Section: ENT

Original Research Article

CORRELATION BETWEEN TYMPANIC MEMBRANE PERFORATION SIZE AND SITE WITH HEARING LOSS IN PATIENTS WITH INACTIVE MUCOSAL CHRONIC OTITIS MEDIA

Nidhi Bhardwaj[1], Shahzad Ahmad[2], Achin Pant[3]

[1]*Assistant Professor, Department of ENT, V.C.S.G Government Institute of Medical Science & Research, Srinagar (Garhwal), Uttarakhand, India.*
[2]*Professor & Head, Department of ENT, GMC, Haldwani, Uttarakhand, India.*
[3]*Associate Professor, Department of ENT, GMC, Haldwani, Uttarakhand, India.*

Received : 23/12/2025
Received in revised form : 05/02/2026
Accepted : 24/02/2026

Corresponding Author:
Dr. Nidhi Bhardwaj,
Assistant Professor, Department of ENT, V.C.S.G Government Institute of Medical Science & Research, Srinagar (Garhwal), Uttarakhand, India.
Email: drnidhibhardwaj251@gmail.com

DOI: 10.70034/ijmedph.2026.1.488

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2026; 16 (1); 2839-2845

ABSTRACT

Background: Chronic otitis media (COM) remains a common cause of preventable conductive hearing loss, particularly in developing countries. Tympanic membrane (TM) perforation disrupts sound transmission, and the extent of hearing loss is influenced by various perforation characteristics. However, the relative contribution of perforation size and site remains debated. This study evaluated the correlation between TM perforation size and site with hearing loss in patients with inactive mucosal COM.

Materials and Methods: This cross-sectional study was conducted at the ENT Department of Dr. Sushila Tiwari Government Hospital and GMC Haldwani over 21 months. A total of 200 ears from 148 patients aged 6–60 years with inactive mucosal COM were examined. TM perforation size and site were documented using oto-microscopy and template-based measurement. Pure tone audiometry was performed following ISO 8253-1 standards. Data were analyzed using SPSS version 17. Descriptive statistics summarized baseline characteristics. Pearson's correlation assessed the relationship between perforation size and hearing thresholds, while Chi-square tests and one-way ANOVA evaluated associations between perforation site, duration of discharge, and severity of hearing loss. A p-value ≤ 0.05 was considered significant.

Results: Of the 200 ears evaluated, unilateral perforations constituted 64.9%, with the left ear slightly more affected (51%). Small perforations (1–25%) were most common (51%). Conductive hearing loss (CHL) was the predominant type, affecting 64.3% of right ears and 55.9% of left ears. Severity analysis showed that mild CHL was the most frequent category (48%), while profound loss was uncommon (4.5%). Perforation size demonstrated a strong positive correlation with pure tone average ($r = 0.690$, $p < 0.001$). Larger and subtotal perforations were associated with significantly greater hearing loss. Posterior perforations showed higher rates of moderate to profound hearing loss compared to anterior perforations ($p = 0.004$). Longer duration of ear discharge was also significantly associated with increased severity of hearing loss ($p = 0.005$).

Conclusion: Hearing loss in inactive mucosal COM is predominantly conductive and significantly influenced by the size and site of TM perforation. Larger and posterior perforations, as well as prolonged ear discharge, are associated with greater auditory impairment. Early diagnosis, targeted management, and timely surgical intervention are essential to prevent progressive hearing deterioration in affected patients.

Keywords: Chronic otitis media, Tympanic membrane perforation, Conductive hearing loss, Pure tone audiometry, Hearing loss severity.

