ORIGINAL STUDY — HAND AND WRIST

acta orthopaedica belgica, 2025, 91, 299-307

doi.org/10.52628/91.3.14385

Comparison of surgical treatment for Carpal Tunnel Syndrome with corticosteroid injection and platelet-rich plasma injection

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The most common entrapment neuropathy is carpal tunnel syndrome (CTS). Treatment options include both surgical and conservative procedures. The purpose of this study is to compare surgical treatment, corticosteroid injection, and platelet-rich plasma (PRP) injection in mild and moderate CTS and assess their clinical, electrophysiological, and ultrasonographic superiority over each other. This research was carried out using a prospective, randomized, controlled design. The study included 92 wrists from 68 participants with mild to moderate carpal tunnel syndrome. Following patient randomization, the first group underwent surgical treatment, the second group received steroid injections guided by ultrasonography, and the third group received PRP injections guided by ultrasonography. Prior to treatment, as well as one, three, and six months later, patients had evaluations. The patients' functional status and the severity of their symptoms were assessed using the Boston Carpal Tunnel Questionnaire (BCTQ), while the visual analog scale (VAS) was used to determine the patients' pain levels. Patients also had electrodiagnostic examinations, and ultrasonography was used to measure the median nerve's cross-sectional area (CSA) and flattening ratio (FR). The VAS and BCTQ showed significant improvements in all groups; however, surgical treatment outperformed the other two treatment modalities. While there was no significant change in compound muscle action potential amplitude in either group, surgical treatment was found to be superior in other electrophysiological measures. Before treatment, there was a difference in the groups' CSA measurements, and following treatment, all three treatment groups showed significant improvements. FR remained unchanged across all groups. In patients with mild to moderate CTS, injection procedures are useful, but surgical treatment has been shown to be more effective in terms of both clinical outcomes and electrophysiological parameters.

Keywords: Carpal tunnel syndrome, Electrophysiology, Platelet-rich plasma injection, Corticosteroid injection, Surgical treatment, Ultrasonography.

INTRODUCTION

Carpal tunnel syndrome (CTS) is the most common form of entrapment neuropathy. Clinically, CTS is defined by symptoms and signs of compression of the median nerve as it passes under the transverse carpal ligament at the wrist level. Patients complain of numbness and pain in the hand, especially as symptoms increase at resting times and at night[1]. CTS treatment ranges from conservative approaches (oral medications, night splints, physical therapy modalities, and injection treatments) to surgical decompression of the median nerve. Although conservative treatment is indicated for mild-to-moderate cases of CTS, surgical procedures are recommended for CTS patients whose symptoms do not improve after receiving conservative treatment. However there is no consensus about the optimal treatment method for mild-to-moderate CTS[2].

Corticosteroid (CS) injection is found to be effective in the treatment of CTS through several mechanisms, including anti-inflammatory, anti-ischemic, and vasoconstrictive effects. As a result, it reduces edema within the carpal tunnel and tunnel pressure and eliminates pressure on the median nerve[3].

Platelet-rich plasma (PRP) is an autologous fraction of human blood, containing a higher concentration of platelets than normal blood levels, and various growth factors. Growth factors play a role in the treatment of musculoskeletal disorders by promoting tissue healing and remodeling. PRP also reduces inflammation and

increases angiogenesis[4]. Several studies have shown that PRP has a beneficial effect on nerve regeneration[5]. Currently, considering these effects, the use of PRP in the treatment of CTS has become common[6].

Surgical release of the carpal tunnel is known to be effective and widely preferred. Although it is a definitive treatment, it is not always the best choice for all CTS patients. It is the first treatment choice for patients with severe CTS and who have developed muscle atrophy. Moreover, it can be used for patients who fail to get enough relief with conservative management and who have prolonged CTS[2,7].

In this study, it is aimed to determine the clinical, electrophysiological, and ultrasonographic outcomes of CS injection, PRP injection, and surgical treatment for mild and moderate CTS and to compare the groups with each other.

MATERIALS AND METHODS

This prospective randomized controlled study was conducted between January 2022 and January 2023. Patients (aged 18–70) with a minimum of 3 months duration of symptoms and mild to moderate CTS were included in the study. Patients were excluded based on the following criteria: 1) Patients with severe CTS diagnosed with EMG or the presence of thenar atrophy, 2) Polyneuropathy, 3) Previous injection therapy for CTS, 4) Previous CTS surgery, 5) Pregnancy or lactation. In the power analysis performed before starting the study, the minimum sample size was calculated as 54. As a result, out of the 91 patients initially evaluated, a total of 68 patients who met the criteria were included in the study. Patients who met the criteria were randomized using the closed envelope method into three groups: Surgical treatment group (25 patients and wrists), CS treatment group (20 patients and 32 wrists), and PRP treatment group (23 patients and 35 wrists).

