# Clinical signs and symptoms of tinnitus in temporomandibular joint disorders: A pilot study comparing patients and non-patients

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**Background.** Tinnitus is one of the otologic symptoms commonly reported to be associated with temporomandibular disorder (TMD), and questions regarding its nature and cause continue to plague the clinical and research community.
**Objectives.** The current pilot study aimed to investigate the clinical signs and symptoms of presenting tinnitus in a group of individuals with TMD (group A), and compare them with a group with tinnitus but without TMD (group B). Twenty participants were included in the study, 10 from each group.
**Methods.** All participants underwent basic audiological as well as ear, nose and throat (ENT) evaluations to establish group A and group B. For tinnitus assessment, all participants completed a tinnitus survey questionnaire, and their tinnitus was evaluated using tinnitus matching procedures.
**Results.** Findings revealed clinically relevant differences in attributes of tinnitus in patients with and without TMD. Most of the participants in group A matched their tinnitus to a 6 000 Hz tone or noise, at lower intensity levels than participants in group B, although these results were not statistically significant. Participants in group A associated their tinnitus with a single sound whereas some participants in group B associated it with more than one sound. More participants in group B reported the duration of their tinnitus as constant.
**Conclusions.** Tinnitus may occur in patients with TMD, and be of high frequency. This highlights the importance of thorough assessment for patients with tinnitus as this might have implications for diagnosis and management.

***Keywords: matching, pitch, tinnitus retraining therapy, temporomandibular disorder***

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Although tinnitus has been described for centuries, theories about its origin, assessment and treatment continue to evolve (Viirre, 2007). Tinnitus is a common otological disorder that is characterised by the perception of sound in the absence of an external sound source. Its many possible causes, generation and various management strategies are topics of continued scientific enquiry and much controversy (Salvinelli, Casale, Paparo, Persico & Zini, 2003; Ariizumi, Hatanaka & Kitamura, 2010; Vielsmeier *et al*., 2011). A review of the current literature indicates a continued need for research into tinnitus in pursuit of appropriate treatment strategies to enhance the quality of life of the tinnitus sufferer, hence the current study.

Successful management of tinnitus continues to be challenging, arguably owing to the fact that a number of possible causes of tinnitus exist, with the most understood being those of objective tinnitus (Hall & Haynes, 2001). Subjective tinnitus is however more common. Among the causes of objective types of tinnitus are extra-auditory disorders, namely, temporomandibular disorders (TMDs) (Crummer & Hassan, 2004) vascular disorders, neurological disorders and eustachian tube disorders (Crummer & Hassan, 2004). In audiological practice, tinnitus often presents as a concomitant symptom of hearing loss, which commonly resolves when hearing loss is managed (Ariizumi *et al*., 2010). Other studies have reported tinnitus in individuals with 'hidden hearing loss' as indicated by a normal audiogram but reduced wave I amplitude on auditory brainstem response testing (Schaette & McAlpine, 2011). In cases where hearing loss is not part of the presenting symptomatology, careful assessment and characterisation of the presenting tinnitus can guide diagnosis of other conditions and/or guide the tinnitus treatment plan. TMD is well documented as being frequently associated with tinnitus (Vielsmeier *et al*., 2011).

TMD is a collective term that describes various related disorders affecting the temporomandibular joint (TMJ), and muscles of mastication, as well as associated structures, with common symptoms such as pain and restricted jaw opening (Dimitroulis, 1998; Sobhy *et al*. 2004). These signs and symptoms may manifest in areas of the face and neck, the temporal, occipital and frontal areas of the head, as well as the preauricular and auricular areas. A number of patients with TMJ disorder may also present with aural symptoms, of which the most commonly reported is tinnitus (Vielsmeier *et al*., 2011). Although tinnitus in TMD is a documented common symptom, it does not occur as frequently nor is it as specific a symptom as the most common clinical features that include orofacial pain, joint noise and limited jaw function (Dimitroulis, 1998). The association between tinnitus and TMD has been confirmed by numerous other studies, some reporting an increased prevalence of tinnitus in TMD (Chole & Parker, 1992; Wright & Bifano, 1997; Vielsmeier *et al*., 2011). There is agreement that individuals with TMD may present with tinnitus as a primary or as a secondary complaint (Chole & Parker, 1992), thus highlighting the importance of careful assessment and management, including appropriate referral for the tinnitus sufferer.

Although tinnitus in TMD has been documented to be objective in nature (Crummer & Hassan, 2004), evidence exists that it can also be subjective. According to Salvinelli *et al.* (2003) TMD results in subjective rather than objective tinnitus. Subjective tinnitus refers to an auditory sensation that is not related to the perception of external, acoustic stimulation of the cochlea. The causes of subjective tinnitus include otologic diseases or hearing loss, ototoxicity, and metabolic and psychogenic disorders (Crummer & Hassan, 2004). Viirre (2007) makes specific reference to salicylate toxicity, noise exposure, and endolymphatic hydrops as noteworthy causes of acute forms of tinnitus, thus highlighting the importance of establishing the clinical signs and symptoms in this population.