INTRODUCTION

Chronic otitis media (COM) continues to be a major cause of preventable hearing impairment, particularly in developing countries such as India where community prevalence ranges from 7–8%.[1] Middle-ear disease accounts for a significant proportion of the 360 million people worldwide living with disabling hearing loss, with adolescents and young adults disproportionately affected.[2] Inactive mucosal COM, characterized by a persistent central tympanic membrane (TM) perforation, remains a common clinical presentation in otology practice.[3]

TM perforation results from chronic middle-ear infection, trauma, barotrauma, or iatrogenic causes such as syringing or myringotomy with tube insertion.[4] It is a key diagnostic criterion for chronic suppurative otitis media, typically associated with ≥12 weeks of otorrhoea,[11] and middle-ear infections remain the most prevalent cause.[5] The TM is essential for both sound collection and sound-pressure gain, contributing approximately 20–25 dB of amplification through the tympano-ossicular system.[6] Perforation disrupts this mechanism, leading primarily to conductive hearing loss (CHL), which generally does not exceed 15 dB in isolated central perforations but may be greater in large or total perforations or when ossicular disease coexists.[7,8]

The relationship between perforation size and hearing loss is well established. Multiple studies consistently demonstrate a direct and proportional increase in hearing loss with increasing perforation size due to reduction in effective TM vibratory area and increased acoustic shunting.[9] However, the influence of perforation site remains controversial. Some studies suggest that posterior perforations produce greater CHL because of their proximity to the round window niche, resulting in more significant sound energy dissipation.[10] Conversely, other researchers report no significant association between perforation location and severity of hearing loss, attributing hearing impairment predominantly to perforation size alone.[7,11]

Diagnosis is generally made using otoscopy, though small perforations may require oto-microscopy or impedance studies.[12] Advances such as computer-assisted video-otoscopy have further improved accuracy and reduced inter-observer variability.[12,13] Understanding these relationships is essential for accurate prognostication, surgical planning, and optimizing patient outcomes. Therefore, this study aims to determine the type and severity of hearing loss associated with different perforation sizes and locations in patients with inactive mucosal COM.

MATERIALS AND METHODS

Study Design and Setting

This cross-sectional observational study was conducted in the Department of Otorhinolaryngology, Dr. Sushila Tiwari Government Hospital affiliated with Government Medical College (GMC) Haldwani, Uttarakhand. The study was carried out over a period of 21 months, from January 2020 to September 2021, including 18 months of data collection and 3 months of data analysis and interpretation. Ethical approval was obtained from the Institutional Research and Ethics Committee of GMC Haldwani (539/GMC/IEC/2019/Reg No.506/IEC/R-17-12-2019), and written informed consent was taken from all eligible participants in accordance with the Declaration of Helsinki.

Sample Size Determination and Study Population

The sample size was calculated using a documented prevalence of 13.5% TM perforation in the study by Olowookere et al.[14] Using the formula $n = Z^2pq/d^2$ with $Z = 1.96$, $p = 0.135$, $q = 0.875$, and $d = 0.05$, the minimum sample size was computed to be 181.5. After adjusting for 10% attrition, the final sample size was determined as 200 ears. Consecutive patients presenting to the ENT outpatient department and inpatient ward within the study period were screened, and those meeting eligibility criteria were recruited.

Inclusion and Exclusion Criteria

Patients aged 6–60 years with inactive mucosal chronic otitis media and a dry central tympanic membrane perforation for at least 6 weeks were included. Subjects were excluded if they had active or squamosal CSOM, marginal or attic perforations, age below 6 or above 60 years, sensorineural or mixed hearing loss unrelated to perforation, multiple perforations, evidence of ossicular chain disruption, otitis externa, tympanosclerosis, prior ear surgery, traumatic perforation, or refusal to provide consent.

Clinical Evaluation and Data Collection

Screening began with otoscopic examination using a Welch Allyn 3.5V Halogen HPX otoscope after disinfecting aural specula with cetrimide solution. An interviewer-administered questionnaire documented demographic details, presenting symptoms (hearing loss, tinnitus, otalgia, vertigo, otorrhoea), duration of illness, history of ototoxic drug exposure, trauma, previous ear surgery, and noise exposure. Tuning fork tests using 256 Hz, 512 Hz, and 1028 Hz were performed under standard conditions.

Audiological Assessment

Pure tone audiometry (PTA) was performed in a soundproof booth (ambient noise level 20 dBA) using an advanced digital audiometer (ELKON eda Giga 3), calibrated according to ISO 8253-1:1989 standards. Air conduction thresholds were measured at 250, 500, 1000, 2000, 4000, and 8000 Hz, and bone conduction thresholds at 500, 1000, 2000, and 4000 Hz. Testing began with the better ear or the right ear if uncertain. Threshold determination followed the standard Hughson–Westlake procedure. Pure tone average (PTA) was calculated as the mean of air conduction thresholds at 500, 1000, and 2000 Hz. The air–bone gap (ABG) was computed using corresponding bone conduction thresholds. Conductive hearing loss was defined as ABG ≥15 dB; WHO criteria were used to classify degree of hearing loss.

