Acta Scientific Otolaryngology (ISSN: 2582-5550)

Volume 4 Issue 7 July 2022

Research Article

The Hearing Aids in Overall Management of Tinnitus and its Concomitant Variables

Rajendra Kumar Porika[1]* and Balakrishnan Doraisami[2]

[1]Audiologist and Speech Language Pathologist, Ali Yavar Jung National Institute of Speech and Hearing Disabilities (Divyangjan), Regional Centre, Secunderabad, Telangana State, India

[2]Professor of ENT and Head of the Department of Audiology and Speech Language Pathology, SRM Medical College Hospital and Research Centre, SRM Institute of Science and Technology, Tamilnadu, India

***Corresponding Author:** Rajendra Kumar Porika, Audiologist and Speech Language Pathologist, Ali Yavar Jung National Institute of Speech and Hearing Disabilities (Divyangjan), Regional Centre, Secunderabad, Telangana State, India.

DOI: 10.31080/ASOL.2022.04.0460

Received: February 02, 2022

Published: June 14, 2022

Abstract

The perception of sound in the ears in the absence of external sound is defined as tinnitus. It is frequently associated with sensory neural hearing loss. Hearing aids are known to be one of the best management options. The aim and objective of the study is to assess the relative efficacy of three types of digital programmable hearing aids in the management of tinnitus and its concomitant variables such as age, gender, etiology, duration, nature, laterality, laterality and severity of tinnitus and also duration of hearing loss in individuals with hearing loss using Tinnitus Handicap Inventory - Telugu version (THIT) questionnaire.

A total of 108 participants with an age range of 18 - 81 years with had a complaint of tinnitus and hearing loss were considered for the study. The participants were allocated in three hearing aid groups of 36 subjects each i.e. Digital with Basic programming (D-Basic), Digital with Tinnitus Specific programming (DTS) and Digital with Inbuilt Masking facility (DIM). The purposive random sampling method was used for the study. The pre and post THIT scores were compared and analyzed using paired t-test analysis.

The results showed differences in THIT mean scores and improvement was seen in all hearing aid groups combined and individual groups with respect to the age, gender, duration of tinnitus, aetiology of tinnitus, nature of tinnitus, types of tinnitus, laterality of tinnitus, severity grade of tinnitus, severity of hearing loss in both right and left ear, and duration of hearing loss.

The study concluded that Hearing aids are effective in management of tinnitus, all the three types of digital programmable hearing aids provided appreciable mitigation of effects of tinnitus. Among all the groups, DIM group showed better improvement followed by DTS and D-Basic.

Keywords: Tinnitus; Ear; Sensori-neural Hearing Loss (SNHL)

Introduction

The sensation of sound in the ears or head in the absence of external sound is defined as tinnitus. There are many theories, regarding the causation of tinnitus. Majumdar, Mason and Gibbin (1983) noted that 'while tinnitus may accompany almost any ear disorder, the site of origin and its generation are unknown' [1]. Tinnitus is known to be accompanied with Sensori-neural Hearing Loss (SNHL), in several patients. Around seventeen percent of the

world population estimated to have tinnitus, at some point in their life. Within the group of tinnitus patients, 20% of the patients, harbor a severe degree of tinnitus [2]. However, there is a very wide difference, in the prevalence rate, across the globe. These discrepancies arise, due to varying differences in the definitions of tinnitus. As age increases, the occurrence of tinnitus increases [3].

The very first step in the management of a tinnitus subject is to obtain a clear case history, audiological testing and subjective evaluation by using questionnaires. Out of the several available tools, the Tinnitus Handicap Inventory (THI) developed by Newman., *et al*. in 1996 is the most popular [4]. This questionnaire got translated in local vernacular language Telugu i.e. Tinnitus Handicap Inventory - Telugu version (THI-T) [5]. The questionnaire contains 25 questions which address three domains, namely, functional domain (12 questions), emotional domain (8 questions) and catastrophic domain (5 questions). The patient himself, responds to each question, with a choice of three options namely, Yes/Sometimes/No. These three options are given a rating score of 4, 2 and 0, respectively. The total score is calculated by summing up the rating scores of all the 25 questions. Based on this total THI score, the severity of the handicap of a tinnitus sufferer is graded, as enunciated by Aksoy., *et al*. in 2007 (Table 1) [6].

Total THI score	Tinnitus severity grade
0 - 16	Slight handicap
18 - 36	Mild handicap
38 - 56	Moderate handicap
58 - 76	Severe handicap
78 - 100	Catastrophic handicap

Table 1: Grades of tinnitus severity based on the THI total scores (Aksoy., *et al*. 2007).

