Prognosis of conservative treatment in individuals with temporomandibular disorders and tinnitus: a systematic review

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Summary

Introduction: There are reports in the literature of improved tinnitus after treatment for temporomandibular disorders (TMDs), however there’s the lack of standardization of these interventions. The aim was analyzed the results of conservative treatment in individuals with TMDs in terms of tinnitus. The target outcome of the studies was subjective perception of improvement in tinnitus before and after conservative treatment.

Methods: A systematic review was performed, according to Cochrane’s recommendations, registered on Prospero (CRD42017063832). In the universe of 1052 titles, 211 abstracts were read and 10 full articles were selected and divided into groups: group 1 - Individuals with TMD/tinnitus treated with a myorelaxant splint and group 2 - Individuals with TMD/tinnitus treated with a myorelaxant splint and associated therapies such as: physiotherapy, acupuncture among others.

Results: The two groups showed promising results in terms of tinnitus improvement and remission, with a statistically significant different in group 2, which exhibited a higher percentage of improvement or remission, suggesting that the combination of a myorelaxant splint and other conservative therapies is the best approach.

Conclusion: TMD treatment showed good results for improvement in tinnitus, particularly in those who complained of muscle pain.

Level of evidence: II a.

KEY WORDS: tinnitus, temporomandibular joint syndrome, conservative treatment.

Introduction

The temporomandibular joint (TMJ) is situated anteriorly to the external acoustic meatus (ear canal) between the head of the mandible and the mandibular fossa (squamous and tympanic parts of the temporal bone). It contains an articular disk covered by a fibrous capsule and interposed anteriorly into the lateral pterygoid muscle and posteriorly into the fat pad. The muscles of mastication are responsible for movement in this joint. Anatomical relationship between the TMJ and the ear begins with embryonic development of the first pharyngeal arch, and the innervation of some structures by the trigeminal nerve can generate pain throughout the facial region.

Anatomical dysfunctions of the TMJ are defined as temporomandibular disorders (TMD), which affect the TMJ, masticatory and facial muscles, spreading to the stomatognathic and auditory systems. Its etiology is multidimensional and involves neurobiological, biomechanical, neuromuscular and biopsychosocial factors. An assessment of the anatomical and mechanical characteristics associated with the TMJ can serve as the basis for understanding an individual’s clinical condition.

The main incapacitating symptoms are muscle and/or joint pain, restricted or deviated joint movement, joint noises, headaches, neck pain, earache and tinnitus.

Tinnitus is the term for hearing sounds in the inner ear that are not from an external source and can be mild, characterized by occasional ringing of varying intensities, or severe, in the form of constant loud noise that is untreatable.

Considered one of the greatest medical mysteries, it is suggested that the somatosensory stimuli that induce tinnitus are closely linked to anomalous cross-modal plasticity of somatosensory-auditory interactions, whereby the somatic modulations of tinnitus are the result of abnormal auditory neural interactions and the distortion of normal synaptic activity in the central nervous system, that is, information on muscle contractions is carried by the somatosensory system and, on reaching the cuneiform nucleus, can influence tinnitus through its projection on the auditory...
pathway due to hyperactivity in the cochlear nucleus. In particular, stimulation of specific ipsilateral cranial nerves (branches of the trigeminal nerve) modulates hyperactivity in the dorsal cochlear nucleus (DCN), which explains how ipsilateral tinnitus can be modulated by moving the head and neck. There is a number of TMD conservative treatment options. From the use of myorelaxant splint isolately or associated to other therapies such as physiotherapy, acupuncture, lasertherapy, and cognitive-comportamental therapy, to the injection of hyaluronic acid in patients with inflammatory-degenerative TMJ disease related to cervical spine disorders. The interaction between tinnitus and TMD is a long-standing and complex issue; tinnitus is known to be more prevalent among those suffering from TMD when compared to the general population and conservative treatment of the symptoms of muscle significantly improves tinnitus. Thus, the aim of this systematic literature review is to assess the results of conservative treatment in individuals with temporomandibular disorders in terms of improving tinnitus.

Materials and methods

This research was ethically conducted according to international standards as described in Padulo et al.11. The systematic review was performed to answer the following question: does conservative treatment in individuals suffering from temporomandibular disorders improve tinnitus? Based on this question, the review was carried out in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.12 A protocol was published in the PROSPERO database (http://www.crd.york.ac.uk/PROSPERO) under CRD42017063832.

