Research Article

Effectiveness of an Early Occupational Therapy Intervention in Post-Surgery Carpal Tunnel Syndrome Patients

Aliasghar Jamebozorgi[1], Mahrokh Ghahari[2], Fatemeh Jameh Bozorgi[3], Mahnaz Hejazi-Shirmard[1*]

1. Department of Occupational Therapy, School of Rehabilitation, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
2. Department of Occupational Therapy, School of Rehabilitation Sciences, Iran University of Medical Sciences, Tehran, Iran.
3. Department of Occupational Therapy, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran.

*** Correspondence author:** Mahnaz Hejazi-Shirmard, Ph.D
Department of Occupational Therapy, School of Rehabilitation, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
Email: m.hejazishirmard@yahoo.com
Tel: +989124846811

ORCID ID:
Aliasghar Jamebozorgi: 0000-0002-4041-9207
Mahrokh Ghahari: 0000-0002-2501-6477
Fatemeh Jameh Bozorgi: 0009-0009-0023-1662
Mahnaz Hejazi-Shirmard: 0000-0002-9732-5498

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Running title: Early Occupational Therapy after Carpal Tunnel Release

Abstract

Background: Carpal tunnel syndrome (CTS) is the most prevalent peripheral neuropathy affecting the upper limb, and Carpal Tunnel Release (CTR) is the preferred treatment for moderate to severe cases. This semi-experimental study aimed to investigate the effectiveness of an early occupational therapy intervention for post-surgery patients with CTS.

Material and methods: Twenty women with idiopathic CTS who were surgery candidates were recruited and assessed before undergoing the surgery. After surgery, they were assigned to the intervention group (n=10) or control group (n=10). The control group received standard care, while the intervention group underwent an early occupational therapy intervention (10 sessions over 3 weeks). The range of motion, hand and pinch strength, and pain level were measured using a Goniometer, Hand Dynamometer, Pinch Gauge, and Visual Analogue Scale (VAS), respectively. The Boston Carpal Tunnel Questionnaire (BCTQ) evaluated symptom severity and hand function. To compare variables between groups, we used paired sample t-tests, independent t-tests, and Fisher's exact tests.
Results: The intervention led to significant improvements in wrist active flexion, two-point, and three-point pinch strength in the intervention group. Both groups had reduced pain intensity, with a significantly greater decrease in the intervention group. The intervention group also showed better results in symptom severity and functional status, with the improvement in symptom severity being significantly greater ($p \leq 0.05$).
Conclusions: Early occupational therapy following CTR is probably more effective than routine interventions in enhancing pinch strength and alleviating pain and symptoms. Nevertheless, randomized controlled trials are necessary to determine how long these benefits last.
Keywords: Carpal tunnel syndrome, Pinch Strength, Occupational therapy, Treatment outcome

Introduction

Carpal tunnel syndrome (CTS) is one of the most common entrapment neuropathies affecting the upper limb [1]. The prevalence of CTS varies across different countries and populations. Some studies estimate that up to 3% of the general population is affected, although other reports suggest higher figures [2]. Despite the unknown exact causative mechanism of CTS, it has been traditionally linked to increased pressure on the Median nerve as it travels from the forearm to the palm, passing underneath the transverse carpal ligament, which leads to mechanical compression and ischemic damage to the nerve [1, 3]. Symptoms of CTS include numbness, paresthesia, tingling, pain within the median nerve distribution (the thumb, index, and middle fingers), and loss of motor control, resulting in different levels of reduced function and disability [3]. Importantly, CTS has significant economic implications, particularly as it impacts active individuals and is frequently regarded as a work-related disorder [2]. Additionally, similar to other hand disorders, CTS significantly impairs daily living activities [1].

CTS management involves either conservative or surgical interventions [1, 4]. Surgery is typically recommended for individuals with persistent symptoms unresponsive to conservative treatments, those with more severe symptoms such as thenar muscle atrophy, or those with electrophysiologically severe disease [5]. Common surgical approaches include Open Carpal Tunnel Release (Open CTR) and Endoscopic Carpal Tunnel Release (Endoscopic CTR) [5]. During surgery, the transverse carpal ligament is divided to increase the carpal tunnel's volume and alleviate pressure on the median nerve. In Open CTR, the ligament is divided through a palmar incision, while Endoscopic CTR involves dividing the transverse carpal ligament without affecting the overlying structures [5].

