The Journal of International Advanced Otology

J Int Adv Otol 2021; 17(2): 145-9 • DOI: 10.5152/JIAO.2021.8873

Original Article

Manipulation of Hearing Aid Gain and Tinnitus Relief: A Paired Comparison Study

Sindhu Parthasarathy, Hemanth Narayan Shetty

Department of Speech and Hearing, J.S.S. Institute of Speech and Hearing, Mysuru, Karnataka, India

Cite this article as: Parthasarathy S, Shetty H. Manipulation of hearing aid gain and tinnitus relief: a paired comparison study. *J Int Adv Otol.* 2021; 17(2): 145-9.

OBJECTIVES: The objective of the study is to compare amplification strategies on tinnitus relief. A repeated measure research design was used to determine the best strategy that provides a significant relief on tinnitus and improvements in speech perception.

METHODS: We recruited 20 participants in the age range of 30-60 years (mean age = 47.95 years) having mild to moderately severe sloping sensorineural hearing loss with continuous tonal tinnitus. We grouped the participants into mild and severe, based on the scores obtained in the Tinnitus Handicap Inventory. We evaluated tinnitus pitch and loudness using the adaptive method. Besides, we assessed signal to noise ratio 50 (SNR 50) from each of the programs. We carried out a paired comparison method to determine the best strategy among the 3 in which the maximum preference score was obtained on tinnitus relief by a test hearing aid programmed with 3 programs.

RESULTS: Each group of participants significantly preferred the strategy for the gain in hearing aid set at tinnitus pitch on tinnitus. However, there was no significant difference between the SNR 50 scores in the 3 gain settings.

CONCLUSION: An additional gain set at tinnitus pitch after alleviating hearing loss by the prescriptive method was found to be the best strategy for effective masking of tinnitus and that led to tinnitus relief without compromising speech perception.

KEYWORDS: Tinnitus, hearing aids, tinnitus pitch, gain

INTRODUCTION

Tinnitus is a sound that originates in the head without any external stimulus.[1] Assessment of tinnitus pitch and loudness necessitates initiating any rehabilitation program. The management options for tinnitus include hearing aid,[2] tinnitus retraining therapy,[3] sound therapy,[4] etc. Hearing aids have been a useful tool in tinnitus management, especially for those clients who have hearing loss.[2] The hearing aid is effective in suppressing tinnitus.[5] Amplified sound which emanates from hearing aids, acts as a masker.[6] This reduces awareness on tinnitus directly and reduces stress indirectly,[7] which in turn lower drivers gain adaptation or inhibition.[8]

Modifications in the settings of hearing aids add a meaningful approach to tinnitus relief.[9,10] Choosing the right fitting formula for individuals with tinnitus is one of the essential criteria where DSL (i/o) gives more gain at a low frequency than NAL-NL2.[11] The fitting of open ear devices in the treatment of tinnitus is useful.[7] The compression threshold set as low as 30 dB SPL in hearing aids alleviates tinnitus.[7] Switching off the noise reduction circuit and changing the directional sensitivity of the microphone to omnidirectional lead to tinnitus relief.[12] The features explained above in the hearing aid enhance the ambient noise and results in tinnitus relief, but induces annoyance when listening.

Shetty and Pottackal[13] advised adjusting the gain at tinnitus pitch using DSL (I/o) v5 for managing tinnitus and speech perception. The study revealed a significantly lesser gain adjustment in DSL (I/o) v5 than NAL-NL 2 at tinnitus pitch, which alleviates the symptoms of tinnitus and improves speech perception. To deduce, rather than just fitting the hearing aid for their hearing loss, one step further in gain optimization at the tinnitus pitch is required for effective reduction of tinnitus. However, in their study, an attempt was not made to compare prescriptive gain and optimized gain at the tinnitus pitch. Thus, in the present study, a repeated measure research design was used to determine the best program to alleviate hearing loss without compromising speech perception and provide maximum relief from tinnitus. We hypothesized that adjusting the gain at the tinnitus pitch would establish

Corresponding author: Sindhu Parthasarathy, e-mail: sindhunp11@gmail.com
Received: August 26, 2020 • **Accepted:** September 12, 2020
Available online at www.advancedotology.org

