Journal of Orthopaedic Surgery and Research

SYSTEMATIC REVIEW

Open Access

Meta-analysis on effects of lymphatic drainage techniques in the management of carpal tunnel syndrome

Sina Shahshenas[1], Hossein Yarmohammadi[3,2], Masood Soltanipur[3,2] and Zahra Sheikhi[2,3*]

Abstract

Background Carpal tunnel syndrome (CTS) is a common neuropathy caused by median nerve compression, leading to pain, numbness, and functional impairment. While surgical decompression remains the definitive treatment for severe cases, non-surgical approaches are often utilized for symptom management. Lymphatic drainage techniques, including manual lymphatic drainage (MLD) and Kinesio taping, have been proposed as potential therapies for CTS by reducing edema and nerve compression. However, their efficacy remains uncertain. This study aimed to evaluate the effects of lymphatic drainage techniques on symptom severity, functional outcomes, nerve conduction parameters, and pain relief in patients with CTS.

Methods This meta-analysis was conducted following PRISMA guidelines. A comprehensive search of PubMed, Scopus, and Web of Science databases was performed up to February 2025. Studies assessing the effects of lymphatic drainage techniques (MLD, Kinesio taping, or compression therapy) on CTS-related outcomes were included. Two meta-analytical approaches were used: (1) between-group differences comparing intervention and control groups and (2) within-group changes pre- and post-intervention. Primary outcomes included the Boston Symptom Severity Scale (BSSS), Boston Functional Status Scale (BFSS), Visual Analog Scale (VAS), median nerve cross-sectional area (CSA), hand grip strength, and nerve conduction studies.

Results Twelve studies met the inclusion criteria, with a total of 479 participants. The between-group meta-analysis revealed significant pain reduction (VAS: SMD = -0.31, 95% CI: -0.51 to -0.12, $p < 0.05$) and improvements in CSA (SMD = 0.39, 95% CI: 0.10 to 0.68, $p < 0.05$). Median nerve motor and sensory velocities also improved significantly ($p < 0.05$). However, BSSS and BFSS did not show significant differences between groups. The within-group analysis demonstrated significant improvements in symptom severity (BSSS: MD = -10.80, 95% CI: -14.73 to -6.78, $p < 0.05$) and functional status (BFSS: MD = -6.44, 95% CI: -8.78 to -4.09, $p < 0.05$). The subgroup analysis showed that treatment benefits were sustained over time, with no significant differences between short-term and long-term follow-ups.

Conclusions Lymphatic drainage techniques offer a promising non-invasive approach for CTS, decreasing pain, reducing edema, and enhancing nerve conduction. While intra-group improvements were notable, limited between-group differences were observed.

*Correspondence:
Zahra Sheikhi
954230010@shahed.ac.ir

Full list of author information is available at the end of the article

Keywords Carpal tunnel syndrome, Lymphatic drainage, Manual lymphatic drainage, Kinesio taping, Nerve conduction, Pain management, Meta-analysis

Introduction

Carpal tunnel syndrome (CTS) is one of the most common entrapment neuropathies, characterized by compression of the median nerve within the carpal tunnel. It presents with symptoms such as pain, numbness, and weakness in the hand, significantly impairing daily activities and reducing quality of life [1]. While surgical decompression remains the definitive treatment for severe or refractory cases, a variety of non-surgical interventions are commonly employed to alleviate symptoms, particularly in mild to moderate stages of the condition [2].

Among non-surgical approaches, lymphatic drainage techniques have emerged as potential therapies for CTS. Given the role of localized edema, inflammation, and increased interstitial pressure in the pathophysiology of CTS, improving lymphatic flow may reduce tissue swelling, alleviate nerve compression, and enhance symptom relief [3]. Manual lymphatic drainage (MLD), a massage-based therapy designed to stimulate lymphatic circulation, is the most widely recognized method. MLD involves gentle, rhythmic massage techniques intended to stimulate lymphatic flow and reduce localized edema. In CTS, MLD is typically applied to the affected limb and surrounding areas to decrease perineural swelling. However, other approaches, such as Kinesio taping and compression therapies, have also been explored for their lymphatic-draining effects and potential to mitigate CTS symptoms [4, 5]. Kinesio taping, a method involving the application of elastic therapeutic tape, aims to lift the skin microscopically, facilitating lymphatic drainage and improving circulation [6].

Despite growing interest in lymphatic drainage as a therapeutic modality for CTS, the evidence base remains limited and fragmented. Studies vary widely in methodology, patient populations, intervention protocols, and reported outcomes, contributing to a lack of consensus on its efficacy. While some studies suggest significant improvements in symptom relief and functional outcomes, others report only modest or inconsistent benefits. The objective of this meta-analysis is to evaluate the effects of lymphatic drainage techniques on the management of CTS.

Methods

This systematic review and meta-analysis were conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Supplementary File S1) [7]. A protocol for a systematic review was registered in the International Prospective Register of Systematic Reviews (PROSPERO) with the registration code "CRD420250652458"".

Search strategy

A comprehensive search was performed across multiple electronic databases, including PubMed, Scopus and Web of Science, up to February 2025. A combination of key words was searched (Supplementary File S2). The search strategy combined keywords and Medical Subject Headings (MeSH) terms related to "lymphatic drainage" and "carpal tunnel syndrome." Search terms included combinations of the following: "lymphatic drainage," "manual lymphatic drainage," "Kinesio taping," "compression therapy," "median nerve compression," and "carpal tunnel syndrome." Reference lists of included studies and relevant systematic reviews were manually screened to identify additional eligible articles.

Eligibility criteria

Studies were included in this review if they met the following criteria:

1. **Population**: Adults (18 years and older) diagnosed with CTS using clinical or electrodiagnostic criteria.
2. **Intervention**: Lymphatic drainage techniques, including MLD, Kinesio taping, compression therapy, or other lymphatic-focused interventions.
3. **Comparison**: Studies with or without a comparator group (e.g., placebo, standard care, or other therapeutic modalities).
4. **Outcomes**: Studies reporting at least one of the following: Symptom improvement (such as pain assessed using the Visual Analog Scale [VAS] or other scales, numbness, or paresthesia), Functional outcomes (such as muscle latency indices, grip strength, hand dexterity), Quality of life, Adverse events.
5. **Study Design**: Randomized controlled trials (RCTs), cohort studies, case-control studies, and quasi-experimental studies.

Studies were excluded if they: Focused on unrelated conditions or interventions, Did not include original data (including narrative reviews, editorials, or conference abstracts), Were published in languages other than English.

Data extraction

Two independent reviewers screened titles, abstracts, and full-text articles for eligibility. Discrepancies were resolved through discussion or consultation with a third reviewer. Extracted data included: Study characteristics (authors, year, country, sample size, and study design), Participant mean age, Intervention details (type of lymphatic drainage technique, frequency, duration, and protocol), Outcome measures (symptom severity, functional outcomes, quality of life, and adverse events).

Data synthesis and Meta-Analysis

A qualitative synthesis was conducted to summarize the characteristics and findings of the included studies. For specific outcomes (including Boston symptom severity scale (BSSS), Boston functional status scale (BFSS), Median cross-sectional area (CSA), hand grip, median nerve conduction (MNC), and VAS), a meta-analysis was performed. We extracted the mean and standard deviation (SD) of outcomes and then calculated the mean difference (MD), and standard mean difference (SMD) for the mean difference. In some studies, instead of mean and SD for outcomes, the median, minimum, and maximum were reported that these measures convert to equivalent mean and SD using the Wan et al. method [8].

Two distinct approaches were used for the meta-analysis:

1. **Difference Between Groups**: In the first approach, we calculated the difference in outcomes before and after the intervention separately for the intervention and control groups. These pre-post differences were then compared between the two groups, and the pooled results were analyzed using meta-analysis.
2. **Within-Group Changes**: In the second approach, we focused on the intervention group alone. The mean outcomes before and after the intervention within the intervention group were analyzed, and the pooled results were summarized using meta-analysis.