CTR has a high success rate, potentially reaching up to 90% [5], but the remainder experience poor outcomes, and like any surgery, it comes with complications. Post-surgery complications for CTR may include nerve injury, neuroma formation, palmar arch injury, hematomas, Complex Regional Pain Syndrome (CRPS), tendon adhesions, bowstringing of the flexor tendons, and pain. Despite being the most common intervention, the effectiveness of surgery remains debated [6].

Consequently, rehabilitation professionals are investigating methods to enhance post-surgical outcomes, although only a few studies have assessed the effectiveness of these rehabilitation approaches. Key rehabilitation approaches include wrist immobilization with orthosis, scar desensitization, exercises, cold and ice therapy, multi-modal hand rehabilitation, laser therapy, and electrical modalities [5]. There is no agreed-upon standard for clinical practice interventions and rehabilitation protocols used by therapists post-CTR [7]. In their randomized controlled trial, Salehi et al. found that a comprehensive intervention incorporating exercise, splinting, and electroacupuncture is more effective for the functional recovery of patients with mild to moderate CTS compared to routine interventions (splinting alone) and exercise combined with splinting [8]. Unfortunately, despite with limited evidence supporting the effectiveness of post-surgery rehabilitation interventions, many patients either skip rehabilitation entirely or delay starting it [9], however, preliminary and limited evidence suggests that better outcomes, including improved grip strength, lower symptom severity and a facilitated return to work, may be associated with early rehabilitation and shorter immobilization periods [10-11].

As previously noted, the current research on the effectiveness of rehabilitation interventions, especially occupational therapy, for patients with CTS is both limited and of poor quality [5]. On the other hand, while research suggests that initiating rehabilitation interventions promptly after CTR can significantly enhance patient outcomes, these interventions are often delayed, starting two weeks post-surgery [7, 12]. It seems that by prioritizing early rehabilitation, we could enhance the full potential for recovery and improve the overall well-being of patients. Therefore, this study aimed to evaluate the effectiveness of a comprehensive early occupational therapy intervention in patients with post-surgery CTS.

Materials and Methods

Study Design

In this semi-experimental study, twenty women with CTS were recruited from those referred to Akhtar Hospital in Tehran for surgery. The inclusion criteria for participants were: diagnosis of CTS by a surgeon using EMG, NCV and clinical tests; age range of 24 to 64; no history of diabetes or thyroid disorders; no previous injuries or surgeries affecting the median nerve; and no other peripheral neuropathies in the upper limbs. Patients who underwent additional interventions during the study or missed more than one session were excluded. Participants were initially evaluated, and then all underwent surgery performed by a single surgeon using Open Carpal Tunnel Release (CTR). Post-surgery, participants were referred to occupational therapy and were divided into control and intervention groups based on their willingness to receive further interventions.

This study was approved by the Ethics Committee at the Shahid Beheshti University of Medical Sciences (IR.SBMU.RETECH.REC.1401.303), and written consent was obtained from all participants before the study.

Intervention

The intervention group participated in 10 occupational therapy sessions over 3 weeks. These sessions generally included techniques for edema control and reduction, active and passive range of motion exercises for fingers and wrist, progressive resistance exercises for hand muscles, as well as flexor tendon and median nerve glides. Additionally, desensitization and sensory retraining techniques were employed [13-15].

The patients participated in 2 to 3 forty-five-minute sessions per week. During the first two weeks, the focus was primarily on wound management, reducing and controlling edema (through the use

of pressure bandages, elevation, and techniques such as overhead fisting), and gradually incorporating flexor tendon gliding and median nerve glides. From the second week onwards, there was a focus on increasing wrist extension to enhance median nerve excursion, while avoiding excessive tension. Edema reduction techniques, such as compression gloves and contrast baths, were continued as needed. Median nerve gliding exercises were performed within a greater range of motion according to the patient's tolerance. Patients were encouraged to gradually use their hands in light and gentle daily activities. By the end of the week, the focus shifted to strengthening the pinch and grip, and gradually incorporating strengthening exercises based on the patient's tolerance [3]. Additionally, the patients were instructed to perform the exercises at home. The interventions were conducted by an occupational therapist specialized in hand injury rehabilitation. Participants in the control group were not deprived of standard interventions. Upon discharge, they were given standard recommendations based on routine hospital care, including the surgeon's instructions, and were directed to the occupational therapy ward for evaluation.

