Post-Operative Outcome of Surgical Decompression for Carpal Tunnel Syndrome

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ABSTRACT

Introduction: Carpal Tunnel Syndrome (CTS) is the most common compressive neuropathy in the body, which results from median nerve entrapment within the carpal tunnel. Carpal Tunnel Syndrome main features include hand pain and paresthesia, which affect the activity of daily living. Surgical treatment is reserved for severe compression and for those who did not respond to conservative modalities. Longstanding compression of the median nerve may result in irreversible neuropathy, explaining the persistence of symptoms after surgical release.

Method: This prospective observational repeated measure design study was conducted at Royal Rehabilitation Center at King Hussein Medical Center in January – December 2019. Patients who underwent surgical release of CTS were evaluated by Boston Carpal Tunnel Questionnaire (BCTQ) before the surgery and three months after to measure the outcome of surgery.

Results: The outcomes of 176 patients (138 females, 38 males), who were surgically treated for CTS, showed significant improvements at three months after surgery in all items of both elements of BCTQ: Symptom Severity Score (SSS) and Functional Severity Score (FSS).

Conclusions: Surgical release of CTS is an effective intervention to relieve patients' symptoms and improve their function. The improvement in postoperative Boston Scores reflected this result when compared to pre-surgery values. All age groups demonstrated significant improvement in postoperative scores. Memorable, patients older than 40 years showed lower scores than younger age group. CTS- night symptoms improvement was more significant than daytime symptoms.

Keywords: Boston Questionnaire, Carpal Tunnel Syndrome, Hand numbness, Nerve conduction study.

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Introduction

Carpal Tunnel Syndrome (CTS) is the most common compressive neuropathy in the body, which results from median nerve entrapment within the carpal tunnel [1]. Most cases of CTS are idiopathic. However, structural and occupational factors play an essential role [2]. Compression of median nerve manifests by numbness and tingling sensation in radial 3½ digits that worsen at night. Thenar muscle atrophy occurs in severe and longstanding cases, eventually, this leads to hand weakness which might affect daily living activity [3].

accordingly [4] [5]. Conservative treatment is the first management line; this includes NSAIDs, physiotherapy, splinting, and steroid injection [6].

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CTS is diagnosed based on the clinical picture and is confirmed by the Nerve Conduction Study (NCS). NCS can determine the severity of nerve compression, which we depend on to choose the line of treatment Surgery, which is the first option in severe compression cases and in mild and moderate cases that fail conservative treatment, aimed to relief the median nerve compression by releasing the transverse carpal ligament which forms the roof of carpal tunnel. The surgical release can be performed through open or endoscopic techniques. Both procedures have the same long-term outcome, but the advantage of an open procedure over the endoscopic one is that it is a short and cost-effective procedure [7]. However, longstanding CTS might be complicated by neuropathy explaining the persistence of symptoms after surgical treatment [8].

Methods

This is a prospective observational repeated measures design study conducted at Royal Rehabilitation Center at King Hussein Medical Center in January – December 2019. Patients who were diagnosed with severe compression on NCS and those with mild and moderate compression who failed conservative treatment underwent carpal tunnel release.

Patients were evaluated preoperatively on the day of surgery using Boston Carpal Tunnel Questionnaire (BCTQ), which is a CTS-specific scale described in 1993 by Levine et al., it is a measure of the severity of self-reported symptoms and functional status of the patients. BCTQ consists of two elements: Symptom Severity Scale (SSS) and Functional Severity Scale (FSS). SSS includes eleven items, while FSS consists of eight questions. Each item in both scales is represented according to the severity by points from 1 to 5. One point does not reflect any symptoms or disability, while severe symptoms or disability take 5 points [9].

In this article, we use an Arabic translated Levine questionnaire model. When we applied the questionnaire, we found some confusing items for the patients; for example, some patients did not have answers regarding the writing item for being illiterate or evaluated for the non-dominant hand. Furthermore, even when the dominant hand was evaluated, some patients did not answer this item because they did not write for a long time in their life. Therefore, we did not calculate it in the overall average of their score.

