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EVALUATING HEARING LOSS BASED ON TYMPANIC MEMBRANE PERFORATION SIZE AND LOCATION IN CHRONIC SUPPURATIVE OTITIS MEDIA: A CROSS-SECTIONAL STUDY

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ABSTRACT

Introduction: Hearing impairment is a significant global health problem with a profound impact on quality of life. Chronic suppurative otitis media (CSOM) is a common cause, leading to tympanic membrane perforation. This study aimed to evaluate the relationship between hearing loss and tympanic membrane perforation size and location in CSOM mucosal type disease. **Methodology:** A cross-sectional study was conducted in ENT OPD, Dr. B.R.A.M. Hospital from July 2022 to June 2024 on participants aged 15-60 years with dry ear CSOM-mucosal type disease. Data collection involved photographing tympanic membrane perforations using an oto-endoscope and conducting pure tone audiometry to assess the hearing loss. Perforation size was classified into three groups (small, medium, and large), and location was documented in four quadrants. Hearing loss was categorized using Clark's classification. **Results:** The study included 90 patients (109 tympanic membranes). The majority were females (68%) aged 15-25 years (36.6%). Unilateral perforation was more common (79%). Most perforations were medium-sized (41.3%) and located anterior to the malleus handle (42.2%). Mean Hearing loss was 35.3 ± 6.68 for small perforations, 39.7 ± 7.12 for medium perforations, and 45.9 ± 5.65 for large perforations. Hearing loss and severity increased with perforation size. Perforations located in posterior quadrant were associated with greater hearing loss. Hearing loss was frequency dependent with different sizes of perforation showing "inverted V" pattern in audiogram with 2000Hz being least affected frequency. No clear pattern of frequency dependent hearing loss was observed in terms of location of perforation. **Conclusion:** This study confirms the relation between degree of hearing loss and tympanic membrane perforation size and location in CSOM. Larger and posterior perforations are associated with higher degree and severity of hearing loss. Lower frequencies were primarily affected by hearing loss, which was frequency dependant.

KEYWORDS

chronic suppurative otitis media, hearing loss, conductive hearing loss, audiometry, tympanic membrane perforation

INTRODUCTION:

Hearing impairment is a major health problem all over the world. This disability affects the quality of life and has a considerable deteriorating effect on the family, social, and economic aspects of life. Hearing loss in at least one ear today affects over 1.5 billion people globally. According to a 2024 World Health Organization report, over 5% i.e., 430 million of the global population require rehabilitation to address their severe hearing loss including 34 million children. It is anticipated that by 2050 over 700 million individuals which is 1 in every 10 people will have disabling hearing loss.[1]

It was discovered that 60.27% of cases of conductive deafness were caused by chronic suppurative otitis media (CSOM).[2] It is the most prevalent illness seen in ENT clinics. At least 0.5% of people have CSOM, which is characterised by tympanic membrane perforation.[3] Fundamentally connected to the transmission and amplification of sound entering the inner ear, the tympanic membrane is a thin membrane that divides the middle ear from the external ear. Other most common causes for tympanic membrane perforation are infections (serous otitis media, TB, acute otitis media) and trauma (barotrauma, temporal bone fracture).[4]

Various authors have documented the association between tympanic membrane perforation and degree of hearing loss. A greater awareness of the effect of perforation on the middle ear would assist clinicians estimate the severity and occurrence of hearing loss. The purpose of this study is to compare the size of the perforation and its location on the tympanic membrane with the degree of hearing loss as determined by Pure Tone Audiometry. Assessing hearing loss at various frequencies brought on by variations in the size and location of tympanic membrane perforations is the secondary goal.

Methodology:

Study Setting And Design: This cross-sectional analytical study was conducted at the Department of Otorhinolaryngology, Dr. B.R.A.M. Hospital, Raipur, India for 24 months from July 2022 – June 2024.

Study Participants: All the patients between 15-60 years of age with Chronic Suppurative Otitis Media mucosal type disease having dry ear visiting OPD.

Sample Size Calculation: The sample size was calculated based on [5] with a 95% confidence limit and 5% relative precision using the following formula.

$$n = \frac{z^2.p.(1-p)}{e^2}$$

The sample size came to be 88.

Inclusion Criteria: Inclusion criteria include individuals between the ages of 15-60 years diagnosed with Chronic Suppurative Otitis Media (CSOM) of mucosal type disease (inactive or quiescent stage), experiencing a hearing complaint (decrease in hearing), with no active ear discharge (dry ear), having either unilateral or bilateral CSOM, willing to participate and give their informed consent.

Exclusion Criteria: Exclusion criteria include patients with Attico Antral-type chronic suppurative otitis media, mucosal-type chronic otitis media with active discharge (wet ear), patients with mixed or sensory neural hearing loss, and those who have had ear surgery.