Search strategy

The strategies were aimed at achieving a comprehensive search, including descriptors (DECs and MESH) and free text (FT), based on the four elements of the PICO framework (patient, intervention, comparison, outcome) present in the title, namely (tinnitus OR ringing in the ears OR ear buzzing) AND (temporomandibular disorders OR temporomandibular joint OR temporomandibular dysfunction OR craniofacial dysfunction) AND (conservative therapy OR treatment).

The searches were conducted between February and May 2017 and were revised in June of the same year. The following databases were searched: Pubmed, ScienceDirect, SCOPUS, Web of Science, Scientific Electronic Library On-line (SciELO) and Latin American and Caribbean Health Sciences Literature (LILACS), in addition to the grey literature: OpenGrey.eu, DissOnline, with no language or date restrictions. There was no manual search of the articles included to prevent the risk of bias.

Eligibility criteria

Inclusion criteria were clinical trials (randomized or not) or observational studies that evaluated improvement in tinnitus among individuals with temporomandibular disorders after conservative treatment by comparing data before and after intervention. Exclusion criteria were studies repeated on different databases and articles whose subjects exhibited other auditory pathologies, such as bilateral hearing loss, vertigo, ear pain, dizziness, ear fullness, Meniere’s disease, as well as nonauditory conditions such as cervical spine and hormonal disorders.

Data extraction

The articles were initially selected based on the previously defined search strategies and in accordance with the eligibility criteria. The resulting titles and abstracts were evaluated independently by two researchers who were not blind to the relevant Authors or journals. Any differences were resolved by discussion. The entire text of the potentially eligible articles was obtained and analyzed in full. The target outcome of the studies was subjective perception of improvement in tinnitus before and after conservative treatment of TMD. The data from the articles were analyzed and the Authors were contacted to obtain additional information. In addition to information on the outcomes, the Authors’ names, title, year of publication, country, pathology, intervention, number of sessions and groups studied were also extracted. A standard data extraction form was created based on the model adopted by Cochrane.

Assessing risk of bias

Risk of bias was assessed in line with the recommendations of the Cochrane handbook and Newcastle-Ottawa scale, adapted for observational studies and illustrated in Table I. The quality of the studies was evaluated independently by two researchers and differences were resolved by consensus. The maximum score possible was ten and the items assessed on the scale were: 1. representativeness of the sample; 2. sample size; 3. non-respondents; 4. ascertainment of exposure (risk factor); 5. comparability, to determine whether the subjects in different outcome groups are comparable based on the study design or analysis and controlling confounding factors; 6. assessment of the outcomes and 7. statistical test.

Data analysis

The studies assessed tinnitus before and after treatment through subjective questionnaires that resulted in varied data collection; some used the visual analogue scale (VAS) or Tinnitus Handicap Inventory, while others did not quantitatively explain the scores, making it impossible to perform a meta-analysis in this systematic literature review. However, in order to compare tinnitus remission or improvement for the different TMD treatments, the
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Results

Of the 1052 titles, 211 abstracts were considered relevant based on searches of the aforementioned databases and 21 articles were selected to be read in full. Of these, 11 were excluded for not meeting the eligibility criteria (Tab. II).

Thus, 10 complete articles were included in the qualitative analysis. The flow diagram illustrating the search and selection process is shown in Figure 1. The articles were divided into two groups as a function of the TMD treatments applied: group 1 - Individuals with TMD/tinnitus treated with a myorelaxant splint and group 2 - Individuals with TMD/tinnitus treated with a myorelaxant splint and associated therapies, such as: physiotherapy, acupuncture, biofeedback therapy, and cognitive behavioral therapy; however, no studies were found that compared the different treatments at the same time. The details of each study in groups 1 and 2 are displayed in Tables III and IV, respectively.

Group 1. Subjects with TMD / tinnitus treated with a myorelaxant splint (Michigan splint)

In a study by Felício et al.15, auditory symptoms were observed in individuals suffering from temporomandibular disorders. Of the 58 participants, women predominated (86.21%), aged between 30 and 50 years. Twenty-eight subjects exhibited no tinnitus and of the 36 who reported it prior to treatment onset, 27 showed a significant improvement after using a splint for two months. The subjects characterized tinnitus as “short high pitched whistle” often accompanied by tingling, an important element in differentiating between tinnitus and other auditory pathologies. Improvements in the auditory symptoms were observed as a function of the occlusal splint, that is, the treatment favored symptom remission, once again demonstrating the relationship between the symptoms and TMDs.

