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Tinnitus in patients with orofacial complaints

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Abstract

Background This study explored subjective tinnitus frequency in patients referred to an interdisciplinary orofacial pain clinic using the "web-based interdisciplinary symptom evaluation" (WISE) tool, which included a wide range of psychometric data. Our goal was to analyze the correlation between orofacial complaints and tinnitus, as well as their association with other psychometric data—an approach that, to our knowledge, has not been undertaken to this extent before.

Methods From 2017 to 2020, we analyzed 1369 anonymized patient records using completed WISE. This included diverse questionnaires and symptom-related screener questions. Positive screening responses triggered additional assessments, such as short Tinnitus Handicap Inventory (THI-12) and Patient Health Questionnaire 4 (PHQ-4). Ear symptoms, tinnitus severity and tinnitus frequency were evaluated. Furthermore, Spearman correlations were performed with other questionnaires addressing pain, anxiety, depression, health, stress and insomnia.

Results Among 1369 patients with orofacial complaints, 69% were female. Notably, 19.7% (269) completed THI-12 due to severe ear symptoms; of these, 62.1% were female. Female mean THI-12 score was significantly lower ($p = 0.007$) with 9.3 (SD = 7.0) compared to males 11.6 (SD = 6.8). Additionally, there was a significantly different gender distribution between all patients with tinnitus and those with severe tinnitus ($p = 0.032$), with an increased proportion of men in the latter group. THI-12 positively correlated with all WISE questionnaires, strongest with PHQ-4 ($p < 0.01$).

Conclusions Our study unveils a common co-occurrence of orofacial and ear complaints, particularly tinnitus. The practical implication of the observed gender differences suggests that in male patients presenting with orofacial pain, tinnitus and its associated distress should be actively addressed to initiate a multidisciplinary treatment approach.

Clinical trial number Not applicable.

Since this study was a retrospective analysis of anonymized data, trial registration was not necessary.

Keywords Tinnitus, Temporomandibular dysfunction, TMD, Somatosensory tinnitus, Orofacial complaint, WISE, Web-based interdisciplinary symptom evaluation

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Background

Patients with orofacial complaints, especially with symptoms of temporomandibular joint disorders (TMD), frequently report ear symptoms such as tinnitus, aural fullness, otalgia or ear pressure [1–3]. Both conditions, TMD and tinnitus are common conditions in the general population with prevalence rates of 18–31% [3–5] and 7.7–23.3% [6], respectively.

The close anatomical relationship of the masticatory muscles, the temporomandibular joint (TMJ) and anatomical structures of the ear (external auditory canal, middle ear, Eustachian tube) partially explains how certain symptoms can be linked to one another. A meta-analysis from 2016 [7] showed that TMD can lead to otologic complaints, such as aural fullness, otalgia or tinnitus. A first description of a possible relationship between tinnitus and TMD dates back to 1934 by Costen [8, 9]. Two relatively recent systematic reviews analyzed several studies and confirmed an association between TMD and tinnitus [1, 2].

Tinnitus is defined as the perception of sounds without the presence of an external acoustic stimulus [10] and can be divided into an objective and subjective tinnitus. An objective tinnitus is a sound that is caused by sound sources in the body and can sometimes be objectified by the examiner [11]. Objective tinnitus includes vascular sounds in arteriovenous malformation, blood vessel tumors and other vascular pathologies, or myoclonus of the ear respectively palatal muscles. Only a small percentage of tinnitus belong to the group of objective tinnitus, most forms of tinnitus are classified as subjective [12]. The etiology of subjective tinnitus is highly complex and the subject of ongoing research. Different models are used to explain the processes that can lead to the perception of subjective tinnitus [13–16]. In summary, it is assumed that after peripheral hearing loss, compensatory adaptations occur in the central auditory pathway. In the last instance, neuronal hyperactivity occurs in the central auditory cortex [17–21]. However, perception of this activity requires connections to other brain areas, such as the dorsolateral, prefrontal, and parietal cortex, as well as the amygdala and hippocampus [22–25]. These regions, part of the "non-classical pathways," are crucial for attention, awareness, emotion, and memory, influencing tinnitus perception and individual impairment [13, 14, 26–28].

A subgroup of subjective tinnitus is the so-called somatosensory or somatic tinnitus [29, 30]. This is a tinnitus condition, which is caused or modifiable in terms of perception by altered somatosensory afference from the TMJ area or cervical spine [31–35]. A systematic review reported weak evidence for an association between subjective tinnitus and cervical spine disorders, and a bidirectional relationship between tinnitus and TMD [1]. Cervical or temporomandibular somatosensory information such as touch, pain or temperature are transmitted to the brain via afferent fibers whose cell bodies are located in the dorsal root ganglia or in the trigeminal ganglion [30]. However, some of these afferents also project to the central auditory system and alter the synchrony or spontaneous rate of neuronal firing in the inferior colliculus, the cochlear nuclei, especially the dorsal cochlear nucleus, or the auditory cortex [32–36]. In animal models as well in the clinical situation, a somatosensory tinnitus can be modulated or rarely even induced by altered activity of the somatosensory afferents originating in the cervical spine or TMJ area [30, 37]. The existence of this connection is also supported by the fact that multidisciplinary treatments such as occlusal splints, physiotherapy, biofeedback or massage can have positive effects on the perception of tinnitus [8]. Among others this could be demonstrated in a randomized controlled trial studying the effect of orofacial treatment in patients experiencing somatosensory tinnitus [38]. To diagnose a somatosensory tinnitus, either voluntary movements or somatic maneuvers, ideally performed in a sound proof chamber, can usually modulate the tinnitus [31, 33, 39, 40]. However, a consensus meeting panel indicated that the absence of this modulation capacity does not exclude the diagnosis of a somatosensory tinnitus [33]. If a somatosensory tinnitus is suspected, a potential treatment approach might involve targeting the structures that modulate tinnitus. Possible therapies include body awareness training, massage, physiotherapy, occlusal splints, injections into the affected muscle groups, or local and systemic drug treatments such as analgesics or muscle relaxants [41].

