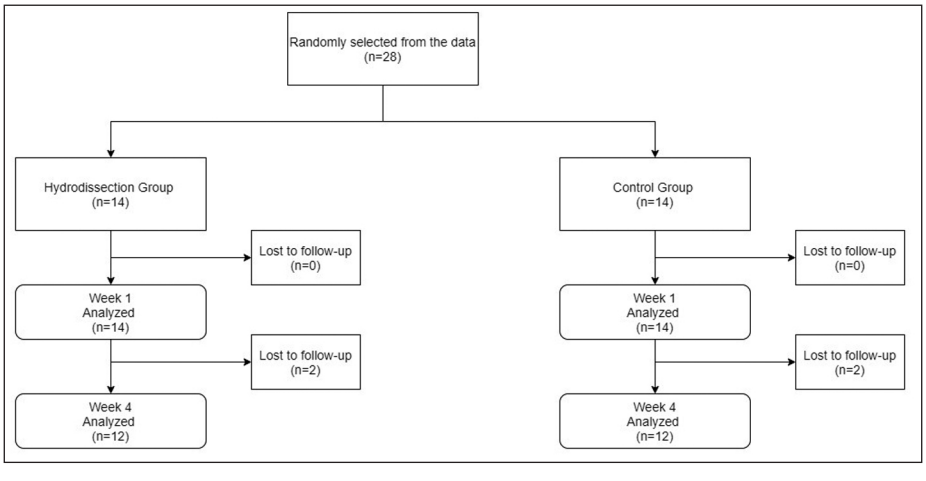

FIGURE 3: Flow chart of the study.

TABLE 1: Baseline demographic and clinical characteristics of study groups.

Variables	Hydrodissection group (n=14)	Control group (n=14)	p value
Female, n (%)	10 (71.4)	7 (50)	0.25
Age at study inclusion, years, median (minimum; maximum)	49 (37; 59)	46 (26; 65)	0.89
BMI (kg/m^2), median (minimum; maximum)	27.7 (20.4; 34.2)	29.0 (19.8; 35.6)	0.49
Education, n (%)			
- <High school	6 (42.9)	4 (28.6)	0.43
- ≥High school	8 (57.1)	10 (71.4)	
Occupation, n (%)			
- Worker	0 (0.0)	4 (28.6)	0.06
- Civil servant	2 (14.3)	2 (14.3)	
- Private sector employee	8 (57.1)	3 (21.4)	
- Retired	3 (21.4)	1 (7.1)	
- Unemployed	1 (7.1)	4 (28.6)	
The injection site, n (%)			
- Dominant hand	7 (50.0)	8 (57.1)	0.71
- Non-dominant hand	7 (50.0)	6 (42.9)	
Symptom duration, month	30.0 (3.0; 120.0)	10.5 (3.0; 84.0)	0.11
Severity of CTS on EMG, n (%)			
- Mild	2 (14.3)	3 (21.4)	0.62
- Moderate	12 (85.7)	11 (78.6)	
HGS (kilograms)	62.5 (20.0; 85.0)	50.0 (20.0; 130.0)	0.91
CSA of median nerve (cm2)	0.105 (0.070; 0.140)	0.120 (0.080; 0.250)	0.13
BCTQ, SSS	2.63 (1.90; 4.36)	2.50 (1.27; 3.36)	0.18
BCTQ, FSS*	3.50 (2.00; 4.25)	2.44 (1.00; 4.62)	0.08
SF-12 physical component score	38.85 (29.63; 56.13)	43.42 (22.90; 53.75)	0.82
SF-12 mental component score	49.09 (31.28; 65.10)	49.03 (22.94; 61.18)	0.89

*n=12 for Control Group; Data were given as median (minimum; maximum) or percentage (%), otherwise specified; BMI: Body mass index; CTS: Carpal tunnel syndrome; EMG: Electromyography; HGS: Hand grip strength; CSA: Cross-sectional area; BCTQ: Boston Carpal Tunnel Questionnaire; SSS: Symptom Severity Scale; FSS: Functional Status Scal; SF: Short Form.

tion with or without hydrodissection was effective in the short-term treatment of CTS; however, the results demonstrated no significant difference between the two study groups except that the improvement of the FSS score of BCTQ was significantly better in the hydrodissection group at 1 week after injection.

