Manual Therapy Applied to the Cervical Joint Reduces Pain and Improves Jaw Function in Individuals with Temporomandibular Disorders: A Systematic Review on Manual Therapy for Orofacial Disorders

Fernanda M.G. Liberato, PT, PhD
Thiago V. da Silva, PT
Cintia H. Santuzzi, PT, PhD
Néville Ferreira Fachini de Oliveira, PT, PhD
Lucas R. Nascimento, PT, PhD
Center of Health Sciences
Universidade Federal do Espírito Santo
Vitória, Brazil.

Correspondence to:
Fernanda Mayrink Gonçalves Liberato
Av. Marechal Campos, 1468 - Bonfim, Vitória - ES | CEP 29047-105
Email: nandamayrink@yahoo.com.br

Submitted August 30, 2021; accepted November 29, 2022.

Aims: To examine the effect of manual therapy applied to the cervical joint for reducing pain and improving mouth opening and jaw function in people with TMDs. **Methods:** A systematic review of randomized controlled trials was performed. Participants were adults diagnosed with TMDs. The experimental intervention was manual therapy applied to the cervical joint compared to no intervention/placebo. Outcome data relating to orofacial pain intensity, pressure pain threshold (PPT), maximum mouth opening, and jaw function were extracted and combined in meta-analyses. **Results:** The review included five trials involving 213 participants, of which 90% were women. Manual therapy applied to the cervical joint decreased orofacial pain (mean difference: –1.8 cm; 95% CI: –2.8 to –0.9) and improved PPT (mean difference: 0.64 kg/cm^2; 95% CI: 0.02 to 1.26) and jaw function (standardized mean difference: 0.65; 95% CI: 0.3 to 1.0). **Conclusion:** Manual therapy applied to the cervical joint had short-term benefits for reducing pain intensity and improving jaw function in women with TMDs. Further studies are needed to improve the quality of the evidence and to investigate the maintenance of benefits beyond the intervention period. *J Oral Facial Pain Headache 2023;37:101–111. doi: 10.11607/ofph.3093*

Keywords: *manipulation, mobilization, massage, pain, rehabilitation, temporomandibular joint*

Temporomandibular disorders (TMDs) are defined as a group of conditions that affect the masticatory muscles, the temporomandibular joint (TMJ), and/or associated structures.[1] About 10% of the adult population suffers from TMDs, which are the main cause of nonodontogenic orofacial pain in women 20 to 40 years of age.[2–4] The prognosis of TMDs is controversial, and acute episodes may progress to recurrent or chronic orofacial pain.[5] Orofacial pain typically limits mouth opening and the performance of everyday activities that require mandibular movements, such as biting, chewing, talking, and kissing.[6,7] This may ultimately reduce an individual's quality of life and community participation.[8,9]

Over 50% of patients with TMDs also present with complaints of neck pain.[10] A relationship between orofacial and neck pain has been described in patients with TMDs attributed to neuronal and biomechanical associations with the cervical spine.[1,11–13] Nociceptive afferents from the trigeminal nerve and the cervical spine both synapse in the subnucleus caudalis; therefore, cervical nociceptive afferents can excite second-order neurons that also receive input from facial tissues. The convergence of nociceptive stimuli to the same brain region alters pain modulation, which may trigger referred pain and change the activity of the masticatory and cervical muscles.[14,15] In addition, potential pain input from regions outside trigeminal receptive fields (eg, the dorsal horn of the spinal cord) may excite brain structures that communicate with the trigeminal nuclei and modulate their functions. Changes in the mobility of the cervical joint are also observed in people with TMDs, as well as less activation of the deep cervical flexor musculature.[15–17] Although a causative relationship is not fully established, the literature suggests a comorbidity between these two conditions.[10,17] Therefore, a broad

Table 1 Inclusion Criteria
Design
Randomized controlled trials
Participants
Adults (> 18 y)
Diagnosis of TMDs
Intervention
Experimental intervention = manual therapy applied to the cervical joint
Outcome measures
Measures of pain, mouth opening, and/or mandibular activity

cervical spine examination is recommended in patients with TMDs, and the addition of interventions focused on the cervical joint may help reduce the presence and intensity of the disorder.

Many interventions are recommended to treat neck pain, such as exercises, laser treatment, dry needling, and manual therapy.[18] Manual therapy includes any manual technique such as manipulation (ie, localized force of high velocity and low amplitude directed at specific spinal segments) or mobilization (ie, low-velocity or small- or large-amplitude passive movement or neuromuscular techniques within the patient's physiologic range of motion).[19,20] The effectiveness of manual therapy applied to the cervical joint may be due to neuroanatomical interactions[1] and/or to neurophysiologic effects that influence pain, motor control, and sympathetic nervous system activity.[21] One systematic review,[22] which included a meta-analysis based on three randomized trials, reported that manual therapy applied to the cervical joint may reduce orofacial pain (standardized mean difference [SMD]: −1.4; 95% CI: −2.4 to −0.5, I^2 = 81%) and improve the pressure pain threshold (PPT) of the masticatory muscles (SMD: 1.2; 95% CI: 0.06 to 2.4, I^2 = 89%). However, the review did not examine the carryover of improved pain to activities of daily living.

Therefore, the aim of the present systematic review was to update the evidence for manual therapy applied to the cervical joint for reducing orofacial pain and to examine effects on mouth opening and jaw function in people with TMDs. The specific research questions were as follows: *(1)* In people with TMDs, does manual therapy applied to the cervical joint reduce pain and increase mouth opening?; and *(2)* Are any benefits carried over to activity?

Materials and Methods

This review was prospectively registered at PROSPERO (CRD42020192734) and is reported according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement guidelines (www.prisma-statement.org/).

Identification and Selection of Trials

Searches were conducted in the MEDLINE (1946 to March 2021), AMED (1986 to March 2021), Embase (1947 to March 2021), Cochrane (2005 to March 2021), Global Health (1910 to March 2021), and PEDro (to March 2021) databases for relevant studies without date or language restrictions. The search strategy was registered at PubMed/MEDLINE, so the authors received monthly notifications of potential papers related to this systematic review. Search terms included words related to TMDs, the cervical joint, and randomized clinical trials (Appendix Table 1). Titles and abstracts were displayed and screened to identify relevant studies. The full texts of the relevant peer-reviewed papers were retrieved, and their reference lists were screened to identify further relevant studies. The Methods sections of the retrieved papers were extracted and reviewed independently by two reviewers (C.H.S. and F.M.G.L.) using predetermined criteria (Table 1). Both reviewers were blinded to authors, titles, journals, and results. Disagreements or ambiguities were resolved by consensus after discussion with a third reviewer (T.V.S.).