Carpal tunnel release was performed in a standard technique by four upper limb surgeons. Surgeries were done under local anesthesia with the application of a tourniquet in all cases. A vertical incision ulnar to palmer crease started jut distal to wrist crease with extension distally for 3 cm towards the projection between 3rd and 4th fingers. The median nerve was released by the transection of the transverse carpal ligament. No neurolysis was done after nerve release. The wound was closed by interrupted 3/0 nylon sutures, and bulky dressing were applied for two weeks.

Patients were encouraged to move their hands and fingers immediately postoperatively, and they were followed after two weeks to check their wounds and remove stitches. A patient who demonstrated wound problems or other complications was followed at four weeks. All patients were followed again at three months, and any complications, as well as their BCTQ, were documented.

We applied BCTQ twice for patients with a bilateral release for each hand separately; this was not confusing for patients as the minimum time between the two surgeries were three months. Some patients did not attend the three-months follow-up appointment; therefore, the questionnaire was completed by contacting them through the phone. Patients' ages, gender, comorbidities, and NCS values were obtained and recorded.

Two hundred and nine patients were operated on for CTS at Royal Rehabilitation Center from January to December 2019. Only 33 patients did not attend for the follow-up of three-month and did not answer the phone survey. Therefore, they were excluded from the study due to a lack of postoperative follow-up. One hundred seventy-six patients were evaluated before and three months after surgery and were included in this study.

This study has been approved by the local ethical committee of the Jordanian Royal Medical Services. Verbal consent for the study and a written one for the surgery were obtained from all the patients.

STATISTICAL DATA ANALYSIS

The means and standard deviations were used to describe the continuously measured variables and the frequencies and percentages for the categorically measured variables.
In addition, the Kolmogrove-Smirnove statistical test and the Histograms were used to assess the statistical Normality assumption of metric variables. The Levenes test was used to assess the equality of statistical variance assumption for continuous variables across the levels of categories.
The Cronbach's alpha (α) test was used to assess the reliability of the Boston Carpal Tunnel Syndrome Questionnaire (BCTQ) indicators. In addition, the Paired samples t-test was used to assess the statistical significance of mean differences on patients measured BCTQ Symptom and functionality scores between their pre & post-surgical periods, the magnitude of change in the patients measured outcomes were expressed as Cohen's D effect size statistic for the paired samples t-test.

To understand better how the surgical intervention may have affected the patients symptoms and functionality while controlling for the patients' measured covariates (namely: the patient's age, gender, affected extremity, and time), the data was transposed from wide-to-long data using the data restructuring feature in the analysis program, the resulted restructured data matrix contained (N=176*2 repeated measures= 352 patient records) then the Generalized Linear Mixed Models (GLMM) were applied to the restructured data in order to assess the effect of the surgery on patients measured burden of symptoms and functionality scores accounting for the covariates measured by the study.
The SPSS IBM version 21 was used for the data analysis, and the alpha significance level was considered at 0.050 level.

RESULT

One hundred seventy-six patients diagnosed with Carpal Tunnel Syndrome (CTS) were enrolled electively into the study. The (table I) demonstrated the patients' sociodemographic characteristics.
The majority of patients (78.4%) were females. The mean age of the patients' sample was equal to 51.77 (± 13.83) years, with a range of 72 years (15 – 87years). However, most of the patients (55.1%) were older than fifty years. The right hand was affected in 59.7% of cases. In addition, 15 (8.5%) patients were operated on for both hands, and they were analyzed separately for each hand.

According to NCS-based CTS severity, 98(55.7%) patients had severe compression, 74 (42%) patients had moderate compression, and only 4(2.3%) patients had mild compression. This is explainable because mild and moderate cases were treated conservatively, and just those who failed non-surgical treatment underwent surgical release while all severe cases planned for surgery from the first presentation.

Four patients (2.3%) were complicated by wound infection, and they were treated by antibiotics and dressing. Eleven patients (6.25%) developed wound dehiscence, all those patients had diabetes, and their wound healed uneventfully after one to two weeks of simple wound care.

Table-I: Descriptive analysis of the patients' sociodemographic and presenting complaints. N=176.