Table 1. Details of Participants

Subject Number	Age	Pure Tone Average (HL)	Tinnitus	Tinnitus Pitch	Tinnitus Intensity (HL)	THI Raw Scores	THI Nominal
1	50	43.75	Unilateral	6000	55	18	Mild
2	50	43.75	Unilateral	4000	50	18	Mild
3	56	68.75	Unilateral	250	75	20	Mild
4	56	73.75	Unilateral	250	80	20	Mild
5	52	55.00	Unilateral	1500	60	22	Mild
6	58	67.75	Unilateral	6000	75	28	Mild
7	60	32.50	Unilateral	500	45	28	Mild
8	34	48.75	Unilateral	3000	55	24	Mild
9	40	60.00	Unilateral	250	70	22	Mild
10	50	42.75	Bilateral	2000	50	26	Mild
11	58	61.00	Unilateral	250	70	58	Severe
12	35	58.75	Unilateral	3000	65	64	Severe
13	33	62.50	Unilateral	3000	80	68	Severe
14	45	48.75	Unilateral	1500	60	68	Severe
15	48	68.75	Unilateral	250	75	76	Severe
16	34	63.75	Bilateral	4000	75	64	Severe
17	40	48.75	Unilateral	250	60	68	Severe
18	59	59.50	Unilateral	3000	75	68	Severe
19	53	55.25	Unilateral	500	65	70	Severe
20	44	43.75	Unilateral	4000	55	60	Severe

THI, Tinnitus Handicap Inventory.

a significant reduction in tinnitus and improve speech perception. Signal to noise ratio 50 (SNR 50) test was used to check for speech perception ability in degraded listening conditions at the set program. As the study involves the manipulation of gain at the tinnitus pitch, it should be ensured that speech perception is not compromised. Hence SNR 50 was performed to check if the gain variation affects speech perception. The present study aims to compare 3 gain settings in the hearing aid to conclude whether any of the gain settings can successfully lead to concurrent relief on tinnitus and as well speech perception.

METHOD

To study the manipulation of gain in hearing aid to reduce tinnitus, we carried out a prospective 1-shot test and randomized repeated measures with a comparative research design.

MAIN POINTS

- The study investigated the best gain setting in hearing aids for tinnitus relief and speech perception in those individuals who experienced tinnitus even after being fitted with a hearing aid at the prescriptive target.
- The majority of the participants preferred an increase in the gain at the tinnitus pitch for tinnitus relief.
- None of the gain-setting strategies in the hearing aid caused a significant change in speech perception abilities in the study participants.
- Deducing gain setting at the tinnitus pitch is the best strategy to lessen both tinnitus percept and speech perception.

Subject Selection

Twenty participants within the age range of 30-60 years (mean age = 47.95 years) were considered. We recruited participants who had bilaterally mild to moderately severe sensorineural hearing impairment with either bilateral or unilateral tonal tinnitus (tinnitus pitch ranged from 250 to 4000 Hz) at the time of post-hearing aid fitting at the prescriptive gain. They had normal middle ear status as indicated by "A" type tympanogram with elevated or absent reflexes at frequencies from 250 Hz to 4 kHz (in octave). They were naïve hearing-aid users. Participants were native speakers of Kannada. None of them had any neurological, psychological, and cognitive problems. Tinnitus Handicap Inventory was administered to each participant. The participants were grouped into mild or severe groups based on the score (Table 1) obtained on the inventory, and each participant was grouped to the mild group or severe group. Ten participants' scores on Tinnitus Handicap Inventory were within the mild range, and the score of the remaining 10 participants were in the severe range.

Tinnitus Pitch and Loudness Matching

To assess the pitch and loudness of tinnitus, an adaptive procedure developed by Jastreboff et al.[14] was used. A calibrated diagnostic 2-channel audiometer Maico MA 53 (Berlin, Germany) was used with a TDH 39 headphone to obtain tinnitus pitch and loudness. If the participant had unilateral tinnitus, the ear not having tinnitus was used to match tinnitus pitch and loudness. However, ipsilateral matching was done for individuals having bilateral tinnitus. Loudness matching was performed at octave frequencies from 125 Hz to 8000 Hz (above 8 kHz if required). For loudness matching, the initial presentation level was set at 5 dB SL,[14] and it was varied in 1 dB step size until the patient was able to match the loudness. A pair of loudness-matched tones were presented sequentially at the octave and mid octave frequencies to match the pitch. We instructed each participant to report the tone that was closer to his/her tinnitus. This procedure continued for consecutive octave frequencies until the participant was able to match the pitch.