All participants were evaluated before and one month after surgery by an occupational therapist who was blinded to the group allocation. A demographic questionnaire was used to gather patient information. The range of motion, hand and pinch strength, and pain level were measured using a Goniometer, Hand Dynamometer and Pinch Gauge, and Visual Analogue Scale (VAS), respectively. Additionally, the Boston Carpal Tunnel Questionnaire (BCTQ) was utilized to evaluate the severity of symptoms and hand function.

Outcome Measures

Range of Motion: The range of motion for active flexion and extension of the wrist, as well as Total Active Motion (TAM) of the thumb and index fingers, was assessed using a goniometer. To assess the range of motion, participants were seated behind an adjustable height table. They were instructed to flex and extend their wrists in the sagittal plane while keeping their shoulders adducted. The forearm was positioned in pronation and supination, respectively. The stationary arm of the goniometer was placed along the midline of the forearm, while the movable arm remained parallel to the third metacarpal's longitudinal axis. TAM of the thumb and index fingers was determined by summing the degrees of flexion at the metacarpophalangeal, proximal, and distal interphalangeal joints while making a fist, and then subtracting the extension deficits at each joint [16]. Evaluating the TAM of fingers is a gold standard measurement in reporting outcomes after hand injuries [16].

Hand and Pinch strength: Grip strength was assessed using a Hydraulic Hand Dynamometer (Model: SH5001), and pinch strength was evaluated with a Jamar Hydraulic Pinch Gauge. All measurements were taken with participants seated, shoulder adducted and in neutral rotation, elbow at 90º flexion, forearm in a neutral position, and wrist in 0 to 30º extension and 0 to 15º ulnar deviation. Participants were instructed to exert maximum force on the dynamometer and/or pinch gauge [17]. Participants were instructed to squeeze the dynamometer with maximum effort to evaluate their grip strength. For pinch strength assessment, they were asked to use the pinch gauge by pinching it with the thumb and lateral aspect of the middle phalanx of the index finger, the pads of the thumb and index fingers, and the pads of the thumb, index, and middle fingers for the key pinch, two-point pinch, and three-point pinch, respectively [17]. Each measurement was conducted three times, and the average of readings was recorded. Pinch strength assessment is reliable. Although validity and responsiveness are less reported, there is a strong correlation between pinch and grip strength, and a moderate correlation with dexterity [18].

Pain: The intensity of pain experienced by patients was measured using the Visual Analogue Scale (VAS) before and after the intervention. VAS is a widely used patient-reported outcome measure (PROM) for individuals with CTS [19]. It evaluates the intensity of pain experienced by the patient on a scale ranging from 0 to 10, where 0 represents “no pain at all” and 10 indicates “the worst pain imaginable”. VAS is an easy-to-use, reliable, and valid tool for measuring pain severity or intensity [20].

Symptom severity and functional status: The Boston Carpal Tunnel Questionnaire (BCTQ) is a disease-specific measure of self-reported symptom severity and functional status in individuals with CTS [21]. It is recognized as a standardized, valid, reliable, and responsive instrument for evaluating these aspects. The BCTQ consists of two subscales: the "Symptom Severity Scale," which includes 11 questions rated on a five-point scale, and the "Functional Status Scale," comprising eight items rated based on the degree of difficulty on a five-point scale. The total score for each subscale ranges from 1 to 5, with higher scores indicating greater levels of disability [22]. The BCTQ showed moderate correlations with objective measures, and there is a strong correlation between the scores of its two subscales [23-24].

Statistical Analysis

Descriptive statistics, including mean ± standard deviation, were used to describe both independent and dependent quantitative variables. Paired sample t-tests, independent t-tests, and Fisher's exact tests were employed to compare quantitative and qualitative variables between the two groups. The data analysis was conducted using SPSS software version 21, with statistical significance set at $P<0.05$.

Results

Twenty women with CTS (control group=10, intervention group=10) participated in this study. The mean age of the control group was 54.1±5.9, while that of the intervention group was 52±4.3 years. Results from the independent t-test indicated no statistically significant difference in age between the groups (p=0.53), although the intervention group had a significantly higher Body Mass Index (BMI) (p=0/03). Additionally, Fisher's exact test showed no significant difference between the groups regarding the affected hand (Table 1).

