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Original research

Effect of Dry Needling versus Neural Mobilization Technique on Velocity and Latency of Median Nerve in Patients with Carpal Tunnel Syndrome.

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Abstract

Background: The effectiveness of dry needle (DN) and median nerve mobilization (NM) has been reported in carpal tunnel syndrome (CTS) management. However, no research has been conducted to compare DN versus NM on CTS clinical symptoms and median nerve conduction **Methods**: In this randomized clinical trial, thirty CTS patients were randomized into two equal groups, either receiving DN or NM, for 4 weeks with 3 sessions a week. Pain intensity during activity, severity of symptoms, and median nerve parameters were assessed prior to and following treatment by the Visual Analogue Scale, CTS-6 scale, and Nerve conduction studies, respectively.The study employed mixed MANOVA to compare differences within a nd between groups.Use the Bonferroni post hoc test to determine which differences were significant. **Results**: Dry needle showed a greater decrease in median nerve sensory onset latency ($p = 0.02$) compared to NM, while motor amplitude was higher ($p= 0.03$) in NM than DN, with a mean difference indicating the potential of a clinically meaningful. NM patients improved significantly in all outcomes ($p <0.05$), however, pain intensity, symptom severity, and sensory onset latency were the only statistically significant changes within DN group ($p<0.05$). **Conclusion**: 4 weeks of either DN or NM are similar in decreasing clinical symptoms of CTS. Both techniques can decrease sensory onset latency, however, DN is more efficient. Neural mobilization is better in improving both conduction of sensory and motor median nerves, specifically the motor median nerve amplitude.

Keywords: Carpal tunnel syndrome, CTS, Dry needling, Median nerve conduction, Neural mobilization, Neurodynamic.

INTRODUCTION:

Carpal tunnel syndrome (CTS) is a major upper extremity nerve compression syndrome, responsible for approximately 90% of all entrapment cases. The prevalence varies from 5.8% in women and 0.6% in men in the general population[1] Typical symptoms of carpal tunnel syndrome (CTS) often include numbness, tingling, burning sensations, or complete sensory loss in the areas of the hand supplied by the median nerve. Damage to the median nerve affects all nerve functions beyond the site of injury, characterized by electrophysiological findings that typically show prolonged distal latency and slowed conduction velocity in the sensory, motor, or both components of the median nerve, compared to normal values or unaffected nerves in the same individual [2].

These associated deficits can impair hand function and negatively impact the patient's overall quality of life[3] Therefore, diagnosis of CTS is based mainly on clinical examination that includes sensitive and specific provocative tests and/or electrodiagnostic studies[4]

The economic consequences of CTS are considerable, including lost productivity, medical expenses, and reduced earnings. [3,5] The annual cost of carpal tunnel releases in the US exceeds $2 billion, with over 500,000 surgeries performed at a cost of $2,149 to $9,927 per patient[6].

Patients occasionally prefer conservative therapy over surgical release because they are anxious about the pain., inconvenience, or risks Included compared to Operative care[7]**.** Furthermore, Manual therapy offers comparable benefits to surgery at a reduced cost [8]. One effective conservative method for CTS management in clinical practice is median nerve mobilization (NM). A systematic review studied the efficacy of nerve gliding exercises for CTS. alone or combined with additional therapies such as (soft tissue mobilization, splinting, tendon mobilization exercises, ultrasound, and carpal mobilization techniques). The studies consistently showed large effect sizes for pain reduction, improved pain thresholds, and decreased temporal summation, pressure pain threshold, and function of CTS patients [9] Another systematic review addressed three main median nerve mobilization techniques (Distal nerve tensioning, Upper quarter nerve tensioning, and Nerve gliding) that showed variation of nerve mobility degrees and excursion and the treatment outcomes varied as well [10]Furthermore, a significant difference in clinical symptoms after using Upper quarter nerve tensioning compared to carpal bone mobilization and no intervention. In addition, it is commonly used in clinical practice as more familiar to clinicians.