Regarding the relationship between TMD and tinnitus, Mottaghi et al. demonstrated in a meta-analysis that the prevalence of tinnitus was significantly higher in individuals with TMD (ranging from 35.8% to 60.7%) compared to those without TMD (9.7% to 26%), with an odds ratio of 4.45 [2]. Additionally, there are indications that temporomandibular joint problems might influence the tinnitus-related distress [42]. In these cases with suspected somatosensory tinnitus, multidisciplinary patient care is the most efficacious treatment [43]. The Department of Otorhinolaryngology – Head and Neck Surgery of the University Hospital Zurich (USZ) has been collaborating closely with the Center of Dental Medicine of the University Zurich (UZH) in the field of tinnitus and possible TMD for over 10 years. This latter institution has a specialized interdisciplinary unit dedicated to the diagnosis and treatment of orofacial pain and dysfunction. Since the year 2017, patients who visit this consultation are assessed with a standardized, digital screening

questionnaire called WISE (web-based interdisciplinary symptom evaluation) [44]. This is an internet-based set of questionnaires that allows the clinic to schedule the initial consultations according to the identification of possible comorbidities. Due to the known correlation between orofacial and ear complaints, this set of questionnaires also includes the presence of tinnitus as well as the distress caused by it. The assessment of comorbidities in patients with orofacial complaints is of great importance since the level of suffering of these patients is also determined by psychosocial factors [45]. To the best of our knowledge, no study has yet been conducted on various modifiable psychosocial factors, measured by different questionnaires, in patients with orofacial complaints and tinnitus.

The specific objectives of this retrospective study was to examine the data collected by the WISE with regard to the frequency of tinnitus complaints in a population that visited the Center of Dental Medicine of the University of Zurich (UZH) due to orofacial complaints. Furthermore, the correlation of the tinnitus questionnaire with the other questionnaires used in the WISE was analyzed. A prespecified hypothesis was that a high or low level of tinnitus-related distress would allow conclusions to be drawn about the extent of other values recorded in the areas of pain, insomnia, depression, and anxiety.

Methods

Study design and setting

This study involved a retrospective analysis of the data obtained through the WISE questionnaire. The study included patients who were referred to the interdisciplinary orofacial pain clinic at the Center of Dental Medicine of the UZH. The study period covered data from March 2017 to December 2020.

Only one dataset per participant was included in the analysis, and no follow-up data was accessed.

Participants and Ethics

Participants were aged between 18 and 99 years at the time they completed the WISE questionnaire. Since our retrospective study only analyzed anonymized data with no possibility of identifying individual participants, approval from the ethics committee and informed consent of the patients was not required, in accordance with the guidelines of the Swiss Human Research Act.

Digital screening questionnaire WISE

Since March 2017, the Center of Dental Medicine of the UZH has implemented a standardized digital screening tool known as WISE [44]. This comprehensive system incorporates a set of questionnaires and symptom-specific screeners with options ranging from "not at all," "a little," to "a lot". The presentation of a follow-up case finding questionnaire is only triggered if a screener question is answered with "a little" or "a lot". These screener questions are designed to shorten the time required to complete the WISE questionnaires, thereby improving patient compliance. The ear-related screener question in WISE askes: "During the last 4 weeks, how much have you been bothered by any of the following problems? Ear pain, ear pressure, tinnitus (e.g. ringing noise)" (Fig. 1). If patients respond “a little” or “a lot” the following question appears: “From which ear complaints did you suffer for the last 4 weeks? Ear pain, Ear pressure / fullness, Tinnitus”. The tinnitus-specific screener question addresses the laterality of the complaint (Fig. 1).

Until November 30, 2017, patients who responded "a little" or "a lot" to the ear symptom question and positively to the tinnitus question were directed to complete a short version of the Tinnitus Handicap Inventory (THI-12). However, an internal analysis revealed that the 48 patients who answered "a little" had very low THI-12 scores with a mean of 2.1 and a median of 1.0 points out of a possible 24. Therefore, as of December 1, 2017, WISE was re-programmed so that the THI-12 questionnaire only appeared if the response to the ear symptom screener question was "a lot" and the subsequent tinnitus screener question was positive.

Tinnitus Handicap Inventory (THI) und THI-12

Newman et al. [46] created a validated questionnaire to identify and measure tinnitus and assess its negative impact on daily life, known as the Tinnitus Handicap Inventory (THI). This tool comprises 25 questions with the response options "no", "sometimes", or "yes". To quantify the severity, the responses are scored: "no" scores zero points, "sometimes" scores two points, and "yes" scores four points, allowing a maximum possible score of 100. The THI has been translated and validated in numerous languages including German [47]. A shorter version of the THI, known as the THI-12, includes 12 selected questions from the original questionnaire. This abbreviated version has also been applied in various languages [48]. In the THI-12, responses are categorized as "never", "sometimes", or "frequently" with corresponding scores of "0", "1", or "2". The maximum score for the THI-12 is 24, where a score of 24 indicates the highest level of impairment due to tinnitus, and a score of 0 indicates no impairment. The grading system used in this study followed the methodology outlined by Bankstahl et al. [48], with tinnitus severity categorized as follows: 0—6 = «no handicap», 7—10 = «mild handicap», 11—14 = «moderate handicap», 15—24 = «severe handicap».

