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ASSOCIATION OF HEARING THRESHOLDS WITH FREQUENCY, TYMPANIC MEMBRANE PERFORATION SIZE, AND DISEASE DURATION IN INACTIVE MUCOSAL CHRONIC OTITIS MEDIA

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ABSTRACT

Background: Inactive mucosal chronic otitis media (COM) is a middle-ear condition characterized by a persistent tympanic membrane perforation without active ear discharge. It is an important cause of preventable conductive hearing loss, particularly in developing countries. Hearing impairment may be influenced by several factors, including tympanic membrane perforation size, disease duration, and test frequency. The relationship between these factors requires further clinical evaluation.

Methods: This hospital-based observational study included 100 perforated ears of patients diagnosed with inactive mucosal chronic otitis media. Demographic characteristics, tympanic membrane perforation size, disease duration, and audiological findings were recorded. Hearing thresholds, pure-tone average (PTA), and air-bone gap (ABG) were assessed using pure-tone audiometry at different frequencies. Statistical analysis was performed to evaluate the relationship between hearing thresholds and the clinical parameters.

Results: Females constituted 56% of the participants, while males constituted 44%. Large central tympanic membrane perforation was the most common perforation type (49%), followed by moderate central perforation (30%). Mild conductive hearing loss was observed in 44% of participants, moderate hearing loss in 38%, and moderately severe hearing loss in 18%. Mean hearing thresholds were higher at high frequencies (46.3 ± 11.5 dB HL) than at low frequencies (28.4 ± 8.7 dB HL). Mean PTA increased with disease duration, from 31.6 ± 6.4 dB among patients with disease duration of less than 5 years to 47.5 ± 10.3 dB among those with disease duration of more than 10 years. Hearing loss also increased with increasing tympanic membrane perforation size, with subtotal perforations demonstrating the highest mean PTA (50.8 ± 9.4 dB). The mean ABG increased from 24.2 ± 5.4 dB at 500 Hz to 30.9 ± 7.1 dB at 2000 Hz.

Conclusion: Hearing impairment in patients with inactive mucosal chronic otitis media was associated with tympanic membrane perforation size, disease duration, and test frequency. Larger perforations and longer disease duration were associated with greater hearing impairment, while hearing thresholds and ABG showed higher values at higher frequencies.

KEYWORDS: Inactive mucosal chronic otitis media; hearing threshold; tympanic membrane perforation; pure-tone audiometry; air-bone gap; conductive hearing loss; disease duration

INTRODUCTION

Chronic otitis media (COM) is characterized by a persistent abnormality of the pars tensa or pars flaccida of the tympanic membrane and may result from previous acute otitis media, negative middle-ear pressure, or otitis media with effusion. The World Health Organization has estimated that 65–330 million people worldwide are affected by chronic suppurative otitis media, with approximately 50% experiencing associated hearing impairment.[20]

The major mechanisms contributing to hearing loss in chronic suppurative otitis media include impairment of the tympano-ossicular impedance-matching mechanism, reduction of the baffle effect of the round window, and cochlear dysfunction. Previous studies have also demonstrated a relationship between hearing thresholds and the duration of ear discharge. Inactive mucosal COM, formerly referred to as the inactive mucosal form of chronic suppurative otitis media, is characterized by a persistent tympanic membrane perforation without active ear discharge. It remains an important cause of preventable hearing loss, particularly in developing countries, where recurrent upper respiratory tract infections, socioeconomic factors, limited access to healthcare, and delayed treatment may contribute to disease persistence.[9,21]

Chronic inflammation may produce structural changes in the tympanic membrane and middle ear, resulting in conductive hearing loss of varying severity depending on the extent of impairment of sound transmission. In some

patients, disease progression may involve the cochlea and result in mixed hearing loss, with adverse effects on communication, education, occupational functioning, and overall quality of life.[2,14]

The degree of hearing loss associated with inactive mucosal COM is influenced by several anatomical and pathological factors. Among these, the size and location of the tympanic membrane perforation are particularly important. A larger perforation reduces the effective vibrating area of the tympanic membrane and alters the pressure differential across the membrane, potentially impairing sound transmission through the ossicular chain. Consequently, larger perforations may be associated with elevated hearing thresholds. Frequency may also influence hearing thresholds because the acoustic characteristics of the tympanic membrane and middle-ear system vary across frequencies.[7]

Disease duration is another potentially important factor. Prolonged middle-ear inflammation may be associated with progressive mucosal changes, ossicular alterations, tympanosclerosis, fibrosis, and, in some cases, cochlear involvement.[6,8] However, considerable interindividual variation exists, highlighting the multifactorial nature of hearing impairment in chronic otitis media.

