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Temporomandibular Disorders and Bruxism in Patients Attending a Tinnitus Clinic

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Abstract: The current study investigated the coexistence of temporomandibular disorder (TMD) and/or bruxism among 51 individuals seeking treatment in a tinnitus clinic. All participants completed a Hebrew version of the Tinnitus Handicap Inventory (THI), depression and anxiety questionnaires, and the diagnostic criteria TMD (DC/TMD) questionnaire. In addition to questionnaires, the participants underwent a clinical evaluation of the oral cavity, facial muscles, and the temporomandibular joint (TMJ). Thirty-four participants (66.7%) were diagnosed with bruxism, while TMD was found in 14 (27.5%) of the cases. Patients with both tinnitus, TMD and bruxism scored the highest in the anxiety questionnaire. The severity of depression was found to be significantly associated with the tinnitus severity. These results emphasize the clinical bond between tinnitus, TMD, and bruxism.

Keywords: bruxism; TMD; tinnitus

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1. Introduction

Temporomandibular disorder (TMD) refers to the whole range of disorders involving the masticatory muscles, the temporomandibular joint (TMJ), and nearby structures [1]. It occurs in approximately 5–12% of the population, and about 50–60% of individuals with TMJ disorders will seek treatment [2]. TMD affects mostly women, especially those aged 20–45 years, and represents the main reason for facial pain caused by non-odontogenic reasons [3]. A patient presenting with TMD characteristically feels pain in the head, face, ear, or teeth, and may exhibit TMJ dysfunction, such as limited mouth opening, TMJ clicking, and functional discomfort. The etiology of TMD is multifactorial, involving genetics, biology, environmental reasons, cognition, emotional and psychological distress, age, sex, and habits, such as smoking or teeth clenching [4]. The most common clinical signs include chronic myofascial pain of the masticatory muscles, and limited mouth opening [5]. TMD can occur concomitantly with chronic tension headaches, migraine headaches, fibromyalgia/generalized pain, lower back pain, autoimmune diseases, sleep apnea, and psychiatric disorders [6].

Clicking sounds originating from the TMJ are generated during mouth opening, closing, or movement. The sound derives from the extension of the condylar head over the edge of a displaced articular disc. When clicking is objectively verified by the examiner, further investigation is warranted to evaluate the occlusion, joints, and the masticatory muscles [7], although clicking alone does not increase the risk of developing TMJ pain [8].

TMD is often diagnosed by the Diagnostic Criteria for TMD (DC/TMD) or the Research Diagnostic Criteria for TMD (RDC/TMD) from which the DC/TMD had originated. DC/TMD is composed of Axis I, which provides physical information, including articular information (e.g., TMJ disc displacement) and extra-articular information (e.g., facial

myalgia), and Axis II which provides psycho-social information (e.g., anxiety) [6]. Axis II is especially relevant to the current study because of the observed overlap of the reported psychological factors contributing to TMD and tinnitus [3].

