Is there a link between tinnitus and temporomandibular disorders?

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Statement of problem. The frequent concurrence of tinnitus and temporomandibular joint and masticatory muscle disorders (TMD) has led to the assumption that a possible relationship exists between these 2 conditions.

Purpose. The present prospective clinical study was conducted to assess the possible association between tinnitus and TMD and to investigate the effect of stomatognathic therapy on tinnitus distress.

Material and methods. The prevalence of TMD and tinnitus was investigated in a consecutive series of 951 patients at the Department of Prosthetic Dentistry at the University Medical Center Regensburg, Germany. Patients with TMD and simultaneous tinnitus were included in the prospective clinical trial (n=25). Baseline examination comprised a detailed functional analysis, diagnosis of temporomandibular joint and masticatory muscle disorder, and a tinnitus questionnaire. All the participants received individual dental functional therapy (oral splints, physiotherapy). The effects of functional therapy on TMD and tinnitus symptoms were examined 3 to 5 months after the initiation of dental functional therapy. Means (standard deviations) were calculated, and 1-way ANOVA was used to investigate statistical differences (α=.05). The differences of the 2 binary outcomes were compared with the Pearson χ^2 test, and the relative risk was calculated.

Results. Prevalence of tinnitus was found to be 8 times higher in participants with TMD (30 of 82 [36.6%]) than in participants without TMD (38 of 869 [4.4%]). All the participants with unilateral TMD and unilateral tinnitus showed these conditions on the same side. Stomatognathic therapy improved tinnitus symptoms in 11 of 25 participants (44%).

Conclusions. The results of this study and the prospective clinical trial showed a significant correlation between tinnitus and TMD. The observed treatment outcome suggests that dental functional therapy may have a positive effect on TMD-related tinnitus. (J Prosthet Dent 2014;111:222-227)

Clinical Implications

There is a correlation between tinnitus and temporomandibular disorders, and stomatognathic treatment may positively influence temporomandibular joint and masticatory muscle disorder related tinnitus. Therefore, screening for temporomandibular joint and masticatory muscle disorder symptoms in all patients with tinnitus and using temporomandibular joint and masticatory muscle disorder therapy may be appropriate.

The frequent concurrence of tinnitus and temporomandibular joint and masticatory muscle disorders (TMD) has resulted in speculation that there may be a specific TMD-related form of tinnitus. The prevalence of tinnitus in patients with TMD as a main symptom has been reported to range from 2% to 59%.[1-6] The initial claim of a possible

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link between tinnitus and TMD was made by Costen in 1934.[7] Although the structural theories of Costen[7] have been discarded, they have been the basis of various studies that evaluated a possible link between the 2 symptoms. However, the scientific community still debates whether tinnitus and TMD are coexistent or independent or whether the 2 symptoms have a causal connection.[2,3,8-14] In addition, tinnitus and TMD may theoretically occur simultaneously as consequences of a collective trigger such as mental pressure, physical stress, or a specific medication.[9,10] Besides being based on epidemiologic studies, a causal relationship between tinnitus symptoms and TMD has been deduced from the observation of 2 different clinical phenomena. Ren and Isberg[12] investigated the prevalence of tinnitus and TMD and showed that, in 53 participants with unilateral tinnitus and unilateral anterior disk displacement, both symptoms were observed on the same side in 50 participants (94.3%). Furthermore, tinnitus intensity and tinnitus can be altered (mostly enhanced) by mandibular movements, by mastication or by pressure applied to the TMJ.[8,11,15] Nonetheless, there is still no scientific explanation for these 2 phenomena, and, in some studies, no correlation between TMD and tinnitus could be found. A correlation between TMD and tinnitus may suggest that appropriate TMD treatment in patients with TMD and concomitant tinnitus will also eliminate or at least reduce the severity and distress of the perceived tinnitus. Conflicting evidence exists regarding the outcome of stomatognathic therapies such as splints or physiotherapy on TMD-related tinnitus. Various studies on this matter have been conducted, but the success rate of such measures has varied widely.[3,5,6,16-21] The literature generally lacks prospective controlled studies on the efficacy of TMD therapy for concomitant tinnitus. Moreover, the placebo effect on tinnitus was assumed to be considerable.[15] The present prospective clinical study was conducted to verify the potential correlation between TMD and tinnitus on the basis of 3 research hypotheses:

1. The prevalence of perceived tinnitus is higher in participants with TMD than in participants without TMD.
2. For participants with both tinnitus and TMD, TMD is found on the same side.
3. Dental functional therapy has a positive effect on perceived tinnitus distress.