Assessment of Characteristics of Trials

Methodologic quality.

The methodologic quality of the included trials was assessed by extracting the PEDro scores from the Physiotherapy Evidence Database (www.pedro.org.au). The PEDro scale is an 11-item scale designed for rating the methodologic quality (internal validity and statistical information) of randomized trials. Each item, except for item 1, contributes 1 point to the total score (range: 0 to 10 points). When a trial was not included in the database, it was scored by a reviewer who had completed the PEDro scale training tutorial (F.M.G.L.).

Participants.

Trials involving adults with diagnoses of TMDs were included. Number of participants, age, pain duration, and diagnostic criteria were recorded to assess the similarity of the studies.

Intervention.

Trials were included if the experimental intervention was manual therapy applied to the cervical joint. *Manual therapy* was defined as the application of manual force to the cervical joint, muscles, or connective tissues using techniques such as massage therapy, joint mobilization, and/or manipulation.[23] The control intervention could be no intervention or a placebo intervention. Session duration, session frequency, and program duration were recorded to assess the similarity of the studies.

Measures.

Four outcomes were of interest: orofacial pain intensity, PPT, maximum mouth opening, and jaw function. The measurement of orofacial pain intensity had to

be based on validated self-report methods (eg, visual analog scale [VAS] or numeric rating scale). When multiple measures of pain intensity were reported in one study (eg, pain at rest, worst pain, minimum pain), the results of the individual measurements were averaged.[24] The measurement of PPT had to be a direct measure of the minimum amount of pressure needed to trigger a pain sensation (eg, using a pressure algometer).[25,26] When multiple measures of PPT were reported in one study (eg, for the masseter and temporalis muscles), the results of the individual measurements were averaged.[24] The measurement of maximum mouth opening had to be a direct measure of the distance between the incisal edges of the maxillary and the mandibular reference teeth, corrected for anterior overbite or open bite[27,28] (eg, using a caliper or analog/digital rulers). The measurement of activity had to be representative of everyday jaw function, such as eating or laughing (eg, the Mandibular Function Impairment Questionnaire). When multiple questionnaires assessing jaw function were reported in one study, the questionnaire with more activities was used. The timing of the measurements and the procedure(s) used to measure the outcomes were recorded to assess the appropriateness of combining studies in a meta-analysis.

Data Analysis

Information about the methods (ie, design, participants, intervention, measures) and results (ie, number of participants and mean and SD values of the outcomes of interest) were extracted by two reviewers (F.M.G.L. and T.V.S.) and checked by a third reviewer (L.R.N.). If the information was not available in the published trials, details were requested from the corresponding author.

The postintervention scores were used to obtain the pooled estimate of the effect of intervention using a random-effects model. A visual inspection of the distribution of effect sizes in the forest plots was performed, and the I^2 value was calculated to indicate the proportion of variance that was due to heterogeneity.[29] I^2 values > 50% are indicative of important heterogeneity.[29,30] The analyses were performed using Review Manager version 5.4 (The Nordic Cochrane Centre). For all outcome measures, the critical value for rejecting the null hypothesis was set at a level of .05 (two-tailed). The pooled data for each outcome were reported as the weighted mean difference (MD) or as the SMD between groups with the corresponding 95% CI. When trial data could not be included in a pooled analysis, the between-group result was reported.

The GRADE (Grading of Recommendations Assessment, Development, and Evaluation) system was used to summarize the overall quality of evidence for each outcome, which could range from very low to high quality.[32] High-quality evidence was downgraded by one rating level if one of the following prespecified criteria was present: low methodologic quality (most trials had PEDro score < 6); inconsistency of estimates among pooled studies (I^2 > 50%) or assessment was not possible (no pooling); indirectness of participants (most trials did not report pain duration or the analyses mixed acute and chronic participants); and imprecision (pooling < 300 participants for each outcome).[24,33] Two reviewers (F.M.G.L. and L.R.N.) assessed the quality of the evidence using the GRADE system, with potential disagreements resolved by consensus (T.V.S.).

RESULTS

Flow of Trials through the Review

The electronic search strategy identified 814 papers. After screening titles, abstracts, and reference lists, 18 potentially relevant full papers were retrieved, but 10 were duplicates. From the remaining 8 papers, 3 failed to meet the inclusion criteria (see Appendix Table 1), resulting in 5 papers included in the review (Fig 1). All information was extracted from the original publications, and no authors needed to be contacted for more detailed information.

Characteristics of Included Trials

The 5 trials involved 213 participants (90% women) and investigated the effects of manual therapy applied to the cervical joint for improving orofacial pain intensity (n = 4), PPT (n = 3), maximum mouth opening (n = 3), and jaw function (n = 2; Table 2).

Methodologic quality.

The mean PEDro score of the trials was 7 (range: 5 to 8; Table 3). All trials randomly allocated their participants, had < 15% dropouts, and reported point estimate, variability, and between-group differences. Most trials had similar groups at baseline (80%), blinded assessors (80%), and concealed allocation (60%). On the other hand, most trials did not blind participants (80%) or therapists (100%), which is difficult or impossible during complex interventions, and did not report whether an intention-to-treat analysis had been undertaken (60%).

Participants.

Trials included participants with a mean age ranging from 25 to 35 years. Most participants were women (90%). The included participants were diagnosed with myalgia or mixed TMDs according to the Diagnostic Criteria for TMDs (DC/TMD) or Research Diagnostic Criteria for TMDs (RDC/TMD). On average, the participants had orofacial pain ranging from 6 months to 6 years across trials.

