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Median nerve mobilization techniques in the treatment of carpal tunnel syndrome: A systematic review

Yi Huey Lim BSc (Occupational Therapy)[a,b,*], Derserri Y. Chee BSc (Hons) (Occupational Therapy)[a], Sonya Girdler PhD[a], Hoe C. Lee PhD[a,*]

[a] School of Occupational Therapy and Social Work, Curtin University, Bentley, Western Australia, Australia
[b] Occupational Therapy Department, Tan Tock Seng Hospital, Singapore, Singapore

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ABSTRACT

Study Design: Systematic review.
Introduction: Median nerve mobilization is one of the interventions used in the treatment of carpal tunnel syndrome (CTS). However, it is uncertain how many types of mobilization techniques are described in the current literature or the relative effectiveness of these techniques in treating CTS.
Purpose of the Study: The aim of this review was to describe the types and effectiveness of median nerve mobilization techniques studied in the CTS literature.
Methods: Electronic searches of 5 databases and manual searches of references lists located randomized controlled trials studies published between 2000 and April 2015. Quality appraisal for each study was conducted using the Standard Quality Assessment Criteria for Evaluating Primary Research Papers from a Variety of Fields by 2 independent reviewers.
Results: Nine randomized controlled trial studies describing various median nerve mobilization techniques used in the treatment of CTS were included. All studies were rated as of "adequate", "good", or "strong" quality for the Standard Quality Assessment Criteria. Three techniques of median nerve mobilization were described. Treatment outcomes included measures of electrodiagnostic testing, functional performance, pain, physical examination, sensation, and strength. Standardized mean differences for the treatment outcomes ranged from very small to large (0.05-1.71).
Conclusion: The findings are inconclusive regarding the effectiveness of each mobilization technique due to methodological limitations in the current body of research. Therefore, there is a clear need for high-quality controlled studies to examine various approaches to median nerve mobilization techniques in the treatment of CTS.
Level of evidence: 2a.

Introduction

Carpal tunnel syndrome (CTS) describes an upper extremity neuropathy of the median nerve, often attributable to increased pressure in the carpal tunnel resulting in compression of the median nerve.[1] According to the United States 2010 National Health Interview Survey, the prevalence of self-reported clinician diagnosed CTS and work-related CTS was 8% and 2.1%, respectively.[2] CTS substantially impacts on quality of life and the performance of daily activities,[3] with the median lost work time from work-related CTS being 27 days longer than most work-related disorders.[4] In the United States, the medical costs of CTS are estimated to exceed $2 billion annually.[4]

CTS is commonly classified as mild, moderate, or severe.[1] Mild and moderate symptoms of CTS include paresthesia of the palmar aspect of the thumb, index finger, middle finger, and radial half of the ring finger,[5,6] although the palm itself remains unsymptomatic.[6] Individuals with severe symptoms of CTS may present with thenar atrophy and loss of sensibility,[1] resulting in gradual weakness and loss of hand function.[7,8]

Treatment of CTS depends on severity and includes surgical and nonsurgical options. Surgery involves release of the carpal tunnel

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* Corresponding authors. School of Occupational Therapy and Social Work, Curtin University, GPO Box U1987, Perth, Western Australia 6845, Australia. Tel.: +61 8 9266 3600.
E-mail addresses: yihuey.lim@postgrad.curtin.edu.au (Y.H. Lim), h.lee@curtin.edu.au (H.C. Lee).

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and is generally recommended for those with severe symptoms who are unresponsive to nonsurgical treatments.[9] Nonsurgical interventions are for those with mild to moderate symptoms of CTS, which include wrist orthosis, exercises, ultrasound, and steroid injections.[10,11]

Median nerve mobilization is commonly used in the management of CTS,[12] involving a range of exercises aimed at mobilizing the median nerve with the goal of reducing pressure within the carpal tunnel.[13] Although some techniques simultaneously stretch the nerve from both ends, others place tension on the nerve at one end while releasing the tension at another.[14,15] It is uncertain how many mobilization techniques are described in the current literature. Furthermore, systematic reviews have compared the relative effectiveness of various median nerve mobilization techniques in treating CTS; however, pooled analysis of techniques failed to consider the relative effectiveness of each technique in treating CTS.[11,12] Therefore, the aim of this review was to describe the types of median nerve mobilization techniques studied in the CTS literature, evaluating their effectiveness relative to control or comparison interventions.

Methods

The protocol for this systematic review was registered in PROSPERO, CRD42015019429.[16] This review adopted the common principles and techniques employed in systematic reviews.