Microscopic Examination and Perforation Measurement

Each eligible ear was examined under a Karl Kaps Asslar D-35614 operating microscope. After anesthetizing the external auditory canal with 4% lignocaine-soaked cotton, meticulous aural cleaning was performed when required. A sterilized 10 mm × 10 mm cigarette paper template was inserted into the canal and positioned over the tympanic membrane. The margin of the perforation was carefully traced using a sickle knife. The template was removed, and the outlined perforation margins were enhanced with a pencil. The perforation dimensions were then measured using a vernier caliper in two axes, and perforation size was expressed as surface area (mm^2) and categorized by percentage of TM involvement. Site was recorded according to quadrants (anterosuperior, anteroinferior, posterosuperior, posteroinferior).

Statistical Analysis

Data were entered and analyzed using SPSS version 17.0 (IBM Corp., Armonk, NY). Descriptive statistics, including means, standard deviations, frequencies, and percentages, were used to summarize demographic characteristics, duration of ear discharge, perforation size and site, and patterns of hearing loss. The relationship between tympanic membrane perforation size and hearing levels was assessed using Pearson's correlation coefficient. Associations between categorical variables—including perforation site (anterior, posterior, multiple quadrants), duration of discharge, and severity of hearing loss (slight, moderate, severe, profound)—were evaluated using the Chi-square test (χ^2). All tests were two-tailed, and a p-value ≤ 0.05 was considered statistically significant.

RESULTS

A total of 200 ears from 148 patients with tympanic membrane perforation in either or both ears were studied. Ages ranged from 10 – 64 years, with a mean age of 34.5 ± 15.7 years. A high proportion of the participants; 98 (66.3%) were within the younger age group of 10 – 39 years. There were 67 (45.3%) males and 81 (54.7%) females; ratio of 1:1.2. Students accounted for up to one-third; 49 (33.1%) of the study population. Majority of the patients belonged to lower middle and lower class constituting 33.8% and 29.7% respectively. There was a total of 96 (64.9%) unilateral and 52 (35.1%) bilateral TM perforations. The left ear recorded the higher number of TM perforation among the study ears; 102 (51.0%). Ear discharge was the commonest symptom in the patients 112 (75.7%) followed by hearing loss (48.5%) and ear itching (44%) respectively. [Table 1]

Table 1: Baseline Demographic and Clinical Characteristics of Patients with Tympanic Membrane Perforation (n = 148 patients; 200 ears)

Variable	Frequency	%
Age (years)		
10 – 19	22	14.9
20 – 29	47	31.8
30 – 39	29	19.6
40 – 49	25	16.9
50 – 59	16	10.8
60 – 69	9	6
Mean age in years	34.5 ± 15.7	
Gender		
Male	67	45.3
Female	81	54.7
Occupation		
Students	49	33.1
Traders	36	24.3
Govt job	21	14.2
Farmer	10	6.8
Artisans*	8	5.4
Unemployed	8	5.4
Teacher	6	4.1
Others**	10	6.7
Socioeconomic status		
Upper	18	12.2
Upper Middle	32	21.6
Upper Lower	4	2.7
Lower Middle	50	33.8
Lower	44	29.7
Laterality of TM Perforation		
Unilateral		
Right	46	31.1
Left	50	33.8
Bilateral	52	35.1
Side of perforated ear (n=200)		
Right	98	49.0

Left	102	51.0
Symptoms of TM Perforation (n=200)		
Ear discharge	112	56.0
Hearing loss	97	48.5
Ear Itching	88	44.0
Ear Pain	52	26.0

*Artisans included electricians, painters, carpenters and welders; **Others included retirees, soldier, security man, journalist, house help and cleaner; TM – Tympanic Membrane.