The prevalence of tinnitus in TMD patients has received much review, and the difference in findings and reports encourages one to be critical in interpreting the results. For example, Tuz, Onder and Kisnisci (2005) suggested a significantly higher prevalence of tinnitus and vertigo in their symptomatic TMD group than in the asymptomatic control group. In contrast, Bernhardt *et al.* (2004) investigated whether signs of TMD are more frequently displayed in patients with tinnitus than in those without tinnitus. Findings indicated that the tinnitus group reported more pain on the palpation of the masticatory muscles in comparison with the control group. Additional evidence for TMJ-tinnitus association is provided by

Morgan (1992) who examined 20 patients who were not known to have TMD but presented with a chief complaint of tinnitus. Findings indicated that 19 of the 20 presented with one or more clinical indications of jaw joint disorder, and that an examination of the TMJ should be performed when an otological examination is unable to determine the cause of the tinnitus (Morgan, 1992). Most recently, Vielsmeier *et al.* (2011) concluded that classic risk factors for tinnitus such as older age, male gender and hearing loss are less relevant in tinnitus sufferers with TMD. These authors assert that their findings suggest a causal role of TMD in the generation as well as the maintenance of tinnitus. This causal relationship has implications for the tinnitus treatment strategy adopted by the clinician.

Early studies showed that TMD treatment can alleviate tinnitus. Therefore, knowledge of the accurate diagnosis of the cause of tinnitus and its presentation, as well as audiological attributes, can significantly add value to the management of this patient population. As early as 1964, investigations by Kelly and Goodfellow indicated an elimination and/or improvement of tinnitus following TMD therapy in a significant number of the participants in their study. Wright and Bifano (1997) documented that 56% of their participants reported that their tinnitus had been resolved and 30% reported significant improvement following TMD therapy. Sobhy *et al.* (2004) reported improved cochlear functioning, as evidenced by the objective increase in distortion product levels on otoacoustic emissions at most frequency bands, and subjective improvement in tinnitus on self-assessment questionnaires. All these studies provide evidence for an influence of the somatosensory system on tinnitus perception. Vielsmeier *et al.* (2011) report that approximately two-thirds of tinnitus sufferers can change the loudness and pitch of their tinnitus by employing somatic manoeuvres such as jaw clenching or tensing their neck muscles. These findings show that clinicians should be aware of the fact that tinnitus can be a sign and symptom of TMD and that a careful case history can result in an appropriate referral to a TMD clinic. Alleviation of tinnitus through appropriate TMD therapy avoids inappropriate and ineffective treatment options in the TMD population such as the use of sound generators. Audiologists can play a crucial role in the correct diagnosis and treatment of tinnitus in the TMD population, and the subsequent improvement in quality of life (Ariizumi *et al.*, 2010).

Evidence exists for the importance of appropriate assessment and management of the tinnitus sufferer as a way of ensuring positive quality of life. For example, a study performed by Erlandsson, Rubenstein, Axelson and Carlsson (1991), regarding the psychological dimensions in patients with disabling tinnitus and craniomandibular disorders, indicated that patients with persistent tinnitus experience distress similar to that in patients with chronic pain. In addition, increased levels of depression have been reported in patients with tinnitus (Camparis, Formigoni, Teixeira & de Siqueira, 2005). It is therefore also crucial that psychological observations of the patient complaining of tinnitus be considered in order to achieve successful management. These observations may be made through the use of a self-report questionnaire to determine the extent of interference that the tinnitus causes in an individual's work, social and mental activities.

In order to provide appropriate tinnitus treatment guidelines, and to determine the efficacy of the treatment, accurate measurement of the presenting tinnitus is important. In addition to a physical examination by an otolaryngologist, and basic audiometric testing by an audiologist, Henry, Zaugg and Schechter (2005) argue that it is also essential for each patient with presenting tinnitus to be evaluated audiologically to determine the pitch and the loudness of the tinnitus. A paucity of data exists on these tinnitus characteristics in TMD. Existing evidence points to the controversy about TMD resulting in either subjective or objective tinnitus, although Felicio, Faria, da Silva, de Aquino and Junqueira (2004) did report that tinnitus with TMD is usually of high frequency and moderate intensity, and episodic in nature, which differentiates it from most types of tinnitus commonly associated with otoneurological signs. However, these authors did not specify the tinnitus frequency and intensity ranges which may be of benefit during tinnitus masking procedures and during tinnitus retraining therapy. Therefore, the purpose of the current pilot study was to investigate and compare the clinical signs and symptoms of tinnitus in patients with and without TMD.

# Method

## Objectives

The primary aim of the current pilot study was to establish clinical signs and symptoms of tinnitus in patients with TMD, with the following specific objectives:

- To gather and compare descriptions of subjective tinnitus in groups of tinnitus sufferers with and without TMD through data collected via a questionnaire.
- To gather and compare descriptions of the clinical signs of tinnitus in groups of tinnitus sufferers with and without TMD through data obtained via tinnitus matching procedures.