Data Collection Procedure: Following a thorough history and ENT examination, an oto-endoscope was used to take photographs of the tympanic membrane perforation in order to record its location and size. To determine the extent and kind of hearing loss, the patient received pure tone audiometry (PTA) on the same visit using the Interacoustics Diagnostic Audiometer AC-40. In the PTA, for air conduction, frequencies from 250 Hz to 8000 Hz and bone conduction frequencies from 250 Hz to 4000 Hz were tested.

The Size Of The Perforation Was Classified Into Three Groups: Group 1 - small perforation with one quadrant involved; Group 2 - moderate size perforation with two quadrants involved; Group 3 - large perforation involving three or all quadrants. By anatomically separating the pars tensa into four quadrants, the perforation's location was recorded as antero-superior (AS), antero-inferior (AI), postero-superior (PS), and postero-inferior (PI). According to Clark's classification, the subjects' hearing loss was divided into the following categories based on the audiogram results from the pure tone audiometry: normal hearing (-10 to 15 dB), minimal hearing loss (16 to 25 dB), mild hearing loss (26 to 40 dB), moderate hearing loss (41 to 55

dB), moderately severe hearing loss (56 to 70 dB), severe hearing loss (71 to 90 dB), and profound hearing loss (more than 90 dB).

Data Analysis: Microsoft Excel was used to enter the data, while SPSS version 26 was used for analysis. Percentages and frequencies were computed. The means and standard deviations of the data were displayed.

RESULTS:

The study involved 90 patients, with the majority aged between 15-25 years (36.60%). Females constituted 68% of the patients, while males made up 32%. Most patients had unilateral conditions (79%), with the right ear affected in 38.90% of cases, the left ear in 40%, and both ears in 21.10%. Regarding perforation size, 30.30% were small, 41.30% medium, and 28.40% large. The perforation locations varied, with the most common being AS+AI (24.80%), followed by AI (17.40%) and AS+AI+PI (17.40%). (See Table 1.)

Table 1. Clinical Characteristics Of The Study Participants

Variable	Number of Patients	Percentage
Age (30.16 ± 11.22 years)		
15-25 years	33	36.60%
26-35 years	29	32.20%
36-45 years	17	18.90%
>46 years	11	12.30%
Total	90	100%
Sex		
Female	61	68%
Male	29	32%
Total	90	100%
Laterality		
Unilateral	71	79%
Bilateral	19	21%
Total	90	100%
Affected Side		
Right ear	35	38.90%
Left ear	36	40%
Both ears	19	21.10%
Total	90	100%
Size of Perforation		
Small (1 quadrant)	33	30.30%
Medium (2 quadrants)	45	41.30%
Large (3 or 4 quadrants)	31	28.40%
Total	109	100%
Location of Perforation		
AS	5	4.60%
AI	19	17.40%
PS	2	1.80%
PI	7	6.40%
AS-AI	27	24.80%
PS-PI	2	1.80%
AI-PI	16	14.70%
AS-AI-PI	19	17.40%
PS-PI-AI	3	2.80%
AS-AI-PI-PS	9	8.30%
Total	109	100%

Table 2 shows a significant association between the size of perforation and both the severity and location of hearing loss. Mild hearing loss is most common with small and medium perforations, while moderate hearing loss is more frequent with medium and large perforations. Regarding location, AI (anterior inferior) perforations are predominantly small, while AS+AI+PI (anterior superior + anterior inferior + posterior inferior) perforations are mostly medium.

Table 2. Association between Size of Perforation and Severity/ Location of Hearing Loss

Variable	Size of Perforation			Chi-Square	P-Value
	Small	Medium	Large		
Severity					
Mild	23	27	8	22.301	0.008*
Moderate	8	17	23		
Moderately Severe	0	1	0		
Normal	2	0	0		
Location of Perforation					
AI	14	3	0	42.937	0.027*
AI-PI	10	5	1		
AI-PI-PS	0	3	0		
AS	5	0	0		
AS-AI	17	10	0		
AS-AI-PI	5	14	0		
AS-AI-PI-PS	3	6	0		
PI	4	3	0		
PS	0	2	0		
PS-PI	0	2	0		

Table 3 indicates that mean hearing loss varies with the size and location of perforation across different frequencies. Small perforations result in an overall mean hearing loss of 35.3 dB, with specific losses ranging from 33.0 dB at 2000 Hz to 38.8 dB at 4000 Hz. Medium perforations show a higher overall mean hearing loss of 39.7 dB, with losses between 37.4 dB at 2000 Hz and 41.9 dB at 4000 Hz. Large perforations have the highest overall mean hearing loss at 45.9 dB, with specific losses from 43.5 dB at 2000 Hz to 46.3 dB at 4000 Hz. For location, AS+AI+PI+PS perforation has overall mean losses of 50.6 db, whereas PS quadrant and PS+PI quadrant perforations have an overall mean hearing loss of 46.1 dB and 44.3dB respectively.

