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RESEARCH ARTICLE
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IMPEDANCE AUDIOMETRY IN GERIATRIC POPULATION WITH HEARING LOSS – A CROSS SECTIONAL STUDY

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Abstract

Introduction: Hearing loss in the geriatric population, commonly termed presbycusis, results from age-related physiological changes, noise exposure, medical conditions, and genetic predisposition. Impedance audiometry is a valuable tool for evaluating middle ear function. This study aims to assess impedance audiometry findings in elderly individuals with hearing loss.

Objective: To determine the results of impedance audiometry in geriatric patients (aged 60 years or more) with hearing loss and to correlate these findings with the degree of hearing loss using pure tone audiometry.

Materials and Methods: This cross-sectional observational study was conducted at the Department of ENT and HNS, Adichunchanagiri Hospital and Research Centre, BG Nagara over 18 months. A total of 100 patients aged 60 years or more with hearing loss were included and a detailed ENT examination, pure tone audiometry, and impedance audiometry (tympanometry and stapedial reflex testing) were performed.

Results: The majority of patients had bilateral hearing loss, among which tympanometry predominantly showed normal middle ear function. Stapedial reflex was absent in most cases. A significant correlation was found between tympanometry findings and the type of hearing loss.

Conclusion: Impedance audiometry effectively evaluates middle ear function in the elderly and supports pure tone audiometry findings. While sensorineural hearing loss with normal middle ear function was most common, abnormal results were primarily linked to mixed hearing loss.

Keywords: Presbycusis, impedance audiometry, tympanometry, stapedial reflex, sensorineural hearing loss.

Introduction

Hearing loss in older adults, or presbycusis, is a common, progressive condition that significantly impacts communication, quality of life, and overall health. Its prevalence increases with age, affecting a large proportion of those over 65 years worldwide [1]. Presbycusis is generally accepted to be caused by a variety of physiological degenerations, as well as the cumulative effects of noise exposure, medical conditions, and treatment for these conditions, as well as inherited predisposition [2]. Presbycusis involves mechanical, neurological, and sensory changes in the auditory system. Neuronal degeneration and hair cell loss lead to sensorineural hearing loss, while middle ear structural changes, such as tympanic membrane thickening or ossicular stiffness, can cause conductive loss. These changes result in gradual, symmetrical high-frequency hearing loss, initially affecting speech understanding and later sound detection and localization. [3].

In elderly patients, impedance audiometry offers useful information on middle ear function. While abnormalities such as Type As, Ad, B, or C may suggest ossicular stiffness, membrane thinning, fluid accumulation, or Eustachian tube dysfunction respectively, tympanometry frequently reveals typical patterns (Type A) in sensorineural loss. Because of middle ear pathology or neuronal degeneration, stapedial reflexes are often missing or exaggerated. When paired with pure tone audiometry, these results provide a thorough evaluation of the sort of hearing loss (conductive, sensorineural or mixed hearing loss) and its underlying causes [4].

This study aims to analyze the results of impedance audiometry in geriatric patients with hearing loss to understand the changes in the ear related to aging.

Methodology

This cross-sectional observational study was carried out in the Department of ENT and HNS at Adichunchanagiri Hospital and Research Centre, Adichunchanagiri University, BG Nagara, over a duration of 18 months, from July 2023 to January 2025. The study included 100 patients aged 60 years or older who presented with complaints of hearing loss. After obtaining detailed informed consent, all participants underwent a comprehensive evaluation. This included meticulous history taking to identify potential contributing factors, a complete ENT examination to rule out any obvious ear pathology, and audiological assessments consisting of pure tone audiometry and impedance audiometry (tympanometry and stapedial reflex testing). Patients with a history of ear surgery, recurrent ear discharge, tympanic membrane perforation, diabetes, pre-eclampsia, psychiatric illness, use of ototoxic medications, childhood-onset hearing loss, or chronic noise exposure were excluded to minimize confounding factors.

Statistical Analysis

All collected data were entered into a Microsoft Excel spreadsheet and analyzed using SPSS software. The Chi-square test was used to assess the significance of categorical variables, with a p-value < 0.05 considered statistically significant.

Results

The study included 100 geriatric patients, with males comprising 66% and females 34%, indicating a higher prevalence of males in the sample. The age distribution was skewed towards the younger segment of the elderly population, with 59% between 60 and 71 years, 32% between 72 and 83 years, and only 9% between 84 and 95 years. A significant majority of participants (82%) exhibited bilateral hearing loss, while 12% had hearing loss in the left ear and 6% in the right ear.