Over the decades, it is well known that the hearing aids serve as a primary treatment to tinnitus sufferers with a complaint of hearing impairment [7]. Recently, new technological designs have been introduced in hearing aids. Such newer designs employ multiple microphones, noise reduction and adaptation to changes in ambient noise. There is a wide spread usage of the hearing aids, in different tinnitus treatment and management approaches. Though the hearing aids were interpreted as it is only masker tool, but there are limited studies documented to show which technology or aspect of the hearing aid really effects in reduction of severity of tinnitus. The exact mechanism by which the benefit occurs is uncertain. Unfortunately, there are only a limited number of studies, in this field. Thus, there is a need to critically evaluate the efficacy of hearing aids in mitigating tinnitus.

From the review of related studies, it is evident that the tinnitus patients suffer and their routine life is also affected. In the management of tinnitus patients have tried to verify the effectiveness of hearing aids stimulation both alone and in combination with other treatment techniques for tinnitus problem and their quality of life by evaluating the tinnitus severity both pre and post using Tinnitus Handicapped Inventory (THI).

Aims and Objectives

The aim of the study is to assess the relative efficacy of digital programmable hearing aids in the overall management of tinnitus and its concomitant variables in individuals with hearing loss using Tinnitus Handicap Inventory - Telugu version (THIT) questionnaire.

The objective of the study is to evaluate the perception of tinnitus using THIT questionnaire before and after fitting of three types of hearing aids, in terms of the following concomitant associated variables (factors) such as age, gender, duration of tinnitus, aetiology of tinnitus, type of tinnitus, nature of tinnitus, laterality of tinnitus, severity of tinnitus, severity of hearing loss and in the left ear and duration of hearing loss.

Methodology

The purposive random sampling method was used for the study. The sample size was arrived by using the prevalence of tinnitus and applying the appropriate sample size formula. A total of 108 patients, age above 18 years of both genders who were suffering with tinnitus (severe above severity) and hearing loss (moderate and above severity) and those who were going to be fitted with appropriate hearing aids for the first time were included. The subjects suffering from external and middle ear disorders, chronic neurological disorders, and those who were already have taken or taking some treatment for tinnitus were not included in the study.

The study was initially approved by the Institutional Ethics Committee of SRM University (1239/IEC/2017). The informed consent was obtained from all the participants of the study. Detailed case history, clinical examination, basic audiological tests, and speech audiometry including high frequency audiometry, Pitch Matching tests and Residual Inhibition tests were done.

The THIT was administered to obtain the effect of tinnitus on the subjects. One of the three design-types of digital programmable hearing aids were fitted in the subjects, by qualified, audiologists. The fitting of hearing aids was confirmed by strict adherence to current standard practices and clinical guidelines. The patient and the servicing audiologist had full autonomy in the selection and fitting of the type of hearing aid, per requirement and affordability. All the subjects obtained hearing benefit from the amplification, as confirmed by Speech Identification Scores, Hearing in Noise test and by patient reported outcomes.

Each subject instructed about the care and maintenance of hearing aids. The subjects were advised to use the hearing aids, for a minimum of 2-6 hours daily. After one month of usage, a follow-up visit was done, for monitoring proper use and compliance. After two months of regular use, the THIT scores were repeated.

Statistical analysis was done using Statistical Package for the Social Sciences (SPSS) version 26, (year: 2017). Paired 't'-test was used for comparing pre and post THIT scores. During the study period, care was taken that the patient medicines prescribed for co-existing conditions like diabetes, hypertension etc, were continued. The intervention for tinnitus management was only the wearing of the hearing aids. Absolute privacy and confidentiality were maintained by the investigators.

Study assumed with following Hypothesis that there will be no differences in the THI scores with respect to the over-all effect in tinnitus before and after fitting of digital hearing aids viz. Digital with Basic programming (D-Basic), Digital with Tinnitus Specific programming (DTS) and Digital with Inbuilt Masking facility (DIM).

Results

This study was done to know the effect of different digital hearing aids, in the management of tinnitus. A total of 108 subjects (65 males and 43 females) with tinnitus and sensori-neural hearing impairment participated in the study. The age range was between 18 to 81 years with an average age of 55.8, 53, 51 and 53.6 for D-Basic, DTS, DIM and all groups combined respectively.