MATERIAL AND METHODS

Participants

The study was approved by the ethics boards of the University of Regensburg (request 08/27), and written informed consent was obtained from all the participants. Between May 2008 and April 2009, a consecutive series of 951 patients referred to the outpatient clinic of the Department of Prosthodontics were asked about the presence of tinnitus. Of the 951 patients, 82 presented to the Department of Prosthodontics because of acute TMD problems or because they had already received previous TMD therapy at the time of their visit. All patients with TMD and simultaneous tinnitus (n=30 [3.2%]) agreed on a detailed clinical examination of both syndromes (see "Classification of TMD and tinnitus") and were included in the study. However, 5 of these 30 patients with concomitant tinnitus and TMD decided against the TMD therapies suggested because they refused the necessary treatment and recall appointments.

Classification of TMD and tinnitus

Baseline examination of each participant with TMD and concomitant tinnitus (n=30) comprised the following:

1. A detailed functional analysis of the masticatory system, including detailed pain history, palpation of the temporomandibular joints (TMJ), compression and traction, auscultation of TMJs for joint sounds, palpation of masticatory muscles, limitations or disturbances of mandibular movements, dental status, dynamic and static occlusion, and checking for oral parafunction (bruxism, clenching, and mobility of teeth).
2. Examination and diagnosis according to the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD).[22] The RDC/TMD classifies patients into diagnostic group I (muscle disorders), group II (disk displacement), and group III (arthralgia, osteoarthritis, and osteoarthrosis).
3. A tinnitus questionnaire (Tinnitus Handicap Inventory) for evaluating the location of ear sounds, tinnitus duration, and parameters of the influence on tinnitus quality and intensity, such as movements of the mandible and grinding.[23]

One dentist (RB) experienced in TMD management in strict accordance with specific diagnostic guidelines to avoid interexaminer variability carried out all clinical and functional examinations.

Therapeutic measures

For each participant, an individual therapeutic strategy was discussed in detail with the participant and was modified according to the specific diagnosis. The following 2 therapeutic measures were applied:

1. Intraocclusal stabilization appliances (occlusal splint), either stabilization splints (Michigan type) or distraction splints (dorsal pivot), were applied overnight.[24-27] Michigan-type splints stabilized occlusion and relaxed masticatory muscles by raising the vertical dimension of occlusion to an equable and synchronous occlusal position.[24] Distractive elements (fulcrums) were placed on both sides of the distal parts of the distraction splints, which resulted in mandibular rotation that led to the distraction of the condyle and, therefore, to the enlargement of the joint space. After 2 weeks, distraction splints were replaced by stabilization splints.
2. Dependent on the clinical appearance, individual physiotherapeutic treatments were conducted by a professional physiotherapist. The applied

physiotherapeutic techniques included passive muscle stretching and massaging of the affected masticatory elevator muscles, thermotherapy (moist heat), traction of the TMJs, and coordination exercises.

Reevaluation

Three to 5 months after the initiation of dental functional therapy, the participants were asked about changes in tinnitus, pain in the TMJs or masticatory muscles, joint sounds, and limitations of mandibular movements. The rating was carried out according to a verbal analog scale and comprised the answers no change to baseline, improvement, complete remission, or impairment. Patients were again asked to complete the Tinnitus Handicap Inventory (THI) questionnaire and were examined according to the RDC/TMD.[22]

The statistical analysis was conducted with statistical software (PASW Statistics v17.0; SPSS Inc). Means (standard deviations [SD]) were calculated, and 1-way ANOVA was used to investigate statistical differences (α=.05). The differences of the 2 binary outcomes were compared with the Pearson χ^2 test, and the relative risk was calculated.