Maximum number of study subjects had a duration of ear discharge ranging from 1-3years, constituting 35.7% and 36.2% respectively in right and left year. The small perforation; 54 (55.1%) and 48 (47%) was more in the right and left ears respectively, while the anterior and multiple predominated in the site of perforation; 93 (46.5%) and 83 (41.5%) respectively. [Table 2]

Table 2: Distribution of Duration of Ear Discharge, Perforation Size, and Perforation Site in Affected Ears (n = 200)

Variable	Total (n=200)	Right Ear (n=98)	Left Ear (n=102)
	Frequency (%)		
Duration of discharge			
3month – 1 year	23 (11.5)	11 (11.2)	12 (11.8)
1-3 years	72 (36)	35 (35.7)	37 (36.2)
3-6 years	55 (27.5)	27 (27.5)	28 (27.4)
6-9years	20 (10)	10 (10.2)	10 (9.8)
≥9years	30 (15)	15 (15.3)	15 (14.7)
Size (% area)			
Small (1-25)	102 (51.0)	54 (55.1)	48 (47.0)
Medium (26-50)	52 (26.0)	21 (21.4)	31 (30.4)
Large (51-75)	35 (17.5)	17 (17.4)	18 (17.6)
Subtotal (76-100)	11 (5.5)	6 (6.1)	5 (4.9)
Site			
Multiple*	83 (41.5)	43 (43.9)	40 (39.2)
Anterior**	93 (46.5)	42 (42.9)	51 (50.0)
Posterior***	24 (12)	13 (54.16)	11 (45.84)

*Multiple = AI+PI, PI+AS+AI, All 4; **Anterior = Anterosuperior (AS) and Anteroinferior (AI); ***Posterior = Posterosuperior (PS) and Posteroinferior (PI); % Area – Percentage of Tympanic Membrane Involved

Figure 1: Perforation sites. A. Perforation seen in postero-superior quadrant of left ear. B. Perforation seen in antero-inferior and postero-inferior quadrants in left ear. C. Perforation in posterior quadrant of right ear. D. Perforation in inferior quadrant of left ear

The conductive hearing loss had the highest prevalence; 63 (64.3%) and 57 (55.9%) in the right and left ears of the study ears respectively. The slight conductive hearing loss accounted for more of the hearing loss in the study and control ears; 81 (67.5%) and 14 (87.5) respectively. [Table 3]

Table 3: Comparison of Conductive and Mixed Hearing Loss Severity Between Study Ears and Control Ears

Variable	Study Ear (n=179)		Control Ear (n= 28)	
	CHL (n=120)	MHL (n=59)	CHL (n=16)	MHL (n=12)
	Frequency (%)			
Side				
Right	63	26	9	6
Left	57	33	7	6
Severity of Hearing loss				
Slight (26 - 40)	81 (67.5)	5 (8.5)	14 (87.5)	4 (33.3)
Moderate (41- 60)	34 (28.3)	27 (45.7)	1(6.25)	8 (66.7)
Severe (61- 80)	5 (4.2)	19 (32.2)	1(6.25)	0 (0.0)
Profound (≥ 81)	0 (0.0)	8 (13.6)	0 (0.0)	0 (0.0)

CHL – Conductive Hearing Loss; MHL – Mixed Hearing Loss

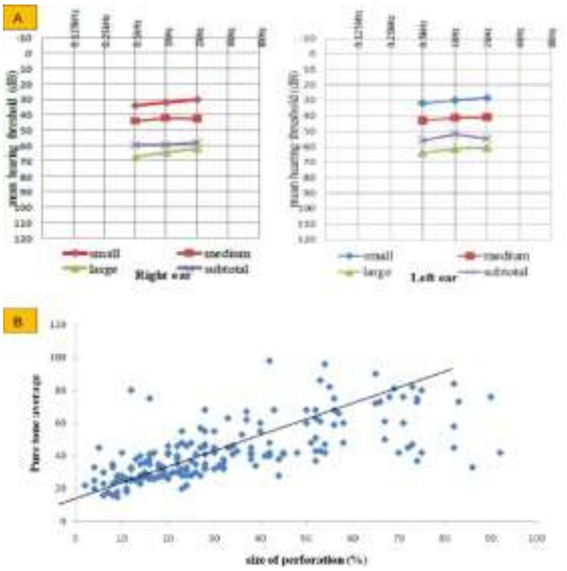

Figure 2: Correlation between Pure Tone Average (dB) and the Size of TM Perforation. A. Summary of Average Pure Tone Audiogram and Size of TM Perforation. B. Scatter plot of Pure Tone Average (dB) Versus the Size of TM Perforation (%).