A total of 101 subjects were having bilateral hearing loss, remaining two had hearing loss in right ear and five had hearing loss in left ear. The subjects complained of tinnitus sensation in right ear, left ear and both ears were 16, 21 and 71 respectively. On performing pure tone audiometry evaluation the pure tone average in right ear found to be 82, 72, 56 and 70 dB HL in D-Basic, DTS, DIM and all groups combined respectively. On observing audiograms it was noticed that 68 subjects were having sloping type of audiogram. Loudness matching test was done the subjects tinnitus was matched at 59 dB HL (on average) among a total of 90 subjects. On performing pure tone audiometry, the pure tone average in left ear found to be 83, 73, 62 and 73 dB HL in D-Basic, DTS, DIM and all groups combined averages respectively. On observing the subject(s) audiograms it was noticed that 69 subjects were having sloping type of audiogram. Loudness matching test was done the subjects tinnitus was matched at 61 dB HL (on average) among a total of 91 subjects.

The Behind the ear (BTE), Receiver in the Canal (RIC), Completely in the Canal (CIC) type of hearing aids were fitted and used by the subjects. Eight subjects were fitted with hearing aids in the right ear only; nine subjects were fitted with hearing aids in left ear only. A total of 91 subjects were fitted with hearing aids bilaterally, in both the ears.

The results of our study indicate that the amplification yielded by the digitally programmable hearing aid, also mitigated the effects of tinnitus. All the 108 patients in our study had shown significant improvements in the tinnitus status. The improvement had manifested across all the three hearing aid groups combined (n = 108) and individual group(s) namely D-Basic (n = 36), DTS (n = 36), and DIM (n = 36), irrespective of the design type of hearing aid worn by the individual subject (Table 2). The difference in mean scores after fitting of hearing aids indicated an improvement in THIT scores in all the three individual groups combined. All the t-values are statistically significant ($p < 0.01$).

Hearing aid Group(s)	D-Basic (N = 36)	DTS (N = 36)	DIM (N = 36)	Total (3 groups combined) (N = 108)
THIT scores				
Mean score before fitting	81.8	77.1	73.3	77.4

Mean score after fitting	49.6	33.5	21.3	34.8
Difference in the means	32.2	43.5	51.9	42.5
t - value	8.7**	13.9 **	18.3**	21.2**

Table 2: THIT scores, of all 108 subjects, and individual groups (D-Basic, DTS and DIM) before and after hearing aid fitting.

df = 35 ,** - $p < 0.01$.

The DIM hearing aids gave benefit to 33 (91%) patients, the DTS hearing aids gave benefit to 24 (66%) subjects and the D-Basic Hearing aids gave benefit to 13 (36%) patients only. Overall the combined Hearing aids gave benefit to 70 (65%) patients (Table 3). All the three types of hearing aids, yielded statistically significant benefits.

Grades of Severity	All the three groups combined (n = 108)		D-Basic group: (n = 36)		DTS group: (n = 36)		DIM group: (n = 36)	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
No or Slight handicap (THIT 0-16)	0	21 (19%)	0	0	0	6 (16%)	0	15 (41%)
Mild handicap (THIT 18-36)	0	49 (45%)	0	13 (36%)	0	18 (50%)	0	18 (50%)
Moderate handicap (THIT 38-56)	0	18 (16%)	0	9 (25%)	0	7 (19%)	0	2 (5%)
Severe handicap (THIT 58-76)	51 (47%)	15 (13%)	12 (33%)	10 (27%)	17 (47%)	4 (11%)	22 (61%)	1 (2%)
Catastrophic handicap (THIT 78-100)	57 (52%)	5 (4%)	24 (66%)	4 (11%)	19 (52%)	1 (2%)	14 (38%)	0
Total number and % within group	108 (100%)	108 (100%)	36 (100%)	36 (100%)	36 (100%)	36 (100%)	36 (100%)	36 (100%)

Table 3: The Severity grades of tinnitus (based on the THIT scores), before and after fitting, group wise.

In our study, we analyzed the contributions of independent concomitant associated variables (factors) (a) age, (b) gender, (c) duration of tinnitus, (d) aetiology of tinnitus, (e) type of tinnitus, (f) nature of tinnitus, (g) laterality of tinnitus, (h) severity of tinnitus, (i) severity of hearing loss in the right ear, (j) Severity of hearing loss in the left ear, and (k) duration of hearing loss.

Results of analysis: Comparison of THIT Mean scores on all the subjects with respect to the age of subjects

The pre and post scores on THIT before and after fitting of the hearing aids for all the subjects (n = 108) with respect to each age-wise groups (18-39 years, 40-59 years, 60 years and above) are presented in table 4. The improvements in the post-fitting THIT scores, age-wise, in the entire 108 subjects. The t-values for testing the improvements in the post fitting mean THIT scores are found to be statistically significant ($p < 0.01$) in all the three age-wise groups.

