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The Effectiveness of Exercise Therapy and Dry Needling on Wrist Range of Motion, Pinch and Grip Force in Carpal Tunnel Syndrome: A Randomized Clinical Trial

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Abstract

Background: Carpal tunnel syndrome (CTS) is the most prevalent form of peripheral neuropathy. There are various treatments for carpal tunnel.
Objectives: In this study, we evaluated the effect of electroacupuncture and exercise on pinch and grip strength and wrist range of motion in patients with mild to moderate CTS.
Methods: Sixty patients with carpal tunnel syndrome were evaluated in this study, only five of whom were male. In this study, patients were divided into three groups. The control group consisted of 20 patients who only used splints in the second group, in addition to splints, special exercises were administered, and the third group, electroacupuncture, and brace were prescribed for 12 sessions of 40- minute duration. study time was 6 weeks. The parameters of pinch force, grip force, ROM (flexion and extension) were evaluated at baseline and after the treatment.
Results: In this study, 55 women and 5 men with an average age of 49.23 ± 8.96 were enrolled. At the final follow up, significant improvements in all parameters were found in third groups ($P < 0.05$), except flexion of the wrist in the control group ($P = 0.098$). Our findings indicate that exercise therapy had more effect on ROM of flexion than acupuncture and acupuncture had more effect on pinching than exercise therapy but the effect sizes were weak. Also, the efficacy of splint alone was less than intervention groups in all parameters.
Conclusions: Results of this study demonstrated that adding exercise or acupuncture to nocturnal splinting, the functional improvement is more in patients with mild to moderate carpal tunnel syndrome and these interventions could be adopted in the management of these patients.

Keywords: Carpal Tunnel Syndrome, Splint, Exercise, Acupuncture

1. Background

Carpal tunnel syndrome (CTS) is the most common peripheral nerve entrapment and also the most common pressure neuropathy in upper limbs (1, 2). CTS found in 3.8% of the general population and it can affect people of any age (3), although it mostly influences the 40 - 60 years old (2). Clinical characteristics of CTS include numbness, pain or paresthesia in distal parts of the median nerve (thumb, pointing finger, middle finger and radial part of the ring finger) and a decrease of gripping power and hand function. These symptoms often get worse at night, and during the day, activities that require hand bending are difficult to handle (3, 4).

Different treatment methods for CTS exist. they are divided into two groups: conservative treatment and surgery (5). Conservative treatments are usually used for patients with mild to moderate CTS (6), These treatments include the following: oral steroids, injection of corticosteroids, vitamins B6 and B12, nonsteroidal anti-inflammatory drugs (NSAIDs), ultrasound, yoga, carpal bone mobilization and using hand splint (5). Although the effectiveness of using corticosteroids CTS brace has been shown in recent studies, the effects of these treatments are short-term (7). Every treatment has some complications. For example, renal, gastric and liver side effects in using NSAIDS or steroidal drugs, Also tendon tear, and the probability of damage to the median nerve after injection of corticosteroids in the

wrist (8, 9).

The effects of treatments such as massage, exercise, and acupuncture have varied in different studies (3, 10, 11). Although acupuncture is used to treat mild to moderate carpal tunnel syndrome, there are various opinions regarding this treatment (12). The studies over a couple of decades have been conducted using acupuncture and electroacupuncture after a peripheral nerve injury can promote nerve repair and blood supply (13-16). Yang et al determine the effectiveness of acupuncture and oral steroids on CTS. Their results show that "acupuncture treatment can be considered as an alternative therapy for those who do not opt for early surgical decompression" (17). Using full-time splints is effective but there is a limitation in patients' daily activities which causes the ones to complain (13, 18). Vincent et al. (2016)'s study on 181 CTS patients with chronic mild to moderate symptoms shows that combining electroacupuncture with nocturnal splints treatments provide small improvements in symptoms (19). Chung et al. (19) studies showed that the use of acupuncture with splinting or splint alone significantly improves wrist skills and pinching force of mild to moderate CTS patients without the need to surgery, but the effectiveness of electroacupuncture with night splinting is more than splinting alone. Zavela (20) also reported the effectiveness of acupuncture in recovering normal gripping power in CTS patients.

On the other hand, Heebner and Roddey (21) in a study evaluated the effect of adding nerve mobilization exercises (nerve gliding) to standard care (splint and tendon gliding) in patients with carpal tunnel syndrome. Evaluating the results of a range of motion extension of elbow and wrist in an upper limb median nerve tension test in the first and sixth months after treatment showed no significant difference in results between two groups of standard care and nerve mobilization. Akalin et al. (22) study on 28 CTS patients indicates that the nerve and tendon gliding exercise have a better effect but it was not statistically significant and they suggest further research on the topic. Pinar et al. (23) compared the nerve gliding exercise combined with conservative therapy with a splint on 26 women with CTS. They found that nerve gliding exercise can improve functional, especially in grip strength, and more pain reduction. In many guidelines, wrist splinting is recommended as the primary treatment option for CTS patients despite no promise in its effectiveness (24-26).

Our study differs from previous studies in that instead of comparing acupuncture, exercise therapy, and splint treatments. We chose this trail because there is no specific recommendation about the use of acupuncture and the effectiveness of exercise therapy (19, 27, 28). There is limited evidence regarding the efficacy of acupuncture and exercise therapy and previous studies of CTS have not dealt with a Comparison of acupuncture and exercise therapy effectiveness on ones (29-33).