Outcome data were pooled using both random-effects and fixed-effects models to account for heterogeneity across studies. Heterogeneity was assessed using the I^2 statistic, with thresholds for low ($I^2 < 25\%$), moderate ($I^2 = 25–50\%$), and high ($I^2 > 50\%$) heterogeneity. If heterogeneity was high ($I^2 > 50\%$) and is statistically significant ($p < 0.1$), the random-effects model was considered appropriate. Conversely, if heterogeneity was low or moderate ($I^2 \leq 50\%$) and not statistically significant ($p \geq 0.1$), the common-effects model was applied.

Subgroup analyses were conducted based on both study follow-up (short-term vs. long-term) and treatment technique (MLD, Kinesio taping, or CDT). Follow-up durations of less than 6 weeks were categorized as short-term, while durations of 6 weeks or more were considered long-term.

Risk of Bias assessment

Risk of bias was assessed for all included studies using tools appropriate to their study design. For randomized controlled trials (RCTs), we used the Cochrane Risk of Bias 2 (RoB 2) tool. This tool evaluates five domains: (1) bias arising from the randomization process, (2) bias due to deviations from intended interventions, (3) bias due to missing outcome data, (4) bias in measurement of the outcome, and (5) bias in selection of the reported result. Each domain was judged as having a low risk of bias, some concerns, or high risk of bias. The overall risk of bias for each study was determined accordingly [9]. For non-randomized studies, we applied the ROBINS-I (Risk Of Bias In Non-randomized Studies of Interventions) tool. This instrument evaluates seven domains: (1) bias due to confounding, (2) bias in selection of participants, (3) bias in classification of interventions, (4) bias due to deviations from intended interventions, (5) bias due to missing data, (6) bias in measurement of outcomes, and (7) bias in selection of the reported result. Judgments for each domain were rated as low, moderate, serious, or critical risk of bias. An overall judgment was then made for each study [10]. Two independent reviewers evaluated each study, and disagreements were resolved through discussion or consultation with a third reviewer.

Results

Our research initially identified 130 articles. After eliminating 63 duplicate records, 67 unique studies remained. Following a review of titles and abstracts, we excluded 31 publications, resulting in a final selection of 36 articles that met our initial requirements. After a comprehensive evaluation, 24 studies were disqualified for reasons such as insufficient data ($n = 16$), lacking relevance to lymphatic drainage ($n = 2$), lacking relevance to carpal tunnel syndrome ($n = 2$), and absence of English full text ($n = 4$). After through screening, 12 studies met the inclusion criteria (Table 1) [11–22]. This process is shown in the PRISMA flow chart diagram (Fig. 1). Finally, meta-analysis was performed using two distinct approaches for following outcomes (Figs. 2, 3, 4 and 5): BSSS, BFSS, VAS, CSA, Hand grip, Median nerve motor amplitude, Median nerve motor latency, Median nerve motor velocity, Median nerve sensory amplitude, Median nerve sensory latency, Median nerve sensory velocity.

Figures 6 shows the results of assessing bias in RCTs and non-randomized designs. Based on the result obtained from RoB-2 for RCTs, only three studies were judged low risk of bias while presence of moderate to high level of bias occurred in eight studies. The only non-randomized interventional study was assessed as having a moderate risk of bias according to ROBINS-I.

Table 1 Characteristics of included articles

Study	Population		Intervention	Design	Instruments	Follow-up Duration (weeks)	Treatment time	Sessions number	Session's duration
	Control group	Experimental group							
Kablan et al., Turkey (2025) [11]	**N**: 27 **Age***: 48.9 ± 9.9	**N**: 27 **Age**: 48.9 ± 9.9	MLD	RCT	BSSS, BFSS, CSA, HG, MNC, PPT, VAS	6	6 weeks	12	40 min
Leblebicier et al., Turkey (2025) [12]	**N**: 18 **Age**: 47.9 ± 7.7	**N**: 16 **Age**: 52.7 ± 6.7	MLD	RCT	BSSS, BFSS, MNC, Tinel's sign, Phalen's sign, PPT, VAS	4	4 weeks	20	15 min
Chen et al., Taiwan (2024) [13]	**N**: 18 **Age**: 47.2 ± 3.17	**N**: 19 **Age**: 49.8 ± 8.47	KT	RCT	BSSS, BFSS, MNC, VAS	6	6 weeks	12	2 days
Cihan et al., Turkey (2024) [14]	**N**: 27 **Age**: 48.15 ± 7.40	**N**: 27 **Age**: 50.30 ± 7.08	MLD	RCT	BSSS, BFSS, CSA, Tinel's sign, Phalen's sign	4	4 weeks	20	20 min
Unal et al., Turkey (2024) [15]	**N**: 13 **Age**: 52.69 ± 8.61	**N**: 14 **Age**: 48.71 ± 10.80	KT	RCT	BSSS, BFSS, CSA, MNC, VAS	3	3 weeks	3	5 days
Movaghar et al.**, Iran (2023) [16]	**N**: 15 **Age**: 27.6 ± 3.08	**N**: 15 **Age**: 27.47 ± 3.94	KT Cupping	RCT	BSSS, BFSS, CSA, VAS	4	4 weeks	7	3 days
Ayhan et al., Turkey (2019) [17]	**N**: N/A **Age**: N/A	**N**: 41 **Age**: 56.05 ± 8.16	CDT	Quasi-experimental	CSA, DN4, MNC, Quality of life, Q-DASH, Lymphedema volume	3	3 weeks	15	2 h
Güner et al., Turkey (2018) [18]	**N**: 13 **Age**: 44.33 ± 9.21	**N**: 11 **Age**: 47.71 ± 4.97	KT	RCT	BSSS, BFSS, HG, MNC, Pinch, VAS	3 & 12	3 weeks	10	2 days
Kaplan et al., Turkey (2018) [19]	**N**: 32 **Age**: 42.3 ± 9.8	**N**: 33 **Age**: 43.1 ± 9.2	KT	RCT	CSA, VAS	3 & 12	3 weeks	6	3.5 days
Yildirim et al., Turkey (2018) [20]	**N**: 10 **Age**: 48.70 ± 7.61	**N**: 11 **Age**: 48.81 ± 6.40	KT	RCT	BSSS, BFSS, CSA, DN4, HG, Moberg, Pinch, VAS	3 & 6	6 weeks	3	N/A
Geler et al., Turkey (2015) [21]	**N**: 20 **Age**: 48.95 ± 6.0	**N**: 20 **Age**: 49.8 ± 11.5	KT	RCT	BSSS, BFSS, DN4, HG, VAS	4	4 weeks	4	5 days
Karpuz et al., Turkey (2015) [22]	**N**: 26 **Age**: 49.2 ± 10.4	**N**: 26 **Age**: 47 ± 10.4	KT	RCT	BSSS, BFSS, CSA, HG, PSQI, VAS	4	4 weeks	8	N/A

BSSS: Boston symptom severity scale, BFSS: Boston functional status scale, CDT: Complex decongestive therapy, CSA: Median cross-sectional are, DN4: Douleur neuropathique 4 questionnaire, HG: Hand grip, KT: Kinesio Taping, MLD: Manual lymphatic drainage, MNC: Median nerve conduction, N: Number, PPT: Pain pressure threshold, PSQI: Pittsburgh sleep quality index, Q-DASH: Quick disabilities of arm, shoulder & hand, RCT: Randomized control trial, VAS: Visual analogue scale

*: Mean ± SD; **: Movaghar et al. study included two experimental group (KT and cupping); cupping group population features were mentioned in the control group section

Difference between groups

The meta-analysis comparing intervention and control groups revealed mixed findings across different outcome measures. BFSS did not show a significant difference between groups ($SMD = -0.24$, 95% $CI: -0.57–0.08$, $p = 0.14$, $I^2 = 61.2\%$) (Fig. 2a). Similarly, BSSS showed no significant improvement ($SMD = -0.15$, 95% $CI: -0.52–0.22$, $p = 0.41$, $I^2 = 69.4\%$) (Fig. 2c). However, VAS demonstrated a significant reduction in pain scores in the intervention group compared to the control ($SMD = -0.31$, 95% $CI: -0.51–-0.12$, $p < 0.05$, $I^2 = 0\%$) (Fig. 2e). Hand grip strength significantly improved following the intervention ($SMD = -0.29$, 95% $CI: -0.51–-0.07$ $p;< 0.05$, $I^2 = 0\%$) (Fig. 3c), as did the median nerve cross-sectional area ($SMD = 0.39$, 95% $CI: 0.10–0.68$, $p < 0.05$, $I^2 = 0\%$) (Fig. 3a).

