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Tinnitus with Temporomandibular Joint Disorders: A Specific Entity of Tinnitus Patients?

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Abstract

Objective. Tinnitus is frequently associated with temporomandibular joint (TMJ) dysfunction. However, the nature of the relationship is not fully understood. Here the authors compared 30 patients with a confirmed diagnosis of temporomandibular joint dysfunction and tinnitus to a group of 61 patients with tinnitus but without any subjective complaints of TMJ dysfunction with respect to clinical and demographic characteristics.

Study Design. Case-control study.

Setting. Tertiary referral center.

Subjects. Tinnitus patients with and without TMJ dysfunction presenting at the Department of Prosthetic Dentistry and the Tinnitus Clinic at the University of Regensburg.

Results. Tinnitus patients with TMJ disorder had better hearing function ($P < .0005$), lower age ($P = .001$), and lower age at tinnitus onset ($P = .002$) and were more frequently female ($P = .003$). Their subjectively perceived tinnitus loudness was lower ($P = .01$), and more of them could modulate their tinnitus by jaw or neck movements ($P = .001$).

Conclusion. Classical risk factors for tinnitus (age, male gender, hearing loss) are less relevant in tinnitus patients with TMJ disorder, suggesting a causal role of TMJ pathology in the generation and maintenance of tinnitus. Based on this finding, treatment of TMJ disorder may represent a causally oriented treatment strategy for tinnitus.

Keywords

tinnitus, temporomandibular joint, somatic, risk factor, pathophysiology, hearing

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Tinnitus is a frequent disorder that is characterized by the perception of sound in the absence of an external sound source. The most important risk factors for the development of tinnitus are age, hearing loss, and gender.[1] Functional imaging studies in patients with tinnitus have demonstrated changes of neuronal activity in central auditory pathways in tinnitus patients. It is assumed that these changes emerge in the central nervous system as the consequence of the attempt of the brain to compensate for reduced auditory input due to hearing loss.[2]

There is also abundant clinical evidence for an influence of the somatosensory system on tinnitus perception. Approximately two-thirds of people with tinnitus are able to alter the loudness and pitch of their tinnitus via somatic maneuvers, such as jaw clenching or tensing their neck muscles.[3-5] Furthermore, tinnitus is frequently associated with disorders of the temporomandibular joint (TMJ). This association was described in 1934 by Costen[6] and confirmed by many studies that reported an increased prevalence of tinnitus among patients with TMJ dysfunction.[7-9]

However, even if the relationship between tinnitus and TMJ dysfunction has been well documented, its nature is yet not fully understood. One clinically highly relevant question is whether TMJ disorders cause tinnitus or whether temporomandibular dysfunction is rather a symptom of tinnitus. If TMJ disorder is causing tinnitus, one would expect that tinnitus patients with and without comorbid TMJ dysfunction

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Table 1. Tinnitus Patients with Temporomandibular Joint (TMJ) Disorder: Comparison between Those with Primary Complaint of Tinnitus and Those with Primary Complaint of TMJ Disorder

	Primary Complaint Tinnitus	Primary Complaint TMJ Disorder	t/χ^2	*P* Value
No.	15	15		
Age, y, mean ± SD	45.3 ± 11.2	38.4 ± 18.1	1.3	.22
Age at onset, y, mean ± SD	36.0 ± 12.2	33.1 ± 17.2	0.5	.63
Duration, y, mean ± SD	9.1 ± 9.7	6.8 ± 10.7	0.6	.58
Gender, male/female	8/7	4/11	2.2	.14
Hearing loss, dB HL over all frequencies, mean ± SD	18.2 ± 15.4	10.4 ± 11.5	1.5	.13
Tinnitus Handicap Inventory (0-100), mean ± SD	48.2 ± 23.6	28.2 ± 19.0	2.4	.026
Loudness (0-100), mean ± SD	56.4 ± 22.8	45.1 ± 21.4	1.3	.22
Time aware of tinnitus (0%-100%), mean ± SD	66.9 ± 27.1	42.5 ± 36.6	1.9	.07
Begin (1 = gradually/2 = abruptly/no information)	7/5/3	6/7/2	0.4	.54
Pulsatile (1 = no/2 = yes, like the heartbeat/3 = yes, but other than the heartbeat/no information)	10/2/1/2	8/3/2/2	0.8	.68
Masking (1 = no/2 = yes/no information)	4/9/2	3/10/2	0.2	.66
Modulation by jaw or neck movements (no/yes/no information)	5/6/4	4/9/2	2.7	.26
Hyperacousis (never/rarely/sometimes/usually/always/no information)	1/3/7/0/2/2	0/2/6/2/2/3	4.3	.51

would differ in their risk factor profiles. In detail, one would expect better hearing function and a different age and gender distribution among tinnitus patients with comorbid TMJ dysfunction.

