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Research Article

Factors Associated with Upper Extremity Functionality After Mini-Open Release Surgery for Treatment of Carpal Tunnel Syndrome

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Abstract

Aim: The objective of this study was to investigate the correlation between upper extremity functionality, pain intensity, muscle strength, and symptom severity among patients diagnosed with carpal tunnel syndrome (CTS) who underwent mini-open release surgery.
Material and Method: This retrospective study entailed the review of medical records of 70 patients diagnosed with CTS who underwent mini-open release surgery between January 2021 and January 2023. Data were collected from preoperative assessments and routine follow-up evaluations conducted at 3 months post-surgery. Upper extremity functionality was assessed utilizing the Disabilities of Arm, Shoulder, and Hand (DASH) questionnaire, pain severity was determined using the Visual Analog Scale (VAS), muscle strength was evaluated through hand grip strength, and disease severity was measured using the Boston Carpal Tunnel Questionnaire (BCTQ).
Results: A statistically significant improvement was observed in DASH questionnaire scores, VAS scores, hand grip strength, and BCTQ scores at the 3-month follow-up compared to preoperative values ($p<0.05$). Furthermore, significant correlations were found between DASH questionnaire scores and VAS scores, hand grip strength, and BCTQ scores during postoperative assessments ($p<0.05$).
Conclusion: Mini-open-release surgery demonstrates effectiveness as a surgical approach for achieving favorable clinical outcomes in patients with CTS. Furthermore, our findings suggest that postoperative upper extremity functionality may be influenced by factors such as pain intensity, symptom severity, and hand grip strength. Therefore, we advocate for the integration of these factors into postoperative patient evaluation protocols and treatment programs to optimize patient outcomes.

Keywords: Functionality, carpal tunnel syndrome, treatment, mini-open-release surgery

INTRODUCTION

Carpal tunnel syndrome (CTS) is characterized by symptomatic compression of the median nerve at the wrist level (1). CTS stands out as one of the most prevalent entrapment neuropathies, impacting the upper extremity and leading to constraints in daily activities. Among individuals affected by CTS, sensory manifestations including paresthesia, dysesthesia, muscular weakness in median nerve-innervated muscles, and compromised upper extremity functionality are frequently encountered (2). The prevalence of CTS within the community is estimated to be approximately 8% (3), with an incidence roughly 2-3 times higher in women than in men (4).

Conservative treatments for CTS commonly include the use of wrist splints, anti-inflammatory and analgesic medications, physiotherapy modalities, and occasionally corticosteroid injections into the carpal tunnel (5,6). Surgical decompression techniques are reserved for patients who fail to respond to conservative interventions. These surgical procedures may involve either open or endoscopic approaches. Surgical interventions have been shown to alleviate CTS symptoms in approximately 70–90% of patients (7,8). For instance, Verdugo et al. (9) demonstrated that surgical intervention provides greater relief of symptoms compared to wrist splinting in patients with CTS.

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Studies have indicated a correlation between increased compression on the median nerve in individuals with CTS and motor nerve involvement, resulting in symptoms such as hand weakness, diminished function, heightened pain intensity, and atrophy of the thenar region muscles of the hand (10). Consequently, these symptoms lead to a decline in activities of daily living (11), particularly exacerbated by repetitive wrist flexion and extension movements (12). Such impairments have been shown to have a detrimental impact on upper limb functionality and future quality of life (13). Moreover, investigations have highlighted associations between hand functionality, pain severity, and grip strength in patients with CTS (13). Additionally, it has been documented that atrophy of the lumbrical muscles of the 2nd and 3rd fingers during the later stages of CTS leads to hand weakness and a decline in fine motor skills (14).

In the existing literature, studies predominantly focus on investigating factors influencing upper extremity functionality in patients diagnosed with CTS (13,15). However, there are no studies examining the factors related to upper extremity functionality following surgery in CTS patients. Thus, the objective of our study was to investigate the factors associated with upper extremity functionality in patients with CTS who have undergone mini-open release surgery.

MATERIAL AND METHOD

Ethical Aspect and Study Design

Ethical approval for this retrospective and cross-sectional study was granted by the local ethics committee (Number: 5-2024/11), and the research adhered to the principles outlined in the Declaration of Helsinki. In order to use the data, all participants were contacted, and their written and verbal consents were obtained.