Search strategy

CINAHL, Scopus, MEDLINE (Ovid), EMBASE, and Cochrane Library electronic databases were searched to identify relevant studies published from 2000 to April 2015. Medical Subject Heading (MeSH) terms included “carpal tunnel syndrome” and “nerve mobilization” supplemented with free text words and synonyms. A manual review of the references of included studies and previous systematic reviews ensured all appropriate studies were identified. No language limits were applied, with languages other than English translated.

Inclusion/exclusion criteria

Inclusion criteria were established a priori with studies included if they (1) compared median nerve mobilization and a control or comparison intervention with the treatment of CTS and (2) diagnosed individuals with CTS based on clinical and electrophysiological evidence. Studies were excluded if they were (1) a nonrandomized controlled trial, (2) surgically treated CTS, or (3) systematic reviews, conference proceedings, abstracts, thesis, or technical reports.

Study selection

Two reviewers (Y.H.L and D.Y.C.) independently applied the inclusion/exclusion criteria to the titles and abstracts of identified articles to screen for inclusion. These reviewers then independently screened the full text of each study to determine if they met criteria. Disagreements were resolved to consensus through discussion.

Study quality assessment

Two reviewers independently assessed the methodological quality of included studies using the Standard Quality Assessment Criteria for Evaluating Primary Research Papers from a Variety of Fields (Table 1),[17] a validated 14-item assessment checklist in which points were awarded to each criterion (yes = 2, partial = 1, and no = 0). Summary scores for individual studies were then converted to percentage scores out of the total possible score of 28, enabling comparison of methodological quality across selected studies with percentages categorized as strong (score of $> 80\%$), good (70%-80%), adequate (50%-69%), or limited ($< 50\%$), respectively.[18] Studies with percentage scores below 50% were excluded from the review. Disagreements were resolved via discussion until consensus.

Data extraction

Data were extracted from included studies independently by 2 reviewers according to the methods as outlined in the Centre for Reviews and Dissemination[19] and inclusive of descriptions of participants, intervention, control/comparison, outcome measures, results, and quality rating of the study.

Data synthesis and analysis

Given the small number of included studies in this systematic review, meta-analysis was not possible. Instead, a narrative review was undertaken to summarize findings and provide an assessment of methodological issues. However, where sufficient data were provided, standardized mean differences (SMDs) and 95% confidence intervals were calculated using Review Manager Software version 5.3.[20] SMDs were interpreted as follows: very small (≥ 0.01, < 0.20), small (≥ 0.20, < 0.5), medium (≥ 0.05, < 0.80), and large (≥ 0.08, < 1.30).[21,22]

Table 1
Criteria for assessing methodological quality

Items		Answers
1.	Question/objective sufficiently described?	Yes/partial/no
2.	Study design evident and appropriate?	Yes/partial/no
3.	Method of subject/comparison group selection or source of information/input variables described and appropriate?	Yes/partial/no
4.	Subject (and comparison group, if applicable) characteristics sufficiently described?	Yes/partial/no
5.	If interventional and random allocation was possible, was it described?	Yes/partial/no
6.	If interventional and blinding of investigators was possible, was it reported?	Yes/partial/no
7.	If interventional and blinding of subjects was possible, was it reported?	Yes/partial/no
8.	Outcomes and (if applicable) exposure measure(s) well defined and robust to measurement/misclassification bias? Means of assessment reported?	Yes/partial/no
9.	Sample size appropriate?	Yes/partial/no
10.	Analytic methods described/justified and appropriate?	Yes/partial/no
11.	Some estimate of variance is reported for the main results?	Yes/partial/no
12.	Controlled for confounding?	Yes/partial/no
13.	Results reported in sufficient details?	Yes/partial/no
14.	Conclusions supported by the results?	Yes/partial/no