A second clinically relevant question is whether tinnitus with and without TMJ comorbidity are fundamentally different disease entities. In this case, one would expect relevant differences in the clinical characteristics of both groups.

Here we approached these 2 questions by comparing tinnitus patients with and without TMJ dysfunction with respect to their tinnitus risk factors and their clinical characteristics.

Materials and Methods

In this prospective study, all patients (951 patients) presenting between May 2008 and April 2009 at the Outpatient Clinic of the Department of Dentistry at the University of Regensburg with complaints of temporomandibular joint dysfunctions were assessed for concomitant tinnitus complaints. Patients received comprehensive diagnostic workup, including functional analysis of the masticatory system and an examination according to the Research Diagnostic Criteria for Temporomandibular Disorders. Patients reporting tinnitus were investigated in the ear, nose, and throat (ENT) clinic. A subgroup of 30 patients (3.2%) was identified suffering from both TMJ disorder and tinnitus. Among these 30 patients, 15 had presented primarily at the Multidisciplinary Tinnitus Clinic of the University of Regensburg because of their tinnitus and were then referred to the Department of Dentistry. Patients with tinnitus and confirmed TMJ disorder were compared to a group of 61 patients presenting at our tinnitus center in the same time period with tinnitus but without any subjective complaints of TMJ dysfunction. All patients gave written informed consent for participation in the study, which has been approved by the ethical committee of the University of Regensburg (request 08/27).

All patients received an ENT examination, including an otoscopy and a pure-tone audiogram.

Furthermore, they completed an abbreviated version of the Tinnitus Sample Case History[10] and the German version of the Tinnitus Handicap Inventory (THI).[11,12]

Within the group of tinnitus patients with TMJ dysfunction, we differentiated between those who presented with the primary complaint of TMJ dysfunction at the Department of Prosthodontics and those who presented with the primary complaint of tinnitus at the tinnitus center. The 3 groups were compared with respect to hearing function, age, age at onset, gender, type of onset (gradual vs abrupt), type of tinnitus (pulsatile vs nonpulsatile), loudness, awareness, masking, somatosensory modulation, hyperacousis, and tinnitus handicap as assessed by the THI.

Results are expressed as mean ± standard deviation (SD). Continuous variables are expressed as mean ± SD, and categorical variables are expressed as a percentage. Comparisons among groups were made by *t* test for continuous variable and χ^2 tests for categorical variables. Because the 2 groups of tinnitus with TMJ disorder did not differ in the investigated characteristics, we pooled these 2 groups for the comparison with the tinnitus group without TMJ complaints. The statistical analysis was carried out using an SPSS statistical package (version 15.0 for Windows; SPSS, Inc, an IBM Company, Chicago, Illinois).

Results

Demographic and clinical characteristics of all 3 groups are displayed in **Table 1**. Among the tinnitus patients with TMJ disorder, those who presented with the primary complaint of tinnitus had a significantly higher THI score than those who presented with the primary complaint of a TMJ disorder ($P = .03$; mean difference: 20; 95% confidence interval [CI], 2.7-37.3). In the other investigated parameters, there were no

Table 2. Comparison of Tinnitus Patients with and without Temporomandibular Joint (TMJ) Disorder