Results of analysis: Comparison of THIT Mean scores on all the subjects with respect to the gender of subjects

The pre and post scores on THIT before and after fitting of the hearing aids for all the subjects (n = 108) with respect to each gender group are presented in table 5. The difference in mean

All Hearing aid Groups combined (N = 108)	18 to 39 yrs (N = 17)		40 to 59 yrs (N = 51)		Above 60 yrs (N = 40)	
THIT Score	Mean	SD	Mean	SD	Mean	SD
Pre fitting	77.1	12.9	78.2	12.0	77.0	11.7
Post fitting	32.7	21.8	34.0	20.8	36.5	20.2
Difference in the means	44.4		44.1		40.1	
t - value	0.00 **		0.00 **		0.00 **	

Table 4: THIT Mean scores, of all 108 subjects, pre & post hearing aid fitting, age-wise comparison.

** p < 0.01 Highly significant.

scores after fitting of hearing aids indicated an improvement in THIT scores in both females and male groups. All the t-values are statistically significant (p < 0.01). Overall, in 43 female subjects the pre fitting hearing aid THI scores were 76 and post fitting reduced to 31.9. Overall, in 65 male subjects pre fitting THI scores were 78, post fitting reduced to 36. More improvement was seen in females with a difference of mean score 44.9 where as in males only 41.2.

All Hearing aid Groups combined(N = 108)	Female (N = 43)		Male (N = 65)	
THIT score	Mean	SD	Mean	SD
Pre fitting	76.8	12.0	78.0	12.0
Post fitting	31.9	20.5	36.7	20.6
Difference in the means	44.9		41.2	
t - value	0.00 **		0.00 **	

Table 5: THIT Mean scores, of all the 108 subjects, pre & post hearing aid fitting, gender-wise comparison. ** p < 0.01 Highly significant.

Results of analysis: Comparison of THIT Mean scores on all the subjects with respect to the duration of tinnitus.

The pre and post scores on THIT before and after fitting of the hearing aids for all the subjects (n = 108) with respect to each duration of tinnitus group (0-5 years, 5-10 years, and above 10 years group) are presented in table 6. The difference in mean scores after fitting of hearing aids indicated an improvement in THIT scores in all the three duration of tinnitus groups. All the t-values are statistically significant (p < 0.01).

All Hearing aid Groups combined (N = 108)	0 to 5 yrs (N = 64)		5 to 10 yrs (N = 20)		Above 10 yrs (N = 24)	
THIT score	Mean	SD	Mean	SD	Mean	SD
Pre fitting	76.8	12.8	80.30	9.696	77.42	11.549
Post fitting	30.0	18.0	39.10	21.750	44.17	22.940
Difference in the means	46.7		41.200		33.250	
t - value	0.00 **		0.00 **		0.00 **	

Table 6: THIT Mean scores, of all the 108 subjects, pre & post hearing aid fitting, with respect to the duration of tinnitus.

** p < 0.01 Highly significant.

Results of analysis: Comparison of THIT Mean scores on all the subjects with respect to the aetiology of tinnitus

The pre and post scores on THIT before and after fitting of the hearing aids for all the subjects (n = 108) with respect to each aetiology of tinnitus groups namely Presbyacusis, Occupational, idiopathic and other health issues are presented in table 7. The difference in mean scores after fitting of hearing aids indicated an improvement in THIT scores in all the four aetiology groups. All the t-values are statistically significant (p < 0.01).

All Hearing aid Groups combined (N = 108)	Presbycusis (N = 42)		Occupational (N = 15)		Idiopathic (N = 42)		Other health issues (N = 9)	
THIT score	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Pre fitting	76.9	11.0	81.3	12.2	75.4	12.3	84.4	12.0
Post fitting	36.0	20.3	40.5	20.7	34.5	21.8	21.5	9.8
Difference in the means	40.9		40.8		40.9		62.8	
t - value	0.00 **		0.00 **		0.00 **		0.00 **	

Table 7: THIT Mean scores, of all 108 subjects, pre & post hearing aid fitting, with respect to the aetiology of tinnitus.

** p < 0.01 Highly significant.

Results of analysis: Comparison of THIT Mean scores on all the subjects with respect to the type of tinnitus

The pre and post scores on THIT before and after fitting of the hearing aids for all the subjects (n = 108) with respect to each type of tinnitus groups (ringing, hissing, roaring, cooing, and other types) are presented in table 8. The difference in mean scores after fitting of hearing aids indicated an improvement in THIT scores in all the five types of tinnitus groups. All the t-values are statistically significant (p < 0.01).