	Frequency	Percentage
Gender		
Female	138	78.4
Male	38	21.6
Age (years) -Mean (SD)		51.77 (13.83)
Age groups		
≤30 years	11	6.3
31-40 years	28	15.9
41-50 years	40	22.7
>50 years	97	55.1
Affected extremity		
Left hand	71	40.3
Right Hand	105	59.7
Presenting complaints severity		
Mild	4	2.3
Moderate	74	42
Severe	98	55.7

Regarding the BCTQ results, the values were calculated by taking the average of all results for each patient individually then by calculating the average of all patients together; this was done separately for each score: SSS and FSS. The results showed that SSS preoperatively for all patients was 3.88, and the FSS was 3.71. At three months follow up after CTS release, they were 2.14, 2.15 respectively, as shown in (Figure 1).

Similarly, the results were measured for each gender independently. For males, the SSS score was 3.78, and FSS was 3.59. Three months post-surgery, they improved to 2.02, 2.06, respectively. For females, the SSS score before surgery was 3.91, which improved to 2.18 after surgery. Correspondingly, FSS decreased from 3.74 to 2.17.

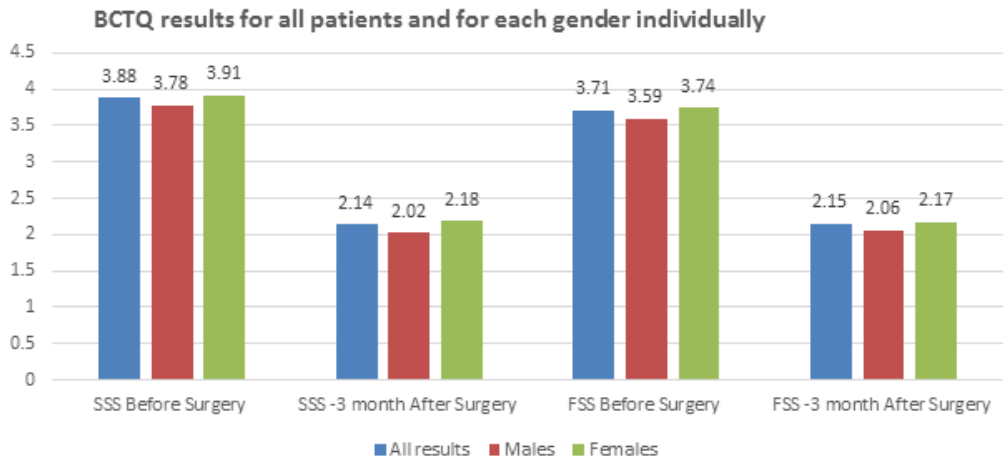


Figure 1: Boston Carpal Tunnel Questionnaire Results

To assess the magnitude and significance of the change in the CTS diagnosed patients perceived overall symptoms and functionality scores, the paired samples t-test was used to compare the patients' baseline measured overall mean scores on those outcomes before and after the surgery.

Firstly, (Table II) showed that the patients overall mean perceived CTS symptom score was rated with 3.88 points out of 5, SD=0.66 points, which is expressed verbally as being medium to severe before the surgery, and this had declined to 2.14 out of 5 points (which is between slight to medium symptom severity on average) at three months after the surgical intervention. The paired samples t-test showed that there had been a statistically significant decline in patients' symptoms scores, and the Cohens' D suggested a significantly high improvement in patients' symptoms in general, Cohens D= 1.64, $p<0.001$.

However, the CTS diagnosed patients' overall mean functional difficulty was rated with a 3.71 out of 5 collective points, indicating moderate to intense difficulty. However, this difficulty declined with surgery to 2.15 out of 5 points on average at three months' time points; the decline in the patients' perceived difficulty was statistically significant, $p<0.001$. According to the paired samples t-test and the size of the change in patients' difficulty was high, Cohen's D=1.78, denoting a significant decline in patients' collective difficulty at three months after the surgery according to the Cohen's D effect size statistic.