Regarding DN, The efficacy of this treatment for carpal tunnel syndrome is not well established. because the current literature still needs further high-quality randomized controlled trials that address DN's role in CTS management. However, the published trials showed DN enhances wrist mobility in patients with CTS, but exercise therapy had a better effect [11] . The previous randomized controlled study assessed Immediate effects of dry needling on thenar muscles in laborers with CTS, reported that Median sensory latency (SDL) improved significantly in the DN group and Boston CTS Questionnaire score after 2 weeks [12]. Another randomized clinical study showed that DN using the fascial winding technique showed a substantial improvement in the Boston CTS Questionnaire, as well as in the intensity of pain [13].

Either DN or NM is effective, but with different mechanisms of action. Dry needling decreases central nervous system excitability by influencing peripheral pain signals, spinal cord activity, and brain regions involved in pain processing[14,15]**.** While neurodynamic exercises enhance nerve function by improving axonal transport and conduction, allowing for greater movement of the median nerve within the carpal tunnel. [16,17].

However, the findings of the clinical trials [11-13, 16, 17] that revealed the effectiveness of both techniques in CTS management, up to the best of the author's knowledge, no published research has compared DN and NM in the management of CTS regarding clinical symptoms and median nerve conduction.

Therefore, The objective of this study is to establish the superiority of DN versus NM for CTS patients on pain intensity during activity, symptom severity, nerve conduction studies assessing velocity, amplitude, and latency of motor and sensory median nerve.

Besides, the current findings would contribute to the published evidence management of using DN and NM, which add benefits for clinical practice. Whereas, diagnostic techniques and interventions used in the current study are readily available to clinicians. In addition, the findings could help in treating CTS patients according to deficits that are present in the examination. Furthermore, both techniques are easy to perform by clinicians, and NM could be applied to patients as a home program. Furthermore.

METHODS

Ethical concerns

Our study followed the Declaration of Helsinki guidelines and received ethics committee approval from the Faculty of Physical Therapy (P.T.REC/012/005440)." All participants were verbally informed about the study procedures and gave their written consent to participate, ensuring they understood their rights, confidentiality, and freedom to withdraw at any time.

Design: A parallel Single-blind RCT (Randomized Controlled Trial).

Setting: This study was carried out in Al-Behera Governorate, Egypt.

Sample size estimation: Sample size calculation was performed using G*POWER statistical software (version 3.1.9.2; Franz Faul, Universität Kiel, Germany) based on data of sensory distal latency derived from Rezazadeh et al., 2023 [12] and revealed that the required sample size for this study was 15 subjects in each group. The calculation is made with α=0.05, power = 80%, and effect size = 1.1 . The study's flowchart is illustrated in **Figure 1**. which involved 48 Subjects, with 10 Ruled out and 8 declined. Thirty patients were randomly allocated to either the intervention or control group.

Patients' recruitment and characteristics

Forty-eight patients of CTS were recruited through referrals from orthopedic or neurological physicians and announcements at Governmental hospitals and educational institutes after ethical approval

The inclusion criteria were as follows: Both genders were included, Between 20 and 45 years old [18], clinical Symptoms: pain, tingling sensation, paresthesia along the course of the median nerve, Clinical signs: included positive Phalen's and Tinel's tests, with nerve conduction studies indicating mild to moderate carpal tunnel syndrome (CTS) characterized by a median-ulnar palmar sensory latency difference exceeding 0.5 milliseconds or median delayed motor latency > 4 mms [19] , patients should be able to read the CTS-6, and Katz Hand Diagram questionnaires and understand the steps of clinical test, and symptoms for at least 2 weeks in at least two digits on one hand that include the thumb, index, middle, or ring fingers, on hand pain diagram classic, probable, or possible pattern were chosen and adequate wrist mobility enabling provocative tests to be performed" [20,21]

The exclusion criteria were individuals suffering from cervical disorders (+ve Spurling test) [22] , history of carpal tunnel release in the same hand, history of seizures or other neurological conditions, renal impairment or uncontrolled diabetes mellitus, brachial plexus injury or thoracic outlet syndrome (+ve elevated Arm Stress/ Roos test or Adson's test).

