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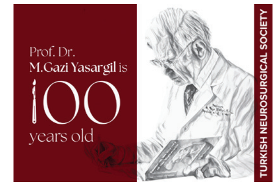

Original Investigation

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Comparison of Preoperative and Postoperative Clinical and Electrophysiological Results of Patients with Carpal Tunnel Syndrome Presenting a Positive Scratch Collapse Test

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ABSTRACT

AIM: To examine the correlation between clinical outcomes and electrophysiological findings following open carpal tunnel release (CTR) surgery in patients with a positive scratch collapse (SC) test, and to the postoperative course of the SC test.

MATERIAL and METHODS: The study included 29 patients who had a positive SC test and a confirmed diagnosis based on nerve conduction study (NCS) findings. The findings of Boston Carpal Tunnel Questionnaire (BCTQ), visual analog scale (VAS), NCS, and SC test were assessed preoperatively and postoperatively at the 2nd and 8th weeks. The correlations between NCS findings and BCTQ and VAS scores were analyzed.

RESULTS: Significant postoperative improvements were observed in BCTQ and VAS scores at the 2nd and 8th weeks. In the 8th week, NCS findings also showed significant improvement; however, no correlation was found between NCS findings and functional scores. The SC test became negative in 89.6% (n=26) of patients postoperatively.

CONCLUSION: In the early period following open CTR surgery, there is no correlation between improvements in NCS findings and functional scores. However, in 90% of patients with a positive preoperative SC test, the test became negative early after the open CTR surgery. Therefore, the SC test can be used to evaluate postoperative treatment results because it is easily applicable, repeatable, and cost-effective compared with NCS.

KEYWORDS: Carpal tunnel, Scratch collapse, Nerve conduction study, Boston carpal tunnel questionnaire, Postoperative period

ABBREVIATIONS: SC: Scratch collapse, **NCS:** Nerve conduction study, **VAS:** Visual analog scale, **BTCQ:** Boston carpal tunnel questionnaire, **CTS:** Carpal tunnel syndrome, **CTR:** Carpal tunnel release, **EMNG:** Electroneuromyography, **DML:** Distal motor latencies, **CMAP:** Combined muscle amplitude potential, **AAEM:** American Association of Electrodiagnostic Medicine, **SCV:** Sensory nerve conduction velocity, **SSS:** Symptom severity scale, **FSS:** Functional status scale

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INTRODUCTION

Carpal tunnel syndrome (CTS) is the most common compression neuropathy. Although entrapment neuropathies affect a localized portion of the nerve, they can lead to significant physical, psychological, and economic consequences. Although physical examination alone is often sufficient for diagnosis, electroneuromyography (ENMG) is used to confirm the diagnosis and assess disease severity (22). Demyelination is the primary pathological mechanism in compression neuropathies; however, axonal damage may also develop in advanced stages (27). Several studies have shown that electrophysiological findings may not improve postoperatively, even when patients experience symptomatic and functional relief (15,24). Although various studies have compared conservative and surgical treatments for CTS, there is no proven scale to evaluate the treatment results of these entrapment neuropathies except for clinical assessments (4,18).

The scratch collapse (SC) test is a physical examination technique used in entrapment neuropathies, offering high sensitivity and specificity compared to other diagnostic maneuvers (5). In this test, the examiner gently scratches the skin over the nerve compression site for a few seconds while the patient resists external shoulder rotation. Following scratching, a sudden loss of muscle resistance occurs. The exact mechanism of the SC test remains unclear. However, it is believed that either the cutaneous silent period (CSP) or elevated levels of substance P, a neurotransmitter, may cause a sudden decrease in muscle strength as a protective mechanism against pain (3).

Postoperative clinical evaluations, ultrasonographic measurements, and nerve conduction study (NCS) findings often yield inconsistent results when assessing surgical outcomes (4,16,18). Additionally, there is no consensus on the optimal timing for these assessments.