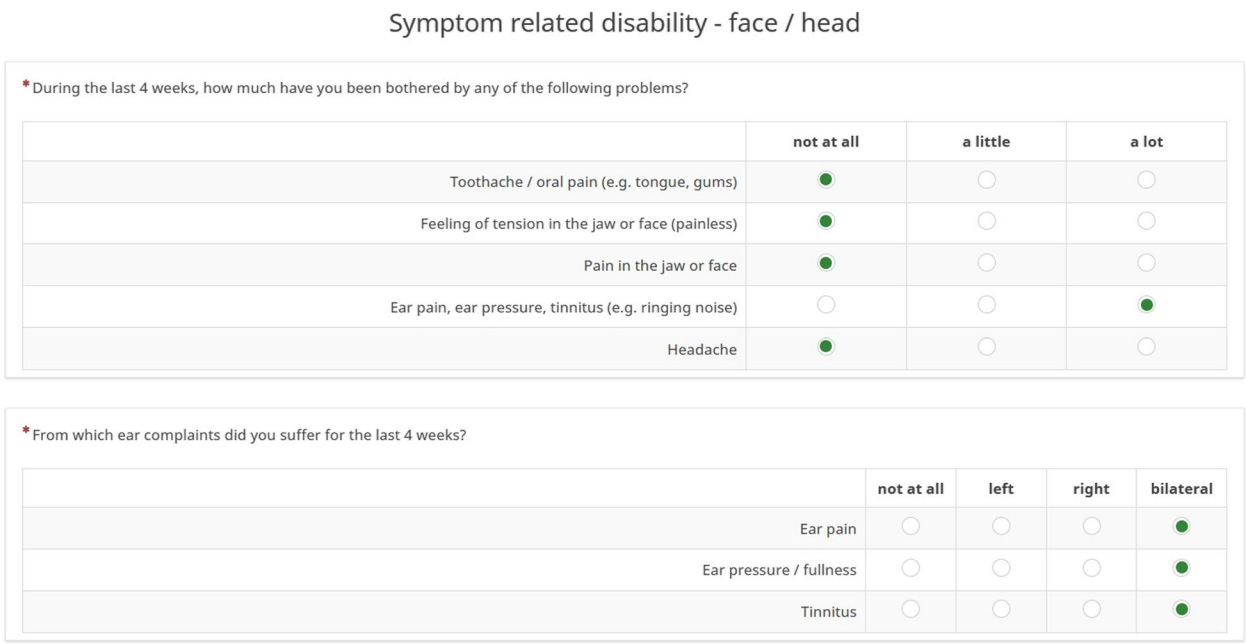

Fig. 1 Print screen from a sample WISE-questionnaire

Graded Chronic Pain Scale 2.0 (GCPS)

The Graded Chronic Pain Scale 2.0 (GCPS) [49] consists of eight questions. The first question addresses the number of days the patient was unable to engage in their normal activities due to pain over the last 30 days. The number of days determines disability points (DP) ranging from 0 to 3. Questions 2 to 4 ask about current, the most severe pain, and the average pain experienced in the last 30 days, each on a Likert scale from 0 to 10. The average of these three questions, multiplied by 10, represents the pain intensity, which may influence the differentiation between Grade I and Grade II.

Questions 5 to 8 explore on a Likert scale of 0 to 10 the pain interference during the last 30 days with usual and daily activities, participation in family and leisure activities, and the ability to perform work or household tasks. The average of these scores, multiplied by 10, is assigned DP from 0 to 3. The DP determined by Question 1 and Questions 5–8 are then summed to calculate the overall disability score.

The grading system is structured as follows: Grade I = less than 3 DP and < 50 pain intensity (low disability–low intensity), Grade II = less than 3 DP and ≥ 50 pain intensity (low disability–high intensity), Grade III = 3–4 DP (high disability–moderately limiting), Grade IV = 5–6 DP (high disability–severely limiting).

The GCPS was separately assessed for the head (GCPS-H) and the body (GCPS-B) in case the screener question indicated pain in either of these areas.

Patient Health Questionnaire 4 (PHQ-4)

The Patient Health Questionnaire 4 (PHQ-4) is used to assess anxiety and depression [50]. It consists of two subscales: the GAD-2 (the first two questions of the General Anxiety Disorder Questionnaire; GAD-7) and the PHQ-2 (the first two questions of the Patient Health Questionnaire 9; PHQ-9). Total scores of 6 to 8 or subscale scores of 3 to 4, respectively, indicate a possible disorder. In the WISE algorithm, the case finding instruments GAD-7 and PHQ-9 were presented if the respective subscale scores were 2 or higher.

Patient Health Questionnaire 9 (PHQ-9)

The Patient Health Questionnaire-9 (PHQ-9) [51, 52] is a widely recognized tool for assessing the severity of depression. It consists of nine items designed to assess both the presence and intensity of depressive symptoms over the past two weeks. Respondents select from four response options: 0 = "not at all", 1 = "several days", 2 = "more than half the days", and 3 = "nearly every day". The responses lead to a total score ranging from 0 to 27 with the following severity categories: 0–4 indicating "none/minimal", 5–9 representing "mild", 10–14 classified as "moderate", 15–19 as "moderately severe", and scores above 19 reflecting "severe" depressive symptoms.

Generalized Anxiety Disorder 7 (GAD-7)

The Generalized Anxiety Disorder 7 (GAD-7) scale [53, 54] is a widely used tool for assessing anxiety levels in

patients. This concise questionnaire comprises seven items designed to evaluate the presence and severity of general anxiety over the preceding two weeks. The response options are the same as those used in the above-mentioned PHQ-9. The total score ranges from 0 to 21, with anxiety severity classified as follows: 0–4 = "none/minimal", 5–9 = "mild", 10–14 = "moderate", and > 14 = "severe".

Patient Health Questionnaire Stress (PHQ-stress)

Stress factors were assessed using the section "PHQ-stress" from the German version of the PHQ (PHQ-D) [55]. It measures psychosocial strain during the last month by ten items including health, work/financial, social and traumatic stress. Ratings comprise "not at all bothered" (0), "bothered a little" (1) and "bothered a lot" (2). The summation shows cumulative values between "0" and "20" which represent the severity of stress. No cut-off scores exist for PHQ-stress.

Pain Catastrophizing Scale (PCS)

The Pain Catastrophizing Scale (PCS) [56] assesses catastrophic thoughts and related behaviors. This questionnaire comprises 13 items, each rated on a 5-point Likert scale from 0 (not at all) to 4 (all the time). Scores range from 0 to 52, with higher scores indicating greater levels of catastrophizing. The PCS can also be analyzed across three subscales: Helplessness (items 1–5 and 12), Magnification (items 6, 7, and 13), and Rumination (items 8–11).

Insomnia Severity Index (ISI)

The Insomnia Severity Index (ISI) assesses sleep disturbances [57, 58]. It consists of 8 questions (item 1 is divided into 3 sub-questions), focusing on sleep in items 1–5. Responses are rated on a 5-point Likert scale ranging from 0 to 4, with 4 indicating a significant problem. The total score ranges from 0 to 28, with the following interpretation: 0–7 = "no clinically significant insomnia", 8–14 = "subthreshold insomnia", 15–21 = "clinical insomnia (moderate severity)", and scores > 21 = "clinical insomnia (severe)".

