ORIGINAL ARTICLE ASIAN JOURNAL OF MEDICAL SCIENCES

Auditory perception in adult hearing aid users with and without auditory training - A comparative study

Ritam Ray[1], Ritam Majumdar[2], Nirmalya Ghosh[3]

[1]Associate Professor, Department of ENT, [2]2nd Year MBBS Student, [3]Audiologist and Speech and Language Pathologist, Department of Paediatrics, Burdwan Medical College, Burdwan, West Bengal, India

Submission: 17-01-2023 Revision: 02-03-2023 Publication: 01-04-2023

ABSTRACT

Background: Individuals with sensorineural hearing loss can regain some lost auditory function with the help of hearing aids, but it may be insufficient under non – optimal condition. Future research aspect lies in processing strategy and training to enhance effects of auditory training and rehabilitation of patients using hearing aids. So research is done to supplement the rehabilitation process with patient centric education, counseling and auditory training to help the listener compensate for loss of auditory signal and improve communication. Whether age-related hearing loss can be decreased by auditory training along with hearing aid is to be researched as it is not clear from previous scientific works whether the outcome is significantly better than those with hearing aid who have not received training. **Aims and Objectives:** The aim of the study was to determine the role of auditory training for improvement of auditory perception in aged patients with age-related sensorineural hearing loss using binaural hearing aid. **Materials and Methods:** This prospective observational study was conducted in Otorhinolaryngology department of Burdwan Medical College and Hospital, Burdwan, a rural based tertiary care hospital in Burdwan for 2 months from June 2022 to July 2022 and 50 aged patients with audiologically proven age related sensorineural hearing loss using hearing aid were included in this study after through history taking and meticulous clinical examination after getting institutional ethics committee clearance. Patients were divided in two groups, 25 in experimental group (with auditory training) and 25 in control group (without auditory training) and result was analyzed. **Results:** Formal auditory training was able to improve the central auditory skills of hearing aid users. Improvement was noted in an objective neurophysiologic correlate and perceived by patients, as revealed in a self-assessment questionnaire. **Conclusion:** Formal auditory training in adult hearing aid users promotes: Improvement in auditory skills for sound localization, memory for nonverbal sounds in sequence, auditory closure, and figure-to-ground for verbal sounds. Greater benefits with hearing aids in reverberant and noisy environments.

Key words: Age-related hearing loss; Hearing aid; Auditory perception; Auditory training

Access this article online

Website: http://nepjol.info/index.php/AJMS

DOI: 10.3126/ajms.v14i4.51534

E-ISSN: 2091-0576

P-ISSN: 2467-9100

INTRODUCTION

Speech recognition in adverse condition becomes difficult especially with old age more likely to be in patients having presbycusis or age related hearing loss (ARHL).[1] ARHL is more prominent in presence of background noise to competing speak signals or to rapid speech.[2] It's incidence is 25% of the general population of 60 years or more and is expected to increase with the age of the population.[3] Previous research has shown that cognitive function search as memory and attention also affect speech perception difficulties.[4,5]

Many researches have suggested that auditory training may be beneficial to ARHL or presbycusis patients.[6-9] Auditory training for hearing rehabilitation involves

Address for Correspondence:
Nirmalya Ghosh, Audiologist and Speech and Language Pathologist, Burdwan Medical College, Burdwan, West Bengal, India.
Mobile: 7548033834. **E-mail:** ritamnirmalya@gmail.com

active listening to auditory stimuli and aims to improve ability of patients to comply non-optimal conditions.[10,11] It allowed patients with ARHL to engage in perceptual learning, which may lead to better understanding and communication.[12]

Aims and objectives

The aim of the study was to determine the role of auditory training for improvement of auditory perception in aged patients with age-related sensorineural hearing loss using binaural hearing aid.

MATERIALS AND METHODS

This prospective observational study was conducted in Otorhinolaryngology department of Burdwan Medical College and Hospital, Burdwan, a rural based tertiary care hospital in Burdwan for 2 months from June 2022 to July 2022 and 50 aged patients with audiologically proven age-related sensorineural hearing loss using hearing aid were included in this study after through history taking and meticulous clinical examination after getting institutional ethics committee clearance.