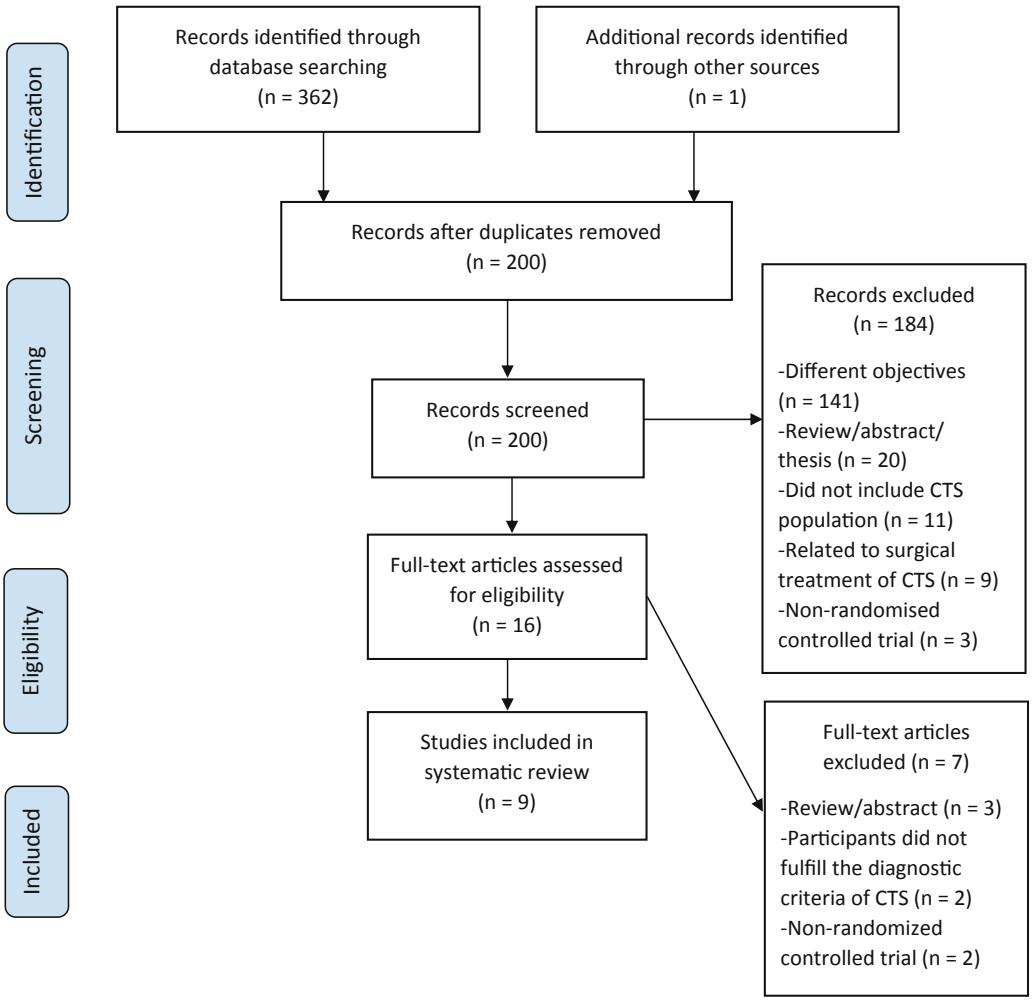

Fig. 1. A flow chart of the search strategy based on PRISMA flow diagram. CTS = carpal tunnel syndrome; PRISMA = Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

Results

Study selection

Initial searches of all databases identified 362 articles for potential inclusion. A manual search of reference lists revealed one additional study. Following removal of duplicates and application of the inclusion/exclusion criteria to the articles, 9 studies met the eligibility criteria (Fig. 1). Key reasons for exclusion were that the articles had differing objectives to those of the review, failure to assess or diagnose CTS in the sample, or used nonrandomized controlled study design.

Methodological quality and risk of bias of included studies

Although the inclusion criterion for methodological quality assessment was set a prior at 50%, no study was excluded from the review based on this criterion, with the quality of included studies being strong for 3, good for 2, and adequate for 4 studies. Common limitations across included studies were insufficient

Table 2
Methodological quality of included studies

Study	Items on standard quality assessment checklist													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Akalin et al[23]	+	+	±	+	+	−	−	±	±	+	+	±	+	+
Atya and Mansour[24]	+	±	±	+	+	−	−	±	±	+	+	±	±	+
Bardak et al[25]	+	+	+	+	+	+	−	±	±	+	+	+	+	+
Baysal et al[26]	+	+	±	+	+	+	−	±	±	+	+	±	+	±
Heebner and Roddey[27]	+	±	+	±	+	−	−	±	±	+	−	±	+	+
Horng et al[28]	+	+	+	+	+	+	−	±	±	+	+	±	+	+
Pinar et al[29]	+	+	±	−	±	-	−	±	±	+	+	±	+	±
Schmid et al[30]	+	±	±	+	+	+	−	+	±	+	+	+	+	+
Tal-Akabi and Rushton[31]	+	+	±	+	+	−	−	+	±	+	−	±	+	+

+ = yes; − = no; ± = partial.

