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Research Article

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

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ABSTRACT

Introduction: 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 quasi-experimental study aimed to investigate the effectiveness of early occupational therapy intervention in post-surgery patients with CTS.

Materials and Methods: Twenty women with idiopathic CTS who were candidates for surgery were recruited and assessed before surgery. After surgery, they were assigned to the intervention (n=10) or control group (n=10). The control group received standard care, while the intervention group underwent early occupational therapy intervention (10 sessions over 3 weeks). Range of motion, hand and pinch strength, and pain level were measured using a goniometer, hand dynamometer, pinch gauge and visual analog scale (VAS). The Boston carpal tunnel questionnaire (BCTQ) was used to evaluate symptom severity and hand function. We used paired sample t-tests, independent t-tests and Fisher's exact tests to compare variables between groups.

Results: The intervention significantly improved wrist active flexion and two-point and three-point pinch strengths 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 symptom severity and functional status results, with a significantly greater improvement in symptom severity ($P \leq 0.05$).

Conclusion: Early occupational therapy following CTR is more effective than routine interventions in enhancing pinch strength and alleviating pain and symptoms. Nevertheless, randomized controlled trials are necessary to determine the duration of these benefits.

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Introduction

Carpal tunnel syndrome (CTS) is one of the most common entrapment neuropathies affecting the upper limbs [1]. The prevalence of CTS varies across countries and populations. Some studies estimate that up to 3% of the population is affected, although other reports suggest higher estimates [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, leading 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]. CTS has significant economic implications, particularly because it impacts active individuals and is frequently regarded as a work-related disorder [2]. Additionally, similar to other hand disorders, CTS significantly impairs daily activities [1].

CTS management involves either conservative or surgical intervention [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 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 in endoscopic CTR, the transverse carpal ligament is divided 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, come with complications. Post-surgery complications of CTR may include nerve injury, neuroma formation, palmar arch injury, hematoma, complex regional pain syndrome, tendon adhesions, bowstringing of the flexor tendons and pain. Despite being the most common intervention, the effectiveness of surgery remains controversial [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 orthoses, scar desensitization, exercises, cold and ice therapy, multi-modal hand rehabilitation, laser therapy and electrical modalities [5]. Therapists do not use an agreed-upon standard for clinical practice interventions and rehabilitation protocols 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 than routine interventions (splinting alone) and exercise combined with splinting [8]. Unfortunately, despite 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 facilitated return to work, may be associated with early rehabilitation and shorter immobilization periods [10, 11].

As previously noted, current research on the effectiveness of rehabilitation interventions, especially occupational therapy, for patients with CTS is both limited and of poor quality [5]. However, 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]. Prioritizing early rehabilitation can enhance the full potential for recovery and improve patients' overall well-being. Therefore, this study aimed to evaluate the effectiveness of comprehensive early occupational therapy in patients with post-surgery CTS.

Materials and Methods

Study design

In this quasi-experimental study, 20 women with CTS were recruited for surgery from those referred to Akhtar Hospital in Tehran City, Iran. The inclusion criteria included diagnosis of CTS by a surgeon using electromyography (EMG), nerve conduction velocity (NCV) and clinical tests; age range of 24 to 64 years, 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. The exclusion criteria included patients who underwent additional interventions during the study or missed more than one session. Participants were initially evaluated and all underwent surgery by a single surgeon using open CTR. Post-surgery, participants were referred to occupational therapy and divided into control and intervention groups based on their willingness to receive further interventions.

Intervention

The intervention group participated in 10 occupational therapy sessions over three weeks. These sessions included techniques for edema control and reduction, active and passive range of motion exercises for fingers and wrists, progressive resistance exercises for hand muscles, and flexor tendon and median nerve glides. Additionally, desensitization and sensory retraining techniques have been 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 and median nerve gliding. From the second week onwards, the focus was on increasing wrist extension to enhance median nerve excursion while avoiding excessive tension. Edema reduction techniques, such as compression gloves and contrast baths, were used 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 for 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 exercises at home. The interventions were conducted by an occupational therapist specializing in hand injury rehabilitation.

Participants in the control group were not deprived of standard intervention. 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.

An occupational therapist who was blinded to the group allocation evaluated all participants before and one month after surgery. A demographic questionnaire was used to collect 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 analog scale (VAS), respectively. Additionally, the Boston carpal tunnel questionnaire (BCTQ) was used 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 and total active motion (TAM) of the thumb and index fingers was assessed using a goniometer. To assess the range of motion, the participants were seated behind an adjustable height table. They were instructed to flex and extend their wrists in the sagittal plane while keeping their shoulder adducted. The forearm was positioned in the pronation and supination positions. The stationary arm of the goniometer was placed along the midline of the forearm, and 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 the fingers is the gold standard for 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 using a Jamar hydraulic pinch gauge. All measurements were taken with participants seated, shoulder adducted and in neutral rotation, elbow at 90° flexion, forearm in a neutral position, and wrist in 0-30° extension and 0-15° ulnar deviation. The participants were instructed to exert maximum force on the dynamometer and/or pinch gauge [17]. The participants were instructed to squeeze the dynamometer to evaluate their grip strength with maximum effort. For pinch strength assessment, the participants were asked to use the pinch gauge by pinching it with the thumb and lateral aspect of the middle phalanx of the index finger, pads of the thumb and index fingers and pads of the thumb, index finger, and middle fingers for the key, two-point and three-point pinches, respectively [17]. Each measurement was conducted three times, and the average reading was recorded. The pinch strength assessment was 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 VAS before and after the intervention. VAS is a widely used patient-reported outcome measure 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 BCTQ is a disease-specific measure of self-reported symptom severity and functional status in patients with CTS [21]. It is 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 ranged from 1 to 5, with higher scores indicating greater disability [22]. The BCTQ showed moderate correlations with objective measures, and a strong correlation was observed between the scores of its two subscales [23, 24].