Regarding nerve conduction parameters, median nerve motor amplitude showed no significant difference ($SMD = 0.73$, 95% $CI: -0.02–1.47$, $p = 0.05$, $I^2 = 78.6\%$) (Fig. 4a), and neither did motor latency ($SMD = -0.03$, 95% $CI: -0.50–0.44$, $p = 0.90$, $I^2 = 66.2\%$) (Fig. 4c). However, median nerve motor velocity significantly

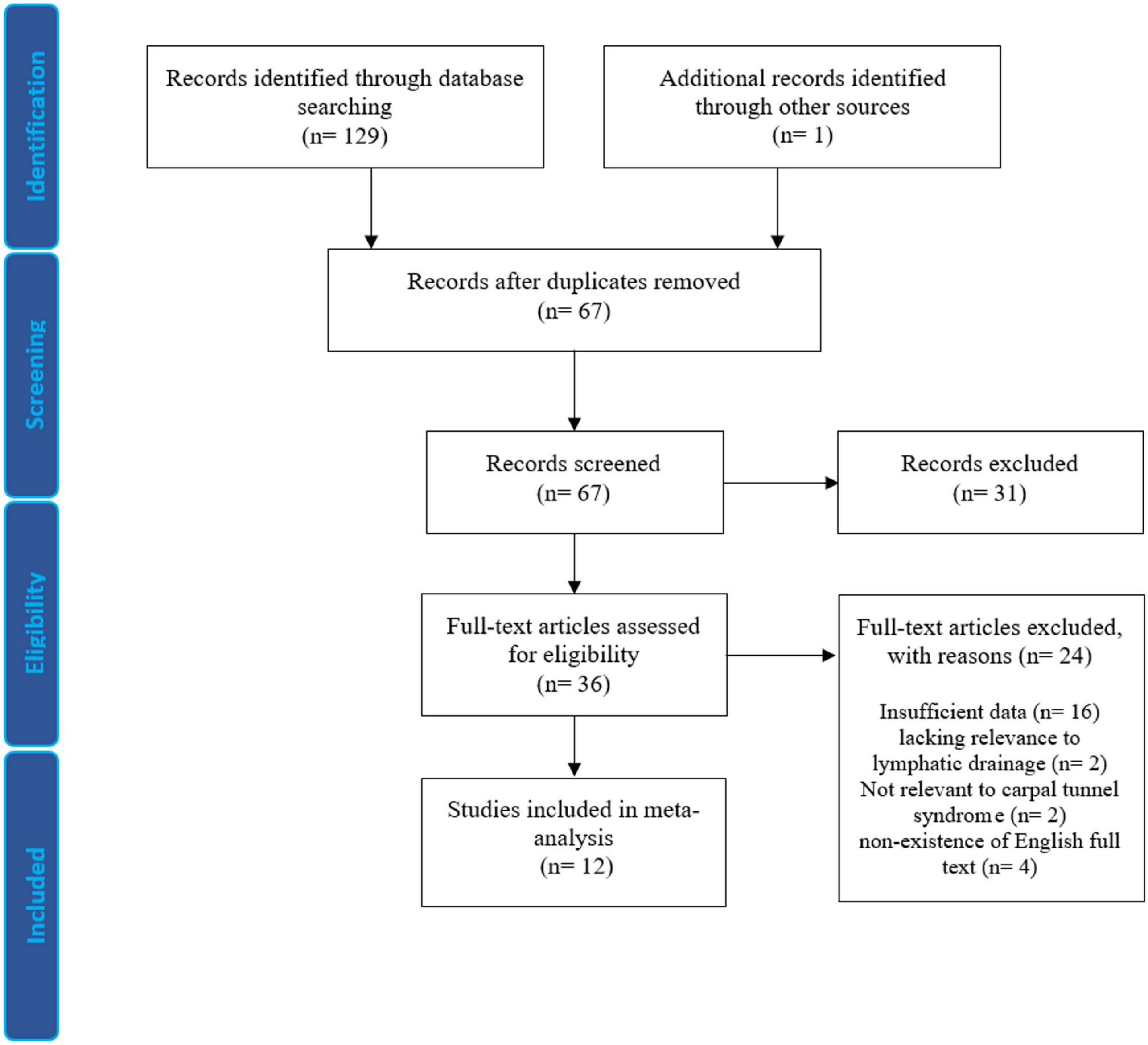

Fig. 1 PRISMA flow diagram

improved post-intervention (*SMD* = *0.48, 95% CI: 0.13–0.83,p* < 0.05, I^2 = *0%*) (Fig. 4e). Median nerve sensory conduction measures followed a similar trend, with sensory amplitude and latency showing no significant changes (*SMD = -0.19,-0.13, 95% CI: -0.50–0.13,-1.39–1.13,p* = 0.24,*0.84,* I^2 *= 0%,90.8%; respectively*) (Fig. 5a and c), whereas sensory velocity significantly improved (*SMD* = *0.50, 95% CI: 0.22–0.78,p* < 0.05, I^2 = *33.4%*) (Fig. 5e).

Within-Group changes

The within-group analysis demonstrated significant improvements in several outcome measures following lymphatic drainage interventions. BFSS showed a statistically significant enhancement post-intervention (*MD = -6.44, 95% CI: -8.78–-4.09,p* < 0.5, I^2 *= 91%*) (Fig. 2b), as did BSSS (*MD = -10.80, 95% CI: -14.73–-6.78,p* < 0.5, I^2 *= 96.1%*) (Fig. 2d). Pain reduction, as measured by the VAS (Fig. 2f), was also significant within the intervention group (*MD = -3.25, 95% CI: -4.11–-2.39,p* < 0.5, I^2 *= 85.4%*). However, hand grip strength did not exhibit a statistically significant change post-intervention (*MD = -1.67, 95% CI: -3.78–0.43,p* = 0.11, I^2 *= 97.6%*) (Fig. 3d). In contrast, the median nerve cross-sectional area significantly improved (*MD* = *6.83, 95% CI: 2.32–11.34,p* < 0.05, I^2 = *63.6%*) (Fig. 3b).

Regarding nerve conduction studies, median nerve motor amplitude did not show a significant within-group difference (*MD* = *5.05, 95% CI: -0.02–10.13,p* = 0.05, I^2 *= 83.8%%*) (Fig. 4b), but motor latency significantly