This study aimed to investigate the postoperative electrophysiological and clinical outcomes in patients with moderate to severe CTS who did not benefit from conservative treatment and to analyze the change in nerve conduction velocities after surgery. It further aimed to determine the role of NCS and SC test in postoperative follow-up.

MATERIAL and METHODS

This retrospective, observational clinical study was approved by the Ankara Etlik City Hospital, Local Institutional Ethics Committee (decision no:2024-635, date: 17/07/2024). The study was conducted jointly at two care centers: secondary and tertiary.

Between January 2022 and 2024, patients aged 18–75 years who had NCS findings consistent with CTS, a positive SC test, and who underwent open carpal tunnel release (CTR) surgery were included. During retrospective screening, the following were excluded: 392 patients owing to missing study parameters [Boston Carpal Tunnel Questionnaire (BCTQ), postoperative NCS, visual analog scale (VAS)], 3 patients with revision surgeries, 13 patients with polyneuropathy, 27 patients with diabetes mellitus, 2 patients with thyroid disease, and 4 patients with cervical radiculopathy. Of the remaining 65 patients, 35 had a negative SC test and were excluded. As a result, 29 patients were included in the study. All surgeries were performed by two surgeons using a standard open incision technique under local anesthesia. Patients were discharged the same day and followed up postoperatively at the 2nd and 8th weeks. Preoperative and 8-week postoperative ENMG evaluations were performed by two neurologists.

Parameters Analyzed in the Study

ENMG: Distal motor latency (DML), combined muscle amplitude potential, motor conduction velocity, and sensory conduction velocity were evaluated during the preoperative and 8th-week postoperative ENMG evaluations. NCS findings were classified by neurologists according to the recommendations of the American Association of Electrodiagnostic Medicine (AAEM) during the preoperative and postoperative periods (26). NCS was performed using a Neuropack S1 MEB-9400K (Nihon Kohden, Tokyo, Japan), with filter settings between 20 and 2000 Hz. The median nerve compound muscle action potential, DML, and motor nerve conduction velocity were measured by orthodromically stimulating the median nerve at the wrist, with recording electrodes placed on the abductor pollicis brevis muscle. Sensory nerve conduction velocity was recorded at the wrist using antidromic stimulation with ring electrodes placed around the proximal and middle phalanges of the second finger. The skin temperature of the hand was maintained between 32°C and 34°C.

BCTQ: It is the most commonly used test for evaluating and standardizing treatment outcomes in entrapment neuropathies. This scale provides symptomatic and functional assessment. It consists of two subscales. The symptom severity scale (SSS) contains 11 questions; each question is scored from 1 (mildest) to 5 (most severe). The mean score (sum of scores/11) is calculated. The functional status scale (FSS) contains eight questions assessing difficulty with performing daily tasks, each scored from 1 to 5. The mean score (sum of scores/8) is calculated. In both scales, the maximum score is 5, and the magnitude of the score determines the severity of symptoms and disability. This score was evaluated preoperatively and postoperatively at the 2nd and 8th weeks.

SC test: This test evaluates for a sudden decrease in muscle strength after scratching the nerve compression site. This test was performed preoperatively and postoperatively at the 2nd and 8th weeks, with all evaluations conducted by the same surgeon. A positive test response is characterized by a momentary loss of voluntary strength in a specific muscle group in the limb, and it has been associated with CSP. CSP refers to the withdrawal response of a limb to a noxious stimulus, functioning as an inhibitory spinal reflex mediated by A-delta fibers. This reflex has also been demonstrated using EMG (9,17). Another theory suggests that substance P plays a role in the effectiveness of the test. In normal tissues, the scratching stimulus does not evoke a response; however, in areas of nerve damage, it triggers an allodynic response, potentially leading to excessive release of substance P. Histopathological studies have documented increased levels of substance P in nerve and surrounding tissues obtained from patients undergoing open CTR surgery (23). Furthermore, substance P levels are known to increase in peripheral nerve endings following nerve damage or in chronic inflammatory conditions (7). This correlation between elevated substance P and nerve damage may help explain the reflexive muscle collapse observed in a positive SC test (14).