Statistical analysis

Descriptive statistics, including Mean±SD, were used to describe 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. Data were analyzed using SPSS software, version 21, with statistical significance at $P<0.05$.

Results

Twenty women with CTS (10 in the control and 10 in the intervention groups) 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).

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

Following the intervention, a significant increase was observed in wrist active flexion and the TAM of the thumb and index fingers in the intervention group. However, when comparing the two groups, only the difference in wrist active flexion range of motion was statistically significant ($P\leq0.05$).

The control group experienced a significant decrease in hand strength, whereas the intervention group 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 ($P\leq0.05$).

Both groups experienced a significant reduction in pain intensity after treatment; however, the intervention group demonstrated a significantly greater decrease in pain than the control group (P=0.003).

Both groups demonstrated significant improvement in symptom severity; however, the intervention group achieved a statistically greater level of improvement than the control group. Significant improvements were observed in both groups in terms of functional status. However, the intervention group showed greater improvement, although the difference between the two groups was not statistically significant ($P>0.05$).

Table 1. Demographic characteristics of the study groups (n=10)

Variables		Mean±SD/No. (%)		P
		Intervention Group	Control Group	
Age (y)		52±4.3	54.1±5.9	0.53
BMI (kg/m²)		30.4±3.5	26.1±2.7	0.03
Affected hand	Right	8(80)	6(60)	0.62
	Left	2(20)	4(40)	

BMI: Body mass index.

Table 2. Comparison of outcome measures between the study groups (n=10)

Variables		Mean±SD		Independent t-test
		Intervention Group	Control Group	
Wrist active flex	Pre-treatment	54±7.34	54.8±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	106.5±21.99	103.2±27.47	t=-0.29; df=18; P=0.77
	Post-treatment	121.5±23.93	103.7±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	218.4±24.72	t=-0.58; df=18; P=0.56
	Post-treatment	226±22.46	212.8±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	27.2±15.55	26.28±13.02	t=0.08; df=18; P=0.93
	Post-treatment	23.7±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	7.6±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±1.7	6.40±2.5	t=0.62; df=18; P=0.53
	Post-treatment	1.9±1.37	4.1±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	

	Variables	Mean±SD		Independent t-test
		Intervention Group	Control Group	
Functional status	Pre-treatment	3.32±0.6	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.

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Discussion

This study aimed to investigate the effectiveness of occupational therapy interventions in patients with CTS. This is one of the few studies that have examined the effectiveness of occupational therapy interventions in post-surgery patients with CTS. 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 increased range of motion for wrist active extension and flexion and TAM in the index finger and thumb. However, this increase was significant only for wrist active flexion. Conversely, the control group showed a decreased range of motion across all indicators. Both groups experienced a decrease in grip strength. This decrease was significant in the control group but was not significant in the intervention group. This suggests that early intervention, although ineffective in improving grip strength, helped maintain it. Similarly, in the control group, grip strength was decreased for all three evaluated grip types. In contrast, the intervention group exhibited improvements in all three, with only two- and three-point pinch strengths reaching a significant level. Additionally, both groups experienced a reduction in pain intensity, with the intervention group showing a significantly greater decrease than the control group. Finally, both groups showed significant improvements in symptom severity and functional status. The intervention group experienced greater improvement in both subscales than in the control group; however, only the improvement in symptom severity in the intervention group was significantly greater than in the control group.

Researchers have primarily examined the effectiveness of conservative rehabilitation treatments in patients with CTS. However, a scarcity of evidence exists on the effectiveness of post-surgical interventions, particularly occupational therapy, potentially because a significant proportion of patients do not pursue postoperative care [9]. Our findings align with those of Ramadan Shaheen et al. who found that nursing rehabilitation interventions, including 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. suggested that adding exercise and dry needling to the standard intervention (night splint) can improve functional outcomes in patients with mild-to-moderate CTS who have not undergone surgery [8]. Exercises, such as nerve and tendon gliding, enhance venous return by decreasing edema and adhesions and 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]. In the present study, the early inclusion of occupational therapy interventions in the post-operative care of patients with CTS effectively enhanced outcomes through the same mechanism. In their systematic review, Huisstede et al. concluded that short-duration dressings are preferable to long-duration dressings and that sensory retraining programs are more effective than no intervention following CTS surgery [15].

Although 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. Future research should investigate the effectiveness of interventions on daily living activities. Second, no follow-up was conducted due to time constraints. Therefore, we recommend conducting RCTs in future studies to investigate the sustainability of improvements during the follow-up period.

Conclusion

This 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 by patients. The results also support incorporating early rehabilitation into post-surgery care for patients with CTS.

Ethical Considerations

Compliance with ethical guidelines

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

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Authors' contributions

All authors contributed equally to the preparation of this manuscript. Each author approved the submission of the final version of the manuscript.

Conflict of interest

The authors declared no conflicts of interest.

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