2. Objectives

The specific controversy drives the research in which to compare and determine the effectiveness of between the conservative treatments, acupuncture and exercise therapy. Because of the low cost and non-invasive nature of acupuncture and exercise therapy and relative acceptance of these treatments in the society and presence of limited studies about their effectiveness in CTS patients, so the aim of current study was comparing the short-term effects (6 weeks) of acupuncture and nerve and tendon gliding exercises on patients' function including gripping, pinching, and range of motion of the wrist of mild to moderate CTS patients.

3. Methods

The current study is a randomized controlled clinical trial performed on patients with Carpal tunnel syndrome, referring to the Sports and Exercise Medicine Clinic of Imam Hossein Hospital in Tehran in 2017. Of the 237 patients evaluated, only 60 patients had the required conditions for entry into the study (Figure 1). Also, Table 1 shows the inclusion and exclusion criteria.

After giving explanations and obtaining informed consent, Patients enrolled in the study. At first, all patients were under full clinical examination that has been explained in the Patients evaluation subsection. The form used in the study included demographic characteristics (gender, age, marital status, place of living, weight, and height), medical history (smoking history, underlying diseases, alcohol consumption, drugs used) and Clinical information (affected hand, pain severity, and duration of CTS).

3.1. Intervention

Block randomization is a commonly used method in clinical trial design to reduce bias (34). Random allocation software is suitable software to control different attributes of the random allocation sequence (35). People with carpal tunnel were randomly divided into three groups (20 patients with CTS in each group). In the control group, the patients received only night splint for 6 weeks. In the intervention group 1, splint and exercise therapy were applied two times a day for 6 weeks (Figure 2). In the intervention group 2, splint and electroacupuncture were performed (40 minutes per session, 2 times a week for 6 weeks) in two

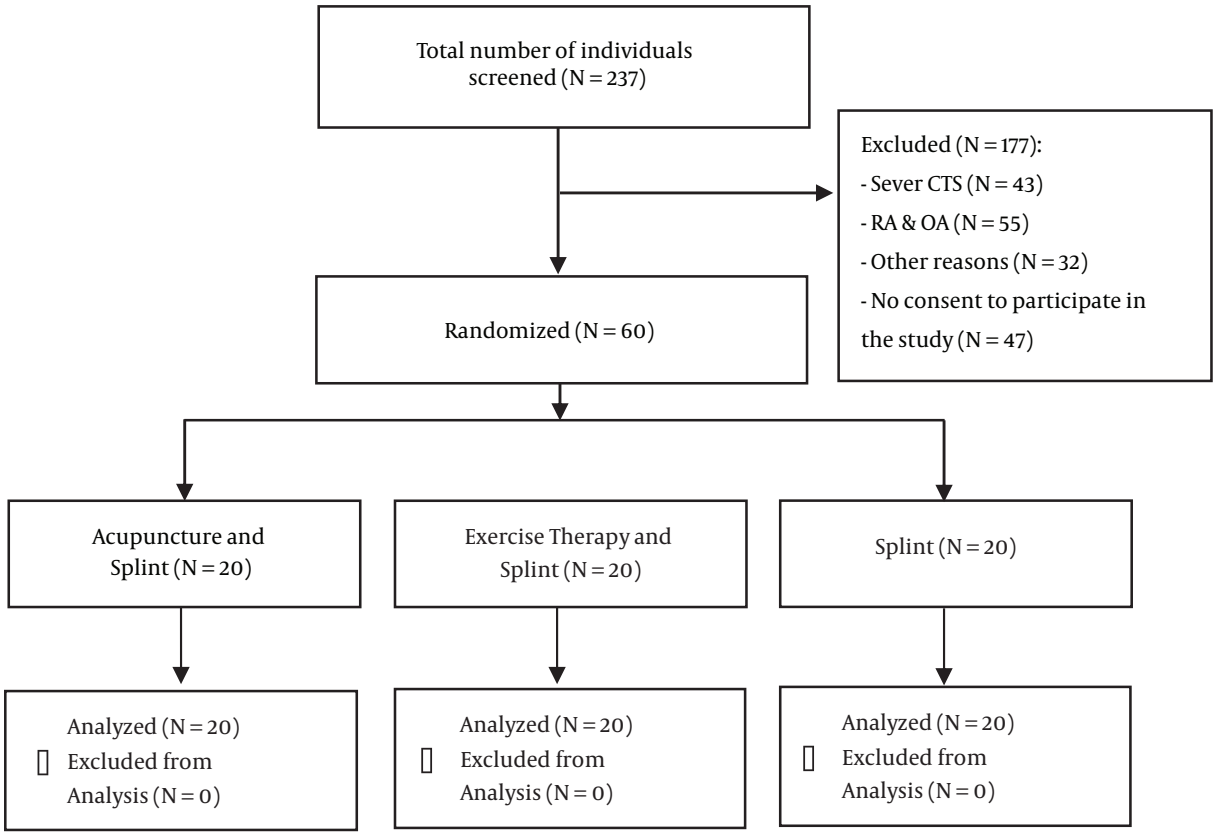

Figure 1. The study flowchart

Table 1. Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Mild to moderate CTS	Severe stage of the disease during the study
Absence of autoimmune or inflammatory diseases	Refusal to perform exercises
Using splint and any treatment for CTS	Diabetes mellitus
No symptoms of muscle atrophy or weakness	Using acetaminophen for more than 7 days because of severe pain, pregnancy
No previous taking steroidal drugs	No referring at the requested time for acupuncture,
The lack of severe limitation in upper extremities that inhibit the desired exercise from the patient (such as wrist fracture, deep scarring, burning, presence of cyst or tumors in the area of wrists, and history of wrist surgery)	Using NSAID or gabapentin or any other medication or any contraindication for needling such as local infection, bleeding tendency or a history of needling shock.

points of PC-7 (Daling) and PC-6 (Nei Guan). PC-7 was located on the flexor area of the forearm in the middle transverse crease between palmaris longus and flexor carpi radialis tendons and PC-6 is 5 cm proximal to PC-7 (Figure 3) (36). These acupoints were chosen because of their efficiency which had been reported in a previous study (37). To find acupoints, the patients were asked to press the little and thumb finger together for the better presentation of the tendons (palmaris longous and Flexor carpi radialis).