Injustice Experience Questionnaire (IEQ)

The Injustice Experience Questionnaire (IEQ) [59–61] assesses perceived injustice resulting from injuries, abuse, or accidents. Twelve questions evaluate the frequency of thoughts, beliefs, and feelings related to injury experiences. Responses are rated on a scale from 0 to 4, where 0 = "never", 1 = "rarely", 2 = "sometimes", 3 = "often", and 4 = "all the time." The maximum possible score is 48 with two subscales, "Severity/Irreparability" (items 1, 2, 4, 5, 6, and 8) and "Blame/Unfairness" (items 3, 7, 9, 10, 11, and 12), each have a maximum score of 24.

Brief Illness Perception Questionnaire (B-IPQ)

The Brief Illness Perception Questionnaire (B-IPQ) [62] assesses cognitive and emotional perceptions of illness and health risk. The questionnaire consists of 8 questions covering various characteristics of illness perception, which are rated on an 11-point Likert scale from 0 to 10. The maximum possible score is 80.

Statistics

Statistics were computed using R (version 4.2.1.; R Core Team, 2021) and packages 'tidyverse', 'qgraph', and'corrplot'. For testing of distributions between and within data subsets,

Chi-square tests were used. Mean differences were tested with parametric Welch Two Sample T-tests or non-parametric Wilcoxon rank sum tests depending on normal distribution properties in the underlying data. For the exploratory correlational analyses, Spearman correlations were used. We applied two-sided testing whenever appropriate and the global significance threshold was set to $p \leq 0.05$. Only existing data were used in the analysis, and missing data were not imputed. Correlations were performed only on the available datasets.

Results

Patient sample

Between March 2017 and December 2020, a total of 1369 patients visited the orofacial pain clinic at the Center of Dental Medicine of the UZH. Of these, 815 patients (59%) (Fig. 2) reported having ear symptoms such as ear pain, ear pressure / fullness, and/or tinnitus (Fig. 1). Among them, 430 patients (31%) indicated they suffered "a little" from ear symptoms, while 385 patients (28%) reported suffering "a lot" (Fig. 2). Overall, 35% ($n = 476$, green in Fig. 2) of all patients who visited the Center of Dental Medicine of the UZH had tinnitus, with 15% experiencing mild tinnitus and 20% experiencing pronounced tinnitus (Fig. 2).

The mean age of the total sample with orofacial complaints ($n = 1369$, orange in Fig. 2) was 46.6 ± 16.3 years (range 18–90, median 46). The mean age of patients with tinnitus of any severity ($n = 476$, green in Fig. 2) was 46.6 ± 15.3 years (range 18–83, median 47), while the mean age of patients with pronounced tinnitus ($n = 269$, blue in Fig. 2) was 45.2 ± 14 years (range 18–81, median 44). There was no significant age difference between the groups mentioned above ($p\ min = 0.217$).

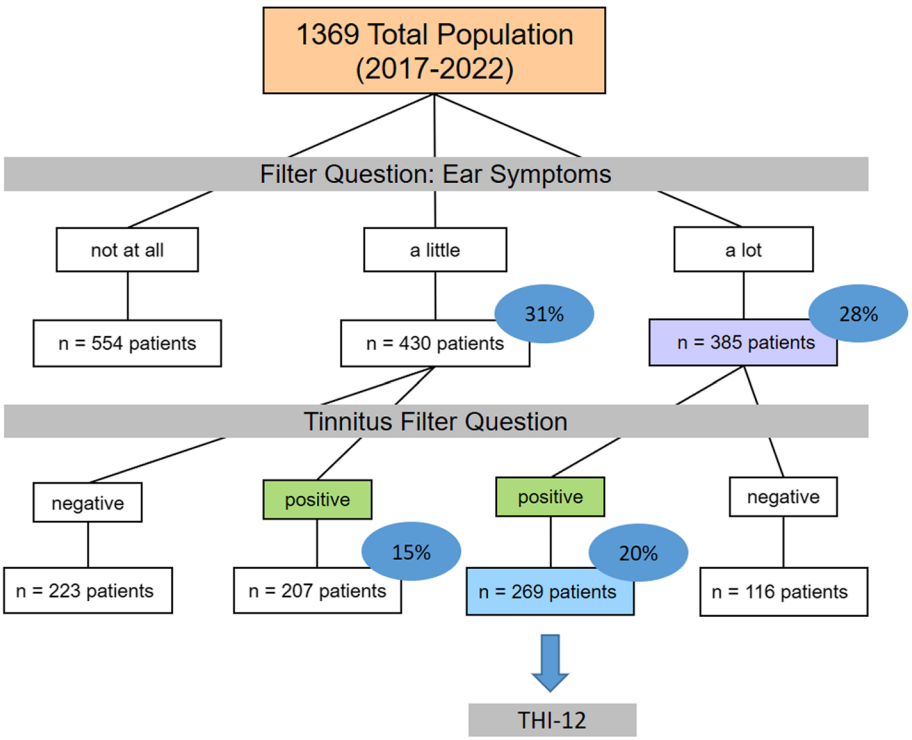

Fig. 2 Subgroups of the patient sample

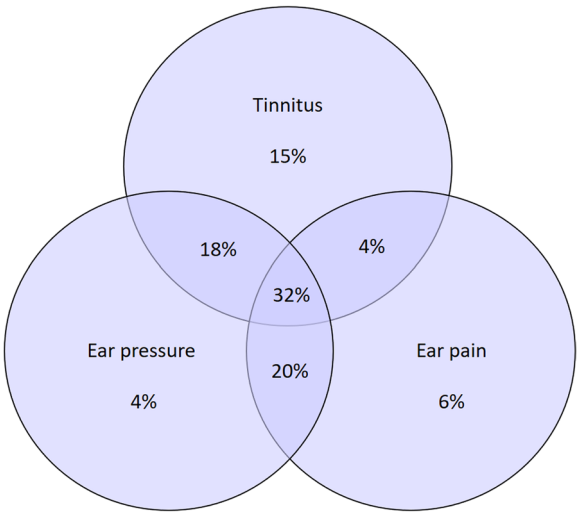

Fig. 3 Venn diagram of ear symptoms in patients who suffered 'a lot' from it. The intersections show the percentage of how frequently ear symptoms co-occur in patients with orofacial complaints

