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Original Article

Is Boston questionnaire an alternative to electromyography for evaluation of the surgical outcome for carpal tunnel syndrome?

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ABSTRACT

Objectives: This study aims to identify the optimal follow-up method for evaluation of the surgical outcome for carpal tunnel syndrome (CTS).

Patients and methods: Between January 2006 and December 2010, 61 hands of a total of 46 patients (7 males, 39 females; mean age 56.0±10.4 years; range, 20 to 71 years) with a diagnosis of CTS were retrospectively analyzed. All operations were performed by a single surgeon with a mini-incision distal to the transverse carpal ligament. At a mean follow-up of seven years after surgery, electromyography (EMG) was repeated for all patients. The Boston Carpal Tunnel Questionnaire (BCTQ), Boston Symptom Severity Scale, Boston Functional Status Scale, palmar pinch strength, grip strength, and EMG of the patients were compared before and after surgery.

Results: The mean follow-up was 84±10 (range, 72 to 104) months. There were significant improvements in the Boston Symptom and Functional Scale scores postoperatively, as well as in the grip and pinch strength. After surgery, EMG findings improved in 83.6% of the patients. However, there was no significant correlation between pre- and postoperative Boston Symptom Severity Scale scores, functional status, pinch and grip strengths, and pre- and postoperative EMG results.

Conclusion: Our study results demonstrate that the symptom severity and functional status scores of the BCTQ are favorable, and this tool is reliable and easy-to-apply for the diagnosis and follow-up of CTS surgeries.

Keywords: Boston scale, carpal tunnel surgery, carpal tunnel syndrome, correlation, electromyography.

Carpal tunnel syndrome (CTS) is the most common entrapment neuropathy among women aged between 40 and 60 years with an incidence in the general population of 2 to 3%.[1-5] Symptoms of CTS include tingling and burning sensations, sensory loss, weakness, and pain in the median nerve sensory area. Latency in nerve conduction velocity can be measured objectively by electrophysiological evaluations.[6] Provocative tests, such as the Tinel's test, Phalen's test and reverse Phalen's test, can be performed during the physical examination. Various clinical, radiological and electrophysiological methods, and various types of questionnaires (i.e., Disabilities of the Arm, Shoulder, and Hand [DASH], Michigan Hand Outcome Questionnaire [MHQ], and Boston Carpal Tunnel Questionnaire [BCTQ]) have been developed for the pre- and postoperative evaluation of the surgical outcomes for CTS. The most specific of these methods is the Boston scale, as described by Levine et al.[7] Although some patients may have problems adjusting to BCTQ, it is a reliable, repeatable, and self-consistent questionnaire.[7,8] However, it still remains unclear whether a physical examination, the Boston scale or electromyography (EMG) is the most effective follow-up method for the evaluation of surgical outcomes for CTS.

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In the present study, we aimed to identify the optimal follow-up method for the evaluation of the surgical outcome for CTS.

PATIENTS AND METHODS

In this retrospective study, surgical outcomes of 61 hands of a total of 46 patients (7 males, 39 females; mean age 56.0±10.4 years; range, 20 to 71 years) diagnosed with CTS and operated between January 2006 and December 2010 were retrospectively reviewed. All surgeries were performed by a single surgeon with a mini-incision distal to the transverse carpal ligament. Inclusion criteria were as follows: having regular follow-ups before and after surgery, recording of physical examinations and measurements, and completion of preoperative EMG. At a mean of seven years after surgery, EMG was repeated for all patients. Those with peripheral neuropathy, having an old fracture of the wrist, a known anomaly and/or recurrent CTS were excluded from the study. A written informed consent was obtained from each patient. The study protocol was approved by Medicine Faculty of Akdeniz University Ethics Committee. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Carpal tunnel syndrome was diagnosed based on clinical examination findings of patients who described night and day pain, weakness, median nerve sensory region numbness, and paresthesia. Assessment of atrophy of the thenar muscles, provocative tests (Tinel's test, Phalen's test, and carpal tunnel compression test), upper extremity motor-sensory examination, and the palmar pinch and grip strength were performed during the physical examination. Evaluations for grip strength and pinch strength were made using a Jamar® dynamometer (Baseline® Hydraulic Hand Dynamometer; White Plains, NY, USA) and a mechanical pinch gauge (Baseline® Mechanical Pinch Gauge; White Plains, NY, USA), respectively. All measurements were done in a position that arms of the patients were parallel to the body with the elbow flexed at 90°, and the forearm and wrist in a neutral position. Three measurements with the maximum possible force were made per test, and the average values were calculated in kg-force. The dominant hand and the operated side of the patients were recorded.