Several studies have investigated the relationship between tympanic membrane perforation characteristics and hearing thresholds, although findings regarding the influence of perforation size, frequency, and disease duration have not been entirely consistent. Some studies have demonstrated a positive relationship between perforation size and hearing threshold, whereas others have reported more modest associations after consideration of middle-ear volume, ossicular-chain status, and individual anatomical differences.[12,19]

Relatively few studies have simultaneously evaluated frequency-specific hearing thresholds, tympanic membrane perforation size, and disease duration in patients with inactive mucosal COM. Understanding these associations may assist in clinical prognostication, surgical decision-making, patient selection for tympanoplasty, and counseling regarding expected hearing outcomes.

The present study aimed to evaluate the association between hearing thresholds and three important clinical variables—frequency of hearing assessment, tympanic membrane perforation size, and disease duration—in patients with inactive mucosal chronic otitis media. The study assessed frequency-specific hearing impairment using pure-tone audiometry and evaluated whether larger tympanic membrane perforations and longer disease duration were associated with greater hearing loss.

MATERIALS AND METHODS

Study Design

This was a prospective cross-sectional observational study conducted among patients with inactive mucosal chronic otitis media.

Study Period

The study was conducted from January 2019 to October 2020.

Study Population

The study population consisted of patients with inactive mucosal chronic otitis media attending the outpatient department of Otorhinolaryngology and Head and Neck Surgery at S. Nijalingappa Medical College and HSK Hospital, Bagalkot, Karnataka, India.

Sample Size

The study included 100 perforated ears from patients with inactive mucosal chronic otitis media.

Sample Size Estimation

The sample size was estimated using OpenEpi software, version 2, at a 95% confidence level. Based on a previous study by Rao VV et al., in which large central tympanic membrane perforation was reported as the most common type, with a prevalence of 50.36%, the estimated sample size was 97 and was rounded to 100.

The formula used for sample-size estimation was:

$$n = [DEFF \times N \times p(1 - p)] / [d^2/Z^2_{1-\alpha/2} \times (N - 1) + p(1 - p)]$$

Inclusion Criteria

Patients aged more than 18 years, of either sex, with unilateral or bilateral inactive mucosal chronic otitis media and no history of ear discharge for at least 6 weeks were included. Patients with minimal to moderately severe hearing loss, up to 60 dB, were eligible for inclusion.

Exclusion Criteria

Patients with squamosal-type chronic otitis media, previous surgery involving the affected ear, tympanic membrane perforation secondary to other causes such as trauma or tuberculosis, complications of chronic otitis media, or hearing loss greater than 60 dB were excluded.

Ethical Considerations
The study was approved by the Institutional Ethics Committee of the medical college. Written informed consent was obtained from all participants before enrollment.

Data Collection
All patients were informed about the nature of the study, and written informed consent was obtained. A detailed clinical history was recorded for each participant, followed by a comprehensive ENT examination.
The tympanic membrane was examined using otoscopy and otomicroscopy to assess the site and size of the perforation and to identify the presence of polypoidal middle-ear mucosa or granulation tissue.
Pure-tone audiometry was performed using an Amplaid Diagnostic Type 4 audiometer according to the modified Hughson–Westlake method. The type and degree of hearing loss were determined in decibels (dB). The average air-conduction threshold was calculated at 500, 1000, and 2000 Hz. The air-bone gap was calculated as the average difference between air- and bone-conduction thresholds at 500, 1000, and 2000 Hz.

Statistical Analysis
Statistical analysis was performed using SPSS software. The results were analyzed using the reported unpaired t-test. A p-value of <0.05 was considered statistically significant.

RESULTS

Table 1. Age Distribution of Patients

Age group (years)	Number	Percentage (%)
18–20	10	10
21–30	30	30
31–40	28	28
41–50	20	20
51-60	12	12

A total of 100 ears from patients diagnosed with inactive mucosal type chronic otitis media were included in the study. The patients ranged in age from 18 to 60 years, with a mean age of 34.8 ± 10.7 years. The majority of patients belonged to the 21–40 years age group (58%).