Programming and Recording the Output of Hearing Aid at Tinnitus Pitch

The Sorino X Mini RIC hearing aid (Hamburg, Germany) was programmed using DSL i/p (v-5). The option of directionality was disabled, the noise reduction circuit was switched off, and the compression threshold was set at 30 dB SPL. We measured the real-ear insertion test to verify gain in the hearing aid on each participant's test ear (tinnitus ear) using Winchamp (v3) software and Fonix 7000 hearing aid analyzer. In the first program, we set the gain at the prescriptive gain. The real-ear unaided response (REUR) and real-ear aided response (REAR) were measured for Digi speech at 65 dB SPL. The output SPL at the ear canal level was measured at octave frequencies from 0.25 kHz to 8 kHz. Real-ear insertion gain (REIG) at octave frequencies from 0.25 kHz to 8 kHz was calculated by subtracting REAR from REUR. It was ensured that REIG was almost matched to the prescriptive target. In the second program, we set the gain according to the participant's preference level. The recorded Ling 6 sounds were presented sequentially in random order at 65 dB SPL. Each participant was instructed to judge the loudness and clarity of these sounds. Depending on the participant's response, the gain in the frequency corresponding to the spectrum of each sound was programmed. In the third program, the gain in hearing aid at the tinnitus pitch was varied systematically. Each participant was instructed to pay attention to the tinnitus and report the level of hearing aid gain at which tinnitus was masked. Standardized sentences were presented at 65 dB SPL and concurrently the hearing aid gain was systematically increased in 1 dB step size to the point where the hearing aid suppressed the participant's tinnitus. The minimum gain above the prescriptive target at which the participant reports suppression of tinnitus is defined as gain at the tinnitus pitch. The gain (in SPL) at the tinnitus pitch in 3 different programs P1, P2, and P3 was measured from the REIG curve. The gain at the tinnitus pitch was calculated by subtracting the gain (in SPL) between programs (P1, P2, and P3) at the tinnitus pitch. A total of 2 gain differences at the tinnitus pitch were determined (i.e., P3 – P1 and P3 – P2).

SNR 50

Stimulus Preparation

We prepared speech-shaped noise, which had a spectrum similar to that of the standardized sentence. The procedure for generating speech-shaped noise is given elsewhere.[15] Three lists of standardized Kannada sentences developed by Geetha, Sharath, and Manjula[16] were used. These sentences are phonetically and phonemically balanced across the list. Each sentence in the list consisted of 5 target words. For each sentence, the root mean square (RMS) was identified, and then the noise was added at the desired SNR. Ten sentences of the first list were mixed with speech-shaped noise at different SNRs, ranging from +12 dB to −6 dB SNR in 2-dB step size. The following formula was used to add noise to each sentence using AuX viewer software. Similarly, to the other 2 lists of sentences, the noise was added at different SNRs. The code mentioned below was used to generate the desired SNR.

$$\mathbf{SNR} = \mathbf{wave}(\text{filename})@\mathbf{rms} >> 500\ \mathbf{ramp}(\mathbf{wave}(\text{"}\mathbf{noise}\text{"})@\mathbf{rms}, 20)$$

In 10 sentences, the noise embedded at different SNRs was randomized. Each sentence was presented at 65 dB SPL through a loudspeaker positioned at 1 m distance at 45° azimuths away from the participant. Each participant who was fitted with the test hearing aid in the ear having tinnitus was instructed to repeat the sentence. The SNR level at which the testing started (L) and the number of correctly recognized target words in each sentence were noted down. The total number of target words from all sentences was added (T). Also, the total number of words per decrement (W) and SNR decrement step size in each sentence (d) were noted down. The obtained values were substituted to the Spearman–Karber equation, given below, to determine SNR 50%. The below equation was used to calculate SNR 50. SNR 50 was obtained from each of the 3 programs of the hearing aid from each participant. The 3 programs were counterbalanced using the Lattin square method to obtain SNR 50 from each participant.

$$50\text{ point} = L + (0.5 \times d) - d(T)/W$$

Evaluation of Tinnitus Relief From Three Programs in Hearing Aids Using Paired Comparison