The study was approved by the institutional ethics committee (İ02-82-22). Written informed consent was obtained from all included patients after a thorough explanation of the study design. The study was conducted in accordance with the principles of the Declaration of Helsinki. Furthermore, the study has been registered in ClinicalTrials.gov under the registration number NCT06852131.

Patients thought to have CTS based on a clinical history and physical examination underwent electrodiagnostic examinations (EDX) to confirm the clinical diagnosis of CTS. Patients' demographic data were collected before treatment. Visual analog scale (VAS) and Boston Carpal Tunnel Questionnaire (BCTQ) were measured at baseline and at 1-, 3-, and 6-month follow-up after treatment. At each follow-up visit EDX and ultrasonographic evaluation were performed.

The severity of symptoms in the patients was evaluated using the VAS. VAS is a scoring system that ranges from 0 (no pain) to 10 (worst pain). The patient marks the point on the scale that corresponds to their complaint

The BCTQ includes two sections: Boston Symptom Severity Scale (BSSS, 11 questions) and the Boston Functional Status Scale (BFSS, 8 questions). Each question is scored from 1 to 5. The average value is calculated for each section. Higher scores indicate greater severity and decreased functional capacity

Ultrasonography (US)

In both measurements and injections, the patients were positioned as follows: shoulder in a neutral position, elbow at 90º flexion, forearm supinated, wrist in slight extension, and fingers in semi-flexion. For examination, a linear array probe portable US device (Clarius, L7 HD3 Linear Scanner) was used. Median nerve CSA was measured using the manual trace method in axial view in the proximal carpal tunnel (at the scaphoid-pisiform level), where the median nerve's largest enlargement was found. The mean of cross-sectional area (CSA) was calculated using three consecutive measurements (mm^2) and recorded. The flattening ratio (FR) was calculated by dividing the transverse diameter of the nerve by its anteroposterior diameter.

EDX

All EDX were performed using the Medtronic Key-Point EMG device (Denmark) by a neurology expert. Sensory and motor conduction studies of the median nerve and sensory conduction studies of the ulnar nerve were performed using standard techniques of supramaximal stimulation. Stimulation intensity was increased (3 mA for sensory or motor studies) each time until supramaximal stimulation was reached and maximal action potential was achieved. Sensory nerve conduction studies were performed with an antidromic method. Median nerve sensory nerve conduction velocity (SNCV) and sensory nerve action potential (SNAP) amplitude were calculated by recording from thumb and ulnar nerve from the 5th finger. Median nerve compound muscle action potential (CMAP) amplitude and distal motor latency (DML) were recorded from the abductor pollicis brevis.

Comparing with our clinical neurophysiology laboratory's normal values, the patients with only abnormal SNCVs (small or slow) with normal motor conduction were classified as electrophysiologically mild CTS patients. The patients were classified as having moderate CTS if their SNCVs were slow or SNAPs were small and the median distal motor latency was prolonged. The patients without a measurable sensory potential with small median CMAP or the patients without any median sensory or motor potential across the wrist were classified as having severe CTS[8].

Intervention

US-guided injections were performed for CS and PRP treatments by an orthopedic surgeon. Injections were administered to both hands in the same session for bilateral CTS patients. At the scaphoid-psiform level, using an in-plane ulnar approach, the needle was advanced over the ulnar artery and ulnar nerve. After the needle tip passed the flexor retinaculum and reached the edge of the median nerve, the injection was performed. All patients were observed for complications after the injection.

CS Treatment

After skin sterilization, 1mL of triamsinolon 40 mg/mL was injected.

PRP Treatment

Under sterile conditions, 10 ml of venous blood was drawn from each patient into vacuum tubes. The tubes were centrifuged at 700 rpm for 10 minutes (Centrifuge 800D). As a result of centrifugation, three layers were obtained: the upper plasma layer, the middle buffy coat layer, and the lower red blood cell layer. 1 ml of PRP ready for injection was collected from the buffy coat layer. No buffering or activating agent was used.

