

Somatosensory tinnitus and temporomandibular disorders: A common association

H. A. Didier^{1,2,3,4,5}  | A. M. Cappellari³  | F. Sessa^{1,2}  | A. B. Gianni^{1,2}  |
A. H. Didier⁴  | M. M. Pavesi⁵  | M. P. Caria⁶  | M. Curone⁷  | V. Tullo⁷  |
F. Di Bernardino^{8,9}  | E. Iacona⁸  | G. Lilli⁷  | S. Barozzi⁷  | M. Aldè⁸  |
G. De Bortoli⁸  | D. Zanetti^{8,9}  | F. Arnone¹⁰  | G. Bussone⁷ 

¹Department of Biomedical, Surgical and Dental Sciences, University of Milan, Milan, Italy

²Maxillo-Facial Surgery and Dental Unit, Fondazione IRCCS Ca' Granda Ospedale Maggiore Policlinico, Milan, Italy

³Department of Neuroscience, Fondazione IRCCS Ca' Granda Ospedale Maggiore Policlinico, Milan, Italy

⁴UOC Hospital Pharmacy, Fondazione IRCCS Ca' Granda Ospedale Maggiore Policlinico, Milan, Italy

⁵Istituto Stomatologico Italiano, Milan, Italy

⁶CERISMAS (Research Centre in Health Care Management), Catholic University Milan, Milan, Italy

⁷Casa di Cura del Policlinico Igea Headache Center, Milan, Italy

⁸Department of Clinical Sciences and Community Health, University of Milan, Milan, Italy

⁹Audiology Unit, Department of Specialist Surgical Sciences, Fondazione IRCCS Ca' Granda Ospedale Maggiore Policlinico, Milan, Italy

¹⁰Azienda Ospedaliera Santi Paolo e Carlo, Milan, Italy

Correspondence

F. Sessa, Department of Biomedical, Surgical and Dental Sciences, University of Milan, Via Francesco Sforza 28, 20122 Milano (MI), Milan, Italy.
Email: fabiola.sessa@unimi.it

Abstract

Background: Although the association between tinnitus and temporo-mandibular disorders (TMD) has been frequently reported, their rate of association in the literature shows a great variability.

Objective: We aimed to investigate the prevalence of TMD in patients with somatosensory tinnitus and, vice versa, the occurrence of somatosensory tinnitus in patients with TMD.

Methods: The study included patients with somatosensory tinnitus (audiological group) and patients with TMD (stomatological group), evaluated at the audiologic and stomatologic clinics of the Policlinic Hospital of Milan, Italy. Common causes of tinnitus, such as hearing and neurological disorders, were excluded. A cervicogenic somatic tinnitus was also ruled out. Different TMD symptoms, including joint noise and joint pain, were considered. The collected data were analysed using descriptive statistical methods, and the Pearson's Chi-squared test was performed to study the prevalence of the different symptoms by clinical groups.

Results: Audiological group included 47 patients with somatosensory tinnitus. Overall, TMD was diagnosed in 46 patients (97.8%), including TMJ noise in 37 (78.7%), clenching in 41 (87.2%) and pain in 7 (14.8%) patients. Stomatological group included 50 patients with TMD, including joint noise in 32 (64.0%), clenching in 28 (56.0%) and TMJ pain in 42 (84.0%) patients. A somatosensory tinnitus was diagnosed in 12 (24.0%) patients.

Conclusion: Our study showed a high prevalence of TMD in patients with tinnitus, as well as a not uncommon occurrence of tinnitus in patients presenting with TMD. The distribution of TMD symptoms, such as joint noise, and joint pain was different between the two groups.