Bruxism is a repetitive uncontrolled parafunction consisting of excessive and abnormal activation of the TMJ, the jaws, and the masticatory muscles (especially the temporalis and the masseter muscles), such as clenching or grinding of the teeth by bracing or thrusting of the mandible. It is argued that bruxism should not be considered a disorder but rather a risk factor for oral health because it is a behavior that may or may not increase the risk for chronic muscular pain, TMJ pain and disc disorder, teeth wear or destruction, and TMD [9]. There are two types of bruxism, sleep and awake [10]. Sleep bruxism, whose prevalence is 8% among the adult population, originates in the brainstem by the reticular ascending system's increasing the activity of the motor and autonomic systems of the masticatory muscles [11]. Awake bruxism, which is prevalent in 20% of the population, is strongly related to stress and anxiety. Little is known about its physiology and pathophysiology, but stress, anxiety, and low socioeconomic status have been considered risk factors. Unlike sleep bruxism, which is mostly characterized by teeth grinding, awake bruxism is usually associated with jaw clenching, making its diagnosis more complicated signs are not always apparent, such as the absence of dental wear [12–16]. The diagnosis of bruxism is problematic since it is based upon medical history and examination. Not all patients are aware of their parafunctions and oral behaviors, nor do they all present with definitive signs of the condition. Specifically, a hallmark of bruxism is dental wear, but clenching and bracing of the jaws, while causing pain, do not necessarily cause teeth wear. The impression of the teeth on the tongue is called "indentations", this is also a sign of bruxism. According to numerous studies, awake bruxism is more prevalent in women, while no sex-related differences have been shown for sleep bruxism in either children or adults [13–19]. In 2018 a report of "work in progress" to establish a consensus regarding bruxism had offered a grading system with respect to bruxism: 1. Possible bruxism (based on self-report), 2 Probable bruxism (based on clinical examination with or without self-report), 3 Definite Bruxism (based on instrumental assessment with or without self-report and/or clinical assessment). Instrumental diagnosis of definite bruxism is not a readily available clinical test nor is it standardized hence bruxism in this study is graded a "Probable Bruxism" [20].

Tinnitus is defined as a sound that is perceived in the absence of real acoustic stimuli. Patients may describe a variety of sounds [21]. Objective tinnitus can also be heard by the examiner, and the sound is often caused by a noise created in the patient's body such as jaw clicking or blood vessel malformation. Subjective tinnitus is perceived only by the patient [22]. Some patterns of tinnitus have a somatic component: this kind of tinnitus is directly influenced by the upper somatosensory system of the cervical and head area. Consequently, activating this system via muscle contractions of the head and neck can lead to either modulating ongoing tinnitus perception, occurring in 80% of the cases, or arousing sounds that might be considered as tinnitus, occurring in 50% of the cases of people not presenting with tinnitus [23]. The phenomenon of somatic tinnitus was explained physiologically. According to Levine et al. (2007), afferent fibers conveying the temporomandibular somatosensory to the brain (which are projecting from the trigeminal ganglion), also project on their way to the central auditory system since they are adjacent and overlapping. This explains why the auditory system is influenced by the somatosensory system causing what is called tinnitus [24]. TMD and tinnitus are two different medical conditions which derive from two anatomically separate yet adjacent structures, the TMJ and the ear. This proximity might suggest their co-occurrence. According to the somatosensory tinnitus theory, the communication between these structures relates to the dorsal cochlear nucleus [21]. The somatosensory tinnitus theory was first described by Levine in 1999, according to which, the DCN is disinhibited due to somatosensory input [25]. Since then, numerous studies have shown that this theory is clinically valid, although no neuroanatomical study was published. Tinnitus and TMD were reported to significantly co-occur. Mijiritsky et al. [3] found that 30.6% of the patients presenting with TMD reported

tinnitus as well. Other studies demonstrated rates of co-occurrence of TMD and tinnitus ranging between 8–25% [26]. Bruxism has also been shown to be related to the severity of tinnitus, and chronic facial pain was higher among patients presenting with both sleep bruxism and tinnitus [27].

The current study aimed to investigate the prevalence and correlation of coexisting TMD and bruxism among patients presenting to the tinnitus clinic in a tertiary medical center, and evaluate the effect of these medical conditions on the patients' mood.

2. Materials and Methods

2.1. Study Sample

The study sample consisted of 51 consecutively treated patients who attended a tinnitus clinic at a tertiary referral center. The sample included 24 females (47.1%) and 27 males (52.9%), aged 23 to 77 years old. Inclusion criteria were as follows: presence of tinnitus for at least 6 months as reported by a patient; diagnosis of tinnitus based on physical and an audiometric examination by a single examiner; age $\geq$ 18 years old; males and females. Exclusion criteria included the following: presence of vestibular schwannoma diagnosed on MRI scan when was suspected; other tumors in the head and neck area; past radiation treatment in the region of the head and neck; a history of facial bone trauma; previously diagnosed TMJ pathology; pulsatile tinnitus; age < 18 years old; inability to respond questionnaires for any reason. If a patient was found to be in need of a mental health care, a referral was made. The study was approved by the ethical review board. All the participants agreed to participate and signed informed consent.