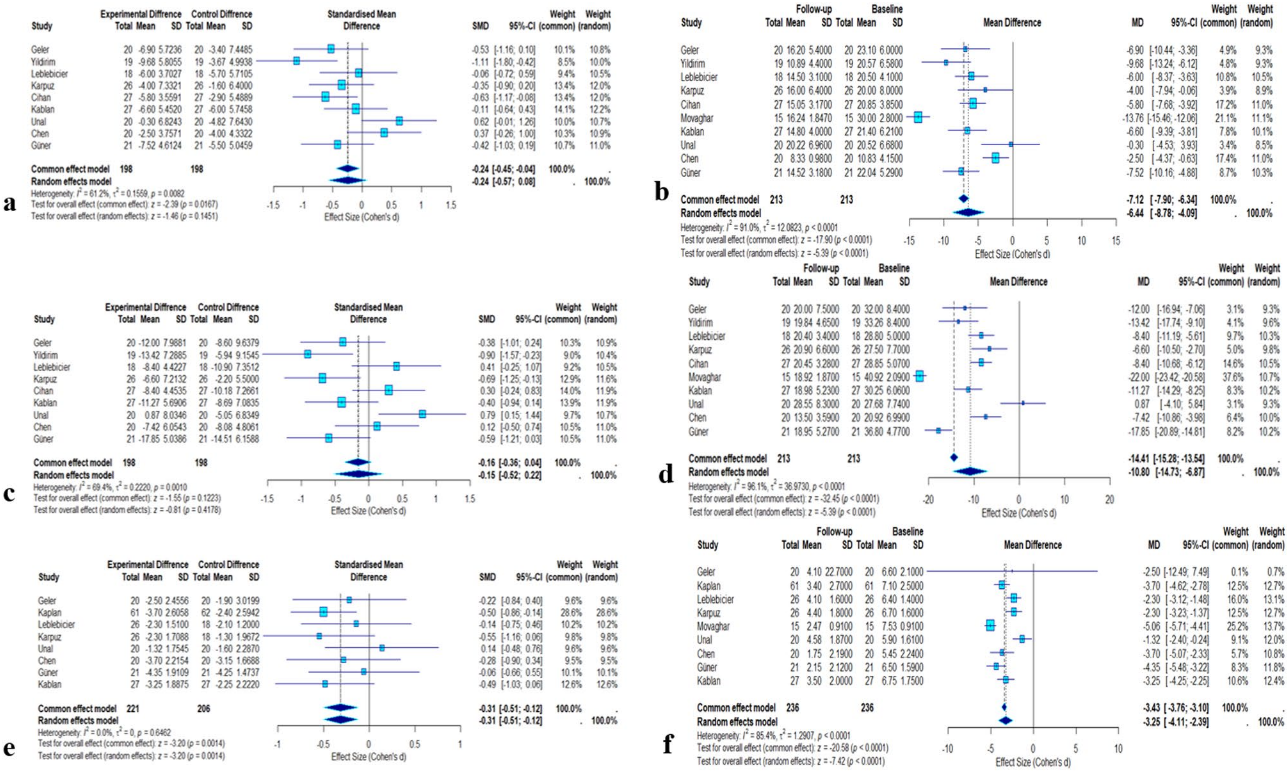

Fig. 2 Questionnaires' outcomes analysis: **a**) Boston functional status scale difference between groups; **b**) Boston functional status scale within-group changes; **c**) Boston symptom severity scale difference between groups; **d**) Boston symptom severity scale within-group changes; **e**) Visualize analogue scale difference between groups; **f**) Visualize analogue scale within-group changes

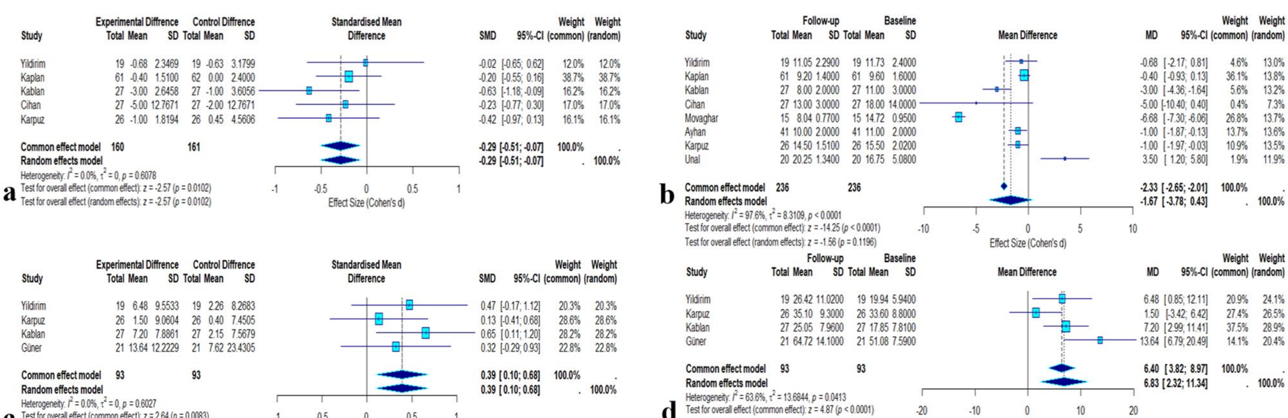

Fig. 3 Structural and Functional outcomes analysis: **a**) Median cross-sectional area difference between groups; **b**) Median cross-sectional area within-group changes; **c**) Hand grip difference between groups; **d**) Hand grip within-group changes

improved (*MD = -0.52, 95% CI: -0.98–-0.05,p* = 0.02, I^2 = *59.2%*) (Fig. 4d). Similarly, motor velocity showed a statistically significant enhancement (*MD* = *5.46, 95% CI: 3.16–7.76,p* < 0.05, I^2 = *0%*) (Fig. 4f). Among sensory conduction measures, sensory amplitude and latency did not show significant improvements (*MD* = *0.74,-0.25, 95% CI: -1.86–3.34,-0.85–0.36,p* = *0.57,0.42,* I^2 = *0%,85%; respectively*) (Fig. 5b and d), whereas sensory velocity demonstrated a significant increase (*MD* = *6.83, 95% CI: 4.61–9.06,p* < 0.05, I^2 = *0%*) (Fig. 5f).

Subgroup analysis

Subgroup analyses were conducted for both the between-group and within-group meta-analyses to compare short-term (< 6 weeks) and long-term (≥ 6 weeks) follow-ups (Supplementary File S3 and S4). However, none of the comparisons reached statistical significance, indicating

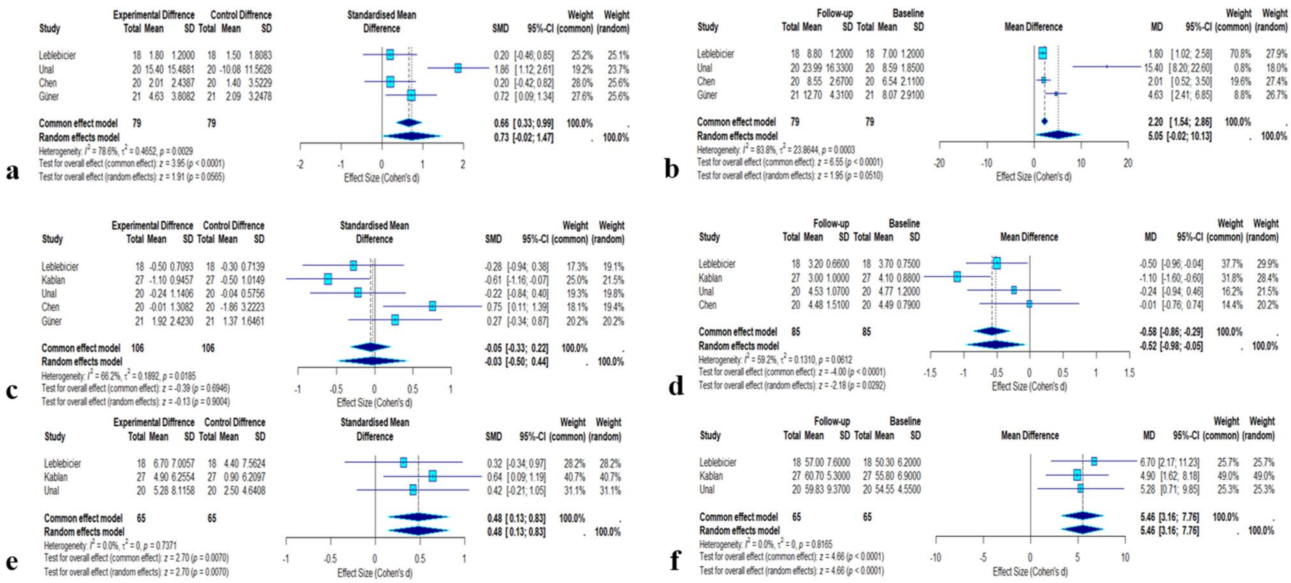

Fig. 4 Median nerve motor conduction: **a**) Amplitude difference between groups; **b**) Amplitude within-group changes; **c**) Latency difference between groups; **d**) Latency within-group changes; **e**) Velocity difference between groups; **f**) Velocity within-group changes