## Participants

Participants for the current pilot study were recruited by means of a non-probability quota sampling strategy. A purposive convenience sampling technique was adopted as the sample was selected from a location convenient to the researchers at a local academic TMD clinic and ear, nose and throat (ENT) clinic in Johannesburg. The study included two groups of participants (*N*=20). Group A consisted of 10 patients diagnosed as having tinnitus with TMD, and group B consisted of 10 patients diagnosed as having tinnitus of other aetiologies excluding TMD. For the participants with TMD, the diagnosis of TMD was determined by a clinical, stomatognathic examination of TMD (Dimitroulis, 1998), conducted by a specialist dentist. Patients had to present with the signs and symptoms typically associated with TMD, with tinnitus being one of the complaints. An important inclusion criterion for participants with tinnitus and TMD was that they had to present with hearing within normal limits from pure tone audiometry testing. Participants were also assessed by an ENT specialist to rule out any other conditions associated with tinnitus. Although age and gender are reported to be risk factors (Vielsmeier *et al.*, 2011), their effect is inconsistent (Davis & El Refaie, 2000). These were therefore not controlled for in the current pilot study, an acknowledged limitation which is an identified implication for future studies.

The profile of the participants is depicted in Table 1.

## Research design

This study made use of an exploratory non-experimental between-subjects research design, as the performances of separate groups of participants were measured, and comparisons were made between the groups. Comparisons between group A (patients with TMD) and group B (non-TMD patients) were made with regard to their performance on certain criterion variables (Devlin, 2006).

## Materials and procedures

Permission to conduct the study was obtained from the Medical Human Research Ethics Committee (Protocol Number: M060105) and approval was obtained from all relevant authorities and departments at the research site. Research conduct adhered to and was guided by the ethical principles and practices advocated by the South African Medical Research Council (2003).

The following test protocol was adopted for all participants:

All participants were requested to complete a questionnaire (Appendix A) pertaining to the perception of their tinnitus with regard to onset, duration, location, pitch, intensity and treatment, as well as the effect that the tinnitus has on their lifestyle. This questionnaire was adapted from the Carolina Ear and Hearing Clinic (2005) tinnitus questionnaire, as well as the health questionnaire of the TMD clinic.

**Table 1. Profile of participants (*N*=20)**

| | Group A (TMD group) *n*=10 | Group B (non-TMD group) *n*=10 |
|---|---|---|
| Male | 1 | 5 |
| Age range | 21 - 52 years | 19 - 70 years |
| Mean age | 29.7 years | 42.2 years |

TMD = temporomandibular disorder.

All participants underwent a TMD examination. The examination included detailed case history, palpation of head and neck areas for evaluation of tenderness, mouth opening, examination of the masticatory musculature, lateral and protrusive excursion measurements, palpation of the joint and muscles of mastication, endfeel (the nature of resistance felt by the examiner just prior to the border for a passive joint movement), jointplay (measurement of joint surface roughness), dynamic pain test (this test requires only a slight resistance to the patient's mandible during active movements in all directions), static pain test (this requires heavy manual resistance executed by the examiner) and joint sounds (clicking and crepitation) (Dimitroulis, 1998).

All participants were referred for an ENT evaluation. A comprehensive audiometric test battery was conducted on all participants. For patients with TMD, normal hearing function was required for inclusion in the study.

Lastly, all participants underwent a tinnitus matching procedure.

Specifically, the following audiological measures and procedures were adopted in the current study:

1. *Otoscopy:* an otoscopic evaluation of participants' ears for the presence of impacted wax, otitis externa, possible otitis media, perforated tympanic membranes, collapsed ear canals, presence of any growths and any other ear disorders was conducted. Abnormal otoscopic findings such as cerumen or other obstruction may contribute to audible tinnitus (Crummer & Hassan, 2004).

2. *Impedance audiometry* in the form of tympanometry (through the use of Inter-Acoustic AZ26 tympanometer) was utilised to assess the status and integrity of middle-ear functioning. Standard single frequency tympanometry using an 85 dB SPL tone set at 226 Hz was done. The primary purpose of impedance audiometry was to determine the status of the tympanic membrane and middle ear via tympanometry. Tympanometry for the participants with TMD was performed to ensure normal middle ear status and normal eustachian tube functioning. The presence of middle ear pathology such as otitis media and otosclerosis has been reported to cause audible tinnitus (Tyler, 2000).

3. *Pure tone audiometry*: Conventional (250 - 8 000 Hz) pure tone air and bone conduction audiometry (with pulsed stimuli) was performed on all participants (using the bracketing method) through the use of Inter-Acoustic AC 40 diagnostic audiometer. The criteria used to define normal hearing were those of pure tone thresholds of 25 dBHL or lower across all frequencies, with the absence of an air-bone gap. Where pure tone air conduction and tympanometry were abnormal at any test frequencies for the participants with TMD, these participants were excluded from the study, and were referred to ENT specialists for assessment, management and appropriate audiological rehabilitation.