The average pure tone audiogram increased with an increase in the size of TM perforation. The highest average pure tone audiogram; 67.4dB was recorded in the right ear with large TM perforation at frequency of 500Hz (Figure 2 A). The pure tone average significantly depended on the size of TM perforation. This finding was statistically significant (p = 0.000). There was a positive relationship between the size of perforation and pure tone average with a Pearson's correlation coefficient = 0.690. This finding was statistically significant (p = 0.000). [Figure 2 B]

TM – Tympanic Membrane; dB – Decibels

The posterior and multiple TM perforations recorded more severe forms of hearing loss; 8.35% of profound hearing loss and 16.2% severe hearing loss within the groups respectively. This was statistically significant (p = 0.004). Duration of discharge more than 6-9years, ≥9years recorded more severe form of hearing loss, 28.0% of profound hearing loss and 31.2% severe hearing loss within the groups respectively. This was statistically significant (p = 0.005). The larger the size of TM perforation, the severity of the hearing loss increased. This was statistically significant (p< 0.001). [Table 4]

Table 4: Association of Perforation Site, Duration of Ear Discharge, and Perforation Size with Severity of Hearing Loss

Variable	Severity of Hearing Loss [Frequency (%)]				p value
	Slight (n=86) (26-40dB)	Moderate (n=61) (41-60dB)	Severe (n=24) (61-80dB)	Profound (n=8) (> 81dB)	
Site of TM Perforation					
Multiple (n=74)	30 (40.5)	29 (39.2)	12 (16.2)	3 (4.1)	0.004
Anterior (n=81)	49 (60.5)	24 (29.6)	5 (6.2)	3 (3.7)	
Posterior (n=24)	7 (29.16)	8 (33.3)	7 (29.16)	2 (8.35)	
Duration Of Ear Discharge					
3month–1 year (n=23)	15 (65.2)	4 (17.3)	3 (13.0)	1 (4.3)	0.005
1-3 years (n=66)	33 (50)	31 (47.0)	2 (3.0)	0(0.0)	
3-6 years (n=49)	30 (61.2)	19 (38.77)	0 (0.0)	0 (0.0)	
6-9 years (n=16)	8 (50.0)	3 (18.75)	5 (31.2)	0 (0.0)	
≥9years (n=25)	0 (0.0)	4 (16.0)	14 (56.0)	7 (28.0)	
(% Area)					
Small (1-25) (n=81)	64 (79.0)	15 (18.5)	2 (2.5)	0 (0.0)	<0.0001
Medium (26-50) (n=52)	18 (34.6)	28 (53.8)	5 (9.6)	1 (1.9)	
Large (51-75) (n=35)	3 (8.6)	12 (34.3)	14 (40.0)	6 (17.1)	
Subtotal (>76) (n=11)	1 (9.1)	6 (54.5)	3 (27.3)	1 (9.1)	

TM – Tympanic Membrane; dB – Decibels

DISCUSSION

This study examined the correlation between tympanic membrane (TM) perforation size and site with hearing loss in patients with inactive mucosal chronic otitis media. Most participants were adolescents or young adults, with 66.3% aged 10-39 years, similar to report from Olowookere et al., where 45.5% belonged to the same age group.[14] Females constituted a slight majority, consistent with studies by Anand et al., and Metgudmath et al., suggesting higher healthcare-seeking behavior among women in developing regions.[15,16] The predominance of students and individuals from lower socioeconomic groups aligns with earlier evidence that CSOM is more common in younger and economically disadvantaged populations.[15]

Otorrhoea was the most frequent symptom, followed by hearing loss and itching, consistent with findings by Aneesa et al., Dawood et al., and Sunny et al.[17,18,19] Hearing loss as a presenting complaint has similarly been highlighted in multiple Indian studies.[17,18]