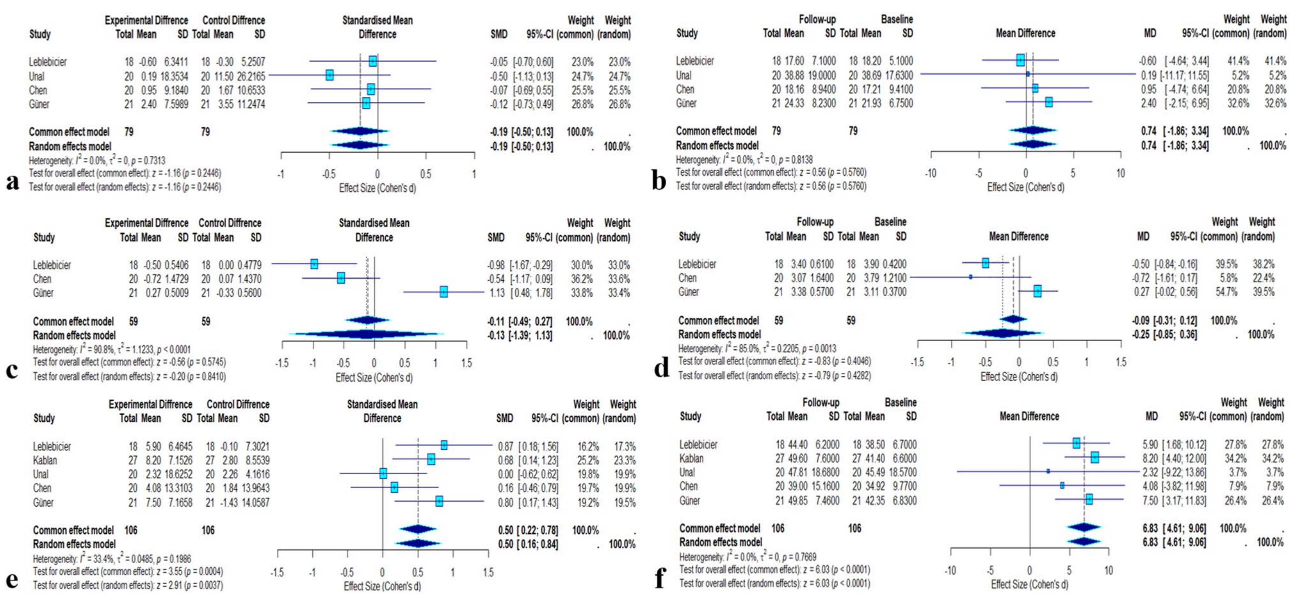

Fig. 5 Median nerve sensory conduction: **a**) Amplitude difference between groups **b**) Amplitude within-group changes **c**) Latency difference between groups **d**) Latency within-group changes **e**) Velocity difference between groups **f**) Velocity within-group changes

no substantial difference in the effects of lymphatic drainage interventions between the two follow-up durations. Subgroup analyses based on treatment technique (MLD, Kinesio taping, or CDT) were also performed (Supplementary Files S5 and S6). Overall, the majority of comparisons showed no statistically significant differences in effect sizes between the different intervention types. However, two analyses yielded significant results: one favoring MLD for median nerve motor latency (*SMD* = *-0.58, 95% CI: -0.90–-0.06,p* < 0.05, *I² = 0%*), and another favoring MLD for median cross-sectional area (*MD* = *-3.12, 95% CI: -4.44–-1.80,p* < 0.05, *I² = 0%*).

Discussion

This meta-analysis provides a comprehensive evaluation of the effects of lymphatic drainage techniques on CTS. Our findings indicate that while lymphatic drainage interventions, including MLD and Kinesio taping, contribute to symptom relief and functional improvements, their effectiveness varies across different outcome measures. Pain reduction, as measured by the VAS, showed

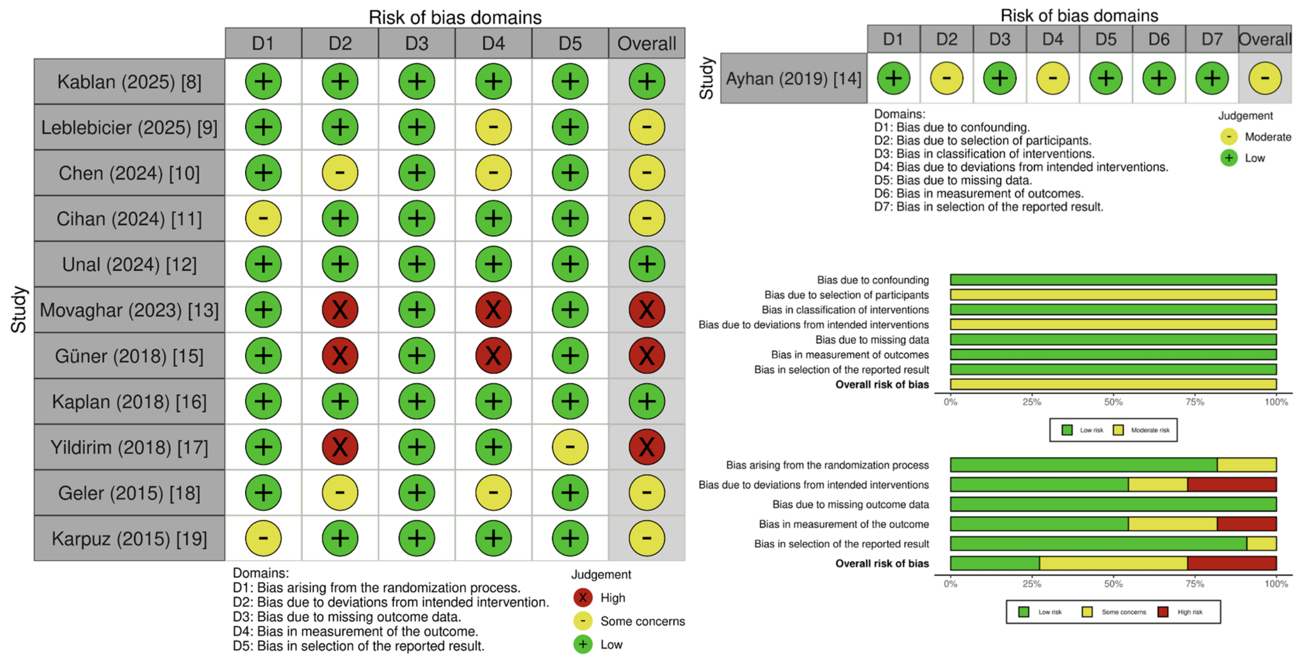

Fig. 6 Risk of bias for RCTs and non-randomized trials

a significant improvement in both between-group and within-group analyses, reinforcing the role of lymphatic drainage in alleviating discomfort associated with CTS. Similarly, the median nerve CSA demonstrated a consistent reduction, suggesting that lymphatic interventions may contribute to decreasing tissue swelling and nerve compression. In contrast, functional outcomes such as the BFSS and BSSS showed significant improvements in the within-group analysis but did not reach statistical significance in the between-group comparison, highlighting a potential placebo effect or the influence of other confounding factors. Additionally, while nerve conduction parameters exhibited mixed results, sensory and motor nerve velocities significantly improved, indicating potential benefits of lymphatic techniques in enhancing neural function. Overall, these findings suggest that lymphatic drainage techniques may serve as a beneficial adjunct therapy for CTS, particularly in pain management and nerve decompression, but their effects on functional recovery remain inconclusive.