Surgical Treatment

All surgeries were carried out with standard open technique. Each procedure was performed with the wide-awake local anesthesia, no tourniquet (WALANT) technique, and under 20 cc local anesthesia (lidocaine) was administered a half hour before the operation. In the supine position, the incision was made at the point where the long axis of the third web met the Kaplan line and extended proximally. When the wrist crisis was reached, it was moved to the ulnar side to protect the palmar cutaneous branch of the median nerve. After the skin and subcutaneous tissue, the transvers carpal ligament was seen directly. Then the transvers carpal ligament was released until the median nerve was totally decompressed. The skin was closed with nonabsorbable sutures, and a bulky bandage was applied. The patients were discharged on the same day. Two weeks later, they were called for a control assessment, and the sutures were removed.

Statistical analyses were performed using StataMP13 (StataCorp. Stata Statistical Software: Release 13). The Shapiro-Wilk test showed the data distribution's normality. Mean ± standard deviation (SD) was used for the normally distributed continuous data. Percentages were given for categorical data. The chi-square test was used for categorical outcomes. A t-test was performed for parametric data between groups. To compare between >2 groups, the ANOVA test was used for normally distributed data, and Kruskal-Wallis was used for non-normally distributed data. Wilcoxon and Friedmann's test were used to compare repeated measures on the same subjects. Post-hoc analysis was performed. p-value < 0.05 was considered significant.

RESULTS

Table I summarizes the patients' demographic data. There was no significant difference between the groups. In Table II and Figure 1, patients' VAS, BSSS, and BFSS are shown. In the surgical treatment group, significant improvements in both the VAS and BCTQ were noted at each follow-up visit.

The results of the EDX are presented in Table III and Figure 2. Significant differences in CMAP amplitude were not seen at each time point in all groups. In the comparison between groups, a difference was observed in SNCV at 3 and 6 months and in DML at 6 months. The improvement was more pronounced for the surgical treatment group.

In all groups, while FR remained unchanged at all time points, CSA showed a significant decrease at the 1st month control, and remained unchanged at 3 and 6 months (Table IV and Figure 3). The differences between groups in CSA before treatment were also observed in post-term controls. Posthoc analyses revealed that the reason for this difference was PRP treatment.

DISCUSSION

The purpose of this study was to compare PRP injections, CS injections, and surgical treatment for mild to moderate CTS. In this study, surgical treatment was found to be more effective in both early and late stages than CS injection and PRP injection in mild to moderate CTS.

Table I. — Comparison of general characteristics.

	Total	Surgical Treatment Group n= 25	CS Treatment Group n= 32	PRP Treatment Group n= 35	p
Number of patients (n, %)	68 (100)	25 (36.76)	20 (29.41)	23 (33.82)	
Number of wrists (n, %)	92 (100)	25 (27)	32 (35)	35 (38)	
Sex (n, %) Female Male	 62 (91) 6 (9)	 23 (92) 2 (8)	 18 (90) 2 (10)	 21 (91) 2 (9)	0.972 [a]
Age, Mean±sd	49.13±9.64	52.48±10.36	46.90±10	47.43±7.69	0.089 [b]
BMI (kg/m^2) Mean±sd	30.05±4.63	31.40±4.96	28.78±3.58	29.68±4.87	0.150 [b]
Lesion Site (n, %) Left Right	 46 (50) 46 (50)	 16 (64) 9 (36)	 14 (44) 18 (56)	 16 (46) 19 (54)	0.257 [a]
Grade (n, %) Mild Moderate	 32 (35) 60 (65)	 8 (32) 17 (68)	 13 (41) 19 (59)	 11 (31) 24 (69)	0.691 [a]

CS: Corticosteroid PRP: Platelet Rich Plasma, BMI: Body mass index; a: Chi-square test, b: T-test.

Table II. — Comparison of VAS and BCTQ between surgery, CS and PRP groups.