Analysis of ear symptoms in patients who suffered 'a lot' from it

In the subgroup suffering "a lot" from ear symptoms ($n=385$, purple in Fig. 2), nearly a third (32%) experienced the combination of ear symptoms with tinnitus, ear pressure, and ear pain (Fig. 3). Ear pressure was the most frequently reported symptom with 74%, followed by tinnitus with 69% and ear pain with 62%. It was observed that ear pressure and ear pain often occurred in combination with one or two other ear symptoms, whereas 15% reported only having tinnitus. The combination of tinnitus alone with ear pain and without ear pressure appeared to be less common (4%) compared to other combinations, such as ear pressure and tinnitus (18%) and ear pressure and ear pain (20%) (Fig. 3).

Gender distribution between groups

The gender distribution in the overall sample with orofacial complaints ($n=1369$, orange in Fig. 2), in the subgroup with any degree of tinnitus ($n=476$, green in Fig. 2), and in the subgroup with pronounced tinnitus ($n=269$, blue in Fig. 2) was compared. It was found that primarily women with 69% visited the clinic for orofacial complaints ($n=1369$, orange in Fig. 4). However, the percentage of men increased to 38% in the subgroup with pronounced tinnitus ($n=269$, blue in Fig. 4). This difference in gender distribution was statistically significant (chi_squared = 4.5578, $p=0.033$). The subgroup with any degree of tinnitus, including mild tinnitus ($n=476$, green in Fig. 4), did not show a significant difference in gender distribution compared to either the overall sample ($n=1369$, orange in Fig. 4) or the subgroup with pronounced tinnitus ($n=269$, blue in Fig. 4). The age

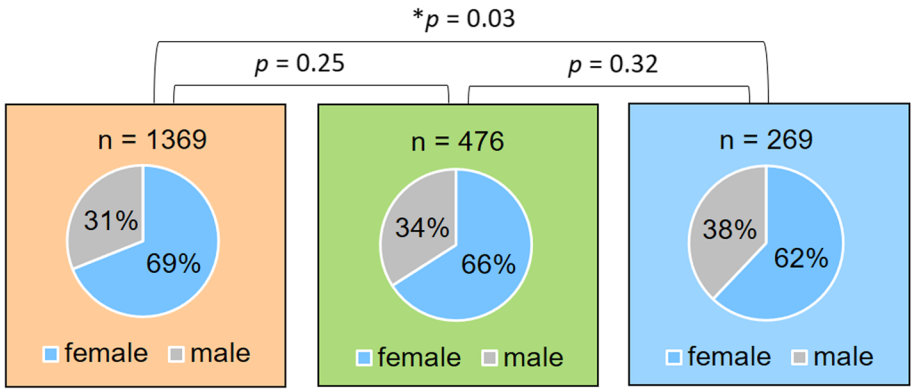

Fig. 4 Gender distribution between groups

distribution between genders in the groups described above did not differ significantly ($p\ min = 0.125$).

Comparison of THI-12 Score by Gender

Patients who rated their ear symptoms as "a lot" and had tinnitus completed the THI-12 questionnaire ($n = 269$, blue in Fig. 2). The mean score for this subgroup was 10.2 ($SD = 0.4$), indicating a mild to moderate handicap. The mean THI-12 score was significantly different ($t(267) = 2.73$, $p = 0.007$) between women (9.3, $SD = 7.0$) and men (11.7, $SD = 6.8$) (Fig. 5). The grading scale [48] reflected a mild handicap for women and a moderate handicap for men.

Correlations between questionnaires

Two patients discontinued the WISE completion after scoring the THI-12 ($n = 269$, blue in Fig. 2). For this reason, the number of patients for whom correlation could be calculated was reduced to 267 for the mandatory questionnaires like PCS, PHQ-stress, and PHQ-4. Certain questionnaires were only administered if the screener question was answered positively. Consequently, the number of comparisons with THI-12 was reduced to 236 for GCPS_H, 204 for GCPS_B, 147 for ISI, 223 for B-IPQ, 132 for IEQ, 123 for GAD_7, and 105 for PHQ_9. In the Spearman Rho correlation analysis of the patients with orofacial complaints and pronounced tinnitus the THI-12 showed the highest correlation with