Objective outcomes

The observed improvements in nerve conduction velocity and median nerve CSA following lymphatic drainage interventions can be explained by the role of tissue fluid dynamics in CTS pathophysiology. CTS is characterized by increased interstitial pressure within the carpal tunnel, which can lead to vascular congestion, perineural edema, and subsequent compression of the median nerve. This compression impairs nerve function by disrupting axonal transport, reducing blood supply, and increasing inflammatory mediators, ultimately slowing neural conduction [3]. Lymphatic drainage techniques, including MLD and Kinesio taping, may mitigate these effects by promoting fluid clearance, reducing local edema, and alleviating mechanical compression on the nerve.

Reduction in CSA, observed in our analysis, suggests a structural benefit of lymphatic drainage, likely resulting from decreased perineural swelling. Studies have demonstrated that median nerve enlargement in CTS correlates with symptom severity and nerve dysfunction, and interventions that reduce nerve swelling are associated with functional recovery [23]. By facilitating the removal of interstitial fluid and inflammatory byproducts, lymphatic drainage may help restore normal nerve morphology, thereby reducing CSA and relieving compression. Additionally, improved nerve conduction velocity observed in this meta-analysis may result from enhanced microcirculation and reduced ischemic stress on the median nerve. Chronic nerve compression leads to hypoxia and metabolic dysfunction, both of which contribute to slowed neural transmission [24]. Lymphatic drainage may improve local perfusion by decreasing extravascular pressure and enhancing capillary exchange, which could support nerve repair and optimize signal conduction. This is further supported by the significant improvement in sensory and motor velocity, which may indicate partial restoration of neural function due to improved metabolic conditions and reduced inflammatory burden. These findings suggest that lymphatic drainage techniques may play a role in modulating the pathophysiological mechanisms of CTS, offering a non-invasive means to improve neural function and nerve morphology. However, further research is needed to explain the precise mechanisms and long-term efficacy of these interventions in different patient populations.

Subjective outcomes

The significant improvements in pain scores and questionnaire-based assessments, such as the VAS, BSSS, and BFSS, suggest that lymphatic drainage interventions may provide meaningful symptom relief in patients with CTS. Pain reduction, observed in both between-group and within-group analyses, is a particularly important finding, as pain is a major contributor to functional impairment and reduced quality of life in CTS patients. Several mechanisms may explain the analgesic effects of lymphatic drainage. First, reducing interstitial fluid accumulation and perineural edema may directly relieve mechanical compression on the median nerve, leading to decreased nociceptive signaling. Additionally, MLD and Kinesio taping may stimulate mechanoreceptors and proprioceptive pathways, potentially modulating pain perception through a gate control mechanism. The activation of these sensory pathways could inhibit pain-transmitting nociceptive signals at the spinal level, providing symptomatic relief [25].

Furthermore, the improvements in BSSS and BFSS scores, though significant in the within-group analysis but not in the between-group comparison, suggest that while patients perceive symptom relief and functional enhancement following lymphatic drainage interventions, these benefits may not be substantially greater than those seen in control groups. This could be attributed to placebo effects, natural disease fluctuations, or the influence of other concurrent therapies. Nonetheless, subjective symptom improvement remains clinically relevant, as patient-reported outcomes play a crucial role in determining treatment efficacy.

Another potential factor contributing to subjective symptom relief is the impact of lymphatic drainage on inflammation and neural sensitization. Chronic compression of the median nerve leads to local inflammatory mediator release, contributing to pain hypersensitivity. By facilitating the clearance of inflammatory cytokines, lymphatic drainage may reduce neural irritability and central sensitization, leading to a decrease in perceived pain intensity [26, 27]. These findings indicate that lymphatic drainage techniques can be valuable adjuncts in CTS management, particularly for symptom relief. However, the discrepancy between subjective improvement and objective functional outcomes suggests that while these interventions may enhance patient-perceived wellbeing, their role in reversing underlying nerve dysfunction remains uncertain. Future studies should further investigate the long-term effects of lymphatic drainage on both subjective and objective measures to establish its clinical utility in CTS treatment.

Subgroup analyses based on treatment technique revealed that most interventions, including MLD, Kinesio taping, and CDT, demonstrated comparable effects across outcomes. However, MLD showed significantly greater effectiveness in reducing both median nerve motor latency and cross-sectional area. These findings suggest that MLD may offer specific neurophysiological and anatomical benefits in managing CTS. Further studies are warranted to confirm these findings and explore underlying mechanisms.

Short-Term and Long-Term effects

The subgroup analysis comparing short-term (< 6 weeks) and long-term (≥ 6 weeks) follow-up durations revealed no statistically significant differences in the effects of lymphatic drainage interventions. This lack of statistically significant differences may suggest that symptom improvements were maintained at follow-up; however, it is important to note that treatment durations were not uniform across studies. In some cases, long-term follow-up groups may have also received longer treatment courses, making it difficult to distinguish whether improvements were due to sustained effects or extended therapy. This is a promising finding, as many conservative treatments for CTS provide only temporary relief, whereas lymphatic drainage appears to offer durable benefits without requiring continuous intervention.

One explanation for this sustained improvement is the ability of lymphatic drainage techniques, such as MLD and Kinesio taping, to reduce perineural edema and optimize fluid dynamics in the carpal tunnel. By alleviating nerve compression and promoting local circulation, these techniques may create a stable physiological environment that prevents symptom recurrence even after the intervention period ends [28, 29]. The improvements in CSA suggest that the intervention helps resolve swelling and mechanical stress on the median nerve, which may contribute to the long-term preservation of nerve function.

The persistence of pain reduction, as measured by the VAS, also supports the durability of lymphatic drainage's effects. Pain in CTS is influenced by multiple factors, including inflammation, neural compression, and sensitization of nociceptive pathways [3]. Lymphatic drainage may counteract these mechanisms by enhancing interstitial fluid clearance and reducing local inflammatory mediators, leading to prolonged symptom relief. Additionally, improvements in functional scores (BSSS and BFSS) were observed in within-group analyses, indicating that participants experienced meaningful improvements in hand function and daily activities. Although these functional benefits did not reach statistical significance in the between-group comparison, their persistence over time suggests that lymphatic drainage contributes to maintaining hand mobility and reducing discomfort in everyday tasks.

While the findings indicate that lymphatic drainage has lasting benefits, it is important to consider potential factors influencing treatment response over time. The absence of a significant difference between short- and long-term follow-ups may reflect the persistence of treatment benefits; however, it does not necessarily imply progressive improvement, especially given the potential variation in treatment intensity and duration. This raises the question of whether maintenance therapy, periodic booster sessions, or patient-guided self-lymphatic drainage could further enhance long-term outcomes. Additionally, patient adherence and variability in treatment protocols over extended periods may have influenced the observed effects, highlighting the need for standardized protocols in future research.

Overall, these findings reinforce the potential of lymphatic drainage as an effective and sustainable therapeutic option for CTS. The sustained benefits in pain relief and nerve function suggest that it may serve as a valuable adjunct to other conservative or rehabilitative approaches. Future studies should explore long-term effects to optimize treatment durability, compare lymphatic drainage with other standard therapies over extended follow-up durations, and investigate whether combining it with other modalities could further enhance clinical outcomes.

Clinical implications

The findings of this meta-analysis highlight the potential of lymphatic drainage as a non-invasive, cost-effective, and accessible therapeutic option for managing CTS. Given the growing interest in conservative management strategies, lymphatic drainage techniques offer a promising alternative or adjunct to conventional treatments [30]. Unlike surgical interventions, which are associated with risks, recovery time, and financial burden, lymphatic drainage provides a low-risk option that can be easily integrated into rehabilitation programs and even performed as a self-care technique with proper training. Also, in some conditions including lymphedema or pregnancy, interventional therapies may not be considered as feasible as other conservative options [31].

One of the key advantages of lymphatic drainage is its ability to address the underlying pathophysiology of CTS by reducing edema, improving microcirculation, and alleviating nerve compression [32]. The sustained improvements observed in nerve conduction velocity, median nerve CSA, and pain relief suggest that this intervention not only provides symptomatic relief but also contributes to maintaining nerve function over time. This makes it particularly relevant for patients with mild to moderate CTS who seek to avoid or delay surgical interventions. Additionally, it may serve as an adjunctive therapy for post-surgical patients to reduce swelling and enhance recovery.