Neurophysiological studies were performed by a single investigator using EMG (Viasys Healthcare, Madison, WI, USA) and findings of EMG were evaluated on the basis of the following neurophysiological classification:[9] Extreme CTS: absence of thenar motor (and sensory) response; Severe CTS: absence of median sensory nerve action potentials (SNAPS) (digit-wrist segment) and abnormal distal motor latency (DML); Moderate CTS: slowing of median digit-wrist segment and abnormal DML; Mild CTS: slowing of median digit-wrist segment and normal DML; Minimal CTS: Standard negative hands with abnormal comparative or segmental (<7-8 cm) tests; Negative: normal findings in all tests (including comparative or segmental tests).

The physical examination results (Phalen's and Tinel's tests, carpal tunnel compression test, thenar atrophy, grip and palmar pinch strength), responses to the Boston questionnaire, pillar pain, incision site problems, and recurrence were recorded at the postoperative follow-ups. All patients were required to complete the Turkish version of the Boston questionnaire.[10] The results of the Boston Symptom Severity Scale, Boston Functional Status Scale, palmar pinch strength test, grip strength test, and EMG of the patients were compared before and after surgery.

Statistical analysis

Statistical analysis was performed using the IBM SPSS for Windows version 22.0 software (IBM Corp., Armonk, NY, USA). Descriptive data were presented in mean ± standard deviation (SD), median (min-max) or number and frequency. The normality hypothesis was tested using the Shapiro-Wilk test. To determine the significance of differences between pre- and postoperative values of the two measurements, the Wilcoxon test for data without normal distributions and paired t-test were performed with normal distributions. The Spearman correlation test was performed to evaluate the relationship between ordinal or continuous variables without normal distributions. The effect size was used to describe the strength of the correlation based on the guide of Evans[11] for the absolute value of r: 0.00-0.19: "very weak"; 0.20-0.39 "weak"; 0.40-0.59 "moderate"; 0.60-0.79 "strong"; 0.80-1.0 "very strong". A p value of <0.05 was considered statistically significant.

RESULTS

Surgery was performed for both hands in 15 of 46 patients (13 were females and 2 were males). For those who underwent bilateral surgery, the mean duration

TABLE 1
Changes in EMG values before and after surgery

	Preoperative EMG							
	1		2		3		*Total*	
Postoperative EMG	n	%	n	%	n	%	n	%
0	1		8		2		11	18.0
1	3		21		14		38	62.3
2	0		4		5		9	14.8
3	0		0		3		3	4.9
Total	4	6.6	33	54.1	24	39.3	61	

EMG: Electromyography.

from the first to the second surgery was five months. The mean duration from the onset of symptoms to surgery was 49±34 (range, 6 to 120) months. The mean follow-up period was 84±10 (range, 72 to 104) months.

Of 61 hands, 32 were left and 29 were right. The dominant side of the operated hands was right in 55 hands and left in six hands. None of the patients had pillar pain, incision site problems, or recurrence postoperatively.

In EMG evaluation, 0 indicates normal, 1 indicates mild, 2 indicates moderate, and 3 indicates severe. A significant improvement was found between the preoperative (median: 2; range, 1 to 3) and postoperative EMG values (median: 1; range, 0 to 3) (z: -6,394; p<0.001 WSRT). Postoperative EMG findings improved (mild, moderate) in the patients who had advanced EMG findings (moderate, severe) preoperatively, and there was a significant correlation between them.