Table 3
Characteristics of included studies describing the distal nerve tensioning technique

Study	Participants	Intervention	Control/comparison	Outcome measures	Results	Quality rating
Akalin et al[23]	$N = 28$ Age range: 38-64	Wrist orthosis with distal nerve tensioning and tendon gliding ($n = 14$) Repeat exercise: 5 sets of 10 repetitions/d over 4 wk	Wrist orthosis only ($n = 14$)	Measured at baseline and at 8-wk follow-up Functional performance: BCTQ Physical examination: Phalen's test and Tinel's sign Sensation: 2-PD Strength: Martin Vigorimeter	Functional performance: no significant difference between groups Physical examination: no significant difference between groups Sensation: no significant difference between groups Strength: significantly increased pinch strength in the intervention group compared with comparison group (mean ± SD, intervention, 35.27 ± 9.7, vs comparison, 30.0 ± 9.3; $P = .026$). No significant difference in grip strength between groups	Good 20/28 72%
Atya and Mansour[24]	$N = 30$ Age range: 30-45	Distal nerve tensioning and tendon gliding ($n = 15$) Repeat exercise: 3 sets of 10 repetitions/d over 2 mo	Low-level laser treatment ($n = 15$)	Measured at baseline and end of treatment session (4 wk or 2 mo) Electrodiagnostic test: NCS Pain: VAS Strength: handheld dynamometer	Electrodiagnostic test: significantly improved in the comparison group compared with intervention group ($P < .05$) Pain: significantly reduced pain in the comparison group compared with intervention group (mean ± SD, intervention, 5.2 ± 1.52, vs comparison, 2.86 ± 1.30; $P < .05$) Strength: significantly increased grip strength in the comparison group compared with intervention group (mean ± SD, intervention, 11.6 ± 2.92, vs comparison, 16.2 ± 2.27; $P < .05$)	Adequate 18/28 64%
Bardak et al[25]	$N = 111$ Age range: 22-74	Standard treatment with exercise (distal nerve tensioning and tendon gliding) ($n = 35$) Only exercise ($n = 35$) Repeat exercise: 3 sets of 5 repetitions/d over 6 wk	Standard treatment (including wrist orthosis and betamethasone injection) ($n = 41$)	Measured at baseline and at 8-wk follow-up Functional performance: STP and FSS Pain: VAS Physical examination: Tinel's test, Phalen's test, reverse Phalen's test, and compressions test Sensation: 2-PD	Functional performance: significantly improved functional performance score in the standard treatment with exercise group compared with exercise group (mean ± SD, standard treatment with exercise, 10.8 ± 4.2, vs exercise, 15.2 ± 6.26; $P < .001$). No significant difference between standard treatment with exercise and standard treatment groups Pain: not reported Physical examination: difference between groups not reported Sensation: not reported	Strong 24/28 86%
Baysal et al[26]	$N = 28$ Age range: 47.8-51.4 Attrition rate: 22%	Wrist orthosis, ultrasound with distal nerve tensioning and tendon gliding ($n = 8$) Wrist orthosis with distal nerve tensioning and tendon gliding ($n = 12$) Repeat exercise: 5 sets of 10 repetitions/d over 3 wk	Wrist orthosis and ultrasound ($n = 8$)	Measured at baseline, 3-wk, and at 8-wk follow-ups Electrodiagnostic test: NCS Function: BCTQ Pain: VAS Physical examination: Phalen's test and Tinel's test Sensation: 2-PD Strength: handheld dynamometer and standard dynamometer	Electrodiagnostic test: no significant difference between groups Functional performance: no significant difference between groups Pain: no significant difference between groups Physical examination: no significant difference between groups Sensation: no significant difference between groups Strength: no significant difference between groups	Good 21/28 75%

(*continued on next page*)

Table 3 (*continued*)