Table-II: Descriptive analysis and bivariate analysis of the patients' overall (BCTQ) domains of symptom severity and functionality before and after the surgery. N=176

	Before surgery	**3 months after surgery**	**Mean difference (95% C.I)**	**Cohen's D**	**p-value**
SSS, mean (SD)	3.88 (0.66)	2.14 (0.97)	1.74 (1.61 :1.88)	1.642	<0.001
FSS, mean (SD)	3.71 (0.70)	2.15 (0.99)	1.55 (1.41:1.70)	1.682	<0.001

In order to ascertain the effect of the surgery on CTS diagnosed patients' symptoms and difficulty; the analysis went a further step, the Generalized Linear Mixed Methods (GLMM) was used to regress the patients self-rated symptoms score from before-to-after the surgery accounting for the patients' covariates (age, gender, affected side and time points pre and post the surgery). The data was transposed from wide to long data, and the multivariate analysis was conducted on the patients' measured vector of symptoms and difficulty each in a separate analysis model. (Tables III and IV).

The GLMM analysis of patients' symptoms score showed that the patients' gender did not significantly affect their measured symptoms before and after the surgery, $p=0.228$. However, the analysis model showed that patients aged > 40 years compared to the younger group demonstrated significantly greater symptoms on average, $p<0.001$, indicating that patients aged >40 may still experience significantly higher symptoms on average than younger patients before and after surgery, note (Figure 3). Nonetheless, the analysis model showed that the patients' CTS affected extremity side did not converge significantly on their mean symptoms score, $p=0.250$. Nevertheless, the analysis model showed that the patients measured symptoms score significantly less at three months after the surgery than their pre-surgical symptoms score on average, $p<0.001$, well by considering the other predictors as accounted for in the analysis model.

Table-III: Multivariate Generalized Linear Mixed Method Analysis of the CTS patients' symptom severity score from before and after surgery. N= 352.

	Beta coefficient	95% C.I Beta		p-value
		Lower	*Upper*	
Intercept	3.596	3.365	3.773	<0.001
Gender = Male	-0.158	-0.415	0.099	0.228
Age > 40 years	0.358	0.164	0.552	<0.001
Affected side= Right extremity	0.118	-0.09	0.326	0.250
Time: 3 months post-surgery	-1.744	-0.1882	-1.607	<0.001

Dependent variable= The patients measured symptoms score.

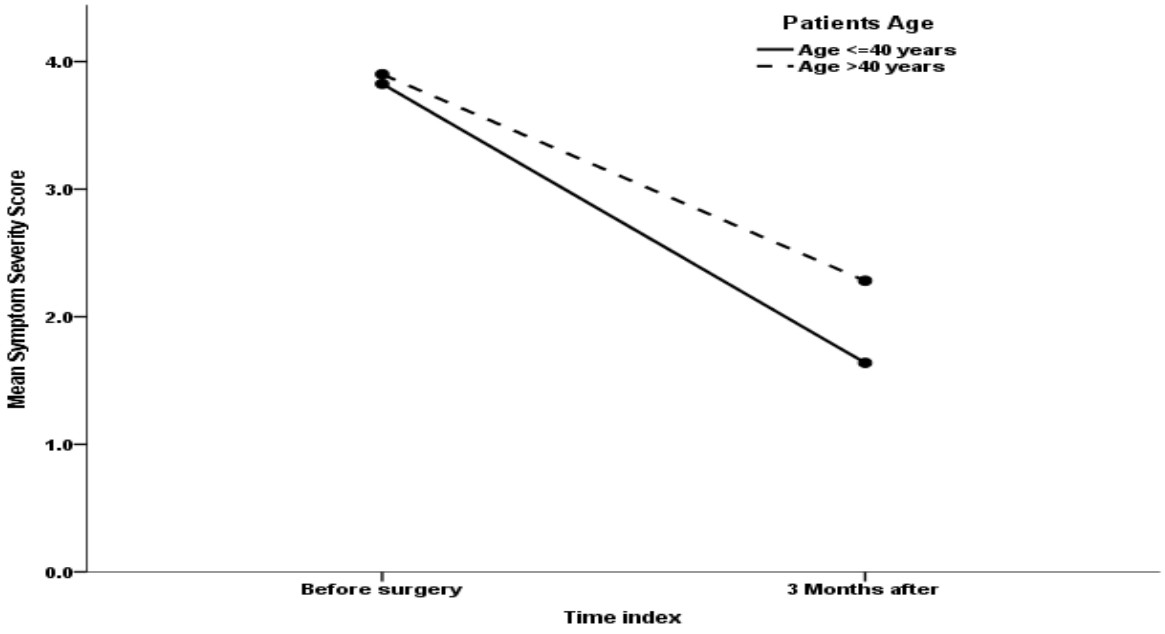


Figure-2: The association between time and carpal tunnel syndrom patients symptoms before and after the surgery accounting for age as a subgroup analysis.

