

Effect of Using Amplification Device for Treatment of Tinnitus Inpresbycusis in First Time Hearing Aid Users

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Abstract: The present study aimed to examine the impact of first time users of amplification devices by participants having presbycusis on tinnitus. Pure tone Audiometry along with immittance audiometry and speech Audiometry was carried out. The Tinnitus handicap inventory (THI) questionnaire, developed by Newman et al. (1996), was administered in all participants for pre and post hearing aid fitting conditions. The statistical analysis used were descriptive of mean, standard deviation, paired t-test and Welch two-sample t-test using SPSS software. The tinnitus profile varied among the participants in terms of onset, severity, site and duration. Majority of the participants (78.3%) in the study reported unilateral tinnitus. All of them were fitted with body worn analog hearing aids of different models with fitting style depending upon their nature of hearing loss. Administration of THI yielded changes in scores between the pre-hearing aid fitting and post-hearing aid fitting condition. Paired t-test revealed that there is a significant reduction [$t(43) = 12.3271, p < .05$] in tinnitus impact following amplification in the presbycusis cases. Welch two-sample t-test results revealed that there is no significantly greater decrease [$t(19.906) = 1.155, p < .05$] of tinnitus after fitting with pseudo-binaural hearing aids instead of unilateral hearing aids thus suggesting that pseudo-binaural fitting of amplification device will not have any greater impact on severity of tinnitus in presbycusis cases.

Keywords: Tinnitus, Hearing Aids, THI

I. Introduction

Tinnitus is defined as an aberrant perception of sound reported by a patient that is unrelated to an external source of stimulation (Shulman, 1988). Dauman and Tyler (1992) proposed that pathologic tinnitus is head noise lasting at least 5 minutes that occurs more than once per week. About 70%-85% of hearing impaired population is affected by tinnitus and 25% of tinnitus sufferers are bothered enough to seek medical attention. A study of the prevalence of tinnitus in children and the elderly found the incidence of tinnitus in presbycusis to be 11% (Podoshin, Ben-David & Tetzler, 1997). It is generally agreed that the incidence of tinnitus increases with age. The risk for the development of tinnitus rises with increasing age and with increasing noise exposure (Ahmad & Seidman, 2004). Hoffman and Reed (2004) compared six studies that obtained age-specific tinnitus prevalence data in adults. Each of these studies showed a trend of increasingly greater prevalence at higher age decades. Heller (2003) reported that the prevalence of tinnitus is 12.1% in 60-69 year olds as compared to 4.7% in 20-29 year olds.

There are various potential possible causes of tinnitus (Moller, 2011). One of the highest risk factors for tinnitus is noise exposure. Henry et al. (2005) noted that prolonged sound exposure and noise trauma represented the most commonly known factor associated with the onset of tinnitus. Two possible causes of tinnitus may be secondary neural degeneration (i.e. Eighth nerve to cochlear nucleus, etc) in the central nervous system (CNS) and changes in the balance of excitation and inhibition in auditory pathways (Morest et al., 1998). The degree and the impact of tinnitus on an individual person vary widely for the different kinds of tinnitus and also from individual to individual. Tinnitus often fluctuates over time and circumstances. Kochkin and Tyler (2008) noted that tinnitus may impact a person's emotional well-being and may negatively impact socialization, relaxation, job performance contributing to psychological problems such as depression, stress, anxiety, anger, and even suicidal thoughts.

Presbycusis is the universal term applied to age related hearing loss due to the contributions of a lifetime of abuse to the auditory system (Gates and Mills, 2005). With the life expectancy on the rise and 65 and older age group growing more rapidly than any other age group, the number of older adults reporting a hearing loss is likely to increase (Heine & Browning, 2001; Harhager, 2007). It is estimated that 21 million older adults will have an age related hearing loss by the year 2030 (Garstecki, 1996; Weinstein, 2000). In general the symptoms of presbycusis includes a reduction in hearing sensitivity and speech understanding in noisy

environment, slowed central processing of acoustic information and impaired localization of sound sources (Gates and Mills, 2005).

Comprehensive diagnosis and treatment of tinnitus is possible by an integrated multidisciplinary approach. Basic diagnostic assessment protocol includes steps like taking history of the tinnitus, tinnitus questionnaires and tinnitus severity grading; clinical examination; Subjective Audiological tests like Audiometry, psychoacoustic tinnitus measurement- tinnitus pitch and loudness matching; and objective Audiological tests like acoustic examination (OAE), brainstem auditory evoked potentials (BAEP), event related potentials (ERP), vestibular evoked myogenic potentials (VEMP); Neuroimaging techniques ; Neuro-vascular examinations and blood tests; psychological and psychiatric examinations.