Regarding perforation characteristics, unilateral TM perforation was more common than bilateral perforation, comparable to findings from Rana et al., where unilateral perforation predominated.[20] The left ear was marginally more affected, a trend also noted in other series though not clearly explained; handedness has been suggested as a factor in trauma-related perforations. Small perforations were the most frequent, consistent with reports from Lavanya et al., although some studies reported more large perforations depending on classification criteria and etiology.[21]

Anterior and central quadrant perforations accounted for the majority of cases. This pattern corresponds with the anatomical vulnerability of the pars tensa, which is the most dependent and least supported region of the TM,[22,23] and is commonly involved in tubo-tympanic (safe type) disease.[24] Similar observations have been reported across multiple studies by Sood et al., Menon et al., and Begh et al.[22-24] Posterior or marginal perforations, which are associated with unsafe CSOM and cholesteatoma, were understandably rare due to exclusion criteria.

Conductive hearing loss (CHL) was the predominant audiological abnormality, occurring in 64.3% of right ears and 55.9% of left ears. This is consistent with numerous studies by Anand et al., and Metgudmath et al., demonstrating CHL as the principal deficit due to loss of TM surface area and disruption of the transformer mechanism of the middle ear.[15,16] Comparable results have been reported by Gupta et al., and Khurshid et al,[10,25] Mixed hearing loss also occurred, consistent with findings by Bhiryani et al., suggesting toxin diffusion or chronic inflammatory effects on the cochlea.[26] No isolated sensorineural hearing loss was identified, likely due to exclusion of ototoxic or noise-related hearing loss. However, a few studies by Sood et al., and Menon et al., reported SNHL in CSOM associated with unsafe disease or cholesteatoma.[22,23]

Mild hearing loss was the most common severity category, corroborating findings from earlier TM perforation studies by Sood et al., Menon et al., and Begh et al.[22-24] The greatest deficits occurred at lower frequencies, especially around 500 Hz, aligning with the expected pattern of low-frequency CHL reported previously by Khurshid et al., and Bhiryani et al.[25,26] This reflects the greater dependence of low frequencies on TM and ossicular integrity.

A major finding was the strong positive correlation between perforation size and hearing loss severity (Pearson $r = 0.690$, $p < 0.001$), consistent with multiple earlier studies by Aslıer et al., Khurshid et al., and Bhiryani et al.[7,25,26] Larger and subtotal perforations demonstrated significantly higher air-bone gaps and pure tone averages, supporting the established principle that reduced TM surface area decreases the TM-oval window amplification ratio.[10,25,26]

Perforation site also influenced auditory outcomes. Posterior perforations demonstrated a higher proportion of moderate to profound loss, consistent with the round-window baffle theory, where simultaneous stimulation of both windows diminishes cochlear input.[25] Although Gupta et al. later challenged this concept,[10] several clinical studies by Aslıer et al., and Naseema et al., still support increased loss in posterior perforations.[7,27]

Duration of discharge showed a statistically significant association with hearing loss severity, similar to findings from Aslıer et al., and Naseema et al., found no such relationship.[7,27] This suggests that chronic inflammation exerts cumulative effects on middle-ear mechanics over time.

Limitations

This study has certain limitations that should be acknowledged. Although known confounders such as ototoxic drug exposure, traumatic perforations, and unsafe CSOM were excluded, other subtle factors contributing to hearing loss—such as early ossicular chain erosion, subclinical cochlear involvement, and long-standing inflammatory changes—could not be fully controlled. The inability to eliminate all confounding variables is inherent in clinical studies involving live patients rather than controlled experimental models. Additionally, while meticulous microscopic examination and standardized audiometry were used, variations in patient cooperation, chronicity of disease, and environmental influences may have subtly affected threshold measurements. Finally, this study was conducted at a single tertiary-care centre, which may limit the generalizability of the findings to broader community settings.