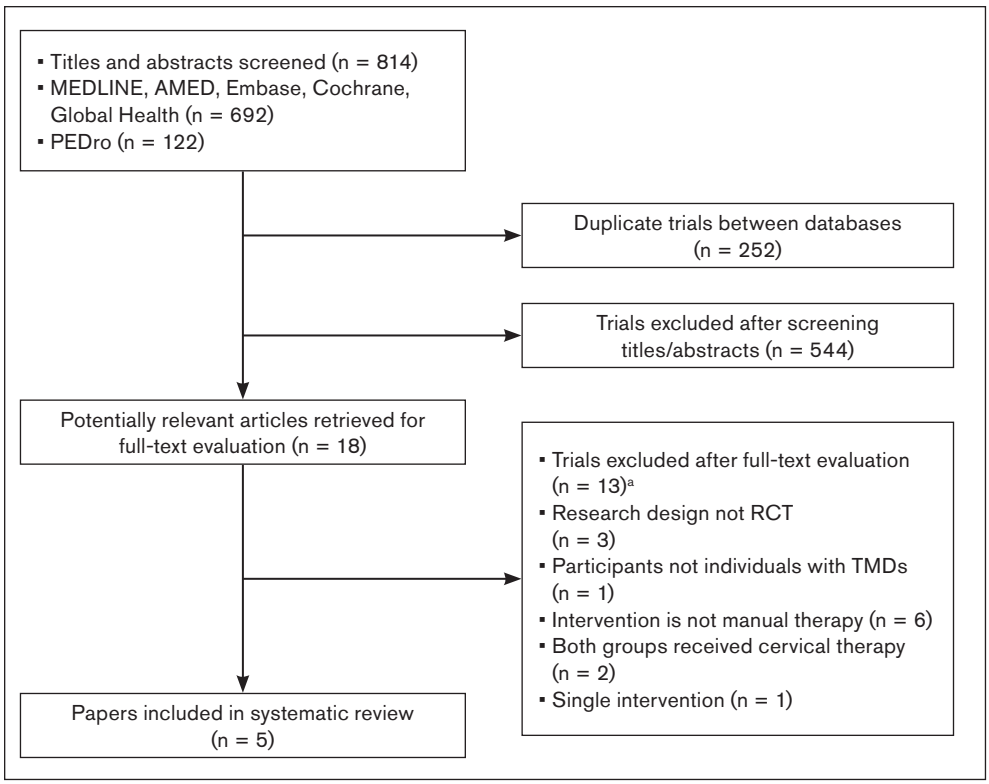


Fig 1 Flowchart of study inclusion. [a] Trials may have been excluded for failing to meet more than one inclusion criterion (see Appendix Table 2).

Table 2 Characteristics of the Included Trials (n = 5)

Study	Participants	Intervention	Outcome measures
Bortolazzo et al[34] (2015)	n = 10 Mean (SD) age = 25 (7) y Female sex = 100% Pain duration = 1–5 y Type of TMD = myalgia	Experimental = cervical manipulation; 3–9 reps x 1/wk x 5 wk Control = sham cervical manipulation; 30 s x 1/wk x 5 wk	Mouth opening = caliper ruler (mm) Measurements = 0, 5 wk
Calixtre et al[38] (2018)	n = 61 Mean (SD) age = 26 (5) y Female sex = 100% Pain duration = 5 (range 2–10) y Type of TMD = myalgia or mixed (myalgia + arthralgia or myalgia + disc displacement)	Experimental = cervical mobilization and cervical exercises; 15–20 min × 3/wk × 5 wk Control = no treatment	Orofacial pain intensity = VAS (0–10 cm; anchors were not reported) PPT = caliper (kg/cm^2) Jaw function = MFIQ (0–52) Measurement = 0, 5 wk
Corum et al[35] (2018)	n = 60 Mean (SD) age = 27 (7) y Female sex = 100% Pain duration = > 6 mo Type of TMD = myalgia or disc displacement or mixed (myalgia + disc displacement)	Experimental = cervical manipulation; 1/wk × 6 wk Control = sham cervical manipulation; 1/wk × 6 wk Both = education and cervical exercises	Orofacial pain intensity = VAS (0–10 cm; anchors: no pain to pain as bad as could be) PPT = caliper (kg/cm^2) Mouth opening = 10-cm ruler (mm) Measurements = 0, 6 wk
La Touche et al[37] (2013)	n = 32 Mean (SD) age = 34 (8) y Female sex = 66% Pain duration = 11 (6) mo Type of TMD = myalgia	Experimental = cervical mobilization; 7 min x 1–2/wk × 2 wk Control = sham cervical mobilization; 7 min x 1–2/wk × 2 wk	Orofacial pain intensity = VAS (0–100 mm; anchors: no pain to worst pain) PPT = caliper (kg/cm^2) Measurements = 0, 2 wk
Reynolds et al[36] (2020)	n = 50 Mean (SD) age = 35 (13) y Female sex = 86% Pain duration = 6 (7) y Type of TMD = myalgia or mixed (not specified)	Experimental = suboccipital release + cervical manipulation; 4–8 reps x 1/wk × 4 wk Control = suboccipital release + sham cervical manipulation; 4–8 reps × 1/wk × 4 wk Both = education and home-based exercises	Orofacial pain intensity = VAS (0–10; anchors not reported) Mouth opening = caliper ruler (mm) Jaw function = JFLS (0–200) Measurements = 0, 4 wk

MFIQ = Mandibular Function Impairment Questionnaire ; JFLS = Jaw Function Limitation Scale.

Table 3 PEDro Criteria and Scores of the Included Trials (n = 5)

Study	Random allocation	Concealed allocation	Groups similar at baseline	Participant blinding	Therapist blinding	Assessor blinding
Bortolazzo et al[34] (2015)	Y	N	N	N	N	Y
Calixtre et al[38] (2018)	Y	Y	Y	N	N	Y
Corum et al[35] (2018)	Y	N	Y	N	N	N
La Touche et al[37] (2013)	Y	Y	Y	Y	N	Y
Reynolds et al[36] (2020)	Y	Y	Y	N	N	Y

Study	< 15% dropouts	Intention-to-treat analysis	Between-group difference reported	Point estimate and variability reported	Total (0 to 10)
Bortolazzo et al[34] (2015)	Y	N	Y	Y	5
Calixtre et al[38] (2018)	Y	Y	Y	Y	8
Corum et al[35] (2018)	Y	N	Y	Y	5
La Touche et al[37] (2013)	Y	N	Y	Y	8
Reynolds et al[36] (2020)	Y	Y	Y	Y	8

Y = yes; N = no.

Intervention.

In all trials, the experimental intervention was manual therapy delivered as manipulation,[34–36] mobilization,[37] or mobilization associated with exercises,[38] carried out in rehabilitation centers. Participants received, on average, three to nine repetitions (or 7 to 20 minutes) of manual therapy, one to three times per week, over 4 weeks (SD: 1.5). The control group received no intervention[38] or a placebo intervention.[34–37] Two trials[35,36] delivered additional interventions (eg, cervical exercises, education, or home-based exercises) to both groups.