Felício et al.16 tested a protocol to quantify the frequency and severity of TMD symptoms according to the perception of patients, in two stages. In the first part of stage 1 participants answered questions on the presence of auditory signs and the most prevalent symptoms, such as pain in the muscles of mastication and/or TMJ during jaw movements and on palpation of the structures. In part two the subjects indicated the severity of TMD-related signs and symptoms,
including tinnitus, using a visual analogue scale (VAS).

In stage 2, involving treatment with an occlusal splint made from thermopolymerizable acrylic resin (n=42), 34 subjects reported the presence of tinnitus characterized by a brief high-pitched sound similar to a whistle. After 50 days of use, participants once again completed a VAS-type questionnaire and the results showed improvement in 26 subjects, whereas 16 reported more severe tinnitus. It was concluded that, despite the positive outcome of tinnitus remission, participants whose treatment was not successful reported more severe tinnitus. This was attributed to the improvement in painful TMD symptoms, which switched subjects’ focus from pain to tinnitus.

Webster et al.10 studied the effect of TMD treatment on perceived tinnitus. Forty-two patients were examined by the same specialists and 15 (average age 37.7 years) who met the inclusion criteria were diagnosed with TMD and tinnitus, of whom 86.7% were women. They were treated by continuous use of a Michigan splint for 5 months and tinnitus severity was assessed by VAS before and after treatment. There was a significant reduction in tinnitus severity (p<0.001) in 11 patients and 4 (26.66%) reported their tinnitus had disappeared, which was explained by their younger age, with minimum exposure to noise and few audiometric changes.

Uemoto et al.17 assessed the impact of treatment with a thermoplastic acrylic resin splint on the frequency of ear disorders, including tinnitus, in patients with TMD. Of the 19 who completed 2 to 6-month-long treatment, there was a decline in the prevalence of tinnitus from 14 to 6 individuals (68.5%) and a slight improvement in its intensity in the others, indicating that the myorelaxant splint is a conservative and reversible therapy capable of improving TMD-related ear symptoms.

Strom et al.18 assessed the effect of treatment with an intraoral splint for six months on tinnitus in 45 pa-
patients (24 men and 21 women) with an average age of 48 years and long-term tinnitus (6.5 years), recorded on a VAS. Twenty patients exhibited a reduction in TMD symptoms and improved tinnitus and were released from treatment. The remainder 25 began the second stage of the study and were submitted to 5 to 6 thirty-minute acupuncture sessions with 3 manual stimulations, combined with the splint. The 45 participants were reassessed one year after treatment and subjective tinnitus had declined from 78 to 52 according to the VAS. This reduction was observed in both the splint group and splint plus acupuncture group, demonstrating that many patients with tinnitus and muscle pain can benefit from treatment with an intraoral splint and acupuncture.

In another study, Attanasio et al.19 found a correlation between tinnitus and TMDs in 86 subjects of both sexes, aged between 18 and 60 years. The final sample in the study was composed of 55 individuals. Those with tinnitus were evaluated for TMDs and classified into three groups: group 1 - No TMDs, group 2 - Predisposed to TMDs and group 3 - With TMDs. All participants completed a VAS and Tinnitus Handicap Inventory (THI) before and after treatment under the supervision of the same researcher. They were treated with a neuromuscular occlusal splint for six months and then asked again about the severity of their symptoms using the same VAS and questionnaire (THI). Group 1 (n=10) displayed a significant decrease in scores on the THI (25.33%) and VAS (22.92%). Declines in group 2 (n=30) and 3 (n=15) were 38.58% and 65.38% on the THI and 25.54%
Table II. Characteristics of the studies included. Intervention: occlusal splint.

