Does Conservative Temporomandibular Therapy Affect Tinnitus Complaints? A Systematic Review

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Aims: To investigate whether temporomandibular disorders treatment can positively influence tinnitus complaints. Methods: Four online databases (PubMed, Web of Science, Scopus, and the Cochrane Library) were searched up to August 2018 for relevant studies. Two independent reviewers extracted the data and performed a risk of bias assessment. Results: A total of 11 studies were included. These studies showed an overall positive effect of the combination of splint therapy and exercise treatment on tinnitus severity and intensity (as measured on a visual analog or numeric rating scale), as well as on global perceived effect. One study specified that the treatment effect was only present in patients with severe to very severe tinnitus, while the others found an effect in the overall study group. The risk of bias in the included studies was high, mainly due to lack of statistical analyses between groups and before vs after treatment, incomplete presentation of the data, and selective reporting. Additionally, most included studies showed a lack of information concerning blinding of the subjects, therapists, and investigators. The heterogeneity of the inclusion criteria, outcome measurements, and treatments made data pooling and meta-analysis impossible. Conclusion: There is low-quality evidence for a positive effect of conservative temporomandibular disorders treatment on tinnitus complaints. The combination of splint therapy and exercise treatment is currently the best investigated treatment approach, showing a decrease in tinnitus severity and intensity. Despite the low level of evidence and the methodologic issues in the included studies, it is noteworthy that all included studies show positive treatment effects. J Oral Facial Pain Headache 2019;33:308–317. doi: 10.11607/ofph.2055

Keywords: occlusal splints, physical therapy modalities, somatic, somatosensory, temporomandibular joint disorders

Tinnitus, the perception of sound in the absence of a corresponding external auditory stimulus, occurs in a large portion of the adult population, with a prevalence ranging from 10% to 15%. Tinnitus may affect patients’ quality of life (QoL), is associated with depression, can result in reduced productivity at work, and may cause sleeping difficulties. Various types of tinnitus exist, with two main subtypes: objective and subjective tinnitus. In some cases, internal somatosounds can cause the tinnitus; eg, turbulences of the blood flow. In these cases, the underlying generator is often measurable or detectable by the physician, and objective tinnitus can be considered. In the absence of any acoustic stimulus (internal or external), it is called subjective tinnitus, which is the most common form of tinnitus.

Subjective tinnitus can additionally be classified based on its etiology. Most tinnitus complaints derive from underlying otologic pathology, such as age-related hearing loss and noise trauma. In other cases, tinnitus can be attributed to the somatosensory system of the cervical spine or temporomandibular area. This type of tinnitus is called somatic or somatosensory tinnitus (ST) and has been described in 36% to 43% of the population with subjective tinnitus. Vice versa, tinnitus was found to be eight times more prevalent in patients with temporomandibular disorders (TMD) compared to patients without TMD.
A physiologic explanation for ST is found in the existence of connections between the cervical somatosensory system and cochlear nuclei (CN).\textsuperscript{10,11} Cervical somatosensory information is conveyed to the brain by afferent fibers, the cell bodies of which are located in the dorsal root ganglia or the trigeminal ganglion. Some of these fibers also project to the central auditory system. This enables the somatosensory system to influence the auditory system by altering spontaneous rates or synchronicity of firing among neurons in the CN, inferior colliculus, or auditory cortex. In this way, the somatosensory system is able to alter the intensity and character of tinnitus.\textsuperscript{12}

Up to 60% of patients with TMD also perceive tinnitus, which is more than in the general population.\textsuperscript{13} Additionally, the fact that tinnitus can be triggered by altered somatosensory input from the temporomandibular area suggests that the treatment of TMD might decrease tinnitus severity. However, it is not known to date if there is any evidence for this suggestion or how strong this possible evidence is. Therefore, the aim of this review was to investigate whether TMD treatment can positively influence tinnitus complaints.

Materials and Methods

Search Strategy
A systematic search was conducted in the online databases PubMed, Web of Science, Scopus, and the Cochrane Library up to August 2018. The search strategy was based on the PICO (population, intervention, comparison, outcome) framework, and the following search was entered in the different databases:

(“tinnitus”[Mesh] AND “craniomandibular disorders”[Mesh]) OR ("physical therapy modalities”[Mesh] OR “dental care”[Mesh] OR “occlusal splints”[Mesh]) OR (physical therapy modalities OR splint therapy OR TMD therapy)).