4. *Speech audiometry* was conducted using monitored live voice to validate the audiogram and to determine the presence of conductive, cochlear or retrocochlear pathology. Monitored live voice was used as it was convenient, allowed for flexibility and reduced test time (Thibodeau, 2007). Speech reception threshold was performed using the CIDW1 spondee word list and speech discrimination testing was conducted using the NAL word list.

5. *Psychoacoustical measurements* of tinnitus were performed through headphones using the AC40 audiometer. These consisted of tinnitus pitch- and loudness-matching procedures as these measures aid in documenting the nature and severity of the tinnitus, as well as facilitating appropriate use of acoustical therapy and evaluation of treatment effects (Henry *et al*., 2005). Firstly, a noise band centred at the frequency of 1 kHz and a tone at 1 kHz was presented in an alternating fashion, at 20 dB SL (Bauer & Brozoski, 2006). Thereafter, if the individual matched their tinnitus to a tone, a comparison of two tones of different frequencies was performed, with f1 being of lower frequency than f2 (2AFC procedure) (Bauer & Brozoski, 2006). The tone was presented at the following comparative frequencies, 1 kHz v. 2 kHz, 2 kHz v. 3 kHz, 3 kHz v. 4 kHz, 4 kHz v. 6 kHz and 6 kHz v. 8 kHz. If 1 kHz was selected, the 2AFC procedure proceeded downward in frequency. If the individual matched their tinnitus to a noise band, comparative noise bands were presented, beginning at 2 kHz. This 2AFC procedure was continued until there was a frequency reversal (Henry *et al*., 2005). The final frequency selected was confirmed by an octave confusion test, whereby the selected tone was compared with a tone one octave higher.

Following tinnitus pitch matching, tinnitus loudness matching was performed at the frequency of the selected tone or noise band, beginning at 20 dBSL. The intensity was presented in 1 dB increments or decrements, depending on whether the individual reported their tinnitus as being louder or softer than the presented tone or noise band.

### Data analysis

The differences in clinical symptoms of tinnitus between the two groups were descriptively analysed, which involved describing and comparing the set of data obtained from the questionnaires administered to each group. Quantitative analysis of the clinical signs of tinnitus was performed using the two-independent *t*-test of unequal variance (Devlin, 2006).

### Reliability and validity

Test reliability was controlled and maintained at a high level by standardising test administration, ensuring proper equipment calibration, and controlling patient variables. For all audiological assessments precautionary measures advocated by Bess and Humes (1990) were followed in terms of proper maintenance and calibration of the equipment, optimising testing environment, and correct earphone and bone vibrator placement. All testing was conducted in a soundproof booth with equipment that was calibrated on an annual basis, with biological calibration conducted before every test session. All participants were tested by the same researcher using the same audiological test procedures. Furthermore, all patients were tested in the mornings to reduce the effect that fatigue can have on patients' responses to behavioural audiometry testing. Similar protocols existed for ENT and dental assessments where appropriate.

However, threats to validity in the current study were present. This included the fact that the study was not double-blind, as the researcher was aware of which participants were in the each group, and there was no random selection of participants to reduce bias in the sample. Finally, because of the sample size and the fact that the data were collected in one hospital in Gauteng, South Africa, the researcher's ability to generalise the results from the sample studied to the total population of patients with TMD is limited.

## Results and discussion

The demographic profile of the participants as depicted in Table 1 closely resembled the documented profiles of tinnitus sufferers in both groups with regard to age and gender. Evidence suggests that tinnitus in non-TMD tends to occur in the older age group and in more males than females – a similar trend noted in the current study. Furthermore, although the effect of gender on the prevalence of tinnitus is inconsistent (Davis & El Refaie, 2000) TMD is generally considered to be more prevalent among females with 4 females being affected to every 1 male (Vernon, Griest & Press, 1992; Dimitroulis, 1998), a trend also identified in the current sample. It is therefore felt that the study sample is a fair representation of the populations studied.

### Subjective tinnitus descriptions (questionnaire)

An analysis of data from the questionnaire revealed the following:

*Consistency of tinnitus:* Relevant differences between the two groups were noted as far as consistency of tinnitus presentation was concerned. A large majority of participants (8 of the 10) in the non-TMD group as opposed to only 3 of the 10 participants in the TMD group reported the frequency and duration of their tinnitus to be constant. These findings are consistent with reports by Felicio *et al*. (2004) which indicate that tinnitus in TMD is of high frequency, moderate in intensity and episodic in nature, thus differentiating it from most types of tinnitus commonly associated with otoneurological pathologies.

*Nature of tinnitus:* With regard to participants' perception of their tinnitus, all participants in the TMD group indicated their tinnitus to be of a single sound, whereas three participants in the non-TMD group associated their tinnitus with more than one sound. The most common types of sound experienced by participants in group A were ringing and whistling.

Ringing and buzzing were the most commonly experienced sounds reported by participants in group B. The results from the non-TMD group are consistent with findings by Baguley (2002), who reported the most common descriptors of tinnitus to be hissing, sizzling and buzzing.