On the preoperative EMG evaluation of 61 hands, four (6.6%) were found to be mild, 33 (54.1%) to be moderate, and 24 (39.3%) to be severe. Postoperative EMG findings were found to be normal in 11 (18%), mild in 38 (62.3%), moderate in nine (14.8%), and severe in three (4.9%) cases. After surgery, EMG findings improved in 83.6% of patients. The EMG findings of 24 (39.3%) hands which were severe preoperatively improved to normal in two hands, mild in 14, and moderate in five postoperatively. For three hands, there was no change in the EMG findings (Table 1).

There was a significant improvement between the mean pre- and postoperative Boston Symptom Severity Scores (3.6±0.6 [range, 2.36 to 4.72] vs. 1.2±0.3 [range, 1 to 2.54], respectively, z: -6.799; p<0.001; WSRT, Table 2), as well as between the mean pre- and postoperative Boston Functional Status Score (3.4±0.7 [range, 1.87 to 4.87] vs. 1.3±0.3 [range, 1 to 2.12]), respectively z: -6.795, p<0.001; Table 2).

There was also a significant improvement between the mean pre- and postoperative rough grip strength measurements (21±6.0 vs. 25±6.0, respectively, t: -12,99; p<0.001; paired t-test) and palmar pinch strength measurements (7.3±2.6 vs. 9.6±2.7, respectively, t: -12,55; p<0.001; paired t-test; Table 2).

There was no significant correlation between EMG results and both pre- and postoperative Boston Symptom Severity Scale, functional status, pinch

TABLE 2
Changes between preoperative and postoperative Boston symptom severity scores and Boston functional status, grip strength and palmar pinch strength

		Preoperative			Postoperative				
	n	Mean±SD	Median	Min-Max	Mean±SD	Median	Min-Max	Test	*p*
Boston symptom*	61	3.6±0.6	3.63	2.36-4.72	1.2±0.3	1.09	1-2.54	z: -6.799	<0.001
Boston functional*	61	3.4±0.7	3.5	1.87-4.87	1.3±0.3	1.25	1-2.12	z: -6.795	<0.001
Palmar pinch†	61	7.3±2.6	7	3-14	9.6±2.7	9	4-15	t: -12.992	<0.001
Grip strength†	61	21±5.7	20	9-34	25.4±5.9	24	12-40	t: -12.55	<0.001

SD: Standard deviation; Min: Minimum; Max: Maximum; * Wilcoxon Signed-Rank Test; † Paired t test.

TABLE 3
Correlation between postoperative Boston score and pinch and grip strength

	Pinch (postoperative)	Grip (postoperative)
Boston symptom postoperative		
r	-0.140	-0.093
p	0.281	0.475
Boston functional postoperative		
r	-0.258*	-0.251
p	0.045	0.051
Grip strength postoperative		
r	0.658*	-
p	<0.001	-

* p<0.05; Spearman Correlation Test; r: Spearman Correlation Coefficient.

strength, grip strength (max r: 0.188 and p>0.05). There was no statistically significant correlation between preoperative Boston Functional Status Score and Boston Symptom Severity between preoperative pinch and grip strengths (Max r: -0.229 and p>0.05). However, a significant strong positive correlation was found between preoperative grip and pinch strength measurements (r: 0.703; p<0.001).

There was no significant correlation between postoperative Boston Symptom Severity Scale scores and the postoperative pinch (r: -0.140; p>0.05) and grip strength (r: -0.093; p>0.05) measurements. The postoperative functional status and grip strength (r: -0.258; p=0.045) were weakly, negatively, and significantly correlated. However, the postoperative functional status and pinch strength were at borderline, not significantly correlated (r: -0.251; p=0.051; Table 3). There was a moderate, positive, and significant correlation between the Boston Symptom Severity Scale scores and function status before and after surgery (r: 0.466; p<0.001).

