

Manual therapy intervention in the treatment of patients with carpal tunnel syndrome: median nerve mobilization versus medical treatment

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Background

Carpal tunnel syndrome (CTS) is the most common entrapment neuropathy. Median nerve mobilization is a manual therapy intervention used for treating CTS.

Aim

The aim of the present study was to investigate the effectiveness of median nerve mobilization in relieving manifestations of CTS when compared with conventional medical treatment.

Patients and methods

A total of 28 CTS patients were divided into two groups: patients in group I ($n = 18$) underwent median nerve mobilization, and those in group II ($n = 10$) underwent conventional medical treatment. Median nerve mobilization consisted of 18 treatments (three/week for 6 weeks). Patients were assessed for hand sensitivity, paresthesia, strength, pain, night awakening, thenar eminence atrophy, and were subjected to Phalen's test, Tinel's sign, Boston Carpal Tunnel Questionnaire's Symptom Severity Scale (BCTQ-SSS) and Functional Status Scale (BCTQ-FSS), and sensory and motor conduction studies for median nerve at baseline and at 6 weeks after treatment.

Results

At baseline versus at 6 weeks, pain, sensation, paresthesia, tingling, Tinel's signs, and Phalen's test outcomes were significantly improved in both groups; wrist flexion and extension improved only in group I. The difference between group I and group II after 6 weeks was significant as regards tingling, pain, wrist flexion, and extension. BCTQ-SSS and BCTQ-FSS scores improved after 6 weeks compared with baseline in patients in group I, whereas in group II the improvement was observed in BCTQ-FSS; the difference between the groups was significant. Sensory nerve conduction velocity, sensory distal latency, sensory amplitude, distal motor latency, and motor amplitude were significantly improved after 6 weeks in group I. In addition, there was a change in the grade of CTS, whereas in group II there was improvement only in sensory nerve conduction velocity; the difference between the groups was not significant.

Conclusion

CTS improves after median nerve mobilization, which is better than conventional medical treatment. It provides support for the use of manual therapy in conservative management of CTS with satisfactory results.

Keywords:

carpal tunnel syndrome, manual therapy, median nerve mobilization, nerve conduction study

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Introduction

Carpal tunnel syndrome (CTS) is the most common entrapment neuropathy. It is characterized by signs and symptoms resulting from the compression of the median nerve within the carpal tunnel, which is located between the transverse carpal ligament and the carpal bone at the wrist. CTS is a common condition that affects between 3 and 6% of the population. Women are affected up to five times more often than are men [1–3]. It causes dysesthesia and hypoesthesia, motor deficit, and pain, especially at night, within the median nerve distribution in the fingers that are secondary to the mechanical compression and local ischemia [4,5].

Most cases of CTS are idiopathic; however, CTS may be associated with systemic conditions including rheumatoid arthritis or psoriatic arthritis (causing thickening of the articular and peritendineal synovium), diabetes mellitus, pregnancy, thyroid disease, acromegaly, osteoarthritis, gout, and fibromyalgia syndrome, which cause a reduction in the size of the carpal tunnel or an increase in the volume

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of its content, causing compression of the median nerve. CTS may also be caused by local trauma and by overuse and prolonged improper positioning of the hand or wrist, mainly because of occupational causes such as continuous use of the computer mouse and highly repetitive or forceful work involving hand, thus causing wrist vibration [6,7].

Empirical evidence indicates that many patients with CTS have self-limiting symptoms and respond to nonoperative conservative treatments, including rest, modification of physical behaviors, splinting, nerve-gliding exercises, manual therapy techniques, and anti-inflammatory medications [3,8].

Manual therapy techniques designed to release tissue adhesions and increase the range of motion (ROM) of the wrist may alleviate the mechanical compression of the median nerve without the need for surgical intervention. Increased joint motion may improve blood flow within the vasa nervorum, thereby alleviating local ischemic effects on the median nerve favoring nerve regeneration and healing [8].

Manual therapy of the median nerve involves chiropractic, soft tissue mobilization, median nerve mobilization, and carpal bone mobilization.

The aim of the current study was to investigate the effectiveness of one of the manual therapy intervention – neurodynamic mobilization techniques (median nerve mobilization) – in relieving signs and symptoms of CTS when compared with conventional medical treatment.