In terms of loudness perception, there was no difference between the two groups as more than half of participants in both groups reported their tinnitus to be of intermediate intensity. These differences are inconsistent with findings reported by Vernon *et al*. (1992) who investigated tinnitus attributes that are likely to be predictable of TMD origin.

Although a difference was noted in the duration and frequency of the tinnitus, there was not much difference noted between the two groups with regard to the amount of interference the tinnitus causes for daily activities. Tinnitus was reported to cause no interference for 6 of the participants in group A, in comparison with 5 participants in group B.

## Tinnitus matching procedures

From basic audiometry testing results, all participants in group A had hearing within normal limits with mean air conduction thresholds across all frequencies ranging from 6.67 dB HL to 23.33 dB HL in the right ear, and 2.5 dB HL to 20.8 dB HL in the left ear. All participants presented with type A tympanograms bilaterally with speech audiometry scores with a mean PB max of 99% in the right and 90% in the left ear. The presence of normal audiological results did not require the application of statistical tests for analysis, but were important in ensuring that the tinnitus in group A participants was not confounded by the presence of a hearing loss.

Data from the tinnitus matching procedures revealed that 8 of the participants in the TMD group matched their tinnitus to a 6 000 Hz sound, with 6 of these 8 participants having matched it to a tone and 2 to a narrow band noise (Fig. 1).

Although this may be indicative of a specific attribute of tinnitus with TMD, there are a number of other pathologies with tinnitus occurrence within the 6 000 Hz frequency region. In general, pitch matches for noise-induced hearing loss and presbyacusis have been reported to be between 2 000 and 8 000 Hz. Tinnitus pitch has been noted to occur in the frequency region of maximum hearing loss (Tyler, 2000). However, in the present study, these confounding variables of noise-induced hearing loss and presbyacusis were eliminated in the TMD group as they were all confirmed to have hearing within normal limits, and had undergone ENT evaluation to ensure no other otologic origin of the tinnitus.

In comparison, participants in the non-TMD group matched their tinnitus across a wider range of frequencies, with half having matched their tinnitus to an 8 000 Hz tone, 3 to a 1 000 Hz tone, 1 to a 3 000 Hz tone and 1 to a 250 Hz noise (Fig. 2).

Despite the seemingly clear clinical differences between the two groups, statistical analysis of the tinnitus pitch using the two independent t-test of unequal variance revealed no statistically significant differences between the two groups ($t_{(10)}$=2.22, $p$=0.272, $p$>0.05). However, the lack of statistically significant differences can be attributed to the small sample size in the current study. Despite the lack of statistically significant results, the pitch matching results are consistent with reports by Felicio *et al*. (2004) who reported tinnitus with TMD was normally of high frequency.

The pitch matching results are very useful in counselling a tinnitus sufferer. Pitch match is also useful for the selection and fitting of tinnitus maskers (Henry *et al*., 2005). Hence, tinnitus pitch characteristics in patients with TMD may need to be investigated further, using a larger sample of participants, with the use of extended high-frequency testing. Furthermore, reports and/or clinical findings of high-pitched tinnitus may signal a need for referral to a TMD clinic for assessment and management as TMD therapy has been documented to alleviate tinnitus symptoms (Wright & Bifano, 1997).

With regard to tinnitus loudness, again there was no statistically significant difference between the two groups ($t_{(11)}$=2.20, $p$=0.098, $p$>0.05). However, generally, the TMD group participants matched their tinnitus to a lower intensity, with a mean intensity of 25.4 dB HL (Fig. 3), in comparison with participants in the non-TMD group, who matched their tinnitus to a mean intensity level of 33.5 dB HL (Fig. 4).

The fact that the TMD group (group A) presented with normal hearing sensitivity could be an influencing factor in the perception of tinnitus loudness. Published evidence indicates that the loudness of tinnitus is usually found to be only a few decibels above a person's threshold for the frequency being tested (Henry & Meikle, 2000); hence lower levels are noted for the group with better hearing thresholds. A recent study by Martines *et al*. (2010) reported tinnitus loudness levels between 0 and 15 dB above threshold in individuals with varying degrees of sensorineural hearing loss.