CONCLUSION

This study demonstrates that tympanic membrane perforation in inactive mucosal chronic otitis media has a clear and measurable impact on hearing outcomes. Young and middle-aged adults constituted the majority of affected individuals, and unilateral disease was more common than bilateral involvement. Conductive hearing loss emerged as the predominant type of hearing impairment associated with TM perforation, emphasizing the mechanical disruption of middle-ear sound transmission. A strong positive correlation was found between the size of the perforation and the severity of hearing loss, with larger and subtotal perforations producing significantly greater auditory deficits. Perforation site also played a critical role; posterior perforations were associated with more severe hearing loss compared to anterior or central perforations, likely due to their influence on the round-window sound pressure mechanics. Furthermore, the duration of ear discharge showed a significant association with worsening hearing thresholds, underscoring the detrimental effects of prolonged middle-ear inflammation. Overall, these findings highlight the importance of early diagnosis, timely management of chronic otitis media, and surgical intervention when appropriate to prevent progression to moderate or severe hearing loss. The study underscores the clinical value of assessing both size and site of perforation during evaluation and reinforces the need for patient education and prompt treatment to mitigate long-term auditory disability.

REFERENCES

1. Khairkar M, Deshmukh P, Maity H, Deotale V. Chronic Suppurative Otitis Media: A Comprehensive Review of Epidemiology, Pathogenesis, Microbiology, and Complications. Cureus. 2023;15(8):e43729. 10.7759/cureus.43729.
2. Onifade A, Katolo HW, Mookerjee S, Bhutta MF. Epidemiology of Chronic Suppurative Otitis Media: Systematic Review To Estimate Global Prevalence. J Epidemiol Glob Health. 2025;15(1):55. 10.1007/s44197-025-00396-9.
3. Yuan VG, Xia A, Santa Maria PL. Chronic suppurative otitis media: disrupted host-microbial interactions and immune dysregulation. Front Immunol. 2025;16:1547206. 10.3389/fimmu.2025.1547206.
4. Pontillo V, Cavallaro G, Barbara F, Mastrodonato M, Murri A, Quaranta N. Recurrent tympanic perforation after myringoplasty: a narrative literature review and personal experience. Acta Otorhinolaryngol Ital. 2023;43:S41-7. 10.14639/0392-100X-suppl.1-43-2023-05.
5. Schilder AG, Chonmaitree T, Cripps AW, et al. Otitis media. Nat Rev Dis Primers. 2016;2(1):16063. 10.1038/nrdp.2016.63.
6. Bergevin C, Olson ES. External and middle ear sound pressure distribution and acoustic coupling to the tympanic membrane. J Acoust Soc Am. 2014;135:1294-312. 10.1121/1.4864475.
7. Aslıer M, Özay H, Gürkan S, Kırkım G, Güneri EA. The Effect of Tympanic Membrane Perforation Site, Size and Middle Ear Volume on Hearing Loss. Turk Arch Otorhinolaryngol. 2019;57:86-90. 10.5152/tao.2019.4015.
8. Park H, Hong SN, Kim HS, et al. Determinants of conductive hearing loss in tympanic membrane perforation. Clin Exp Otorhinolaryngol. 2015;8(2):92-6. 10.3342/ceo.2015.8.2.92.
9. Kolluru K, Kumar S, Upadhyay P. A Study of Correlation Between Tympanic Membrane Perforation Size With Hearing Loss in Patients With Inactive Mucosal Chronic Otitis Media. Otol Neurotol. 2021;42:e40-4. 10.1097/MAO.0000000000002840.
10. Gupta S, Harshvardhan R, Samdani S. To Study the Association of the Size and Site of Tympanic Membrane Perforation with the Degree of Hearing Loss. Indian J Otolaryngol Head Neck Surg. 2019;71:1047-52. 10.1007/s12070-017-1102-9.