	Tinnitus without TMJ Disorder	Tinnitus with TMJ Disorder	t/χ^2	*P* Value
No.	61	30		
Age, y, mean ± SD	52.8 ± 12.6	41.9 ± 15.2	3.6	.001
Age at onset, y, mean ± SD	44.9 ± 12.7	34.6 ± 14.6	3.2	.002
Duration, y, mean ± SD	7.7 ± 6.1	8.0 ± 10.0	−0.1	.89
Gender, male/female	44/17	12/18	8.8	.003
Hearing loss, dB HL over all frequencies, mean ± SD	26.9 ± 15.7	14.3 ± 13.9	3.7	<.0005
Tinnitus Handicap Inventory (0-100), mean ± SD	42.5 ± 22.5	38.2 ± 23.3	0.8	.42
Loudness (0-100), mean ± SD	64.0 ± 20.2	51.0 ± 22.4	2.6	.01
Time aware of tinnitus (0%-100%), mean ± SD	69.4 ± 28.4	55.2 ± 33.7	1.9	.052
Begin (1 = gradually/2 = abruptly/no information)	28/29/4	13/12/5	0.1	.81
Pulsatile (1 = no/2 = yes, like the heartbeat/3 = yes, but other than the heartbeat/no information)	43/10/6/2	18/5/3/4	0.1	.94
Masking (1 = no/2 = yes/no information)	16/36/9	7/19/4	4.4	.11
Modulation by jaw or neck movements (no/yes/no information)	47/13/1	9/15/6	14.5	.001
Hyperacousis (never/rarely/sometimes/usually/always/no information)	7/10/23/11/9/1	1/5/13/2/4/5	3.6	.61

Table 3. Patients with Tinnitus as the Primary Complaint: Comparison of Those with and without Temporomandibular Joint (TMJ) Disorder

	Tinnitus without TMJ Disorder	Tinnitus with TMJ Disorder	t/χ^2	*P* Value
No.	61	15		
Age, y, mean ± SD	52.8 ± 12.6	45.3 ± 11.2	−2.1	.04
Age at onset, y, mean ± SD	44.9 ± 12.7	36.0 ± 12.2	−2.3	.03
Duration, y, mean ± SD	7.7 ± 6.1	9.1 ± 9.7	0.63	.53
Gender, male/female	44/17	8/7	2.0	.161
Hearing loss, dB HL over all frequencies, mean ± SD	26.9 ± 15.7	18.2 ± 15.4	1.9	.056
Tinnitus Handicap Inventory (0-100), mean ± SD	42.5 ± 22.5	48.2 ± 23.6	0.82	.42
Loudness (0-100), mean ± SD	64.0 ± 20.2	56.4 ± 22.8	1.2	.23
Time aware of tinnitus (0%-100%), mean ± SD	69.4 ± 28.4	66.9 ± 27.1	−0.29	.78
Begin (1 = gradually/2 = abruptly/no information)	28/29/4	7/5/3	0.34	.56
Pulsatile (1 = no/2 = yes, like the heartbeat/3 = yes, but other than the heartbeat/no information)	43/10/6/2	10/2/1/2	0.68	.71
Masking (1 = no/2 = yes/no information)	16/36/9	4/9/2	2.5	.29
Modulation by jaw or neck movements (no/yes/no information)	47/13/1	(5/6/4)	11.8	.003
Hyperacousis (never/rarely/sometimes/usually/always/no information)	7/10/23/11/9/1	1/3/7/0/2/2	3.2	.67

statistically significant differences between these 2 groups (see **Table 1**). However, there were highly significant differences between tinnitus patients with and without TMJ with respect to hearing function, age, age at onset, and gender distribution. Tinnitus patients with TMJ disorder had better hearing function ($P < .0005$; mean difference: 12.6 dB; 95% CI, 5.9-16.3), had lower age ($P = .001$; mean difference: 10.9 years; 95% CI, 4.9-16.9), had lower age at tinnitus onset ($P = .002$; mean difference: 10.2 years; 95% CI, 5.9-16.7), and were more frequently female ($P = .003$; 40% with TMJ disorder, 28% without TMJ disorder, difference 12%; odds ratio, 3.9). Among the tinnitus characteristics, there were significant differences in the modulation of tinnitus by jaw or neck movements. Of tinnitus patients, 50% with TMJ disorders but only 21% of tinnitus patients without TMJ disorders reported somatosensory modulation ($P = .001$; difference 19%; odds ratio, 3.7). Tinnitus loudness was reported to be higher by tinnitus patients without TMJ disorder ($P = .01$; mean difference 13.1; 95% CI, 3.1-23.1). The other investigated factors did not differ significantly between groups (see **Table 2**). When only patients with the primary complaint of tinnitus were analyzed, those with TMJ disorder were younger ($P = .04$; mean difference 7.4 years; 95% CI, 0.3-14.5), had an earlier onset of tinnitus ($P = .03$; mean difference 8.9 years; 95% CI, 1.1-16.7), and reported more frequently modulation of tinnitus by jaw or neck movements ($P = .003$; 40% with TMJ disorder, 21% without TMJ disorder, difference 19%; odds ratio, 2.5). There were also trends toward better hearing ($P = .06$) and female gender ($P = .16$) among patients with TMJ disorder (see **Table 3**).