All Hearing aid Groups combined (N = 108)	Ringing (N = 42)		Hissing (N = 12)		Roaring (N = 7)		Cooing (N = 28)		Other (N = 19)	
THIT score	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Pre fitting	76.7	12.9	77.1	13.0	67.4	10.7	79.5	10.8	80.7	10.0
Post fitting	29.3	18.2	23.0	11.2	22.0	12.0	42.6	19.4	47.7	24.0
Difference in the means	47.3		54.1		45.4		36.8		32.9	
t - value	0.00 **		0.00 **		0.00 **		0.00 **		0.00 **	

Table 8: THIT Mean scores, of all 108 subjects, pre & post hearing aid fitting, with respect to the type of tinnitus.

** p < 0.01 Highly significant.

Results of analysis: Comparison of THIT Mean scores on all the subjects with respect to the nature of tinnitus

The pre and post scores on THIT before and after fitting of the hearing aids for all the subjects (n = 108) with respect to each nature of tinnitus group namely, whether continuous and intermittent, are presented in table 9. The difference in mean scores after fitting of hearing aids indicated an improvement in THIT scores in both the nature of tinnitus groups. All the t-values are statistically significant (p < 0.01).

All Hearing aid Groups combined (N = 108)	Continuous (N = 61)		Frequently (N = 47)	
THIT score	Mean	SD	Mean	SD
Pre fitting	78.2	12.6	76.7	11.1
Post fitting	32.3	22.0	38.0	18.3
Difference in the means	45.8		38.7	
t - value	0.00 **		0.00 **	

Table 9: THIT Mean scores, of all 108 subjects, pre and post hearing aid fitting, with respect to nature of tinnitus.

** p < 0.01 Highly Significant.

Results of analysis: Comparison of THIT Mean scores on all the subjects with respect to the laterality of tinnitus

The pre and post scores on THIT before and after fitting of the hearing aids for all the subjects (n = 108) with respect to each laterality of tinnitus groups (i.e. right ear, left ear, both ears and mid line laterality) are presented in table 10. The difference in mean scores after fitting of hearing aids indicated an improvement in THIT scores in all the four laterality of tinnitus groups. All the t-values are statistically significant ($p < 0.05$).

All Hearing aid Groups combined (N = 108)	Right Ear (N = 16)		Left Ear (N = 21)		Both Ears (N = 68)		Mid line (N = 3)	
THIT score	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Pre fitting	78.8	10.9	73.2	11.0	78.6	12.2	78.0	17.7
Post fitting	39.6	19.3	32.8	15.2	33.8	22.2	46.6	25.3
Difference in the means	39.2		40.3		44.7		31.3	
t - value	0.00 **		0.00 **		0.00 **		0.01 *	

Table 10: THIT Mean scores, of all 108 subjects, pre & post hearing aid fitting, with respect to the laterality of tinnitus.

** $p < 0.01$ Highly Significant, * $p < 0.05$ Significant.

Results of analysis: Comparison of THIT Mean scores on all the subjects with respect to the severity of tinnitus

The pre and post scores on THIT before and after fitting of the hearing aids for all the subjects (n = 108) with respect to each severity grade of tinnitus group (Severe and Catastrophic grading) are presented in table 11. The difference in mean scores after fitting of hearing aids indicated that there is an improvement in THIT scores in both the severity grade of tinnitus groups. The t-values are statistically significant ($p < 0.01$).

All Hearing aid Groups combined (N = 108)	Severe (N = 53)		Catastrophic (N = 55)	
THIT scores	Mean	SD	Mean	SD
Pre fitting	67.4	7.0	87.3	6.3
Post fitting	29.4	16.8	40.0	22.6
Difference in the means	38.0		47.3	
t - value	0.00 **		0.00 **	

Table 11: THIT Mean scores, of all 108 subjects, pre & post hearing aid fitting, with respect to the severity of tinnitus.

** $p < 0.01$ Highly Significant.

Results of analysis: Comparison of THIT Mean scores on all the subjects with respect to the severity of hearing loss in right ear

The pre and post scores on THIT before and after fitting of the hearing aids for all the subjects (n = 104) with respect to each severity of hearing loss in right ear (moderate, moderately severe, severe and profound hearing loss) are presented in table 12. The difference in mean scores after fitting of hearing aids indicated an improvement in THIT scores in all the four groups of severity of hearing loss in right ear. All the t-values are statistically significant ($p < 0.05$).

All Hearing aid Groups combined (N = 104)	Moderate (N = 21)		Moderately severe (N = 29)		Severe (N = 42)		Profound (N = 12)	
THIT score	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Pre fitting	70.1	8.6	76.5	13.6	81.6	11.6	79.8	5.9
Post fitting	23.3	15.5	29.5	17.8	41.8	21.7	47.5	18.7

Difference in the means	46.7	46.9	39.8	32.3
t - value	0.01 *	0.00 **	0.00 **	0.00 **

Table 12: THIT Mean scores, of all 104 subjects, pre & post hearing aid fitting, with respect to the severity of hearing loss in right ear.