Patients and methods

A total of 28 patients with established clinical and electrophysiological evidence of idiopathic CTS were included in our study. All patients were women. Their ages ranged from 17 to 55 years with a mean \pm SD of 34.05 ± 10.19 . The disease duration ranged from 4 to 16 months with a mean \pm SD of 12.0 ± 3.5 . All patients were housewives. Overall, 26 patients had unilateral CTS and two patients had bilateral CTS, which was diagnosed electrophysiologically. On the basis of electrophysiological studies, there were 18 patients with moderate CTS (all with unilateral) and 10 patients with mild CTS (eight unilateral and two bilateral), and they were distributed equally between the two groups. All patients attended rheumatology and rehabilitation outpatient clinic in Minia University Hospital, Egypt, over a period from March 2014 to August 2014. The nature of the present study was explained to all patients. The clinical

examination and nerve conduction studies represent standard care and pose no ethical conflicts. The nature of the study was explained to the patients and their relatives and an oral consent was taken from the patients or their relatives.

Exclusion criteria for patients included previous carpal tunnel surgery, CTS due to underlying cause (diabetes mellitus, pregnancy, thyroid disease, and acromegaly) or other musculoskeletal condition (osteoarthritis, rheumatoid arthritis, gout, psoriatic arthritis, and fibromyalgia syndrome), patients under physical treatment, or those who received local injection.

Patients were divided into two groups according to the method of treatment. Group I comprised 18 patients (16 unilateral and two bilateral) with CTS and were treated with neurodynamic mobilization technique (median nerve mobilization), six patients with mild degree CTS, and 12 patients with moderate degree CTS; group II comprised 10 patients with unilateral CTS and underwent conventional medical treatment (NSAIDs, diclofenac 150 mg/day for 2 weeks and 1500 μ g vitamin B₁₂ per day for 6 weeks), four patients with mild degree CTS, and six patients with moderate degree CTS.

Patients were subjected to the following:

- (1) Through history-taking, clinical examination,
- (2) Functional assessment using Boston Carpal Tunnel Questionnaire (BCTQ) [9], patient self-rated the degree of pain using visual analogue scale (VAS) [10],
- (3) Electrophysiological study of the median nerve (these were carried out for all patients in both groups at baseline and at 6 weeks after treatment), and
- (4) Neurodynamic mobilization techniques (median nerve mobilization) for patients in group I.

Clinical examination was conducted at baseline and at 6 weeks after treatment. The ROMs for flexion and extension of each wrist was measured using a goniometer; patients were assessed for hand sensation, paresthesia, hand strength, hand and forearm pain, night awakening, and thenar eminence atrophy, and were subjected to Phalen's test or the wrist flexion test [11] and Tinel's sign [12].

BCTQ [9] was used for the assessment of severity and function at baseline and after 6 weeks of treatment. The questionnaire comprises two scales: a Symptom Severity Scale (SSS) and a Functional Status Scale (FSS).

The SSS consisted of 11 questions with multiple choice responses, scored from 1 point (mildest) to 5 points

(most severe). The overall symptom-severity score was the mean of the ratings on the 11 items. The questions addressed the clinical areas of CTS symptoms: severity of nocturnal pain, frequency of nocturnal awakening due to pain, severity of daytime pain, frequency of daytime pain, duration of daytime pain, severity of numbness, severity of weakness, severity of tingling, severity of nocturnal numbness/tingling, frequency of nocturnal awakening due to numbness/tingling, and difficulty in gripping small objects.

The FSS consisted of eight daily activities that are performed by most individuals and are commonly affected by CTS. They include the following: writing, holding a book, buttoning clothes, gripping the telephone, opening jars, performing household chores, carrying a grocery bag, and bathing and dressing. The patients rated their ability to perform the activity on a scale that ranged from 1 point (no difficulty with the activity) to 5 points (cannot perform the activity at all). The overall score for the FSS was the mean of the ratings on the eight daily activities.

Patients self-rated the degree of pain using VAS [10]. Using VAS, patients could indicate their assessment along a distance of 10 cm, ranging from 0 (no pain at all) to 10 (the most intense pain imaginable).

Electrophysiological study of the median nerve: Median nerve was studied by sensory nerve conduction velocity and distal motor latency at the baseline examination and at 6 weeks after the end of the manual therapy. The severity of the CTS (mild, moderate, or severe) was assessed according to the general guidelines [13]:

- (1) *Mild:* Median sensory nerve conduction slowing and/or median sensory amplitude decreased but more than 50% of the reference value (no motor involvement).
- (2) *Moderate:* Median sensory and motor slowing, and/or sensory nerve amplitude potential less than 50% of the reference value.
- (3) *Severe:* Absence of median sensory nerve amplitude potential with motor slowing or median motor slowing with decreased median motor amplitude or compound muscle action potential abnormalities with evidence of axonal injury on needle testing of the thenar muscles.