RESULTS

Overall, 951 participants (473 men and 478 women) with a mean (SD) age of 54.1 ±17.1 years (range, 8-98 years) of the Outpatient Department of Prosthodontics were asked about perceived tinnitus, and 68 participants (7.2%) reported tinnitus. Of the 951 participants, 82 were diagnosed with TMD (8.6%), and the simultaneous occurrence of both symptoms was found in 30 of the 951 participants (3.2%). Of the 869 participants in the control group, 38 experienced tinnitus (4.4%), and 30 of the 82 participants with TMD (36.6%) also had tinnitus ($P<.0001$). The relative risk (8.37), that is the likelihood of having tinnitus was 8.37 times higher for participants with TMD than for participants without TMD.

No significant difference in the prevalence of tinnitus could be found between men (32 of 473 [6.8%]) and women (36 of 478 [7.5%]) ($P=.64$). In contrast, the prevalence of TMD was twice as high in female participants (56 of 478 [11.7%]) than in male participants (26 of 473 [5.5%]) ($P=.001$). Similarly, there were more women with TMD and concomitant tinnitus than men (women, 19 of 478 [4.0%]; men, 11 of 473 [2.3%]; $P=.026$). According to the RDC/TMD, group I disorders (muscle disorders) were diagnosed in 14 of 30 participants (47%) with concurrent tinnitus, group II disorders (disk displacement) in 18 of 30 participants (57%), and group III disorders (arthralgia, osteoarthritis, osteoarthrosis) in 10 of 30 participants (34%). These figures indicate that 12 of 30 participants (40%) had an RDC/TMD diagnosis in more than 1 group.

In the patient population with both tinnitus and TMD (n=30), all the participants with unilateral TMD and concomitant unilateral tinnitus had both symptoms on the same side (8 of 8). Individuals with bilateral TMD symptoms (n=17) showed either bilateral (14 of 17) or unilateral (3 of 17) tinnitus. Five participants had bilateral tinnitus with concomitant unilateral TMD.

All 25 participants who consented to the clinical study at baseline were interviewed 3 to 5 months after the initiation of dental functional therapy (none were lost to follow-up). Improvement or complete remission of TMD symptoms was reported by 18 of 22 participants with myofascial pain (81.8%, in 11 of 16 participants with joint sounds (68.8%), and in 3 of 6 participants experienced limited mandibular movements (50%). Complete remission of tinnitus after individual dental functional therapy was reported by 2 of 25 participants (8%), improvement of perceived tinnitus by 9 of 25 participants (36%), and no change from baseline by 14 of 25 participants (56%); there were no reports of any impairment due to tinnitus. Among the 30 participants with simultaneous tinnitus and TMD, 10 were classified as having acute or subacute tinnitus (perception duration less than or equal to 12 months) and 20 as having chronic tinnitus (perception duration longer than 12 months). The efficacy of dental functional therapy on perceived tinnitus significantly differed among participants with acute or subacute and chronic tinnitus. All 8 participants with acute tinnitus either stated improvement (n=7) or total remission (n=1) of tinnitus, whereas 14 of the 17 study participants with chronic tinnitus (82%) reported no change (Table I).

Fourteen of these 25 participants were treated with a distraction splint, and 11 of 25 participants were treated with a Michigan-type splint. The type of splint (distraction splint or Michigan-type splint) did not have a statistically significant influence on the change in tinnitus symptoms ($P=.893$). Physiotherapy was prescribed for 16 of 25 participants with tinnitus and TMD. Improvement or total remission of the perceived tinnitus was reported by 8 of 16 participants (50%) who received physiotherapy but only by 3 of 9 participants (33%) without physiotherapy. According to the RDC/TMD, improvement or complete remission of tinnitus was significantly more often reported by participants with arthrogenic (group II and group III) disorders (group II, 7 of 14 [50%]; group III, 4 of 8 [50%]) than by participants with myogenic (group I) disorders (3/12 [25%]; $P<.001$ for both comparisons).

