

Review

Effect of temporomandibular disorder therapy on otologic signs and symptoms: a systematic review

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SUMMARY The most common temporomandibular disorders (TMD) signs and symptoms are related to muscle sensitivity through palpation, restricted mouth opening, asymmetric mandibular movements, joint sounds, pain and otologic signs and symptoms. To date, counselling, occlusal splints, exercises, biofeedback and acupuncture are examples of conservative modalities proposed for TMD therapy. The aim of this systematic review was to investigate the effect of these conservative therapies for TMD on otologic signs and symptoms. The authors searched the following electronic databases published up to 1st May 2015: PubMed, LILACS, Scopus, Web of Science and Science Direct with no time or language limitations. Using a two-phase selection process, the authors identified 08 articles and used them to conduct a qualitative analysis. Methodological quality of each article was performed with the aid of 'Quality Assessment of a Cohort Study' and 'Quality Assessment of a Randomized Clinical Trial', developed by the Dutch

Cochrane Centre, a centre of the Cochrane Collaboration. This systematic review showed in seven of the eight studies included that a total or partial resolution of otologic complains occurred after counselling, exercise therapies and occlusal splint therapy. Upon the limitations of the studies included in this systematic review, the present outcomes suggested that there is insufficient evidence in favour or against the conservative therapies for TMD on changes in otologic signs and symptoms. Thus, further studies with a higher level of evidence and more representative samples should be conducted to better understand the relationship of TMD therapy changes on otologic complains.

KEYWORDS: conservative treatment, temporomandibular disorders, otologic signs and symptoms, systematic review

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Introduction

Temporomandibular disorders (TMDs) have been defined by the American Academy of Orofacial Pain as an umbrella of clinical conditions affecting the masticatory muscles, the temporomandibular joint (TMJ) and associated structures (1).

The most common TMD signs and symptoms are related to muscle sensitivity through palpation, restricted mouth opening, asymmetric mandibular movements, joint sounds, muscles and TMJ pain (2).

Less frequent but also usual, otologic signs and symptoms may be present in patients with TMD and

have been described decades ago (3). The most common otologic symptoms associated with TMD are tinnitus, dizziness, vertigo, earache, hypoacusis sensation, ear fullness, hyperacusis and stuffy sensation (4). Studies have tried to demonstrate the association between these otologic complains and TMD (5–8).

Epidemiological findings showed that the prevalence of otologic symptoms in the general population may vary from 10% to 31% and increases up to 85% in patients with TMD (8). Studies have postulated that the association between otologic complains and TMD may be due to intimate anatomical relationship between the TMJ (4), muscles innervated by the trigeminal nerve and ear structures (9).

The multifactorial diversity that may lead to the onset of TMD makes it challenging to identify an association for the presence of otologic complains on a TMD population (10). The efficacy of TMD treatment on comorbid otologic symptoms is still controversial. Up to date, conservative techniques such as counselling, occlusal splints, myofunction therapy, exercises, manual therapies, biofeedback and acupuncture (9) are described for TMD therapy.

Studies have tested splint therapy as well as some conservative therapeutic modalities for TMD patients with otologic complains, and they appear to be effective for the reduction of secondary otalgia (11), ear fullness, earache and tinnitus in patients with TMD (9, 12). Occlusal splints have been frequently employed for TMD management (13). However, the therapeutic effect and mechanisms of action of this modality are not fully understood. Some hypothesis credited to a combination of several peripheral, central and behavioural modifications (14). Furthermore, some benefit on psychological factors, such as symptoms of anxiety, depression and pain catastrophising (15), reduction in pain intensity and muscle sensitivity (16) and cognitive awareness and placebo (17), may also be possible mechanisms of action.

The effects of TMD therapy are not always positive, and one study has shown no differences in otologic complains (5, 11). Therefore, the aim of this systematic review was to answer the focused question: 'In adult patients with TMD and related otologic complains, what is the effect of conservative therapies on changes in otologic signs and symptoms?'

Methods

Protocol and registration

This systematic review was reported following the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-analysis checklist (PRISMA) (18). The systematic review protocol was registered at the International Prospective Register of Systematic Reviews (PROSPERO) under number CRD42015023947.