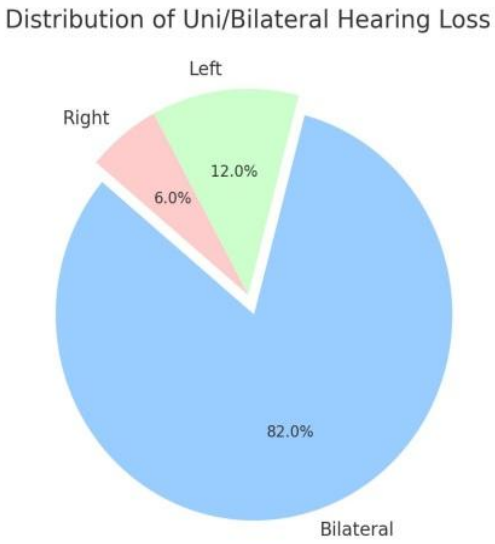
Table 1: Gender Distribution in the study

Sex	Count	Percentage
Male	66	66
Female	34	34
Total	100	100

Table 2: Age distribution in the study

Age	Count	Percentage
60-71	59	59
72-83	32	32
84-95	9	9
Total	100.0	100.0

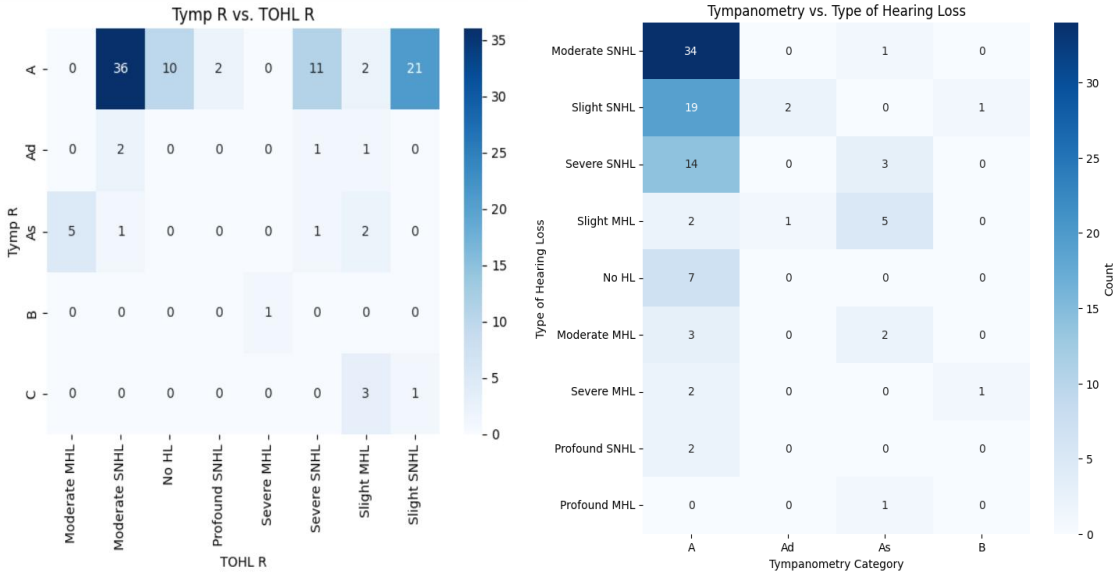
Graph 1: Bar Chart of Uni/Bi Distribution



The mean decibel loss for the right ear was 44.66 dB (SD ±15.68), with a median of 45.75 dB and a range of 15–81.25 dB. For the left ear, the mean decibel loss was 47.99 dB (SD ±17.95), with a median of 48.4 dB and a range of 10–86.25 dB. Pure tone audiometry revealed that moderate sensorineural hearing loss (SNHL) was the most common type in the right ear (39%), followed by slight SNHL (22%), severe SNHL (13%), and mixed hearing loss (MHL) (14%). Similarly, in the left ear, moderate SNHL was most prevalent (35%), followed by slight SNHL (21%), severe SNHL (17%), and MHL (17%). This distribution highlighted the predominance of sensorineural impairments among elderly patients with hearing loss.