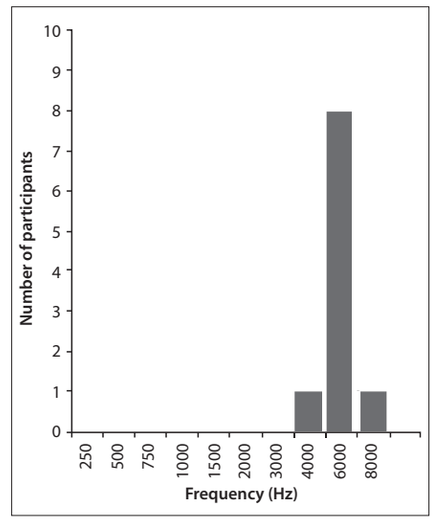


*Fig. 1. Tinnitus pitch matching for group A (TMD group).*

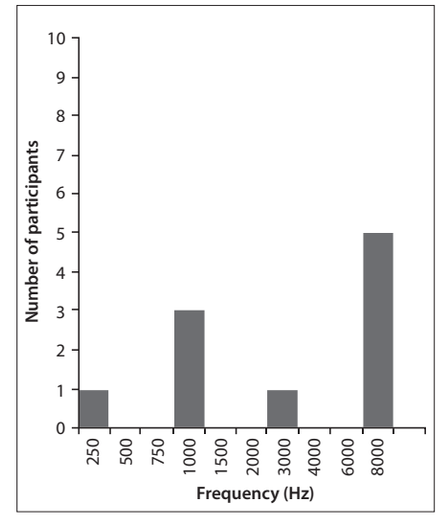


*Fig. 2. Tinnitus pitch matching for group B (non-TMD group).*

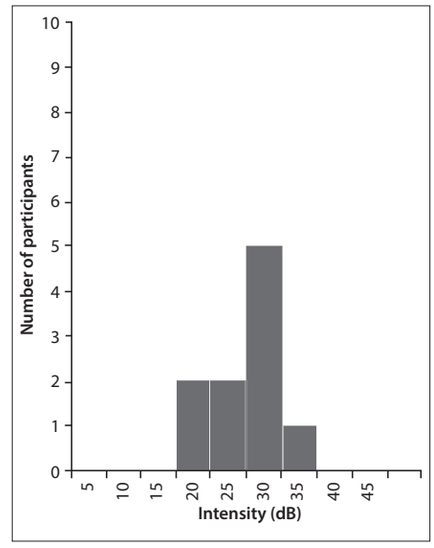


*Fig. 3. Tinnitus loudness matching for group A.*

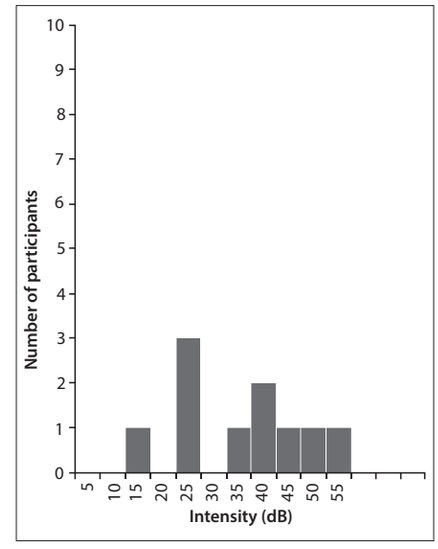


*Fig. 4. Tinnitus loudness matching for group B.*

Hence, results obtained from tinnitus loudness matching are consistent with these findings.

## Conclusions

The attributes of tinnitus in patients with TMD were found to differ from those experienced by non-TMD patients. Although most participants in group A matched their tinnitus to a 6 000 Hz tone or noise, at lower intensity levels than participants in group B, results were not statistically significant. Results obtained from the study highlight the fact that tinnitus is a presenting problem in patients with TMD. This implies the need for improved awareness and understanding of the relationship between TMD and the ear in terms of tinnitus as a symptom, as well as a multidisciplinary approach to tinnitus assessment and management which includes dental professionals.

Future research should be conducted on matched groups with regard to age and gender. In addition, further investigation regarding the attributes of tinnitus in TMD patients should include extended high-frequency testing because it is a useful indicator of tinnitus pitch. The current study should also be conducted on a larger scale with a bigger sample size to overcome the statistical significance limitations of the current study.

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**References**

Ariizumi, Y., Hatanaka, A. & Kitamura, K. (2010). Clinical prognostic factors for tinnitus retraining therapy with a sound generator in tinnitus patients. J Medi Dent Sci, 57, 45-53.

Baguley, D. M. (2002). Mechanisms of tinnitus. Br Med Bull, 63, 195-212. doi:10.1093/bmb/63.1.195

Bauer, C.A. & Brozoski, T.J. (2006). Effect of gabapentin on the sensation and impact of tinnitus. Laryngoscope, 116, 674-681. doi:10.1097/01.MLG.0000216812.65206.CD

Bernhardt, O., Gesch, D., Schwahn, C., Bitter, K., Mundt, T., Mack, F., John, U. (2004). Signs of temporomandibular disorders in tinnitus patients and in a population-based group of volunteers: Results of the Study of Health in Pomerania. J Oral Rehabil, 31, 311-319. doi:10.1046/j.1365-2842.2003.01249.x

Bess, F. H. & Humes, L. E. (1990). Audiology: The fundamentals. Baltimore: Williams & Wilkins.