The physician used the thin sterile needle (0.25 × 25 mm size gauge) with the frequency of 60 - 100 Hz and the intensity of the flow went up to the threshold of pain tolerance. Then, the physician vertically inserted needles into specific points in the depth of 2 to 5 mm. Acetaminophen was used in all three groups if needed.

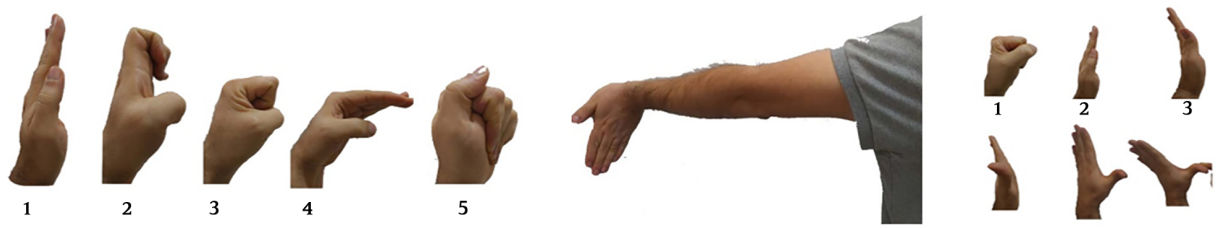

Figure 2. Tendon gliding (left) and median nerve gliding exercise (right) and stretching exercise (middle). The patients were asked to do each position for 5 seconds, and repeat each position 10 times for at least two times a day

Figure 3. Acupuncture points

3.2. Patient Evaluation

The neurologist takes the history and physical examination for the diagnosis of patients and disease severity. Also, EMG/NCV was used. To evaluate the response to treatment quality of life (symptoms and functional status), Carpal tunnel questionnaires was used, which is recommended by the American Academy of Orthopedic Surgeons (38, 39). Also, the visual analog scale (VAS) used for pain intensity evaluated from zero (complete analgesia) to 10 (the most experienced patient's pain). Afterward, The Boston Carpet tunnel questionnaire (BCTQ) used to evaluate the patients' performance and the severity of symptoms. BCTQ consists of 8 questions about functional status (BCTQ FUNCT) and 11 questions about the severity of the symptoms (BCTQ SYMPT). The items of each part were scored from 1 to 5. 1 was mildest and a scale of 5 was most severe. The reliability and sensitivity of the Persian version used in the current study were confirmed in a previous study (40).

The Physical examination used in the current study was made based on at least one of the following clinical criteria: Tinel sign test, Phalen maneuver test, numbness or tingling in fingers and median nerve compression (41). Patients diagnosed with CTS were confirmed by the presence of at least one of EMG/NCV criteria which were included: DML $\geq$ 4.2 ms, DSL $\geq$ 3.6 ms, and W-P SNCV $<$ 40 ms (42).

The maximum grip force (in kg) was measured by using Jamar hand hydraulic dynamometer. Moreover, a pinch dynamometer was used to evaluate the pinch force. All the measurements were performed when the patient was in a sitting position, shoulder in adduction and neutral rotation, elbow in 90° flexion, forearm in a neutral position, wrist in 0° to 30° dorsiflexion and 0° to 15° ulnar flexion. The patients were asked to maintain maximum grip strength. Measurements were repeated three times and their mean was calculated. During measurement, Jamar dynamometer was kept from the top and the bottom to prevent from affecting device weight to the measurement. All the measurements were evaluated by the same device both before and after the treatment (43). To evaluate the range of motion (ROM) the active wrist flexion and extension were measured by using a goniometer (Plastic goniometer MSD). All the measurements were performed in a sitting position with shoulder abducted to 90°, the elbow flexed to 90°, and the palm facing the ground. The forearm was midway between supination and pronation. The examiner was a caution to avoid radial or ulnar deviation of the wrist and flexion of the fingers. The examiner put the center fulcrum of goniometer on the lateral aspect of the wrist over the triquetrum and aligned proximal and distal arm with the lateral midline of the ulna and fifth metacarpal respectively. Then the examiner asked the patients to flex the wrist. The examiner used one hand to align the distal arm of the goniometer with the 5th metacarpal at the end of the flexion while the patients

maintaining the wrist in that position and the ROM degrees was recorded. To measure active wrist extension, the examiner performed all processes like active wrist flexion except in extension movements (44). At this stage, none of the patients were excluded from the study.

To reduce the bias, a researcher who did not know about grouping the patients carried out the entrance and evaluation of information after the end of treatment (triple-blind, randomized clinical trial). However, to prevent the inadvertent pre- and post-intervention events, the sports and exercise medicine specialist and student were aware of the groups and procedures.