		Surgical Treatment Group n= 25 Mean±sd		CS Treatment Group n= 32 Mean±sd		PRP Treatment Group n= 35 Mean±sd		p[x]
VAS	**Before Treatment**	7.16 ± 1.18		6.41 ± 1.85		6.86 ± 1.59		0.377
	1. Month	2.36 ± 1.68	**0.000** [p1]	4.37 ± 2.77	**0.000** [p1]	5.79 ± 1.95	**0.010** [p1]	**0.000**
	3. Month	2.00 ± 1.28	0.455 [p2]	4.83 ± 3.17	0.148 [p2]	5.29 ± 2.07	0.360 [p2]	**0.000**
	6. Month	2.14 ± 1.75	0.883 [p3]	4.95 ± 2.64	0.839 [p3]	4.96 ± 2.50	0.720 [p3]	**0.001**
BSSS	**Before Treatment**	3.25 ± 0.63		2.88 ± 0.67		3.03 ± 0.6		0.103
	1. Month	1.82 ± 0.59	**0.000** [p1]	2.51 ± 1.03	**0.023** [p1]	2.75 ± 0.59	**0.011** [p1]	**0.000**
	3. Month	1.71 ± 0.68	0.099 [p2]	2.73 ± 1.13	0.207 [p2]	2.75 ± 0.66	0.788 [p2]	**0.000**
	6. Month	1.65 ± 0.83	0.778 [p3]	2.73 ± 1	0.896 [p3]	2.66 ± 0.8	0.568 [p3]	**0.001**
BFSS	**Before Treatment**	3.45 ± 0.93		3.07 ± 1.1		3.16 ± 0.79		0.296
	1. Month	2.44 ± 0.97	**0.002** [p1]	2.68 ± 1.31	0.092 [p1]	3.17 ± 1.02	0.328 [p1]	**0.000**
	3. Month	1.98 ± 0.81	**0.031** [p2]	2.9 ± 1.31	0.107 [p2]	3.04 ± 1.22	0.900 [p2]	**0.000**
	6. Month	2.05 ± 1.03	0.258 [p3]	2.77 ± 1.15	0.806 [p3]	3.1 ± 1.12	0.673 [p3]	**0.020**

CS: Corticosteroid PRP: Platelet Rich Plasma, VAS: Visual Analog Scale, BSSS: Boston Symptom Severity Scale, BFSS: Boston Functional Status Scale; P1: Comparison between pre-treatment and 1st month control (Wilcoxon); P2: Comparison between 1st month control and 3rd month control (Wilcoxon); P3: Comparison between 3rd month control and 6th month control (Wilcoxon); px: Comparison between groups (ANOVA for parametric data, Kruskal Wallis test for non-parametric data); Bold values are significant at $p<0.05$.

In recent years, a safe, easily accessible, low-cost US has gained popularity for both the diagnosis and treatment of CTS. Despite its many advantages, it should be remembered that US depends on user experience. The US enables the visualization and simultaneous examination of the carpal tunnel, its anatomical structures, and the median nerve[9]. The meta-analyses have revealed that the US has 86% specificity and 77% sensitivity in diagnosing of CTS[10]. In studies, measurement of the median CSA at the pisiform level is the most useful and favored parameter for the diagnosis of CTS[10]. Other measurements, such as swelling ratio, reticular springing, and FR, can be used. The combined use of many parameters helps prevent the diagnosis from being affected by factors such as height and gender, which may cause changes in the median nerve and carpal tunnel anatomy[12]. In this study, after the diagnosis of CTS was determined by EDX, US-guided measurements of median nerve CSA and FR were used to support the diagnosis. Changes in US parameters were measured post-treatment follow-up.

At the one-month follow-up, there were noticeable improvements in the CSA measurements in all three groups. FR measurements showed no significant differences between treatment groups. According to a meta-analysis of diagnostic US measures, the most accurate cut-off value for confirming CTS was found to be 9 mm2. Additionally, the diagnostic value of FR measurements could not be determined[13].

There was no significant change in the CMAP amplitude in any of the treatment groups. This result is