Camparis, C. M., Formigoni, G., Teixeira, M. J. & de Siqueira, J. T. (2005). Clinical evaluation of tinnitus in patients with sleep bruxism: Prevalence and characteristics. J Oral Rehabil, 32 (11), 808-814. doi:10.1111/j.1365-2842.2005.01519.x

Carolina Ear and Hearing Clinic. (2005). Tinnitus questionnaire. Retrieved from https://www.medclick24-7.com/medclinics/cehc/forms/tinnitus/tinnitus.htm

Chole, R. A. & Parker, W. S. (1992). Tinnitus and vertigo in patients with temporomandibular disorder. Arch Otolaryngol Head Neck Surg, 118, 817-821. doi:10.1001/archotol.1992.01880080039010.

Crummer, R. W. & Hassan, G. A. (2004). Diagnostic approach to tinnitus. Am Fam Physician, 69(1): 120-126.

Davis, A. & El Refaie, A. Epidemiology of tinnitus. (2000). In R. S. Tyler (Ed.), Tinnitus handbook. (pp. 1-25). San Diego: Singular Thomson Learning.

Devlin, A. S. (2006). Research methods: Planning, conducting and presenting research. Belmont: Thomson/Wadsworth.

Dimitroulis, G. (1998). Temporomandibular disorders: A clinical update. BMJ, 317, 190-194.doi:org/10.1136/bmj.317.7152.190

Erlandsson, S. I., Rubenstein, B., Axelson, A. & Carlsson, S. G. (1991). Psychological dimensions in patients with disabling tinnitus and craniomandibular disorders. Br J Audiol, 25, 15-24. doi:10.3109/03005369109077860

Felicio, C. M., Faria, T. G., da Silva, M. A. M. R., de Aquino, A. M. C. M. & Junqueira, C. A. (2004). Temporomandibular disorder: Relationship between otologic and orofacial symptoms. Revista Brasileira de Otorhinolaringologia, 70(6), 786-793.

Hall, J. W. & Haynes, D. S. (2001). Audiologic assessment and consultation of the tinnitus patient. Seminars in Hearing, 22, 37-49. doi:10.1055/s-2001-13019

Henry, J. A. & Meikle, M. B. Psychoacoustic measures of tinnitus. (2000). J Am Acad Audiol, 11,138-155.

Henry, J. A., Zaugg, T. L. & Schechter, M. A. (2005). Clinical guide for audiologic tinnitus management I: Assessment. Am J Audiol, 14(1), 21-49. doi:10.1044/1059-0889(2005/004)

Kelly, H. T. & Goodfellow, D. J. (1964). Vertigo attributable to dental and temporomandibular joint causes. J Prosthet Dent, 14, 159-173. doi:10.1016/0022-3913(64)90131-3

Martines, F., Bentivegna, D., Di Piazza, F., Martines, E., Sciacca, V. & Martinciglio, G. (2010). Investigation of tinnitus patients in Italy: Clinical and audiological characteristics. Int J Otolaryngol, 2010: 2-8. doi:10.1155/2010/265861

Morgan, D. H. (1992). Tinnitus of TMJ origin: A preliminary report. Journal of Craniomandibular Practice, 10, 124-129.

Salvinelli, F., Casale, M., Paparo, F., Persico, A. M. & Zini C. (2003). Subjective tinnitus, temporomandibular dysfunction, and serotonin modulation of neural plasticity: causal or causal triad? Med Hypotheses, 61(4), 446-448. doi:10.1016/S0306-9877(03)00194-4

Schaette, R. & McAlpine, D. (2011). Tinnitus with a normal audiogram: Phyisiological evidence for hidden hearing loss and computational model. J Neurosci, 31(38), 1342-1347. doi:10.1523/JNEUROSCI.2156-11.2011

Sobhy, O. A., Koutb, A. R., Abdel-Baki, F. A., Ali, T. M., El Raffa, I. Z. & Khater, A. H. (2004). Evaluation of aural manifestations in tempero-mandibular joint dysfunction. Clin Otolaryngol, 29 (4), 382-385. doi:10.1111/j.1365-2273.2004.00842.x

South African Medical Research Council. (2003). General principles including research in children, vulnerable groups, international collaboration and epidemiology. Retrieved from http://www.sahealthinfo.org/ethics/ethicspolicy.htm

Thibodeau, L. M. (2007). Speech audiometry. In R. J. Roeser, M. Valente & H. Hosford-Dunn (Eds.), Audiology: Diagnosis (pp. 288-313). New York: Thieme Medical Publishers.

Tuz, H. H., Onder, E. M. & Kisnisci, R. S. (2005). Prevalence of otologic complaints in patients with temporomanibular disorder. *Am J Orthod Dentofacial Orthop*, 123(6), 620-623. doi:10.1016/S0889-5406(03)00153-7

Tyler, R.S. (2000). The psychoacoustical measurment of tinnitus. In R. S. Tyler (Ed.), Tinnitus handbook (pp. 149-181). San Diego: Singular Thomson Learning.

Vernon, J., Griest, S. & Press, L. (1992). Attributes of tinnitus that may predict temporomandibular joint dysfunction. Journal of Craniomandibular Practice, 10 (4), 282-287.