3.3. Statistical Analysis

The normality of variables was assessed with the Kolmogorov Smirnov test. The descriptive statistics (frequency, mean, standard deviation, and frequency percentage) and inferential statistics (paired sample *t*-test, chi-square, and analysis of variance ANOVA) were used to analyze the obtained data. A P value < 0.05 was considered statistically significant. SPSS software (version 22) was used for statistical analysis.

3.4. Ethics Approval

The protocol of this study was approved by the Ethics and Research Committee of Shahid Beheshti University of Medical Sciences (IR.SBMU.MSP.REC.1395.152) and was registered in IRCT under the code IRCT20180212038693N1.

4. Results

Fifty-five females and 5 males with the mean age of 49.23 $\pm$ 8.96 participated. The youngest was twenty-two and the oldest was seventy years old. Demographic and clinical information of the control group (N = 20) are as follows:

Gender: female: 19 (95%) and male: 1 (5%), age (year): 47.4 $\pm$ 8.96 $\pm$ SD, height (cm): 163.5 $\pm$ 7.8 $\pm$ SD, weight (kg): 77.9 $\pm$ 9.4 $\pm$ SD hand with CTS problem: right: 12 (60%), left: 8 (40%), job: employed: 12 (60%) and housewife: 8 (40%), the severity of the problem: mild: 13 (65%) and moderate: 7 (35%), systemic problems : 6 (30%) patient

Demographic and clinical information of the exercise therapy + Brace (N = 20) group are as follows:

Gender: female: 19 (95%) and male: 1 (5%), age (year): 49.55 $\pm$ 8.41 $\pm$ SD, height (cm): 160.2 $\pm$ 5.8 $\pm$ SD, weight (kg): 78.78 $\pm$ 10.8 $\pm$ SD hand with CTS problem: right: 8 (40%), left: 12 (60%), job: employed: 15 (75%) and housewife: 5 (25%), the severity of the problem: mild: 12 (60%) and moderate: 8 (40%), systemic problems : 5 (25%) patient

Demographic and clinical information of the acupuncture + Brace (N = 20) group are as follows:

Gender: female: 18 (90%) and male: 2 (10%), age (year): 50.75 $\pm$ 9.59 $\pm$ SD, height (cm): 159.35 $\pm$ 5.3 $\pm$ SD, weight (kg): 77.5 $\pm$ 12.85 $\pm$ SD hand with CTS problem: right: 9 (45%), left: 11 (55%), job: employed: 18 (90%) and housewife: 2 (10%), the severity of the problem: mild: 13 (65%) and moderate: 7 (35%), systemic problems : 7 (35%)patient

There was no statistically significant difference between gender, age, height, weight, the presence of systemic disease, job, involved hand, and disease severity in three treatment groups ($P > 0.05$)

The current study showed the grip force, pinch force and range of motion (flexion and extension) of the wrist were significantly improved in CTS patients at the end of 6 weeks in all three groups ($P < 0.05$). Although using brace alone (control group) did not have any significant effect on the wrist flexion and extension (P = 0.098 and 0.093) (Table 2).

The between-groups analysis indicates that acupuncture affected the pinch force more than exercise therapy and it was statistically significant F (df = 2) = 0.035, P = 0.001 but weak (P Eta squared = 0.001). Also, the efficacy of exercise therapy was more than acupuncture in parameters of grip force and ROM (both flexion and extension) but just ROM of flexion was statistically significant F (df = 2) = 0.000, P = 0.001 but weak (P Eta squared = 0.012).

5. Discussion

The purpose of this study was comparing the short-term effects (6 weeks) of acupuncture and nerve and tendon gliding exercises on patients' function, including gripping, pinching, and range of motion of the wrist in patients with mild to moderate CTS.

There was no statistically significant difference between Demographic information in three treatment groups. Also, there was no significant difference between variables of pinch and grip force, wrist flexion and extension in the three groups before treatment which shows the randomization of samples and the absence of bias in sample selection.

Based on this study's findings, in all three groups gripping and pinching force of the wrist after treatment were increased significantly. But exercises had an effect on ROM of flexion and acupuncture had an effect on pinching but the effect sizes were weak. Also splint alone had the least effect on gripping and pinching of CTS patients.

The results of the current study indicate that the effectiveness of electroacupuncture with night splinting is more than splinting alone. Also, it can improve gripping power in CTS patients and increase handgrip strength.

Table 2. Mean Scores of Grip and Pinch Force and Range of Motion (Flexion and Extension) in CTS Patients

Variable	Baseline (Mean ± SD)	After Treatment (Mean ± SD)	Difference	P Value	Effect Size
Grip force, kg					
Control	16.9 ± 5	17.95 ± 5.1	1.05 ± 1.43	0.054	0.103
Brace + Exercise therapy	18.78 ± 5.7	22.95 ± 5.1	4.15 ± 4.1	< 0.001	0.359
Brace + acupuncture	18.8 ± 4.32	21.15 ± 4.78	2.35 ± 4.33	0.025	0.249
Pinch force, kg					
Control	6.03 ± 1.4	6.67 ± 1.7	0.65 ± 0.52	0.082	0.201
Brace + Exercise therapy	5.26 ± 1.23	6.58 ± 1.4	1.05 ± 1	< 0.001	0.447
Brace + acupuncture	5.45 ± 0.66	6.57 ± 0.92	1.12 ± 1.08	< 0.001	0.573
Flexion, cm					
Control	83.28 ± 3.8	83.62 ± 3.89	0.34 ± 0.89	0.098	0.044
Brace + Exercise therapy	77.57 ± 6.15	83.17 ± 3.42	5.6 ± 4.21	< 0.001	0.490
Brace + acupuncture	82.47 ± 4.31	84.13 ± 3.39	1.67 ± 2.01	0.002	0.209
Extension, cm					
Control	66.2 ± 5.39	67.37 ± 4.77	1.16 ± 1.28	0.093	0.114
Brace + Exercise therapy	64.77 ± 3.69	71.32 ± 2.9	6.55 ± 2.97	< 0.001	0.702
Brace + acupuncture	68.36 ± 3.14	69.75 ± 3.84	1.39 ± 2.34	0.015	0.194