The studies have illustrated that thickened flexor tenosynovium due to inflammation, and pathological edema are the causes of increased pressure within the carpal tunnel, contributing to decreased median nerve mobility.[17,18] Detaching the median nerve from tendons within the carpal tunnel and subsynovial connective tissue has been demonstrated to improve symptoms of CTS.[19,20] The purpose of hydrodissection is to enhance the mobility of the median nerve as a result of the disruption of the fibrotic connective tissue.[10] Evers et al. demonstrated that US-guided hydrodissection with normal saline could decline gliding resistance of the median nerve within the carpal tunnel in cadaveric wrists.[9]

There is no consensus regarding the minimum volume of injected fluid required for a significant effect and the number of sessions of nerve hydrodissection in the literature.[21] We chose the 3 mL volume to avoid the pressure and pain associated with high-volume injections that could potentially have a detrimental effect on the carpal tunnel area. In a study in which hydrodissection was performed using a total volume of 3 mL in the elderly population, similar to our study, no difference was found between hydrodissection with lidocaine and normal saline and hydrodissection with low and high dose triamcinolone.[12]

In a study investigating whether different injectate volumes of perineural dextrose injection had dif-

TABLE 2: Comparison of percentage changes of baseline and 1st-week measurements between study groups.

Variables	Hydrodissection group (n=14)	Control group (n=14)	p value
HGS	25.00 (00.00; 50.00)	15.63 (-9.09; 100.00)	0.41
CSA of median nerve	-16.67 (-40.00; 0)	-16.83 (-46.15; -4.00)	0.57
BCTQ, SSS	-33.58 (-51.98; 3,54)	-30.54 (-50.00; 0)	0.57
BCTQ, FSS*	-47.46 (-65.47; 10.00)	-13.97 (-46.15; 0)	0.016
SF-12 physical component score	-0.39 (-52.11; 69.29)	3.46 (-14.54; 59.05)	1.00
SF-12 mental component score	5.52 (-14.56; 83.95)	7.93 (-21.39; 75.55)	0.71

*n=12 for Control Group; Data were given as median of percentage change (%) (minimum; maximum); HGS: Hand grip strength; CSA: Cross-sectional area; BCTQ: Boston Carpal Tunnel Questionnaire; SSS: Symptom Severity Scale; FSS: Functional Status Scale; SF: Short Form.

TABLE 3: Comparison of percentage changes of baseline and 4th-week measurements between study groups.

Variables	Hydrodissection group (n=12)	Control group (n=12)	p value
HGS	23.61 (0; 57.14)	16.25 (-25.00; 125.00)	0.67
CSA of median nerve	-25.00 (-45.00; 0)	-32.67 (-61.54; 0)	0.64
BCTQ, SSS	-43.34 (-68.55; -31.18)	-38.29 (-70.24; -6.41)	0.27
BCTQ, FSS*	-53.25 (-69.06; -21.60)	-33.33 (-64.00; 37.50)	0.053
SF-12 physical component score	31.80 (-4.17; 64.58)	12.94 (-2.31; 101.94)	0.45
SF-12 mental component score	4.53 (-34.89; 69.12)	13.14 (-19.69; 57.38)	0.49

*n=11 for Hydrodissection Group, n=9 for Control Group; Data were given as median of percentage change (%) (minimum; maximum); HGS: Hand grip strength; CSA: Cross-sectional area; BCTQ: Boston Carpal Tunnel Questionnaire; SSS: Symptom Severity Scale; FSS: Functional Status Scale; SF: Short Form.

ferent effects on CTS patients, better visual analog scale reduction was found in the 4 mL group at 4 and 12 weeks as well as BCTQ improvement at 1, 4, and 12 weeks, compared to 1 mL and 2 mL groups. However, no significant difference between groups was detected in the CSA of the median nerve at any follow-up time points.[22]