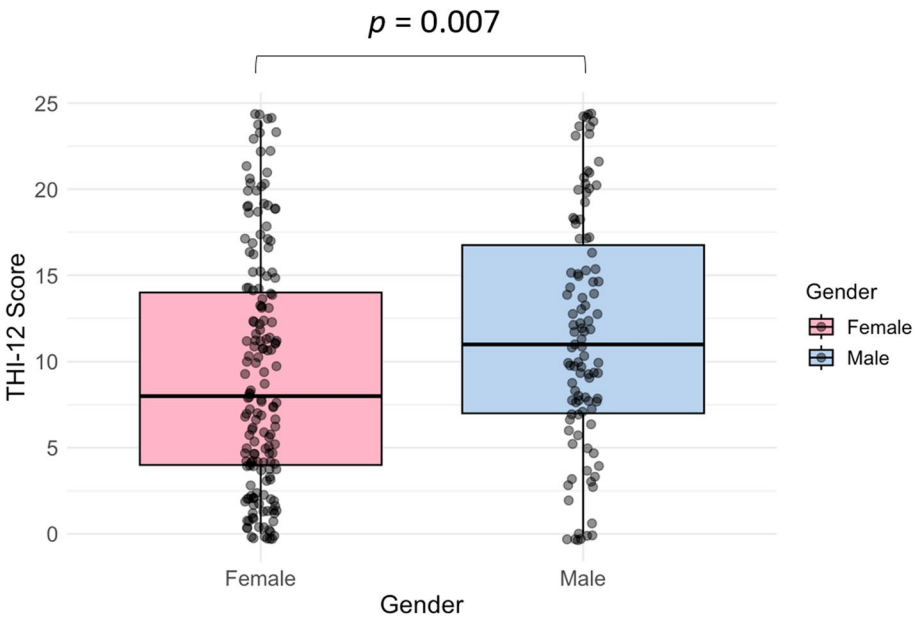

Fig. 5 Comparison of THI-12 Score by Gender

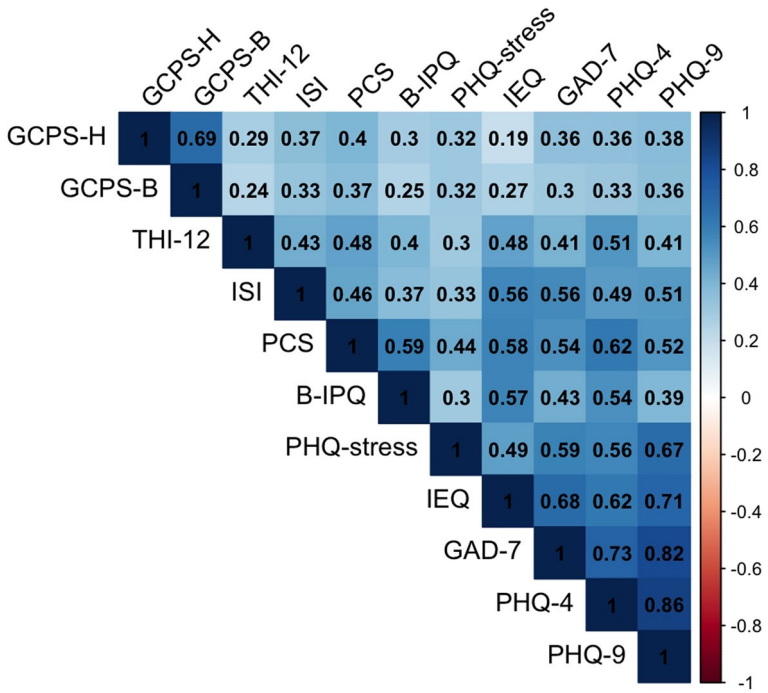

Fig. 6 Correlations matrix plot. GCPS-B = Graded Chronic Pain Status (Body); GCPS-H = Graded Chronic Pain Status (Head); PHQ-stress = Patient Health Questionnaire Stress; PHQ-9 = Patient Health Questionnaire 9; GAD-7 = Generalized Anxiety Disorder 7; PCS = Pain Catastrophizing Scale; PHQ-4 = Patient Health Questionnaire 4; ISI = Insomnia Severity Index; IEQ = Injustice Experience Questionnaire; B-IPQ = Illness Perception Questionnaire; THI-12 = Tinnitus Handicap Inventory 12

the PHQ-4 (correlation coefficient $r_{s=}$ 0.510**, **significant at the 0.01 level, two-sided), followed by the PCS ($r_s = 0.477$**) and the IEQ ($r_s = 0.476$**) (Fig. 6). The latter two questionnaires also demonstrated a high correlation with each other, which could be observed in the weighted correlation network graph through the thick and dark blue connections (Fig. 7). The graph also clearly showed a high correlation between PHQ-4 and PHQ-9, as well as between PHQ-4 and GAD-7, given that the PHQ-4 is composed of questions from both the PHQ-9 and GAD-7. All questionnaires appeared to be highly correlated with each other, with the exception of the two GCP scales

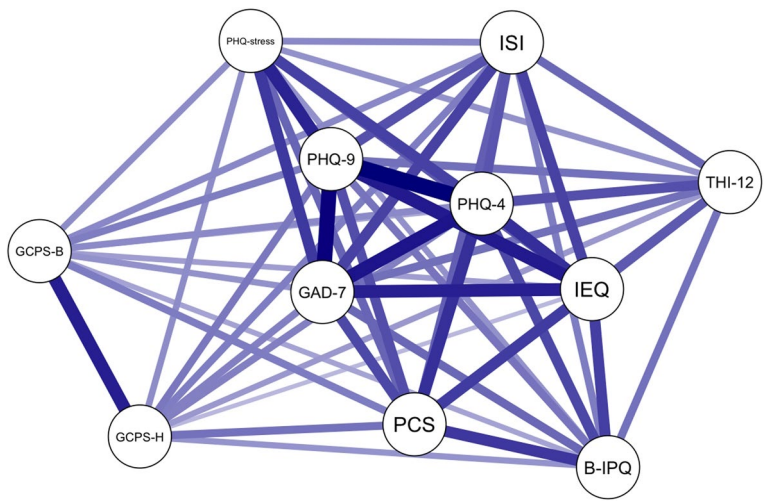

Fig. 7 Weighted correlation network graph: The higher the correlation between two questionnaires, the thicker and bluer the line between them. The arrangement of the questionnaires in space is based on these correlations

(Figs. 6 and 7). However, the latter showed a very high correlation with each other (rho = 0.69, $p < 0.001$) (Figs. 6 and 7).

Discussion

The aim of this study was to determine the prevalence and further understand the relationship between tinnitus and sociodemographic parameters in patients experiencing orofacial complaints. Only few other studies have investigated a sample size of over 1000 patients with orofacial complaints such as TMD or dental problems [63–66]. In a meta-analysis by Mottaghi et al. [2], the prevalence of tinnitus among patients with TMD ranged from 35.8% to 60.7%, compared to 9.7% to 26.0% in patients without TMD. The prevalence of tinnitus in patients with orofacial complaints observed in our study (35%) aligns well with the tinnitus prevalence associated with TMD found in this meta-analysis [2]. The study of Buergers et al. [8] showed almost the same percentage of 36.6%. This rate seems to be considerably higher than the general prevalence of tinnitus in Europe (14.7%) [6] and worldwide, as reported in a systematic review and meta-analysis (14.4%) [67]. A systematic review by Skog et al. [68] found the prevalence of tinnitus among TMD patients ranged from 3.7% to 70%, while in control groups without TMD, the prevalence varied between 1.7% and 26%. Similarly, a meta-analysis by Omidvar and Jafari [69] demonstrated an odds ratio of 1.78 to 7.79 for tinnitus in patients with TMD, and an odds ratio of 1.80 to 7.79 for TMD in tinnitus patients. Similar results could be found in a lately published systematic review with a significant odds ratio for TMD patients having tinnitus of 1.56, and a significant odds ratio of 2.86 for tinnitus patients having TMD [70].