Eligibility criteria

The studies selected in this review were those with TMD patients associated with otologic signs and symptoms treated with conservative therapies such as physiotherapy, cognitive behavioural therapy, manual therapy, myofunction therapy, acupuncture, dry needling or any other type of conservative treatment. TMD studies (from both temporomandibular joint and masticatory muscles) should be assessed through Research Diagnostic Criteria/Temporomandibular Disorders (RDC/TMD) (19) or Diagnostic Criteria/Temporomandibular Disorders (DC/TMD) (20), or it should be informed other criteria for classification described in the literature. Otologic signs and symptoms should be assessed by patient's self-report, questionnaires or appropriated examination. Indeed, included studies needed to describe whether these conservative treatments affected modifications on the otological signs and symptoms of patients with TMD. No language or time restrictions were applied.

Exclusion criteria

The following exclusion criteria were applied: 1 studies that included subjects under 18 years old; 2 studies assessing patients without otologic signs and symptoms; 3 reviews, letters, case reports, conference abstracts; 4 no conservative treatment; 5 studies assessing patients without TMD; 6 studies with no treatment; 7 duplicated studies on the same population; 8 absence of detailed methods and results; 9 studies not using criteria for TMD diagnosis; 10 studies evaluating comorbid otolaryngological diseases.

Information sources

Appropriate truncation and word combinations were selected and adapted for each database search.

Search strategies were specifically developed to each of the following electronic database: PubMed, LILACS, Scopus, Web of Science and Science Direct (more information on the search strategies is provided in Appendix S1, which can be found in the supplementary data in the online version of this article). Furthermore, partial grey literature search through Google Scholar was performed. Lastly, a handsearch of the references of the included studies was performed. The references were managed and the duplicates were removed by using appropriate software.* Both electronic database searches and the grey literature searches were conducted from their starting coverage date through 1st May 2015.

Study selection

The selection was completed in two stages. In the first phase, titles and abstracts of all electronic databases were screened independently by two reviewers (J.S.N. and A.L.P.). The studies that did not appear to meet the eligibility criteria were excluded. In phase two, the same eligibility criteria were applied to the full text of the studies by the same reviewers. Any disagreement in both phases was resolved by discussion until a mutual agreement between the two reviewers was attained. A third author (Y.M.C.) was involved when required to make a final decision.

Data items and data collection process

Two authors (J.S.N. and A.L.P.) collected the required information from the selected studies, and the accuracy of the information collected was discussed. Any mistyping in this process was evaluated by a third author (I.P.T). The data collected consisted of study characteristics (authors, year of publication, country, design), population characteristics (sample size, age of participants, demographic features), intervention characteristics (methods) and outcome characteristics (findings, therapy, follow-up and main conclusions). If the required data were not complete, attempts were made to contact the authors to retrieve any pertinent unpublished information.

Risk of bias in individual studies

The methodology of the selected studies was assessed by the risk of bias tool 'Quality Assessment of a Cohort Study' and 'Quality Assessment of a Randomized Clinical Trial' (Appendix S2) developed by the Dutch Cochrane Centre, a centre of the Cochrane Collaboration (21). These validity tools consist originally of eight and nine items, respectively, which have to be scored with a plus '+', a minus '-' or a question mark '?'. Studies accomplishing 4 or more 'plusses' were considered as 'methodological acceptable'. This evaluation was performed by the first and second author (J.S.N and A.L.P). Disagreements have been solved by the assistance of a third expert (Y.M.C.).

Results

Studies selection

The final electronic search on databases revealed 731 records. After removing the duplicates, a comprehensive evaluation of the abstracts was performed and 573 articles were excluded, resulting in a final number of 158 articles. Handsearch of 10 additional and selected studies and 53 from grey literature search were performed. Thereafter, 24 full-text articles from databases and six additional studies identified from reference lists and grey literature were screened according to the inclusion and exclusion criteria. Finally, after phase 2, 22 studies were excluded due to different reasons (see Appendix S2) and eight studies were included in this review. Details about the search strategy are shown in Fig. 1.