Discussion

The main findings of our study are significant differences in age, hearing function, and gender distribution between tinnitus patients with and without TMJ disorder. These differences between the 2 groups also would have survived a correction for multiple comparisons.

Higher age, male gender, and hearing loss are well known as risk factors for the development of tinnitus.[1] Tinnitus patients with TMJ disorder exhibit these risk factors to a lesser extent. This suggests that pathology of the temporomandibular joint plays a causal role in the development of tinnitus. Animal data have elucidated the neural connections by which TMJ dysfunction may contribute to the generation and maintenance of tinnitus.[13] In guinea pigs, trigeminal nerve stimulation has been shown to modulate activity in the central auditory pathway via the dorsal cochlear nucleus.[14,15]

The TMJ is sensorially innervated by the trigeminal nerve. Thus, altered trigeminal input due to TMJ dysfunction may cause activity changes in the dorsal cochlear nucleus[16] and farther upstream along the central auditory pathway, which finally result in tinnitus perception.

The groups with and without TMJ disorder differed in the influence of somatosensory modulation on tinnitus. Tinnitus patients with TMJ disorders reported much more frequently such an influence. These findings suggest that the existence of somatosensoric influences in the generation of tinnitus is reflected by lasting somatosensoric modulation of tinnitus loudness, supporting the concept of somatosensoric tinnitus.[17] This also implies that this patient group may respond better to treatment modalities targeting the somatosensoric system.[18] Apart from the difference in somatosensory stimulation, we only found a difference in tinnitus loudness between the two groups. However, this may be an artifact because the difference disappears when only patients with tinnitus as the primary complaint are compared. All other clinical characteristics were similar between patients with and without TMJ disorder, suggesting that tinnitus with TMJ disorder is not a separate entity of tinnitus but that tinnitus patients with and without TMJ disorder share a similar final neuronal pathway.

Thus, in line with recent longitudinal data,[19] our findings suggest that TMJ disorder may play a causal role in the generation and maintenance of tinnitus and is not just a symptom of tinnitus. This is of high clinical relevance because, based on this reasoning, treatment of the TMJ pathology can be considered a causally oriented treatment for tinnitus similar to treatment of hearing disorders by hearing aids[20] or cochlear implants.[21] This is supported by preliminary results of tinnitus improvement after successful treatment of TMJ disorders.[22]

As a surprising result, we found that apart from the tinnitus handicap, there were no significant differences within the group of tinnitus patients with TMJ disorder between those patients who presented with the primary complaint of tinnitus and those with the primary complaint of TMJ disorder. Even if the statistical power of the comparison of the 2 subsamples is limited because of the relatively small sample size, this finding suggests that the assessed clinical characteristics do not really determine which of the 2 symptoms is more bothersome for the individual patient.

We are aware that our results have to be confirmed by additional studies involving larger samples before further firm conclusions can be drawn. Hereby our results provide an estimate for calculating appropriate sample sizes. A particular strength of our study, however, is the fact that diagnosis of TMJ disorder and tinnitus was based not only on the patient's self-report but also on an examination by a specialist in prosthetic dentistry and on otologic and audiologic examinations by otologists.

Conclusion

Classical risk factors for tinnitus (age, male gender, hearing loss) are less relevant in tinnitus patients with TMJ disorder, suggesting a causal role of TMJ pathology in the generation and maintenance of tinnitus. On the basis of this finding, treatment of TMJ disorder may represent a causally oriented treatment strategy for tinnitus.

Author Contributions

Veronika Vielsmeier, study design, patient examination, data analysis, manuscript writing; **Tobias Kleinjung**, study design, patient examination, approval of final manuscript; **Jürgen Strutz**, study design, approval of final manuscript; **Ralf Bürgers**, study design, patient examination, approval of final manuscript; **Peter Michael Kreuzer**, data analysis, approval of final manuscript; **Berthold Langguth**, study design, patient examination, data analysis, manuscript writing.

Disclosures

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