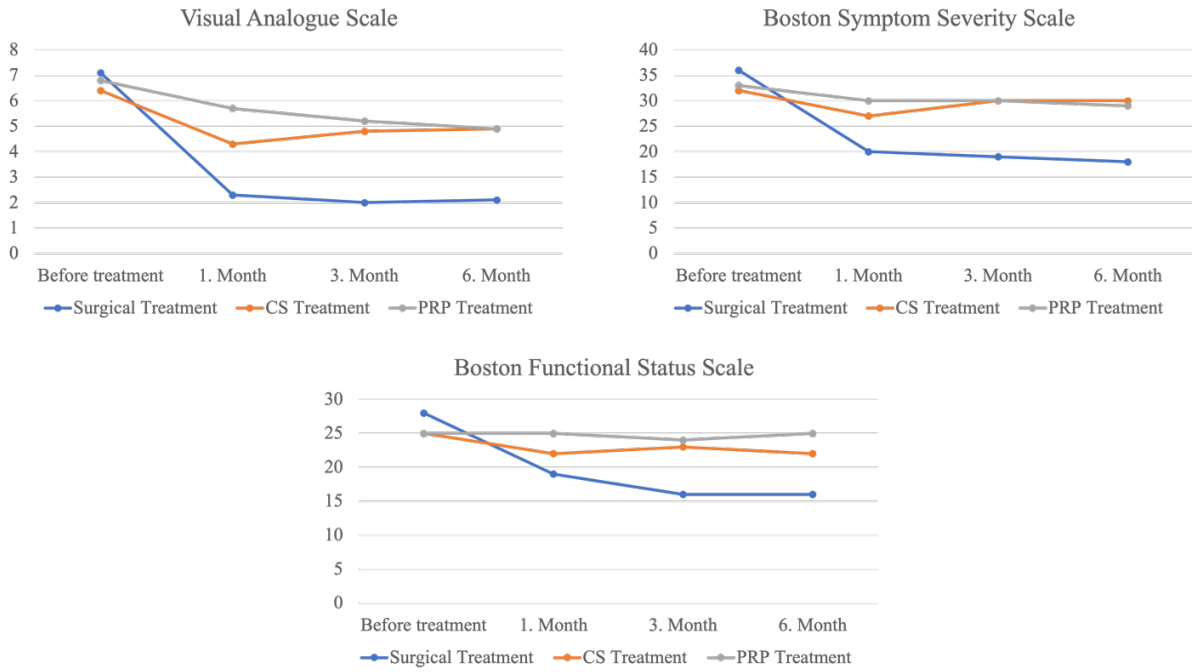

Fig. 1 — Comparison of VAS and BCTQ between surgery, CS and PRP groups.

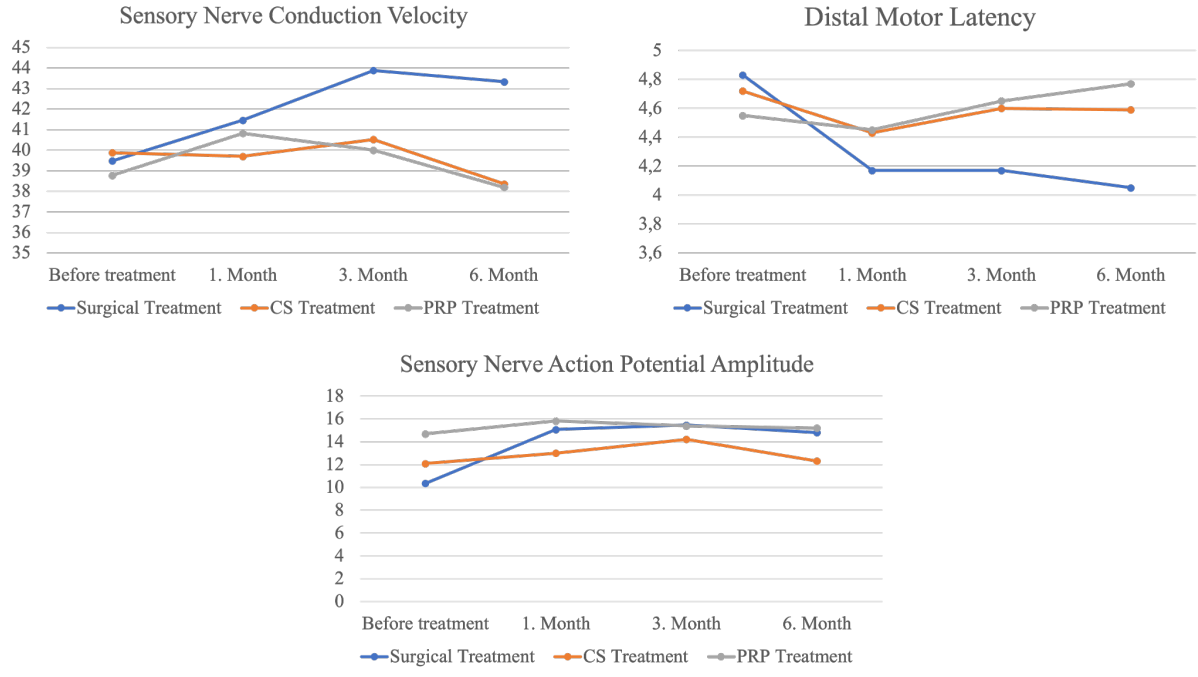

Fig. 2 — Comparison of EDX between surgery, CS and PRP groups.

thought to be caused by the study's inclusion of mild and moderate CTS patients. The CMAP amplitude, which was previously at normal values, is expected to remain constant.