2.2. Tinnitus Severity and Side

To quantify the severity of the tinnitus, each patient was asked to complete the Tinnitus Handicap Inventory (THI) questionnaire which were translated and validated into Hebrew version [28]. The THI score evaluates tinnitus severity on a scale of 0 to 100. The severity of tinnitus was classified in to five grades based on the THI score: (1) grade 1—no handicap or slight tinnitus, were diagnosed when the score received value between 0 and 16; (2) grade 2—mild tinnitus, when the score was between 18 and 36; (3) grade 3—moderate tinnitus, when the score received value between 38 and 56; (4) grade 4—severe tinnitus, when the score received value between 58 and 76; and (5) grade 5—catastrophic tinnitus, when the score was between 78 and 100. The side of tinnitus appearance was classified into three groups: (1) right side only, (2) left side only, and (3) both sides.

2.3. Depression and Anxiety Severity

To evaluate the severity level of depression and anxiety the participants were asked to complete the Beck's Depression Inventory (BDI) [29] and the State Anxiety Inventory (SAI) [30] questionnaires. The BDI score evaluates depression severity on a scale of 0 to 63. Based on BDI score patients were classified into four groups of depression severity: (1) the person is not depressed, when the score was between 0 and 9; (2) mild-moderate depression, when the score was between 10 and 18; (3) moderate-severe depression, when the score was between 19 and 29; and (4) severe depression, when the score was over 30. The SAI score evaluates anxiety severity on a scale of 20 to 80. Based on the SAI score, patients were classified into three groups of anxiety severity: (1) no or low anxiety, when the score was between 20 and 37; (2) moderate anxiety, when the score was between 38 and 44; (3) high anxiety, when the score was over 45.

2.4. TMD and Bruxism Prevalence

TMD and bruxism were diagnosed based on both patients' response to DC/TMD criteria (Axis 1 and Axis 2) [5] and a clinical evaluation (by a single physician) which included the following: (1) TMJ (e.g., clicking, movement evaluation, maximum mouth opening), (2) masticatory muscles sensitivity during palpation, (3) dental wear of the teeth, (4) soft tissue of the oral cavity, (e.g., presence of teeth indentations on the tongue, linea

alba signs over the buccal mucosae). No distinction was made between "Sleep Bruxism" or "Awake Bruxism" in this study. TMD and bruxism prevalence among population suffering from tinnitus was calculated.

2.5. Statistical Analysis

The data were recorded and analyzed using the SPSS software package (Statistical package for Social Sciences, Version 20.0, SPSS, Inc., Chicago, IL, USA). Patient's age, THI, BDI and SAI scores were distributed normally. Assessment of normal distribution was based on a one-sample Kolmogorov–Smirnov test. An independent samples *t*-test was carried out to identify significant differences in age, THI score between sexes. Mann–Whitney test was run to find the differences in THI severity levels between sexes. A Pearson correlation analysis was carried out to detect any association between age and THI score. A Chi-square test was carried out to detect any association between tinnitus side and sex/tinnitus severity, bruxism/TMD presence and sex, clicks presence and sex. A one-way ANOVA test was carried out to detect significant differences in THI, BDI and SAI scores between the TMD/bruxism groups. Post hoc multiple comparisons were carried out to detect significant differences between the groups. Linear regression analysis using enter method was carried out to reveal factors associated with tinnitus severity, when THI score was set as dependent variable. The level of statistical significance was set at $p < 0.05$.

3. Results

3.1. Demographic Features of the Study Sample

The study sample included 51 patients: 27 males (52.9%) and 24 females (47.1%). The mean age was 51.26 ± 17.97 years (range 21–86 years). The mean age did not significantly differ between the genders and was 49.88 ± 18.20 years for males and 52.75 ± 17.98 years for females ($p = 0.578$).