In the same manner, the GLMM was used to regress the patients measured difficulty (self-rated functionality) due to their CTS from before to after the surgery, (Table VI), the yielded multivariate analysis model showed that the patients' gender and affected hand did not converge significantly on their mean self-rated difficulty score, p>0.050 each respectively. However, the multivariate analysis model showed that patients aged >40 years measured significantly more incredible difficulty before and after the surgery on average than those aged ≤ 40 years, p=0.012.

Furthermore, the patients perceived CTS difficulty was significantly less at three months' post-surgery than at baseline before the surgical intervention had been implemented to their extremity, p<0.001. Figure-3 shows that the patient's functional difficulty declined substantively from before to 3-months after the surgery for all patients, but evidently, patients aged >40 years still have significantly greater difficulty regardless of the surgical intervention.

Table-IV: Multivariate Generalized Linear Mixed Method Analysis of the CTS patients' functionality from before to after the surgery.

	Beta coefficient	95% C.I Beta		p-value
		Lower	*Upper*	
Intercept	3.395	3.131	3.658	<0.001
Sex=Male	-0.14	-0.402	0.122	0.293
Age>40 years	0.295	0.066	0.523	0.012
Affected side= Right extremity	0.193	-0.03	0.416	0.193
Time: 3 months post-surgery	-1.555	-1.692	-1.417	<0.001

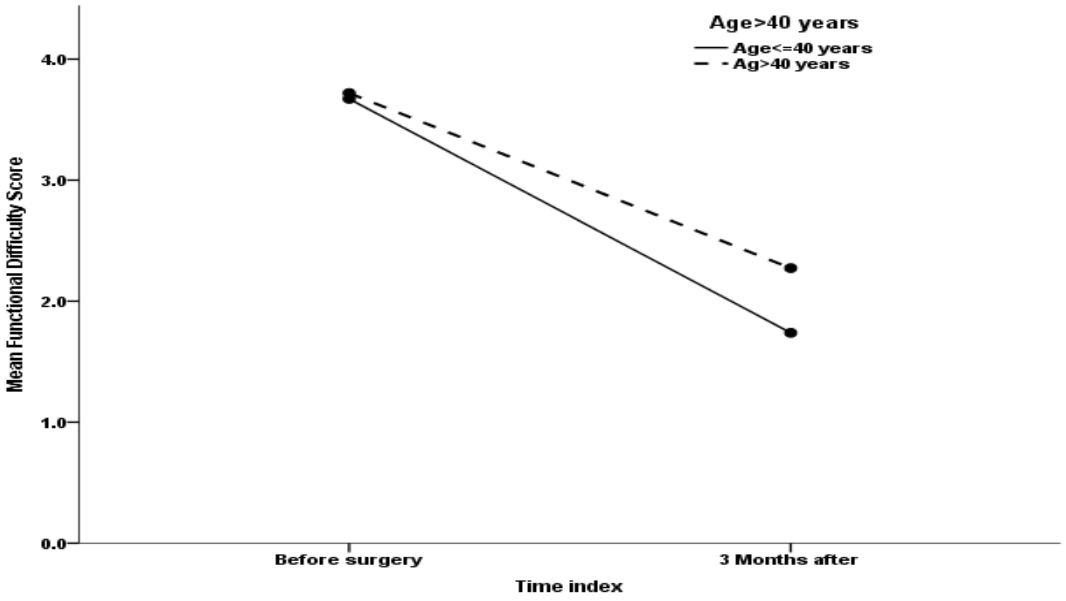


Figure-3: The association between time and carpal tunnel syndrom patients self-rated funcitonal difficulty before and after the surgery accounting for age as a subgroup analysis.

The Cronbach's alpha test was used to assess the reliability of the indicators measured with the BCTQ. The resulted findings from the analysis showed that the BCTQ indicators were measured reliably, Cronbach's alpha=0.97 at baseline and 0.98 after three months from the surgery.