Inclusion criteria

The following criteria were included in the study:

- Patients giving written informed consent for participating into the study
- Age >50 years of age with presbycusis
- Patient willing to use binaural hearing aid having no prior auditory training
- Bilateral symmetrical mild to moderately severe high frequencies sloping sensorineural hearing loss
- Binaural behind the ear hearing aid users for at least 6 months
- Symmetric pure-tone thresholds and symmetric audiogram pattern
- Symmetric word recognition scores of 70% or more and negative PI-PB roll over.

Exclusion criteria

The following criteria were excluded from the study:

- Patients not giving informed consent
- Patient having prior auditory training
- Patients who not willing using hearing aid
- Patients willing using hearing aid monaural
- Patient not suffering from neurological, psychological, cognitive, or mental disturbances.

Patients were divided in two groups, 25 in experimental group (with auditory training) and 25 in control group (without auditory training). The abbreviated profile of hearing aid benefit (APHAB) is a self-assessment questionnaire with seven ration score through 24 questionnaire. The scores shows A- Always (99%), B- Almost (87%), C- Generally (75%), D- Half-the-time (50%), E- Occasionally (25%), F- Seldom (12%), and G- Never (1%). APHAB will be used to quantify auditory difficulties experienced in daily situations involving communication in quiet, noisy, and reverberant environments. It is usually administered before and after fitting amplification as a mechanism to verify the benefit provided by hearing aids. All subjects completed an APHAB in two different situations, before and after auditory training in the experimental group, and as initial and final evaluations in the control group. As subjects already wearing hearing aids in both situations, patients will asked to answer the questionnaire using only the column corresponding to "with hearing aids."

Design of auditory training program

Our formal auditory training program is organized into eight, 1-h sessions, hold twice a week for 4 weeks (Table 1). All sessions will be performed with hearing aids and design to provide intensive stimulation and challenge the auditory system. Score will be varied from positive (easier) to negative (more difficult) during each activity that involves ignoring competitive stimuli. Activities are pointing to sentences, figures, digits, verbal repetition.

Methods of auditory training

Auditory training programs, after a consideration of auditory skills level, pertain to the stimuli used in training activities. Auditory training programs include both analytic and synthetic kinds of training activities.

In Analytic training the subject's attention is focused on segments of the speech signal, such as syllables or phonemes. More emphasis is placed on utilizing acoustic cues, such as the presence or absence of voicing in the words *boat* and *goat* than on gaining meaning from the speech signal. Presumably, one's ability to recognize these segments in isolation will carry over to real-word communication tasks, allowing them to recognize connected discourse better.

In synthetic training subject learn to recognize the meaning of an utterance, even if they do not recognize every sound or word. They do not perform an analysis of the signal on a sound-by-sound or syllable-by-syllable basis.

Based on capacity of auditory cortex to recognize itself in response to sensory stimuli. Plasticity in the brain enables neuronal pathways to develop a direct response to stimuli with a great degree. Auditory training has an impact on speech perception. Auditory plasticity supports the theory that auditory training has important role in auditory

rehabilitation. It is expected from the study to develop and auditory training programs to be well established in the medical field so as to help the older persons of the society s suffering from ARHL or presbycusis to undergo an auditory training and enhancement program along with hearing aid.

Abbreviated profile of hearing aid benefit[13]

Instructions

Please circle the answer that comes closest to your everyday experience. Notice that each choice includes a percentage. You can use this to help you decide on your answer. For example, if a statement is true about 75% of the time, circle "C" for that item. If you have not experienced the situation we describe, try to think of a similar situation that you have been in and respond for that situation. If you have no idea, leave that item blank.

RESULTS

All data obtained from APHAB were statistically analyzed. The Student t-test was used to compare the performance variance of subjects from both control and experimental groups, in both evaluations (pre- and post-training), considering the APHAB. The significance level was set at 5% (P=0.05), and confidence intervals were established at 95%.

Finally, in Table 2 (Benefit observed in APHAB of control and experimental groups when comparing pre- and post-training administration), we present the comparison of benefit observed through the administration of the APHAB to the control and experimental groups. No differences were noted for the control group, while there was a trend toward statistical significance for the experimental group in the reverberation and background noise sub-scales.