Outcome measures.

Four trials[35–38] measured orofacial pain intensity using a 0 to 10 VAS. Three trials[35,37,38] measured PPT using an algometer (kg/cm^2). Three trials[34–36] measured unassisted maximum mouth opening without pain using either an analog or a digital ruler (millimeters). Two trials[36,38] measured jaw function using self-report questionnaires.

Effect of Manual Therapy Applied to the Cervical Joint

Orofacial pain intensity.

The effect of manual therapy applied to the cervical joint on orofacial pain intensity was examined by pooling postintervention data from four trials.[35–38] Overall, low-quality evidence indicated that manual therapy applied to the cervical joint reduced orofacial pain intensity by −1.8 cm (95% CI: −2.8 to −0.9, I^2 = 74%, P < .01, Appendix Fig 1). When the trials were grouped according to the duration of pain, pain intensity was reduced in individuals with < 12 months of pain duration (MD: −2.7 cm; 95% CI: −3.3 to −2.1, I^2 = 0%, P < .01) and with a duration > 12 months (MD: −1.1 cm; 95%: CI: −1.8 to −0.4, I^2 = 0%, P < .01).

Pressure pain threshold.

The effect of manual therapy applied to the cervical joint on PPT was examined by pooling postintervention data from three trials.[35,37,38] Overall, low-quality evidence indicated that manual therapy applied to the cervical joint improved PPT by 0.64 kg/cm^2 (95% CI: 0.02 to 1.26, I^2 = 92%, P < .01, Appendix Fig 2). When trials were grouped according to the duration of pain, the PPT improved in individuals with less than 12 months of pain duration (MD: 0.92 kg/cm^2; 95% CI: 0.51 to 1.34, I^2 = 65%, P < .01). Only one trial suggested a small positive effect on PPT in individuals with pain duration > 12 months (MD: 0.10 kg/cm^2), but this estimate was very imprecise (95% CI: −0.15 to 0.35, P = .43).

Maximum mouth opening.

The effect of manual therapy applied to the cervical joint on maximum mouth opening was examined by pooling postintervention data from three trials.[34–36] Overall, low-quality evidence indicated that manual therapy applied to the cervical joint may have had a small beneficial effect on maximum mouth opening (MD 1.5 mm), but this estimate was very imprecise (95% CI: −1.8 to 4.9, I^2 = 0%, P = .37, Appendix Fig 3).

Jaw function.
The effect of manual therapy applied to the cervical joint on jaw function was examined by pooling postintervention data from two trials.[36,37] Overall, moderate-quality evidence indicated that manual therapy applied to the cervical joint improved jaw function by an SMD of 0.65 (95% CI 0.3 to 1.0, $I^2 = 0\%$, $P < .01$, Appendix Fig 4) in individuals with pain duration > 12 months. No trials examined jaw function in individuals with pain duration < 12 months.

DISCUSSION

This systematic review provided low-quality evidence that manual therapy applied to the cervical joint reduces pain in people diagnosed with TMDs. Moreover, moderate-quality evidence indicated that benefits were carried over to improving jaw function.

Orofacial pain intensity was measured using a validated self-report scale, which provides patient-centered data that are unique in capturing patients' own opinions regarding the effect of the intervention.[39,40] Although this review was not designed to determine the mechanisms that lead to orofacial pain improvements, which could be neurologic, biomechanical, or improvements in the general mood and well-being of patients, the results provided support for using manual therapy applied to the cervical joint because the magnitude of the effect was not only statistically significant but also clinically relevant. Previous trials have indicated that reductions > 1.7 are associated with significant clinical improvements in individuals with chronic pain, and therefore the mean reduction of 1.8 (out of 10) found in the present review could be considered clinically relevant.[41,42] Moreover, as the mean baseline pain intensity across trials was 4.8 (SD: 1.5), a reduction of 1.8 represents nearly a 40% reduction, which is beyond the cutoff scores for changes in pain scales.[43] There was some statistical heterogeneity in meta-analyses that disappeared when trials were grouped according to the duration of pain symptoms. Preliminary analysis of the 95% CI suggests that manual therapy is effective in people reporting pain duration of < 12 months. Manual therapy also showed beneficial effects in people reporting pain duration for > 12 months, but the estimate was imprecise. Due to the small number of available trials, subgroup analyses could not be performed.[44] On the other hand, improvements in self-reported pain intensity were supported by validated and reliable measurements of PPT.[45] Larger trials are recommended to strengthen the quality of evidence regarding pain intensity.

Moreover, moderate-quality evidence indicated that the benefits regarding pain were carried over to improving jaw function, as also measured using self-report questionnaires. Neurophysiologic mechanisms such as innervation[14] and the biomechanical interaction between the cervical joint and the TMJ[46] may explain improvements in jaw function that require submaximal mouth opening. The magnitude of the effect was positive and moderate, but imprecision in the CIs suggests that further trials should include measures of jaw function as outcomes instead of maximum mouth opening. Since publication of the International Classification of Functioning, Disability, and Health, patient-reported outcome measures have been recommended to guide routine patient care because they are unique in capturing the patients' own opinions about the impact of their health condition and the treatment on their lives that the outcomes reflect.[47,48] Although maximum mouth opening is a quite common outcome in trials related to the cervical joint, most jaw function in everyday activities does not require extreme ranges of motion. Previous trials suggest that interventions focused on the TMJ appear to be more effective for improving maximum mouth opening.[18,49]

A limitation of the trials included in this review was the fact that, despite achieving good methodologic quality, the quality of the evidence varied from low to moderate due to small samples and indirectness of the participants caused by a varied range of pain duration. Furthermore, the included clinical trials did not provide clear evaluations of the cervical joint and might have included individuals with no cervical impairments, which gives little room for improvements. On the other hand, studies were clinically homogenous regarding the characteristics of the intervention, which indicate that three to nine repetitions (or 7 to 20 minutes) of manual therapy applied to the cervical joint, one to three times per week, over 4 weeks (SD: 1.5) reduces pain and improves jaw function in women with TMDs. In addition, it is important to highlight that participants in the included trials were predominantly women, as TMDs are more prevalent in women. Therefore, caution should be taken when extending these results to men. Larger trials are warranted to reduce the indirectness of participants by establishing proper inclusion criteria regarding pain intensity and cervical impairments, which may reduce the imprecision related to the CI of the estimates of effect.

