ORIGINAL ARTICLE

Magnitude of Hearing Loss Concerning the Site of Tympanic Membrane Perforation: A Cross-Sectional Study at a Single Institution in Rawalpindi

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ABSTRACT

Objective: To determine the relationship between the site of tympanic membrane perforation and the magnitude of hearing loss.

Study Design: Cross-sectional study.

Place and Duration of Study: The study was conducted at the Department of ENT, Combined Military Hospital, Rawalpindi, Pakistan from 1st August 2023 to 31st January 2024.

Methods: Patients aged between 15 and 60 years who presented to the Ear, Nose and Throat (ENT) outdoor department with dry tympanic membrane perforations were included in the study after obtaining informed consent. Enrollment was done using a purposive sampling technique, irrespective of age and gender. Exclusion criteria included profound hearing loss, actively discharging middle ears, cholesteatoma, and cognitive impairment.

The data were collected using a structured departmental proforma. A detailed history and thorough ENT examination were performed, followed by referral for audiological assessment. SPSS version 20 was used for statistical analysis, and a two-tailed *P*-value of <0.001 was considered statistically significant.

Results: A total of 61 patients (52.45% males and 47.54% females) participated, with a mean age of 34.70 ± 11.80 years. The mean hearing loss for posterior perforation was 26.50 ± 5.61 dB, and for anterior perforation, it was 23.47 ± 6.96 dB. The cases with multiple quadrant perforations showed a mean hearing loss of 41.15 ± 8.65 dB.

Conclusion: The study demonstrates a significant relationship between the site of tympanic membrane perforation and hearing loss, with greater hearing loss observed in multiple quadrant and posterior-quadrant perforations. Timely diagnosis and management of middle ear infections can help reduce the burden of hearing loss associated with tympanic membrane perforations.

Keywords: *Ear Ossicles, Hearing Loss, Otitis Media, Tympanic Membrane Perforation.*

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Introduction

The tympanic membrane, also known as the eardrum, is a vital component of the auditory system, serving as a boundary between the outer and middle ear and functioning as the primary structure for capturing sound waves. The tympanic membrane is coupled with the ossicles and vibrates in response to the sound waves.[1] The malleus attaches to the tympanic membrane, connects to the incus, which links to the stapes covering the oval window, a gateway between the middle and inner ear.[2] Sound signals travel through these ossicles to

the inner ear, where sensory neurons process the auditory information, preserving the original frequencies captured by the eardrum.[3]

The tympanic membrane consists of three distinct layers: the outer layer, which is a continuation of the skin lining the external auditory canal; the inner layer, derived from the mucosal lining of the middle ear; and the middle layer, an organized fibrous structure that facilitates sound transmission from the outer to the inner layer.[4]

Chronic suppurative otitis media (CSOM) is a persistent inflammatory condition affecting the middle ear cleft, and is characterized by ear discharge resulting from a perforated eardrum, lasting at least 6 weeks, and mostly complicated by hearing impairment.[5] Chronic inflammatory processes damage the epithelial structure of the tympanic membrane and also destroy the ossicular structures, contributing to the development of conductive hearing loss (CHL).[6] The ongoing damage to the ossicles in chronic suppurative otitis media (CSOM) can lead to a disruption in sound conduction and allow the absorption of toxins through the oval window, potentially impacting the sensory cells responsible for processing higher frequencies and contributing to sensorineural hearing loss.[7]

Hearing impairment negatively affects overall well-being and is a major contributor to the years lived with disability.[8] Most people with CSOM lose their hearing temporarily or permanently, with normal audible range typically falling between 10 and 40 dB.[9] Hearing impairment results in significant psychosocial and physical issues account for variable amount of depression in the disease survivors.[10] The timely diagnosis and adequate treatment are crucial for the hearing preservation. The global prevalence of ear drum perforations necessitates the ongoing process of data recording. This study aimed to investigate the relationship between the site of tympanic membrane dry perforation and the magnitude of hearing loss. The site of tympanic membrane perforation directly affects the severity of hearing loss; as certain areas play a more critical role in sound transmission. Perforations in the central or posterior regions tend to cause more significant hearing impairment due to their proximity to the ossicles and middle ear structures.[11] The rationale of this study was to explore this relationship, providing insights for accurate diagnosis, tailored treatment, and improved patient outcomes.

Methods

This cross-sectional study was carried out at the Department of ENT, Combined Military Hospital, Rawalpindi, Pakistan from 1st August 2023 to 31st January 2024 after approval from the hospital's Ethical Committee vide letter serial number: 673, dated: 22nd July 2023. A total of 61 patients were enrolled based on the inclusion criteria through purposive sampling.

The inclusion criteria were patients of either gender, aged 15 to 60, with dry perforations, whether unilateral or bilateral. The patients who were excluded from this study were those with profound hearing loss, active middle ear infections, evidence of cholesteatoma, and severe cognitive impairment.