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Title</th>
<th>Place</th>
<th>N</th>
<th>Methodology</th>
<th>Treatment</th>
<th>Results</th>
<th>Conclusion</th>
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<tr>
<td>Felício et al., 1999</td>
<td>Ear symptoms in temporomandibular disorders before and after occlusal treatment</td>
<td>Brazil</td>
<td>58 subjects with TMD: 28 without and 36 with tinnitus</td>
<td>Questionnaire Ear, nose and throat examinations</td>
<td>Occlusal splint for 2 months</td>
<td>Of the 36 participants with tinnitus, 27 improved</td>
<td>Significant improvement in tinnitus</td>
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<td>Felício et al., 2006</td>
<td>A preliminary protocol for multi-professional centers for the determination of signs and symptoms of temporomandibular disorders</td>
<td>Brazil</td>
<td>42 subjects with TMD: 8 without and 34 with tinnitus</td>
<td>Visual analogue scale for TMD symptoms and severe tinnitus</td>
<td>Occlusal splint (worn for a total of 50 days: continuous use for 15 days and only at night for the remainder)</td>
<td>Of the 42 participants with TMD, 16 reported tinnitus even after using the splint and 26 did not</td>
<td>Increase in perceived tinnitus even after improvement in TMD symptoms.</td>
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<tr>
<td>Webster et al., 2011</td>
<td>Evaluating the effect of the temporomandibular disorder treatment over tinnitus</td>
<td>Brazil</td>
<td>15 subjects with TMD and tinnitus</td>
<td>Visual analogue scale for TMD symptoms and severe tinnitus Bilateral otoscopy, anterior rhinoscopy and oral examination</td>
<td>Michigan splint for 5 months, continuous use</td>
<td>Of the 15 participants, tinnitus disappeared in 4 and a significant reduction was observed in the remainder (11)</td>
<td>There was a significant decline in perceived tinnitus in those submitted to TMD treatment</td>
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To be continued
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<tr>
<td>Wright and Bifano, 1997</td>
<td>Tinnitus improvement through TMD therapy</td>
<td>USA</td>
<td>83 individuals with TMD and tinnitus</td>
<td>RDC/TMD Tinnitus-related questionnaire Study period: 2 years</td>
<td>Splint 6 hours of behavioral therapy Stretching exercises Prescribed medication Individual psychological consultations</td>
<td>52 participants (56%) reported their tinnitus had cleared; 28 (30%) that it had significantly improved; and 13 (14%) related little or no improvement</td>
<td>Individuals with coexisting TMD and tinnitus were more likely to exhibit tinnitus remission or improvement following TMD treatment</td>
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<td>Tullberg and Emmberg, 2006</td>
<td>Long-term effect on tinnitus by treatment of temporomandibular disorders: a two-year follow-up by questionnaire</td>
<td>Sweden</td>
<td>73 subjects with TMD and tinnitus</td>
<td>Questionnaire, clinical examination Before and two years after treatment</td>
<td>Individual treatment plan: jaw relaxation: occlusal splint; minimal occlusal adjustment; isobonic and isometric exercises; 1 to 6 sessions of laser therapy</td>
<td>73% of subjects reported an improvement in tinnitus and 27% showed no change</td>
<td>Signs and symptoms of TMD were common in subjects suffering from tinnitus and TMD treatment exhibited a long-term beneficial effect on tinnitus, particularly in those with the mild form</td>
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and 47.97% on the VAS, respectively. In group 3, two of the 15 patients were completely cured. There was a general improvement in quality of life, which was more pronounced in group 3, and in almost all cases the perceived severity of tinnitus decreased. Only two patients in group 2 showed no change in tinnitus, but their answers to the questionnaires demonstrated better acceptance of the condition. Tinnitus did not worsen in any of the participants and the treatment was most effective in patients with TMD (group 3). The Authors concluded that when the most common causes of tinnitus are excluded, such as ear disorders and neurological diseases, the functionality of the TMJ should be assessed in order to treat its pathology and improve or resolve tinnitus.

Group 2. Subjects with TMD/tinnitus treated with a myorelaxant splint (Michigan splint) and associated therapies

Wright and Bifano\(^\text{20}\) studied 93 patients aged between 18 and 67 years (mean age 31 years) suffering from TMD and tinnitus. The subjects were examined by the same specialists, according to research diagnostic criteria for temporomandibular disorders (RDC/TMD) and a questionnaire for tinnitus. The conservative treatment selected was the use of a splint, instructions for self-care (avoid chewing gum and hard foods), six hours of behavioral therapy with psychologists, stretching exercises and postural training by a physiotherapist, prescribed medication such as nonsteroidal anti-inflammatories and tricyclic antidepressants, and individual sessions with a psychologist. Of the 93 patients: 52 (56%) reported their tinnitus had cleared; 28 (30%) that it had significantly improved; and 13 (14%) related little or no improvement. The Authors attributed these results to the fact that the patients were young, with short-term and typically unilateral tinnitus that began at approximately the same time as the symptoms of TMD, worsened along with these symptoms and seemed to be stress-related, in addition to the fact that they had normal hearing with no hearing loss. As such, patients with coexisting TMD and tinnitus were more likely to exhibit tinnitus remission or improvement following TMD treatment.