VAS: This was used to assess pain intensity. It consists of a 10 cm line with endpoints representing 0 (no pain) and 10 (worst imaginable pain).

Statistical Analysis

All analyses were conducted using the Jamovi Project (2022, Jamovi Version 2.3, Computer Software). The findings of this study are expressed as frequencies and percentages. Normality analysis was assessed using the Shapiro–Wilk test, skewness, kurtosis, and histograms. Categorical variables were presented as absolute numbers with percentages. Continuous variables were compared between responders and nonresponders using the Mann–Whitney U-test and Kruskal–Wallis H-test, and are presented as medians with interquartile ranges. Categorical data were compared using the chi-squared test or Fisher's exact test, as appropriate. Changes in VAS, BCTQ-SSS, and BCTQ-FSS scores were analyzed using the Friedman test, and ENMG findings were compared using the Wilcoxon signed-rank test. Spearman's correlation was used to investigate associations among BCTQ, VAS, and electrophysiological findings. A p-value of <0.05 was considered statistically significant.

RESULTS

Overall, 70% of the patients were females, with a mean age of 50 years (range: 36–65 years). The preoperative VAS score was 5 (3–6), BCQT-SSS was 3.6 (1.8–4.5), and BCQT-FSS was 3.9 (2.0–4.6). In the postoperative evaluation, the SC test remained positive in 3 patients at the 2nd week, while it became negative in 26 patients (89.6%; Table I).

Analysis of the clinical outcomes revealed that the preoperative VAS, BCTQ-SSS, and BCTQ-FSS scores were significantly higher than the postoperative scores at the 2nd and 8th weeks (Table II, Figure 1). Furthermore, scores at the 2nd week were also higher than those at the 8th week. In short, all clinical outcomes showed significant improvements at the 2nd postoperative week compared with the preoperative period, and these improvements continued through the 8th week.

Table III presents the preoperative and postoperative ENMG findings. Assessment of electrophysiological findings revealed significant improvements were observed across all parameters at the 8th postoperative week compared with the preoperative period (Table III, Figure 2).

Table IV summarizes the severity of CTS in the preoperative and postoperative periods based on the AAEM criteria. None of the patients had severe CTS. Of the 10 patients with severe CTS preoperatively, only 5 (50%) showed a reduction in disease severity by the 8th week postoperatively. The remaining five patients were still classified as having severe CTS at that time. All patients who experienced a reduction in severity were reclassified as having moderate CTS.

Among the 19 patients with moderate CTS preoperatively, 42% (n=8) showed regression to mild CTS during the postoperative period. However, 57.9% (n=11) of the patients did not experience any reduction in disease severity. According to the NCS findings, no patient was considered healthy at the8th postoperative week.

In the analysis of postoperative VAS and BCTQ scores in correlation with NCS findings at the 8th postoperative week, no correlation was observed between the 2nd and 8th week measurements (Table V).

Table I: Demographics and Clinical Characteristics of Study Participants

Variables	Results
Age, median (min-max), years	50 (36-65)
Sex, female/male, n (%)	20 (68.9) / 9 (31.1)
Side of pain, n (%)	
Right	15 (51.7)
Left	14 (48.3)
Baseline scratch collapse test, n (%)	29 (100.0)
Baseline BCTQ-SSS score (median, min-max)	3.6 (1.8-4.5)
Baseline BCTQ-FSS score (median, min-max)	3.9 (2.0-4.6)
Postoperative scratch collapse test, n (%)	
Positive	3 (10.4)
Negative	26 (89.6)

