REVIEW

DOI: 10.5935/0946-5448.20210014

International Tinnitus Journal. 2021;25(1):71-75

Tinnitus, Use and Evaluation of Sound Therapy, Current Evidence and Area of Future Tinnitus Research

Adaobi E. Osuji*

ABSTRACT

Tinnitus is one of the otologic symptoms seen in persons with ear pathologies. It is defined as an acoustic sensation in the ear without a corresponding external acoustic stimulus. Tinnitus is said to be generated from the higher auditory centres because of reduced feedback from the peripheral or neural component but can be an outcome of irritation at different levels of the auditory system. Several treatment modalities have been tried in the management of tinnitus, either as a single treatment or as part of combination therapy. They range from lifestyle or dietary modification, medications, surgery, to Tinnitus Retraining Therapy (TRT), use of sound generating devices, hearing aids and cochlear implants. Current literature has shown that the prevalence of tinnitus is highly variable and reflects the difference in symptom criteria and patient selection for the various treatment modalities. This variability is also visible in the outcomes of cases where the various treatment modalities have been used. In the presence of an augmented hearing, the brain can focus on the meaningful sound generated externally while suppressing or even aborting the tinnitus. Future tinnitus research needs to apply the highest level of randomization and blinding, in line with the high subjectivity of tinnitus and the possibility of a response with control. The natural sequence of tinnitus is characterized by the conditioning or habituation and possible gradual attenuation of symptom, this implies that there is a limit to which the benefits observed was due to our intervention rather than a natural process of this symptom.

Keywords: Tinnitus; Symptom, Hearing loss.

Department of Advanced Audiology: Audiovestibular Medicine, Ear Institute and University College, London, United Kingdom

*Send correspondence to:
Adaobi E. Osuji
Department of Advanced Audiology: Audiovestibular Medicine, Ear Institute and University College, London, United Kingdom. E-mail: adaobi.osuji.19@ucl.ac.uk Phone: +41302040753
Paper submitted on March 08, 2021; and Accepted on April 30, 2021

INTRODUCTION

Ludwig van Beethoven, the renowned music composer of all times often complained "My ears Whistle and buzz all day and night. I can say I am leading a wretched life." He suffered from tinnitus as a result of sensorineural hearing loss, which he described as a harsh roaring in his ears[1] Beethoven died in 1827[1] but unfortunately, even after several decades of knowledge of tinnitus, there has been minimal advancement in its treatment. Tinnitus is one of the otologic symptoms seen in persons with ear pathologies. "noise in the ear" as it is called in common parlance, can be generated by pathology present at any point along the auditory pathway from the external ear to the brain[2]. Tinnitus is defined as an acoustic sensation in the ear without a corresponding external acoustic stimulus, it is often referred to as 'phantom noise[2]. It can be described as buzzing, ringing, whistling, roaring, pulsatile, etc. It is associated with hearing loss in the sense that it usually precedes hearing loss and persists in the presence of an existing hearing loss[3] It can be subjective or objective. The objective tinnitus also called somato-sounds, is heard by the patient and often by the examiner. It is usually caused by physical causes, like pathologies involving blood vessels or structures near the inner ear. Tinnitus can often be picked up as spontaneous otoacoustic emissions[3] This objective type makes up about 5% of tinnitus cases Diverse conditions can cause objective tinnitus, and these include pathologies that can cause pulsatile tinnitus like arteriovascular malformations, vascular tumours, atherosclerosis, ectopic carotid artery, persistent stapedial artery, dehiscent jugular bulb, cardiac murmurs, pregnancy, thyrotoxicosis, Paget's disease, hypertension, to mention but a few. Muscular causes of objective tinnitus include palatal myoclonus, stapedial muscle spasm, and patulous eustachian tube[3] on the other hand, subjective tinnitus is only heard by the person with tinnitus, and not necessarily generated by physical causes. This makes up 95% of tinnitus cases. Pathologies in which subjective tinnitus can be present include presbycusis, otosclerosis, noise trauma, Meniere's disease, acoustic neuroma, middle ear diseases, wax impaction, otitis externa, temporomastoid joint disorders, depression, etc. subjective tinnitus can also be drug-induced and has been associated with the use of anticancer drugs like cisplatin, antimalarials like quinine, antibiotics like aminoglycosides, antihypertensives like diuretics, and non-steroidal anti-inflammatory agents like aspirin, diclofenac, and ibuprofen[3]. In most objective tinnitus with underlying pathology, treatment of the primary cause may put an end to the tinnitus, but in cases with subjective tinnitus, the treatment of a suspected underlying pathology may not abort the tinnitus Tinnitus can be transient and abort spontaneously, however, it is chronic and unlikely to be aborted spontaneously when it has remained for more than three months.