Patients with mild and moderate degree CTS were included in the current study.

Neurodynamic mobilization techniques (median nerve mobilization) [14,15] was used for patients in group I. The patients were scheduled to receive three sessions per week for 6 weeks.

Neurodynamic mobilization techniques (median nerve mobilization) include nerve-gliding exercises and the upper limb tension test 2a mobilization of the median nerve for 20 min. The order of the upper limb tension test 2a was standardized as slight glenohumeral abduction, shoulder girdle depression, elbow extension, lateral rotation of the whole arm, extension of the wrist, thumb, and fingers, and finally glenohumeral abduction. All movements were taken to the end of the available range (R2) or to the point where the first symptoms were produced (P1).

Statistical analysis

Statistical analysis was performed with SPSS Statistical Software version 16 (SPSS Inc., Chicago, Illinois, USA). The range, mean, and SD were calculated for interval and ordinary variables. The level of statistical significance was set at a *P* value level less than 0.05.

Results

All patients in group I and group II had paresthesia, tingling, pain, night awakening, and positive outcomes for Phalen's and Tinel's tests. A total of 17 patients (95%) in group I and all patients in group II had their sensation affected (hypoesthesia).

After 6 weeks of manipulation, patients in group I underwent neurodynamic mobilization techniques (median nerve mobilization); for each of them, a statistically significant improvement was observed as regards sensation, paresthesia, strength, night awakening, tingling, pain, Phalen's test, Tinel's sign, and extension and flexion of the wrist joint ($P \leq 0.0001$) (Table 1).

There was a significant difference after 6 weeks of treatment in patients in group I undergoing neurodynamic mobilization techniques (median nerve mobilization) as regards functional assessment and nerve conduction studies – SSS score, FSS score, VAS, motor distal latency, sensory distal latency, and sensory amplitude – ($P \leq 0.0001$), motor amplitude ($P = 0.041$), and sensory conduction velocity ($P = 0.002$) for each of them. There was a significant difference as regards the change in the grade of CTS ($P = 0.01$) for patients in group I. There was no significant difference as regards motor conduction velocity (Table 2).

In group II, in which patients underwent conventional medical treatment, there was a significant difference after 6 weeks of treatment as regards sensation, strength, night awakening, pain ($P \leq 0.0001$); paresthesia and Phalen's test ($P = 0.001$); and tingling and Tinel's sign

($P = 0.025$) for each of them. There was no significant difference as regards extension and flexion of the wrist joint in patients at baseline and at 6 weeks after treatment (Table 1).

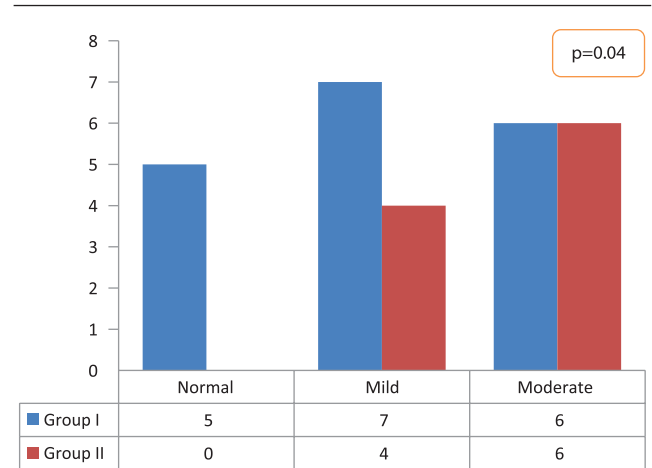
In group II, in which patients underwent conventional medical treatment, there was a significant difference after 6 weeks of treatment as regards SSS score, FSS score, VAS ($P \leq 0.0001$), and sensory amplitude ($P = 0.036$) for each of them. There was no significant difference as regards motor distal latency, motor amplitude, motor conduction velocity, sensory distal latency, and sensory conduction velocity or the change in the grade of CTS (Table 2).

On comparing the clinical data of patients in group I, who underwent neurodynamic mobilization techniques (median nerve mobilization), with those in group II, who only underwent medical treatment, after 6 weeks of treatment, a significant difference was observed as regards tingling, extension and flexion of the wrist joint ($P \leq 0.0001$), night awakening and pain ($P = 0.038$) for each of them. There was no significant difference as regards sensation, paresthesia, strength, Phalen's test, and Tinel's sign (Table 1).