KEYWORDS

audiology, bruxism, dentistry, somatosensory disorders, temporomandibular joint disorders, tinnitus

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1 | INTRODUCTION

Tinnitus is the conscious awareness of a tonal or composite noise for which there is no identifiable corresponding external acoustic source. Tinnitus is a heterogeneous condition with respect to its perceptual characteristics, causes and comorbidities.¹ One viable explanation of this heterogeneity is the existence of multiple tinnitus subtypes, which can be classified according to their clinical profiles, aetiologies and response to treatment.²⁻⁶

A specific subtype of tinnitus is somatosensory tinnitus (ST), where somatosensory input from the upper cervical spine or temporomandibular area influences the tinnitus percept through existing brainstem connections. Both the auditory and somatosensory systems converge upon and interact within the DCN. If the activity of the DCN's somatosensory-interacting fusiform cells exceeds an individual's tinnitus threshold, then tinnitus results.⁷ This neurophysiological pathway could explain the greater prevalence of tinnitus in patients with temporomandibular disorders (TMD) (30.4%–64.0%), compared with the prevalence in the general population.⁸⁻¹³ However, other literature data report an extremely wide range of the prevalence of tinnitus in patients with TMD, ranging from 3.7% to 76.0%.¹⁴⁻¹⁸

The first aim of our study was to investigate the prevalence of TMD in patients with somatosensory tinnitus. The second aim was to evaluate the occurrence of somatosensory tinnitus in patients coming from different clinical settings.

2 | MATERIALS AND METHODS

The study included patients with somatosensory tinnitus (Audiological group) and patients with TMD (Stomatological group), evaluated at the audiologic and stomatologic clinics of the Policlinic Hospital of Milan, Italy, and referred to the tertiary university stomatognathic unit for the evaluation, diagnosis and treatment.

Audiological group patients were selected from a population of patients referred to the audiologic clinic for tinnitus, with the diagnosis of somatic tinnitus based on the audiologic evaluation.¹⁹ Common causes of tinnitus were excluded by the audiologist, such as hearing loss, Meniere's disease, progressive middle ear pathology and intracranial disorders. Patients with cervicogenic somatic tinnitus were excluded from the study, as suggested by other authors

for the differential diagnosis with TMD,¹⁹ which can also be associated with somatosensory tinnitus.²⁰ All patients in audiological group were then referred to the stomatologic clinic to investigate the presence of TMD. Stomatological group patients presented to the stomatologic clinic for TMD symptoms.

According to the diagnostic criteria for temporomandibular Disorders Axis I (DC/TMD),²¹ TMD was diagnosed as any condition associated with pain and dysfunction of the masticatory muscles or the temporomandibular joint (TMJ).²² Bruxism or clenching, which are an oral parafunction often related to TMD, were also evaluated.^{23,24} All patients completed a written questionnaire providing information on different TMD symptoms (joint noise, joint pain and functional limitation), as well on the presence of tinnitus.

The patients with tinnitus were then referred to the audiologic clinic to exclude alternative or concurrent causes of tinnitus.

2.1 | Statical analysis

All statistical analyses were performed with the statistical software SPSS (SPSS 25.0, SPSS Inc.). The collected data were analysed using descriptive statistical methods to study the prevalence of the different dysfunctions by clinical group. Chi-squared test was used for categorical variables, a difference of $p > .001$ has been considered statistically significant.

The participation in the study for both groups was voluntary and anonymous. Patients signed a written informed consent for the publication of the results. The research was conducted according to the guidelines of the Declaration of the World Medical Association Declaration of Helsinki of 1975, as revised in 2008; all the procedures have been approved by the Ethical Committee (Area 2, Milano, Italy) of the Fondazione IRCCS Ca' Granda Ospedale Maggiore Policlinico (IRB: 653).

3 | RESULTS

A total of 97 patients (63 women), mean age 39.6 years (SD 15.6, range 9–82) were included in the study. Clinical features of our patients are summarized in Table 1, along with the results of Pearson's Chi-squared tests.

	Stomatological (n = 50)	Audiological (n = 47)	χ^2	p-Value
	%	%		
Tmj pain	84.0	14.9	46.3	<0.000
Tmj noise	64.0	78.7	2.6	0.110
Clenching	56.0	89.4	13.4	<0.000
At least one tmj problem	96.0	97.9	0.3	0.594
Tinnitus	24.0	100.0	58.7	<0.000

TABLE 1 Prevalences of tinnitus and of temporomandibular joint disorders (clenching, pain and noise) by groups in the study sample.

Audiological group included 47 patients with somatosensory tinnitus. Overall, a TMD disorder was diagnosed in 46 patients (97.8%), including TMJ noise in 37 (78.7%), clenching in 41 (87.2%) and pain in 7 (14.8%) patients.