POSSIBLE PATHOPHYSIOLOGY OF TINNITUS

Johannes Muller a prominent psychologist in the 19th century said tinnitus was a result of overstimulation of the auditory nerve associated with brain pathology, weakness or disease of the auditory nerve, while MacNaughton Jones in 1891 reported that tinnitus was an outcome of irritation at different levels of the auditory system. In the same light, tinnitus is said to be generated from the higher auditory centres as a result of reduced feedback from the peripheral or neural component. Thus, reduced firing in the auditory nerve fibres, leads to a feedback mechanism to the brain, which results in an increased spontaneous neuronal activity in higher auditory centres and consequently generating 'phantom noise[2]. According to House and Brackman in 1981, tinnitus is generated in the brain, thus cutting the auditory nerve does not eradicate tinnitus This was buttressed by Cope et al in 2011[2] when they noted that after removal of acoustic schwannoma, tinnitus was perceived in the dead ear in the presence of complete hearing loss Some authors have reported increased spontaneous activity in the auditory cortex, inferior colliculus, and dorsal and ventral cochlear nucleus in the presence of tinnitus On the other hand, Liebermann et al, 1984[2] confirmed a decreased spontaneous firing in the auditory nerve fibres. It has also been reported that the temporal aspect of neural activity which includes the altered rate, temporal discharge pattern, and/or temporal correlation between discharge patterns of different nerve fibres, may also be of importance in the generation of tinnitus[3]

TREATMENT MODALITIES FOR TINNITUS

Several treatment modalities have been tried in the management of tinnitus, either as a mono treatment or as part of combination therapy. They range from lifestyle or dietary modification, medications, surgery, to Tinnitus Retraining Therapy (TRT), use of sound generating devices, hearing aids and cochlear implants[3]. Dietary modifications may be effective in cases where the tinnitus is caused by the substance being avoided. This also includes avoiding medications that are known to induce tinnitus. Medications that have been tried in tinnitus treatment include alprazolam. Johnson et al in 1993 reported that 76% of their 17 subjects, had a reduction in the severity of their tinnitus with alprazolam dose of 0.5-1.5mg/day. However, they noted that it is not recommended for protracted use due to the problem of dependence associated with this drug[4]. Use of antidepressants like amitriptyline and Nortriptyline was reported by Dobie in 2003 as having 67% efficacy in her study of 92 patients. However, she had a placebo efficacy result of 40% and thus stated that further research is needed to re-evaluate the efficacy of the drugs and confirm results[5]. Betahistine, a medication for vestibular disorders, have also received numerous prescriptions in the treatment of tinnitus. However, it has been reported as being only as effective as a placebo in the reduction of tinnitus[6]. Tinnitus Retraining Therapy (TRT) has been used in the treatment of tinnitus, based on the neurophysiological model. It uses a combination of low-level broadband noise masking for some hours each day, combined with counselling to achieve habituation to

tinnitus and improved patient perception of the tinnitus.[6] Surgery is indicated in the presence of underlying pathologies requiring surgery. Such as glomus tumour, arteriovenous malformations, acoustic neuroma and otosclerosis However, several authors have reported the persistence of tinnitus after surgery in some of these patients[2]. Some clinicians have advocated cochlea nerve sectioning as a way of curtailing intractable tinnitus. As much as this is not widely accepted, some researchers have reported tinnitus persistence after nerve sectioning. The use of hearing aid, maskers, and sound generating devices in the treatment of Tinnitus is referred to as sound therapy. In the United Kingdom, the use of sound therapy often constitutes the treatment offered for tinnitus either in isolation or in combination with other treatment modalities[7] Sound therapy is employed to achieve one or more of the following: habituation, sound enrichment, masking, distraction, improved hearing, relaxation neuromodulation, and reduction of listening effort.

USE OF HEARING AIDS, COCHLEAR IMPLANTS AND SOUND GENERATING DEVICES IN TINNITUS MANAGEMENT

The rationale behind the use of hearing aids, cochlear implants, and sound generating devices used in the management of tinnitus is that tinnitus is often associated with hearing loss and is usually severe with worse hearing loss[2]. It is believed that in the presence of an augmented hearing, the brain can focus on the meaningful sound generated externally while suppressing or even aborting the tinnitus. Several studies have been carried out to assess the effectiveness of these sound devices in the treatment of tinnitus. These devices used for sound therapy in the management of tinnitus can be employed either as amplification only devices like hearing aids or as combination devices where the aim is both amplification and sound generation. Some hearing aid manufacturers have developed hearing aids with unique combination effects, where the device can both amplify sound and generate various sounds which can be programmed in different forms as masking noise. Sound therapy can also be administered with sound generators which aim to mask out the tinnitus sound, by generating sound which can be broadband noise (white, pink, brown noise) or narrow-band noise. In terms of a cochlear implant, it is employed in cases where there is tinnitus in the presence of hearing loss, especially in single-sided deafness due to cochlea deafferentation[8] Usually, in this case, the integrity of the cochlear is partially or completely compromised, and tinnitus is more debilitating[8].