Abbreviation: SD, standard deviation

These results are consistent with the results of other studies (19, 20, 45-47). On the other hand, Yao et al. (48) in a randomized controlled study investigated the effectiveness of 6 sessions of acupuncture compared to placebo acupuncture for treating patients with CTS. Night splinting was also used in both groups. After 6 weeks both treatment and placebo groups had significant improvement in pinching power in comparison with the baseline, but there was no significant difference between the groups so it was reported that acupuncture with bracing has no significant effect on the treatment of mild to moderate CTS. These results are not consistent with the finding of the current study. Although all three groups showed significant improvement in pinching force in the current study but the improvement in the acupuncture group was higher than the control group. This difference could be related to the diversity in intervention methods, some acupuncture sessions and the primary characteristics of patients. In Hessami et al. study showed that the use of splint alone in mild CTS is a suitable and adequate treatment; however, in moderate CTS, taking gabapentin along with splinting and exercise indicated better treatment results compared to splinting alone (49). The current study found that nerve and tendon gliding exercises can improve grip and pinch strength which is consistent with Pinar et al. results (23). Moreover, in Alkalin et al. (22) study the effectiveness of nerve and tendon gliding exercises along with splinting was compared with splinting alone. Results showed an improvement in pinching force in both groups after treatment but the improvement in the mobilization group was higher than splint alone. These results are consistent with the results of the current study. In another study by Madenci et al. (43) was also reported that tendon and nerve gliding exercises with night splint significantly improved the gripping force in CTS patients. Results of Fernandez-de-Las-Penas et al. study (50) in Spain also showed that exercise therapy is effective in improving pinching and gripping power in CTS patients.

The results of the current study showed significant improvement in the wrist range of motion in both acupuncture and exercise therapy groups but using splint alone did not affect the improvement of them. On the other hand, exercise therapy had the most effect on increasing the range of motion. To confirm these results, Chung et al. (19) also showed that wrist functional performance in patients with mild to moderate CTS in the acupuncture + splint group was better than the control group (splinting alone). In another study, Tal-Akabi and Rushton (51) compared the effectiveness of two treatment methods of carpal bone mobilization and neurodynamic mobilization with the control group in CTS patients. Results showed that the wrist range of motion (flexion and extension) in both treatment groups were better than the control group but the difference was not statistically significant because

of the small sample size. CTS is caused by the loss of the physiological movements of the median nerve. Excursion of the wrist flexor tendons required for full finger flexion changed from 23 to 31 mm also Median nerve displacement changed from 9 to 14 mm (52) during wrist extension to flexion, the median nerve at wrist glides 19.6 mm approximately (53). Hence, the nerve and tendon gliding exercises could help to an increased relative excursion of the median nerve in the CT which leads to improvement in the grip and pinch strength (54).

Lastly, it should be noted that the current study was done in comparing the effectiveness of two methods of exercise therapy and acupuncture in treating mild to moderate CTS and achieved valuable information on the effectiveness of exercise therapy and acupuncture in treating these patients which were in line with the results of other similar studies. We have also published the effect of the above methods on the variables of pain, clinical symptoms, and function in another article (55).

Limitations of the present study include the relatively small sample size and the lack of mid-term and long-term monitoring of patients, a limited number of therapeutic sessions in the acupuncture group and if treatment sessions are added, better treatment outcomes might be achieved.

5.1. Conclusions

This study showed the grip force, pinch force and range of motion (flexion and extension) of the wrist were significantly improved in CTS patients at the end of 6 weeks in all three groups. Although using brace alone (control group) did not have any significant effect on the wrist flexion and extension. Probably because of the limited case data. Since there has been no study comparing the effectiveness of acupuncture with exercises in the treatment of CTS, it is not possible to compare the findings of this study with the results of other studies. Therefore, our results need to be confirmed in future studies with a larger sample and long-term monitoring.

Footnotes

Authors' Contribution: Study concept and design: Shahin Salehi and Omid Hesami. Critical revision of the manuscript for important intellectual content: Mohammad Hassabi. Administrative, technical, and material support: Mehrshad Poursaeed Esfehani and Amir Hosein Abedi Yekta. Drafting of the manuscript: Amir Rashed and Mahsa Haghighatzadeh. Study supervision: Shahrzad Khosravi.

Conflict of Interests: Authors mention that there is no conflict of interest in this study

Ethical Approval: The protocol of this study was approved by the Ethics and Research Committee of Shahid Beheshti University of Medical Sciences (IR.SBMU.MSP.REC.1395.152) and was registered in IRCT under the code IRCT20180212038693N1.