DISCUSSION

The literature on the association between tinnitus and TMDs is variable and inconsistent. Numerous attempts have been made to explain the character of this connection according to anatomic, functional, embryologic, or neurologic theories.[13] The present prospective clinical study was conducted to examine a potential correlation between TMD and tinnitus on the basis of 3 research hypotheses:

1. The significantly increased prevalence of tinnitus in participants with TMD supports an association between the 2 symptoms. The percentage of

Table I. Treatment outcome of 30 individuals with TMD and simultaneous tinnitus after dental functional therapy

Symptoms at Baseline	No. Participants in the Study*	No Change n (%)	Improvement n (%)	Complete Remission n (%)	% Improvement/ Complete Remission
Pain (27 of 30)	22 of 27	4 (18)	9 (41)	9 (41)	82
Joint sounds (19 of 30)	16 of 19	5 (31)	5 (31)	6 (38)	69
Limited mandibular movements (9 of 30)	6 of 9	3 (50)	3 (50)	0	50
Tinnitus (30 of 30)	25 of 30	14 (56)	9 (36)	2 (8)	44
Acute tinnitus (10 of 30)	8 of 10	0	7 (87)	1 (13)	100
Chronic tinnitus (20 of 30)	17 of 20	14 (82)	2 (12)	1 (6)	18

*Five of 30 refused to participate.

tinnitus in patients with TMD as a main symptom has been reported to range from 2% to 59%.[1-6] Unfortunately, most published studies have significant weaknesses, such as the lack of well-defined control groups, a retrospective nature, or loss of participants in the follow-up.[2,13] Most of these studies are descriptive because they do not include statistical comparisons between affected participants and a control group. To avoid such statistical limitations, a high number (n=869) of reference patients without TMD were used as a well-defined control group. Nevertheless, the study population was a preselected group of participants, namely patients referred to the clinic of the Department of Prosthodontics. Therefore, the findings may not be transferred to the general population without any restrictions. A significantly higher percentage of participants with TMD had concomitant tinnitus (36.6%) as a major symptom than participants without TMD (4.4%). Therefore, the risk of having tinnitus is 8.37 times higher for patients with TMD than for patients without TMD. The statistically significant difference in the prevalence of tinnitus in participants with and without tinnitus corroborates the association between the 2 symptoms. No significant difference in the prevalence of tinnitus could be found between men (6.8%) and women (7.5%), which is in accordance with some previous investigations[3,14] but also in contrast to others.[2,4] A significant sex difference with a female predominance existed in participants with concomitant TMD and tinnitus, which matches previous reports.[2-4,13] In this trial, the presence or absence of tinnitus was evaluated by simply asking the 951 patients to report tinnitus symptoms. Therefore, false responses were possible, because the reliability and validity of this procedure is unpredictable. Unfortunately, no alternative examination methods or assessment devices exist for objectively verifying the statements of patients.[28] Nevertheless, results concerning the prevalence of tinnitus symptoms based on patient reports may have to be interpreted with caution. As an alternative, various tinnitus questionnaires are available to determine the severity of the handicap and the distress perceived by patients with tinnitus in relation to other patients with tinnitus.[29] However, these questionnaires have not been designed for objectively evaluating the actual presence of tinnitus symptoms or of any treatment-induced changes. For this reason, these questionnaires are not specifically sensitive for the assessment of such measures and, therefore, have not been used in this context.[28]

2. The arbitrary incidence of symptoms on the right or the left in participants with unilateral tinnitus and concomitant unilateral TMD could be interpreted as evidence against an association between tinnitus and TMD. In the present study, all the participants with unilateral TMD and unilateral tinnitus had both symptoms on the same side (8 of 8). This phenomenon has also been documented by other groups and has been quoted as evidence for a causal relationship between tinnitus and TMD.[12,15]