The descriptive analysis and paired samples t-test analysis findings for the patients' repeated measures of the BCTQ are displayed in the (Table V).

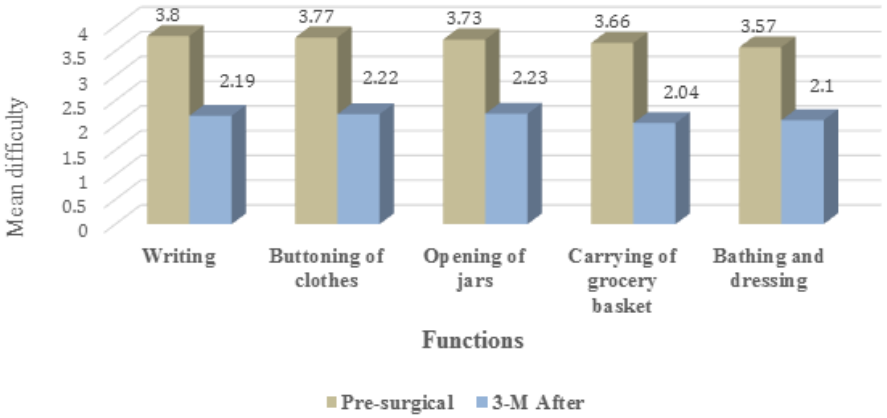
The resulted findings from the analysis showed that all the indicators of the patients CTS symptoms had declined significantly three months after patient'sery with no exception, $p<0.001$. Also the yielded analysis from comparing the CTS diagnosed patient's perceived indicators of functionality showed that all these indicators of difficulty had declined substantially and statistically significantly at three months from the surgery compared to baseline (Figure 4) measures of difficulty doing clothes buttoning, writing, opening jars, carrying grocery bags, and self-bathing, $p<0.001$ each, respectively, according to the paired samples t-test. However, the table-5 displays the computed Cohen's D effect size statistic to depict the magnitude of change in these patients' perceived indicators of CTS symptoms and difficulty. Column number 5 displays the ascending rank order of the effect size for each compared indicator of pain and difficulty; the resulted pattern suggested that the top decline in patients' symptoms were assigned to nightly pain, rate of being awakened up due to pain at night, then hand numbness. At the same time, the lowest change was observed in the patients' daytime perceived pain intensity, frequency of pain episodes, and the duration of the pain during the daytime. This latter finding highlights the difference in the relieving symptoms between night and day times.

Table-V: Descriptive analysis of the Carpal tunnel syndrome diagnosed patients' indicators of disease symptoms and functionality before and after the release surgery. N=176

Boston Carpal Tunnel Questionnaire	**Mean (SD)-Likert Rating**		**Cohens D**	**Effect size Rank**	**p-value**
	Before surgery	***After surgery***			
SYMPTOM SEVERITY SCALE					
▪ How severe is the hand or wrist pain that you have at night?	3.95 (0.79)	2.12 (1.11)	1.71	***2***	<0.001
▪ How often did hand or wrist pain wake you up during a typical night in the past two weeks?	3.95 (.79)	2.16 (1.02)	1.77	***1***	<0.001
▪ Do you typically have pain in your hand or wrist during the daytime?	3.90 (0.75)	2.23 (1.17)	1.51	***10***	<0.001
▪ How often do you have hand or wrist pain during daytime?	3.79 (0.78)	2.22 (1.10)	1.48	***11***	<0.001
▪ How long on average does an episode of pain last during the daytime?	3.80 (0.76)	2.12 (1.12)	1.57	***9***	<0.001
▪ Do you have numbness (loss of sensation) in your hand?	3.91 (0.64)	2.19 (1.10)	1.673	***3***	<0.001
▪ Do you have weakness in your hand or wrist?	3.89 (0.81)	2.12 (1.13)	1.62	***7***	<0.001
▪ Do you have tingling sensations in your hand?	3.81 (0.73)	2.12 (1.05)	1.67	***4***	<0.001
▪ How severe is numbness (loss of sensation) or tingling at night?	3.86 (0.77)	2.11 (1.10)	1.65	***6***	<0.001
▪ How often did hand numbness or tingling wake you	3.83 (0.86)	2.10 (1.02)	1.67	***5***	<0.001
▪ Do you have difficulty grasping and using small objects such as keys or pens?	3.84 (0.82)	2.11 (1.11)	1.59	8	<0.001