Study characteristics

The eight studies were published between 1991 and 2015. They were conducted in Brazil (9), Finland (11), Germany (5, 6), Italy (22), Sweden (23) and United States (24–26) The sample size ranged from 15 (25) to 200 (26) subjects. Five studies reported having used RDC/TMD protocol (5, 6, 9, 24–26) and the other ones used the Helkimo Index (11, 23, 27) and one study based on Wilkes Classification (28) for internal derangement of temporomandibular joint. Six studies (5, 6, 11, 22, 24–26) evaluated individually mixed articular and muscular TMD. One study (9) evaluated only articular TMD, where exercise

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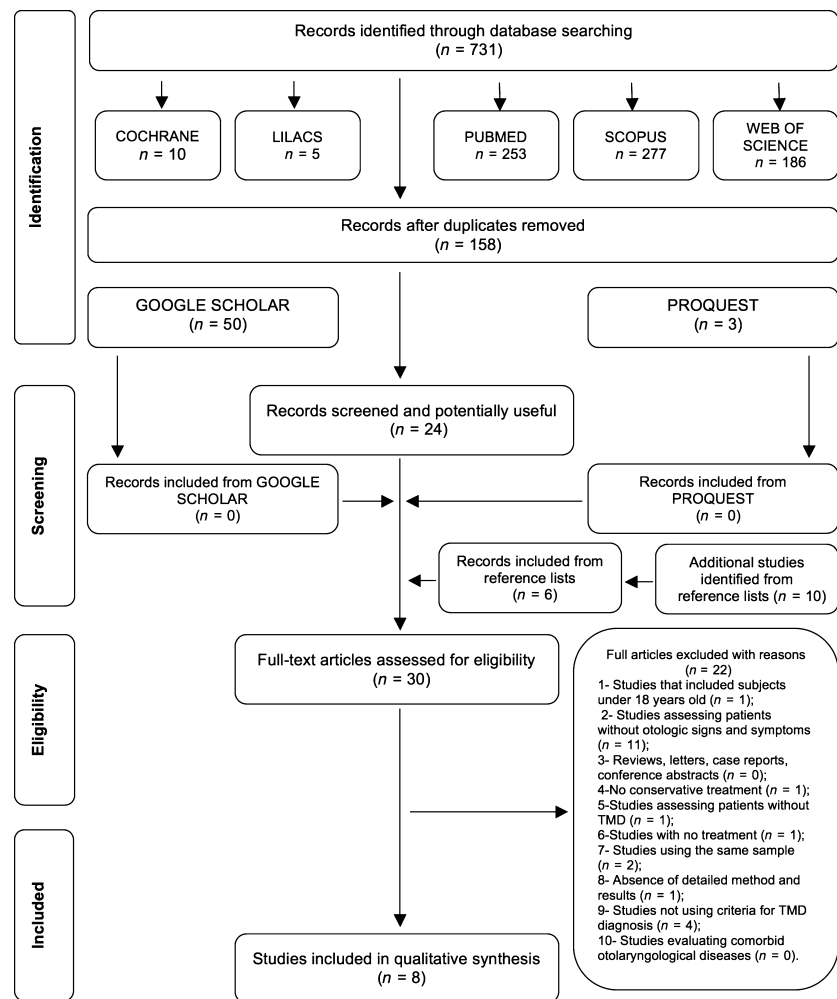


Fig. 1. Flow diagram of literature search and selection criteria.

¹ Adapted from PRISMA.

therapy presented a significant severity reduction on earache, tinnitus and ear fullness. Also, one study (23) evaluated only muscular TMD, showing significant changes in tinnitus, only when associated therapy for occlusal splints, exercise therapy and counselling were performed. A summary of the study descriptive characteristics can be found in Table 1.

Three selected studies designed randomised controlled trials (5, 9, 11, 23) and five were cohort studies (6, 22, 24–26). The majority of patients with TMD presented only tinnitus (5, 6, 22–24) or tinnitus associated with other otologic symptoms (9, 25, 26), and one study involved patients with secondary otalgia (11). The evaluation of otologic signs and symptoms varied widely between the studies. Otologic complains were evaluated based on audiometric evaluation (11,

23, 25), questionnaires (9, 24, 26), indexes for otologic symptoms measures as the Tinnitus Handicap Inventory (THI) (6, 22, 25), the Dizziness Handicap Inventory (DHI) (25) and Visual Analogue Scale (29) (9, 22).

Mean age among the studied patients was 42 years (ranging from 18 to 78 years), and 63.2% of the patients were females. The causes of the tinnitus reported in these studies were largely unknown. Although only few studies (6, 23, 24, 26) reported the duration of otologic symptoms among the patients, the duration varied widely, ranging from 4 months to 49 years.