All participants gave informed Consent, and the questionnaires were explained to them in their native language. A detailed history was taken, and a comprehensive ENT examination was conducted. A video-endoscopic examination of all ears was done to detect the site of the perforation and exclude the possibility of hidden cholesteatoma.

The tympanic membrane was divided into four quadrants by drawing two perpendicular hypothetical lines—one horizontal at the level of the manubrium and one vertical through the umbo. This division created the anterior-superior, anterior-inferior, posterior-superior, and posterior-inferior quadrants. The quadrant-based approach allowed precise perforation localization and facilitated correlation with the degree of hearing loss. After that all the patients were sent for pure tone audiometry (PTA) to assess the hearing threshold and measure the outcome for different frequencies. Different frequencies were used to determine the air-bone gap, such as 250, 500, 1000, and 4000 Hz. The extent of hearing impairment was then measured in relation to the site of eardrum perforation. Data was collected using a predesigned questionnaire, and for statistical analysis, SPSS Version 20 was used. A *P*-value of <0.001 was calculated using a paired sample t-test (two-tailed), considering the burden of anterior perforations versus posterior perforations. It was found statistically significant. The descriptive

analysis was done for all the categorical variables, including qualitative and quantitative. The rules of the Declaration of Helsinki were followed throughout the study.

Results

Our results showed a male predominance, with 52.45% males compared to 47.54% females. The characteristics of the participants are shown in the table-1.

All the cases were with dry perforations, either single or in multiple quadrants. The history of discharging ears was identified in 50 cases, and the history of trauma (barotrauma, temporal bone fractures) was noted in the remaining cases.

In the anterior quadrants, perforations were observed in 23 ears. The patients with anterior perforations were further subdivided into superior and inferior perforations. Specifically, three patients had perforations occupying antero-superior (AS) quadrant, 16 patients had perforations in antero-inferior (AI) quadrants, and four patients had larger perforations occupying the AS and AI sections.

Table-1: Profile of Study Participants (n=61)

Mean age ± Standard Deviation	34.70 ± 11.80 years
Gender	
Males	32 (52.45%)
Females	29 (47.54%)
Residential Habitat	
Rural	24 (39.34%)
Urban	36 (59.01%)
Laterality	
Left Ear	30 (49.18%)
Right Ear	19 (31.14%)
Bilateral Ears	12 (19.67%)

Table-2: Site of tympanic membrane perforation

Site of Perforation	**No. of Patients (n=61)**	**Percentage (100%)**
Anterior Quadrant Perforations (23 ears)		
Anterior-Superior (AS) Quadrant	3	5.0%
Anterior-Inferior (AI) Quadrant	16	26.7%
Anterior-Superior + Anterior-Inferior (AS + AI) Quadrants	4	6.7%
Posterior Quadrant Perforations (18 ears)		
Posterior-Inferior (PI) Quadrant	12	20.0%
Posterior-Superior (PS) Quadrant	5	8.3%
Posterior-Inferior + Posterior-Superior (PI + PS) Quadrants	1	1.7%
Multiple Quadrant Perforations (20 patients)		
Anterior-Inferior + Posterior-Inferior (AI + PI) Quadrants	1	1.7%
Anterior-Superior + Anterior-Inferior (AS + AI) Quadrants	4	6.7%
Anterior-Superior + Anterior-Inferior + Posterior-Inferior (AS + AI + PI) Quadrants	15	25.0%

Table-3: Average hearing loss (n=61)

Classes	**Hearing Loss (Average) dB**	**Number of Cases (n)**
Posterior Quadrant Perforations	26.50 ± 5.61	18
Anterior Quadrant Perforations	23.47± 6.96	23
Multiple Quadrant Perforations	41.15 ± 8.65	20

Similarly, an analysis involving the posterior quadrant revealed that 18 patients had posterior perforations in their tympanic membranes. The posterior quadrant was also subdivided into superior and inferior sections. Out of these, 12 patients showed perforations restricted to posteroinferior (PI) quadrants, 5 five patients had perforations involving posterosuperior (PS) quadrants, and 1 patient had a larger posterior perforation occupying both the PI and PS quadrants.

We observed that 32.7% of patients (20 individuals) had perforations involving multiple quadrants. Specifically, one patient had perforations in the anterior-inferior (AI) and posterior-inferior (PI) quadrants, four patients had perforations in the anterior-superior (AS) and anterior-inferior (AI) quadrants, and 15 patients exhibited perforations involving the anterior-superior (AS), anterior-inferior (AI), and posterior-inferior (PI) quadrants, as detailed in table-2.

Among the individual quadrants, the AI quadrant was the most frequently involved site of tympanic membrane perforation, accounting for 26.7% of the total cases. Hearing loss was classified based on pure tone audiometry findings: 67.21% of cases (41 patients) had conductive hearing loss (CHL), 22.95% (14 patients) had mixed hearing loss (MHL), and 8.19% (5 patients) presented with sensorineural hearing loss (SNHL).