Randomization, allocation concealment, and blinding

"Off-site randomization was conducted using Excel and processed via simple random sampling by another participant who was excluded from the study. Allocation concealment was ensured via closed, opaque, sealed envelopes with unique sequential numbers. After providing informed consent, eligible patients were randomized into two groups: Group A received dry needling (DN) as the intervention, while Group B received median nerve tensioning mobilization as the comparison treatment. The current trial is single-blinded as participants were blinded to the assigned group status.

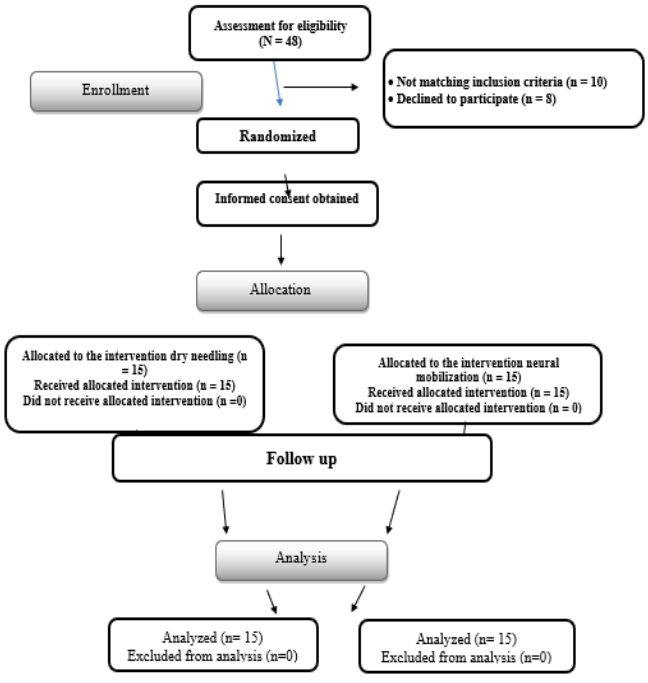

Figure (1): CONSORT flow diagram of the progress through the study phases

Outcome measures: Baseline assessment and after 4-week intervention for both groups. Outcome measures include symptom severity (CTS-6), pain intensity during activity (VAS), sensory conduction velocity, sensory onset distal latency, sensory amplitude, motor conduction velocity, motor distal latency, and motor amplitude of median nerve (Nerve conduction study).

Procedure

Assessment Procedure

Pain intensity

Pain was evaluated with a visual analog scale (VAS) during activity consists of 10-cm line, marked with a single handwritten mark, indicating the patient's pain level during activity, ranging from 0 cm to 10 cm. VAS is valid and shows high reliability with an ICC of 0.97 [95% CI=0.96 to 0.98] [23.]

Symptoms severity

Symptom severity was measued using CTS-6 questionnaire that derived from the Boston Carpal Tunnel Syndrome Questionnaire, with a sensitivity of 75% and specificity of 61% using Latent Class Analysis [21] However, its sensitivity ranged from 81-87% and specificity 91- 95% when surgeons considered as the reference standard [24]

CTS-6 showed higher responsiveness to changes after CTS treatment compared to the quick dash questionnaire [25] and has a discriminative ability to differentiate between levels of CTS severity [26]. Moreover, CTS-6 as moderate to high (0.76- 0.86) interrater reliability and varying levels of experience could not affect its reliability [24,26]

CTS-6 consists of six items, each question is rated on a 5-point scale, where 1 represents the best outcome and 5 represents the worst, with the total score calculated as the average of all responses. Consequently, this instrument is less complicated in scoring techniques and requires less time and effort [26]

Median nerve motor and sensory parameters

Nerve conduction studies (NCS) can determine the severity of median neuropathy and help clinicians select effective CTS treatments [27].