One study presented a well-defined TMD control group with healthy subjects (5, 9) and the other seven (6, 11, 22–26) presented no TMD control. Two

Table 1. Summary of descriptive characteristics of included studies

Study characteristics		Population characteristics		Intervention characteristics			Outcome characteristics	
Author, Year, Country	Study design	Total <i>n</i> / (males; females)	Age mean/ range (years)	TMD diagnostic criteria	TMD classification	Otologic diagnostic criteria	Otologic symptoms	Follow-up period
Erlandsson <i>et al.</i> , 1991, Sweden (23)	Randomised uncontrolled trial	<i>n</i> = 32 14F 18M	50.0 (24–65)	Helkimo	Muscular TMD	Questionnaire Audiometric evaluation	Tinnitus	6 months
							#1 Occlusal splints and exercise therapy #2 Counselling #3 Both #1 and #2	#3 had significantly lower ratings of tinnitus intensity #1 or #2 had no changes in tinnitus (intensity and pleasantness $P < 0.05$)
Wright, 1997, USA (24)	Cohort	<i>n</i> = 93 NA	31.0 (18–67)	RDC/TMD	Muscular TMD Articular TMD	Questionnaire	Tinnitus	ND
							Counselling (100%) Occlusal splints (98%) Exercise therapy (76%)	56% reported that their tinnitus had been resolved, 30% reported a significant improvement, and 14% reported minimal or no change
Wright <i>et al.</i> , 2000, USA (25)	Cohort	<i>n</i> = 15 7F 8M	57.6 (43–74)	RDC/TMD	Muscular TMD Articular TMD	Questionnaire Audiometric evaluation Complementary examinations	Tinnitus Dizziness Otalgia	3 months
							Counselling Occlusal splints	All of the patients achieved at least moderate improvement in one or more of their otologic symptoms.

Table 1. (continued)

Study characteristics		Population characteristics		Intervention characteristics			Outcome characteristics	
Author, Year, Country	Study design	Total <i>n</i> / (males; females)	Age mean/ range (years)	TMD diagnostic criteria	TMD classification	Otologic diagnostic criteria	Otologic symptoms	Follow-up period
Kuttila <i>et al.</i> , 2002, Finland (11)	Randomised controlled trials	<i>n</i> = 36 27F 9M	46 (25–65)*	American Academy of Orofacial Pain and Helkimo	Muscular TMD Articular TMD	Clinical examination Complementary examinations	Secondary otalgia	10 weeks
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Table 1. (continued)

Study characteristics		Population characteristics		Intervention characteristics			Outcome characteristics	
Author, Year, Country	Study design	Total <i>n</i> / (males; females)	Age mean/ range (years)	TMD diagnostic criteria	TMD classification	Otologic diagnostic criteria	Otologic symptoms	Follow-up period
Wright, 2007, USA (26)	Cohort	<i>n</i> = 200 133F 67M	30 (18–78)	RDC/TMD	Muscular TMD Articular TMD	Questionnaire	Tinnitus, otalgia, dizziness vertigo	ND
								55% had resolution of tinnitus and 28% significant improvement. 70% had resolution of otalgia and 24% significant improvement. 63% had resolution of dizziness and 28% significant improvement. 100% had resolution of vertigo.
De Felício <i>et al.</i> , 2008, Brazil (9)	Randomised controlled trials	Case <i>n</i> = 20 20 F Control <i>n</i> = 10 10 F	Case 31.46 (NA) Control 31.46 (NA)	RDC/TMD	Articular TMD	Questionnaire	Earache, tinnitus, ear fullness	Mean of 135 days
								#1 Exercise therapy 11.8 session (9– 13) #2 Control
								The group that received TMD therapy presented reduction in the severity of otologic signs and symptoms

Table 1. (continued)

Study characteristics			Population characteristics		Intervention characteristics			Outcome characteristics		
Author, Year, Country	Study design	Total <i>n</i> / (males; females)	Age mean/ range (years)	TMD diagnostic criteria	TMD classification	Otologic diagnostic criteria	Otologic symptoms	Treatment	Follow-up period	Main results
Buerger <i>et al.</i> , 2014, Germany (6)	Cohort	<i>n</i> = 25 NA	NA	RDC/TMD	Muscular TMD Articular TMD	Questionnaire	Tinnitus	Occlusal splints Exercise therapy	3–5 months	Complete remission of tinnitus was reported by 2 of 25 participants (8%), improvement in perceived tinnitus by 9 of 25 participants (36%), and no change from baseline by 14 of 25 participants (56%)
Attanasio <i>et al.</i> , 2015, Italy (22)	Cohort	Case <i>n</i> = 15 NA Control <i>n</i> = 10	Case 35.00 (6.72) Control 43.9 (SD 7.87)	Wilkes Classification	Muscular TMD Articular TMD	Questionnaire	Tinnitus	Occlusal splints	6 months	A statistically significant decrease in tinnitus for both groups (case: reduction of 65.38%, control 25.33%)

NA, Not available, ND, Not described.