3.2. Tinnitus Severity by Gender and Age

The mean THI score for the studied sample was 50.51 ± 27.43 with a range of 2–100. In males, the mean THI score was 51.41 ± 29.22, whereas in females it was 49.50 ± 25.85. No significant difference was found between the genders ($p = 0.807$). Most females (37.5%) described severe level of tinnitus, whereas in males, catastrophic level of severity was found to be the most frequent (29.6%) with no significant difference between the genders ($p = 0.771$) (Figure 1).

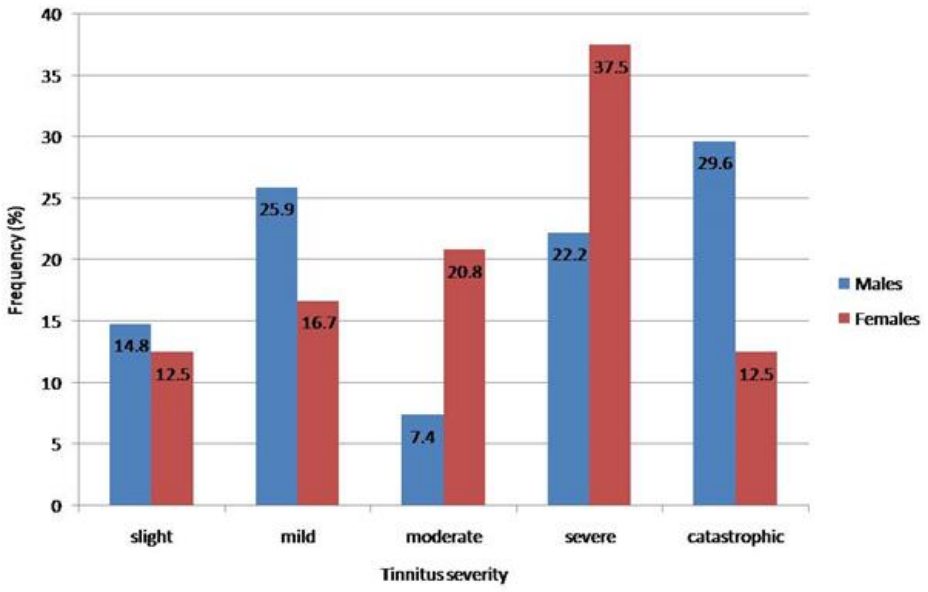

Figure 1. Frequency of tinnitus severity levels in males (blue) and females (red).

A significant negative association was found between patient's age and THI score ($r = -0.293$, $p = 0.039$), namely the milder tinnitus severity levels were found in older patients.

3.3. Tinnitus Side

In most of the cases tinnitus involved both sides (right and left) (72.5% in the combined sample) (Figure 2). No significant differences were found in tinnitus side appearance between the genders ($p = 0.112$). Additionally, no significant difference was found between the severity levels of tinnitus and its uni/bilateral appearance ($p = 0.929$).