CURRENT EVIDENCE AND EVALUATION OF EVIDENCE ON COCHLEAR IMPLANTS, HEARING AIDS, COMBINATION DEVICES AND SOUND GENERATORS USE IN THE MANAGEMENT OF TINNITUS

The review of the current literature has shown that the prevalence of tinnitus is highly variable and reflects the difference in symptom criteria and patient selection for the various treatment modalities[3]. About 15% of adults in the United Kingdom have protracted impulsive tinnitus without any apparent cause, and at least 8% of these patients have their tinnitus affecting their sleep or causing them moderately to severe annoyance, and in 0.5%, their tinnitus severely disturbs their capacity to live a normal life. Therefore, this variability is also visible in the outcomes of cases where the various treatment modalities have been used. For instance, the use of a cochlear implant has appeared promising in the treatment of tinnitus. Ito (1997) reported relief in 77% of the 26 patients who had a cochlear implant for tinnitus and 8% noted worsening of their symptoms.[9] In contrast, Arts et al (2012) in their review work, stated that cochlear implantation suppressed tinnitus in most of the cases and no tinnitus worsening was reported[8] This review by Arts et al did not mention the number of articles reviewed or the number of patients in their review, which may water down the strength of their report. However, they concluded that appropriate patient selection is essential to the outcome of treatment with cochlear implants[8] They believe that positive results are seen in cases where the cochlear implant is done in patients with tinnitus and deafness due to cochlear deafferentation, in the absence of which the use of cochlear implant will have no impact or worsen tinnitus[8] These studies have disregarded the emotional aspect of the effect of tinnitus on these patients, concentrating only on the presence or absence of tinnitus. Also, some of the cases reported had worsening and persistence of tinnitus, which shows that cochlear implant may not be the ideal treatment for tinnitus, despite patient selection. As much as the report from Ito et al and Art et al[9] are primary sources of information from professionals, which gives credence to their findings, it needs to be buttressed with stronger evidence from a systematic review, which will give a holistic assessment of the problem of tinnitus. Van Zon et al in 2015[9], carried out a systematic review of nine studies and looked at speech perception in noise, sound localization, quality of life and tinnitus[10] They concluded that there are no high-level-of-evidence concerning cochlear implantation and one-sided hearing loss. However, they stated that there may be an important benefit of cochlear implant regarding sound localization, and quality of life in patients with tinnitus[10] This study gives stronger evidence and a broader analysis of the role of cochlear implantation in tinnitus treatment.Several studies have looked at the benefit of hearing aid, sound generators, and a combination of both for tinnitus relief. A systematic review was done by Sereda et al (2018)[11] on Sound therapy, looking at the use of amplification devices against sound generators for tinnitus in adults. They looked at eight trials with 590 subjects, and three trials among those considered showed large benefit with hearing aids in terms of health-related quality of life

and listening ability. Their review showed the efficacy of hearing aids in improving results in tinnitus patients when compared to placebo and waiting list[7] One of the studies in their review compared severity of tinnitus in patients using hearing aids as against those using sound generators and it showed no difference in the efficacy of both forms of treatment based on the severity of tinnitus. Furthermore, three of the trials looked at the severity of tinnitus in patients on hearing aid as compared to combination hearing aids. Combination hearing aids were found to be more effective in one study, whereas hearing aids were more effective in the other 2 studies However, none of these three studies comparing hearing aids and combination hearing aids measured the outcome of depressive symptoms, anxiety, and health-related quality of life. This evidence is of high value, coming from a systematic review, and thus seem reliable, however, it seems insufficient. From their systematic review, Sereda et al, (2018)[12] made it obvious that there is no evidence supporting the higher effectiveness of sound therapy over placebo or treatment without a sound device. Also, the evidence showing if one form of sound therapy is more effective than the other is insufficient[12] Therefore, using a combination device, hearing aids, or sound generators result in little or no difference in the severity of tinnitus[11].