***BCTQ:** Boston carpal tunnel questionnaire, **SSS:** Symptom severity scale, **FSS:** Functional status scale.*

Table II: The Time Main Effect on VAS, BCTQ-SSS, and BCTQ-FSS Scores

		Mean SD	Median (min-max)	Mean Rank	p-value
VAS	Pre-operative	4.93±0.96	5 (3-6)	2.98	**<0.001***
	Post-operative 2nd week	2.69±0.85	3 (1-5)	1.86	
	Post-operative 8th week	1.52±0.78	2 (0-3)	1.16	
BCTQ-SSS	Pre-operative	3.53±0.72	3.6 (1.8-4.5)	2.97	**<0.001***
	Post-operative 2nd week	1.81±0.51	1.9 (0.9-3.2)	1.91	
	Post-operative 8th week	1.31±0.23	1.3 (1.0-1.9)	1.14	
BCTQ-FSS	Pre-operative	3.65±0.77	3.9 (2.0-4.6)	3.00	**<0.001***
	Post-operative 2nd week	1.82±0.53	1.8 (1.0-3.5)	1.91	
	Post-operative 8th week	1.31±0.23	1.3 (1.0-1.9)	1.09	

***:** *Friedman test*
***VAS:** Visual analog scale, **BCTQ:** Boston carpal tunnel questionnaire, **SSS:** Symptom severity scale, **FDS:** Functional status scale.*

Table III: The Time Main Effect on Electroneuromyography Results

		Mean SD	Median (min-max)	Mean Rank	p-value
Motor Latency	Pre-operative	5.39±1.44	4.9 (4.02-9.28)	11.5	**<0.001***
	Post-operative 8th week	4.36±1.16	4.1 (3.06-8.28)		
CMAP	Pre-operative	5.61±3.17	5.96 (0.5-10.8)	43.1	**<0.001***
	Post-operative 8th week	6.82±2.66	6.9 (0.7-11.9)		
Motor Velocity	Pre-operative	43.4±6.54	45.0 (30.1-54.8)	40.9	**<0.001***
	Post-operative 8th week	48.9±7.27	50.4 (32.1-58.4)		
Sensory Velocity	Pre-operative	27.2±5.62	27.4 (20.1-36.5)	39.8	**<0.001***
	Post-operative 8th week	35.5±7.34	33.2 (21.7-53.3)		

***:** *Wilcoxon Test*
***CMAP:** Combined muscle amplitude potential.*

Table IV: Patients' Pre- and Post-Operative Severity Levels according to American Association of Electrodiagnostic Medicine Recommendations

	Severity level		
	Mild	Moderate	Severe
Pre-operative	-	19	10
Post-operative	8	16	5

DISCUSSION

This study demonstrates that the SC test is feasible for evaluating surgical success in the early postoperative period following open CTR surgery. Although NCSs collectively indicated postoperative improvement, no significant change in disease severity was observed. Furthermore, individual analysis of NCS findings failed to reliably reflect clinical improvement. Notably, no correlation was found between early postoperative NCS findings (at the 8th week) and the BCTQ scores.

The clinical success rate following open CTR surgery is reported to range between 75% and 90% (6). Various parameters have been used to assess treatment outcomes, including NCS, symptom-based questionnaires, grip strength measurements, complication rates, pain and dexterity assessments, return-to-work times, and overall functional capacity (2). Although some authors advocate for the use of NCS as a standardized tool in evaluating CTS diagnosis and treatment efficacy, others argue that it is not essential. For instance, Heybeli et al. reported improvements in BCTQ scores following open CTR surgery without a corresponding correlation with NCS findings at 3 and 6 months postoperatively (11). However, some studies have found inconsistent and heterogeneous correlations between NCS and clinical outcomes in the postoperative period (1,12,25). Our study found no correlation