Afterwards, the reference lists of the included articles were hand searched for missed publications.

Study Selection
Studies needed to meet the following inclusion criteria: human studies; both tinnitus and TMD were present in the subjects; the studied intervention was a physical therapy treatment modality, dental care, oral appliance, or a combination of the previous; a tinnitus intensity or severity measure was one of the outcome measures; English, French, Dutch, or German language; and presenting original research. Articles not meeting all inclusion criteria were excluded.

After the initial search, all retrieved articles were screened for eligibility based on titles and abstracts. The full texts of included articles were studied.

The inclusion procedure was conducted by the first and second authors independently and supervised by the last author. In case of uncertainty about inclusion, a decision was made in a consensus meeting.

Qualifications of the Investigators
The screening of the literature and risk of bias assessment were performed independently by the first and second authors. The last author supervised the process. The first, fifth, sixth, and seventh authors provided overall expertise on tinnitus complaints, and the third, fourth, and eighth authors provided overall expertise on TMD.

Data Items and Collection Process
All relevant information extracted from the selected studies is presented in Tables 1 and 2. Table 1 describes the results of the cohort studies, and Table 2 describes the results of the randomized controlled trials (RCTs) and controlled trial.

Risk of Bias in Individual Studies
To investigate the methodologic quality of the included RCTs and the controlled trial, the PEDro scale was used, as recommended by the Physiotherapy Evidence Database. The purpose of the PEDro scale is to rapidly identify which of the (R)CTs are likely to be externally valid (item 1), internally valid (items 2 through 9), and have sufficient statistical information to make the results interpretable (items 10 and 11). The scale is comprised of 11 items with “yes” or “no” answers, and the total score is calculated by summing the number of “yes” answers for items 2 through 11 (item 1 is not considered the total score). Points are only awarded when a criterion is clearly satisfied.

The methodologic quality of the cohort studies was assessed using the quality assessment tool for before-after (pre-post) studies with no control group developed by the National Institutes of Health (NIH). This validity tool consists of 12 items scored with “yes,” “no,” and “other” (cannot determine [CD], not applicable [NA], or not reported [NR]) answers. The quality rating can be poor, fair, or good quality. A rating of poor quality translates to a high risk of bias, and good quality translates to a low risk of bias.

The methodologic quality assessment was performed by the first and the second authors independently. Afterwards, the results were compared, and disagreements were discussed to reach a consensus. The level of evidence was scored based on the Grading of Recommendations, Assessment, Development, and Evaluations (GRADE) system.
### Table 1 Summary of the Cohort Studies

<table>
<thead>
<tr>
<th>Study, country, design</th>
<th>Population characteristics</th>
<th>Intervention and control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michiels et al15 (2015), Italy; Cohort</td>
<td>N = 15</td>
<td>Male: NR; Female: 7; Age: 57.6 ± 6.7 y; Diagnosis: Tinnitus or dizziness and TMD or otalgia</td>
</tr>
<tr>
<td>Wright et al20 (2000), USA; Cohort</td>
<td>N = 93</td>
<td>Male: NR; Age: 31 (18–67 y); Diagnosis: TMD</td>
</tr>
<tr>
<td>Suvinen et al23 (1997), Australia; Cohort</td>
<td>N = 221</td>
<td>Female: 163; Male: 58; Age: 35 (18–81 y); Diagnosis: TMD</td>
</tr>
<tr>
<td>Buergers et al9 (2014), Germany; Prospective cohort</td>
<td>N = 25</td>
<td>Female: NR; Male: NR; Age: NR; Diagnosis: TMD and tinnitus</td>
</tr>
<tr>
<td>Peroz17 (2001), Germany; Cohort</td>
<td>N = 221</td>
<td>Female: 163; Male: 58; Age: 35 (18–81 y); Diagnosis: TMD</td>
</tr>
<tr>
<td>Sobhy et al16 (2004), Egypt; Cohort</td>
<td>N = 30</td>
<td>Female: 25; Male: 5; Age: 24.3 (11–40 y); Diagnosis: TMD and otalgia or tinnitus</td>
</tr>
<tr>
<td>Buergers et al9 (2014), Germany; Prospective cohort</td>
<td>N = 25</td>
<td>Female: NR; Male: NR; Age: NR; Diagnosis: TMD and tinnitus</td>
</tr>
<tr>
<td>Wright et al20 (2000), USA; Cohort</td>
<td>N = 15</td>
<td>Female: 7; Male: 8; Age: 57.6 (43–74 y); Diagnosis: Tinnitus or dizziness and TMD or otalgia</td>
</tr>
</tbody>
</table>