DISCUSSION

In this study, six behavioral auditory processing tests were used to evaluate the participants and these are sound

Questionnaire	Without my hearing aid	With my hearing aid
1. When I am in a crowded grocery store, talking with the cashier, I can follow the conversation	A B C D E F G	A B C D E F G
2. I missa lot of informationwhen I'm listeningto a lecture	A B C D E F G	A B C D E F G
3. Unexpected sounds, like a smoke detector or alarm bell are uncomfortable	A B C D E F G	A B C D E F G
4. I have difficulty hearing a conversation when I'm with one of my family at home	A B C D E F G	A B C D E F G
5. I have trouble understanding dialogue in a movie or at the theater	A B C D E F G	A B C D E F G
6. When I am listening to the news on the car radio, and family members are talking, I have trouble hearing the news	A B C D E F G	A B C D E F G
7. When I am at the dinner table with several people, and am trying to have a conversation with one person, understanding speech is difficult	A B C D E F G	A B C D E F G
8. Traffic noises are too loud	A B C D E F G	A B C D E F G
9. When I am talking with someone across a large empty room, I understand the words	A B C D E F G	A B C D E F G
10. When I am in a small office, interviewing or answering questions, I have difficulty following the conversation	A B C D E F G	A B C D E F G
11. When I am in a theater watching a movie or play, and the people around me are whispering and rustling paper wrappers, I can still make out the dialog	A B C D E F G	A B C D E F G
12. When I am having a quiet conversation with a friend, I have difficulty understanding	A B C D E F G	A B C D E F G
13. The sounds of running water, such as a toilet or shower, are uncomfortably loud	A B C D E F G	A B C D E F G
14. When a speaker is addressing a small group, and everyone is listening quietly, I have to strain to understand	A B C D E F G	A B C D E F G
15. When I'm in a quiet conversation with my doctor in an examination room, it is hard to follow the conversation	A B C D E F G	A B C D E F G
16. I can understand conversations even when several people are talking	A B C D E F G	A B C D E F G
17. The sounds of construction work are uncomfortably loud	A B C D E F G	A B C D E FG
18. It's hard for me to understand what is being said at lectures or church services	A B C D E F G	A B C D E F G
19. I can communicate with others when we are in a crowd	A B C D E F G	A B C D E F G
20. The sound of a fire engine siren close by is so loud that I need to cover years	A B C D E F G	A B C D E F G
21. I can follow the words of a sermon when listening to a religious service	A B C D E F G	A B C D E F G
22. The sound of screeching tires is uncomfortably loud	A B C D E F G	A B C D E F G
23. I have to ask people to repeat themselves in one-on-one conversation in a quiet room	A B C D E F G	A B C D E F G
24. I have trouble understanding others when an air conditioner or fan is on	A B C D E F G	A B C D E FG

A: Always (99%), B: Almost Always (87%), C: Generally (75%), D: Half-the-time (50%), E: Occasionally (25%), F: Seldom (12%), G: Never (1%)

Table 1: Formal auditory training (FAT) schedule

Session	Test	Auditory skill	Ear
1, 2 and 3	Synthetic sentences nonverbal dichotic test	Figure to ground for sentences and nonverbal sounds	LE/RE RE/LE
4, 5 and 6	Dichotic digits	Figure to ground for digits	LE/RE
7 and 8	Speech in noise (Sentences)	Auditory closure	RE/LE

Table 2: Benefit observed in APHAB for control and experimental groups comparing pre- and post-training administration

APHAB	Experimental				Control			
	EC (%)	RV (%)	BN (%)	AV (%)	EC (%)	RV (%)	BN (%)	AV (%)
Mean	−2.9	−2.6	−6.0	−3.5	2.1	1.3	3.6	1.0
Median	−5.0	−6.0	−13.0	0.0	2.0	0.0	4.0	2.0
SD	11.2	6.1	10.1	7.5	7.9	7.8	9.1	7.3
VC	−251	−134	−126	−202	397	−1822	253	730
Min	−19.0	−13.0	−21.0	−20.0	−11.0	−12.0	−14.0	−13.0
Max	19.0	5.0	4.0	1.0	15.0	10.0	12.0	8.0
N	25	25	25	25	25	25	25	25
CI	9.0	4.5	7.5	5.6	5.9	5.8	6.7	5.4
P-value	0.312	0.091	0.070	0.218	0.430	0.789	0.329	0.730