3. The improvement of perceived tinnitus after stomatognathic therapy has been seen as evidence for an association between TMD and tinnitus.[3,5,6,17,18] In the present study, improvement of tinnitus after stomatognathic treatment was reported by 11 of 25 participants (44%). Previous studies have shown comparable and even higher percentages of improvement or complete remission of TMD-related tinnitus after various stomatognathic treatment regimens, ranging from 43% to 86%.[3,6,17-20] The reevaluation period of the present study was relatively short (3-5 months after the initiation of dental functional therapy), and, therefore, it is desirable to evaluate the long-term therapeutic outcome after several years. In general, tinnitus is a symptom and not a diagnosis, and studies on the outcomes of specific tinnitus therapies must not be overinterpreted because of the lack of objective and standardized examination methods and classification systems for estimating parameters, for example, tinnitus severity. Because tinnitus cannot be measured or imaged, there is no satisfying objective method for

a reliable and valid diagnosis of tinnitus, and, therefore, data on the epidemiology of tinnitus and treatment outcomes have to be interpreted with caution. The finding in the present study that dental functional therapy improved tinnitus in approximately 50% of the participants is difficult to explain. An objective review of the literature shows that the effects of TMD therapies on tinnitus are little understood. In the authors' opinion, tinnitus and TMD are associated, and both symptoms are often exacerbated by psychological stress.[28] Even if the 2 symptoms are merely coexistent and not causally connected, a reduction of overall stress by reducing TMD symptoms may positively influence tinnitus. Stress, therefore, may be considered as a predisposing collective trigger for both symptoms. This consideration may explain why some patients with TMD also have tinnitus and why TMD therapies often have a positive effect on the severity of tinnitus.

Many methods for treating TMD have been described over the past few years, but oral splints and physical therapy are the most frequently used procedures.[3,6,13] None of the stomatognathic treatments or oral splints tested in the present study seemed to be more effective than the other, which corroborates previous reports.[6,21] Patients with arthrogenic TMD more frequently reported improvement of tinnitus than did patients with myogenic TMD. These statements contrast with reports that explain the positive effect of stomatognathic treatments on tinnitus by reducing muscular tension and hyperactivity.[6] Dental functional therapy resulted in eliminating or significantly reducing tinnitus in all participants with acute or subacute TMD-related tinnitus (8 of 8 [100%]); the percentage of improvement of tinnitus in participants with chronic tinnitus was significantly lower (3 of 17 [7.6%]).

It has to be clearly stated that no randomization for the different therapeutic methods was used and that one operator (RB) did all examinations. Tinnitus is a phantom perception of sounds that is de facto susceptible to placebo effects[28]; various clinical trials have shown a considerable placebo effect during tinnitus treatment (up to 30%).[15,30,31] No control group with placebo or no treatment was included in the present investigation because an effective therapy for TMD must not deliberately be withheld from patients with TMD and tinnitus just to be able to evaluate the effect of placebo treatment or of no treatment on tinnitus symptoms. Therefore, it can be assumed that a high percentage of patients who showed improvement of their tinnitus symptoms after TMD treatment in the trial (11/25 [44%]) may have to be attributed to the placebo effect or the natural fluctuation of symptoms. Moreover, it would be improper to provide specific treatment recommendations, and all results concerning the treatment outcome of specific TMD therapies in this study have to be considered against the backdrop of these limitations.

Tinnitus is not an isolated single clinical entity, the origin of many incidences of tinnitus is still unknown, and there are many possible causes of tinnitus besides TMD, such as conductive, noise-induced, and cochlear hearing loss; complications to medical treatment (such as through antibiotics, antidepressants, salicylates, and cytostatica); pathologies of the auditory nerve (such as vestibular schwannoma); and cerebrovascular diseases.[28] The potential influence of all these parameters could not be considered in the present investigation. Therefore, the results from this study regarding the influence of TMD on tinnitus and the effect of dental functional therapy on tinnitus severity should be interpreted with caution.

CONCLUSIONS

The verification of the 3 study hypotheses and the consequential findings of this prospective clinical trial reinforce the putative association between tinnitus and TMD. Whether TMD and tinnitus are coexistent, independent, or causally connected may not be concluded from the present study.

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