11. Rasheed AM. Does the Location of a Small Tympanic Membrane Perforation Affect the Degree of Hearing Loss in Adult Patients with Inactive Mucosal Chronic Suppurative Otitis Media? Int Tinnitus J. 2024;27:135-40. 10.5935/0946-5448.20230021.
12. Metcalfe C, Muzaffar J, Orr L, Coulson C. A systematic review of remote otological assessment using video-otoscopy over the past 10 years: reliability and applications. Eur Arch Otorhinolaryngol. 2021;278:4733-4741. 10.1007/s00405-020-06596-2.
13. Sousa LR, Fraga GA, Costa ISPD, Almeida ACF, Sassi TSDS, Lourençone LFM. Diagnostic accuracy of the video otoscope in tympanic membrane perforation. Braz J Otorhinolaryngol. 2024;90:101336. 10.1016/j.bjorl.2023.101336.
14. Olowookere SA, Ibekwe TS, Adeosun AA. Pattern of tympanic membrane perforation in ibadan: a retrospective study. Ann Ib Postgrad Med. 2008;6:31-3. 10.4314/aipm.v6i2.64048.
15. Anand R, Verma V, Singh AB, et al. To Assess the Effect of Duration and Size of Perforation of Tympanic Membrane on Hearing in Patients of Chronic Otitis Media Mucosal Type. Ann Afr Med. 2025;24:610-6. 10.4103/aam.aam_74_24.
16. Metgudmath RB, Gulaganji R. The sound of silence: a study on tympanic membrane perforation and its effects on hearing in chronic otitis media. Int J Health Sci Res. 2023;13:370-6. 10.52403/ijhsr.20231048
17. Aneesa M, Siraj S, Ali A. Correlation of tympanic membrane perforations with hearing loss. Int J Otorhinolaryngol Head Neck Surg. 2019;5(5):1213-6. 10.18203/issn.2454-5929.ijohns20193857.
18. Dawood MR. Frequency Dependence Hearing Loss Evaluation in Perforated Tympanic Membrane. Int Arch Otorhinolaryngol. 2017;21:336-42. 10.1055/s-0037-1598597.
19. Sunny E, Mayappa NT, Kumar RD. Otoendoscopic Analysis of Hearing Loss Correlated with Tympanic Membrane Perforation Site and Size. J Med Sci. 2025;11:00379. 10.5005/jp-journals-10045-00379.
20. Rana AK, Upadhyay D, Yadav A, et al. Correlation of tympanic membrane perforation with hearing loss and its parameters in chronic otitis media: An analytical study. Indian J Otolaryngol Head Neck Surg 2020;72:187–93. 10.1007/s12070-019-01740-9
21. Lavanya M, Srinivas V. A study on correlation of size and site of tympanic membrane perforation with degree of conductive hearing loss in chronic otitis media. MedPulse Int J ENT. 2020;16:29–32. 10.26611/10161632.
22. Sood AS, Pal P, Kumar A. Tympanic membrane perforation: correlation of hearing loss with its site and size. Int J Otorhinolaryngol Head Neck Surg. 2018;4:397–402. 10.18203/issn.2454-5929. ijohns20180016
23. Menon AG, Kaushik M, Nevil V, et al. A comparative study of middle ear evaluation by otomicroscopy and otoendoscopy in cases of chronic suppurative otitis media. Arch Clin Exp Surg. 2017;6:149–155. 10.5455/aces.20161017105309
24. Begh RA, Kishore K, Kalsotra G, Saraf A, Kalsotra P. Impact of Site, Size and Duration of Tympanic Membrane Perforation on Hearing Loss and Postsurgical Outcome. Indian J Otolaryngol Head Neck Surg. 2022;74:699-706. 10.1007/s12070-021-02487-y.
25. Khurshid N, Khurshied S, Khizer MA, Hussain A, Safoor I, Jamal A. Relationship of Hearing Loss and Tympanic Membrane Perforation Characteristics in Chronic Suppurative Otitis Media Patients. Cureus. 2022;14:e32496. 10.7759/cureus.32496.
26. Bhiryani MA, Panchal AJ, Kumar R, Kapadia PB, Mandal MM. A Study to Assess the Effect of Size & Site of Tympanic Membrane Perforation on Hearing Loss. Indian J Otolaryngol Head Neck Surg. 2022;74:4460-6. 10.1007/s12070-021-02967-1.
27. Naseema N, Ravindran D, Santhi T. Relationship between size and site of tympanic membrane perforations and pure tone audiometry results. J Med Sci Res. 2022; 10:216-21. 10.17727/JMSR.2022/10-40.