APHAB: Abbreviated profile of hearing aid benefit. EC: Ease of communication. RV: Reverberation. BN: Background noise. AV: Aversiveness of sound. SD: Standard deviation. VC: Variation coefficient. CI: Confidence interval

localization; memory for verbal sounds in sequence; memory for nonverbal sounds in sequence; word recognition score with recorded stimuli; speech-in-noise test and dichotic digits test. All patients exhibited abnormal results on at least one of the tests during the pre-training evaluation. Auditory difficulty could not be predicted by either functional gain or word recognition scores in quiet, as results were within normal limits under such conditions. Before the auditory training program, performance in the control group was generally poorer than in the experimental group.

The performance of the experimental group during the post-training evaluation was better than the first evaluation, since the comparison between pre-training and post-training performance resulted in positive values for all tests. Statistically significant differences were observed in sound localization, memory for nonverbal sounds in sequence, the speech in noise test, dichotic digits demonstrating an improvement. This is interpreted to mean that formal auditory training was effective in improving central auditory skills.

This was confirmed by the results of the present study during the speech in noise test, in which the subjects' performance was negatively influenced by the introduction of noise. The stimuli were the same in both quiet and noise; only the order of presentation was changed. The results indicate that amplification provided by the hearing aids was insufficient to maintain the same quality in both quiet and noisy environments. However, this auditory skill may be improved with auditory training. Finally, it is possible that hearing aid fitting alone fails to produce the ideal environment for the auditory system and its skills. When a central auditory processing disorder co-exists with peripheral hearing loss, compensation obtained from hearing aids is at times insufficient to compensate for the auditory processing disorder (APD), and the patient may become dissatisfied and frustrated with the performance of the hearing aids. Based on our results, auditory processing evaluations should seriously be considered during the hearing aid fitting process.

While there were no significant differences between right and left ears for either group on any of the experimental measures, individual results for some patients in both the control and experimental groups demonstrated asymmetrical results in central auditory processing tests, such as dichotic digits and speech in noise. Such differences were minimized for subjects in the experimental group after the completion of training.

The APHAB self-assessment questionnaire was selected in this study to help determine whether the expected/observed changes in behavioral evaluations would interfere with the patient's subjective evaluation. There does not appear to be a specific self-assessment questionnaire designed to quantify changes observed in adult hearing aid users following a specific auditory training program. However, APHAB has been shown to be a powerful instrument for recording the benefit of a specific

therapeutic approach. Thus, we felt it the most appropriate self-assessment questionnaire for our study.

Although subjects in both groups were similar in peripheral hearing status and hearing aid technology, environmental differences are expected and may account for differences in subjective measures such as self-assessment questionnaires.

Communication improvement in noisy environments should be the primary goal of any auditory training program, especially since such environments are common in everyday life. A hearing aid fitting would likely effectively compensate for the loss of sensitivity. However, there is still the chance of having a subject whose hearing thresholds have been made normal but who has an auditory processing disorder. Such a patient would not complain of difficulties in receiving sounds but rather in interpreting them, especially in the presence of increasing noise. It is suggested that administering an auditory training program, as described in the present study, and a self-assessment questionnaire, such as the APHAB, could make the assessment and identification of hearing-impaired patients with an additional auditory processing disorder easier.

Limitations of the study

The sample size was small. More sample size is required to reach into confirmed conclusion. The study has been done in a single centre.

CONCLUSION

The results of the present study suggest that formal auditory training was able to improve the central auditory skills of hearing aid users. Improvement was noted in an objective neurophysiologic correlate and perceived by patients, as revealed in a self-assessment questionnaire. Therefore, we strongly advocate investing time searching for the presence of a central auditory processing disorder during the course of all hearing aid fittings. Furthermore, programs for rehabilitation of these skills are essential for all patients identified, regardless of age.