A systematic review discovered that sensory nerve conduction studies had higher sensitivity (73.4%) and specificity (93.6%) than motor nerve conduction studies, which had sensitivity of 56.2% and specificity of 95.8% [28]

Procedure of NCS

Electrodes of NCS are 3 electrodes, a ground electrode, and two adhesive surface recording electrodes (one active and one reference electrode) connected to a computer processing. The procedure involved sensory testing using ring electrodes on digit III (more sensitive than digit II), followed by motor response assessment via recording electrodes on the 2nd lumbrical muscle, stimulating the median nerve at the wrist.

For median sensory nerve conduction studies, a maximal current was applied to record responses from digits II-IV. Motor responses were recorded from the abductor pollicis brevis muscle with stimulation at the wrist and elbow. The orthodromic technique was used for both sensory and motor median nerve conduction studies, as illustrated in Figures (2,3)

Amplitude measurements were taken peak-to-peak for sensory responses and base-to-peak for motor responses. If median sensory responses (digits II-III) or motor responses (abductor pollicis brevis) were unrecordable, alternative motor recordings were obtained from the 2nd lumbrical muscle with median nerve stimulation at the wrist [29].

Fig (2) Recording sites of motor NCS

Fig (3) Recording sites of sensory NCS

Intervention

All the patients in the two treatment groups received twelve sessions, scheduled three times weekly over four weeks [11,17,30], either dry

needle (group A) or neural mobilization (group B) according to the randomization. A single physiotherapist with three years of dry needling experience administered treatment to all patients.

Dry needling

The patient was placed in a comfortable position to access the treatment area. The skin was prepared with 70% alcohol. Dry needling was applied to the flexor region of the forearm , mainly in the flexor carpi radialis tendon, and then A sterile, thin needle (0.25 × 25 mm) was inserted 2-5 mm deep into specific points using the dynamic technique [11] (Fig. 4). Once removing the needle, tissue compression lasted 5-10 seconds or 30-60 seconds for bleeding [31.] Patients were instructed to use ice or heat therapy after the session to manage pain [15].

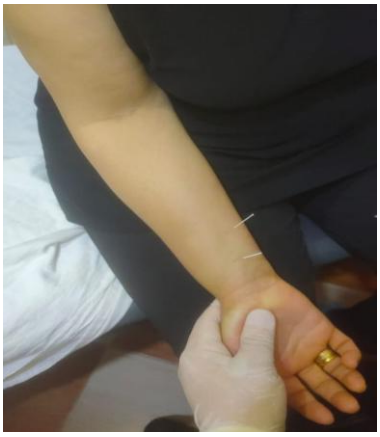

Fig (4): Locations of dry needling

Neural tensioning mobilization

This technique is based on applying tension to the median nerve through joint movements that were simultaneously performed. The patient lay supine with shoulder girdle depression, 110º glenohumeral abduction, and lateral rotation. Wrist and fingers were extended, forearm supinated, and elbow extended to terminal position, reproducing clinical symptoms. If the pain increased, elbow extension was reduced by 5-10º. From this new terminal position, 10 elbow flexion/extension movements were done while keeping the other joints in the test position **(Figures 5,6).** Four sets of 10 reps were performed at 6 seconds per cycle, with a 10-second hold, and 1 min rest after each cycle[32].

Figure (5): Illustrates Glenohumeral abduction-wrist extension, and supination

Figure (6): Illustrates the end of the extent of elbow extension that produces median nerve symptoms

Statistical analysis

Statistical comparisons between groups were facilitated through independent sample t-tests for demographic characteristics and Chi-square tests for categorical variables like sex distribution. The Shapiro-Wilk test assessed data normality, whereas Levene's test evaluated variance equality across groups. A two-way mixed-design multivariate analysis of variance (MANOVA) examined the impact of group and time on various outcome measures, including pain intensity (VAS), symptom severity (CTS-6), electrophysiological parameters (sensory and motor amplitude, latency), and VLC. To account for multiple comparisons, Bonferroni adjustments were applied, with statistical significance set at $p < 0.05$. The entire statistical analysis was performed using IBM SPSS Statistics version 25 for Windows (IBM SPSS, Chicago, IL, USA).