It is therefore of great importance that patients with orofacial complaints, such as TMD, were also screened for tinnitus and related psychological symptoms. The Center for Dental Medicine of the UZH has established a questionnaire catalog called WISE [44], which includes screener questions and the specific administration of follow-up questionnaires for the standardized assessment of possible comorbidities. A thorough evaluation of all symptoms can provide practical benefits in determining an individualized assessment and treatment plan for patients with orofacial complaints and tinnitus, addressing both somatosensory and potentially psychological aspects [71].

Close collaboration among various specialists, such as dentists, otolaryngologists, physiotherapists, and psychiatrists/psychotherapists, is of great importance for patients with orofacial complaints such as TMD and tinnitus. The significance of interdisciplinary approaches is also reflected in the correlation analyses between the various questionnaires administered. In patients with pronounced tinnitus ($n = 269$, blue in Fig. 2) a significant correlation was found with several other questionnaires, particularly the PHQ-4 ($r_s = 0.510^{**}$), followed by the PCS ($r_s = 0.477^{**}$) and the IEQ ($r_s = 0.476^{**}$) (Fig. 6 and 7). The PHQ-4 is a screening tool assessing anxiety and depression through two questions each, which are also included in the PHQ-9 and GAD-7. The latter two questionnaires were not administered in cases of low PHQ-4 scores. Therefore, the highly significant correlations among the PHQ-4, PHQ-9, and GAD-7 questionnaires are not surprising. In general, a significant correlation was observed in this sample experiencing orofacial complaints and pronounced tinnitus between tinnitus severity (THI-12) and depression/anxiety (PHQ-4). A correlation between tinnitus severity and depression and/or anxiety has already been described in several studies [72, 73]. Additionally, there was a significant correlation between tinnitus severity (THI-12) and the expression of pain catastrophizing (PCS). Catastrophizing thought patterns in tinnitus patients have been previously demonstrated by Cima et al. [74], who used a Tinnitus Catastrophizing Scale (TCS) similar to the PCS. Furthermore, a significant correlation was also found between tinnitus severity (THI-12) and the injustice experience (IEQ), although this questionnaire was only offered to and completed by half of the patients with pronounced tinnitus. This means that the screener for the injustice experience was positive in half of the patients with pronounced tinnitus and orofacial complaints. In these patients, a positive correlation with tinnitus distress, as measured by the THI-12, was also observed. Therefore, severity/irreparability and blame/unfairness appear to correlate with tinnitus severity in patients with orofacial complaints. To our knowledge, this correlation has not been documented in any previous study. Further investigations of the IEQ with tinnitus patients, including those without orofacial complaints, would be desirable for future research.

The neuro-pathophysiology in structural and functional MRI studies of TMD-related pain has recently been reviewed by Yin et al. [75]. Changes were observed in the following pathways: the classic trigemino-thalamocortical system and the lateral and medial pain systems [75]. When comparing brain activities associated with TMD-related pain to those observed in tinnitus, notable activity is found in both conditions within the thalamus, anterior cingulate cortex (ACC), and insula. The thalamus plays a crucial role in the transmission and processing of sensory signals. In the context of TMD, the ACC is described as a key center for the affective and motivational aspects of pain [75]. In tinnitus, the ACC is involved in various networks related to perception, salience, and stress [76]. The insula processes interoceptive

and emotional stimuli. TMD and tinnitus both show involvement of the thalamus, ACC, and insula, indicating that similar neural mechanisms might play a role in the processing of pain and tinnitus perception. This could potentially explain the high correlation found in the above-mentioned questionnaires.

Of all the patients who presented at the clinic for orofacial complaints, 59% experienced ear symptoms such as tinnitus, ear pressure, and ear pain (Fig. 2). This percentage is slightly lower than that reported in another publication [77], which noted 87%. However, that study also included additional symptoms like deafness, dizziness, and balance disorder. Among patients who reported suffering 'a lot' from ear symptoms ($n=385$, purple in Fig. 2), ear pressure was the most frequently reported symptom with 74%, followed by tinnitus with 69% and ear pain with 62% (Fig. 3). Overall, only 30% of patients reported ear pressure and/or ear pain without tinnitus, which was surprising, as TMD is often associated with symptoms like otalgia, as seen in another study [64] with 69%. The lower percentage in our study might be explained by the fact that patients with a broad spectrum of orofacial complaints were seen rather than only those with clinically confirmed TMD. Further, only patients with severe ear symptoms were assessed with the respective questionnaires. In general, patients with orofacial complaints and severe ear symptoms often presented with a combination of ear symptoms, and nearly a third (32%) experienced the combination of tinnitus, ear pressure, and ear pain (Fig. 3).

It was observed that the majority of patients attending the clinic for orofacial complaints at the Center for Dental Medicine of the UZH were female (69% women compared to 31% men). Interestingly, the proportion of women decreased in the subgroup with tinnitus (66% women and 34% men) and showed a significant difference in the subgroup with pronounced tinnitus (62% women, 38% men; chi_squared = 4.5578, $p=0.033$) (Fig. 4). This suggests that men with orofacial complaints are more likely to have tinnitus, especially pronounced tinnitus, compared to women, although the number of men remains lower than the one of women. The generally higher number of women in the clinic for orofacial complaints at the Center for Dental Medicine of the UZH aligns with findings from a study of 180,308 patients and 525,707 dental check-ups, where more women than men reported orofacial pain (odds ratio 2.58, 95% CI = 2.48–2.68) [78]. Other studies have also shown that women are more likely to experience orofacial complaints and/or TMD [8, 79–81]. The reasons for this remain elusive. Anatomical differences, gonadal hormones, pain perception and differing immune responses between genders are being discussed as confounders [82]. All this parameters were not accessed in our study and the results could not have been adjusted for this possible confounders. Interestingly, studies on tinnitus at the USZ revealed that the majority of patients in the tinnitus specialty clinic were male (59–68%) [83–86]. The burden of tinnitus is often greater among patients attending specialty clinics compared to the general population, where tinnitus prevalence is more evenly distributed between genders, with 14.0% in men and 15.2% in women in Europe [6]. Therefore, the higher proportion of men attending the tinnitus clinic could contribute to the significantly higher percentage of men with orofacial complaints and pronounced tinnitus compared to all men with orofacial complaints (Fig. 4). This may be attributed to differences in health-seeking behaviors between genders, likely influenced by varying psychological factors, coping strategies, or sociocultural explanations, which could also act as confounders in the results.