Vielsmeier, V., Kleinjung, T., Strutz, J., Burgers, R., Kreuzer, P. M. & Langguth, B. (2011). Tinnitus with temporomandibular joint disorders: A specific entity of tinnitus patients? Otolaryngol-Head Neck Surg, 145(5), 748-752. doi:10.1177/0194599811413376

Viirre, E. (2007). Cognitive neuroscience in tinnitus research: A current review. Int Tinnitus J, 13(2), 110-117.

Wright, E. F. & Bifano, S. L. (1997). Tinnitus improvement through TMD therapy. J Am Dent Assoc, 128, 1424-1432.

Appendix A

**Subject Number:**

**Age:** **Gender:**

**Do you have or have you had any of the following conditions (Please circle if yes). If you suffer from a condition that is not listed, please add it to the end of the list.**

| | | | |
|---|---|---|---|
| anemia | heart disease | kidney disease | tumor |
| arthritis | high blood pressure | nervous disorders | ulcers |
| asthma | low blood pressure | rheumatic fever | radiation therapy |
| blood disease | hepatitis | scarlet fever | venereal disease |
| cancer | jaundice | stroke | |
| diabetes | liver disease | thyroid problems | |
| epilepsy | lung disease | tuberculosis | |

(Adapted from School of Oral Health Sciences, TMD Clinic)

**TINNITUS is defined as a noise in the ear. Please answer the following questions about your tinnitus.**

**1. How long have you been aware of your tinnitus?**

**2. Did the tinnitus come on gradually or suddenly?**

**3. Where does your tinnitus appear to be located?**

- ○ In the left ear only
- ○ In the right ear only
- ○ In both ears
- ○ In the head
- ○ Not sure
- ○ Other

**4. At present is your tinnitus constantly there or do you hear it only part of the time?**

**5. What does your tinnitus sound like? (Please check ALL the boxes that apply).**

| | | |
|---|---|---|
| a. ☐ Ringing | e. ☐ Whistle | i. ☐ Ocean Roar |
| b. ☐ Sizzling | f. ☐ Crickets | j. ☐ Transformer Noise |
| c. ☐ Hissing | g. ☐ Clear Tone | k. ☐ High Tension Wire |
| d. ☐ Hum | h. ☐ Buzzing | i. ☐ Pulsating |

Continued ...

**6. Are any of the following a possible cause of your tinnitus?**

a. ☐ Infection of ear or sinus

b. ☐ Brief exposure to intense noise

c. ☐ Noise exposure over a long period of time

d. ☐ Whiplash or cervical trauma

e. ☐ Head injury or blow to head

f. ☐ Illness

g. ☐ Drugs

h. ☐ Nothing known

**7. In addition to tinnitus, do you have a hearing loss? If no skip to question #11.**

**8. If you do have a hearing loss, do you currently wear a hearing aid? (please click option)**

○ No

○ Yes in the left ear only

○ Yes in the right ear only

○ Yes in both ears

○ I have no hearing loss

**9. If you do have a hearing loss, which is more of a problem for you, the hearing loss or the tinnitus? (please click option)**

○ Hearing loss

○ Tinnitus

○ Equally bothersome

○ Unsure

**10. Please check the box of any of the treatments you have tried for your tinnitus?**

a. ☐ Hearing aid

b. ☐ Tinnitus masker or other masking device

c. ☐ Biofeedback

d. ☐ Acupuncture

e. ☐ Drug therapy

f. ☐ Dietary modification (low salt, no caffeine)

g. ☐ Jaw joint (TMJ) therapy

h. ☐ Herbal therapy (Ginko etc.)

i. ☐ Tinnitus retraining therapy

Other:

Continued ...

**11. Have any of the treatments helped? If so please list:**

**12. How much of an effort is it for you to ignore your tinnitus when it is present? (please click option)**

- ○ **Easily ignored**
- ○ **Can be ignored with some effort**
- ○ **It takes considerable effort to ignore**
- ○ **Can not be ignored**

**13. How much discomfort do you usually experience when your tinnitus is present?? (please click option)**

- ○ **None**
- ○ **Mild discomfort**
- ○ **Moderate discomfort**
- ○ **A great deal of discomfort**

**14. Do you ever feel irritable because of your tinnitus?**

**15. Do you have sleep problems because of your tinnitus?**

**16. How much interference does tinnitus cause you for the following activities? (Please click the option)**

| | | | | |
|---|---|---|---|---|
| **a. Work Activities** | ○ **None** | ○ **Slight** | ○ **Moderate** | ○ **Great** |
| **b. Social Activities** | ○ **None** | ○ **Slight** | ○ **Moderate** | ○ **Great** |
| **c. Mental Activities** | ○ **None** | ○ **Slight** | ○ **Moderate** | ○ **Great** |
| **d. Over all enjoyment of life** | ○ **None** | ○ **Slight** | ○ **Moderate** | ○ **Great** |

**17. Do you ever have trouble with hearing or sounds (hyperacusis) that seem too loud?**

**If yes do you wear ear plugs?**

(Adapted from Carolina Ear & Hearing Clinic)