TMD = temporomandibular disorders; NR = not reported; VAS = visual analog scale; THI = Tinnitus Handicap Inventory; TMJ = temporomandibular joint; GPE = global perceived effect; THQ = Tinnitus Handicap Questionnaire.
<table>
<thead>
<tr>
<th>Frequency and duration of intervention</th>
<th>Tinnitus severity</th>
<th>Follow-up</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 mo for a minimum of 8 h to a maximum of 15 h per d</td>
<td>VAS-severity THI</td>
<td>Posttreatment</td>
<td>VAS-severity: Significant decrease in all groups between pre- and posttreatment (group 1: –22.92%; ( P = .002 ); group 2: –25.54%; ( P &lt; .001 ); group 3: –47.97%; ( P = .001 )). THI: Significant decrease in all groups between pre- and posttreatment (group 1: –25.33%; ( P = .005 ); group 2: –38.58%; ( P &lt; .001 ); group 3: –65.38%; ( P = .001 )).</td>
</tr>
<tr>
<td>Not specified</td>
<td>THI VAS-change (no change from baseline, improvement, complete remission, impairment)</td>
<td>3–5 mo after initiation of dental functional therapy</td>
<td>THI: NR VAS: 8% reported complete remission, 36% improvement, 56% no change. In patients with acute tinnitus (n = 8), 7 reported improvement, 1 complete remission; 14 of the 17 patients with chronic tinnitus reported no change. Improvement of total remission was reported by 8 of 16 patients who received physiotherapy, but only by 3 of 9 participants without physiotherapy.</td>
</tr>
<tr>
<td>Mean therapy duration: 7 (± 5) mo; acupuncture was given 5 to 6 consecutive sessions</td>
<td>GPE</td>
<td>1 y</td>
<td>GPE: 1 year after therapy, 1 patient reported less tinnitus noises, no change in tinnitus in the other 7 patients.</td>
</tr>
<tr>
<td>Not specified</td>
<td>THQ</td>
<td>After treatment</td>
<td>THQ: Significant decrease of the scores after therapy, which means improvement of tinnitus (20% incidence of tinnitus in this study).</td>
</tr>
<tr>
<td>Splint therapy: 6 mo; acupuncture was given 5 to 6 consecutive sessions</td>
<td>VAS-severity</td>
<td>1 y</td>
<td>VAS: Significant decrease in subjective tinnitus after 1 year. One-third of the patients (15) reported a reduction of 50% or more on their tinnitus evaluation on the VAS scale. All but 6 of the 45 patients reported reduction of their tinnitus.</td>
</tr>
<tr>
<td>Not specified</td>
<td>GPE</td>
<td>6 mo</td>
<td>GPE: Improvement in terms of ringing in the ears was greater in the rapid responding group.* Subjects were divided into rapid and slow responders according to whether their subjective degree of improvement on a VAS scale (TMD pain) at 6 mo following standard simple conservative management was above or equal to/below 50%, respectively.</td>
</tr>
<tr>
<td>Not specified</td>
<td>GPE</td>
<td>Posttreatment</td>
<td>GPE: 56%, 30%, and 14% reported their tinnitus had been resolved, significantly improved, and minimal or no change, respectively.</td>
</tr>
<tr>
<td>3 mo</td>
<td>GPE, THQ</td>
<td>Posttreatment, 6-mo follow-up</td>
<td>GPE: Of the 14 patients who reported tinnitus, 6, 3, and 5 reported resolution, significant to moderate improvement, and minimal to no change, respectively. THQ: No trends for the overall THQ score or any of its three factors being associated with patients’ tinnitus improvement. In patients with at least moderate improvement in their tinnitus, the THQ score decreased from 46.3 to 20.4.</td>
</tr>
</tbody>
</table>
Table 2 Summary of the (Randomized) Controlled Trials