Tullberg and Ernberg\(^\text{21}\) analyzed the presence of signs and symptoms of TMDs in patients with tinnitus and the long-term effect of TMD treatment on tinnitus. An individual treatment plant was proposed, consisting of information on the association between tinnitus and TMDs and the importance of self-care (avoiding chewing gum and hard foods), six hours of behavioral therapy with psychologists, stretching exercises and postural training by a physiotherapist, prescribed medication such as nonsteroidal anti-inflammatories and tricyclic antidepressants, and individual sessions with a psychologist. Of the 93 patients: 52 (56%) reported their tinnitus had cleared; 28 (30%) that it had significantly improved; and 13 (14%) related little or no improvement. The Authors attributed these results to the fact that the patients were young, with short-term and typically unilateral tinnitus that began at approximately the same time as the symptoms of TMD, worsened along with these symptoms and seemed to be stress-related, in addition to the fact that they had normal hearing with no hearing loss. As such, patients with coexisting TMD and tinnitus were more likely to exhibit tinnitus remission or improvement following TMD treatment.

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of participants). The number of sessions varied from 1 to 6, with an average of 3.7. Of the 120 patients who began treatment, only 73 completed it, 73% of whom reported their tinnitus had improved and 27% that it remained unchanged. Two to three years after treatment, the 73 patients completed the same reassessment questionnaire by email and 43% confirmed the improvement in tinnitus; 39% reported no change and 17% that it had worsened. In the control group, 12% stated their tinnitus had improved compared to the previous two years, 32% that it had not changed and 56% that it was worse. It was concluded that the treatment for TMD alleviated tinnitus in the long-term and that the most beneficial effects were observed in patients with intermittent tinnitus. Moreover, those with tinnitus should consult a dentist when medical causes have been ruled out and dentists could also contribute by asking their patients about intermittent tinnitus and conducting a more detailed examination of the masticatory system.

Buergers et al. 23 conducted a clinical prospective study to assess the possible association between tinnitus and TMDs and investigate the effect of stomatognathic treatment on tinnitus-related anxiety. Twenty-five patients underwent functional analysis of the TMJ using RDC/TMD and answered the tinnitus questionnaire (THI). The chosen treatment was a Michigan or distraction splint, individual physiotherapy (massage of the jaw muscles, heat treatment, stretching TMJs and coordinated exercises) for 3-5 months. The results showed complete tinnitus remission in 2 patients, a perceived improvement in 9 and no change in 14. Of the 25 patients, 16 received physiotherapy, 8 of whom exhibited an improvement. The findings demonstrated a significant correlation between tinnitus and TMDs and the treatment outcomes suggest that dental therapy may have a positive effect on TMD-related tinnitus.

Discussion

The quality of the articles included was analyzed according to the adapted Newcastle-Ottawa scale. In the final assessment, 7 studies obtained percentages greater than or equal to 50% (7/10), with a maximum score of 70% (7/10); however, sample sizes in the studies were not calculated with a view to achieving the desired confidence interval and only 3 studies 10,18,22 used a validated measurement tool for assessment. Convenience sampling was found to be very common in the scientific articles and is a worrisome fact. Moreover, it is important for studies to use validated instruments for data collection, such as RDC/TMD, THI, VAS and appropriate statistical tests, with a need for methodological adjustments to enable future comparisons, thereby raising the quality of systematic literature reviews, including those with meta-analyses.

The studies were limited to patients who sought out specific services, characterizing the sample as unrepresentative of the average target population since variables such as ethnicity, sex and geographic location were not taken into account. Results in 8 studies 10,15,17-20,22,23 were self-reported and in the remaining two 16,21 were assessed by comparing patient records. Finally, almost all the studies used appropriate statistical tests, with the exception of three 13,15,21 that did not clearly describe the statistical test applied.