Study	Participants	Intervention	Control/comparison	Outcome measures	Results	Quality rating
Horng et al[28]	$N = 53$ Mean age: 50.5 Attrition rate: 11.7%	Standard treatment with distal nerve tensioning ($n = 19$) Repeat exercise: 3 sets of 5 repetitions/d over 2 mo	Standard treatment (including paraffin therapy and wrist orthosis) ($n = 16$) Standard treatment with tendon gliding ($n = 18$)	Measured at baseline and at 2-mo follow-up Electrodiagnostic test: NCS Functional performance: BCTQ and DASH Pain: VAS Physical examination: Phalen's test and Tinel's test Sensation: SWM Strength: Handheld dynamometer and standard dynamometer	Electrodiagnostic test: no significant difference between groups Functional performance: significantly improved functional performance scores in the standard treatment with tendon gliding group compared with intervention group (mean, standard treatment with tendon gliding, 1.3, vs intervention, 1.6; $P < .04$). No significant difference between standard treatment with distal nerve gliding and standard treatment groups Pain: no significant difference between groups Physical examination: no significant difference between groups Sensation: no significant difference between groups Strength: no significant difference between groups	Strong 23/28 82%
Pinar et al[29]	$N = 26$ Age range: 33-55	Standard treatment with distal nerve tensioning ($n = 14$; 19 hands) Repeat exercise: 5 sets of 10 repetitions/d over 10 wk	Standard treatment (including wrist orthosis and patient training program) ($n = 12$; 16 hands)	Measured at baseline and at 10-wk follow-up Electrodiagnostic test: NCS Pain: VAS Physical examination: Tinel's test and Phalen's test Sensation: SWM and 2-PD Strength: MMT of the abductor pollicis brevis, Jamar hand dynamometer, and Jamar pinch meter	Electrodiagnostic test: no significant difference between groups Pain: no significant difference between groups Physical examination: no significant difference between groups Sensation: no significant difference between groups Strength: significantly increased grip strength in the intervention group compared with comparison group (mean ± SD, intervention, 22.0 ± 6.8, vs comparison, 21.7 ± 4.3; $P < .05$). MMT not reported	Adequate 16/28 57%

BCTQ = Boston Carpal Tunnel Questionnaire; DASH = Disabilities of the Arm, Shoulder and Hand Questionnaire; FSS = Functional Status Scale; MMT = manual muscle test; NCS = nerve conduction studies; 2-PD = 2-point discrimination test; SD = standard deviation; STP = symptom total point; SWM = Semmes-Weinstein monofilament test; VAS = Visual Analogue Scale.

description of participant characteristics, lack of blinding of participants and assessors, and small sample sizes (Table 2).

Study characteristics

The 9 included studies had a total of 404 participants, of which 357 were females and 36 were males. The age of the participants ranged between 18 and 85 years old. Sample sizes of the studies ranged from 20 to 111 subjects. Median nerve mobilization exercises were commonly undertaken in conjunction with tendon gliding exercises,[23-28,30] which facilitate the gliding of the finger tendons through the carpal tunnel region.[32] The major characteristics of the included studies are summarized in Tables 3-5.

Types of median nerve mobilization techniques

Three types of median nerve mobilization techniques were described. The most frequently studied technique was distal nerve tensioning ($n = 6$), followed by upper quarter nerve tensioning ($n = 2$), and nerve sliding ($n = 1$). Figure 2 describes the routine and frequency of the 3 median nerve mobilization techniques.

The included studies used 24 outcome measures covering 6 broad areas: electrodiagnostic testing, functional performance, pain, physical examination, sensation, and strength. Electrodiagnostic tests included nerve conduction study and signal intensity. Functional performance was assessed via the Boston Carpal Tunnel Questionnaire, Brigham and Woman's Hospital Carpal Tunnel Syndrome Questionnaire, Disabilities of the Arm, Shoulder and Hand Questionnaire, Functional Status Scale, symptom total point, and Functional Box Scale. Level of pain was assessed via a Visual Analogue Scale, pain relief scale, and neurodynamic irritability of median nerve. Physical examination involved the use of Tinel's test, Phalen's test, reverse Phalen's test, compression test, upper limb tension test 2a, and range of motion. Sensation response was assessed via a Visual Analogue Scale, 2-point discrimination, and Semmes-Weinstein Monofilament test. Strength was assessed via a Martin Vigorimeter, handheld dynamometer, pinch meter, and manual

Table 4
Characteristics of included studies describing the upper quarter nerve tensioning technique

Study	Participants	Interventions	Control/comparison	Outcome measures	Results	Quality rating
Heebner and Roddey[27]	$N = 29$ Age range: 32-75 Attrition rate: 53.3%	Standard treatment with upper quarter nerve tensioning ($n = 14$) Repeat exercise: 3-5 sets of 10 repetitions/d	Standard treatment (including wrist orthosis and tendon gliding) ($n = 15$)	Measured at baseline, 1-mo, and at 6-mo follow-ups Functional performance: DASH and CTSQ Pain: Neurodynamic irritability of median nerve (R1)	Functional performance: no significant difference between groups Pain: no significant difference between groups	Adequate 17/28 61%
Tal-Akabi and Rushton[31]	$N = 21$ Age range: 29-85	Upper quarter nerve tensioning ($n = 7$) Interventions continued over 3 wk. Frequency of the exercise and treatment were not described	Carpal bone mobilization ($n = 7$) No intervention ($n = 7$)	Measured at baseline and at 3-wk follow-up Functional performance: Functional Box Scale Pain: VAS and pain relief scale Physical examination: range of motion and ULTT2a	Functional performance: no significant difference between groups Pain: difference between groups reported but further analysis not available Physical examination: no significant difference between groups	Adequate 19/28 68%

CTSQ = Brigham and Woman's Hospital Carpal Tunnel Syndrome Questionnaire; DASH = Disabilities of the Arm, Shoulder and Hand Questionnaire; ULTT2a = upper limb tension test 2a; VAS = Visual Analogue Scale.

muscle testing of the abductor pollicis brevis. Each study reported between 2 and 6 treatment outcomes, with 8 out of 9 studies evaluating at least 3 treatment outcomes (Table 6).