On comparing the results of functional assessment and nerve conduction studies for patients in group I, who underwent neurodynamic mobilization techniques

(median nerve mobilization), with those in group II, who underwent only medical treatment, after 6 weeks of treatment, a significant difference was observed as regards VAS ($P = 0.003$), SSS score ($P = 0.005$), and the change in the grade of CTS ($P = 0.04$) (Fig. 1). There was no significant difference as regards FSS, motor distal latency, motor amplitude, motor conduction velocity, sensory distal latency, sensory amplitude, and sensory conduction velocity (Table 2).

Figure 1



Grade of carpal tunnel syndrome (CTS) in patients in group I and group II after 6 weeks of treatment.

Table 1 Clinical data of patients in group I, II at baseline and after 6 weeks of treatment and comparison of patients in both groups

Item	Group I (18 patients)		Group II (10 patients)		Comparison of group I and group II	
	χ^2/t	<i>P</i> value	χ^2/t	<i>P</i> value	χ^2/t	<i>P</i> value
Sensation						
At baseline	17 (95%)	$36.19 \leq 0.0001$	10 (100%)	$20.00 \leq 0.0001$	1.825	0.145
After 6 weeks	0 (0%)		0 (0%)			
Paresthesia						
At baseline	18 (100%)	$32.73 \leq 0.0001$	10 (100%)	10.770.001	1.920	0.166
After 6 weeks	2 (11%)		3 (30%)			
Tingling						
At baseline	18 (100%)	$40.00 \leq 0.0001$	10 (100%)	5.000.025	15.00	≤ 0.0001
After 6 weeks	0 (0%)		6 (60%)			
Pain						
At baseline	18 (100%)	$40.00 \leq 0.0001$	10 (100%)	$13.33 \leq 0.0001$	4.286	0.038
After 6 weeks	0 (0%)		2 (20%)			
Phalen's test						
At baseline	18 (100%)	$36.19 \leq 0.0001$	10 (100%)	10.770.001	3.606	0.058
After 6 weeks	1 (5%)		3 (30%)			
Tinel's sign						
At baseline	18 (100%)	$21.54 \leq 0.0001$	10 (100%)	5.000.025	2.500	0.114
After 6 weeks	6 (33%)		6 (60%)			
Extension						
At baseline	(63–72) 67.7 ± 2.5	$-7.993 \leq 0.0001$	(65–72) 68.8 ± 1.9	$-0.4380.667$	5.221	≤ 0.0001
After 6 weeks	(69–76) 73.5 ± 2.1		(65–73) 69.2 ± 2.2			
Flexion						
At baseline	(58–70) 64.1 ± 2.9	$-7.102 \leq 0.0001$	(60–68) 64.6 ± 2.2	$-0.5140.614$	5.525	≤ 0.0001
After 6 weeks	(65–74) 70.1 ± 2.4		(60–68) 65.1 ± 2.2			

Table 2 Functional assessment and nerve conduction studies of patients in group I and II at baseline and after 6 weeks of treatment and comparison of patients in both groups