The mean hearing loss for the anterior quadrant perforations was 31.56 ± 13.77 dB and 36.29 ± 10.17dB for the posterior quadrant perforations. The cases with multiple perforations showed a mean of 49.39 ± 10.26dB, as depicted in table-3. At the site-specific analysis of perforations, the loss of hearing was declined by increasing the given frequency.

Discussion

Assessment of hearing loss caused by a tympanic membrane perforation is crucial for otologists, as it helps guide appropriate surgical planning, and the possible improvement in hearing leads to a better quality of life for the patient.[12]

In our study, the disease burden was found to be more prevalent among the male gender (52.45%), with a mean age of 34.70 ± 11.80 years. The majority of them were from a rural background (60.65%).

Our findings substantiate those of Upadhyay. et al., revealing a significant male predominance (62.5%) in eardrum perforations, primarily affecting individuals in their 20s and 30s. This aligns with the perception that males, often more inclined towards adventurous hobbies and outdoor activities, are at higher risk.[13] The rural background and underprivileged living conditions are established risk factors for the development of chronic middle ear diseases.[14] Furthermore, the presentation of eardrum perforations in young adulthood may be influenced by societal pressures related to marriage and employment, potentially necessitating reconstructive surgery for these individuals.[15]

The majority of our patients had unilateral involvement; particularly, the left ear was affected in 49.18% of the cases. Similarly, Erlangga. et al., evidenced a higher participation of the left ears (56.7%).[16]

In our results, the type of hearing loss seen was Conductive hearing loss (68.3%), followed by Mixed hearing loss (23.3%) and Sensorineural hearing loss (8.3%). In comparison, Rajput et al. reported that 67.1% had CHL, 11.8% showed MHL, and 16.1% had SNHL.[17] According to the World Health Organization's records, CHL accounts for 10% of total ENT diseases [18]

To minimize potential confounding effects, we excluded patients with active middle ear diseases, as conditions such as mucosal swelling, otitis media, or cholesteatoma can lead to fluctuating or progressive hearing loss. These conditions can distort the assessment of hearing loss, ensuring that our findings specifically reflect the impact of tympanic membrane perforations.[19]

Our study observed a greater proportion of single-quadrant perforations in the AI quadrant (26.7%), followed by the PI quadrant (20%). Among the cases with perforations involving multiple quadrants, the majority (25%) had perforations in the AI, AS, and PI quadrants simultaneously.

Posterior quadrant perforations (20%) demonstrated a greater burden of hearing loss, with a mean loss of 26.50 ± 5.61 dB, compared to anterior quadrant perforations (26.7%), which had a mean loss of 23.47 ± 6.96 dB.

Our results align with those of Kolluru. et al., as we observed a higher mean hearing loss in posterior quadrant perforations (26.50 ± 5.61 dB) compared to

anterior quadrant perforations (23.47 ± 6.96 dB).[20] In contrast, Hussain et al. observed greater hearing loss in anterior quadrant perforations compared to posterior quadrant perforations, with a difference of 5.5 dB The posterior quadrant, near the ossicular chain, is vital for sound transmission, hence proving that perforations here cause greater disruption in auditory conduction.[21,22]

Among multiple-quadrant perforations, the mean hearing loss was 41.15 ± 8.65 dB. Comparing our results with those of Rana et al., they evidenced a hearing loss of 51.56 ± 5.1 dB with multiple quadrant perforations.[23] The greater hearing loss observed in multiple quadrant perforations points to the substantial pressure difference between the external and middle ear, disrupting sound transmission and resulting in more significant hearing impairment.[24]

By targeting the root causes, ensuring prompt and effective treatment, and educating the public on preventive measures, we can effectively lower the burden of deafness caused by CSOM.

A limitation of this study was the inability to fully control for factors that may have influenced the audiometric assessment, as it involved real patients. Additionally, being a cross-sectional analysis with a relatively small sample size, the study relied entirely on patient-reported history regarding ear discharge. Future research with a larger sample size and more comprehensive data collection is needed to enhance evidence-based healthcare planning.

Conclusion

The study found that greater hearing loss is associated with perforations in the posterior quadrant or those involving multiple quadrants simultaneously. Effectively addressing and managing underlying risk factors, such as chronic suppurative otitis media (CSOM), can significantly reduce the hearing impairment caused by these perforations.

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Author Contributions

MA: Conception and design of the work, manuscript writing for methodology design and investigation, data acquisition, curation, and statistical analysis, Validation of data, interpretation, and write-up of results, revising, editing, and supervising for intellectual content, writing the original draft, proofreading, and approval for final submission

SA: Validation of data, interpretation, and write-up of results

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HZ: Data acquisition, curation, and statistical analysis

TA: Manuscript writing for methodology design and investigation

KZM: Writing the original draft, proofreading, and approval for final submission