Participants

Between January 2021 and January 2023, a retrospective analysis was conducted on 70 patients who underwent mini-open release surgery for unilateral carpal tunnel syndrome (CTS) at the Training and Research Hospital. The analysis included an examination of age, gender, body mass index (BMI), preferred surgical treatment methods, and complications. Patients over 65 years of age, patients who underwent a different surgical intervention, and patients who were included in a postoperative physiotherapy and rehabilitation program were excluded from the study.

Surgical Method

Mini-open release surgery is performed in the following sequence: After regional anesthesia, a 2-3 cm longitudinal incision is made distal to the transverse carpal ligament at the level of the third vein under an arm tourniquet. Subcutaneous adipose tissue and palmar aponeurosis are passed, and the distal transverse carpal ligament is reached. At this time, the superficial palmar arch is visualized and protected. The transverse carpal ligament is checked for motor branch variations. Once the median nerve is visualized, an Adson forceps handle is positioned between the nerve and the transverse carpal ligament. Then the skin and subcutaneous tissues are excised proximally, and the transverse carpal ligament is opened with scissors from the ulnar side. Finally, the skin is closed by checking the patency of the transverse carpal ligament (16).

Evaluation Tools

Age, gender, body mass index (BMI), and dominant upper extremity designation of the patients were retrieved from their medical records before the commencement of the study. Measurements of the Disabilities of the Arm, Shoulder, and Hand (DASH) Questionnaire, Visual Analog Scale (VAS), hand grip strength, and Boston Carpal Tunnel Questionnaire (BCTQ) scores of patients with CTS were obtained by reviewing patient records both before mini-open release surgery and three months postoperatively.

Upper Extremity Functionality

In the study, the upper extremity functionality of patients with CTS who underwent mini-open release surgery was assessed using the Turkish version of the DASH questionnaire (17). In the study, specifically, we administered the first part of the DASH questionnaire, comprising 30 items on functional status and symptoms. Among these, 21 items assessed challenges in participating in activities of daily living, while 5 items addressed symptoms such as tingling, weakness, stiffness, and pain, and the remaining 4 items explored aspects related to social function, work, sleep, and self-confidence. Each item was rated on a scale from 1 (no difficulty) to 5 (unable to perform), yielding a total score ranging from 0 to 100. A higher score denoted a greater degree of disability (18).

Pain Severity

The pain severity experienced by patients was assessed utilizing the VAS. This scale comprises a 10 cm line, segmented into 10 parts, with each part corresponding to 1 cm. Patients rate their pain level by indicating a point on the line, with a score ranging from 0 (indicating no pain) to 10 (indicating unbearable pain) (19).

Muscle Strength

Hand grip strength was evaluated using a hand dynamometer (Takei, Japan), with measurement positions aligned according to the guidelines provided by the American Association of Hand Therapists. The assessment was conducted on the side affected by CTS. Each measurement was repeated three times, interspersed with a 30-second rest interval between measurements to minimize fatigue. The maximum recorded value in kilograms (kg) was documented for analysis (20).

Symptom Severity

The severity of CTS symptoms was assessed using the Turkish version of the Boston Carpal Tunnel Questionnaire (BCTQ) (21). The questionnaire comprises two parts: the first part, consisting of 11 questions, evaluates symptom severity, while the second part, comprising 8 questions,

assesses functional status. Each question is rated on a scale from 1 (indicating no symptoms) to 5 (indicating very severe symptoms). The total score is calculated by summing the scores from all questions. The score from the first part indicates the severity of symptoms, categorized as: no symptoms (0-11 points), mild symptoms (12-22 points), moderate symptoms (23-33 points), severe symptoms (34-44 points), and very severe symptoms (45-55 points). A higher score reflects greater symptom severity (21). For our study, only the first part of the BCTQ was utilized.

Statistical Analysis

SPSS software was used to perform statistical analyses. A paired sample t-test was used to compare change over time in data that met normal distribution criteria. Factors associated with fatigue severity were evaluated by Pearson correlation analysis in parametric conditions. The correlation degree was interpreted as follows: a correlation coefficient ranging from 0.05 to 0.4 indicated a low correlation, from 0.4 to 0.7 signified a moderate correlation, and from 0.7 to 1.0 denoted a high correlation, based on established correlation coefficients (22).