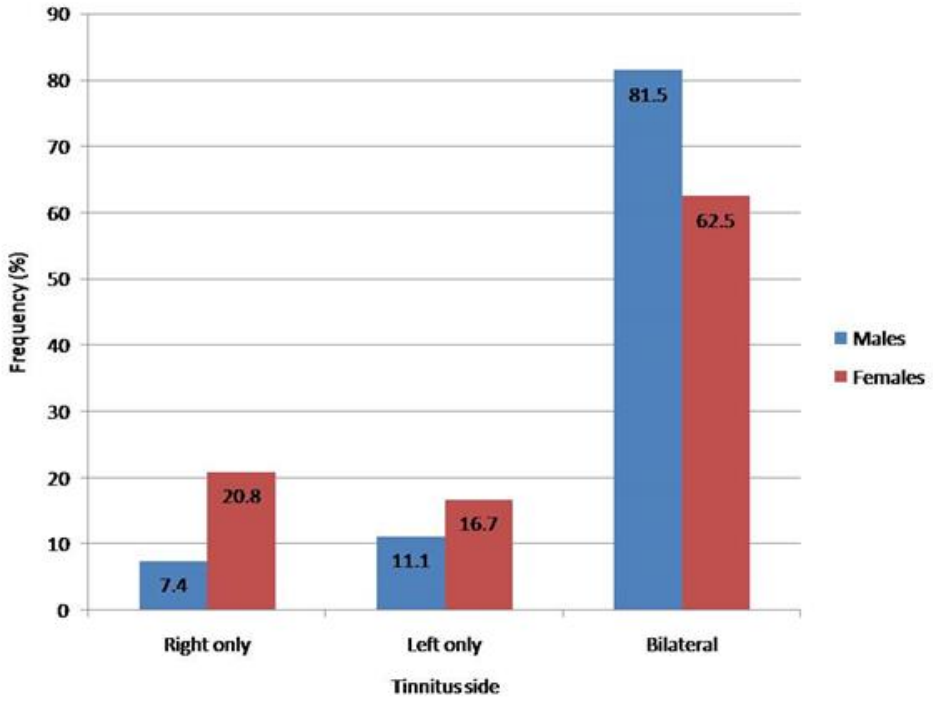

Figure 2. Frequency of tinnitus appearance by its side, in males (blue) and females (red).

3.4. Prevalence of Bruxism and TMD

About 2/3 of the studied sample (66.7%) was diagnosed with bruxism, while TMD was found in 27.5% of the cases (Table 1). No significant differences were found in bruxism and TMD prevalence between the genders ($p > 0.234$) (Table 1). The majority of TMD cases (92.8%) were also diagnosed with bruxism. Only 31.4% of the whole sample (20.8% of females, 40.7% of males) were not diagnosed with TMD and bruxism (Figure 3).

Table 1. Prevalence of bruxism and TMD by gender.

Diagnosis	Gender	*n*	Prevalence (%)	*p*-Value
Bruxism	Male	16	59.3	0.234
	Female	18	75.0	
	Total	34	66.7	
TMD	Male	8	29.6	0.712
	Female	6	25.0	
	Total	14	27.5	

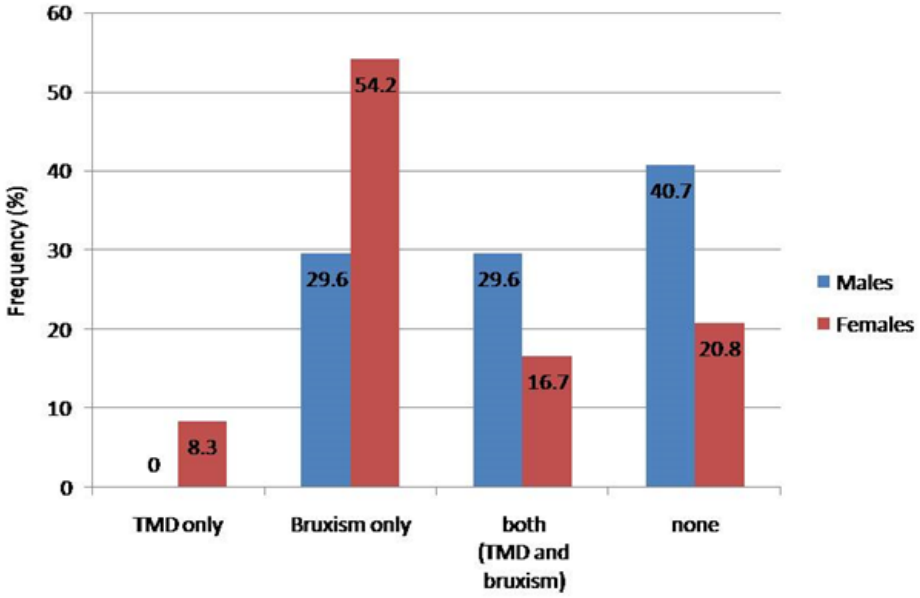

Figure 3. Prevalence of TMD/bruxism among studied sample.