<table>
<thead>
<tr>
<th>Study characteristics</th>
<th>Population characteristics</th>
<th>Intervention and control</th>
<th>Frequency and duration of intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bösel et al (2008), Germany; CT with cross-over design</td>
<td>N = 50; Female: 28; Male: 31; Age: 49 (12–69) y; Diagnosis: chronic tinnitus and at least 1 TMD symptom present</td>
<td>Cross-over of splint therapy and self-therapy (heat treatment, massage of the jaw muscles, and self-monitoring to reduce unconscious muscular tension) vs control</td>
<td>6 wk splint therapy 6 wk self-therapy</td>
</tr>
<tr>
<td>Erlandsson et al (1991), Sweden; RCT with cross-over design</td>
<td>N = 32; Female: 14; Male: 18; Age: 50 (24–65) y; Diagnosis: severe tinnitus and self-reported TMD or headaches</td>
<td>SGT comprising: occlusal splints, occlusal adjustments, and exercise therapy vs BFT comprising: biofeedback training, progressive relaxation, and counseling</td>
<td>Not specified</td>
</tr>
<tr>
<td>Tullberg and Ernberg (2006), Sweden; RCT</td>
<td>Patients (P): n = 73; Control (C): n = 50; Female: 39 P, 27 C; Male: 34 P, 23 C; Age: P = 48 ± 12 y, C = 47 ± 14 y; Diagnosis: patients suffering from combination of tinnitus and TMD, controls suffering from tinnitus</td>
<td>Splints, occlusal adjustments, jaw exercises, and laser therapy vs waiting list</td>
<td>1 to 6 sessions</td>
</tr>
</tbody>
</table>

TMD = temporomandibular disorders; VAS = visual analog scale; CT = controlled trial; NRS = numeric rating scale; GPE = global perceived effect; SGT = stomatognathic treatment; BFT = biofeedback therapy; TQ = Tinnitus Questionnaire.

Fig 1 Flowchart of study selection process.

Results

Study Selection

After the initial search, 28 unique articles were retrieved from the four databases. After selection, based on title and abstract, the full texts of 12 articles were screened, and 11 articles were included in the systematic review. In total, 17 articles were discarded: 2 due to the described population, 3 because of the described intervention, 1 because of the outcome measures, 10 due to the design of the study, and 1 because of the language. Details of the selection process are shown in Fig 1.

Study Characteristics

Of the 11 articles selected for this review, 2 were RCTs, 1 was a controlled trial, and 8 were cohort studies. The treatment of the patients consisted of occlusal dental splints, occlusal dental adjustments, physical therapy, biofeedback therapy, relaxation exercises, counseling, pharmacotherapy, acupuncture, laser therapy, and psychologic therapy. The duration of the interventions ranged from one session to 7 months, although duration and frequency of the interventions were often not specified.

The reported primary tinnitus outcome measures were visual analog scale (VAS) for tinnitus severity (VAS-severity), VAS for change in tinnitus (VAS-change), VAS for tinnitus intensity (VAS-intensity), Tinnitus Questionnaire (TQ), Tinnitus Handicap Inventory (THI), Tinnitus Handicap Questionnaire (THQ), numeric rating scale (NRS) for tinnitus severity (NRS-severity), global perceived effect (GPE), and a custom-made questionnaire.

Risk of Bias and Level of Evidence

The results of the risk of bias assessment are presented in Figs 2 and 3.

Generally, a high risk of bias was present in the included studies. The main methodologic limitations of the studies were related to the lack of statistical analyses between groups and before vs after treatment,
RCT with cross-over design

Swedish, CT

SGT = stomatognathic treatment; BFT = biofeedback therapy; TQ = Tinnitus Questionnaire.