** p < 0.01 Highly Significant, * p < 0.05 Significant.

Results of analysis: Comparison of THIT Mean scores on all the subjects with respect to the severity of hearing loss in left ear

The pre and post scores on THIT before and after fitting of the hearing aids for all the subjects (n = 107) with respect to each severity of hearing loss (moderately severe, severe and profound) in left ear are presented in table 13. The difference in mean scores after fitting of hearing aids indicated an improvement in THIT scores in all the four groups of severity of hearing loss in left ear. All the t-values are statistically significant (p < 0.01).

All Hearing aid Groups combined (N = 107)	**Moderate (N = 23)**		**Moderately severe (N = 28)**		**Severe (N = 38)**		**Profound (N = 18)**	
THIT score	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Pre fitting	68.8	8.3	75.0	13.7	81.7	10.3	84.4	8.7
Post fitting	21.7	8.8	31.7	21.5	39.6	19.9	46.7	22.7
Difference in the means	47.1		43.2		42.0		37.6	
t - value	0.00 **		0.00 **		0.00 **		0.00 **	

Table 13: THIT Mean scores, of all 107 subjects, pre & post hearing aid fitting, with respect to the severity of hearing loss in left ear.

** p < 0.01 Highly Significant.

Results of analysis: Comparison of THIT Mean scores on all the subjects with respect to the duration of hearing loss

The pre and post scores on THIT before and after fitting of the hearing aids for all the subjects (n = 108) with respect to each duration of tinnitus groups (0-5 years, 5-10 years, and above 10 years) are presented in table 14. The difference in mean scores after fitting of hearing aids indicated an improvement in THIT scores in all the three groups of duration of hearing loss. All the t-values are statistically significant (p < 0.01).

All Hearing aid Groups combined (N = 108)	**0 to 5 yrs (N = 59)**		**5 to 10 yrs (N = 22)**		**Above 10 yrs (N = 27)**	
THIT score	Mean	SD	Mean	SD	Mean	SD
Pre fitting	77.2	12.8	78.7	11.8	77.4	10.5
Post fitting	29.9	18.5	41.0	23.2	40.4	20.6
Difference in the means	47.2		37.6		36.9	
t - value	0.00 **		0.00 **		0.00 **	

Table 14: THIT Mean scores, of all 108 subjects, pre & post hearing aid fitting, with respect to duration of hearing loss.

** p < 0.001 Highly Significant.

Discussion

The study was done to know the efficacy of three different digital hearing aid technologies, programs in the management of tinnitus after using hearing aids for two months. Therefore, it is inferred from the results that the tinnitus problem decreased in all the subjects, groups of Hearing aids both in the individual and combined groups.

Results showed the favorable improvements were noted between the pre fitting and the post fitting scores overall in the entire 108 subjects, in the THIT mean scores. The same was reflected in all the three hearing aid groups. The results of our study are in congruence with that of Henry., *et al*. (2015) who validated that hearing aids alone and hearing aid with special features provide significant benefit with respect to reducing the tinnitus affects [8].

On further discriminative analysis of the benefit afforded by the three groups using hearing aids of differing design, The DIM (91%) hearing aids gave higher benefit comparing to the DTS hearing aids (66%) subjects and the D-Basic Hearing aids (36%) only. This benefit with DTS design, could occur because tinnitus masker induces noise continuously. McNeill., *et al*. (2012) stated that results are obtained by masking and high frequency amplification in hearing aids which may be significant contributor in reducing tinnitus [9].

It can be due to the spectrum of D-Basic hearing aids corresponds to a white noise with equal amplitude all over the frequencies. The range of frequency might be taking care of the tinnitus 1 KHz to 2 KHz and with its perceptual loudness and thus divert the attention of the tinnitus sufferer from his tinnitus by masking it. This is in congruence with the study done by Shekahawat., *et al*. (2013). It was stated that at 2 KHz emerged as most preferred output by participants to interfere with their tinnitus than other frequencies [10]. The fine tuning based on the listeners, subject's preference is more important and is strongly recommended. Tinnitus masking through hearing aid helped in reducing tinnitus.

McNeill., *et al*. (2012) studied on tinnitus-pitch masking and its efficacy in the treatment of tinnitus [9]. Their study doesn't support amplification of sound as effective therapy in tinnitus. They found that despite use of appropriate hearing aids, there was no significant relief of tinnitus.

The DIM group showed significantly better THIT scores than the D-Basic group. However, the differences were not significant between DIM and DTS groups. This study is congruent with the study done by Francis Kuk., *et al*. (2010) who stated that all the patients who used Hearing aid with added features such as Zen and Noise program options have reported 100% benefit in addressing tinnitus [11].