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References

1. Ibrahim I, Khan WS, Goddard N, Smitham P. Carpal tunnel syndrome: a review of the recent literature. *Open Orthop J*. 2012;**6**:69–76. doi: 10.2174/1874325001206010069. [PubMed: 22470412]. [PubMed Central: PMC3314870].
2. de Krom MC, de Krom CJ, Spaans F. [Carpal tunnel syndrome: Diagnosis, treatment, prevention and its relevance to dentistry]. *Ned Tijdschr Tandheelkd*. 2009;**116**(2):97–101. Dutch. [PubMed: 19280893].
3. Khosrawi S, Moghtaderi A, Haghighat S. Acupuncture in treatment of carpal tunnel syndrome: A randomized controlled trial study. *J Res Med Sci*. 2012;**17**(1):1–7. [PubMed: 23248650]. [PubMed Central: PMC3523426].
4. Jafari D, Najd Mazhar F, Shariatzadeh H, Shahverdi S, Moghimi Z, Mokhtari T. Inflammation and fibrosis of transverse carpal ligament and flexor tenosynovium in severe idiopathic carpal tunnel syndrome. *Shafa Orthop J*. 2014;**1**(3).
5. Afshin Majd S, Poorfarzam S, Mehdi Barzi D, Moghadamnia M. Comparison of surgical treatment with splinting in treating carpal tunnel syndrome. *Iran J Orthop Surg*. 2013;**11**(1):26–31.
6. Prime MS, Palmer J, Khan WS, Goddard NJ. Is there light at the end of the tunnel? Controversies in the diagnosis and management of carpal tunnel syndrome. *Hand (N Y)*. 2010;**5**(4):354–60. doi: 10.1007/s11552-010-9263-y. [PubMed: 22131913]. [PubMed Central: PMC2988120].
7. Ono S, Clapham PJ, Chung KC. Optimal management of carpal tunnel syndrome. *Int J Gen Med*. 2010;**3**:255–61. doi: 10.2147/ijgm.s7682. [PubMed: 20830201]. [PubMed Central: PMC2934608].
8. Moghaddasi A, Abbasi Dareh Bidi MSR. The effect of 8-week rehabilitation program on pain reduction with carpal tunnel syndrome. *MEJDS*. 2013;**3**(2):43–53.
9. Pomerance J, Zurakowski D, Fine I. The cost-effectiveness of nonsurgical versus surgical treatment for carpal tunnel syndrome. *J Hand Surg Am*. 2009;**34**(7):1193–200. doi: 10.1016/j.jhsa.2009.04.034. [PubMed: 19700068].
10. Tsao JC. Effectiveness of massage therapy for chronic, non-malignant pain: A review. *Evid Based Complement Alternat Med*. 2007;**4**(2):165–79. doi: 10.1093/ecam/nel109. [PubMed: 17549233]. [PubMed Central: PMC1876616].
11. Salehi S, Bohlouli M, Moradi Shahpar F, Poursaeid Esfahani M, Abdollahzadeh Lahiji F, Aslani H. P-50 The impact of stretching and massage therapy on pain and function of females suffering carpal tunnel syndrome. *Br J Sports Med*. 2016;**50**(Suppl 1):A59.2–A59. doi: 10.1136/bjsports-2016-097120.103.
12. Ernst E. Acupuncture: what does the most reliable evidence tell us? *J Pain Symptom Manage*. 2009;**37**(4):709–14. doi: 10.1016/j.jpainsymman.2008.04.009. [PubMed: 18789644].
13. Dong Z, Sun Y, Lu P, Wang Y, Wu G. Electroacupuncture and lumbar transplant of GDNF-secreting fibroblasts synergistically attenuate hyperalgesia after sciatic nerve constriction. *Am J Chin Med*. 2013;**41**(3):459–72. doi: 10.1142/S0192415X1350033X. [PubMed: 23711135].
14. Hsieh CL, Kuo CC, Chen YS, Li TC, Hsieh CT, Lao CJ, et al. Analgesic effect of electric stimulation of peripheral nerves with different electric frequencies using the formalin test. *Am J Chin Med*. 2000;**28**(2):291–9. doi: 10.1142/S0192415X00000349. [PubMed: 10999448].