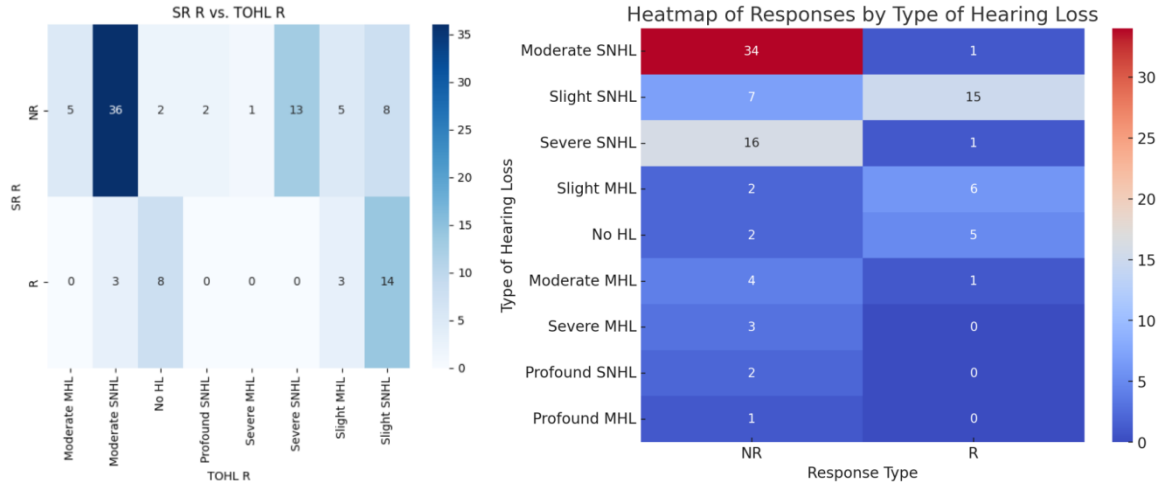
The majority of tympanograms in the right ear showed a Type A pattern (82%), indicating normal middle ear function, followed by Type As (9%), Type Ad (4%), Type C (4%), and Type B (1%). In the left ear, 83% exhibited a Type A tympanogram, followed by Type As (12%), Type Ad (3%), and Type B (2%). The chi-square test showed a highly significant association (Chi-square = 190.69, p-value < 0.001) between tympanometry results and types of hearing loss in both right and left ears. This indicated that SNHL wass predominantly associated with type A tympanograms, highlighting a clear pattern of normal middle ear function in these patients.

Graph 3: Heatmap of Tympanometry Results vs. Types of Hearing Loss in the Left Ear
Graph 2: Heatmap of Tympanometry Results vs. Types of Hearing Loss in the Right Ear



Stapedial reflex responses were similar in both ears, with most participants showing no response (72% right ear, 71% left ear), while a normal reflex was observed in 28% of right ears and 29% of left ears. Both ears showed a significant correlation (Chi-square = 49.94, p-value < 0.0001) between stapedial reflex responses and types of hearing loss, with SNHL predominantly showing no reflex (NR).

Graph 4: Heatmap of Stapedial Reflex Results vs. Types of Hearing Loss in the Right Ear
Graph 5: Heatmap of Stapedial Reflex Results vs. Types of Hearing Loss in the Left Ear



Discussion

Sound waves travel through the external auditory canal, the tympanic membrane vibrates, the middle ear's transformer mechanism activates, sensory hair cells in the cochlea become responsive, and central neuronal connections end at the primary auditory cortex. These processes all interact intricately to produce hearing [5].

Presbycusis refers to age-related hearing loss and includes various forms as described by Schuknecht (1964): sensory, neural, strial, and cochlear conductive types, based on audiogram patterns and temporal bone studies. These forms result from degenerative changes such as loss of cochlear sensory hair cells, degeneration of the cochlear nerve and its central connections, and dysfunction of the stria vascularis, which is vital for cochlear blood supply. Additionally, age-related changes in the external

and middle ear, including increased cerumen impaction, contribute to a higher incidence of conductive hearing loss in the elderly [6]. In the middle ear, age-related changes include a reduction in the vascularity and elasticity of the tympanic membrane, as well as rigidity in the ossicular joints, which may hinder sound transmission [7].

Impedance audiometry, through tympanometry and stapedial reflex testing, offers objective data on tympanic membrane compliance, middle ear pressure, and eustachian tube function. These findings help assess hearing status in geriatric patients and guide management decisions, including hearing aids or surgical options [8].