CS injection treatment is commonly used in CTS, with evidence of short-term efficacy[14,15]. However, the most effective choice of CS and the optimal dosage remain subject of discussion. In the study conducted by Karimzadeh et al., high-dose triamcinolone showed better EDX findings and functional status[16]. Triamcinolone was preferred in this study to achieve the best recovery.

With a variety of healing pathways, PRP treatment has become increasingly popular in recent years for treating musculoskeletal diseases. Its usage in treating CTS has also expanded widely. There is still controversy regarding PRP preparation method, optimum concentration, and treatment session[17]. This

Table III. — Comparison of EDX between surgery, CS and PRP groups.

		Surgical Treatment Group n= 25 Mean±sd		CS Treatment Group n= 32 Mean±sd		PRP Treatment Group n= 35 Mean±sd		p^x
SNCV (m/s)	**Before Treatment**	39.48 ± 5.86		39.88 ± 6.70		38.77 ± 7.05		0.789
	1. Month	41.46 ± 6.18	**0.016** ^{p1}	39.70 ± 5.43	0.211 ^{p1}	40.82 ± 7.77	**0.010** ^{p1}	0.609
	3. Month	43.88 ± 4.85	**0.004** ^{p2}	40.52 ± 6.70	0.707 ^{p2}	40.00 ± 5.94	0.328 ^{p2}	**0.041**
	6. Month	43.33 ± 3.60	0.974 ^{p3}	38.36 ± 6.59	0.015 ^{p3}	38.19 ± 6.24	0.151 ^{p3}	**0.017**
DML (ms)	**Before Treatment**	4.83 ± 0.89		4.72 ± 0.87		4.55 ± 0.61		0.377
	1. Month	4.17 ± 0.55	**0.000** ^{p1}	4.43 ± 0.78	**0.004** ^{p1}	4.45 ± 0.69	0.106 ^{p1}	0.388
	3. Month	4.17 ± 0.46	0.566 ^{p2}	4.60 ± 1.00	0.069 ^{p2}	4.65 ± 0.91	0.056 ^{p2}	0.094
	6. Month	4.05 ± 0.41	**0.040** ^{p3}	4.59 ± 0.77	0.148 ^{p3}	4.77 ± 0.86	0.639 ^{p3}	**0.031**
SNAP Amplitude (µV)	**Before Treatment**	10.35 ± 5.97		12.09 ± 7.39		14.69 ± 8.01		0.058
	1. Month	15.08 ± 8.07	**0.000** ^{p1}	13.00 ± 6.75	0.296 ^{p1}	15.82 ± 8.25	0.402 ^{p1}	0.316
	3. Month	15.46 ± 7.98	0.083 ^{p2}	14.21 ± 8.26	0.416 ^{p2}	15.35 ± 7.97	0.362 ^{p2}	0.579
	6. Month	14.80 ± 5.78	0.195 ^{p3}	12.31 ± 7.42	0.078 ^{p3}	15.19 ± 8.44	0.482 ^{p3}	0.280
CMAP Amplitude (µV)	**Before Treatment**	9.48 ± 3.75		10.56 ± 4.11		10.56 ± 2.98		0.447
	1. Month	9.40 ± 3.25	0.117 ^{p1}	10.03 ± 3.35	0.941 ^{p1}	10.00 ± 3.25	0.230 ^{p1}	0.119
	3. Month	9.21 ± 3.30	0.235 ^{p2}	9.00 ± 2.88	0.181 ^{p2}	9.82 ± 3.02	0.643 ^{p2}	0.539
	6. Month	9.33 ± 3.22	0.290 ^{p3}	9.41 ± 3.52	0.930 ^{p3}	9.32 ± 3.86	0.157 ^{p3}	0.995

CS: Corticosteroid PRP: Platelet Rich Plasma, SNCV: Sensory Nerve Conduction Velocity, DML: Distal Motor Latency, SNAP: Sensory Nerve Action Potential, CMAP: Compound Muscle Action Potential; P1: Comparison between pre-treatment and 1st month control (Wilcoxon); P2: Comparison between 1st month control and 3rd month control (Wilcoxon); P3: Comparison between 3rd month control and 6th month control (Wilcoxon); px: Comparison between groups (ANOVA for parametric data, Kruskal Wallis test for non-parametric data); Bold values are significant at $p<0.05$.

Table IV. — Comparison of USG studies between surgery, CS and PRP groups.