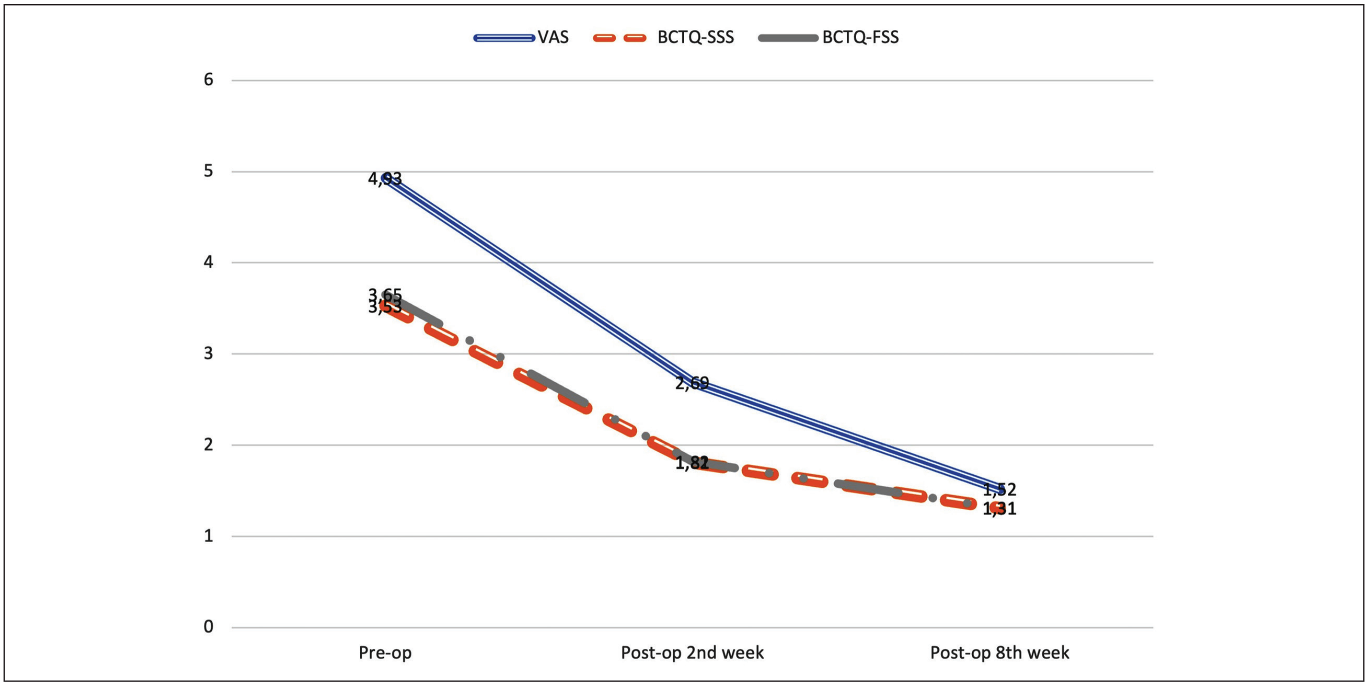

Figure 1: Time based functional scores (**VAS:** Visual analog scale, **BCTQ:** Boston carpal tunnel questionnaire, **SSS:** Symptom severity scale, **FDS:** Functional status scale).