Analysing the results of puretone audiometry, hearing impairment was graded according to the World Health Organisation Grades of hearing impairment (WHO, 2008) [9].

Table 3: World Health Organisation Grades of hearing impairment (WHO, 2008)

Grade of impairment	Corresponding audiometric ISO value
0 - No impairment	25 dB or better (better ear)
1 – Slight impairment	26 – 40 dB (better ear)
2 – Moderate impairment	41 – 60 dB (better ear)
3 – Severe impairment	61 – 80 dB (better ear)
4 – Profound impairment including deafness	81 dB or greater (better ear)

In this study, sensorineural hearing loss was the most prevalent type in both ears, with moderate cases being the most common (39% in right and 35% in left), followed by slight, severe and profound forms. Mixed hearing loss was also observed, though less frequently. Similar studies by **Roth TNin 2011** and **Baraldi GD et.al; 2007** found that sensorineural hearing loss was primary variant of hearing loss in older adults, with moderate and slight SNHL being predominant. [10,11].
This study revealed that, 82% of right ears and 83% of left ears showed Type A tympanograms, indicating normal middle ear function in most participants. Other tympanogram types -As, Ad, B, C were observed in smaller proportions. reflecting middle ear stiffness, hypercompliance, fluid build up, or Eustachian tube dysfunction respectively. These results were consistent with the findings reported by **Sogebi OA et.al; 2017** and **Stenklev NC et.al; 2004** [12, 13]. According to this study, in elderly individuals, sensorineural hearing loss is the most common type, though mixed hearing loss is also frequently seen. Most cases of SNHL show a normal A-type tympanogram, while mixed hearing loss is more often associated with abnormal tympanograms, suggesting underlying middle ear dysfunction. These results are in accoradance with the study by **Jerger J et.al** [14]. These findings highlight the value of impedance audiometry in detecting both conductive and sensorineural components of hearing loss in the elderly.

Stapedial reflex testing showed no response in 72% of right ears and 71% of left ears in the current study, while a reflex was present in 28% of right ears and 29% of left ears. **Sogebi OA et.al** confirmed that reflex presence and absence are strongly associated with SNHL severity [12]. This was comparable with results of **Wolfe J et.al; 2017,** indicating loss of stapedial reflex in age related hearing decline [15]. But in contrast to this, a study by **Kumar M M,** revealed that majority of the elderly patients with hearing loss, had normal response to stapedial reflex [16]. Most patients with an A-type tympanogram had no reflex, while a smaller proportion showed a reflex in both ears in this study. However, a study by **Malouf WT et.al; 2024** , demonstrated that the absence of stapedial reflexes can be linked to middle ear pathologies, as indicated by abnormal tympanograms [17].

Conclusion

The study highlights that sensorineural hearing loss (SNHL) is the most common type of hearing decline in older adults, generally associated with normal middle ear function, as shown by A-type tympanograms. In contrast, mixed hearing loss (MHL) was often linked to abnormal tympanograms, indicating a higher possibility of middle ear pathologies in this group. A notable absence of stapedial reflexes was observed in many patients with both SNHL and MHL, suggesting underlying neural or cochlear dysfunction. Additionally, the absence of stapedial reflexes became more common with increasing severity of hearing loss. These findings emphasize the importance of comprehensive audiological evaluation, including impedance audiometry, in detecting both sensorineural and conductive components of hearing loss in the elderly. Early diagnosis and timely intervention are essential to address hearing impairment and improve the quality of life in this vulnerable population.

Limitations

The study's limitations include a modest sample size that limits generalizability and a cross-sectional design that prevents assessment of hearing loss progression. Excluding patients with certain comorbidities or prior ear conditions may have narrowed the scope of findings. Additionally, the lack of longitudinal follow-up and potential selection bias from convenience sampling could affect the representativeness and depth of the results.

Recommendations

Routine audiological screening and impedance testing should be standard in geriatric care, with early intervention and rehabilitation for those with hearing loss. Further large-scale, longitudinal studies are needed to better understand hearing decline in the elderly.

Conflict of interest: The authors declare no conflict of interest whatsoever.

Ethical statement: Before starting the study ethical clearance was taken from the institutional ethical committee.

Consent for publication: Informed consent was taken from the patients to enroll in the study.

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