		Surgical Treatment Group n= 25 Mean±sd		CS Treatment Group n= 32 Mean±sd		PRP Treatment Group n= 35 Mean±sd		$p^{x\,c}$
CSA ($mm^{2)}$	**Before Treatment**	11.28 ± 1.75		11.68 ± 1.60		9.91 ± 1.84		**0.000**
	1. Month	10.37 ± 1.64	**0.006** ^{p1}	10.66 ± 1.59	**0.001** ^{p1}	9.57 ± 1.50	**0.038** ^{p1}	**0.027**
	3. Month	10.04 ± 1.35	0.177 ^{p2}	10.57 ± 1.89	0.222 ^{p2}	9.33 ± 1.45	0.828 ^{p3}	**0.013**
	6. Month	10.09 ± 1.17	0.861 ^{p3}	10.80 ± 1.98	0.372 ^{p3}	9.49 ± 1.60	0.415 ^{p3}	**0.037**
FR	**Before Treatment**	3.00 ± 0.56		3.12 ± 0.70		2.97 ± 0.71		0.637
	1. Month	3.00 ± 0.74	0.615 ^{p1}	3.21 ± 0.74	0.569 ^{p1}	3.15 ± 0.78	0.688 ^{p1}	0.605
	3. Month	3.05 ± 1.04	0.637 ^{p2}	3.18 ± 0.97	0.888 ^{p2}	3.10 ± 0.94	0.596 ^{p2}	0.861
	6. Month	3.18 ± 0.95	0.227 ^{p3}	2.95 ± 0.85	0.380 ^{p3}	3.23 ± 0.77	0.841 ^{p3}	0.225

CS: Corticosteroid, PRP: Platelet Rich Plasma, CSA: Cross Section Area, FR: Flattening Ratio; P1: Comparison between pre-treatment and 1st month control (Wilcoxon); P2: Comparison between 1st month control and 3rd month control (Wilcoxon); P3: Comparison between 3rd month control and 6th month control (Wilcoxon); px: Comparison between groups (ANOVA for parametric data, Kruskal Wallis test for non-parametric data); Bold values are significant at $p<0.05$.

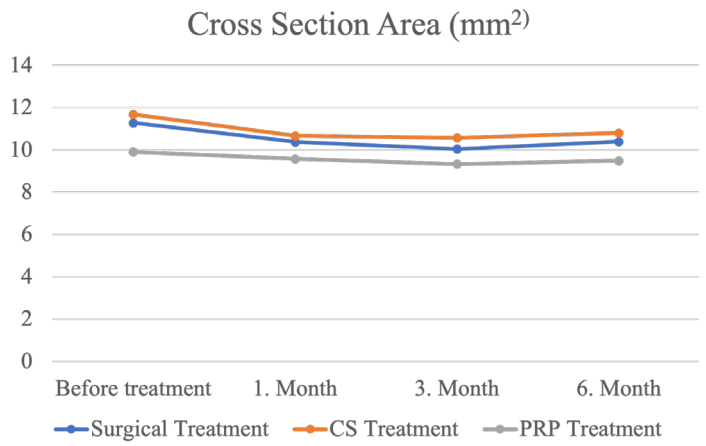

Fig. 3 — Comparison of CSA between surgery, CS and PRP groups.

study aimed to compare different treatment methods, including PRP injection, which has been proven effective in placebo-controlled studies for treating CTS[18,19].

The real-time capability of US allows for precise needle placement in carpal tunnel injections, reducing the risk of nerve and structural injury[20]. Furthermore, using US guidance when performing injections ensures more effective results. In a randomized controlled study, US-guided steroid injections were found to be more effective than blind injections for CTS[21]. A meta-analysis demonstrated the advantages of US-guided corticosteroid injection in improving functional status, reducing the severity of symptoms, and reducing the rate of adverse events in people with CTS[22].

Bleeding, allergic reactions, and infection are all possible complications of CTS injections. Complications of CS injections include depigmentation, subcutaneous atrophy, intraneural injection, and tendon rupture[23]. There were no complications reported in this study following CS and PRP injections.

The standard open surgery that was used in this study is a technique that has been used for many years and allows the median nerve to be totally visualized and relaxed within the carpal tunnel. Open carpal tunnel release is a widely used technique with a high success rate and well-known intraoperative and postoperative complications. (bleeding, palmar cutaneous branch injury, Guyon canal injury, superficial palmar arch injury, median nerve injury, infection, painful scar and complex regional pain syndrome)[24,25]. In this study, patients who did not develop any complications were discharged on the same day.

In a randomized controlled study including 50 CTS patients, Hui et al. compared blind single-dose steroid injection with the open standard carpal tunnel release technique. In the EDX performed at the 20th week, while significant improvement was seen in SNCV and DML in the surgical treatment group, there was no significant difference between the groups[26].