In all the articles included, clinical dental examinations were performed by dental surgeons experienced in temporomandibular disorders (TMDs) and ear exams were carried out by ear, nose and throat specialists. Although the questionnaire by the American Academy of Orofacial Pain questionnaire on research diagnostic criteria for temporomandibular disorders (RDC/TMD) validated for Portuguese is the most recommended tool to standardize research methodologies in this area, only those by Strom et al. 18, Wright and Bifano 20, Wright 22 and Buergers et al. 23 applied it. With respect to perceived tinnitus in these patients, only Attanasio et al. 19 and Buergers et al. 23 applied the Tinnitus Handicap Inventory (THI), while Felício et al. 16, Webster et al. 10, Strom et al. 18 and Attanasio et al. 19 used the VAS to record TMD and tinnitus symptoms, highlighting the lack of standardized methods in the studies analyzed.

In relation to sex, women predominated in studies by Felício et al. 15, Wright 22, Webster et al. 10, and Uemoto et al. 17, whereas of the 45 subjects assessed by Strom et al. 18, only 21 were women. The remaining papers 16, 19,20,23 did not specify participants’ sex. In regard to age, the average for participants was 30 18, 31 20, 37.7 19, 40 to 48 17,18,21 and 54.1 years 23. Studies by Felício et al. 15, Felício et al. 16, Uemoto et al. 17, Webster et al. 10, Attanasio et al. 19, Strom et al. 18 and
Wright\textsuperscript{22} followed similar inclusion and exclusion criteria.

With respect to the most prevalent symptoms of TMDs, the papers by Felício et al.\textsuperscript{15}, Wright\textsuperscript{22}, Webster et al.\textsuperscript{10}, and Wright and Bifano\textsuperscript{20} only specified auditory symptoms and not those related to facial muscles; Felício et al.\textsuperscript{16} highlighted muscle and joint pain as well as joint noises; Uemoto et al.\textsuperscript{17} diagnosed individuals with TMDs as those who exhibited at least 3 of the following symptoms: TMJ pain, headache, muscle pain, restricted jaw movements, abnormal static and dynamic occlusion, pain during chewing, open locked jaw, chewing difficulties, tooth wear, and limited mouth opening. Among parafunc
tional habits, bruxism (teeth grinding) was the most common (78.9\%, 15 patients), similar to Tullberg and Ernberg\textsuperscript{21}, who reported the presence of facial or jaw pain, headaches, jaw fatigue and jaw noises. Attanasio et al.\textsuperscript{19} used Wilkes staging classification and Strom et al.\textsuperscript{18} did not specify TMD symptoms, except for muscle sensitivity.

Time since tinnitus onset, unilateral or bilateral tinnitus and their characteristics may interfere in the result of the therapy applied. Unfortunately, the studies by Felício et al.\textsuperscript{15} and Felício et al.\textsuperscript{16} did not provide this information; Attanasio et al.\textsuperscript{19} reported a minimum time since chronic tinnitus onset of 12 months as the inclusion criterion; Wright\textsuperscript{22} an average of 42 months since tinnitus onset, that is, chronic tinnitus; Webster et al.\textsuperscript{10} mean tinnitus duration of 24 months, which was unilateral in 60% of cases; Uemoto et al.\textsuperscript{17} that unilateral tinnitus was most prevalent, on the right side; Strom et al.\textsuperscript{18} reported long-term tinnitus (6.5 years); Wright and Bifano\textsuperscript{20} observed tinnitus duration of 4 months to 49 years, and Tullberg and Ernberg\textsuperscript{21} recorded average tinnitus duration of 7.5 years, with 63\% of subjects exhibiting bilateral tinnitus and 36\% associating tinnitus onset with periods of increased stress or stressful events such as exposure to loud noises.

All the studies used a myorelaxant splint on the upper arch. The material used may interfere in the proprioceptors of the stomatognathic system, possibly causing bruxism, which could trigger an increase in perceived tinnitus when the splint is made from flexible material. Since Michigan, occlusal and myorelaxant splints are rigid, the Authors used one of the aforementioned synonyms when describing them. Webster et al.\textsuperscript{10} included 5 patients with mild sensorineural hearing loss, which was also the only study that described visual analogue scores for tinnitus before and after treatment for TMDs.

As for the differential diagnosis of muscular and joint TMD with resolution of tinnitus, only the study by THI in its methodology.