Item	Group I (18 patients)		Group II (10 patients)		Comparison of group I and group II	
	χ^2/t	P value	χ^2/t	P value		
SSS score						
At baseline	3–4.63.7 ± 0.5	15.46 ≤ 0.0001	2.8–4.23.3 ± 0.5	5.48 ≤ 0.0001	–3.010	0.005
After 6 weeks	1–2.51.6 ± 0.4		1.4–2.62.1 ± 0.5			
FSS						
At baseline	3.3–4.83.9 ± 0.5	14.22 ≤ 0.0001	2.8–4.63.7 ± 0.6	5.76 ≤ 0.0001	–1.830	0.078
After 6 weeks	1.1–2.51.8 ± 0.4		1.4–2.82.2 ± 0.6			
VAS						
At baseline	6–108.2 ± 0.9	19.02 ≤ 0.0001	6–98 ± 1.1	7.87 ≤ 0.0001	–3.211	0.003
After 6 weeks	1–42.5 ± 0.9		2–63.8 ± 1.3			
Motor distal latency						
At baseline	3.9–5.94.8 ± 0.7	4.05 ≤ 0.0001	3.8–54.4 ± 0.4	0.660.948	–2.077	0.470
After 6 weeks	3.4–4.74.1 ± 0.4		3.8–54.3 ± 0.4			
Motor amplitude						
At baseline	4.2–8.95.9 ± 1.2	–2.110.041	4.4–12.48 ± 2.5	–0.720.481	–1.991	0.056
After 6 weeks	5.2–12.37.1 ± 2.1		6.1–13.98.8 ± 2.4			
Sensory distal latency						
At baseline	3.6–4.53.9 ± 0.3	3.83 ≤ 0.0001	3.6–4.23.8 ± 0.2	0.080.935	–1.994	0.056
After 6 weeks	2.1–43.5 ± 0.5		3.5–4.23.8 ± 0.2			
Sensory amplitude						
At baseline	7.9–25.515.1 ± 4.2	–5.65 ≤ 0.0001	8.4–23.816 ± 4.9	–2.260.036	0.629	0.534
After 6 weeks	16–29.422.5 ± 3.9		10.7–30.421.3 ± 5.6			
Sensory conduction velocity						
At baseline	29–5038.9 ± 5.3	–3.330.002	32.4–42.639.2 ± 3.6	–1.130.274	1.596	0.122
After 6 weeks	34.2–51.644.2 ± 4.6		34.9–50.441.3 ± 4.9			
Grade of CTS						
At baseline	Mild (6) Moderate (12)	8.000.01	Mild (4) Moderate (6)	NS	6.279	0.04
After 6 weeks	Normal (5) Mild (7) Moderate (6)		Normal (0) Mild (4) Moderate (6)			

CTS, carpal tunnel syndrome; FSS, Functional Status Scale; SSS, Symptom Severity Scale; VAS, visual analogue scale.

Discussion

CTS is the most common entrapment neuropathy [3].

To relieve the pressure on the median nerve, several treatment options, both surgical and conservative, are available [16]. Conservative care with CTS should be emphasized as a logical first step because it can be effective in the management of mild to moderate CTS [17].

The current study investigated the effect of manual therapy techniques as treatment for patients experiencing CTS. In the present study, 28 patients with CTS (26 patients with unilateral CTS and two patients with bilateral CTS) were divided into two groups according to the method used for treatment. Patients in group I (18 patients) underwent neural mobilization and those in group II (10 patients) underwent conventional medical treatment.

All patients in the study were housewives with an age range of 17–55 years and a mean ± SD of 34.05 ± 10.19.

The disease duration ranged from 4 to 16 months with a mean ± SD of 12.0 ± 3.5.

A study by Atroshi *et al.* [18] revealed that CTS is more prevalent in females than in males. In addition, many studies involved female patients, as was the case in the current study: in a study conducted by De-la-Llave-Rincon *et al.* [19] all the included patients were females ($n = 18$); in another study by Baysal *et al.* [15], all the included patients were females ($n = 36$) with clinical and electrophysiologic evidence of CTS; and the study by Pinar *et al.* [20] included only female patients ($n = 26$) with symptoms of CTS. A study by Bongi *et al.* [3] included 20 female and two male patients, and in a study by Akalin *et al.* [21] there were 26 female and two male patients.

The higher incidence in women may be partly due to hormonal factors, but in general, it is believed to be related to a propensity to and higher frequency of musculoskeletal problems among women [22,23]. It has been hypothesized that the higher incidence

of CTS in women than in men is due in part to the differences in carpal tunnel volume between men and women. It has also been suggested that hormonal changes influence the onset of CTS in women [24,25], causing swelling that increases pressure on the median nerve [26].

All our patients were housewives used to with high-intensity housework. This is in agreement with a study by Tang *et al.* [27], where they found that the hand-intensive nature of housework may contribute to a higher incidence in women. In addition, in a study conducted by Baysal *et al.* [15], patients were housewives used to high-intensity housework and computer-using clerks.

In the current study, patients in group I underwent neural mobilization and showed significant improvement in clinical symptoms and functional status of CTS, Phalen's test and Tinel's sign, extension and flexion (ROM) of the wrist joint, VAS, SSS score, and FSS score after 6 weeks of treatment. In addition, there was an improvement in motor distal latency, sensory distal latency, sensory amplitude, sensory conduction velocity, and motor amplitude.

The results of our study are in agreement with those of a study conducted by Baysal *et al.* [15], who used neural gliding for the treatment of patients with CTS for 3 weeks (five sessions per week); they found a significant reduction of pain, improvement in strength and Tinel's sign, and significant improvement as regards FSS and SSS at the end of the treatment. They observed significant improvement in median sensory distal latency; however, there was no significant improvement in median motor distal latency at the end of the treatment. This may be due to the short duration of manipulation, as they treated their patients in five sessions weekly for 3 weeks.