Tinnitus is most likely always multi-factorial. Therapeutic tools include manipulating sensory inputs, modifying psychological influences and variety of direct approaches to the central nervous system. Various therapeutic techniques for management of tinnitus include auditory stimulation and sound enrichment; tinnitus suppression through implantable devices (Baguley, & Atlas, 2007); Tinnitus Retraining Therapy; Cognitive Behavioral Therapy; Pharmacological treatment; Surgical treatments of microvascular decompression and vestibular schwannoma; neuromodulation through amplification devices, cochlear implantations, auditory nerve implantations and brainstem implantations; Transcranial Magnetic Stimulation (TMS) including Transcranial Direct Current Stimulation (TDCS) of the temporal lobe and dorsolateral prefrontal cortex stimulation; cutaneous stimulation of the skin around the ears (Cacace, Cousins, & Pames et al, 1999); and unconventional treatments involving mindfulness and hypnosis; low-level laser therapy; and counseling.

Sound enrichment or auditory stimulation is one of the most employed therapeutic methods and one of the most beneficial for patients suffering from tinnitus (Han, Lee & Kim et al, 2009). Prosthesis and open-ear hearing aids are important for proper treatment of tinnitus. Modern hearing aids can provide amplification at the frequencies where hearing loss occurs, without uncomfortable side effects, such as over amplification or rumbling, which were typical in the old generation devices (Del Bo & Ambrosetti, 2007). Studies (Molini, Faralli, & Calenti et al, 2009) have shown that hearing aids can achieve goals like making patients with mild hearing loss less aware of tinnitus or masking it; improving communication and reducing the discomfort often reported by patients as sounds and voices covered by tinnitus; and stimulating the auditory nervous system in a normal way. Besides hearing aids, the new generation Combi (combination hearing aids) being now available, combine common prostheses with the ability to generate an enrichment sound, similar to what custom sound generators provide (Carabba, Coad & Costantini et al., 2009).

Studies are rare regarding the effects of amplification devices on tinnitus in the Indian scenario and its population. Outcome evaluation in tinnitus participants is important to plan the amplification strategy and fitting criteria in individuals with presbycusis. There are different types of sound enrichment devices available in the world and in that the most effective sound enrichment devices which are used in the patients with hearing impairment are hearing aids (Trotter & Donaldson, 2008). In Indian context, there are no thorough data available to establish this statement. This research may be an elementary research which may emancipate the efficacy of sound enrichment devices such as hearing aids.

The aim of the study was to examine the impact of first time users of amplification devices on tinnitus in participants having presbycusis.

II. Methodology

Participants

A total of sixty participants having sensorineural hearing loss with tinnitus within the age range of 60 to 80 years were selected. Participants were selected from a group who had never been fitted with hearing aids before and whose tinnitus has been very annoying. Neurological disorders leading to hearing loss or tinnitus were ruled out.

Tools

Word lists of spondee words adapted in Bangla (Dutta et al., 2016) and Hindi (ISHA spondee Word list, standardized and used in ENT, Dept. AIIMS, New Delhi); and word lists of phonetically balanced (PB) words adapted in Bangla (Santra, Chatterjee & Shahi, 2016) and Hindi (ISHA PB word list, standardized and used in ENT, Dept. AIIMS, New Delhi) were used for determining the speech recognition thresholds and word recognition scores.

Tinnitus Handicap Inventory (THI) was used to measure the degree of handicap due to tinnitus. The Tinnitus Handicap Inventory (THI) is a tinnitus-specific widespread, and validated questionnaire for quantifying tinnitus severity in patients' daily lives (Newman et al., 1996). This questionnaire is designed to evaluate behavioral and treatment outcomes in emotional and physical aspects of the patients' health and lifestyles. The THI is a self-administered, 25-item questionnaire that is scored on a 3-point rating scale (NO = 0, Sometimes = 2 and Yes = 4). The total THI score is the sum of the scores for the following three subscales: functional,

emotional, and catastrophic. Based on the total THI score, tinnitus sufferers were classified into four categories denoting handicap severity: no handicap or Slight tinnitus (0-16), mild handicap or mild tinnitus (18-36), moderate handicap or moderate tinnitus (38.56), severe handicap or severe tinnitus (58-76) and catastrophic handicap or catastrophic tinnitus (78-100).

Procedure

A detailed case history including medical history, family history, educational history, and economic background was taken. Otoloscopic examination was performed routinely on all participants. GSI 39 Auto Tympanometry audiometer was used to identify and objectively rule out middle ear pathologies. MAICO MA 53 diagnostic audiometer was used for the purpose of Audiological testing of the participants. Pure-tone Audiometry included air conduction (AC) and bone conduction (BC) testing. The method adopted in the study was ascending technique using a modified method of limits procedure. The modified Hughson-Westlake technique (Carhart & Jerger, 1959) as detailed in ANSI S3.21-1978 (R-1992) was followed. Pure tones were used while evaluating Pure-tone thresholds in tinnitus patients since the use of pulse tones may assist some patients in distinguishing between the tones and the tinnitus (Douek & Reid, 1968; Fulton & Lloyd, 1975; Green, 1972; Yantis, 1994). Speech Audiometry was performed to determine the Speech Recognition Threshold (SRT) and Word Recognition Scores (WRS) of the participants. The procedure of speech audiometry or SRT determination was done based on the ascending technique using 5-dB increments recommended by ASHA guidelines (1988).