Conclusions

This systematic review provides low- to moderate-quality evidence that manual therapy applied to the cervical joint had short-term benefits for reducing pain and improving jaw function in women with TMDs. Therefore, manual therapy emerges as an adjoint treatment to be recommended after full

biopsychosocial and interdisciplinary evaluation of each patient. There is still work to be done in this area; in particular, larger high-quality trials to strengthen the quality of the evidence and to include examination of long-term benefits are warranted.

HIGHLIGHTS

- Manual therapy applied to the cervical joint reduces pain in individuals with TMDs.
- Benefits are carried over to improving jaw function.

ACKNOWLEDGMENTS

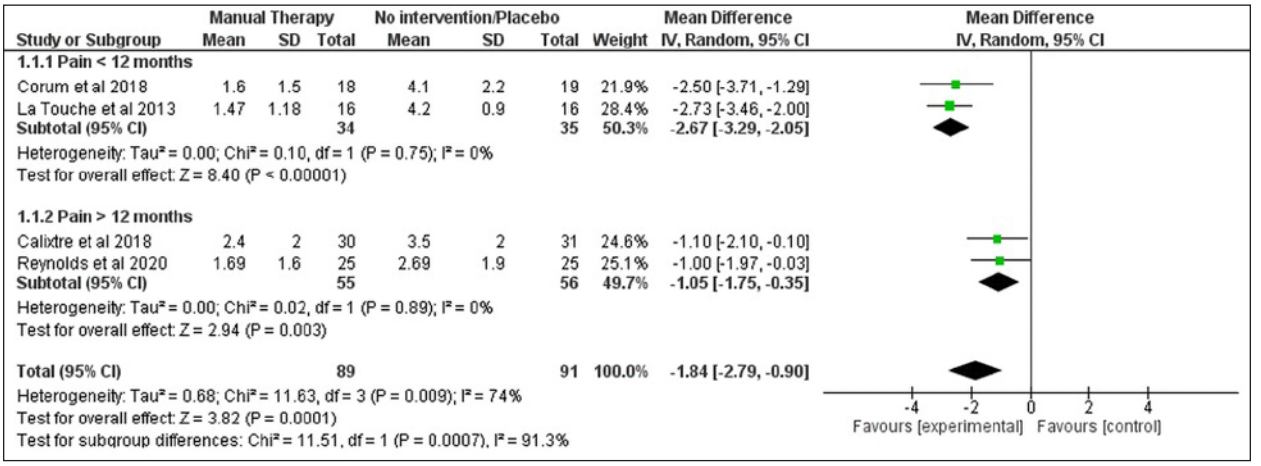
The authors report no conflicts of interest. Author contributions: F.M.G.L.: research design and supervision, selection of trials, data extraction, statistical analysis (execution), writing of the first draft, manuscript review; T.V.S, C.H.S., and N.F.F.O.: selection of trials, data extraction, statistical analysis (design and execution), writing of the first draft, manuscript review; L.R.N.: research design and supervision, selection of trials, data extraction, statistical analysis (design and execution), writing of the first draft, English editing, and manuscript review.