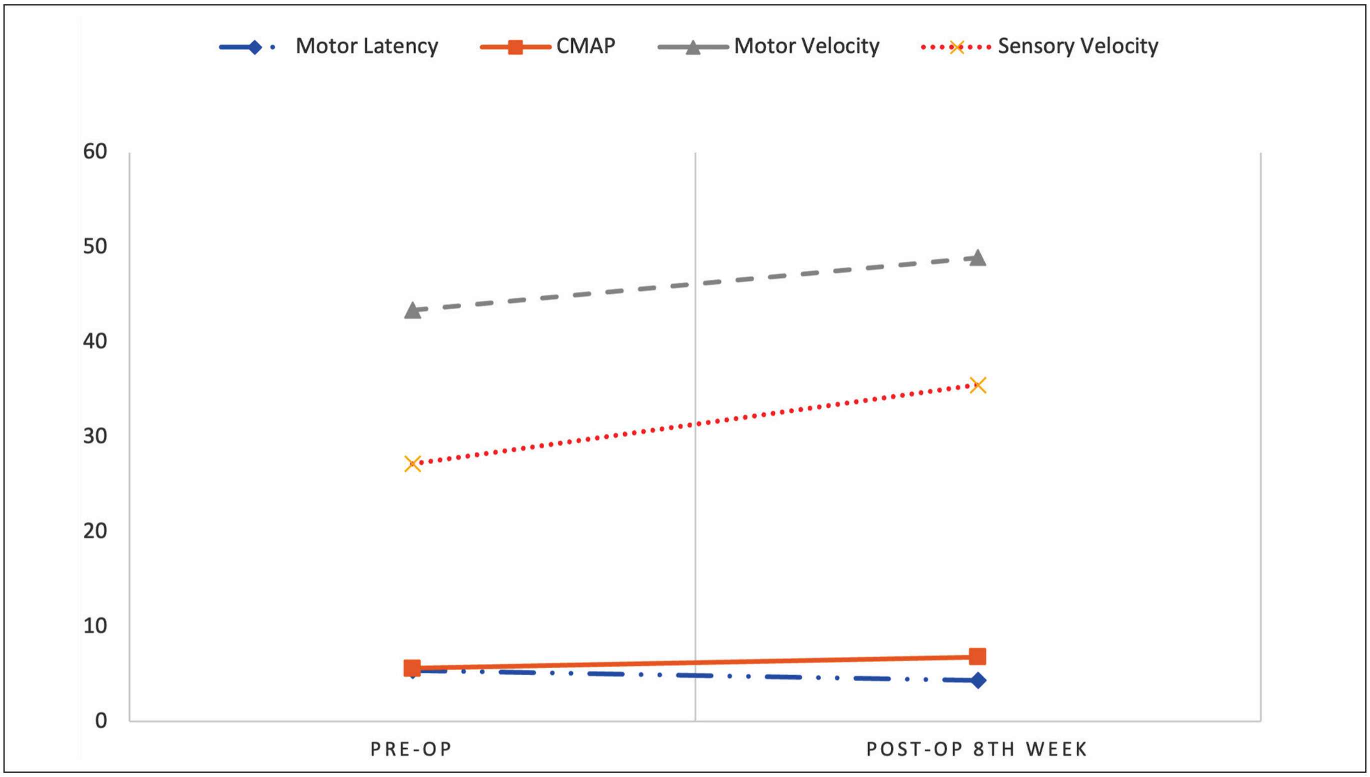

Figure 2: The time main effect on electroneuromyography results (**CMAP:** Combined muscle amplitude potential).

Table V: Spearman's Correlation Coefficients Between 8th Week Postoperative Nerve Conduction Measures and Difference in BCTQ and VAS

Instrument Scale (Post-operative 8th week)	Postoperative 2nd week			Postoperative 8th week		
	VAS	BCTQ SSS	BCTQ FSS	VAS	BCTQ SSS	BCTQ FSS
Motor latency	0.360	-0.178	-0.097	0.256	0.242	0.238
CMAP	-0.354	0.116	0.025	-0.084	-0.060	-0.022
Motor velocity	-0.321	0.282	0.107	0.009	-0.019	-0.146
Sensory velocity	-0.337	0.186	0.024	-0.212	-0.053	-0.236

**p<0.05*

***BCTQ:** Boston carpal tunnel questionnaire, **VAS:** Visual analog scale, **CMAP:** Combined muscle amplitude potential, **SSS:** Symptom severity scale, **FSS:** Functional status scale.*

between postoperative NCS findings and clinical outcomes, including BCTQ-SSS, BCTQ-FSS, and VAS scores. Although NCS findings and clinical outcomes are not correlated, using them together may offer a more comprehensive understanding of postoperative recovery

The SC test is more sensitive and specific in diagnosing CTS and peroneal nerve compression than traditional examination techniques (e.g., Tinel's sign and compression testing) (5,10). Furthermore, the SC test has utility in detecting additional sites of compression and localizing multiple levels of compression along a nerve pathway (8). In our study, the SC test was positive in 29 (45.3%) of 64 patients preoperatively. At the postoperative evaluation, the test became negative in 26 of these 29 patients (89.6%) by the 2nd week, with no further changes noted at the 8th week. Although the electrophysiological findings did not show remarkable improvement by the 8th week, the SC test showed approximately 90% improvement at the 2nd week. This discrepancy may be attributed to persistent nerve impingement at different anatomical sites or inadequate surgical decompression in the three patients whose SC tests remained positive postoperatively. Two main hypotheses have been proposed to explain SC test mechanism: excessive substance P release and the CSP. Regardless of the underlying mechanism, it is possible that the SC test normalizes earlier than EMG findings due to the resolution of excessive substance P or the disappearance of CSP following surgical decompression.