TMD = temporomandibular disorders; VAS = visual analog scale; CT = controlled trial; NRS = numeric rating scale; GPE = global perceived effect;

Tullberg and Ernberg 15  (2006),

Erlandsson et al 14  (1991), Sweden;

Bösel et al 16  (2008), Germany;

RCT with cross-over design

controls suffering from tinnitus

combination of tinnitus and TMD,

Diagnosis: patients suffering from

Age: P = 48 ± 12 y, C = 47 ± 14 y

Male: 34 P, 23 C

Control (C): n = 50

Patients (P): n = 73

least 1 TMD symptom present

Age: 49 (12–69) y

Male: 31

Female: 28

N = 59

self-reported TMD or headaches

Diagnosis: severe tinnitus and

Age: 50 (24–65) y

Male: 18

Female: 14

N = 32

Cross-over of splint therapy

therapy vs waiting list

jaw exercises, and laser

Splints, occlusal adjustments,

muscular tension) vs control
to reduce unconscious

muscles, and self-monitoring
ment, massage of the jaw

and self-therapy (heat treat-

Cross-over of therapy

Duration of intervention

1 to 6 sessions

6 wk self-therapy

6 wk splint therapy

Not specified

Frequency and

duration of intervention

1 to 6 sessions

6 wk self-therapy

6 wk splint therapy

Not specified

Fig 2 Risk of bias assessment for (randomized) controlled trials according to the PEDro Scale. Black = yes; white = no; gray = other (cannot determine, not applicable, not reported).

Study | Eligibility criteria were specified | Randomization subjects | Allocation was concealed | Similarity groups at baseline | Blinding of subjects | Blinding of therapists | Blinding of assessors | Measures of at least one outcome from more than 85% of subjects | Intention-to-treat analysis | Results of between-group analysis for at least one outcome measure | Point measures of variability provided |
--- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
Bösel et al 16 2008 | ○ | ○ | ○ | ● | ○ | ○ | ● | ● | ○ | ○ | ● |
Erlandsson et al 14 1991 | ○ | ○ | ● | ○ | ○ | ○ | ○ | ● | ● | ● | ● |
Tullberg et al 15 2006 | ● | ○ | ○ | ○ | ○ | ○ | ● | ● | ● | ● | ● |

Fig 3 Risk of bias assessment for cohort studies using the quality assessment tool for before-after studies with no control group. Black = yes; white = no; gray = other (cannot determine, not applicable, not reported).

Study | Objective clearly stated | Eligibility criteria prespecified | Participants representative for clinical population | All eligible participants enrolled | Sample size sufficiently large | Intervention clearly described and delivered consistently across participants | Outcome measures prespecified and of good quality | Measures of at least one outcome from more than 85% of subjects | Intention-to-treat analysis | Results of between-group analysis for at least one outcome measure | Point measures of variability provided |
--- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
Attanasio et al 22 2015 | ● | ● | ○ | ○ | ○ | ○ | ● | ● | ● | ● | ● |
Buergers et al 23 2014 | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
Peroz 24 2001 | ● | ● | ○ | ○ | ● | ● | ● | ● | ● | ● | ● |
Sohy et al 25 2004 | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
Ström et al 26 2013 | ● | ● | ○ | ○ | ● | ● | ● | ● | ● | ● | ● |
Suvinen et al 27 1997 | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
Wright and Bifano 28 1997 | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
Wright et al 29 2000 | ● | ● | ○ | ● | ● | ● | ● | ● | ● | ● | ● |

Tinnitus severity outcome | Follow-up | Results
--- | --- | ---
TQ | After first 6 wk of treatment (splint therapy or self-therapy) Posttreatment (12 wk) | TQ: No significant difference between pre- and posttreatment scores in patients with light to moderate tinnitus (TQ: 0–46). Significant decrease in pre- to posttreatment scores in patients with severe to very severe tinnitus (TQ: 47–84). This difference was statistically significant in comparison with the control group.

VAS-intensity (0–100) NRS-severity (1–9) | Posttreatment 6-mo follow-up | VAS-intensity: Significant decrease after SGT or BFT (n = 31). No significant changes after SGT or BFT alone (n = 13 or 18). NRS-severity: No significant changes.

GPE Custom-made questionnaire | Posttreatment (GPE) and 2–3 y follow-up (questionnaire) GPE: 73% reported improvement, 27% reported no change. Questionnaire: Significantly decreased tinnitus severity. Significantly more improved in the patients than in the control group.
incomplete presentation of the data, and selective reporting. Furthermore, the lack of information concerning binding of the subjects, therapists, and investigators caused a high risk of bias. Consequently, the level of evidence of this systematic review is low according to the GRADE system (Tables 3 and 4).

Synthesis of the Results
For each individual study, a summary of the characteristics of the study group, type of intervention, and main results are presented in Tables 1 and 2. Table 1 presents the results of the cohort studies, and Table 2 presents the results of the RCTs and controlled trial.