RESULTS

Subject characteristics:

Table 1 presents the demographic characteristics of both groups, revealing no statistically significant differences in age or sex distribution ($p > 0.05$).

Table 1. Comparison of subject characteristics between both groups (2)

	Group A	Group B	p-value
	Mean ± SD	Mean ± SD	
Age (years)	35.53 ± 9.35	32.87 ± 8.47	0.42
Sex, n (%)			
Females	10 (67%)	13 (87%)	0.19
Males	5 (33%)	2 (13%)	

SD: Standard deviation; p-value: Level of significance

Effect of treatment on VAS, CTS-6, sensory and motor amplitude, latency, and velocity:

A two-way mixed MANOVA showed significant treatment-by-time interaction ($F = 44.08$, $p < 0.001$) and a main effect of time ($F = 214.06$, $p < 0.001$), but no significant main effect of treatment ($F = 1.43$, $p = 0.24$).

Within group comparison

Both groups showed significant reductions in VAS and CTS-6 scores post-treatment ($p < 0.001$). Specifically, Group A exhibited 53.82% and 53.26% decreases in VAS and CTS-6, respectively, while Group B demonstrated 57.35% and 63.19% reductions **(Table 2).**

Table 2. Mean VAS and CTS-6 pre- and post-treatment of groups A and B

	Pre-treatment	Post-treatment			
	Mean ±SD	Mean ±SD	MD	% of change	p-value
VAS					
Group A	6.93 ± 1.16	3.20 ± 1.21	3.73	53.82	0.001
Group B	6.87 ± 0.92	2.93 ± 1.03	3.94	57.35	0.001
MD	0.06	0.27			
	p = 0.86	*p = 0.52*			
CTS-6					
Group A	13.97 ± 3.23	6.53 ± 3.66	7.44	53.26	0.001
Group B	13.50 ± 4.02	4.97 ± 4.42	8.53	63.19	0.001
MD	0.47	1.56			
	p = 0.73	*p = 0.29*			

SD: Standard deviation; MD: Mean difference; p-value: Probability value

Within Group A, a statistically significant reduction in sensory latency was observed post-treatment ($p < 0.001$), whereas no notable changes were detected in sensory and motor amplitude, VLC, or motor latency ($p > 0.05$). Conversely, Group B exhibited substantial improvements, with significant increases in sensory and motor amplitude and VLC, alongside decreases in sensory and motor latency ($p < 0.001$) **(Table 3).**

Table 3. Mean sensory and motor amplitude, latency, and VLC pre- and post-treatment of groups A and B:

	Pre-treatment	Post-treatment			
	Mean ±SD	Mean ±SD	MD	% of change	p-value
Sensory amplitude (uV)					
Group A	32.28 ± 16.32	33.34 ± 15.88	-1.06	3.28	0.19
Group B	34.81 ± 19.60	38.91 ± 20.12	-4.10	11.78	0.001
MD	-2.53	-5.57			
	p = 0.70	***p = 0.41***			
Sensory latency (msec)					
Group A	3.79 ± 0.38	2.89 ± 0.33	0.90	23.75	0.001
Group B	3.75 ± 0.67	3.28 ± 0.56	0.47	12.53	0.001
MD	0.04	-0.39			
	p = 0.87	***p = 0.02***			
Sensory VLC (m/sec)					
Group A	72.80 ± 8.75	73.47 ± 8.23	-0.67	0.92	0.16
Group B	71.87 ± 8.20	74.71 ± 7.33	-2.84	3.95	0.001