Table 3. Mean Hearing Loss At Different Frequencies

Variable	250Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	Overall
Size of Perforation						
Small (1 quadrant)	36.7 ± 10.58	35.5 ± 8.14	33.9 ± 7.78	33.0 ± 7.70	38.8 ± 9.36	35.3 ± 6.68
Medium (2 quadrant)	40.1 ± 10.08	38.9 ± 7.45	38.1 ± 8.74	37.4 ± 9.31	41.9 ± 10.89	39.7 ± 7.12
Large (3 or 4 quadrants)	46.3 ± 10.72	47.3 ± 8.74	46.6 ± 7.00	43.5 ± 8.08	46.3 ± 7.41	45.9 ± 5.65
Location of Perforation						
AI	35.0 ± 10.67	33.4 ± 8.00	31.3 ± 6.84	31.1 ± 7.56	38.7 ± 11.28	33.7 ± 6.93
AI-PI	41.3 ± 10.25	39.4 ± 7.27	36.9 ± 7.93	38.1 ± 10.47	40.3 ± 13.47	38.9 ± 7.54
AI-PI-PS	53.3 ± 11.55	53.3 ± 2.89	53.3 ± 2.89	46.7 ± 7.64	46.7 ± 11.55	42.0 ± 4.51
AS	37.0 ± 8.37	36.0 ± 5.48	30.0 ± 3.54	32.0 ± 5.70	37.0 ± 5.70	33.5 ± 2.56
AS-AI	39.6 ± 10.46	38.5 ± 7.82	38.3 ± 9.30	40.0 ± 8.99	41.7 ± 7.97	39.6 ± 7.01
AS-AI-PI	45.3 ± 9.35	46.1 ± 9.06	46.1 ± 7.37	44.5 ± 8.96	45.3 ± 7.16	40.5 ± 5.88
AS-AI-PI-PS	46.1 ± 13.41	47.8 ± 9.05	45.6 ± 6.35	40.6 ± 5.83	48.3 ± 7.07	50.6 ± 5.83
PI	37.9 ± 12.54	37.1 ± 8.59	40.7 ± 6.73	37.9 ± 8.59	39.3 ± 7.32	38.6 ± 6.75
PS	47.5 ± 3.54	47.5 ± 3.54	45.0 ± 0.00	37.5 ± 3.54	42.5 ± 3.54	46.1 ± 0.88
PS-PI	37.5 ± 3.54	40.0 ± 7.07	45.0 ± 7.07	42.5 ± 3.54	57.5 ± 17.68	44.3 ± 1.77

DISCUSSION:

The purpose of the study was to evaluate the degree of hearing loss in relation to the size and location of tympanic membrane perforation in CSOM mucosal type disease. It included 90 patients (109 tympanic membranes). These results advance our knowledge of how tympanic membrane perforation affects hearing and clinical treatment.

Sociodemographic Distribution: In our study, the mean age of subjects was 30.16 years with a standard deviation of 11.22, with most participants aged 15-25 years and predominantly female. This aligns with findings from studies, which also noted a higher incidence of CSOM in younger females.[5–7] Among the 90 patients, unilateral tympanic membrane (TM) perforation was more common (79%) compared to bilateral perforation (21%), consistent with many studies.[8–11] Medium-sized perforations were the most frequent (41.3%) among the 109 TMs studied, consistent with many studies.[3,10,12] Most perforations were located anterior to the handle of the malleus (42.2%), like the following studies.[13–15]

Mean Hearing Loss With The Size Of TM Perforation: According to our research, the average hearing loss (measured in decibels) for small perforation was 35.3 ± 6.68, for medium perforations it was 39.7

± 7.12, and for large perforations it was 45.9 ± 5.65. This suggests that larger the perforation, the greater the hearing loss. Additionally, Pannu et al. found that large perforation sizes were associated with a statistically significant increase in average hearing loss.[16] Similarly, Nahata et al. discovered that the larger the perforation, the worse the hearing loss.[7] According to Sood et al., the size of the tympanic membrane perforation is the most significant driver of hearing loss, and there is a clear linear correlation between the two variables.[17] Hearing loss due to TM perforation occurs because the sound pressure differential across the tympanic membrane is eliminated, resulting in a reduction in ossicular coupling and a decrease in sound amplification. In contrast, Mallik et al. could not find any relationship between the size of the perforation and the degree of hearing loss.