Despite these promising findings, several gaps in the literature remain. The variability in study methodologies, intervention protocols, and patient populations highlights the need for more standardized and high-quality clinical trials. Future research should focus on optimizing treatment protocols, including session frequency, duration, and combination with other conservative therapies. Moreover, long-term studies with larger sample sizes are needed to determine whether lymphatic drainage can provide sustained benefits beyond the observed follow-up periods.

Another important consideration is the need for greater awareness and clinical integration of lymphatic drainage techniques. Although widely used in lymphedema management, their application in CTS treatment remains underexplored. Expanding training for healthcare providers, such as physical therapists and occupational therapists, could enhance patient access to these interventions. Additionally, investigating self-administered lymphatic drainage techniques could further improve feasibility and long-term adherence [33].

Lymphatic drainage presents a promising, low-cost, and non-invasive approach for CTS management. While preliminary evidence supports its effectiveness in pain reduction, functional improvement, and nerve conduction enhancement, further research is required to establish standardized guidelines and confirm its long-term clinical utility. Integrating lymphatic drainage into multidisciplinary treatment plans may offer an effective strategy for improving patient outcomes while minimizing the need for invasive procedures.

Limitations

Despite the promising findings of this meta-analysis, several limitations must be acknowledged. First, significant heterogeneity was observed among the included studies in terms of intervention protocols, follow-up durations, and outcome measures. Variability in the type, frequency, and duration of lymphatic drainage techniques, whether MLD, Kinesio taping, or compression therapy, may have contributed to inconsistent results, making it difficult to establish standardized recommendations for clinical practice. One potential source of heterogeneity in our findings is the variation in how lymphatic drainage techniques, particularly MLD and Kinesio taping, were applied across included studies. MLD protocols differed in terms of session frequency (ranging from 2 to 5 times per week), session duration (15 to 40 min), and whether it was performed alone or as part of a multi-component intervention like CDT. Similarly, Kinesio taping protocols varied by application technique, tension, anatomical placement, and duration of use. These inconsistencies may influence outcomes such as edema reduction, nerve decompression, and symptom relief. Such methodological diversity likely contributed to the observed variability in effect sizes, particularly in subjective outcomes. Future studies should aim to standardize these interventions to reduce heterogeneity and allow for more direct comparisons of efficacy.

Second, while some studies included control groups, others relied solely on within-group analyses, limiting the ability to determine whether observed improvements were specifically attributable to lymphatic drainage rather than natural symptom progression or placebo effects. The fact that functional scores (BSSS and BFSS) were significantly improved in within-group analyses but not in between-group comparisons suggests that patient-perceived improvements may have been influenced by nonspecific effects such as therapist interaction or expectation bias. Future studies should incorporate well-designed RCTs with appropriate placebo or sham interventions to strengthen causal inferences.

Another limitation is the relatively short follow-up durations in most studies. While our subgroup analysis indicated that improvements were sustained over time, the longest follow-up periods were generally limited to three months. The long-term durability of lymphatic drainage's effects remains uncertain, particularly in comparison to other conservative treatments or surgical interventions. Further research with extended follow-up durations is needed to determine whether symptom relief persists beyond the study periods and whether periodic maintenance sessions are required.

Additionally, objective assessments of neural function, such as nerve conduction studies, showed mixed results. While some parameters such as nerve conduction velocity, improved significantly, others including motor amplitude, sensory latency did not demonstrate meaningful changes. This suggests that while lymphatic drainage may alleviate nerve compression and improve circulation, it may not reverse all aspects of nerve dysfunction, particularly in more advanced cases of CTS. Future research should investigate whether certain patient subgroups (such as those with mild vs. severe CTS) are more likely to benefit from lymphatic interventions.

Lastly, publication bias cannot be ruled out, as studies with negative or non-significant findings may be underreported. The limited number of high-quality RCTs in this field further underscores the need for more rigorous investigations to validate the efficacy and mechanisms of lymphatic drainage in CTS management.

To address these limitations, future research should focus on standardizing intervention protocols, incorporating sham-controlled RCTs, and evaluating long-term outcomes. Additionally, studies comparing lymphatic drainage with other conservative treatments such as splinting, corticosteroid injections, or physical therapy, could provide valuable insights into its relative effectiveness. Investigating the potential for self-administered lymphatic drainage techniques and their impact on long-term symptom management could also improve accessibility and patient adherence.

Conclusion

This meta-analysis supports lymphatic drainage as an effective, non-invasive, and cost-efficient intervention for CTS. It significantly reduces pain, improves nerve conduction, and decreases median nerve CSA, indicating reduced compression and enhanced nerve function. While symptom relief was consistently reported, functional improvements were less clear in between-group analyses. In conclusion, lymphatic drainage represents a valuable adjunct in CTS treatment, offering a safe and practical approach for symptom relief. While further research is needed to confirm its long-term clinical utility and refine treatment protocols, the current evidence suggests that it may serve as a beneficial addition to non-surgical management strategies for CTS.

Abbreviations

BFSS	Boston Functional Status Scale
BSSS	Boston Symptom Severity Scale
CSA	Median nerve cross-sectional area
CTS	Carpal tunnel syndrome
MD	Mean difference
MeSH	Medical Subject Headings
MLD	Manual lymphatic drainage
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-analyses
PROSPERO	International Prospective Register of Systematic Reviews
RCT	Randomized controlled trial
RoB 2	Cochrane Risk of Bias 2
ROBINS-I	Risk Of Bias In Non-randomized Studies of Interventions
SD	Standard deviation
SMD	Standard mean difference
VAS	Visual Analog Scale

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13018-025-05887-w.

Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

Supplementary Material 4

Supplementary Material 5

Supplementary Material 6

Acknowledgements

Not applicable.

Author contributions
S.S. and H.Y. contributed to the search and collaborated in the writing of the first draft. S.S. and M.S. collaborated in data extraction, screening, making the table, and writing the first draft. S.S. and H.Y. contributed to the writing of the first draft and its editing, while Z.S. finalized the manuscript and supervised the process. All authors reviewed and approved the final manuscript.

Funding
There has been no financial support for this work.

Data availability
Data are available if requested from the corresponding author.

Declarations

Ethical approval
Not applicable.

Consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Author details
[1]Student Research Committee, Faculty of Medicine, Shahed University, Tehran, Iran
[2]Integrative Oncology Department, Breast Cancer Research Center, Motamed Cancer Institute, ACECR, Tehran, Iran
[3]Quality of Life Department, Breast Cancer Research Center, Motamed Cancer Institute, ACECR, Tehran, Iran