3.5. Tinnitus/Depression/Anxiety Scores and TMD/Bruxism

THI, BDI and SAI scores were compared between three groups of the patients classified according to their diagnosis with tinnitus only, tinnitus and either TMD or bruxism, tinnitus and both TMD and bruxism. Significant difference was found in SAI scores between the groups ($p = 0.045$) (Table 2). Patients diagnosed with tinnitus and both TMD and bruxism had significantly higher SAI score (mean = 49.17) compared with patients having only tinnitus (mean = 38.75) ($p = 0.037$, Post Hoc analysis). No statistically significant difference was found in THI and BDI scores between the three of the groups ($p > 0.260$) (Table 2). Yet, there was a tendency for all of the studied scores to increase with increased number of TMD/bruxism diagnoses, namely, the tinnitus only group scored the lowest, tinnitus combined with both TMD and bruxism scored the highest (Figure 4). This was especially evident regarding the THI score and the SAI score.

Table 2. Descriptive statistics for the THI, BDI and SAI scores in tinnitus only, tinnitus combined TMD or bruxism, and tinnitus combined TMD and bruxism groups.

Severity Scores	TMD/Bruxism Diagnosis *	*n*	Mean	±SD	*p*-Value #
THI (tinnitus)	Single	23	49.22	25.504	0.829
	Both	12	54.83	30.361	
	None	16	49.13	29.285	
BDI (depression)	Single	23	8.48	6.251	0.260
	Both	12	13.17	13.790	
	None	16	8.13	7.210	
SAI (anxiety)	Single	23	42.00	10.353	**0.045**
	Both	12	49.17	11.731	
	None	16	38.75	10.459	

THI: Tinnitus Handicap Inventory; BDI: Beck's Depression Inventory; SAI: State Anxiety Inventory; SD: Standard Deviation. * Three diagnosis groups: "Single"—tinnitus combined with single TMD or bruxism; "Both"—tinnitus combined with both TMD and bruxism; "None"—tinnitus only. # Significant values are denoted in bold.

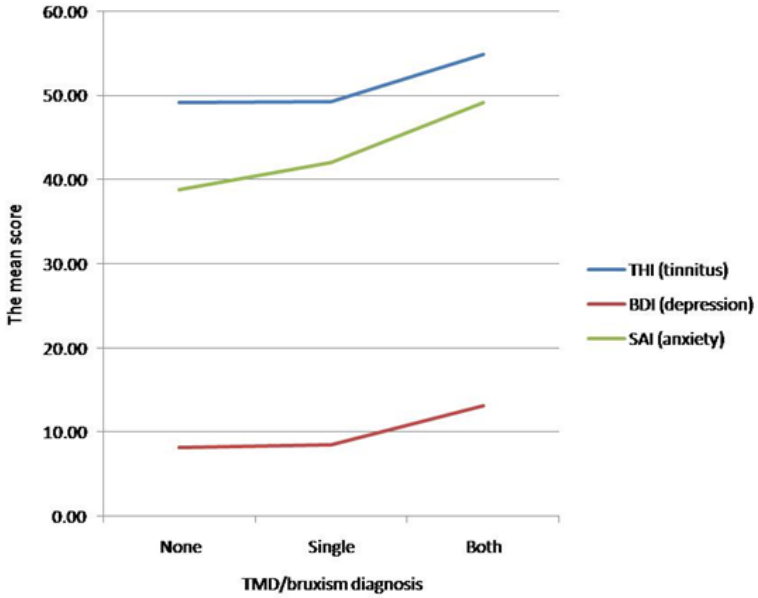

Figure 4. Graphical presentation of the mean THI, BDI and SAI scores in three TMD/bruxism groups.