Tinnitus evaluation

The procedure involved the determination of tinnitus pitch matching with pure tone as well as Narrow Band Noise (NBN), tinnitus loudness matching, minimum masking level and octave confusion testing to track the changes in quality of the perceived tinnitus overtime.

Hearing aid trial

Based on the pure tone thresholds obtained through pure tone audiometry (AC and BC testing), subsequent hearing aid trial was performed in a sound field conditions. Apart from sound field testing the hearing aids were also tested in a noisy environment to check for the presence of any tolerance problem due to amplification. Depending upon the need of the subject, they were then provided with monaural or pseudo-binaural amplification.

Administration of the THI

THI was administered and scored before fitting the participants with appropriate hearing aids. THI was again administered after 3 months of follow up and scores were computed.

III. Results And Discussion

The Audiological and tinnitus profile revealed the following findings: Pure tone average revealed a majority of participants (55%) had moderate to moderately severe sensorineural hearing loss. The degree of sensorineural hearing loss varied from mild to profound degree, thus making the group heterogeneous so that impact on tinnitus can be observed by the first time users of hearing aids. The Mean scores of WRS were obtained as 57.583% (S.D. 12.125) for right ear and 58.833% (S.D. 8.847) for the left ear. All the participants showed reduced WRS scores in their ears irrespective of the degree of hearing loss. The onset of tinnitus was reported to be greater than 10 years in 13 participants and less than 10 years in 47 Participants. The mean of THI scores for all participants was 62.5 (SD. 18.668) which indicated that the subjects had severe rating on THI score. Three types of duration of tinnitus were reported- continuous, frequent and occasional tinnitus.

According to subjective reports of all the cases 78.3% of them reported unilateral tinnitus. It was observed that majority (54.5%) had tinnitus in left ear. The finding of unilateral tinnitus being more common in the left ear has been consistently reported in several studies (Coles, 1984; Meikle et al., 1984; Stouffer & Tyler, 1990). Angelica (2011) reported unilateral tinnitus is the most common type of tinnitus observed in tinnitus sufferers.

The participants were fitted with analog body-worn hearing aids under assistance to disabled persons for purchase/fitting of aids and appliances (ADIP) scheme. Monaural fittings were prescribed for asymmetrical hearing loss (75% of the sample) and pseudo-binaural hearing aids under ADIP Scheme for subjects having symmetrical hearing loss (25% of the sample). Output of hearing aids did not exceed the uncomfortable level.

Pre- hearing aid fitting THI scores:

Individual THI scores were obtained for each participant in pre-fitting condition. Mean THI score obtained in the pre-fitting condition was 62.5 (S.D. 18.671). On an average, severe degree of tinnitus was perceived by the participants in the pre-fitting condition signifying that tinnitus was almost always heard, leading to disturbed sleep patterns and interference with daily activities. Mean of pre-fitting THI scores in subjects fitted with monaural body worn hearing aids was 65.954 with a SD of 99.853 and was 47.329 with a SD of 50.877 for subjects with pseudo-binaural amplification.

Post- hearing aid fitting THI scores:

THI scores of post-hearing aid fitting condition were obtained for all the participants. Different results were obtained when compared to the scores of pre-fitting condition. Mean THI score obtained the in post-fitting condition of hearing aid for all participants after three months of usage was 24.731 (SD=22.353). Mean THI score post-fitting of hearing aid in monaural amplification condition was 20.952 with a S.D. of 23.611 and for pseudo-binaural amplification condition was 16.428 with a S.D. of 14.664.

Newman (1999) stated that the rationale behind tinnitus suppression by hearing aids is that the ambient background noise level is amplified by them and they improve the communication ability thus reducing the stress on the participants. Few studies also involved the administration of the THI on people with tinnitus to quantify the extent of tinnitus annoyance. Surr, Kolb and Cord (1999) in their study applied THI on new hearing aid user participants who had hearing impairment of varying degree. They found a statistically significant reduction in the mean scores in some 90% of tinnitus patients after 6 weeks of hearing aid usage. The study revealed that fitting of hearing aids for the period of three months not only helped them to hear better but reduced the severity of tinnitus handicap. After three months of hearing aid use for the first time by all the participants irrespective of whether they were fitted with monaural or pseudo-binaural body-worn hearing aids the THI score reduced by 39.568% making the perception of tinnitus in mild category. Crocetti (2010) studied the use of hearing aids in tinnitus patients and found out the initial mean THI score before amplification to be 54.221 (SD. 20373) and final mean score after amplification to be 28.324 (SD. 16.50).