RESULTS

The demographic data and clinical evaluation of patients with CTS are presented in Table 1. The mean age of patients included in this study was 57.52±5.74 years.

Table 1. Descriptive values of patients with CTS

Variables		Mean±SD	Min	Max
Age (years)		57.52±5.74	40.00	65.00
BMI (kg/m^2)		26.81±2.31	21.08	32.38
		n	(%)	
Gender	Male	20	28.6	
	Female	50	71.4	
Dominant upper extremity	Right	48	68.6	
	Left	22	31.4	
Side of the surgery	Right	45	64.2	
	Left	25	35.8	

CTS: carpal tunnel syndrome, SD: standard deviation, Min: minimum, Max: maximum, BMI: body mass index

Table 2 shows the preoperative and postoperative comparison of DASH questionnaire, VAS, hand grip strength, and BCTQ scores among the patients with CTS included in the study. According to the results, when the DASH questionnaire, VAS, hand grip strength, and BCTQ scores of patients with CTS were compared preoperatively and postoperatively, a statistically significant difference was found for all parameters ($p<0.05$). Thus, it was observed that the treatment method applied was effective on upper extremity functionality, pain, hand grip strength, and symptom severity.

Table 2. Comparison of preoperative and postoperative evaluations of patients with CTS

Variables		CTS (n: 70) Mean±SD	t	p
DASH (score)	Preoperative	70.64±10.71	25.20	<0.001*
	Postoperative	39.72±10.28		
VAS (cm)	Preoperative	5.94±1.00	18.45	<0.001*
	Postoperative	2.52±0.93		
Hand Grip Strength (kg)	Preoperative	9.96±2.84	-12.81	<0.001*
	Postoperative	17.42±2.74		
Boston Carpal Tunnel Questionnaire (score)	Preoperative	42.36±7.06	14.09	<0.001*
	Postoperative	25.88±4.72		

CTS: carpal tunnel syndrome, SD: standard deviation, DASH: disabilities of the arm, shoulder and hand questionnaire, VAS: visual analog scale, t: Paired sample t-test

Table 3 presents the relationship between the DASH questionnaire and VAS, BCTQ, and hand grip strength results among the patients with CTS included in the study. According to this table, a positive, high level statistical relationship was found between the DASH questionnaire results with hand grip strength and BCTQ results of patients with CTS, while a negative, high level statistical relationship was found between the DASH questionnaire results and VAS ($p<0.05$) (Table 3).

Table 3. Investigation of the relationships between DASH questionnaire and other evaluation parameters in patients with CTS

Variables	DASH (score) (n: 70) r (p)
VAS (cm)	0.894 (<0.001*)
Hand Grip Strength (kg)	-0.800 (<0.001*)
Boston Carpal Tunnel Questionnaire (score)	0.786 (<0.001*)

DASH: disabilities of the arm, shoulder and hand questionnaire, CTS: carpal tunnel syndrome, VAS: visual analog scale, r: Pearson correlation coefficient, *p<0.001

DISCUSSION

In this retrospective study, we examined the preoperative and 3-month postoperative status of patients with CTS who underwent mini-open release surgery and the relationship between postoperative upper extremity functionality and pain intensity, hand grip strength, and CTS symptom severity. Our findings show that mini-open release surgery provides significant improvements in pain relief, increased hand grip strength and decreased symptom severity in patients with CTS. Additionally, we observed a high correlation between pain intensity, hand grip strength, and symptom severity with upper extremity functionality following mini-open release surgery.