3.6. TMJ Clicking

TMJ clicking was detected in 70.59% of the cases (Table 3), with no statistically significant difference between the genders ($p = 0.09$). Only in eight of the patients ($n = 6$ females, $n = 2$ males) with unilateral tinnitus TMJ click was detected on the same side.

Table 3. Clicks prevalence among the studied sample, by gender.

Diagnosis	Gender	*n*	%
Clicks	Male	22	81.48
	Female	14	58.33
	Total	36	70.59
No clicks	Male	5	18.52
	Female	10	41.67
	Total	15	29.41

3.7. Factors Associated with Tinnitus Severity

Depression severity, tongue indentations and TMD/bruxism diagnosis were found to be significantly associated with the tinnitus severity (Table 4). The regression model succeeds to explain almost 46.9% (adjusted $R^2 = 0.439$, $R = 0.72$) of tinnitus severity variance ($p < 0.0001$), when depression was found to be a significant predictive factor of the variance.

Table 4. Model summary and coefficients for THI score prediction.

Variable	Standardized Coefficients	*p*-Value *
Gender	0.045	0.695
Age	−0.196	0.089
Depression score	0.524	**0.001**
Anxiety score	0.171	0.234
Dental wear	0.119	0.371
Tongue indentations	0.323	**0.025**
TMD/Bruxism	0.291	**0.027**

* Significant values are denoted in bold.

4. Discussion

The study sample included 51 patients diagnosed as having tinnitus. Most of them (34/51, 66.6%) were diagnosed as having coexisting probable bruxism according to the

findings of a comprehensive clinical examination and a questionnaire-based evaluation. The study also demonstrated a 25% prevalence (13/51 patients) of the coexistence of tinnitus, TMD, and probable bruxism, and a 27% prevalence (14/51 patients) of the coexistence of tinnitus and TMD in the study population. This rate is higher than the prevalence of TMD in the general adult population (5–12%) as reported by the National Institute of Dental and Craniofacial Research [2]. Similarly, while the reported prevalence of bruxism in the adult population is 8–20% [15–18], we found a prevalence of 66% of bruxism among the study sample of individuals with tinnitus, which is 3 to 8 times higher than the rate in the general population. The findings in this study underpin Levine's theory regarding somatic tinnitus [25], although no neuroanatomical study was published. It might be suggested that earlier studies have used a wide variety of criteria for the diagnosis of TMD and of bruxism, among them: self-reporting, the presence of jaw clicking and dental wear, limited mouth opening, TMJ clicking, and functional discomfort. We accepted evidence from both self-reporting and clinical findings to overcome those shortcomings.

Patients with both tinnitus, TMD and bruxism scored the highest in the SAI score. It may very well be that their higher levels of anxiety are manifested through TMD and bruxism. Although it is well known that anxiety levels are indeed higher among tinnitus patients [31], this specific finding underscores the need for an evaluation by muti-disciplinary team, so that neither of the co-morbidities will be missed.

Another important finding is the correlation between tinnitus severity and depression. This is yet another example of the implication tinnitus may have on patients' quality of life. It emphasizes the need to assess such patients with vigilance, and to involve, if needed, mental health specialists.

Mijiritsky et al. queried patients presenting with TMD if they had tinnitus, and 30.6% replied in the affirmative [3]. This rate is higher than the prevalence of tinnitus in the general adult population. In the current study, we evaluated the patients with tinnitus weather they had TMD and/or bruxism and found similarly high rates. The overlap between the findings of the two separate studies, evaluating the relation between tinnitus, TMD, and bruxism, each from the opposite axis implies a genuine relationship between the disorders. However, given that the diagnosis of each of the three are not clear-cut, conclusions should be made with caution, and even more so since the diagnosis of TMD according to DC/TMD Axis 1 is largely related on the examiner's judgement of the severity of the signs and symptoms.