References

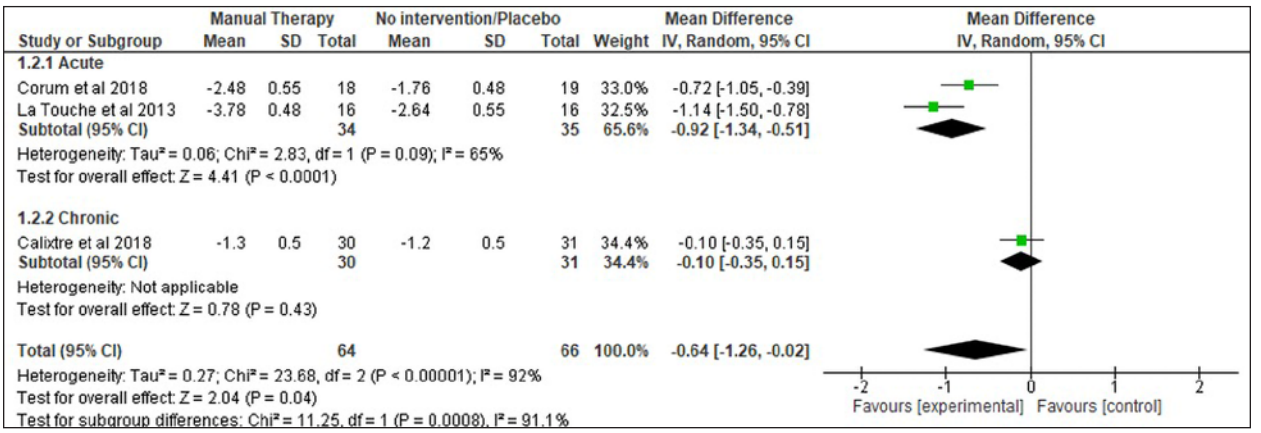
1. De Leeuw R, Klasser GD (ed). Orofacial Pain: Guidelines for Assessment, Diagnosis, and Management, ed 6. Quintessence, 2018.
2. LeResche L. Epidemiology of temporomandibular disorders: Implications for the investigation of etiologic factors. Crit Rev Oral Biol Med 1997;8:291–305.
3. Manfredini D, Guarda-Nardini L, Winocur E, Piccotti F, Ahlberg J, Lobbezoo F. Research diagnostic criteria for temporomandibular disorders: A systematic review of axis I epidemiologic findings. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;112:453–462.
4. Schmid-Schwap M, Bristela M, Kundi M, Piehslinger E. Sex-specific differences in patients with temporomandibular disorders. J Orofac Pain 2013;27:42–50.
5. Rammelsberg P, LeResche L, Dworkin S, Mancl L. Longitudinal outcome of temporomandibular disorders: A 5-year epidemiologic study of muscle disorders defined by research diagnostic criteria for temporomandibular disorders. J Orofac Pain 2003;17:9–20.
6. Dahlström L, Carlsson GE. Temporomandibular disorders and oral health-related quality of life. A systematic review. Acta Odontol Scand 2010;68:80–85.
7. De Resende CMBM, Alves ACM, Coelho LT, Alchieri JC, Roncalli AG, Barbosa GAS. Quality of life and general health in patients with temporomandibular disorders. Braz Oral Res 2013;27:116–121.
8. Armijo-Olivo S, Silvestre R, Fuentes J, et al. Electromyographic activity of the cervical flexor muscles in patients with temporomandibular disorders while performing the craniocervical flexion test: A cross-sectional study. Phys Ther 2011;91:1184–1197.
9. Wadhwa S, Kapila S. TMJ disorders: Future innovations in diagnostics and therapeutics. J Dent Educ 2008;72:930–947.
10. Plesh O, Adams SH, Gansky SA. Temporomandibular joint and muscle disorder-type pain and comorbid pains in a national US sample. J Orofac Pain 2011;25:190–198.
11. Ballenberger N, von Piekartz H, Paris-Alemany A, La Touche R, Angulo-Diaz-Parreño S. Influence of different upper cervical positions on electromyography activity of the masticatory muscles. J Manipulative Physiol Ther 2012;35:308–318.
12. Watson DH, Drummond PD. Head pain referral during examination of the neck in migraine and tension-type headache. Headache 2012;52:1226–1235.
13. Velly AM, Botros J, Bolla MM et al. Painful and non-painful comorbidities associated with short- and long-term painful temporomandibular disorders: A cross-sectional study among adolescents from Brazil, Canada and France. J Oral Rehabil 2022;49:273–282.
14. Armijo-Olivo S, Magee D. Cervical musculoskeletal impairments and temporomandibular disorders. J Oral Maxillofac Res 2013;3:e4.
15. Greenbaum T, Dvir Z, Reiter S, Winocur E. Cervical flexion-rotation test and physiological range of motion—A comparative study of patients with myogenic temporomandibular disorder versus healthy subjects. Musculoskelet Sci Pract 2017;27:7–13.
16. Grondin F, Hall T, Laurentjoye M, Ella B. Upper cervical range of motion is impaired in patients with temporomandibular disorders. Cranio 2015;33:91–99.
17. Von Piekartz H, Pudelko A, Danzeisen M, Hall T, Ballenberger N. Do subjects with acute/subacute temporomandibular disorder have associated cervical impairments: A cross-sectional study. Man Ther 2016;26:208–215.
18. Blanpied PR, Gross AR, Elliott JM, et al. Neck pain: Revision 2017. J Orthop Sports Phys Ther 2017;47:A1–A83.
19. Miller J, Gross A, D'Sylva J, et al. Manual therapy and exercise for neck pain: A systematic review. Man Ther 2010;15:334–354.
20. Bialosky JE, Bishop MD, Price DD, Robinson ME, George SZ. The mechanisms of manual therapy in the treatment of musculoskeletal pain: A comprehensive model. Man Ther 2009;14:531–538.
21. Perry J, Green A. An investigation into the effects of a unilaterally applied lumbar mobilization technique on peripheral sympathetic nervous system activity in the lower limbs. Manual therap 2008;13:492–499.
22. La Touche R, García SM, García BS, et al. Effect of manual therapy and therapeutic exercise applied to the cervical region on pain and pressure pain sensitivity in patients with temporomandibular disorders: A systematic review and meta-analysis. Pain Med 2020;21:2373–2384.
23. French HP, Brennan A, White B, Cusack T. Manual therapy for osteoarthritis of the hip or knee—A systematic review. Man Ther 2011;16:109–117.
24. Nascimento LR, Teixeira-Salmela LF, Souza RB, Resende RA. Hip and knee strengthening is more effective than knee strengthening alone for reducing pain and improving activity in individuals with patellofemoral pain: A systematic review with meta-analysis. J Orthop Sports Phys Ther 2018;48:19–31.
25. Fredriksson L, Alstergren P, Kopp S. Pressure pain thresholds in the craniofacial of female patients with rheumatoid arthritis. J Orofac Pain 2003;17:326–332.
26. Svensson P, Arendt-Nielsen L, Nielsen H, Larsen JK. Effect of chronic and experimental jaw muscle pain on pain-pressure thresholds and stimulus-response curves. J Orofac Pain 1995;9:347–356.
27. Dworkin SF, LeResche L. Research diagnostic criteria for temporomandibular disorders: Review, criteria, examinations and specifications, critique. J Craniomandib Disord 1992;6:301–355.