A meta-analysis was not possible in this systematic literature review due to the subjectivity of the signs and symptoms of TMDs, including tinnitus, making accurate diagnosis difficult, in addition to the lack of standardized methodologies in the studies that assessed tinnitus remission, partial improvement or worsening, since some applied VAS, RDC/TMD or THI, but none applied all three at the same time nor did they quantitatively explain the validated questionnaire scores.

Thus, considering only the effect of the results of conservative TMD treatment on tinnitus in the two groups, the chi-squared test was applied as the only possible method, despite not being the most appropriate. Thus, a comparison of group 1, which obtained a mean of 65\% total recovery or significant improvement, with group 2 (mean of 76\%, Table V) generated a p-value of 0.015. This statistical result highlights the fact that, despite the promising result of conservative TMD treatment, a myorelaxant splint associated with other therapies is more efficient in tinnitus remission than treatment with a splint alone, reinforcing the effect of muscle contractures on the common structures of the auditory and stomatognathic systems.

**Conclusion**

Correlation between tinnitus and TMD poses a complex open problem; as tinnitus is more prevalent among those suffering from TMD compared to the general population, and conservative treatment of the symptoms of muscle has significant impact on tinnitus improvement.

Our objective is to assess the results of conservative treatment in individuals with temporomandibular disorders in terms of improving tinnitus. As such, TMD treatment showed promising results in the remission or improvement of even chronic tinnitus, particularly in individuals with hearing loss who exhibit TMDs associated with muscle pain.

The obtained statistical results highlight the fact that a myorelaxant splint associated with other therapies is more efficient in tinnitus remission than treatment with a splint alone, reinforcing the effect of muscle...
Table V. Percentage improvement in tinnitus in both groups.

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>N (%) with TMD/ Tinnitus</th>
<th>Results N (%) Significant Improvement</th>
<th>Results N (%) Absence</th>
<th>Results N(%) Permanence</th>
<th>Author/Year</th>
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</thead>
<tbody>
<tr>
<td>Felício et al., 1999</td>
<td>36 (100%)</td>
<td>27 (75%)</td>
<td>-</td>
<td>9 (25%)</td>
<td>Wright and Bifano, 1997</td>
<td>93 (100%)</td>
<td>28 (30%)</td>
<td>52 (56%)</td>
<td>13 (14%)</td>
</tr>
<tr>
<td>Felício et al., 2006</td>
<td>34 (100%)</td>
<td>18 (52,94%)</td>
<td>16 (47,05%)</td>
<td></td>
<td>Tullberg and Emberg, 2006</td>
<td>73 (100%)</td>
<td>32 (43%)</td>
<td>12 (17%)</td>
<td>29 (39%)</td>
</tr>
<tr>
<td>Webster et al., 2011</td>
<td>15 (100%)</td>
<td>11 (73,34%)</td>
<td>4 (26,67%)</td>
<td></td>
<td>Wright, 2007</td>
<td>132 (100%)</td>
<td>37 (28%)</td>
<td>72 (55%)</td>
<td>23 (17%)</td>
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<tr>
<td>Uemoto et al., 2012</td>
<td>14 (100%)</td>
<td>6 (42,86%)</td>
<td>8 (57,14%)</td>
<td></td>
<td>Buergers et al., 2014</td>
<td>25 (100%)</td>
<td>9 (36%)</td>
<td>2 (8%)</td>
<td>14 (56%)</td>
</tr>
<tr>
<td>Strom et al., 2013</td>
<td>45 (100%)</td>
<td></td>
<td>20 (44,44%)</td>
<td>25 (55,56%)</td>
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<tr>
<td>Attanasio et al., 2015</td>
<td>15 (100%)</td>
<td>10 (65,38%)</td>
<td>5 (34,62%)</td>
<td></td>
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<tr>
<td>Total</td>
<td>159 (100%)</td>
<td>54 (33,96%)</td>
<td>50 (31,44%)</td>
<td>55 (34,60%)</td>
<td>Total</td>
<td>323 (100%)</td>
<td>106 (32,82%)</td>
<td>138 (42,72%)</td>
<td>79 (24,45%)</td>
</tr>
</tbody>
</table>
contractures on the common structures of the auditory and stomatognathic systems.

Conflict of interest
The Authors have no financial or personal relationship with other people of organizations that could inappropriately influence this work.

References