The clinical parameters, including VAS, BCTQ-FSS, and SSS, improved by the 2nd postoperative week compared to the preoperative period, with continued improvement observed through the 8th week. Although some prior studies have failed to show significant improvements in VAS scores after open CTR surgery, the present study demonstrated otherwise (21). The discrepancy in earlier studies was likely due to the subjective nature of pain assessments (21). Like the current study, Okumura et al. found significant improvements in VAS and BCTQ scores for up to 3 months following endoscopic CTR (20).

The literature presents conflicting results regarding postoperative NCS findings. Kim et al. reported improvements in DML, distal motor amplitudes, distal sensory latency, and distal sensory amplitudes at the 3rd week and 3rd month following open CTR surgery (16). Similarly, Mondelli et al. observed electrophysiological improvements between 1st and 6th months postoperatively (19). However, other studies have not demonstrated statistically significant improvements in postoperative NCS values (13). In our study, although all NCS parameters showed some degree of improvement at 8 weeks postoperatively, none returned to normal levels.

In a study by Aksekili et al., among the seven patients with very severe CTS based on AAEM criteria, none demonstrated electrophysiological improvement at 3 months (1). Furthermore, of the 19 patients in the severe CTS group, 9 improved to a moderate level and 7 to a mild level. Among four patients with moderate CTS, two remained at a moderate level and two improved to a mild level. Similarly, in our cohort, half of the patients with severe CTS improved to a moderate level postoperatively, while the other half showed no change. Among those with moderate CTS, 42% improved to a mild level, and the remainder exhibited no change in disease severity. Consequently, none of the patients in our study exhibited a return to normal NCS values based on AAEM criteria in the postoperative period.

This retrospective study has several limitations. While our sample size was comparable to previous studies, it could have been expanded, given the high prevalence of CTS in the population. However, the number of patients with a positive SC test in the preoperative period, along with their postoperative electrophysiological parameters and clinical outcomes, provides valuable preliminary data that can inform future studies. Another limitation is the relatively short follow-up period. Longer follow-up period could have provided insights into whether further electrophysiological and functional improvements occur over time. For instance, Okamura et al. found that improvements continued during the first 3 months but plateaued between the 3rd and 6th postoperative months (20). Nevertheless, as our study aimed to assess early postoperative outcomes, the current follow-up period was appropriate. A further limitation is the omission of other physical examination findings (e.g., two-point discrimination and opposition strength) in the postoperative assessment. Despite this, our study is the first known in the literature to evaluate the SC test following open CTR surgery, and it may serve as a foundation for future research.

CONCLUSION

In this study, no correlation was observed between improvements in NCS findings and functional scores during the early postoperative period following open CTR surgery. However, in 90% of patients with a positive preoperative SC test, the test became negative two weeks after open CTR surgery. Although demyelination and axonal damage caused by nerve compression in CTS did not improve during the early period following open CTR surgery, the SC test results showed an improvement in that period, likely due to the normalization of neurotransmitter flow after decompression of the nerve. Therefore, the SC test can be used to evaluate postoperative treatment results because it is easily applicable, repeatable, and cost-effective compared with NCS.

Declarations

Funding: This study received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Availability of data and materials: The datasets generated and/or analyzed during the current study are available from the corresponding author by reasonable request.

Disclosure: The authors declare no competing interests.

AUTHORSHIP CONTRIBUTION

Study conception and design: ED, AA

Data collection: OT, ABA

Analysis and interpretation of results: EC, HBC, ED

Draft manuscript preparation: ED, AA, OT

Critical revision of the article: EC, HBC

Other (study supervision, fundings, materials, etc...): ED, ABA

All authors (ED, AA, ABA, EC, OT, HBC) reviewed the results and approved the final version of the manuscript.

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