Two RCTs\textsuperscript{14,15} and one controlled trial\textsuperscript{16} investigated the effect of TMD treatment on tinnitus severity or intensity. These studies showed a positive effect of the combination of splint therapy and exercise treatment on VAS-severity,\textsuperscript{15,16} VAS-intensity,\textsuperscript{14} and GPE.\textsuperscript{15} One study\textsuperscript{16} specified that the treatment effect was only present in patients with severe to very severe tinnitus (TQ score: 47 to 84 points), while the others found an effect in the overall study group.

Additionally, the results of eight cohort studies were considered. Five of these\textsuperscript{9,17–20} investigated the effect of a combination of physical therapy modalities and dental care (oral appliances or occlusal adjustments). No unambiguous conclusions can be drawn from these studies. Improvement in tinnitus severity using GPE was shown in 14% to 86% of the treated patients.\textsuperscript{17,20} Improvement in VAS-change was reported in 44% of the patients in one study.\textsuperscript{9} No significant decrease in THQ score was found.\textsuperscript{18,20}

The remaining three cohort studies\textsuperscript{21–23} used oral appliances without physical therapy modalities. One study combined the oral appliances with acupuncture\textsuperscript{22} and one with counseling.\textsuperscript{23} The application of oral appliances alone resulted in a significant decrease in VAS-severity (23% to 48%) and THI (25% to 65%).\textsuperscript{21} In combination with acupuncture, application of oral appliances showed at least a 50% decrease in VAS-severity in 33% of the patients.\textsuperscript{22} Combination with counseling showed that patients whose TMD improved faster indicated a larger improvement on GPE.\textsuperscript{23}

Differences in outcome measures, unmatched group characteristics, and the absence of a consistent TMD therapy made it impossible to perform either a descriptive analysis or quantitative meta-analysis in this systematic review.

Discussion
This systematic review aimed to investigate whether TMD treatment can positively influence tinnitus complaints.

Overall, positive effects of conservative TMD treatment on tinnitus complaints were found. Several TMD treatment modalities have been described, but the combination of splint therapy and exercise treatment is the most investigated treatment for TMD-related tinnitus complaints. This treatment approach showed a positive effect on tinnitus intensity and GPE in two RCTs and a positive effect on tinnitus severity in patients with severe to very severe tinnitus in one controlled trial. Additionally, five cohort studies investigated a similar treatment approach, showing positive effects on tinnitus complaints in three studies but little effect in the other two. However, it must be noted that improvement in tinnitus complaints can also be caused by the natural course of the tinnitus.

| Table 3 GRADE Evidence for (Randomized) Controlled Trials |
|-----------------|------------------|------------------|
| Outcome                     | No. of participants | Quality of the evidence |
| Tinnitus improvement measured using a variety of scales | 214 (3 studies) | Low (due to serious risk of bias)* |

*Details in Fig 2.

| Table 4 GRADE Evidence Rating for Cohort Studies |
|-----------------|------------------|------------------|
| GRADE domain                | Judgment                     | Concerns                              |
| Risk of bias          | See risk of bias assessment, Fig 2 | Very serious limitations, downgrade 2 levels |
| Inconsistent results   | All studies show consistent decrease of tinnitus symptoms | No serious limitations, no downgrade |
| Indirectness of evidence | There is direct evidence for tinnitus improvement | No serious limitations, no downgrade |
| Imprecision            | The group of 214 included patients is sufficiently large to show a decrease in tinnitus symptoms with 80% power, as calculated in a sample size calculation | No serious limitations, no downgrade |
| Publication bias       | There are no signs of publication bias | No serious limitations, no downgrade |
The effect of oral appliances alone or in combination with acupuncture or counseling are currently not investigated thoroughly enough to be conclusive.

The multifactorial etiology of TMD cannot be ignored, especially when analyzing a patient population with tinnitus. Studies have demonstrated that TMD patients show increased somatization, stress, anxiety, and depression relative to healthy individuals. These symptoms are also often associated with tinnitus itself, and psychologically based treatments such as tinnitus retraining therapy (TRT) or cognitive behavioral therapy (CBT) are currently recommended as best evidence-based treatment in the general tinnitus population. Therefore, specific multimodal therapies incorporating behavioral and educational approaches, which seem to offer more benefit than a single-treatment program, should be advised in patients with TMD-related tinnitus.