We used a paired comparison evaluation to obtain the best program in the hearing aid in which maximum relief was attained. A total of 3 comparisons (prescriptive gain, preferred gain, and adjusted gain) were made per trial. Each participant was instructed to choose 1 program, which gave maximum tinnitus relief against other programs by listening to a sentence presented at 65 dB SPL through a loudspeaker positioned at 0° azimuth and 3 foot away from the participant's test ear. The best program was selected in each of the 3 comparisons (P1 vs. P2, P1 vs. P3, P2 vs. P3). A preference score of 1 mark was assigned for the best program. Likewise, 3 trials were performed. We ensured that the 3 comparisons in each trial were randomized. Finally, the number of times each program was selected for relief from tinnitus was noted down.

RESULTS

The experiment aimed to investigate the manipulation of gain in hearing aids on tinnitus relief and speech perception. These data were subjected to statistical analyses using the Statistical Package for Social Sciences (SPSS) software (version 17.0, IBM Corp, Armonk, New York).

Paired Comparison

The preference scores obtained from the 3 different programs using paired comparisons were analyzed using the Friedman test. The test was performed separately for the mild group and the severe group. For the mild group, the results showed a significant effect of preference scores between programs on tinnitus relief [χ^2 (2) = 6.88, $P < .05$]. Further, a Wilcoxon matched-pairs signed-rank test was conducted to determine which program has caused a difference in the preference score on tinnitus relief in the mild group. The results of this analysis indicated that there was a significant difference in preference score between P1 and P3 ($z = -2.53$, $P < .05$) and between

Table 2. Program Preferred by the Subjects of the Mild and Severe Groups

Mild	Preferred Program	Severe	Preferred Program
Subject 1	Program 3	Subject 11	Program 3
Subject 2	Program 2	Subject 12	Program 3
Subject 3	Program 3	Subject 13	Program 3
Subject 4	Program 3	Subject 14	Program 3
Subject 5	Program 3	Subject 15	Program 2
Subject 6	Program 3	Subject 16	Program 3
Subject 7	Program 3	Subject 17	Program 3
Subject 8	Program 2	Subject 18	Program 2
Subject 9	Program 2	Subject 19	Program 3
Subject 10	Program 2	Subject 20	Program 3

P2 and P3 ($z = -2.11$, $P < .05$) on tinnitus relief. However, there was no significant difference in preference score between P1 and P2 programs on tinnitus relief ($z = -0.175$, $P > .05$). However, in the severe group, it was found that there was a significant difference in preference score between 3 programs on tinnitus relief [χ^2 (2) = 10.00, $P < .05$]. A Wilcoxon matched-pairs signed-rank test was conducted for the severe group to ascertain which program might have caused a significant preference for tinnitus relief. It was found that there was a significant difference in preference score between programs P1 and P2 ($z = -2.23$, $P < .05$), P2 and P3 ($z = -2.23$, $P < .05$), and P1 and P3 ($z = -2.23$, $P < .05$).

Preference Percentage

The paired comparison revealed the preference of the best program for tinnitus relief. In the mild group, 60% (6/10 participants) of the participants preferred gain at the tinnitus pitch (P3 program), 40% (4/10 participants) of the participants opted for the preferred gain (P2 program), and none of them preferred the prescriptive gain (P1 program). Whereas in the severe group, 80% (8/10 participants) of the participants preferred gain at the tinnitus pitch (P3 program), 20% (2/10 participants) of the participants opted for preferred gain (P2 program), and none of them preferred prescriptive gain (Table 2). Thus, in both the groups, a majority of them preferred gain at the tinnitus pitch to obtain maximum relief from tinnitus than the other programs.

Gain Difference

The gain differences between programs at the tinnitus pitch were obtained in each group. From Table 3, it was observed that more gain was required in P1 and P2 than P3 to suppress tinnitus. For the mild group, a gain of 10 dB more was needed in P1 to suppress tinnitus than P3. Besides, a gain of 6.4 dB more was required in P2 to suppress tinnitus than P3. For the severe group, a gain of 15.6 dB was needed in P1 to suppress tinnitus than P3. Also, a gain of 10.4 dB more was required in P2 to suppress tinnitus than P3.