The improvements were seen in all the age groups, entire 108 subjects THIT scores were reduced. This finding concurs with the conclusions of Pinto., *et al*. 2010, who reported that there was no difference in the in terms of age [12]. Apratim Das., *et al*. (2016) conducted a study on the elderly population (60-80 yrs), geriatrics patients found that the usage of hearing aids has the improved health conditions in the patient [13]. Their THI scores reduced after using hearing aids for three months of hearing aid usage amplification fitting for the first time. In our study overall THIT scores reduced to 42.5 after two months of hearing aid usage among all the age groups i.e. from 18 to 60 years.

More improvement was seen in females with a difference of mean score 44.9 where as in males only 41.2. Results showed significant improvements in the post fitting THIT scores regardless of gender, across all the three designs of hearing aids. A salient point to be noted here is that, at present, a very limited number of studies exist, with respect to age.

Similarly improvement in THIT mean scores were seen in all the three duration of tinnitus groups. Kuk., *et al*. (2010) studied the effect of hearing aids on subjects who were suffering since 2 weeks to 40 years more than a decade [11]. Among total participants, 27% were experiencing, suffering with tinnitus from more than 10 years of duration. Eighty seven percent of the participants reported improvement after using hearing aid. However, they have not mentioned age wise data. In our study, results showed that there is an improvement among all the subject groups.

Results infer that the benefits in tinnitus accrue, regardless of the aetiology. These results are in congruence with that of Nicolas-Puel., *et al*. (2002) who studied the characteristics of tinnitus and etiological factors [14]. The study concluded that tinnitus linked to acoustic trauma, presbycusis, and ototoxicity improved with hearing aid amplification.

Another study by Zagolski (2006) studied on 33 participants with mean age of 71 years suffering from very annoying tinnitus and hearing loss they were having tinnitus with presbyacusis as the cause [15]. Among them 28 participants reported reduced tinnitus after being fitted with hearing aids. There is a welcome improvement if the amplification is provided binaurally. Our findings also substantiate the improvement of tinnitus in elderly subjects with tinnitus.

All the five tinnitus groups (ringing, hissing, roaring, cooing, and other types) indicated an improvement in THIT scores. The study done by Nicholas-Puel (2002) reported that the THI pre - post treatment results were analyzed with respect to type of tinnitus, there was a mean improvement with treatment however, found not to be significant [14].

In both the nature of tinnitus groups (continuous and intermittent) mean scores improved after fitting of hearing aids. These results are in congruence with the study done by Surr., *et al*. 1985 [16]. They concluded that the hearing aid amplification provided relief form tinnitus. The enhanced environmental sounds through hearing aid amplification helped in masking the tinnitus.

Improvement in THIT scores noted in all the four laterality (i.e. right ear, left ear, both ears and mid line) of tinnitus groups after fitting of hearing aids. The overall results can only because of the hearing aids amplification and features played an effective role in management of tinnitus. The results are in supportive of several studies done by several research authors mentioned in the review study done by the Shekhawat., *et al*. (2013) [10].

The THIT mean scores improved in both the Severe and Catastrophic severity tinnitus groups. Our results nearly correlated with the observation of Roeser and Price (1980) where the severity rating has a statistical significance which confirms that when tinnitus is mild there is total relief observed more often and partial relief when it was severe [17].

The THIT scores indicated an improvement in in all the four groups of severity of hearing loss (moderate, moderately severe, severe and profound hearing loss) in right ear. Zagloski (2006) in his study concluded that unilateral fitting was effective in treating unilateral hearing loss and bilateral fitting in patients with bilateral tinnitus complaint [15].

The THIT pre and post scores for all the subjects (n = 107) with respect to each severity of hearing loss (moderately severe, severe and profound) in left ear indicated an improvement in THIT scores in all the four groups of severity. Beck in 2011 through his study stated that clinical outcomes are good in mild to moderate sensorineural hearing loss clients with tinnitus [18]. This could be due to poorer perception and lack of recognizing the acoustic signal since it is a profound degree of hearing loss. Das., *et al*. (2016) stated in their study that the monaural fitting was the reason for reducing tinnitus [13]. The impact after fitting hearing aids might be due to amplification in better ear, thus causing sound enrichment and subsequent tinnitus masking.

The pre and post scores of THIT before with respect to duration of tinnitus groups (0-5 years, 5-10 years, and above 10 years) showed improvement after fitting of the hearing aids for all the subjects (n = 108). Kuk., *et al*. (2010) stated that the combined duration of hearing loss and tinnitus prior to first contact from 2 weeks to 40 years [11]. There the patients were categorized in to three groups as i.e. below 1 year, between 1-10 years and 11-20 years, and above 20 years. Overall, they showed 85% of improvement after using hearing aids with advanced musical masking tone.