FUNCTIONAL STATUS SCALE					
▪ Writing	3.80 (0.79)	2.19 (1.07)	1.535	*2*	<0.001
▪ Buttoning of clothes	3.77 (0.76)	2.22 (1.08)	1.486	*3*	<0.001
▪ Opening of jars	3.73 (0.79)	2.23 (1.11)	1.396	*5*	<0.001
▪ Carrying of grocery basket	3.66 (0.73)	2.04 (1.02)	1.638	*1*	<0.001
▪ Bathing and dressing	3.57 (0.72)	2.10 (1.10)	1.405	*4*	<0.001

Figure-4: The carpal tunnel diagnosed patients perceived functionality before and after the release surgery



DISCUSSION

Post-Carpal Tunnel release outcome is an important measure to be identified to reflect the effectiveness of the intervention. Many measures are available to calculate the outcome, but the drawback is that most of them are subjective ones and focus on symptoms or function and return to daily living activity. Other measures use objective parameters such as neuro-electrical findings. Nevertheless: patient's self-reported measures are believed to be more reliable than those elicited by physical exam.

Boston Carpal Tunnel questionnaire addressing both symptoms and function; it used standardized worldwide clear tasks designed for CTS. Therefore, the Boston questionnaire is wildly accepted, reproducible, and validated measures of CTS outcome.

Levine et al., who developed Boston Questionnaire, applied it on thirty-eight patients. After 14 months, the mean symptom-severity score improved from 3.4 points preoperatively to 1.9 points, while the mean functional-status score improved from 3 to 2 points. Levine reproduced his study again on twenty-six patients evaluated after three months of surgery and got comparable results to the previous study [9].

Padua et al. compared results in Boston Questionnaire and electrophysiological findings before carpal tunnel release, then at one and 6-month post-surgery; both measures showed significant improvement at one and six-month follow-up. Nevertheless, the study found no correlation between nerve conduction results and Boston score values [10]. Another comparative study by Mumcu et al. showed similar significant improvement in

NCS and BCTQ at three and six-month follow-up post-surgery without observing any correlation between improvements in nerve conduction and the questionnaire scores [11].
Louie et al. reviewed English language literature for long-term outcomes on carpal tunnel release. Long-term is defined as more than two years after surgery. They found out that carpal tunnel release (open and endoscopic) was a highly effective procedure, but some aspects need further studies to better understand long-term outcomes like recurrence and electromyographic data [12].
Our study analyzed the overall outcome of surgical decompression of CTS by BCTQ at three months follow-up. Not only so, but we also did further analysis to reflect the change on each item of both elements of BCTQ. After surgical release, there was a significant improvement on both symptom severity score and functional status scale. Patients younger than forty demonstrated lower preoperative severity scores on SSS and FSS and superior improvement after surgery. Although the improvement on both elements of BCTQ was significant, the symptoms revealed superior results. Not only that, the postoperative improvement on the score was significant in all items of BCTQ. Number of times that patients awake at night and hand and wrist pain were the most significant and dramatic improvements on patients' symptoms, followed by improved numbness in hands. Daytimes symptoms also significantly improved regardless it demonstrated the lowest ranks. Similarly, all FSS items demonstrated a significant reduction in severity but to a lesser extent than SSS items.

LIMITATION OF THE STUDY

In this study, we believe that three months is a short follow-up period since patients need longer rehabilitation time for recovery. Therefore, we are looking to reproduce this study on those patients after a longer follow-up time. We may add objective measures as nerve conduction study together with the subjective one: BCTQ.

CONCLUSION

This study showed that surgical release of CTS is an effective intervention in relieving patients' symptoms and improving their function. These results demonstrated by improving in BCTQ scores which is a widely accepted measure to assess CTS severity. Improvement in symptoms and function were more noticeable on patients less than 40 years. Additionally, patients demonstrated better night outcome improvement rather than the daytime results.

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