Distal nerve tensioning

Six of the included studies[23-26,28,29] studied the effectiveness of the distal nerve tensioning technique.[32] The methodological quality rating was strong in 2 studies,[25,28] good in 2 studies,[23,26] and adequate in 2 studies.[24,29]

Three studies reported no difference in electrodiagnostic testing and pain outcomes between groups after treatment.[26,28,29] Four studies reported no difference in functional performance outcomes between participants using the distal nerve gliding technique in combination with wearing a wrist orthosis and participants wearing a wrist orthosis alone.[23,25,26,28] However, participants wearing a wrist orthosis alone exhibited improved functional performance outcomes compared with participant performing distal nerve tensioning and tendon gliding exercises ($P < .001$).[25] Participants assigned to tendon gliding with wrist orthosis also demonstrated improved functional performance in comparison to participants assigned to distal nerve tensioning with wrist orthosis.[28] Four studies reported no difference in physical examination and sensation outcomes between groups.[23,26,28,29] Two studies[26,28] found no difference in strength outcomes between groups. In contrast, 2 studies reported increased pinch strength,[23] $P = .026$, and grip strength,[29] $P = .05$, in participants assigned to distal nerve tensioning with wrist orthosis compared with participants assigned to wrist orthosis alone.

The SMD of strength and functional outcomes ranged between very small and large (Table 7). All SMDs, with the exception of grip strength in the study by Atya and Mansour,[24] failed to reach significance. The SMD in the study by Atya and Mansour[24] indicated improved grip strength in the group receiving low-level laser. Recalculation of the SMD undertaken as part of this review revealed discrepancies between the reported results and our calculations in 2 studies,[23,29] which reported that pinch and grip strength was significantly improved in the intervention group, a conclusion not supported by our calculations.

Upper quarter nerve tensioning

Two of the included studies[27,31] studied the upper quarter nerve tensioning technique.[33] The methodological quality rating was adequate in both studies.[27,31] Both studies reported no difference in functional performance outcomes between groups.[27,31] One study[27] found no difference in pain outcomes between participants using the upper quarter nerve tensioning

Table 5
Characteristics of included studies describing the nerve sliding technique

Study	Participants	Intervention	Control/comparison	Outcome measures	Results	Quality rating
Schmid et al[30]	$N = 20$ Age range: 49.9-57.9 Attrition rate: 0.05%	Distal nerve sliding and tendon gliding ($n = 10$) Repeat exercise: 10 sets of 10 repetitions/d	Wrist orthosis only ($n = 10$)	Measured at baseline and 1-wk follow-up Electrodiagnostic test: signal intensity of the median nerve of the carpal tunnel, palmar bowing of the carpal ligament Functional performance: BCTQ Pain: VAS Sensation: VAS	Electrodiagnostic test: no significant difference between groups Functional performance: no significant difference between groups Pain: no significant difference between groups Sensation: no significant difference between groups	Strong 23/28 82%

BCTQ = Boston Carpal Tunnel Questionnaire; VAS = Visual Analogue Scale.