MD	0.93	-1.24			
	p = 0.77	***p = 0.66***			
Motor amplitude (uV)					
Group A	7.47 ± 2.44	7.53 ± 2.41	-0.06	0.80	0.79
Group B	7.77 ± 1.95	9.73 ± 2.89	-1.96	25.23	0.001
MD	-0.30	-2.20			
	p = 0.71	***p = 0.03***			
Motor latency (msec)					
Group A	4.49 ± 0.42	4.45 ± 0.42	0.04	0.89	0.15
Group B	4.52 ± 0.77	4.21 ± 0.73	0.31	6.86	0.001
MD	-0.03	0.24			
	p = 0.91	***p = 0.29***			
Motor VLC (m/sec)					
Group A	69.20 ± 8.77	69.47 ± 8.86	-0.27	0.39	0.22
Group B	70.27 ± 10.90	75.23 ± 10.55	-4.96	7.06	0.001
MD	-1.07	-5.76			
	p = 0.77	***p = 0.12***			

SD: Standard deviation; MD: Mean difference; p-value: Probability value.

Between-group comparison

Post-treatment revealed non-significant differences in pain intensity, symptom severity, sensory amplitude, VLC, and motor latency and VLC. Compared to Group B, Group A exhibited a significant decrease in sensory latency ($p < 0.05$). In contrast, Group B showed a significant increase in motor amplitude compared to Group A ($p < 0.05$) **(Table 2-3).**

DISCUSSION

The objective of this study was to determine the comparison of DN versus NM in the management of mild to moderate patients with CTS. Initially, the study hypothesized that DN and NM would yield similar outcomes in terms of symptom severity, function, VLC, amplitude, and latency of sensory and motor median nerve in CTS patients.

The null hypotheses of VAS, symptom severity, sensory amplitude, sensor VLC, motor latency, and motor VLC were accepted. While the null hypotheses related to motor amplitude and sensory latency were rejected.

Regarding the significant changes within the two groups that either received DN or NM, both groups improved in pain and symptom severity. All nerve conduction findings demonstrated significant changes in MN, however, only sensory onset latency was Markedly decreased in the DN group compared to the NM group.

The finding of decreasing sensory onset DL within the DN group with better improvement than NM is a significant noticeable result that may be related to the kind of sensory fibers, these fibers usually have a lower threshold for stimulation than motor fibers, thus conduction along sensory fibers reaches first and are the ones measured [33]. By definition, Onset response latency measures the time it takes for the fastest sensory axons to transmit signals. This latency is used to calculate the sensory nerve conduction velocity (VLC), which reflects the speed at which electrical signals travel through the nerve. Thus, reflects only the fastest conducting fibers, while other slower conducting fibers with a variation of sensory nerve axons diameters participate in the amplitude but are not reflected in either the latency or conduction VLC measurements.

Accordingly, DN improved the fast conduction of large-diameter sensory axons, as these fibers are the first to be affected by

compression of CTS and improve once this compression begins to release. It was reported that improvement in both sensory DL and symptom severity of pain and numbness was related to each other. Whereas, a previous study [34] showed that cupping therapy resulted in a decrease in sensory symptoms and re-establishment of conduction in more superficial sensory fibers. Moreover, through machine learning algorithm revealed that Sensory latency was a notable determinant of pain severity in CTS [35].

Such an impact of DN on pain intensity and sensory latency could be explained through its effect on the sensitization mechanism that is related to the presence of myofascial pain in CTS patients [36]. The mechanism of surface DN in decreasing pain related to deactivating trigger points through needle stimulation of Aδ fibers, which suppresses C fiber pain transmission via descending pathways and dorsal horn interneuron [31] Furthermore, DN may help in releasing the trigger points that could contribute to myofascial compression on the carpal tunnel and median nerve.

DN group didn't show any further improvement in other NCS variables, which may be attributed to the impact of superficial DN that needed to be enhanced with other interventions. A clinical trial showed that DN with active stretching demonstrated greater efficacy in myofascial pain treatment than active stretching by itself [37].