*Calculated by the authors.

studies (5, 9, 11) had performed a control TMD therapy, which could be specified as no therapy at all or a non-occlusal splint therapy (11).

Maxillary Splint (5, 6, 11, 22–24, 26) or mandibular splint (25) therapy were the most used approach. It could be associated with additional therapies as counselling (5, 23–26), exercise therapy (6, 9, 23, 24, 26), behavioural and individual psychologist (6, 24, 26), progressive relaxation (23), jaw stretching (24, 26) or medications (24, 26).

Risk of bias within studies

All studies were methodologically acceptable, except one (24) which did not present the four or more plusses. The complete analysis of quality assessment items list is presented in Appendix S3. The main methodological limitations of the studies were related to the lack of information about the blinding process of the RCT quality assessment on items 3 (were the patients blinded for treatment?), 4 (were the practitioners blinded for treatment?) and 5 (were the evaluators blinded for treatment?).

Results of individual studies

Erlandson (23) evaluated 32 subjects with only muscular TMD and tinnitus and showed that an improvement in tinnitus was found when occlusal splint, exercise therapy and counselling were used. Wright (1997) in a study with 93 patients with TMD (articular and muscular) and tinnitus found that 56% of the patients reported a full resolution of their tinnitus using a similar strategy. (24) The same author, in 2000 (25), obtained in 15 patients at least a moderate improvement in tinnitus, dizziness and otalgia. In other study, similar results showed 70% resolution for otalgia, 63% for dizziness and 100% for vertigo (26). Indeed, Buergues (6) showed that almost half of the patients (44%) reported an improvement in tinnitus after TMD therapy.

De Felicio (9) and Attanasio (22) used a single approach for TMD. De Felicio (9) evaluated only articular TMD and used a oro-facial myofunctional therapy (OMF), a modality of exercise therapy focusing on tonicity and mobility of oro-facial and cervical musculature. Attanasio (22) underwent the same treatment therapy with occlusal splint for 6 months. However, both proved reduction in the severity of

otologic complains, such as earache, tinnitus and ear fullness, after exercise therapy only (9) and reduction in tinnitus after splint therapy (22).

Kuttila (11), with a sample of 36 patients with TMD and 10 in the control group, concluded that the use of both occlusal splints and non-occlusal splints presented an improvement in secondary otalgia.

Synthesis of results

Because the different outcomes and different groups characteristics were related to the absence of a controlled TMD group or a controlled TMD therapy, neither descriptive clustering nor quantitative meta-analysis was performed in this systematic review.

Discussion

This systematic review investigated the available evidence about the effect of conservative TMD therapy on otologic signs and symptoms and showed that in seven of the eight included studies, a total or partial resolution of otologic signs and symptoms was reported after conservative TMD therapy. Systematic reviews (SRs) are a synthesis and critical assessment of primary studies, and they play an important role in evidence-based decision-making. The SR has the benefit that it provides a systematic overview of what has been published on a specific issue and what current trends are, such as the effect of various treatment modes (30). This study assigned to PRISMA (31) statements for SR for searching for the best available evidence of the use of TMD therapies for the management of otologic symptoms and signals.

Although several studies in the literature investigated the association between TMD and otologic symptoms, the existence of a cause–effect relationship is still controversial. Methodological differences among the studies are evident so the comparison of results is often difficult in many aspects. The clinical relevance of this finding showed a need for further well-designed randomised controlled trials.

The studies included in this SR differ in the otologic symptoms reported as well as in the manner of evaluating these complaints (20, 32). This is possibly a difficult outcome to evaluate also the prevalence of otologic complaints described by subjects. The multifactorial aspects of TMD signs and symptoms should

be taken into account. Based on that, we prioritised that the included studies should evaluate TMD through diagnostic criteria previously validated using the RDC/TMD and Helkimo Index. Although the DC/TMD is the most appropriate tool nowadays, no study using it was included in this review, probably related to the available updated version published in 2014 (20).