Relative differences between all pre- and postoperative measurements were calculated (differences: preoperative value - postoperative value/ preoperative value). There was a higher decrease in the Boston Symptom Severity Scale than the functional scores (z: -0.404; p<0.001). The values of the pinch test also increased more than those of the grip test (z: -4.51; p<0.001, Table 4, Figure 1).

There was no significant relationship between the relative differences of pre- and postoperative EMG recordings relative to other four measurements (max r: 0.184; p>0.05). However, there was a moderate, positive, and significant correlation between relative

TABLE 4
Comparison of the proportional difference between preoperative and postoperative values of Boston symptom severity scores and Boston functional status, grip strength and palmar pinch strength

	Median	Min-max	z	*p*
Boston symptom difference ratio	0.69	0.3-0.79	-0.404	<0.001*
Boston functional difference ratio	0.64	0.2-0.77		
Pinch difference ratio	0.27	0.04-1.3	-4.510	<0.001*
Grip difference ratio	0.19	0.06-1.56		

Min: Minimum; Max: Maximum; * p<0.05; Wilcoxon Signed-Rank Test.

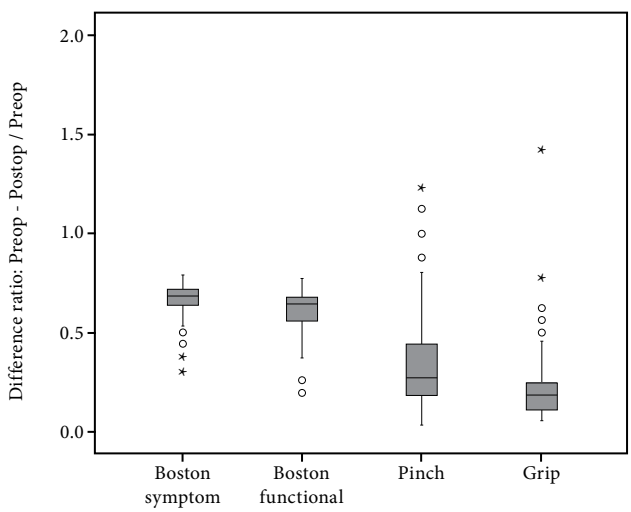

Figure 1. Indications of differences in Boston scale and pinch and grip strength before and after surgery.
Preop: Preoperative; Postop: Postoperative; * Extreme; ○Outlier.

TABLE 5
Correlation between changes in EMG, Boston scale and pinch and grip strengths before and after surgery

	Boston symptom difference ratio	Boston functional difference ratio	Pinch difference ratio	Grip difference ratio
EMG difference ratio				
Spearman correlation coefficient (r)	0.143	0.184	0.066	0.120
p	0.272	0.156	0.613	0.356
Boston symptom difference ratio				
Spearman correlation coefficient (r)		0.453*	0.128	-0.037
p		<0.001	0.325	0.779
Boston functional difference ratio				
Spearman correlation coefficient (r)			0.115	-0.048
p			0.378	0.712
Pinch difference ratio				
Spearman correlation coefficient (r)				0.578*
p				<0.001

EMG: Electromyography; * p<0.05; Spearman correlation test.

differences of the Boston Symptom Severity Scale scores and function status (r: 0.453; p<0.001), as well as between the relative differences of pinch values and grip test results (r: 0.578; p<0.001) (Table 5).

DISCUSSION

Carpal tunnel syndrome is the most common nerve entrapment and the most frequent cause of surgery for hand disease. In patients with mild to moderate CTS, as long as there is no progressive sensory or motor loss on physical examination with an advanced abnormality on the electrophysiological evaluation of patients, the first-line treatment is conservative treatment, which has a success rate varying between 20 and 90%.[12-14] Surgical treatment is reportedly more beneficial than conservative treatment for symptoms of atrophy and weakness that persist for one year or longer, or persistent numbness. For patients with these symptoms, axonal loss should be considered and early surgery should be planned.[15]

Lee and Strickland[16] and Zyluk and Strychar[17] found a significant improvement between pre- and postoperative palmar pinch strengths. However, a study by Klein et al.[18] found no statistically significant improvement in the pinch and rough grip strengths. In our study, we showed a significant improvement in the palmar pinch strength after surgery compared to baseline (mean score, 7 vs. 9, respectively) as well as an increase in the rough grip strength (21 vs. 25 kg, respectively). Zyluk and Strychar[17] reported similar results in a comparison of the distal mini-incision and distal-proximal mini-incision strategies (double incision) (mean value, 16.6 vs. 24.2 kg, respectively).