Stomatological group included 50 patients with TMD, including joint noise in 32 (64.0%), clenching in 28 (56.0%) and TMJ pain in 42 (84.0%) patients. A somatosensory tinnitus was diagnosed in 12 (24.0%) patients.

As reported in Table 1, the statistically significant difference in the prevalence of tinnitus between the two groups was related to the study construction, as the presence of tinnitus was the essential prerequisite for all patients in the Audiological group. The statistically significant difference in the prevalence of joint pain between the two groups also seemed to be related to the patient provenance, that is if the patient was first admitted to the stomatologic clinic or referred to it from the audiological clinic.

On the contrary, the prevalence of TMJ noise did not reach a statistical significance but was extremely high in both groups.

At least one of TMJ disorder was observed in 97.9% of the audiological patients but, in this group, the functional limitation criteria were always absent.

Regarding the parafunctional habit, clenching was observed to be statistically significant more evident in the audiological group compared to the stomatognathic group ($p = .0001$).

4 | DISCUSSION

The main result of our study was the high prevalence of TMD (97.8%) in patients with tinnitus not explained by hearing and neurologic disorders. Although it is known that the prevalence of tinnitus is higher in patients with TMD compared to general population,⁷⁻¹² the reported range of prevalence is extremely wide, ranging from 3.7% to 76.0%.¹⁴⁻¹⁸ Finally, the distribution of specific TMD symptoms was different between patients first evaluated at the stomatologic clinic and those referred to it after evaluation at the audiological clinic for tinnitus. Therefore, in our opinion, the great variability of association between tinnitus and TMD reported in the literature could be partly explained by selective admission of patients only to stomatologic or audiological clinics, as well as the inclusion of distinct types of tinnitus in different studies. Indeed, a flow chart for somatosensory tinnitus has been primarily created as a tool for otorhinolaryngologists and audiologists who always have access to their patients' hearing thresholds, while it could be less useful in other clinical contexts.²⁵

The neurophysiological pathway of somatosensory tinnitus explains the high prevalence of tinnitus in patients with TMD^{8,11,12} in which the increased muscle tension in the masticatory muscles or pressure on myofascial trigger points, present in TMD, could evoke or modulate the tinnitus.¹³

Interestingly, our study shows a high prevalence of TMJ noise in patients with somatosensory tinnitus while, on the contrary, joint pain was more common in patients first evaluated at the stomatologic clinic. This data could suggest a major role for the large diameter

compared to small diameter nerve fibres in evoking or modulating the somatosensory tinnitus.²⁶

Furthermore, high prevalence of pain in the stomatognathic group might confirm the hypotheses that TMD training centres have different groups.

In fact, the occurrence of somatosensory tinnitus in patients presenting with TMD symptoms also resulted unexpectedly lower than in the other group (24.0%). A reason might be that a subclinical TMD was often detected only by physician examination in patients with tinnitus by the audiologists who could exclude other tinnitus causes.

Our study presents several limitations. First, the number of patients included in the study is relatively small. Second, we largely rely on self-reported information since no objective specific test is available for most tinnitus cases.²⁷⁻²⁹ Finally, we did not perform specific tests such as electromyography of neck muscles, which can demonstrate altered activity in patients with TMD,³⁰ to investigate a possible cervical spine dysfunction as concurrent cause of somatosensory tinnitus. For this reason, larger sample studies to evaluate the role of specific TMD symptoms in evoking or modulating the tinnitus are indicated.

Future studies are also needed to better investigate the influence of different subgroups explaining the prevalence of tinnitus by providing in a stomatological setting screening audiological tools.

AUTHOR CONTRIBUTIONS

Conceptualization, A.M.C. and H.D.; Methodology A.M.C. and H.D.; Software, M.M.P., A.H.D., M.C. V. T., M.A. and G.B.; Data curation, F.S. and G.D.B., writing-original draft preparation A.M.C.; writing-review and editing, A.M.C., H.D., F.D.B. and F.S.; Visualization, M.P.C., A.B.G., E.I., G.L., S.B., D.Z. and F.A.; Supervision, A.M.C., H.D. and F.D.B. All authors have read and agreed to the published version of the manuscript.