To our knowledge, two studies comparing the effect of US-guided steroid injection with or without hydrodissection. In the first study, unlike our study, betamethasone as the steroid type and 5 mL volume were used for hydrodissection and outcome scales were not measured in the 1st week as well.[10] At the 4th week follow-up, it was shown that the SSS score of BCTQ decreased more in the control group, and similar to our study, the hydrodissection group did not provide additional improvement.[10] In the second study, triamcinolone as the steroid type, similar to our study, and 10 mL volume, different from our study, were used for hydrodissection.[11] Hydrodissection had no additional effect on any outcome measure at 6- and 12-weeks follow-up.[11] A systematic review has demonstrated

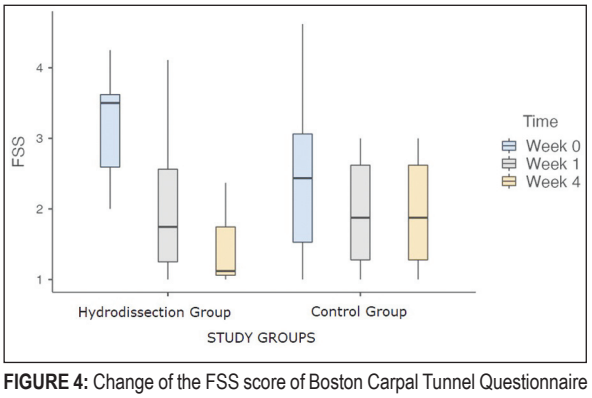

FIGURE 4: Change of the FSS score of Boston Carpal Tunnel Questionnaire according to study groups. FSS: Functional Status Scale.

that the type and dose of steroids do not change the steroid injection efficacy for CTS.[23]

In our study, the improvement of the FSS score of BCTQ was significantly higher in the hydrodissection group 1 week after injection. Early mechanical hydrodissection may affect this difference, but no significant improvement was detected in other parameters compared to the control group. The injec-

tion-related placebo effect may have contributed to this difference at 1 week after injection. Nerve size measurement, unaffected by the injection-associated placebo effect, could potentially be a more objective and physiological evaluation method with changes that could be detected 1 week after injection.[10,21] In our study, the percent changes in CSA of the median nerve between the baseline and the 1st week, and between the baseline and the 4th week between the two groups were comparable. Wu et al. detected that the injected fluid was almost completely absorbed 1 hour after injection.[24] However, it also stated that the hydrodissection effect does not completely depend on the persistence of the fluid bolus and this effect may be long-lasting.[9] We only examined the short-term effects of hydrodissection and no additional effect of hydrodissection was observed at 4-week after injection. Further studies with longer follow-up periods are needed. The injection technique used in the study may play a role in not detecting a significant difference between the hydrodissection group and the control group. Guo et al. suggested that the entire carpal tunnel length may not be hydrodissected by ulnar and radial approaches while the needle may go through the entire carpal tunnel to the distal forearm by modified distal-to-proximal approach.[25] Further studies are necessary to evaluate the efficacy of hydrodissection with the modified distal-to-proximal approach in patients with CTS.

There are some limitations of this study. The first limitation is the relatively small sample size, second is that evaluations are not blinded. Third, the results cannot be generalized to all CTS patients. This study was conducted only on patients with mild to moderate idiopathic CTS. Lastly, the study design is not prospective randomized controlled, which may lead to possible selection bias. Therefore, patients were randomly selected from the data to minimize possible selection bias.

CONCLUSION

Corticosteroid injection with hydrodissection did not provide an additional clinical effect, except for an improvement in functional scores 1 week after injection. More studies with longer follow-up periods and larger sample sizes are needed in terms of different techniques or volumes.

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Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Evren Yaşar;* ***Data Collection and/or Processing:*** *Merve Örücü Atar, Özge Tezen, Şükran Yurtoğulları, Özlem Köroğlu, Eda Gürçay;* ***Analysis and/or Interpretation:*** *Esra Bilgin;* ***Literature Review:*** *Eda Gürçay;* ***Writing the Article:*** *Merve Örücü Atar, Esra Bilgin;* ***Critical Review:*** *Özlem Köroğlu*

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