In previous studies, various scoring systems have been used for the evaluation and standardization of the clinical response to surgical treatment for CTS. These tests are used to evaluate the degree of impairment of the patient preoperatively and to monitor postoperative progress to assess the success of treatment. The most common scoring systems are DASH, Patient Evaluation Measure, MHQ, Upper Extremity Functional Scale, BCTQ, and Hi-Scale.[18] Among these tests, the BCTQ is the most commonly used and most specific tool.[19] Itsubo et al.[20] evaluated 45 patients with the EMG, BCTQ, and DASH before and after surgery to identify possible correlations. Significant improvements were found in EMG and DASH values, but no significant correlation was found between them. In the present study, there were significant improvements in the EMG and BCTQ values after surgery compared to baseline. However, there was no significant correlation between the improvements in EMG and BCTQ values. In a 12-month follow-up study of 138 patients, Svhrijver et al.[21] found that both EMG and Boston functional and symptom scales were significantly improved after surgical treatment. However, they also reported a weak correlation between the EMG and Boston symptom and functional scales and concluded that the EMG and Boston symptom and functional scales were complementary to each other. Chan et al.[22] found

no significant correlation between EMG and Boston symptom and Boston functional scales. However, they indicated that age, sex, and additional diseases were important factors affecting postoperative follow-up, although other studies in the literature found no significant correlation. The authors suggested that possible reasons for these correlations were derived from patient selection, EMG protocol applied, and statistical methods used to evaluate the results and concluded that EMG would be more useful to arrive at a differential diagnosis than patient follow-up. In another study, Zyluk and Strychar[17] found a significant improvement in the pre- and postoperative Boston symptom scores (mean value, 1.1 to 3.3). In the present study, there were significant improvements in the Boston Symptom Severity Scale scores (mean value, 1.09 to 3.63) and the Boston functional status scores (mean value, 1.25-3.50), which are consistent with the findings of previous studies. Bulut et al.[23] studied 39 hands of 38 patients treated surgically with a mini-incision. The patients were evaluated with pre- and postoperative EMG and the Turkish version of the Boston scale. Postoperative EMG and Boston scores of symptom and functional scales were significantly improved, but no significant correlation was found between them. In another study of 44 patients, Heybeli et al.[24] found no significant improvement in the symptom and function scales of the Boston questionnaire.

In the present study, there was a significant correlation between pre- and postoperative Boston Symptom Severity Scale scores and Boston Functional Status Scale scores, indicating that the test results are consistent. The scores of the first scale improved more than the scores of the latter in this study, which is consistent with the findings of previous studies. Moreover, there was a statistically significant improvement between the pre- and postoperative EMG findings. However, we observed no significant correlation between the pre- and postoperative EMG findings, rough grip strength, pinch strength, Boston Symptom Severity Scale scores and functional status.

In addition to rough grip-palmar pinch strength and symptomatic and functional recovery, electrophysiological improvement was also an important finding in the postoperative period, which highlights the superiority of our study, compared to the previous reports in the literature. The present study was also a long-term follow-up study. However, the fact that no other evaluation questionnaire (i.e., DASH or MHQ) was used in our comparison can be considered as the main limitation of this study.

In conclusion, although EMG seems to be more reasonable for the diagnosis and differential diagnosis of CTS, the use of symptom severity and functional status scores of the BCTQ are favorable, and this tool is reliable and easy-to-apply for the diagnosis and follow-up of CTS surgeries.

Declaration of conflicting interests

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