SNR 50

SNR 50 was obtained for each of the programs from the participants of the 2 groups. The data of SNR 50 from the 3 programs were subjected to a Friedman test to evaluate differences in SNR 50 between prescriptive gain (mean = 4.28, SD = 4.08), preferred gain (mean = 3.21, SD = 2.65), and gain at the tinnitus pitch (mean = 3.50, SD = 2.54). The test result revealed that there was no statistically significant difference between programs on SNR 50[χ^2 (2) = 1.14, $P > .05$]. In the severe group, SNR 50 obtained from prescriptive gain was mean = 6.50 with SD = 4.06, the preferred gain was mean = 5.60 with SD = 3.71, and gain at the tinnitus pitch was mean = 4.50 with SD = 3.62. Evaluation of SNR 50 data from the three 3 programs using the Friedman test revealed that there was no statistically significant difference [χ^2 (2) = 4.10, $P > .05$] between the programs on SNR 50. It is inferred that SNR 50 was similar for all 3 programs. This was true for each group.

Table 3. Gain Difference Between Programs in Each Group

Group		P3 – P1	P3 – P2
Mild	Mean	10.14	6.42
	SD	7.104	4.79
Severe	Mean	15.60	10.40
	SD	14.25	11.73

Further, to ascertain if there was any significant difference between groups on SNR 50, a Mann–Whitney *U* test was performed. It was found that there was no significant difference ($U = 136.00$, $z = -0.69$) in SNR 50 between the mild (mean = 3.66, SD = 3.04) and severe (mean = 5.53, SD = 3.62) groups.

DISCUSSION

The study was undertaken to determine the best gain setting in hearing aids to provide tinnitus relief. The best gain setting alleviates hearing loss by appropriate gain and eventually masks audible tinnitus. Thus, in the present study, gain-setting in hearing aids was experimentally altered to see in which program participants received a maximum benefit on both tinnitus relief and speech perception. It was evident that the loudness of tinnitus would be more than 5-10 dB above the threshold.[17] After treating audibility with a hearing aid, the gain at the tinnitus pitch was linearly increased in the step of 1 dB until participants reported tinnitus suppression. It was observed that irrespective of the group, the differences between preferred gain and gain at the tinnitus pitch; prescriptive gain and gain at the tinnitus pitch ranged from 6 to 10 dB and 10 to 15 dB, respectively. This indicates that the gain set at the tinnitus pitch was approximately matched or well above the loudness of tinnitus. The threshold of audibility was alleviated by the prescriptive formula, and additional gain at the tinnitus pitch suppressed tinnitus. Thus, gain set at the tinnitus pitch reported a positive outcome. This is because the amplified frequency response of sentences at the tinnitus pitch masks tinnitus effectively. In paired comparison, the study participants of the mild (60%) and severe (80%) groups have shown a significant preference of program 3 (gain at the tinnitus pitch) for tinnitus suppression. The gain setting in program 3 could have caused effective masking of tinnitus suppression. The study agrees with a previous study by Swathi et al.,[18] who have reported that increased gain at the tinnitus pitch was effective in causing tinnitus suppression, especially when the tinnitus pitch is above 5 kHz. In this study, suppression of tinnitus was evaluated immediately after programming, and 14 of the participants experienced tinnitus relief immediately. Considering the acclimatization period, in the long run, these clients can have much more benefits. The primary purpose of a hearing aid is to alleviate hearing loss and improve speech perception. The hearing aid should not compromise the primary purpose of improving speech perception with gain adjustment at the tinnitus pitch. Thus, in the present study, SNR 50 was compared between 3 programs. The results revealed that SNR 50 remained unaffected with the gain set at the tinnitus pitch from other gain settings of preferred and prescriptive methods. The positive finding of program 3 on tinnitus relief shed light on setting gain at the tinnitus pitch. Besides, the hearing aid's primary concern on speech perception is not compromised in setting the gain at the tinnitus pitch. Thus, the alternative hypothesis is accepted. The present study highlights that a gain setting at the tinnitus pitch according to individual requirement can tackle both hearing loss and associated tinnitus without affecting speech perception. However, the small sample size and the majority of the participants having unilateral tinnitus are limitations of the study. The study results can be considered as preliminary findings to devise future studies with a larger population and with those having unilateral and bilateral tinnitus.