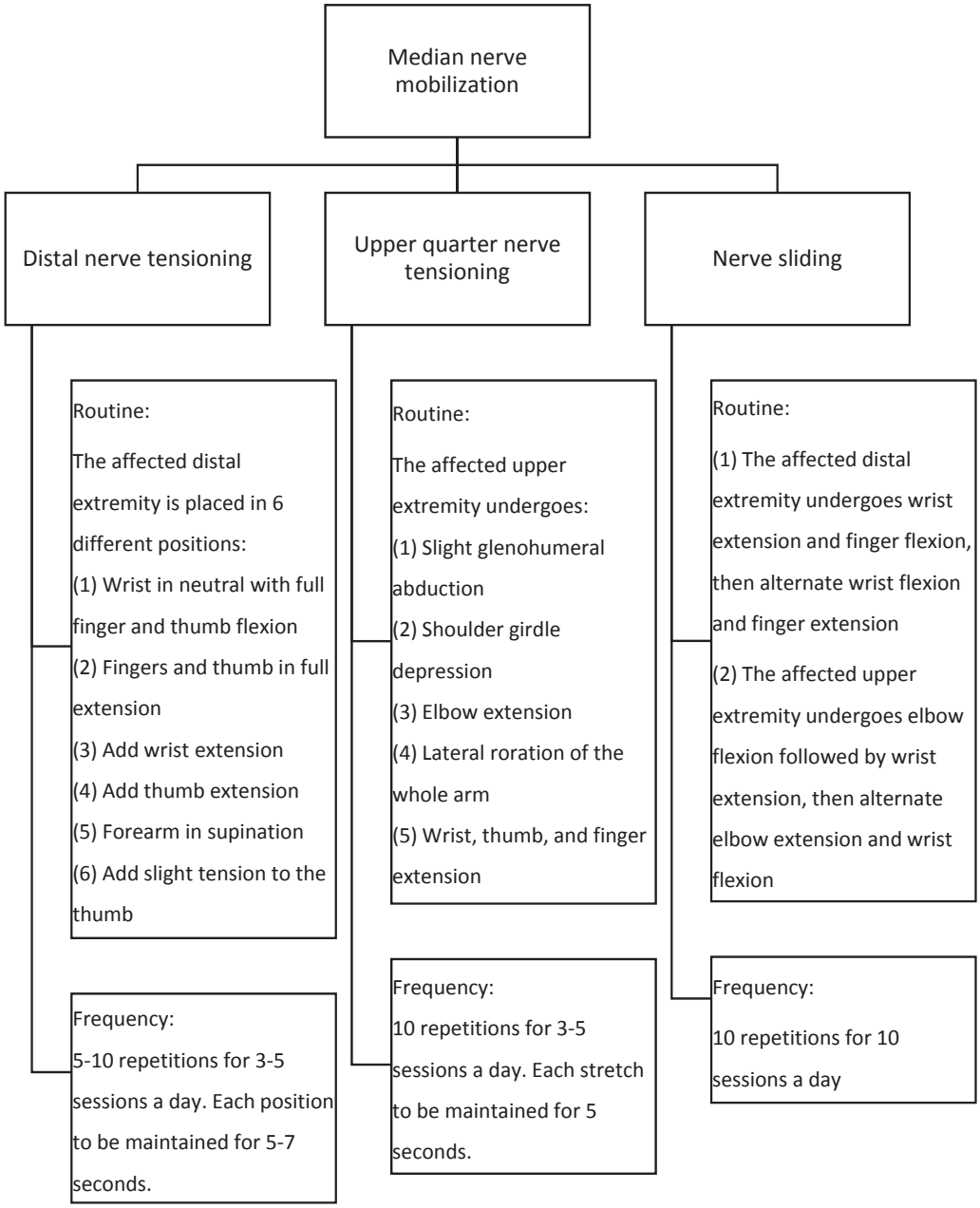

Fig. 2. Description of median nerve mobilization techniques, routines, and frequency of use in the included studies.

technique in combination with wearing a wrist orthosis and participants using a wrist orthosis alone. In contrast, one study[31] reported a significant difference in pain outcomes between the intervention, comparison, and control groups; however, no further analysis was reported. The same study found no difference on physical examination outcomes between groups.

Nerve sliding

One study[30] of strong methodological quality investigated the effect of nerve sliding and tendon gliding exercises on reducing symptoms of CTS.[34] This study reported no significant differences in electrodiagnostic testing, functional performance, pain, or sensation outcomes between participants assigned to nerve sliding and tendon gliding exercises and participants assigned to wrist orthosis alone. Both SMD for pain and functional performance outcomes were small, failing to reach statistical significance (Table 8).

Discussion

This present study systematically reviewed the CTS literature, describing the various approaches to median nerve mobilization used in the treatment of CTS. The effectiveness of 3 mobilization techniques was examined across the 9 studies with great variability in the methodology and treatment outcomes across studies. Overall, the evidence is not sufficiently robust to determine the comparative effectiveness of each mobilization technique in relation to control or comparison interventions.