FUTURE RESEARCH IN TINNITUS MANAGEMENT

There is a need for further research to evaluate the effectiveness of sound therapy and to find a more specific and efficient treatment for tinnitus. Such future research needs to apply the highest level of randomization and blinding, in consideration of the high subjectivity of tinnitus and the huge possibility of a response with control[12]. Moreover, currently, no form of treatment for tinnitus is effective in all patients[13]. Besides, cortical activities which give rise to tinnitus has been shown to involve a complex neuronal network. The advent of transcranial high-definition magnetic stimulation, and functional radiological techniques like the functional Magnetic Resonance Imaging (fMRI), and Positron Emission Tomography (PET), have improved the awareness of tinnitus. In line with this, changes in the neuronal activity in the brain may have gained a little more insight[13] with new perception into three-dimensional processing of tinnitus associated activity. As much as this is now slowly being revealed, it is still far from being fully described or understood[13]. Studies have shown that repetitive transcranial magnetic stimulation (rTMS) is non-invasive, and can induce electrical currents in the brain that can reduce the neuronal activity responsible for tinnitus, but there is paucity of data to verify its long-term safety in patients[13]. However, there is a need for further research in this area, to improve on the understanding of tinnitus, because this will be the key to identifying more specific and targeted treatment approaches that will be effective in all patients.

CONCLUSION

There is still a lot to be understood about tinnitus and this affects the provision of treatment modality for it, but obviously, it is not a 'one cap fits all' scenario. As much as efficacy has been reported with the use of some of these treatment modalities mentioned above, there are findings where the efficacy was not better than placebo. Since the biological sequence of tinnitus is characterized by the conditioning or habituation and possible gradual attenuation of symptom, it may be that there is a limit to which the benefits seen was due to our intervention rather than a natural process of this symptom. However, we cannot yet exclaim "Eureka" like the famous inventor, as regards the treatment of tinnitus because more effort is needed to identify actual pathogenesis or pathophysiology of tinnitus and inform a more targeted approach to its treatment, with a precise and improved result.

REFERENCES

1. Ludwig von Beethoven Website. Accessed on 15th of February 2020.
2. Schaette, R. Tinnitus in men, mice (as well as other rodents) and machines. Hear Res. 2009;311:63-71.
3. Ceramic B, Luxon LM. Tinnitus and other dysacuses in John CW Ed. Scott Brown's Otorhinolaryngology Head and Neck Surgery. Volume 1-3. 8th Ed. CRS Press, UK. 2018;1:3609-19.
4. Johnson RM, Brummett R, Schleuning A. Use of Alprazolam for Relief of Tinnitus. A Double-Blind Study. Arch Otolaryngol Head and Neck Surg. 1993;119:842-5.
5. Dobie R. Depression and Tinnitus. Otolaryngologic clinics of North America. 2003;36:383-8.
6. Wagner I, Hall DA, Smit A, McFerran D, Stegeman I. Betahistine for Tinnitus (Review). Cochrane Database of Systematic Review. 2018; 12:1-2.
7. Sereda M, Hoare DJ, Nicholson R, Smith S, Hall DA. Consensus on Hearing Aid Candidature and Fitting for Mild Hearing Loss, With and Without Tinnitus: Delphi Review. Ear Hear. 2015;36:417- 29.
8. Ito J. Tinnitus Suppression in cochlear Implants Patients. Otolaryngol. Head and Neck Surg. 1997;117:701-703.
9. Arts RA, George EL, Stokroos RJ, Vermeire K. Review: Cochlear Implants as a Treatment of Tinnitus in Single-sided Deafness. Curr. Opin. Otolaryngol Head and Neck Surg. 2012;20:398-403.
10. Van Zon A, Peters JP, Stegeman I, Smit A, Grolman W. Cochlear Implantation for Patients with Single-Sided Deafness or Asymmetrical Hearing Loss: A Systematic Review of the Evidence. Otology and Neurotology. 2015;36:209-19.
11. Sereda M, Xia J, El Refaie A, Hall DA, Hoare DJ. Sound Therapy (Using Amplification Devices and/or Sound Generators) for Tinnitus in Adults (Protocol). Cochrane DB Syst Rev. 2018;6:1-17.

12. Sereda M, Smith S, Newton K, Stockdale D. Mobile Apps for Management of Tinnitus: Users' Survey, Quality Assessment, and Content Analysis. JMIR Mhealth Uhealth, 2009;7:e103-53.

13. Meng Z, Liu S, Zheng Y, Phillips JS. Repetitive Transcranial Magnetic Stimulation for Tinnitus. Cochrane DB Syst Rev. 2011;1:1-6.