15. Lu MC, Ho CY, Hsu SF, Lee HC, Lin JH, Yao CH, et al. Effects of electrical stimulation at different frequencies on regeneration of transected peripheral nerve. *Neurorehabil Neural Repair*. 2008;**22**(4):367–73. doi: 10.1177/1545968307313507. [PubMed: 18663248].
16. Ma T, Kao MJ, Lin IH, Chiu YL, Chien C, Ho TJ, et al. A study on the clinical effects of physical therapy and acupuncture to treat spontaneous frozen shoulder. *Am J Chin Med*. 2006;**34**(5):759–75. doi: 10.1142/S0192415X06004272. [PubMed: 17080543].
17. Yang CP, Wang NH, Li TC, Hsieh CL, Chang HH, Hwang KL, et al. A randomized clinical trial of acupuncture versus oral steroids for carpal tunnel syndrome: A long-term follow-up. *J Pain*. 2011;**12**(2):272–9. doi: 10.1016/j.jpain.2010.09.001. [PubMed: 21111685].
18. Piazzini DB, Aprile I, Ferrara PE, Bertolini C, Tonali P, Maggi L, et al. A systematic review of conservative treatment of carpal tunnel syndrome. *Clin Rehabil*. 2007;**21**(4):299–314. doi: 10.1177/0269215507077294. [PubMed: 17613571].
19. Chung VCH, Ho RST, Liu S, Chong MKC, Leung AWN, Yip BHK, et al. Electroacupuncture and splinting versus splinting alone to treat carpal tunnel syndrome: A randomized controlled trial. *CMAJ*. 2016;**188**(12):867–75. doi: 10.1503/cmaj.151003. [PubMed: 27270119]. [PubMed Central: PMC5008933].
20. Zavela NG. Acupuncture treatment for carpal tunnel syndrome. *Med Acupuncture*. 2010;**22**(4):273–6. doi: 10.1089/acu.2010.0752.
21. Heebner ML, Roddey TS. The effects of neural mobilization in addition to standard care in persons with carpal tunnel syndrome from a community hospital. *J Hand Ther*. 2008;**21**(3):229–40. quiz 241. doi: 10.1197/j.jht.2007.12.001. [PubMed: 18652967].
22. Akalin E, El O, Peker O, Senocak O, Tamci S, Gulbahar S, et al. Treatment of carpal tunnel syndrome with nerve and tendon gliding exercises. *Am J Phys Med Rehabil*. 2002;**81**(2):108–13. doi: 10.1097/00002060-200202000-00006. [PubMed: 11807347].
23. Pinar L, Enhos A, Ada S, Gungor N. Can we use nerve gliding exercises in women with carpal tunnel syndrome? *Adv Ther*. 2005;**22**(5):467–75. doi: 10.1007/bf02849867. [PubMed: 16418156].
24. American Academy of Orthopaedic Surgeons. *Management of carpal tunnel syndrome evidence-based clinical practice guideline*. Rosemont, IL: American Academy of Orthopaedic Surgeons; 2016.
25. Lee S, Glass M, Harris JS, Bernard R, Blais M, Genovese E. *Occupational medicine practice guidelines: Evaluation and management of common health problems and functional recovery in workers*. American College of Occupational and Environmental Medicine; 2008.
26. National Institute for Health and Care Excellence. *Carpal tunnel syndrome*. UK, London: National Institute for Health and Care Excellence; 2012.
27. Kim SD. Efficacy of tendon and nerve gliding exercises for carpal tunnel syndrome: A systematic review of randomized controlled trials. *J Phys Ther Sci*. 2015;**27**(8):2645–8. doi: 10.1589/jpts.27.2645. [PubMed: 26357452]. [PubMed Central: PMC4563334].
28. Emami Razavi SZ, Azadvari M, Kargozar E, Kazemi S. Treatment of carpal tunnel syndrome by acupuncture. *Case Rep Clin Prac*. 2016;**1**(3):74–7.
29. Carlson H, Colbert A, Frydl J, Arnall E, Elliot M, Carlson N. Current options for nonsurgical management of carpal tunnel syndrome. *Int J Clin Rheumtol*. 2010;**5**(1):129–42. doi: 10.2217/IJR.09.63. [PubMed: 20490348]. [PubMed Central: PMC2871765].
30. Cox J, Varatharajan S, Cote P, Optima C. Effectiveness of acupuncture therapies to manage musculoskeletal disorders of the extremities: A systematic review. *J Orthop Sports Phys Ther*. 2016;**46**(6):409–29. doi: 10.2519/jospt.2016.6270. [PubMed: 27117725].
31. Ren YM, Wang XS, Wei ZJ, Fan BY, Lin W, Zhou XH, et al. Efficacy, safety, and cost of surgical versus nonsurgical treatment for carpal tunnel syndrome: A systematic review and meta-analysis. *Medicine (Baltimore)*. 2016;**95**(40). e4857. doi: 10.1097/MD.0000000000004857. [PubMed: 27749538]. [PubMed Central: PMC5059040].
32. Shi Q, Bobos P, Lalone EA, Warren L, MacDermid JC. Comparison of the short-term and long-term effects of surgery and nonsurgical intervention in treating carpal tunnel syndrome: A systematic review and meta-analysis. *Hand (N Y)*. 2018:1.5589447187879E+15. doi: 10.1177/1558944718787892. [PubMed: 30015499].
33. Sim H, Shin BC, Lee MS, Jung A, Lee H, Ernst E. Acupuncture for carpal tunnel syndrome: A systematic review of randomized controlled trials. *J Pain*. 2011;**12**(3):307–14. doi: 10.1016/j.jpain.2010.08.006. [PubMed: 21093382].
34. Efird J. Blocked randomization with randomly selected block sizes. *Int J Environ Res Public Health*. 2011;**8**(1):15–20. doi: 10.3390/ijerph8010015. [PubMed: 21318011]. [PubMed Central: PMC3037057].
35. Saghaei M. Random allocation software for parallel group randomized trials. *BMC Med Res Methodol*. 2004;**4**:26. doi: 10.1186/1471-2288-4-26. [PubMed: 15535880]. [PubMed Central: PMC533876].
36. Deadman P, Baker K, Khafaji M, Al Farsi M. A manual of acupuncture. *J Chinese Med Pub*. 2001:376–80.
37. Ho CY, Lin HC, Lee YC, Chou LW, Kuo TW, Chang HW, et al. Clinical effectiveness of acupuncture for carpal tunnel syndrome. *Am J Chin Med*. 2014;**42**(2):303–14. doi: 10.1142/S0192415X14500207. [PubMed: 24707864].
38. Keith MW, Masear V, Amadio PC, Andary M, Barth RW, Graham B, et al. Treatment of carpal tunnel syndrome. *J Am Acad Orthop Surg*. 2009;**17**(6):397–405. doi: 10.5435/00124635-200906000-00008. [PubMed: 19474449].
39. Levine DW, Simmons BP, Koris MJ, Daltroy LH, Hohl GG, Fossel AH, et al. A self-administered questionnaire for the assessment of severity of symptoms and functional status in carpal tunnel syndrome. *J Bone Joint Surg Am*. 1993;**75**(11):1585–92. doi: 10.2106/00004623-199311000-00002. [PubMed: 8245050].
40. Hassankhani GG, Moradi A, Birjandinejad A, Vahedi E, Kachooei AR, Ebrahimzadeh MH. Translation and validation of the Persian version the Boston carpal tunnel syndrome questionnaire. *Arch Bone Jt Surg*. 2018;**6**(1):71–7. [PubMed: 29430499]. [PubMed Central: PMC5799604].
41. Tetro AM, Evanoff BA, Hollstien SB, Gelberman RH. A new provocative test for carpal tunnel syndrome. Assessment of wrist flexion and nerve compression. *J Bone Joint Surg Br*. 1998;**80**(3):493–8. doi: 10.1302/0301-620x.80b3.8208. [PubMed: 9619944].
42. Keith MW, Masear V, Chung K, Maupin K, Andary M, Amadio PC, et al. Diagnosis of carpal tunnel syndrome. *J Am Acad Orthop Surg*. 2009;**17**(6):389–96. doi: 10.5435/00124635-200906000-00007. [PubMed: 19474448]. [PubMed Central: PMC5175465].
43. Madenci E, Altindag O, Koca I, Yilmaz M, Gur A. Reliability and efficacy of the new massage technique on the treatment in the patients with carpal tunnel syndrome. *Rheumatol Int*. 2012;**32**(10):3171–9. doi: 10.1007/s00296-011-2149-7. [PubMed: 21953301]. [PubMed Central: PMC3456919].
44. Norkin CC, White DJ. *Measurement of joint motion: A guide to goniometry*. FA Davis; 2016.
45. Hoang NS, Sar C, Valmier J, Sieso V, Scamps F. Electro-acupuncture on functional peripheral nerve regeneration in mice: A behavioural study. *BMC Complement Altern Med*. 2012;**12**:141. doi: 10.1186/1472-6882-12-141. [PubMed: 22937957]. [PubMed Central: PMC3479081].
46. Kang HS, Sok SR, Kang JS. Effects of Meridian acupressure for stroke patients in Korea. *J Clin Nurs*. 2009;**18**(15):2145–52. doi: 10.1111/j.1365-2702.2008.02522.x. [PubMed: 19583646].
47. Tsui P, Leung MC. Comparison of the effectiveness between manual acupuncture and electro-acupuncture on patients with tennis elbow. *Acupunct Electrother Res*. 2002;**27**(2):107–17. doi: 10.3727/036012902816026040. [PubMed: 12269719].
48. Yao E, Gerritz PK, Henricson E, Abresch T, Kim J, Han J, et al. Randomized controlled trial comparing acupuncture with placebo acupuncture for the treatment of carpal tunnel syndrome. *PM R*. 2012;**4**(5):367–73. doi: 10.1016/j.pmrj.2012.01.008. [PubMed: 22405683].
49. Hesami O, Haghighatzadeh M, Lima BS, Emadi N, Salehi S. The effectiveness of gabapentin and exercises in the treatment of carpal tunnel syndrome: A randomized clinical trial. *J Exerc Rehabil*.