Received: 11 March 2025 / Accepted: 5 May 2025
Published online: 20 May 2025

References

1. Padua L et al. Carpal tunnel syndrome: updated evidence and new questions, 2023. https://doi.org/10.1016/S1474-4422(22)00432-X
2. Karjalanen T, Raatikainen S, Jaatinen K, Lusa V. Update on efficacy of Conservative treatments for carpal tunnel syndrome, 2022. https://doi.org/10.3390/jcm11040950
3. Malakootian M, Soveizi M, Gholipour A, Oveisee M. Pathophysiology, diagnosis, treatment, and genetics of carpal tunnel syndrome: A review, 2023. https://doi.org/10.1007/s10571-022-01297-2
4. De Vrieze T, et al. Does manual lymphatic drainage add value in reducing Suprafascial fluid accumulation and skin elasticity in patients with breast Cancer-Related lymphedema?? Phys Ther. 2022;102(12). https://doi.org/10.1093/ptj/pzac137.
5. Moharrami M, Nazari B, Anvari HM. Do the symptoms of carpal tunnel syndrome improve following the use of Kinesio tape? Trauma Monthly. 2021;26(4):228–34. https://doi.org/10.30491/tm.2021.274982.1251.
6. Hörmann J, Vach W, Jakob M, Seghers S, Saxer F. Kinesiotaping for postoperative oedema-What is the evidence? A systematic review, 2020. https://doi.org/10.1186/s13102-020-00162-3
7. Page MJ et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews, 2021. https://doi.org/10.1136/bmj.n71
8. Wan X, Wang W, Liu J, Tong T. Estimating the sample mean and standard deviation from the sample size, median, range and/or interquartile range. BMC Med Res Methodol. 2014;14(1). https://doi.org/10.1186/1471-2288-14-135.
9. Cochrane Collaboration. RoB 2: A revised Cochrane risk-of-bias tool for randomized trials|. Cochrane Bias; 2022.
10. Sterne JA, et al. ROBINS-I: A tool for assessing risk of bias in non-randomised studies of interventions. BMJ (Online). 2016;355. https://doi.org/10.1136/bmj.i4919.
11. Kablan N, Mete E, Karatekin BD, Tombul T. The effect of manual lymphatic drainage on intraneural edema of the median nerve in patients with carpal tunnel syndrome: A randomized controlled trial. J Hand Ther. 2025. https://doi.org/10.1016/j.jht.2024.10.002.
12. Akdeniz Leblebicier M, Cihan E, Yaman F, Sahbaz Pirincci C, Ture A, Kavuncu V. Can manual lymphatic drainage be a new treatment option in mild-moderate carpal tunnel syndrome? A randomized controlled study. J Hand Ther. 2025. https://doi.org/10.1016/j.jht.2024.12.020.
13. Chen W-H, et al. Effects of Kinesio tape on individuals with carpal tunnel syndrome: a randomized controlled study. Front Rehabilitation Sci. 2024;5. https://doi.org/10.3389/fresc.2024.1494707.
14. Cihan E et al. Oct., The Impact of Lymphatic Drainage and Nerve Mobilization Techniques on Nerve Morphology in Mild-to-Moderate Carpal Tunnel Syndrome: A Randomized Controlled Trial, Clin Rehabil, vol. 38, no. 12, pp. 1633–1644, 2024, https://doi.org/10.1177/02692155241289101
15. Unal ZK, Bahtiyarca ZT, Altintaş Y, Arslan I, Karaahmet OZ, Akyuz EU. Which kinesiotaping technique is effective? Comparision of two different techniques in patients with carpal tunnel syndrome. Neurol Asia. 2024;29(3):655–63. https://doi.org/10.54029/2024epy.
16. Movaghar S, Roostayi MM, Naimi SS, Daryabor A, Akbari NJ, Mehreganfar B. Comparison of 4 weeks of cupping and Kinesio-taping on clinical and ultrasound outcomes of carpal tunnel syndrome during pregnancy. J Bodyw Mov Ther. 2023;35. https://doi.org/10.1016/j.jbmt.2023.04.048.
17. Ayhan FF, Aykut M, Genç H, Manslz B, Kaplan, Soran A. Is complex decongestive physical therapy safe for median nerve at the level of carpal tunnel in breast cancer related lymphedema? Lymphat Res Biol. 2019;17(1). https://doi.org/10.1089/lrb.2018.0011.
18. Güner A, Altan L, Kasapoğlu M, Aksoy. The effectiveness of the low-power laser and kinesiotaping in the treatment of carpal tunnel syndrome, a pilot study. Rheumatol Int. 2018;38(5). https://doi.org/10.1007/s00296-018-4020-6.
19. Mansiz Kaplan B, Akyuz G, Kokar S, Yagci I. Comparison of the effectiveness of orthotic intervention, kinesiotaping, and paraffin treatments in patients with carpal tunnel syndrome: A single-blind and randomized controlled study. J Hand Ther. 2019;32(3). https://doi.org/10.1016/j.jht.2017.12.006.
20. Yildirim P, Dilek B, Şahin E, Gülbahar S, Kizil R. Ultrasonographic and clinical evaluation of additional contribution of kinesiotaping to tendon and nerve gliding exercises in the treatment of carpal tunnel syndrome. Turk J Med Sci. 2018;48(5). https://doi.org/10.3906/sag-1709-72.
21. Geler Külcü D, Bursali C, Aktaş İ, Bozkurt Alp S, Ünlü Özkan F, Akpinar P. Kinesiotaping as an alternative treatment method for carpal tunnel syndrome. Turk J Med Sci. 2016;46(4):1042–9. https://doi.org/10.3906/sag-1503-4.
22. Karpuz S, et al. Effect of splinting and kinesiotaping treatments on functional status, sleep quality and median nerve cross-sectional area in carpal tunnel syndrome: A single blind prospective randomized controlled study. J Hand Ther. 2025. https://doi.org/10.1016/j.jht.2024.12.001.
23. Asghar A, Naaz S, Ansari S, Kumar A, Singh V. The cross-sectional morphology of median nerve in carpal tunnel of healthy, adult population: A systematic review and meta-analysis. Morphologie. 2023;107(356). https://doi.org/10.1016/j.morpho.2022.05.005.
24. Rempel D, Abrahamsson SO. The effects of reduced oxygen tension on cell proliferation and matrix synthesis in synovium and tendon explants from the rabbit carpal tunnel: an experimental study in vitro. J Orthop Res. 2001;19(1). https://doi.org/10.1016/S0736-0266(00)00005-X.
25. Ha KJ, Lee SY, Lee H, Choi SJ. Synergistic effects of proprioceptive neuromuscular facilitation and manual lymphatic drainage in patients with mastectomy-related lymphedema, Front Physiol, 2017;8, NOV. https://doi.org/10.3389/fphys.2017.00959
26. Schander A, Downey HF, Hodge LM. Lymphatic pump manipulation mobilizes inflammatory mediators into lymphatic circulation. Exp Biol Med. 2012;237(1). https://doi.org/10.1258/ebm.2011.011220.
27. Antoniak-Pietrynczak K, Zorena K, Jaskulak M, Hansdorfer-Korzon R, Koziński M. Effect of Manual Lymphatic Drainage on the Concentrations of Selected Adipokines, Cytokines, C-Reactive Protein and Parameters of Carbohydrate and Lipid Metabolism in Patients with Abnormal Body Mass Index: Focus on Markers of Obesity and Insulin Resistance, Int J Mol Sci, 2023;24(12). https://doi.org/10.3390/ijms241210338
28. Vairo GL, Miller SJ, Rier NMCI, Uckley WBI. Systematic review of efficacy for manual lymphatic drainage techniques in sports medicine and rehabilitation: an Evidence-Based practice approach. J Man Manipulative Therapy. 2009;17(3). https://doi.org/10.1179/jmt.2009.17.3.80e.

29. Keser I, Esmer M. Does manual lymphatic drainage have any effect on pain threshold and tolerance of different body parts? Lymphat Res Biol. 2019;17(6). https://doi.org/10.1089/lrb.2019.0005.
30. Yarmohammadi H, Shahrabi Farahani M, Soltanipur M, Mahdavi Anari SF, Sheikhi Z. A Scoping Review of Lymphedema in Iran, Multidisciplinary Cancer Investigation, 2023;7(4). 16–24, Nov. https://doi.org/10.61186/mci.7.4.16
31. Sheikhi-Mobarakeh Z, Ansari Ramandi MM, Yarmohammadi H, Rooddehghan A, Heydarirad G. Medical procedures safety for breast Cancer survivors considering lymphedema: A systematic review. Multidisciplinary Cancer Invest. Jan. 2021;5(1):1–8. https://doi.org/10.30699/mci.5.1.460-1.
32. Lopera C, Worsley PR, Bader DL, Fenlon D. Investigating the Short-Term effects of manual lymphatic drainage and compression garment therapies on lymphatic function using Near-Infrared imaging. Lymphat Res Biol. 2017;15(3). https://doi.org/10.1089/lrb.2017.0001.
33. Yarmohammadi H, Rooddehghan A, Soltanipur M, Sarafraz A, Mahdavi SF, Anari. Healthc Practitioners' Knowl LymphedemaInt J Vasc Med. 2021;2021:3806150. https://doi.org/10.1155/2021/3806150.

Publisher's note