In agreement with our results, in a study conducted by Pinar *et al.* [20], who used Phalen's test as an outcome, relative risk of success was demonstrated as favorable toward the neural-gliding group. A study by Goodyear-Smith and Arroll [28] and the one by Muller *et al.* [29] concluded that there was a possible benefit in pain reduction and reduced rates of surgical intervention with the use of neural gliding, and thus recommended neural gliding for the benefit of reduced pain. A study by Akalin *et al.* [21] showed significant improvement in the outcomes of Phalen's test and Tinel's sign in their patients treated with neural-gliding exercise. In a study by Tal-Akabi and Rushton [14], which included 21 patients, seven patients treated with neural gliding exercise for 2 weeks demonstrated satisfactory results of ROM of

the wrist joint; the results were found to be significant. In addition, they found that there was a significant difference in patients undergoing neural mobilization as regards VAS score. In a study by Rozmaryn *et al.* [30], who treated patients experiencing CTS with nerve-gliding exercises, 70.2% of the patients showed good or excellent results as regards Phalen's test and Tinel's sign. In addition, they found significant improvement as regards FSS and SSS at the end of the treatment in patients treated with neural mobilization.

In contrast to our results, a study by O'Connor *et al.* [31] concluded that there were no significant benefits to neural gliding as regards neurophysiological studies. This may be because of the difference in the race or the BMI of patients.

In the current study, patients in group II, who underwent conservative medical treatment, showed significant difference as regards clinical symptoms of CTS and VAS after 6 weeks of treatment.

This is in agreement with a study by Harter *et al.* [32], who reported satisfactory results after treating 188 patients with different conservative methods; some patients treated with anti-inflammatory drugs and vitamin B₆ showed improvement in clinical symptoms and pain.

However, in contrast to our results, a study conducted by Tal-Akabi and Rushton [14], which included 21 patients, out of which seven underwent conventional medical treatment, suggested that there was no significant difference in patients on conventional medical treatment as regards VAS score. This may be due to the difference in the degree of CTS.

In the current study, a comparison between the patients in group I, who underwent neural mobilization, and those in group II, who only underwent conservative medication, after 6 weeks of treatment showed an improvement in all patients as regards sensation; there was a significant difference as regards pain and tingling, ROM of the wrist joint (flexion and extension), VAS, and SSS score. There was no significant difference as regards paresthesia, strength, Phalen's test, Tinel's sign, FSS, motor distal latency, motor amplitude, sensory distal latency, sensory amplitude, and sensory conduction velocity.

This was in agreement with a study conducted by Heebner and Roddey [33], in which 60 participants were assessed in two groups: patients in the first group received standard care of medical treatment and those in the second group underwent neural mobilization.

Although the patients in both groups showed improved clinical symptoms, there was no significant difference in the outcome measure between the two groups as regards the symptoms of CTS.

This is in agreement with a study conducted by Baysal *et al.* [15], in which an improvement seen in the neurophysiology of patients undergoing tendon-gliding and nerve-gliding exercises in combination with splinting when compared with the patients undergoing splinting and ultrasound therapy made them think that exercise has an effect on nerve conductivity, whereas ultrasound does not have this effect. A study by Akalin *et al.* [21] compared the group of patients with a wrist splint with patients with a wrist splint in combination with nerve-gliding and tendon-gliding exercises for the efficacy of the treatment. They reported improvement in clinical parameters and FSS in patients in both the groups, but in contrast to our results they reported significant difference in the improvement in the SSS in both groups. This may be due to the use of wrist splint added to neural-gliding exercise.

However, Tal-Akabi and Rushton [14], who compared the results for ROM of the wrist joint (flexion and extension), indicated that the patients undergoing neural mobilization showed significant improvement, whereas patients undergoing conventional medical treatment did not improve on their ROM of the wrist joint.

Conclusion

In the current study, patients experiencing CTS who underwent median nerve mobilization showed satisfactory improvement in their condition when compared with those who underwent conventional medical treatment; therefore, for satisfactory results we recommend the use of manual therapy over the conservative management methods of treating patients with CTS. The benefit of manual therapy is best identified within a specific population of CTS patients. Neural gliding is more effective in a population with less advanced CTS as conservative treatment is directed at patients with mild to moderate symptoms to delay or prevent disease progression and subsequent surgical interventions.

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Conflicts of interest

There are no conflicts of interest.

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