Mean Hearing Loss with the location of TM perforation: In our study, the mean hearing loss is highest for perforations involving all four quadrants. The greatest hearing loss is found in small perforations in the PS quadrant and medium perforations posterior to the malleus handle. In comparison to perforations involving the anteroinferior or anterosuperior quadrants, a 2009 study found that hearing loss was greatest in those involving the posterosuperior and posteroinferior quadrants.[13] In comparison to anteroinferior perforations (29.30 dB), Singh et al. observed that identical size perforations in the posteroinferior quadrant had a higher average hearing loss (40.07 dB).[11] Concerning the various locations of TM perforation, Rana et al. found a similar pattern of mean hearing loss. They concluded that the posterosuperior quadrants exhibit the greatest hearing loss, while the anterosuperior quadrants exhibit the least, and that the maximum hearing loss occurs when all four quadrants are affected.[3] The round window is exposed to incident sound waves in the TM peroration, which is situated posterior to the handle of the malleus. Sound waves impinge directly on both the oval and round windows at the same time, dampening the unilateral flow of sound waves to the oval window. Compared to anteriorly positioned perforations, this results in a greater degree of hearing loss due to the absence of the round window baffle and the ensuing phase difference. Conversely, Mehta et al. concluded that the position of the perforation had no bearing on the difference in sound pressure between oval and circular windows.[18]

Association Between Severity Of Hearing Loss With Size And Location Of Perforation:

In this study, we observed that most small and medium-sized perforations resulted in mild conductive hearing loss (HL), whereas large-sized perforations led to moderate conductive HL. Larger perforations were associated with more severe hearing loss. According to Alsarhan et al., the larger the perforation, the more severe the hearing loss.[19] Gupta came to the conclusion that 79.8% of severe hearing loss and 85% of profound hearing loss were caused by large TM perforations. The larger the perforation, the more severe the hearing loss.[9] Most perforations in the AI (anterior inferior) quadrant were associated with mild conductive hearing loss (HL), while those located in the PI (posterior inferior) quadrant exhibited moderate conductive HL. Notably, perforations situated posterior to the malleus handle were linked to more severe hearing loss, and this association was statistically significant. Khurshid et al. found a statistically significant correlation between the location of the perforation and the degree of hearing loss, with the posterosuperior quadrant perforation producing the greatest degree of impairment ($p = 0.042$). Similar findings were reported in the study of Nepal et al., which concluded that perforations involving the posteroinferior quadrant had the greatest hearing loss.[20]

Mean Hearing Loss At Different Frequencies As Compared To The Size And Location Of Perforation:

The present study shows that mean hearing loss with different sizes of perforation is maximum at 250Hz which gradually decreases to reach minimum value at 2000Hz. Lower frequencies are more affected than higher frequencies. Our observation was like Lerut et al that the hearing loss at frequencies below 2000 Hz was greater than that at frequencies above 2000 Hz, the frequency pattern resembled a "inverted V shape" on the audiogram, with a turning point at about 2000 Hz.[21] Gaur et al observed a modest reduction in hearing loss up to 1500 Hz, after which it became more or less consistent up to 4000 Hz. At higher frequencies, there was some gain.[22] Dawood et al. concluded that hearing loss was larger at lower frequencies and decreased as the frequency increased since the largest hearing loss at 500 Hz was 38.8 dB for air conduction hearing loss and 27.2 dB for ABG level.[23] According to Thorat et al., the highest hearing loss in all perforations was 30 dB at 125 Hz, and it progressively dropped to at least 8 dB at 8000 Hz. They discovered a significant correlation between the extent of hearing loss and the size of the perforation.[24]

The mean hearing loss in decibels with standard deviation at various TM perforation locations with respect to frequencies of 250, 500, 1000, 2000, and 4000 Hz was not uniform in our study. Since there was no pattern of hearing loss, it was not possible to establish a statistically significant relationship between the location of the TM perforation and the amount of hearing loss at each frequency. A study found no statistically significant relationship between frequency-specific hearing loss and the area of perforation in each subgroup of TM perforation locations.[5] Jafarov et al. concluded that no statistically significant air-bone gap differences between TM perforations located at different quadrants were determined.[25] The maximum hearing threshold, on the other hand, was recorded at 250 Hz for anterior perforations and 500 Hz for central and posterior perforations, where 8000 Hz was shown to have the least effect.[7] Dawood's study of the relationship between the mean hearing loss at different speech frequencies and the location of TM perforations revealed that hearing loss was worse at lower frequencies, such as 500 Hz, than at higher frequencies, such as 1000–2000 Hz, regardless of the sizes and locations of TM perforations.[23]

The study did a comprehensive assessment of perforation parameters and contributed to understanding the impact of tympanic membrane perforation on hearing.

CONCLUSION:

According to this study, hearing loss in CSOM is significantly correlated with the size and location of tympanic membrane perforations. Preventing hearing impairment requires early detection and treatment of CSOM. The long-term consequences of perforation and the advantages of early management require more investigation.

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