Table 6
Summary of treatment outcomes assessed in included studies

Study	Treatment outcomes					
	Electrodiagnostic test	Functional performance	Pain	Physical examination	Sensation	Strength
Distal nerve tensioning						
Akalin et al[23]		X		X	X	X
Atya and Mansour[24]	X		X			X
Bardak et al[25]		X		X	X	
Baysal et al[26]	X	X	X	X	X	X
Horng et al[28]	X	X	X	X	X	X
Pinar et al[29]	X		X	X	X	X
Upper quarter nerve tensioning						
Heebner and Roddey[27]		X	X			
Tal-Akabi and Rushton[31]		X	X	X		
Nerve sliding						
Schmid et al[30]	X	X	X		X	
Total number of studies	5	7	7	6	6	5

The findings of this review revealed that the treatment effect varied across mobilization techniques. Although differences did not reach statistical significance in 2 studies,[23,29] the combined use of distal nerve tensioning and wrist orthosis demonstrated a trend toward improvements in strength outcomes compared with the wearing of a wrist orthosis alone. Another study showed that the use of nerve sliding alone had the same treatment effect as the wearing of a wrist orthosis.[30] The variability in findings suggests that various mobilization techniques may have differing effects on treatment outcomes. Earlier research suggested that differing approaches to median nerve mobilization result in varying degrees of nerve excursion.[35] For instance, positioning the wrist in extension combined with elbow flexion may increase the nerve excursion by as much as 30%, compared with wrist extension alone.[36] Varying degrees of nerve mobility may mechanically and differentially impact on the peripheral nervous system,[36] with various approaches to median nerve mobilization resulting in different treatment outcomes. There is a need for further research examining the comparative effectiveness of various approaches to median nerve mobilization and the effect of individual mobilization techniques in the treatment of CTS.

Several methodological issues across the included studies limit the findings of this review. Approximately half of the included studies had less than 15 participants per study group and 8 studies failing to report a power analysis. Small sample size reduces study power and the ability to detect significant differences between groups.[37] Additional methodological shortcomings of the studies included high attrition rate, missing data, failure to control for confounding factors, and inadequate statistical analysis, resulting in possible research bias.[38] With the exception of one study,[31] none assessed for the presence of adverse tension in the median nerve during the study recruitment. Adverse neural tension is believed to be one of the casual factors in the physiopathology of CTS,[39] and median nerve mobilization is likely effective only for patients with adverse tension.[15] Therefore, understanding the true effectiveness of these techniques is dependent on a more complete description of the causative physiopathology of CTS.

The evaluation of the effectiveness of mobilization techniques is affected by the heterogeneity of outcome measures and the absence of a gold standard assessment.[40] Although electrodiagnostic testing is a diagnostic gold standard, due to its high specificity and sensitivity estimates,[6] less than half of the studies included in this review performed this test. Instead, pain and functional performance assessments were the most commonly measured treatment outcomes in this review. More consistent gold standard diagnosis of CTS would significantly strengthen the evidence in this field. Future research needs to address these methodological issues in order to provide high-quality evidence to the field of median nerve mobilization.

Study limitations

The strict selection criteria, leading to the exclusion of some studies, specifically those that did not use a randomized controlled trial design, may limit the findings of this review.

Conclusion

The findings from this review described 3 techniques of median nerve mobilization in the CTS literature. Different approaches to median nerve mobilization appear to affect treatment outcomes differently. However, there is insufficient evidence to determine the comparative effectiveness of each mobilization technique in relation to control or comparison interventions. Future research must address the noted methodological issues in the current body of research if we are to understand the true effectiveness of median nerve mobilization in the treatment of CTS.

Table 7
Standardized mean differences for studies describing the distal nerve tensioning technique

Studies	Grip strength; SMD (95% CI)	Studies	Pinch strength; SMD (95% CI)	Studies	Functional performance; SMD (95% CI)
Akalin et al[23]	0.30 (−0.44 to 1.05)	Akalin et al[23]	0.54 (−0.22 to 1.29)	Akalin et al[23]	−0.17 (−0.91 to 0.57)
Atya and Mansour[24]	−1.71 (−2.56 to −0.86)	Baysal et al[26]	0.55 (−0.46 to 1.55)	Bardak et al[25]	−0.05 (−0.50 to 0.40)
Baysal et al[26]	−0.28 (−1.27 to 0.71)	Pinar et al[29]	0.32 (−0.46 to 1.10)	Baysal et al[26]	−0.50 (−1.50 to 0.50)
Pinar et al[29]	0.05 (−0.72 to 0.82)				

SMD = standardized mean difference; CI = confidence interval.

Table 8
Standardized mean differences for studies describing the nerve sliding technique

Studies	Pain; SMD (95% CI)	Studies	Functional performance; SMD (95% CI)
Schmid et al[30]	−0.23 (−1.11 to 0.65)	Schmid et al[30]	−0.38 (−1.26 to 0.51)

SMD = standardized mean difference; CI = confidence interval.

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Human and Animal Participants: This article does not contain any studies with human participants or animal performed by any of the authors.

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