The intervention techniques that focus on the motion of the nerves, including NM, are based on a specific sequence that more efficiently decreases pressure on the median nerves through axonal transport, maximal excursion, blood flow, and regeneration [31]. In this study, NM effect was reflected in the improvement, specifically sensory amplitude with a mean difference (MD) (-4.1) within DN and a significant increase in motor amplitude between DN and NM groups with MD (-2.20). Both sensory and motor amplitudes of the median nerve reflect several orders of magnitude smaller, consequently indicating real improvement in NCS.

As far as the authors are aware, no study has examined the comparison between DN versus NM in CTS regarding clinical symptoms and median nerve conduction to directly compare. However, some studies investigated the effectiveness of DN or NM on alleviating pain, reducing symptom severity, and improving median nerve conduction in CTS patients.

There is a deficiency in the published literature about DN effectiveness in CTS [11-13,38]. Few studies that addressed DN effect on NCS [12,38]. The results of this study align with previous research that found a reduction in pain intensity in mild and moderate CTS following only one session of DN in forearm trigger points along with a wrist splint [38]. Other study [12] showed DN could be efficient in improving median sensory DL after 2 sessions only with a 48-h interval, and at 2-week follow up relative to the control group received no treatment.

The findings of the current study of NM on NCS were supported by the results of a systematic review and meta-analysis[39] which concluded that manual therapy includes neural and soft tissue mobilization improves NCS that showed a standard mean difference (SMD) of − 0.19 with 95% CI (− 0.40, − 0.02) on motor conduction study and SMD of − 1.15 with 95% CI (− 1.36, − 0.93) on sensory conduction. These findings are consistent with the current study that revealed motor amplitude and VLC of median nerve increased more within NM group than within DN group as amplitude MD -1.96, p= 0.001, VLC MD -4.96, p=0.001 in MN group whereas in DN group MD of -0.06, p= 0.79 and -0.27, p =0.2 respectively.

Another systematic review and meta-analysis in 2023[40] focused on neurodynamic exercises' effect in CTS, consistent with our finding regarding NM on CTS clinical symptoms, revealed that neuro mobilization exercises were better than no treatment on pain (SMD = −2.36, 95% CI −4.31 to −0.41), and functional outcome (SMD = −1.27).

Furthermore, a narrative review includes 17 studies addressing the effect of NM in the management of CTS[41] concluded that neural tissue mobilization significantly enhances pain and functionality, as well as NCS, mainly motor nerve conduction in mild to moderate CTS. Another study [42] compared NM with

other active intervention of carpal bone mobilization, both groups received tendon mobilization exercises as a common supplemen. Our results indicated that NM group achieved more notable improvement regarding symptom severity and nerve conduction VLC.

Limitation

Some limitations of this study should be considered in future studies. Both the therapist and the assessor were not blinded. However, the measured outcomes were self-reported by blinded participants and objectively measured, consequently, the blinding issue would not bias the results. The outcomes measured in the current study reflect a short-term period (4 weeks), thus long-term follow-up is needed to monitor the consistency of the treatment effects. The patients in the current study ranged from mild to moderate cases.

Sensory distal latency in the current study depends on onset latency, however, it would be better to measure peak response latency due to its greater reliability and reproducibility, especially given the typically small amplitudes of sensory nerve action potentials.

Additional studies is required to explore the impact of DN and neuromobilization on CTS, considering the above-mentioned limitations, including long-term monitoring and a wider range of CTS severity based on the electrophysiological measurements.

CONCLUSIONS

The study showed that dry needling and neural mobilization effectively improve symptoms of CTS, with DN more effective in enhancing sensory median nerve latency and neural mobilization able to improve median nerve function, particularly motor amplitude.

Abbreviations

DN: Dry needling
NM: Neural mobilization
NCS: Nerve conduction study
VLC: Velocity of NCS
DL: Distal latency
Mean difference: MD
Standard mean difference: SMD

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Availability of data and materials : The datasets used in this study are available from the corresponding author upon request. This research received ethics approval from Cairo University's Faculty of Physical Therapy Ethics Committee (P.T.REC/012/005440), and participants provided consent for publication of their images. The authors declare no conflicts of interest.

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