The perception of tinnitus and its impact became less in all participants irrespective of, whether they are fitted with monaural body-worn hearing aid or pseudo-binaural hearing aid may be that there has been an instant masking of tinnitus, either perceived in one ear or both the ears. The inference is in agreement with those of Newman (1995). As the population studied in the study was above 60 years, it may be a possibility that all the participants perceived their hearing problem as primary and tinnitus as secondary. Trotter & Donaldson (2008) also reported that the use of binaural hearing aid had significant correlation in reducing the tinnitus handicap. In present study, even though pseudo-binaural hearing aids were used, the impacts were similar to using binaural behind-the-ear hearing aids. One possible reason may be that both the ears are exposed simultaneously to environmental sounds including speech.

Paired t-test results:

Paired t-test was performed in order to check the effect of amplification on reduction of tinnitus in participants with presbycusis with tinnitus as an associated symptom. The results of the t-test statistics (t) are shown in the following table.

Table 1: paired t-test comparing THI scores between pre-fitting and post-fitting condition.

Source	Value	Degrees of freedom (df)	p -value	Interpretation
paired t- test	t(43)=12.3271	43	5.235 X e ⁻¹⁶	Ho ≠ H1

Calculated at p<.05

After the administration of paired t-test, p-value was found to be 5.235 X e⁻¹⁶ at 95% confidence interval for difference of the Means (34.81992, infinity). The sample estimates obtained were Mean of the differences and the value was 40.31818. Hazell et al., (1985) reported that users found sound therapy devices subjectively helpful and reported lower levels of tinnitus annoyance with their use. Literature suggests that hearing aids may have beneficial effects on persons with tinnitus, 90% of tinnitus patients may benefit from amplification (Zugg & Fausti, 2002). Lindberg and Lyttkens (1987) suggested that hearing aids are the mainstay of tinnitus treatment as provided by audiologists. Thus the findings of the present study are in accordance with those evident in literature.

Paired t-test was performed on the presbycusis participants in order to see the efficacy of monaural fitting of hearing aids in the participants on improvement of tinnitus and to check any significant decrease in the Mean of THI scores in the post-fitting condition. The results of the t-test statistics (t) are shown in the following table.

Table 2: paired t-test comparing THI scores between pre-fitting and post-fitting condition on monaural hearing aid fitting.

Source	Value	Degrees of freedom (df)	p - value	Interpretation
paired t- test	t(13)=4.8601	13	0.001	Ho ≠ H1

Calculated at $p < .05$

After the administration of the test, p-value was found to be .001 at 95% confidence interval for the difference of the Means (20.24902, infinity). Sample estimates obtained were Mean of the differences and the value was 31.85714.

Similarly, paired t-test for participants fitted with monaural hearing aids were also found to be significant (p-value of .001 which is indicative of p-value $< .05$). Trotter and Donaldson (2008) reported greater degree of tinnitus reduction in monaurally fitted participants. Thus, the potential reason for decrease of tinnitus impact on fitting the participants with monaural hearing aids may be due to the presentation of amplified sounds in the better ear thus causing sound enrichment and subsequent masking of their tinnitus.

Welch two-sample t-test results:

Welch two-sample t-test was performed to statistically prove that the pseudo-binaural fitting of amplification device will further decrease the impact of tinnitus in the presbycusis cases. The results are shown in the table:

Table 3: Welch two-sample t-test for THI scores of pseudo-binaural hearing aid fitting.

Source	Value	Degrees of freedom (df)	p-value	Interpretation
Welch two Sample t- test	t(19.906)=1.155	19.906	0.261	Ho = H1

Calculated at $p < .05$

After administration of the test, p-value was found to be 0.261 at 95% confidence interval for Mean (-6.824, 23.746). Sample estimates obtained were Mean of x and y which were 40.318 and 31.857, respectively. Binaural hearing aid use appears to offer an advantage on tinnitus suppression over monaural fittings. A questionnaire by Brooks & Bulmer (1981) found that 66.52% of bilaterally aided respondents experienced reduction in tinnitus versus only 12.7% with unilateral aids. Thus, it can be conducted that for the first time users of hearing aids in participants with presbycusis, fitting of hearing aids can play a significant role in reducing the severity of tinnitus as measured by THI scale.

IV. Summary And Conclusions

The study provides outcome results regarding improvement in tinnitus on first time users of hearing aids in persons with tinnitus having presbycusis. Formulation of a management option may be obtained from the current study to reduce the impact of tinnitus in people who have never used a hearing aid before. Geriatric population with poor health conditions may have a way to cure their tinnitus without regular follow-ups to the clinics for other management procedures.

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