CONFLICT OF INTEREST STATEMENT

The authors declared no conflict of interest.

PEER REVIEW

The peer review history for this article is available at <https://www.webofscience.com/api/gateway/wos/peer-review/10.1111/joor.13541>.

DATA AVAILABILITY STATEMENT

The data presented in the study are available on request from the corresponding author.

ORCID

H. A. Didier  <https://orcid.org/0000-0002-9740-6538>

A. M. Cappellari  <https://orcid.org/0000-0003-2530-0846>

F. Sessa  <https://orcid.org/0009-0005-6735-4625>

A. B. Gianni  <https://orcid.org/0000-0002-5983-9674>

A. H. Didier  <https://orcid.org/0000-0002-4563-1805>

M. M. Pavesi  <https://orcid.org/0000-0002-0143-8093>

M. P. Caria  <https://orcid.org/0009-0003-2835-4644>

- M. Curone  <https://orcid.org/0000-0003-3874-2790>
- V. Tullo  <https://orcid.org/0009-0005-0748-7311>
- F. Di Bernardino  <https://orcid.org/0000-0001-7514-5624>
- E. Iacona  <https://orcid.org/0000-0003-1171-8555>
- G. Lilli  <https://orcid.org/0000-0002-6109-5037>
- S. Barozzi  <https://orcid.org/0000-0002-4574-2193>
- M. Aldè  <https://orcid.org/0000-0002-5511-8511>
- G. De Bortoli  <https://orcid.org/0009-0003-6149-8885>
- D. Zanetti  <https://orcid.org/0000-0002-8116-4108>
- F. Arnone  <https://orcid.org/0009-0005-3218-0442>
- G. Bussone  <https://orcid.org/0009-0005-5710-2256>