Therefore, it is inferred from the study results that the tinnitus problem decreased in all the subjects, groups of Hearing aids both the combined and the individual groups. This would be due to the hearing aid amplification and the masking effect provide internally by the instrument and externally due to environmental sounds. The results of this study are in congruence with several research studies [17].

Conclusion

The results of the study substantiate that in subjects with co-existing tinnitus and hearing impairment. Hearing aids are effective in alleviating the tinnitus. The newer hearing aids, which have advanced technological features in their design, provide additional benefits. Thus, it is concluded that the hearing aids are enormously effective in the overall management of tinnitus and its concomitant variables in individuals with tinnitus and sensorineural hearing loss.

Further, it can be concluded that clients having tinnitus associated with hearing loss will be most benefited with usage of hearing aid. However, they should use them for at least 2 months

for acclimatization and to mitigate the overall effects of tinnitus and its concomitant variables. The best among the three technologies is inbuilt masking facility programming hearing aids which not only give relief from tinnitus overall and also provide them with good hearing. Future studies may be conducted using newer technologies on larger tinnitus population for generalization.

Bibliography

1. Majumdar B., *et al*. "An Electrocochleo Graphic study of the effects of Lignocaine on patients with tinnitus". *Clinical Otolaryngology* 8.3 (1983): 175-180.

2. Zeigelboim L G B S., *et al*. "The characteristics of tinnitus in workers exposed to noise". *Brazilian Journal of Otorhinolaryngology* 75.1 (2009): 5-14.

3. Ahmad N and Seidman M. "Tinnitus in the older adult: Epidemiology, pathophysiology and treatment options". *Drugs and Aging* 21.5 (2004): 297-305.

4. Newman CW., *et al*. "Development of the Tinnitus Handicap Inventory". *Archives of Otolaryngology Head Neck Surgery* 122.2 (1996): 143-148.

5. Rajendra Kumar P and Balakrishnan D. "Translation of Tinnitus Handicap Inventory (THI) into the Telugu language and standardization". *The International Journal* 22 (2018): 93-96.

6. Aksoy S., *et al*. "The Tinnitus Handicap Inventory: a study of validity and reliability". *International Tinnitus Journal* 13.2 (2007): 94-98.

7. Searchfiled GD. "Hearing aids and tinnitus". In: Tyler, R. S., eds., Tinnitus Treatment, Clinical protocols, Thieme Medical Publishers, New York (2006): 161-175.

8. Henry James A., *et al*. "Validation of a Novel Combination Hearing Aid and Tinnitus Therapy Device". *Ear and Hearing* 36.1 (2015): 42-52.

9. Celene Mc Neill., *et al*. "Tinnitus pitch, masking, and the effectiveness of hearing aids for tinnitus therapy". *International Journal of Audiology* 51 (2012): 914-919.

10. Giriraj Singh Shekhawat., *et al*. "Prescription of hearing aid output for tinnitus relief". *International Journal of Audiology* 52 (2013): 617-625.

11. Francis Kuk., *et al*. "The efficacy of Fractal Music Employed in Hearing Aids for tinnitus management". *Hearing Review* (2010).

12. Patricia Ciminelli Linhares Pinto., *et al*. "The impact of gender, age and hearing loss on tinnitus severity". *Brazilian Journal of Otorhinolaryngology, Sao Paulo* 76.1 (2010).

13. Apratim Das., *et al*. "Effect of Using Amplification Device for Treatment of Tinnitus in Presbycusis in First Time Hearing Aid Users". *IOSR Journal of Dental and Medical Sciences* 15.8 (2016): 04-09.

14. Nicolas-Puel C., *et al*. "Characteristics of tinnitus and etiology of associated hearing loss: a study of 123 patients". *International Tinnitus Journal* 8.1 (2002): 37-44.

15. Olaf Zagolski. "Management of Tinnitus in Patients with Presbycusis". *International Tinnitus Journal* 12.2 (2006): 175-178.

16. Rauna Surr K., *et al*. "Effect of Amplification on Tinnitus among new hearing aid users". Army Audiology and Speech Center, Water Ereed Army Medical Center, Washington DC, Ear and Hearing 6.2 (1965): 71- 75.

17. Roeser R J and Price DR. "Clinical experience with tinnitus maskers". *Ear and Hearing* 1.2 (1980): 63-68.

18. Beck D L. "Hearing aid amplification and tinnitus: 2011 over view". *Hearing Journal* 64 (2011): 12-14.