One of the most intriguing findings in the study was that 8 of the 14 (57%) patients who complained of unilateral tinnitus had unilateral and ipsilateral objective jaw clicking. This finding supports Levine et al.'s suggestion that somatic tinnitus is triggered by the somatosensory system [24].

Bruxism is thought to be related to stress and anxiety, and tinnitus was also found to co-occur with diagnosed depression and anxiety [32]. This overlap might explain why we did not find a significant difference in anxiety and depression scores between patients presenting with both tinnitus and probable bruxism and/or TMD as opposed to patients presenting with tinnitus only, although we did find a difference in the degree of depression. There was also no significant difference in the THI score between those two groups, suggesting that the presence of TMD does not affect the intrusiveness caused by the tinnitus.

Another interesting finding is the tendency for all of the studied scores to increase with increased number of TMD/bruxism diagnoses. This emphasizes the relation between TMD, bruxism and tinnitus on the one hand, and the intrusiveness of the tinnitus, and their effect on the mood on the other hand. A patient with TMD and bruxism on top of tinnitus is therefore expected to be more affected by the tinnitus, as measured by the THI score, and be more depressed and anxious. This may have implications on the management of such patients, as they may need to be further evaluated by mental health specialists.

The paper presents a series of tinnitus patients who were specifically screened for the co-existence of TMD and bruxism. The purpose of this study was to investigate the

relationship these diagnoses among tinnitus patients. Only a few papers investigated this prevalence in a tinnitus clinic with standardized tools, and almost all of them did not investigate bruxism.

Most of the data in the current study were collected during the COVID-19 era (2020–2021), during a long lockdown period. This fact might have influenced the data collected in the study, since people might not have shown up for clinics as they would in a non-pandemic time. Patients might have underestimated or overestimated their symptoms hence changing their physician visitation routines, and their responses to the clinical examinations and the evaluation questionnaires. According to a study carried out in the early pandemic era, tinnitus symptoms worsened in patients with pre-existing tinnitus in 40% of respondents as a result of the pandemic [33]. The pandemic has resulted in deterioration in mental health status, thus, increase in depression and anxiety levels among a wide variety of individuals (e.g., people who were worried from being infected by the virus, people who were concerned by not being able to work from home) [34]. Consequently, this fact might have resulted in an overestimation of the depression and anxiety levels as reported in the questionnaires. In addition, studies have demonstrated an increase in Bruxism and in TMD during the COVID 19 pandemic. According to a study carried out in 23 maxillofacial departments in Italy, all maxillofacial activity has been reduced because of the pandemic [35–37]. The current study has a few limitations. First, the sample of 51 patients is relatively small and precludes definite conclusions. Second, the patients included in the study sample were seeking a solution for their tinnitus at a specialized clinic. This led to a skewed presentation of the TMD population. Third, as described by Manfredini [11] TMD is an umbrella term embracing different disorders. Therefore, future research should distinguish between subtypes of TMD and the correlation between them, TMD, and tinnitus. Fourth, we did not have a control group for comparison. At the same time, each participant underwent a comprehensive clinical examination of the head, TMJ, neck, and oral cavity, and completed the THI, Beck's Depression Inventory, the State Anxiety Inventory, and the DC/TMD questionnaire. All diagnoses of TMD and bruxism were made according to the DC/TMD Axis 1 and Axis 2 criteria in combination with the clinical examination and the self-reports.

5. Conclusions

The findings of this study demonstrated that clinical relations of both TMD and bruxism in patients suffering from tinnitus clinic are evident, and may have additional effects on the patients' well-being. These findings reinforce the need to educate and elevate the level of awareness among the ENT clinicians, as well as the dental surgeons, oral medicine, maxillofacial surgeons, and health care specialists, regarding the co-existence of tinnitus, TMD and/or bruxism, to bear in mind, and look for it, to avoid misdiagnoses. A patient with tinnitus should therefore be evaluated by a multidisciplinary team.

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