REFERENCES

- De Ridder D, Schlee W, Vanneste S, et al. Tinnitus and tinnitus disorders: theoretical and operational definitions (an international multidisciplinary proposal). *Progress in Brain Research*. Vol 260. Elsevier; 2021.
- Mohan A, Leong SL, de Ridder D, Vanneste S. Symptom dimensions to address heterogeneity in tinnitus. *Neurosci Biobehav Rev*. 2022;134:104542.
- Shargorodsky J, Curhan GC, Farwell WR. Prevalence and characteristics of tinnitus among US adults. *Am J Med*. 2010;123:711-718.
- Langguth B, Kreuzer PM, Kleinjung T, De Ridder D. Tinnitus: causes and clinical management. *Lancet Neurol*. 2013;12:920-930.
- Cederroth CR, Gallus S, Hall DA, et al. Towards an understanding of tinnitus heterogeneity. *Front Aging Neurosci*. 2019;11:53.
- Hall DA, Haider H, Szczepek AJ, et al. Systematic review of outcome domains and instruments used in clinical trials of tinnitus treatments in adults. *Trials*. 2016;17:270.
- Levine RA. (1999) somatic (craniocervical) tinnitus and the dorsal cochlear nucleus hypothesis Levine RA, Oron Y tinnitus. *Handb Clin Neurol*. 2015;129:409-431. doi:10.1016/B978-0-444-62630-1.00023-8
- Van der Wal A, Michiels S, Van de Heyning P, et al. Reduction of somatic tinnitus severity is mediated by improvement of temporomandibular disorders. *Otol Neurotol*. 2022;43(3):e309-e315.
- Kanold PO, Young ED. Proprioceptive information from the pinna provides somatosensory input to cat dorsal cochlear nucleus. *J Neurosci*. 2001;21:7848-7858.
- Michiels S, Ganz Sanchez T, Oron Y, et al. Diagnostic criteria for somatosensory tinnitus: a delphi process and face-to-face meeting to establish consensus. *Trends Hear*. 2018;22:2331216518796403.
- Manfredini D, Olivo M, Ferronato G, Marchese R, Martini A, Guardanardini L. Prevalence of tinnitus in patients with different temporomandibular disorders symptoms. *Int Tinnitus J*. 2015;19:47-51.
- Lam DK, Lawrence HP, Tenenbaum HC. Aural symptoms in temporomandibular disorder patients attending a craniofacial pain unit. *J Orofac Pain*. 2001;15:146-157.
- Sanchez TG, Rocha CB. Diagnosis and management of somatosensory tinnitus: review article. *Clinics (Sao Paulo)*. 2011;66:1089-1094.
- Skog C, Fjellner J, Ekberg E, Häggman-Henrikson B. Tinnitus as a comorbidity to temporomandibular disorders-a systematic review. *J Oral Rehabil*. 2019;46(1):87-99. doi:10.1111/joor.12710
- Chole RA, Parker WS. Tinnitus and vertigo in patients with temporomandibular disorder. *Arch Otolaryngol Head Neck Surg*. 1992;118(8):817-821. doi:10.1001/archotol.1992.0188008039010
- Gelb H, Gelb ML, Wagner ML. The relationship of tinnitus to cranio-cervical mandibular disorders. *Cranio*. 1997;15(2):136-143. doi:10.1080/08869634.1997.11746004
- Tuz HH, Onder EM, Kisnisci RS. Prevalence of otologic complaints in patients with temporomandibular disorder. *Am J Orthod Dentofacial Orthop*. 2003;123(6):620-623. doi:10.1016/s0889-5406(03)00153-7
- Bernhardt O, Gesch D, Schwahn C, et al. Signs of temporomandibular disorders in tinnitus patients and in a population-based group volunteers: results of the study of health in Pomerania. *J Oral Rehabil*. 2004;31(4):311-319. doi:10.1046/j.1365-2842.2003.01249.x
- Ralli M, Greco A, Cialente F, et al. Somatic tinnitus. *Int Tinnitus J*. 2017;21(2):112-121. doi:10.5935/0946-5448.20170022
- Bousema EJ, Koops EA, van Dijk P, Dijkstra PU. Association between subjective tinnitus and cervical spine or temporomandibular disorders: a systematic review. *Trends Hear*. 2018;22:2331216518800640.
- Schiffman E, Ohrbach R, Truelove E, et al. International RDC/TMD consortium network, international association for dental research; orofacial pain special interest group, International Association for the Study of Pain. Diagnostic criteria for temporomandibular disorders (DC/TMD) for clinical and research applications: recommendations of the international RDC/TMD consortium network* and orofacial pain special interest group†. *J Oral Facial Pain Headache*. 2014;28(1):6-27.
- Schiffman E, Ohrbach R. Critical commentary 2: reliability and validity of the DC/TMD Axis I. *J Oral Facial Pain Headache*. 2018;32:22-24.
- Gil-Martínez A, Paris-Alemán A, López-de-Uralde-Villanueva I, La Touche R. Management of pain in patients with temporomandibular disorder (TMD): challenges and solutions. *J Pain Res*. 2018;11:571-587.
- Michiels S, Naessens S, van de Heyning P, et al. The effect of physical therapy treatment in patients with subjective tinnitus: a systematic review. *Front Neurosci*. 2016;10:545.
- Michiels S, Cardon E, Gilles A, et al. The rapid screening for somatosensory tinnitus tool: a data-driven decision tree based on specific diagnostic criteria. *Ear Hear*. 2022;43(5):1446-1471.
- Misra UK, Kalita J, Nair PP. Diagnostic approach to peripheral neuropathy. *Ann Indian Acad Neurol*. 2008;11(2):89-97.
- Calixtre LB, Grüniger BL, Haik MN, Albuquerque-Sendin F, Oliveira AB. Effects of cervical mobilization and exercise on pain, movement and function in subjects with temporomandibular disorders: a single group pre-post test. *J Appl Oral Sci*. 2016;24(3):188-197.
- McFerran DJ, Stockdale D, Holme R, Large CH, Baguley DM. Why is there no cure for tinnitus? *Front Neurosci*. 2019;13:13-802.
- Attanasio G, Leonardi A, Arangio P, et al. Tinnitus in patients with temporomandibular joint disorder: proposal for a new treatment protocol. *J Craniomaxillofac Surg*. 2015;43(5):724-727.
- Armijo-Olivo S, Silvestre RA, Fuentes JP, et al. Patients with temporomandibular disorders have increased fatigability of the cervical extensor muscles. *Clin J Pain*. 2012;28:55-64.

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