28. Ohrbach R, Gonzalez Y, List T, Michelotti A, Schiffman E. Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) Clinical Examination Protocol. Version: June 2, 2013. Accessed 1 May 2023. www.rdc-tmdinternational.org
29. Borenstein M, Hedges LV, Higgins JPT, Rothstein HR. Introduction to Meta-Analysis. John Wiley and Sons, 2011.
30. Bagg MK, McLachlan AJ, Maher CG, et al. Paracetamol, NSAIDS and opioid analgesics for chronic low back pain: A network meta-analysis. Cochrane Database Syst Rev 2018;2018:CD013045.
31. Higgins JPT, Green S, eds. Cochrane Handbook for Systematic Reviews of Interventions. Version 5.1.0 [updated March 2011]. The Cochrane Collaboration, 2011. Accessed May 1, 2023. www.handbook-5-1.cochrane.org
32. Balshem H, Helfand M, Schünemann HJ, et al. GRADE guidelines: 3. Rating the quality of evidence. J Clin Epidemiol 2011;64:401–406.
33. Nicholson V, Watts N, Chani Y, Keogh JWI. Motor imagery training improves balance and mobility outcomes in older adults: A systematic review. J Physiother 2019;65:200–207.
34. Bortolazzo G, Pires PF, Dibai-Filho AV, Berni KCS, Rodrigues BM, Rodrigues-Bigaton D. Effects of upper cervical manipulation on the electromyographic activity of the masticatory muscles and the opening range of motion of the mouth in women with temporomandibular disorder: Randomized and blind clinical trial. Fisioter e Pesqui 2015;22:426–434.
35. Corum M, Basoglu C, Topaloglu M, Diracoglu D, Aksoy C. Spinal high-velocity low-amplitude manipulation with exercise in women with chronic temporomandibular disorders. A randomized controlled trial comparing to patient education. Manuella Med 2018;56:230–238.
36. Reynolds B, Puentedura EJ, Kolber MJ, Cleland JA. Effectiveness of cervical spine high-velocity-low amplitude thrust added to behavioral education, soft tissue mobilization, and exercise for people with temporomandibular disorder with myalgia: A randomized clinical trial. J Orthop Sports Phys Ther 2020;50:455–465.
37. La Touche R, París-Alemany A, Mannheimer JS, et al. Does mobilization of the upper cervical spine affect pain sensitivity and autonomic nervous system function in patients with cervico-craniofacial pain?: A randomized-controlled trial. Clin J Pain 2013;29:205–215.
38. Calixtre LB, Oliveira AB, Rosa LRS, Armijo-Olivo S, Visscher CM, Alburquerque-Sendín F. Effectiveness of mobilisation of the upper cervical region and craniocervical flexor training on orofacial pain, mandibular function and headache in women with TMD. A randomised, controlled trial. J Oral Rehabil 2018;46:109–119.
39. Rose M, Bezjak A. Logistics of collecting patient-reported outcomes (PROs) in clinical practice: An overview and practical examples. Qual Life Res 2009;18:125–136.
40. Pitance L, De Longhi B, Gerard E, et al. Digital pain drawings are a useful and reliable tool for assessing patients with temporomandibular disorders. J Oral Rehab 2021;48:798–808.
41. Dworkin RH, Turk DC, McDermott MP, et al. Interpreting the clinical importance of group differences in chronic pain clinical trials: IMMPACT recommendations. Pain 2009;146:238–244.
42. Farrar JT, Young JP Jr, LaMoreaux L, Werth JL, Poole MR. Clinical importance of changes in chronic pain intensity measured on an 11-point numerical pain rating scale. Pain 2001;94:149–158.
43. Farrar JT, Portenoy RK, Berlin JA, Kinman JL, Strom BL. Defining the clinically important difference in pain outcome measures. Pain 2000;88:287–294.
44. Ryan R. Heterogeneity and subgroup analyses in Cochrane consumers and communication group reviews: Planning the analysis at protocol stage. Cochrane Consumers and Communication Review Group. December 2016. Accessed 1 May 2023. http://cccrg.cochrane.org
45. Costa YM, Morita-Neto O, Araújo-Júnior ENS, Sampaio FA, Conti PCR, Bonjardim LR. Test-retest reliability of quantitative sensory testing for mechanical somatosensory and pain modulation assessment of masticatory structures. J Oral Rehabil 2017;44:197–204.
46. Eriksson PO, Häggman-Henrikson B, Nordh E, Zafar H. Coordinated mandibular and head-neck movements during rhythmic jaw activities in man. J Dent Res 2000;79:1378–1384.
47. Kyte DG, Calvert M, van der Wees PJ, ten Hove R, Tolan S, Hill JC. An introduction to patient-reported outcome measures (PROMs) in physiotherapy. Physiotherapy 2015;101:119–25.
48. Üstün TB, Chatterji S, Bickenbach J, Kostanjsek N, Schneider M. The international classification of functioning, disability and health: A new tool for understanding disability and health. Disabil Rehabil 2003;25:565–571.
49. Calixtre LB, Moreira RFC, Franchini GH, Alburquerque-Sendín F, Oliveira AB. Manual therapy for the management of pain and limited range of motion in subjects with signs and symptoms of temporomandibular disorder: A systematic review of randomised controlled trials. J Oral Rehabil 2015;42:847–861.

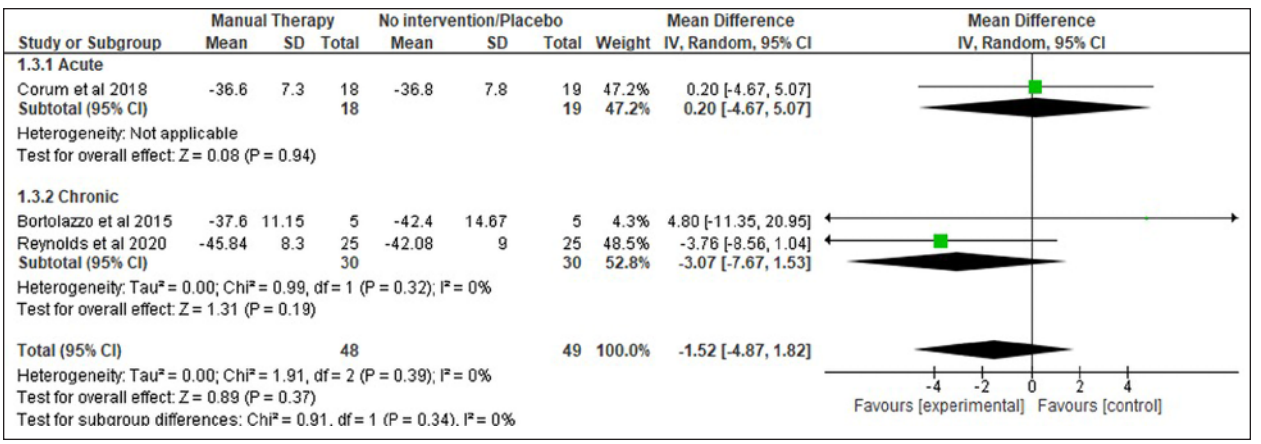
Appendices



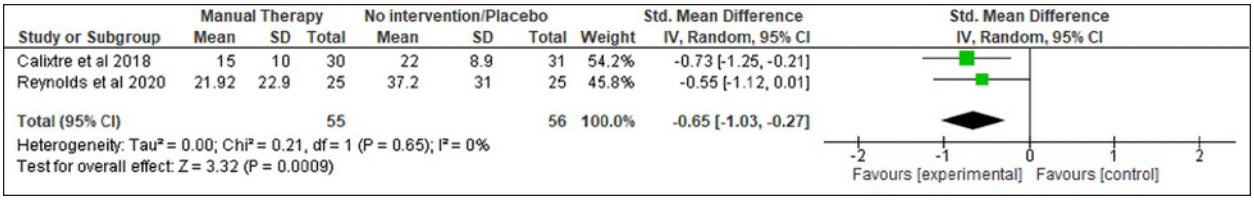
Appendix Fig 1 Mean difference (SD) of the effect of manual therapy applied to the cervical joint on orofacial pain intensity (0–10 points).



Appendix Fig 2 Mean difference (SD) of the effect of manual therapy applied to the cervical joint on PPT (kg/cm^2).