Table 1: Demographic Characteristics of the Study Groups

Variables		**Intervention Group (n=10)**	**Control Group (n=10)**	**P-value**
Age		52±4.3	54.1±5.9	0/53
BMI		30.4±3.5	26.1±2.7	0/03
Affected Hand	**Right**	8 (80%)	6 (60%)	0/62
	Left	2 (20%)	4 (40%)	

Abbreviations: BMI: Body Mass Index.

As Table 2 indicates, at pre-treatment, there were no significant differences in outcome measures between the intervention and control groups, except for symptom severity, which was significantly higher in the intervention group compared to the control group.

Following the intervention, there was a significant increase in wrist active flexion and the TAM of the thumb and index fingers within the intervention group. However, when comparing the two groups, only the difference in wrist active flexion range of motion was statistically significant ($p \leq 0.05$).

Interestingly, the control group experienced a significant decrease in hand strength, whereas the intervention group also showed a reduction in hand strength, but this change was not statistically significant. Similarly, for pinch strength, the control group revealed a decrease in post-treatment compared to pre-treatment, whereas the intervention group showed improvements in all three types of pinch strength. However, the difference between the two groups was statistically significant only for two-point and three-point pinches ($p \leq 0.05$).

In post-treatment, both groups experienced a significant reduction in pain intensity; however, the intervention group demonstrated a significantly greater decrease in pain compared to the control group ($p=0.003$).

Regarding symptom severity, both groups demonstrated significant improvement; however, the intervention group achieved a statistically greater level of improvement compared to the control group. In terms of functional status, significant improvement was found in both groups. However, the intervention group showed a greater improvement, although the difference between the two groups was not statistically significant ($p>0.05$).

Table 2: Comparison of outcome measures between the Study Groups

Variables	Intervention Group (n=10)	Control Group (n=10)	Independent t-test
Wrist Active Flex			
Pre-treatment	54±7.34	54.80±12.75	t=0.17; df=18; p=0.86
Post-treatment	60±11.05	49.50±12.12	t=2.02; df=18; **p=0.05**
Paired t-test	t=2.34; df=9; **p=0.04**	t=1.28; df=9; p=0.23	-
Wrist Active Ext			
Pre-treatment	49±9.94	54±10.49	t=-1.1; df=18; p=0.28
Post-treatment	57±15.85	52±10.85	t=0.82; df=18; p=0.42
Paired t-test	t=-1.65; df=9; p=0.13	t=-0.37; df=9; p=0.71	-
Thumb TAM			
Pre-treatment	106.50±21.99	103.20±27.47	t=-0.29; df=18; p=0.77
Post-treatment	121.50±23.93	103.70±26.23	t=-1.58; df=18; p=0.13
Paired t-test	t=--2.42; df=9; **p=0.03**	t=0.08; df=9; p=0.93	-
Index TAM			
Pre-treatment	213±15.13	218.40±24.72	t=-0.58; df=18; p=0.56
Post-treatment	226±22.46	212.80±21.28	t=-1.34; df=18; p=0.19
Paired t-test	t=-3.07; df=9; **p=0.01**	t=0.68; df=9; p=0.51	-
Hand Strength			
Pre-treatment	27.20±15.55	26.28±13.02	t=0.08; df=18; p=0.93
Post-treatment	23.70±10.71	15.65±7.64	t=1.93; df=18; p=0.06
Paired t-test	t=1.10; df=9; p=0.30	t=2.87; df=9; **p=0.01**	-
Two-Point Pinch			
Pre-treatment	7.28±4.03	5.64±3.94	t=0.92; df=18; p=0.36

Post-treatment	8.55±3.58	5.31±3.09	t=2.16; df=18; **p=0.04**
Paired t-test	t=-1.33; df=9; p=0.21	t=0.57; df=9; p=0.58	-
Three-Point Pinch			
Pre-treatment	7.43±4.73	6.72±4.13	t=0.35; df=18; p=0.72
Post-treatment	9.10±3.87	5.14±3.15	t=2.51; df=18; **p=0.02**
Paired t-test	t=-1.68; df=9; p=0.12	t=1.79; df=9; p=0.11	-
Key Pinch			
Pre-treatment	7.33±3.89	7.60±4.97	t=-0.13; df=18; p=0.89
Post-treatment	9.40±3.71	6.48±3.89	t=1.71; df=18; p=0.11
Paired t-test	t=-2.94; df=9; **p=0.01**	t=1.56; df=9; p=0.15	-
Pain			
Pre-treatment	7±1.70	6.40±2.5	t=0.62; df=18; p=0.53
Post-treatment	1.90±1.37	4.10±1.45	**t=-3.48; df=18; p=0.003**
Paired t-test	t=7.96; df=9; **p≤0.001**	t=7.96; df=9; **p=0.02**	-
Symptom Severity			
Pre-treatment	3.56±0.48	2.68±0.67	t=3.36; df=18; **p=0.003**
Post-treatment	1.61±0.36	2.05±0.49	t=-2.27; df=18; **p=0.03**
Paired t-test	t=14.97; df=9; **p≤0.001**	t=3.23; df=9; **p=0.01**	-
Functional Status			
Pre-treatment	3.32±0.60	2.84±0.57	t=1.87; df=18; p=0.07
Post-treatment	2.03±0.55	2.22±0.59	t=-0.73; df=18; p=0.47
Paired t-test	t=7.63; df=9; **p≤0.001**	t=3.74; df=9; **p=0.005**	-