CONCLUSION

The study concluded that most participants preferred increased gain at the tinnitus pitch compared to the other programs. This is because the amplification frequency response of a sentence at the tinnitus pitch masks tinnitus effectively. In addition, there was no difference between SNR 50 scores in the 3 gain settings. It infers that a hearing aid masks tinnitus effectively when its gain is set at the tinnitus pitch without compromising speech perception.

Ethics Committee Approval: The study was approved by the Research Ethical Committee, J.S.S Institute of Speech and Hearing.

Informed Consent: Written informed consent was taken from all the participants of the study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – H.N.S.; Design – H.N.S.; Supervision – H.N.S.; Resource – S.P.; Materials – S.P., H.N.S.; Data Collection and/or Processing – S.P.; Analysis and/or Interpretation – S.P., H.N.S.; Literature Search – S.P.; Writing – S.P., H.N.S.; Critical Reviews – H.N.S.

Acknowledgements: The authors extend sincere gratitude to all the participants of the study.

Conflict of Interest: The authors have no conflict of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

REFERENCES

1. McFadden D. *Tinnitus: Facts, theories, and treatments.* National Academy Press; 1982.
2. Saltzman M, Ersner MS. A hearing aid for the relief of tinnitus aurium. *Laryngoscope*. 1947;57(5):358-366. [CrossRef]
3. Jastreboff PJ . Phantom auditory perception (tinnitus): mechanisms of generation and perception. *Neurosci Res*. 1990;8(4):221-254. [CrossRef]
4. Folmer RL, Martin WH, Shi Y, Edlefsen LL. Tinnitus sound therapy. In: Tyler RS. *Tinnitus treatment*. New York: Thieme; 2006. p. 176-186.
5. Trotter MI, Donaldson I. Hearing aids and tinnitus therapy: a 25-year experience. *J Laryngol Otol*. 2008;122(10):1052-1056. [CrossRef]
6. Mcneill C, Dayse T, Alnafjan F, Searchfi GD, Welch D. Tinnitus pitch, masking, and the effectiveness of hearing aids for tinnitus therapy. *Int J Audiol*. 2012;51(12):914-919. [CrossRef]
7. Del BL, Ambrosetti U. Hearing aids for the treatment of tinnitus. *Prog Brain Res*. 1999;2007(166):341-345.
8. Moffat G, Adjout K, Gallego S, et al. Effects of hearing aid fitting on the perceptual characteristics of tinnitus. *Hear Res*. 2009;254(1-2):82-91. [CrossRef]
9. Shekhawat GS, Searchfield GD, Kobayashi K, Stinear CM. Prescription of hearing-aid output for tinnitus relief. *Int J Audiol*. 2013;52(9):617-625. [CrossRef]
10. Shekhawat GS, Searchfield GD, Stinear CM. Role of hearing aids in tinnitus intervention: a scoping review. *J Am Acad Audiol*. 2013;24(8):747-762. [CrossRef]
11. Wise K. *Amplification of Sound for Tinnitus Management: A Comparison of DSL [i/o] and NAL-NL1 Prescriptive Procedures and the Influence of Compression Threshold on Tinnitus Audibility*. Auckland: University of Auckland; 2003.
12. May A, Larsen CB, WA. Multi-microphone instruments, DSP and hearing-in-noise. *Hear Rev*. 1998;5(7):42-45.
13. Shetty HN, Pottackal JM. Gain adjustment at tinnitus pitch to manage both tinnitus and speech perception in noise. *J Otol*. 2019;14(4):141-148. [CrossRef]
14. Jastreboff P, Ikner CL, Hassen A. An approach to the objective evaluation of tinnitus in humans. In Proceedings of the IV International Tinnitus Seminar. Bordeaux: France 1992. pp. 27-301.
15. Shetty HN, Mendhakar A. Deep band modulation and noise effects: perception of phrases in adults. *Hear Balanc Commun*. 2015;13(3):111-117. [CrossRef]
16. Geetha C, Kumar KS, Manjula P, Pavan M. Development and standardization of the sentence identification test in the Kannada language. *J Hear Sci*. 2014;4(01)::18-26.
17. Goodwin PE, Johnson RM, Goodwin PE, Johnson RM. The loudness of tinnitus. *Acta Otolaryngol*. 1980;648:353-359.
18. Swathi S, Shetty HN, Jijo PM, Narne VK. Optimization of hearing aid gain for tinnitus relief. In: Conference of National Acoustic Association; Goa: India; 2015.