2018;**14**(6):1067–73. doi: 10.12965/jer.1836420.210. [PubMed: 30656171]. [PubMed Central: PMC6323333].

50. Fernandez-de-Las-Penas C, Cleland J, Palacios-Cena M, Fuensalida-Novo S, Pareja JA, Alonso-Blanco C. The effectiveness of manual therapy versus surgery on self-reported function, cervical range of motion, and pinch grip force in carpal tunnel syndrome: A randomized clinical trial. *J Orthop Sports Phys Ther*. 2017;**47**(3):151–61. doi: 10.2519/jospt.2017.7090. [PubMed: 28158963].
51. Tal-Akabi A, Rushton A. An investigation to compare the effectiveness of carpal bone mobilisation and neurodynamic mobilisation as methods of treatment for carpal tunnel syndrome. *Man Ther*. 2000;**5**(4):214–22. doi: 10.1054/math.2000.0355. [PubMed: 11052900].
52. Szabo RM, Bay BK, Sharkey NA, Gaut C. Median nerve displacement through the carpal canal. *J Hand Surg*. 1994;**19**(6):901–6. doi: 10.1016/0363-5023(94)90087-6.
53. Wright TW, Glowczewskie F, Wheeler D, Miller G, Cowin D. Excursion and strain of the median nerve. *J Bone Joint Surg Am*. 1996;**78**(12):1897–903. doi: 10.2106/00004623-199612000-00013. [PubMed: 8986667].
54. Rozmaryn LM, Dovelle S, Rothman ER, Gorman K, Olvey KM, Bartko JJ. Nerve and tendon gliding exercises and the conservative management of carpal tunnel syndrome. *J Hand Ther*. 1998;**11**(3):171–9. doi: 10.1016/s0894-1130(98)80035-5. [PubMed: 9730093].
55. Salehi S, Hessami O, Rashed A, Hassabi M, PourSaeid Esfehani M, Abedi Yakta A, et al. The assessment of acupuncture and exercise therapy in patients with carpal tunnel syndrome: Randomized clinical trial. *Novel Biomed*. 2019;**7**(4):201–9.