Ly-pen et al. evaluated CS injection and surgical treatment for CTS in a study including 163 participants. The surgery was performed as a limited incision. The injection was performed without US guidance. Pain, functional level, and night numbness were evaluated in a study with a 2-year follow-up period. While both treatment approaches showed considerable improvement, surgical treatment was shown to be more effective than CS treatment[27].

CTS is caused by compression of the median nerve within the carpal tunnel. CS relieves local ischemia, decreases synovial edema or vascular congestion, and reduces pressure and inflammation in the carpal tunnel. PRP also has a similar physiopathological pathway. Because mechanical restriction is present, injection treatments can only provide temporary relief of symptoms. Otherwise, the surgical division of the flexor retinaculum provides further space for the median nerve, thereby permanently resolving the problem. That is why most studies found that initial improvement is reported by many patients after injection; relapses are observed in the long term. Ly-pen in the 2-year follow-up confirms that the longer the period from injection to follow-up assessment, the fewer treatment benefits are observed in the injection group. A total of %15 injection group patients had to undergo surgery because of relapsing symptoms[27].

In a randomized controlled study by Uzun et al., which included a total of 40 mild CTS patients, PRP injection and steroid injection were compared. Patients were evaluated with the BCTQ and EDX at 6 weeks, 3 months, and 6 months. DML did not change in either of the groups during the follow-up, which is similar to this study. By the end of the study, there was no significant difference between the groups in the EDX. Although at the 3-month follow-up, both BSSS and BFSS in PRP injection treatment were found to be significantly better than CS injection; however, at the 6-month follow-up, no significant difference between the groups was observed[28].

In the study of Atwa et al., PRP and CS injections were compared in the treatment of 36 mild and moderate CTS patients. The patients were followed with VAS, BCTQ and EDX at the 1st and 3rd months after treatment. There was a significant improvement in all parameters in both groups. While PRP treatment was found to be superior to steroid treatment in BCTQ and VAS, no difference was found between the groups in EDX[29]. Atwa et al. found that post-treatment EDX outcomes were more prominent, and CMAP amplitude improved following both treatments, in contrast to this study.

In the studies of Uzun et al. and Atwa et al., injections were performed without US guidance. In both studies, PRP was found to be superior in VAS and BCTQ; however, there was no difference in EDX. Unlike the other two studies, this study demonstrated that CS and PRP treatments were not superior.

Senna et al. conducted a study on 98 patients with mild and moderate CTS, comparing US-guided PRP injections with CS injection treatment. Patients were evaluated with VAS, BCTQ, EDX, and CSA measurements at the first and third follow-up months. Significant improvements were observed in both

treatment groups on the VAS and BCTQ. While there was no difference between the two groups in the one-month evaluation, the three-month evaluation showed that PRP treatment was superior to CS treatment. In the EDX, both treatment groups showed a response to treatment in terms of SNCV. PRP treatment was found to be more effective than CS treatment at the 3-month follow-up, but not at the 1-month. In terms of DML, SNAP amplitude and CMAP amplitude, both groups showed significant improvement due to treatment; however, there was no difference between the two treatment approaches. Although both groups had a significant improvement in treatment in CSA measurement, they were not superior to each other[30]. Senna et al.'s study had a shorter follow-up period and demonstrated more pronounced electrophysiological responses to treatments compared to this study. Senna et al.'s study showed an improvement, despite the fact that the CMAP amplitude remained unchanged in this study.

Uzun et al. used triamcinolone in their study, but Atwa et al. and Senna et al. used methylprednisolone. In this study, triamcinolone was also used. Furthermore, each study uses a different protocol for PRP preparation. Treatment response may vary depending on the type of CS used and the PRP preparation technique.

To our knowledge, there is no study in the literature comparing the three treatments. The strongest aspect of this study is that it is a randomized, controlled prospective study comparing three treatments. US-guided injections, CSA measurement, and EDX all play key roles in the study's importance. The limitations of this study include the short follow-up period for evaluating the long-term effects of treatment results and the small number of patients.

CONCLUSION

A 6-month follow-up revealed that, in terms of both clinical evaluation and EDX, surgical treatment was superior to both CS and PRP injection treatments. Larger patient populations and longer follow-up periods are required in future investigations.

Funding Declaration: The authors declare that no funds, grants, or other support were received during the preparation of this manuscript. The authors have no relevant financial or non-financial interests to disclose.

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