Appendix Fig 3 Mean difference (SD) of the effect of manual therapy applied to the cervical joint on maximum mouth opening (mm).



Appendix Fig 4 Standardized mean difference (SD) of the effect of manual therapy applied to the cervical joint on jaw function.

Appendix Table 1 Search Strategy

MEDLINE, AMED, Embase, Cochrane, Global Health
1. exp Craniomandibular Disorders/ or exp Myofascial Pain Syndromes/ (40235)
2. ((masticat$ or myofasc$ or orofacial$) and (pain$ or dysfunction$ or syndrom$)).mp. (34750)
3. (temporomandibular$ or temporo-mandibular$ or craniomandibular$ or craniomandibular$).mp. (62254)
4. (facial pain adj3 (psychogenic$ or atypical or chronic)).mp. (1573)
5. (tmj$ or cmd$ or tmd$ or 'facial arthromyalgia$').mp. (43979)
6 (mpds not (myeloprolif$ or myelo-prolif$)).mp. (612)
7. 1 or 2 or 3 or 4 or 6 (88031)
8. neck/ or neck muscles/ or exp cervical plexus/ or exp cervical vertebrae/ or Atlanto-Axial Joint/ or atlanto-occipital joint/ or axis/ or atlas/ or spinal nerve roots/ or exp brachial plexus/ (250811)
9. (odontoid or cervical or occip$ or atlant$).tw. (801559)
10. 8 or 9 (981281)
11. double-blind method/ or single blind method/ or placebos/ (623785)
12. exp clinical trial/ (2418772)
13. clinical trial.pt. (523179)
14. random$.ti,ab,sh. (3345483)
15. 11 or 12 or 13 or 14 (4625415)
16. 7 and 10 and 15 (748)
17. limit 16 to human [Limit not valid in AMED,CDSR,Global Health; records were retained] (692)
PEDro
Abstract and Title:
Search 1: Temporomandibular and neck
Search 2: Temporomandibular joint disorders and neck
When Searching: Match all search terms (AND)

Appendix Table 2 Excluded Papers (n = 12)

	Reasons for exclusion				
Studies	1	2	3	4	5
Calixtre et al (2016)	✓				
Cuccia et al (2009)		✓			
Ferragud and Gandia (2008)	✓				
Garrigós-Pedrón et al (2018)			✓		
Gesslbauer et al (2018)		✓			
La Touche et al (2009)	✓				
Oliveira et al (2015)		✓			
Oliveira-Campelo et al (2010)				✓	
Serna et al (2020)		✓			
Tuncer et al (2013)		✓			
Von Piekartz and Ludtke (2011)			✓		
Von Piekartz and Hall (2013)		✓			

1 = Research design not RCT.
2 = Experimental intervention not manual therapy applied to the cervical joint.
3 = Both groups received manual therapy applied to the cervical joint.
4 = Participants did not have TMDs.
5 = Single session of treatment.

References of Excluded Papers

1. Calixtre LB, Grüninger BL, Haik MN, et al. Effects of cervical mobilization and exercise on pain, movement and function in subjects with temporomandibular disorders: A single group pre-post test. J Appl Oral Sci 2016;24:188–197.
2. Cuccia AM, Caradonna C, Annunziata V, Caradonna D. Osteopathic manual therapy versus conventional conservative therapy in the treatment of temporomandibular disorders: A randomized controlled trial. J Bodyw Mov Ther 2010;14:179–184.
3. Ferragud PM, Gandia JJ. Efecto de la manipulación de la charnela occipito-atlo-axoidea en la apertura de la boca. Osteopatia Cientifica 2008;3:45–51.
4. Garrigós-Pedrón M, La Touche R, Navarro-Desentre P, Gracia-Naya M, Segura-Ortí E. Effects of a physical therapy protocol in patients with chronic migraine and temporomandibular disorders: A randomized, single-blinded, clinical trial. J Oral Facial Pain Headache 2018;32:137–150.
5. Gesslbauer C, Vavti N, Keilani M, Mickel M, Crevenna R. Effectiveness of osteopathic manipulative treatment versus osteopathy in the cranial field in temporomandibular disorders: A pilot study. Disabil Rehabil 2018;40:631–636.
6. La Touche R, Fernández-de-la-Peñas C, Fernández-Carnero J, et al. The effects of manual therapy and exercise directed at the cervical spine on pain and pressure pain sensitivity in patients with myofascial temporomandibular disorders. J Oral Rehabil 2009;36:644–652.
7. Oliveira-Campelo NM, Rebelatto JR, Vallejo FJ, Alburquerque-Sendín F, Fernández-de-las-Peñas C. The immediate effects of atlanto-occipital joint manipulation and suboccipital muscle inhibition technique on active mouth opening and pressure pain sensitivity over latent myofascial trigger points in the masticatory muscles. J Orthop Sports Phys Ther 2010;40:310–317.
8. Oliveira LB, Lops TS, Soares C, et al. Transcranial direct current stimulation and exercises for treatment of chronic temporomandibular disorders: a blind randomised-controlled trial. J Oral Rehabil 2015;42:723–732.
9. Rodriguez-Blanco C, Morata FM, Heredia-Rizo AM, Ricard F, Almazán-Campos G, Oliva-Pascual-Vaca A. Immediate effects of combining local techniques in the craniomandibular area and hamstring muscle stretching in subjects with temporomandibular disorders: A randomized controlled study. J Altern Complement Med 2015;21:451–459.
10. Serna PD, Plaza-Manzano G, Cleland J, Fernández-de-las-Peñas C, Martín-Casas P, Díaz-Arribas M. Effects of cervico-mandibular manual therapy in patients with temporomandibular pain disorders and associated somatic tinnitus: A randomized clinical trial. Pain Med 2020;21:613–624.
11. Tuncer AB, Ergun N, Tuncer AH, Karahan S. Effectiveness of manual therapy and home physical therapy in patients with temporomandibular disorders: A randomized controlled trial. J Bodyw Mov Ther 2013;17:302–308.
12. Von Piekartz H, Lüdtke K. Effect of Treatment of temporomandibular disorders (TMD) in patients with cervicogenic headache: A single-blind, randomized controlled study. Cranio 2011;29:43–56.
13. Von Piekartz H, Hall T. Orofacial manual therapy improves cervical movement impairment associated with headache and features of temporomandibular dysfunction: A randomized controlled trial. Man Ther 2013;18:345–350.