Patients should be educated regarding the possible causes of TMD, and it is important that they understand their own central role in its management. Although patient education is an essential part in the treatment of TMD, four studies did not implement counseling in their treatment program. Occlusal adjustments were included in two studies, but this is an irreversible treatment that should be looked upon with extreme caution, since evidence for the role of such occlusal adjustments in the management or prevention of TMD is lacking.

Additionally, when studying TMD treatment, only those subjects that require the treatment should be included. In the study from Attanasio et al., for instance, patients without TMD, with a predisposition to TMD, and with TMD were included. All these patients were treated with neuromuscular occlusal dental splints, an older treatment modality to reduce masticatory muscle tension and to protect teeth from bruxism and clenching. In 10 patients, however, no TMD complaints were present, and thus they did not require this treatment. Since splint therapy is not likely to change the tinnitus severity in these patients, the effect of the treatment in patients with tinnitus and TMD will be underestimated in this study.

Another study included tinnitus patients without TMD in the control group and concluded that the patient group improved significantly more in comparison to the control group. Comparability of the study and control groups regarding type of tinnitus is, however, essential, since no improvement in tinnitus complaints can be expected after TMD intervention when the tinnitus is not related to TMD.

The risk of bias in the included studies was high due to several limitations. First, there is lack of homogeneity in the studied population. In four of the included studies, the presence or absence of tinnitus was evaluated by simply asking the patients to report tinnitus symptoms, without performing otologic or audiometric assessment. Therefore, limited information about the tinnitus characteristics was present. Moreover, without performing an ENT examination, it is not possible to confirm the presence of somatic tinnitus because tinnitus and TMD can also occur without causal relation. Additionally, the multifactorial aspects of TMD signs and symptoms should be considered. Some studies only included patients with myofascial TMD pain, while others included patients with different TMD etiologies. Moreover, in some studies, the criteria to confirm the presence of TMD were not clearly stated, and different TMD classification methods were used. The Helkimo Index was used in two studies, while six studies evaluated the TMJ complaints using the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD). The RDC/TMD was the internationally accepted classification system for TMD at the moment of publication of the studies, but as of 2014, the updated version of the RDC/TMD is the most appropriate tool. Due to the lack of homogeneity in both tinnitus and TMD evaluation, generalization of the conclusions is not possible. Furthermore, many different tinnitus outcome measures are used in the included studies. This hampers the comparability of the results. An international standard for outcome measurements in clinical trials of tinnitus is required to enable meta-analysis, as was also ascertained by Hall et al. An international standard is being developed, but to date, no consensus has been reached.

Second, a high risk of bias was present due to a lack of statistical analyses between groups and before vs after treatment; lack of randomization; and lack of blinding of subjects, therapists, and/or assessors, as well as to the incomplete presentation of the data and selective reporting.

A second limitation of the studies included in this review is the lack of evaluation of Axis II findings and the duration of the TMD symptoms. Since the duration of TMD symptoms and psychosocial influences will largely influence the outcome of the TMD therapy, these items should be taken into account in every study investigating the effect of TMD treatment. Moreover, when psychosocial influences are present or TMD symptoms persist, other treatment modalities should be considered, including more psychology-based treatments.

Future research should focus on investigating the effect of the current best evidence-based TMD treatment, including the treatment of coexisting increased somatization, stress, anxiety, and depression. A combination of psychology-based tinnitus treatments, such as TRT or CBT, and TMD treatment can be a good way to include the treatment of psychosocial influences on both TMD and
tinnitus. This type of treatment should be evaluated using high-quality RCTs in large populations of patients with TMD-related tinnitus and using outcome measures with good psychometric properties, such as the Tinnitus Functional Index\textsuperscript{41} or the Tinnitus Questionnaire.\textsuperscript{32}

Conclusions

There is low-quality evidence for a positive effect of conservative TMD treatment on tinnitus complaints. The combination of splint therapy and exercise treatment is currently the best investigated treatment approach, showing a decrease in tinnitus severity and intensity. Despite the low level of evidence and the methodologic issues in the included studies, it is noteworthy that all included studies showed positive treatment effects.

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