Several hypotheses attempt to explain the association between otologic symptoms and TMD, but to date no one has provided a single and convincing elucidation. Studies had already hypothesised that TMD could cause auriculotemporal nerve damage or lead to improper adjustment of intratympanic pressure through auditory tube blockage, producing otologic symptoms (3). Also, mechanisms of referred trigger point may be associated with the otologic complains. Although many hypotheses have been postulated, no consensus has been found among TMD and otologic symptom association yet.

In recent years, scientific research has dealt with the aetiopathogenesis of tinnitus without concrete results and has reactivated the debate about a pathophysiological mechanism for subjective tinnitus over the aetiological and pathogenetic relationship between tinnitus and TMD is continuously ongoing because of the presence of multiple hypotheses and a few scientifically based data (22). Indeed, tinnitus can be a symptom of otologic disorders such as external ear infection, chronic otitis or otosclerosis, dysfunction of vestibulocochlear nerve, medication side effects, nutritional factors or systemic neurological disorders such as acoustic neurona and multiple sclerosis or alteration in blood pressure. A study has dealt with the pathogenesis of tinnitus without conclusive results, where the most well-accepted hypothesis was due to an abnormal nerve conductivity of one or more components of the neural tube that constitute the auditory system (7, 22).

The otologic complains and TMDs have a multifactorial aetiology with unknown factors that may predispose, perpetuate or even initiate these separate disorders. When patients present these associations, the diagnosis becomes complex, resulting in the need for multiple therapies and associated treatment for these patients. The issue of reference for other professionals is relevant when facing patients with TMD-related otologic complains. Differential diagnosis and

different approaches may be essential for a better improvement of these patients.

In seven of the eight studies included in this systematic review, when patients were treated for TMD, a resolution or improvement in otologic symptoms occurred. Management of TMD varies widely; current strategies include splints, exercise, manual therapy, pharmacological interventions (such as non-steroidal anti-inflammatory drugs, muscle relaxants or narcotic analgesics), acupuncture, intra-articular injections with anaesthetics or corticosteroids, psychological interventions (such as relaxation techniques and stress management) or even surgery (33). Although pharmacotherapy has a systemic effect and is not unique treatment for temporomandibular disorder, in one study, about 20% of patients used medications associated with other TMD therapies such as counselling, exercises and splints (24, 26). Seven (6, 11, 22–26) of the eight studies evaluated used occlusal splints for the treatment of otologic complains in patients with TMD. Different dental materials of splints are used in the management of TMD and usually are made of processed hard acrylic. Splints had been suggested to reduce abnormal muscle function and protect teeth from jaw clenching (33, 34).

In this systematic review, the use of occlusal splints ranged from 4 weeks (23) to 6 months (22). Kuttyla *et al.* (11) compared the use of occlusal splints with palatal plates without occlusal coverage for 10 weeks and observed an improvement not only in TMD signs and symptoms but also in earache. Up to now, there are no definitive treatments for TMD; however, stabilisation splints can be an adjunct for symptomatic treatment.

A variety of designs of appliances are used in the management of TMD, including stabilisation and anterior repositioning appliances (33). In a study with 25 subjects with tinnitus-related TMD, eleven subjects had an improvement or resolution of this symptom when evaluated after 5 months of stabilisation use (6). Another recent study (22) also noted this improvement for 6 months. Although overall results are promising on the reduction in otologic symptoms after the use of occlusal splint, no standardisation was established regarding routine, hours of use and period that the therapy must be maintained. Indeed, no study reported any follow-up release after the conclusion of treatment.

In this systematic review, some limitations should be pointed up. We tried to minimise bias across studies and obtain maximal homogeneity among studies by using an appropriate eligibility criterion and selecting only studies with similar sample sizes and clinical methods of TMD and otologic complaints. The results of this SR should be analysed with caution based on the inability to blind clinicians treating patients and also on the absence of more experimental models with healthy individuals and studies with control TMD therapy.

Conclusion

Based upon the limitations of the studies included in this systematic review, the present outcomes suggested insufficient evidence in favour or against the conservative therapies for TMD on changes in otologic signs and symptoms. Thus, further studies with a higher level of evidence and more representative samples should be conducted to better understand the effect of TMD therapy on otologic complaints.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Appendix S1. Database search strategy.

Appendix S2. Articles excluded and the reasons for exclusion.

Appendix S3. (A) Quality assessment of cohort studies. (B) Quality assessment of randomised controlled trials (RCT).