It is shown that the high cost of hearing aids prevents patients from acquiring them, particularly if the patient feels that the benefit will not outweigh the high cost of the investment in many cases. Including an initial auditory processing evaluation and formal auditory training should provide a basis for such patients to feel more confident about purchasing a sophisticated and expensive hearing aid. Audiologists play an important role in this situation by helping patients realize the importance of auditory training and introducing it as a part of the hearing aid fitting process.

After a critical analysis of the results, we can conclude that formal auditory training in adult hearing aid users promotes: Improvement in auditory skills for sound localization, memory for nonverbal sounds in sequence, auditory closure and figure-to-ground for verbal sounds. Greater benefits with hearing aids in reverberant and noisy environments.

REFERENCES

1. Fitzgibbons PJ and Gordon-Salant S. Behavioral studies with aging humans: Hearing sensitivity and psychoacoustic. In: Cordon-Salant S, Frisina R, Popper A and Fay R. editors The Aging Auditory System. Springer Handbook of Auditory Research. Vol. 34. New York: Springer; 2010.
2. Pichora-Fuller MK, Schneider BA and Daneman M. How young and old adults listen to and remember speech in noise. J Acoust Soc Am. 1995;97(1):593-608.
   https://doi.org/10.1121/1.412282
3. Roth TN, Hanebuth D and Probst R. Prevalence of age-related hearing loss in Europe: A review. Eur Arch Otorhinolaryngol. 2011;268(8):1101-1107.
   https://doi.org/10.1007/s00405-011-1597-8
4. Humes LE and Dubno JR. Factors affecting speech understanding in older adults. In: The Aging Auditory System. Germany: Springer; 2009. p. 211-257.
5. Gil D and Iorio MC. Formal auditory training in adult hearing aid users. Clinics. 2010;65(2):165-174.
6. Lavie L, Banai K, Attias J and Karni A. Better together: Reduced compliance after sequential versus simultaneous bilateral hearing aids fitting. Am J Audiol. 2014;23(1):93-98.
   https://doi.org/10.1044/1059-0889(2013/13-0010)
7. Stecker GC, Bowman GA, Yund EW, Herron TJ, Roup CM and Woods DL. Perceptual training improves syllable identification in new and experienced hearing aid users. J Rehabil Res Dev. 2006;43(4):537-551.
   https://doi.org/10.1682/jrrd.2005.11.0171
8. Sweetow RW and Sabes JH. Auditory training and challenges associated with participation and compliance. J Am Acad Audiol. 2010:21(9):586-593.
   https://doi.org/10.3766/jaaa.21.9.4
9. Lavie L, Banai K, Karni A and Attias J. Hearing aid-induced plasticity in the auditory system of older adults: Evidence from speech perception. J Speech Lang Hear Res. 2015;58(5):1601-1610.
   https://doi.org/10.1044/2015_JSLHR-H-14-0225
10. Boothroyd A. Adult aural rehabilitation: What is it and does it work? Trends Amplif. 2007;11(2):63-71.
    https://doi.org/10.1177/1084713807301073
11. Sabes JH and Sweetow RW. Variables predicting outcomes on listening and communication enhancement (LACETM) training. Int J Audiol. 2007;46(7):374-383.
    https://doi.org10.1080/14992020701297565
12. Sweetow RW and Sabes JH. Technologic advances in aural rehabilitation: Applications and innovative methods of service delivery. Trends Amplif. 2007;11(2):101-111.

https://doi.org/10.1177/1084713807301321

13. Cox RM and Alexander GC. The abbreviated profile of hearing aid benefit. Ear Hear. 1995;16(2):176-186. https://doi.org/10.1097/00003446-199504000-00005

Authors' Contributions:
RR - Concept and design of the study, prepared first draft of manuscript; **RM -** Interpreted the results; reviewed the literature and manuscript preparation; **NG -** Concept, coordination, statistical analysis and interpretation, preparation of manuscript and revision of the manuscript.

Work attributed to:
Burdwan Medical College, Burdwan, Purba Bardhaman, West Bengal, India.

Orcid ID:
Dr. Ritam Ray - https://orcid.org/0000-0003-3919-7587
Ritam Majumdar - https://orcid.org/0000-0003-3804-8109
Nirmalya Ghosh - https://orcid.org/0000-0003-0726-8600

Source of Support: Nil, **Conflicts of Interest:** None declared.