Abbreviations: Flex: Flexion; Ext: Extension; TAM: Total Active motion. Values are reported as mean ± SD.

Discussion

This study aimed to investigate the effectiveness of an occupational therapy intervention in patients with CTS. It is among the few studies that have examined the effectiveness of occupational therapy interventions in post-surgery CTS patients. Additionally, to the best of our knowledge, the effectiveness of early interventions in these patients has not yet been studied.

Following an early and comprehensive intervention, the intervention group showed an increase in the range of motion for wrist active extension and flexion, as well as total active motion in the index fingers and thumb. However, this increase was only significant for wrist active flexion. Conversely, the control group exhibited a decrease in the range of motion across all these indicators. Interestingly, both groups experienced a decrease in grip strength. This decrease was significant in the control group, while it did not reach a significant level in the intervention group. This suggests that early intervention, although not effective in improving grip strength, helped to maintain it. Similarly, in the control group, a decrease in grip strength was observed in all three evaluated grip types, while the intervention group exhibited improvements in all three, with only two-point and three-point pinch strength reaching a significant level. Additionally, both groups experienced a reduction in pain intensity, with the intervention group showing a significantly greater decrease compared to the control group. Finally, both groups showed significant improvements in symptom severity and functional status. The intervention group experienced greater improvement in both subscales compared to the control group; however, only the

improvement in symptom severity in the intervention group was significantly greater than that of the control group.

Researchers have primarily examined the effectiveness of conservative rehabilitation treatments for patients with CTS. However, there is a scarcity of evidence on the effectiveness of post-surgical interventions, particularly occupational therapy, potentially due to the fact that a significant proportion of patients do not pursue postoperative care [9]. Our findings align with those of Ramadan Shaheen et al. (2021), who found that nursing rehabilitation interventions, which include physical exercises and patient education, are more effective in alleviating symptoms and reducing the severity of disability than standard hospital interventions [25]. Salehi et al. (2019) also suggested that adding exercise and dry needling into the standard intervention (night splint) can improve functional outcomes in patients with mild to moderate CTS who have not undergone surgery [8]. It seems that exercises such as nerve and tendon gliding not only enhance venous return by decreasing edema and adhesions but also reduce inflammation and pressure within the carpal tunnel. Additionally, range of motion exercises mitigate and even prevent nerve scarring. Overall, these exercises contribute to symptom relief and reduce symptom severity by lowering pressure inside the carpal tunnel [25-26]. It seems that in the present study, the early inclusion of occupational therapy interventions into the postoperative care of patients with CTS was also effective in enhancing outcomes through the same mechanism. In their systematic review, Huisstede et al. (2018) also concluded that short-duration dressings are preferable to long-duration dressings, and sensory retraining programs are more effective than no intervention following CTS surgery [15].

While the current study has valuable findings, it also has limitations. First, we did not use an objective outcome measure to assess the functional outcomes of the intervention and its impact on participants' daily living activities. It is recommended that future research investigate the effectiveness of the interventions on daily living activities. Secondly, there was no follow-up due to time constraints. Therefore, we recommend conducting RCTs in future studies to investigate the sustainability of improvements during the follow-up period.

Conclusion

The study demonstrated that early occupational therapy following CTR is more effective than routine interventions in improving pinch strength and reducing the intensity of symptoms and pain experienced in patients. The findings also support the incorporation of early rehabilitation into post-surgery care for CTS patients.

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Authors' contributions

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Conflict of interest

The authors report no conflict of interest.

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