Patients who rated their ear symptoms as "a lot" and had tinnitus completed the THI-12 questionnaire (Fig. 2), revealing a mean score of 10.2 (SD = 0.4), indicating a mild to moderate handicap. Interestingly, a significant difference was found in the mean THI-12 scores between genders ($t(267)=2.73$, $p=0.007$), with women scoring 9.3 (SD = 7.0) and men scoring 11.7 (SD = 6.8) (Fig. 5). According to the grading scale [48], this corresponds to a moderate handicap for men and a mild handicap for women. Thus, not only does the proportion of men with orofacial complaints increase in the subgroup with pronounced tinnitus, but these men also seem to suffer significantly more from tinnitus as compared to women. These findings highlight the importance of considering the possibility and severity of tinnitus in male patients in an orofacial clinic, which is predominantly attended by female patients. This aspect is especially interesting as previous studies found no gender differences in the THI scores [87–89]. It can thus be assumed that male patients with orofacial complaints and tinnitus experience tinnitus as more distressing than females. However, a multimodal therapy tailored to the complaints is generally recommended for all patients. The interdisciplinary collaboration of various specialties is of great importance in treating tinnitus.

One limitation of this study is that patients who rated their ear symptoms as "a little" and had tinnitus were not directed to complete the THI-12. An internal analysis conducted after the first nine months of using WISE in clinical practice revealed that these patients completed the THI-12 with low scores, leading to the decision to exclude the THI-12 from the WISE for this group to shorten the questionnaire catalogue and promoting compliance. However, we cannot say with certainty that the decision made at that time may have led to a selection

bias for this retrospective analyses. Given the observed gender differences in THI-12 scores, it raises the question of whether women may be more likely to report their ear symptoms as "a lot" and men as "a little". This could explain the gender disparity in the THI-12 scores among the group with pronounced tinnitus, a difference that might not hold if the "a little" group were included with a THI-12 questionnaire. Nevertheless, a gender difference in tinnitus perception appears to be present whether through the classification of the severity of ear symptoms or through the measured severity of the THI-12. Another limitation to mention is the selection bias of the patients. Patients were referred to the specialized orofacial pain clinic by general practitioners or dentists, which may have led to a selection of individuals more severely affected by orofacial complaints. Therefore, this sample cannot be generalized to the wider population with orofacial complaints. Lastly, additional limitation are the retrospective analysis and the reliance on self-reported data.

Conclusion

In the present sample of patients experiencing orofacial complaints nearly 60% reported ear symptoms, 35% tinnitus and 20% pronounced tinnitus. Tinnitus, ear pain and ear pressure often presented combined (32%) in patients who suffered a lot from ear symptoms. The proportion of men experiencing orofacial complaints and reporting tinnitus was higher and the impairment more severe compared to females. The practical implication of the observed gender differences is that, in male patients with orofacial pain, tinnitus and its associated distress should be actively assessed.

Furthermore, positive correlations between patients with orofacial complaints and tinnitus with anxiety & depression, pain catastrophizing and injustice experience could be demonstrated. As a healthcare provider, it is important to inquire about these aspects during a conversation and, if necessary, refer the patient for additional psychotherapy.

This analysis explored the relationship between orofacial complaints and tinnitus. The treatment of orofacial complaints, such as TMD in tinnitus patients can have a positive impact on tinnitus perception [43]. However, there is less information available regarding the reverse relationship. Nonetheless, emphasizing psychotherapy—which is also utilized in tinnitus—may contribute to reducing the severity of muscular or articular symptoms in TMD as well. In general, patients with orofacial complaints and tinnitus should receive a personalized, multidisciplinary therapy. However, further studies are needed to better understand the treatment effects in patients with TMD and tinnitus.

Abbreviations

B-IPQ	Brief Illness Perception Questionnaire
DP	Disability Points
GAD-7	Generalized Anxiety Disorder 7
GCPS	Graded Chronic Pain Scale
GCPS-B	Raded Chronic Pain Scale for the body
GCPS-H	Graded Chronic Pain Scale for the head
IEQ	Injustice Experience Questionnaire
ISI	Insomnia Severity Index
PCS	Pain Catastrophizing Scale
PHQ-4	Patient Health Questionnaire 4
PHQ-9	Patient Health Questionnaire 9
PHQ-stress	Patient Health Questionnaire Stress
THI-12	Short version of the Tinnitus Handicap Inventory
TMD	Temporomandibular Disorders
TMJ	Temporomandibular Joint
USZ	University Hospital of Zurich
UZH	University of Zurich
WISE	Web-based Interdisciplinary Symptom Evaluation

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Authors' contributions

N.P. initiated the collaborative project, cleaned and analyzed the data, wrote the statistical analysis plan, contributed to the interpretation of data, drafted and revised the paper. J.S. cleaned and analyzed the data, wrote the statistical analysis plan, contributed to the interpretation of data, revised the drafted paper. P.N. wrote the statistical analysis plan, contributed to the interpretation of data, revised the drafted paper. D.E. initiated the collaborative project, contributed to the interpretation of data, revised the drafted paper. A.Z.W. cleaned the data, contributed to the interpretation of data, revised the drafted paper T.K. initiated the collaborative project, cleaned and analyzed the data, contributed to the interpretation of data, drafted and revised the paper. N.L. initiated the collaborative project, contributed to the interpretation of data, revised the drafted paper. T.K. and N.L. are joint last authors. All authors read and approved the final manuscript.

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Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Since our retrospective study only analyzed anonymized data with no possibility of identifying individual participants, approval from the ethics committee was not required, in accordance with the guidelines of the Human Research Act.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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