Mini-open surgical techniques offer expedited recovery of hand function post-surgery in contrast to other methods. These techniques present benefits such as minimal scarring, reduced scar tissue pain, and shorter recovery duration. To mitigate complications and enhance patient functional status, numerous researchers favor mini-open release surgery (23,24). Celocco et al. (25) compared the BCTQ results of proximal mini-open technique and limited open technique. They obtained a significant improvement in symptom severity after treatment in the mini-open technique. While symptom severity improved similarly in both groups, improvement in grip strength and pain level was found in favour of mini-open transverse release surgery (25). Calleja et al. (26) showed that different mini-open release surgical approaches resulted in significant improvements in upper extremity functionality in patients with CTS. Atroshi et al. (27) found that mini-open release surgery showed significant improvements in functional status and pain in patients with CTS. Thoma et al. (28) stated that mini-open release surgery was effective in improving pain and grip strength in patients with CTS. In our study, improvements in upper extremity functionality, pain severity, hand grip strength and symptom severity were observed in patients with CTS after mini-open release surgery, in accordance with the results in the literature. Based on all these findings, it can be said that mini-open release surgery reduces the pressure in the carpal tunnel and the compression on the median nerve, reduces the complaints of the patients and improves their functional status.

Subjective questionnaires are more effective than objective measurements in evaluating the general function and disability of the hand from the patient's perspective (29). In studies, there are conflicting results in terms of the relationship between the increase in the occurrence of clinical symptoms and the severity of electromyography findings (30). Therefore, subjective data are thought to reflect clinical symptoms more.

DASH is guiding in determining the functional status of the upper extremity. It is documented that the DASH questionnaire is a validated, sensitive, and reliable measurement tool (31). Bakhsh et al. (32) evaluated the validity and reliability of the DASH questionnaire and BCTQ in patients with CTS and assessed the relationship between these two questionnaires. They found a strong correlation between functional status and symptom severity. Umay et al. (29) found a strong correlation between upper extremity functional status and symptom severity in individuals with CTS. Akçay et al. (33) examined the relationship between functional status, pain level, and symptom severity in women with CTS. They stated that there was a significant relationship between functional status and symptom severity. In our study, a strong correlation was observed between functional status and symptom severity, consistent with existing literature.

Pain is a prevalent symptom among patients with CTS and exerts a notable impact on functional abilities. Elevated pain levels result in restrictions in functional status and activities of daily living (13,15). Akçay et al. (33) identified a significant association between pain level and hand functionality in patients with CTS. In our study, we identified a notable relationship between pain intensity and upper extremity functionality among patients with CTS who underwent mini-open release surgery. These findings suggest that pain may cause loss of functional status by causing kinesiophobia. After mini-open release surgery, the reduction of pain with the reduction of pressure on the median nerve may have been effective in the improvement of the upper extremity functionality of the patients.

The presence of tenar atrophy, which is one of the important symptoms of CTS, negatively affects muscle strength and thus grip strength. Singh et al. (34) examined the relationship between disease severity and grip strength in patients with CTS. They stated that grip strength decreased as the severity of symptoms increased (34). The effects of upper extremity muscle strength on functionality in women with CTS were investigated. In this study, it was stated that muscle strength was affected in patients with CTS, and the DASH questionnaire score and grip strength were related (15). Ise et al. (35) found a significant correlation between grip strength and functionality after release surgery in patients with CTS. In our study, a strong relationship between functional status and grip strength was observed in accordance with the literature. It can be said that the decrease in the complaints of the patients after surgery is effective in increasing the muscle strength and this positively affects the upper extremity functionality.

To the authors' knowledge, this study represents the first investigation into the factors influencing upper extremity functionality following mini-open release surgery in patients with CTS. In this regard, we assert that the findings of this study, which we anticipate will offer valuable contributions to the literature, hold significance.

Our study has several limitations. Firstly, no gender-based evaluation was performed in our study. Secondly, our study only analyzed the factors associated with upper extremity functionality after mini-open release surgery. In future studies, we think that gender-based evaluation and factors associated with upper extremity functionality after different surgical techniques should be examined.

CONCLUSION

To the best of our knowledge, the present study is the first study to examine the factors associated with upper extremity functionality after mini-open release surgery in patients with CTS. In this respect, it is thought that the findings of the current study are important and will make important contributions to the literature. It can be concluded that increased pain and symptom severity and decreased hand grip strength are effective in worsening upper extremity functionality in patients with CTS. On the other hand, mini-open release surgery may be effective in improving upper extremity functionality by reducing pain and symptom severity and increasing hand grip strength

in patients with CTS. We think that it may be useful to consider the results of the this study in future research and clinical practice in patients with CTS.

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