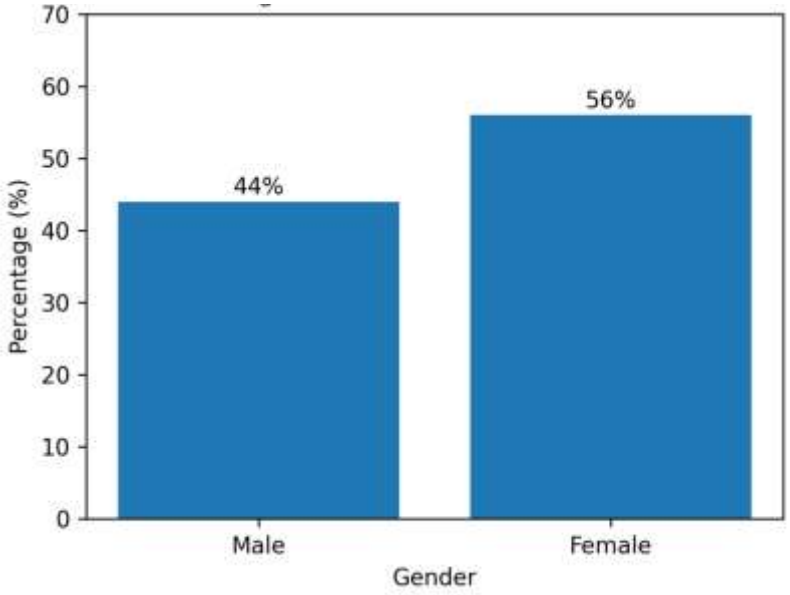

Figure 1 : Gender Distribution

The study included **100 participants**, comprising **56% females** and **44% males**, indicating a slightly higher representation of female patients. This distribution suggests that inactive mucosal chronic otitis media was more frequently observed among females in the present study population.

Site and Size of Tympanic Membrane Perforation

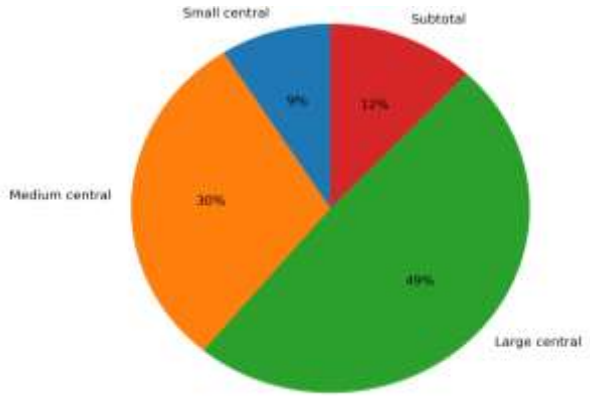

Figure 2: Size and Site of Tympanic Membrane Perforation

Most of the cases were associated with large central tympanic membrane perforations (49%) followed by moderate central tympanic membrane perforations (30%). This showed that there was a high frequency of large tympanic membrane perforations. Small central and subtotal perforations were comparatively less frequent in the sample population..

Degree of Hearing Loss

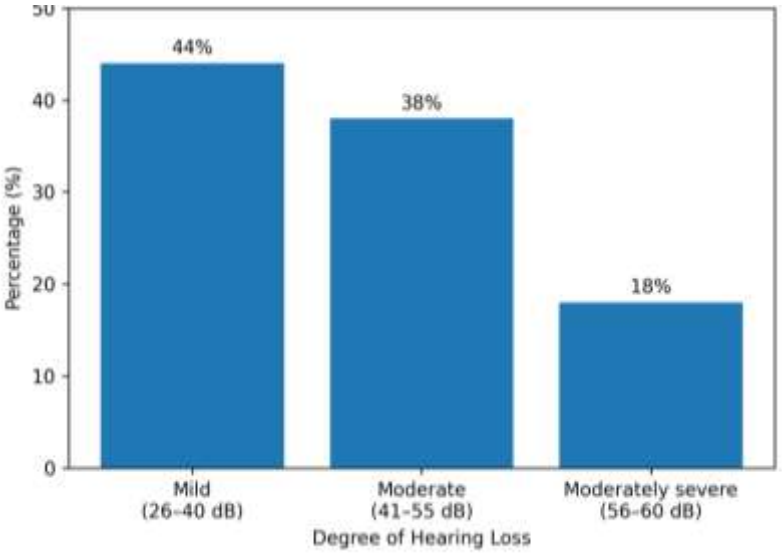

Figure 3: Distribution of Degree of Hearing Loss

Majority of the patients had mild conductive hearing loss (44%), while moderate hearing loss (38%) was seen in a smaller number of patients, showing that relatively minor cases of hearing impairment were more common in the selected sample size. Moderatelypta severe hearing loss (18%) was seen in few patients, as compared to other cases.

Frequency-wise Hearing Thresholds

The mean air-conduction hearing threshold increased progressively with increasing frequency, suggesting greater impairment at higher frequencies.

Table 2. Mean Air-Conduction Thresholds at Different Frequencies

Frequency (Hz)	Mean Threshold (dB HL)	SD
250	24.5	8.3
500	28.2	8.7
1000	32.5	9.1

2000	39.8	10.2
4000	46.7	11.8
8000	52.3	12.6

Frequency Dependence of Hearing Loss

Low-frequency hearing loss (250–1000 Hz) showed significantly better hearing thresholds compared to high-frequency hearing loss (2000–8000 Hz). Unpaired t-test demonstrated a statistically significant difference between low- and high-frequency thresholds (**t = 12.48, p < 0.001**).

Table 3. Comparison of Mean Hearing Thresholds Between Low- and High-Frequency Ranges in Patients with Inactive Mucosal Chronic Otitis Media

Frequency Range	**Mean Hearing Threshold (dB HL)**
Low frequencies (250–1000 Hz)	28.4 ± 8.7
High frequencies (2000–8000 Hz)	46.3 ± 11.5

Relationship Between Duration of Disease and Hearing Loss

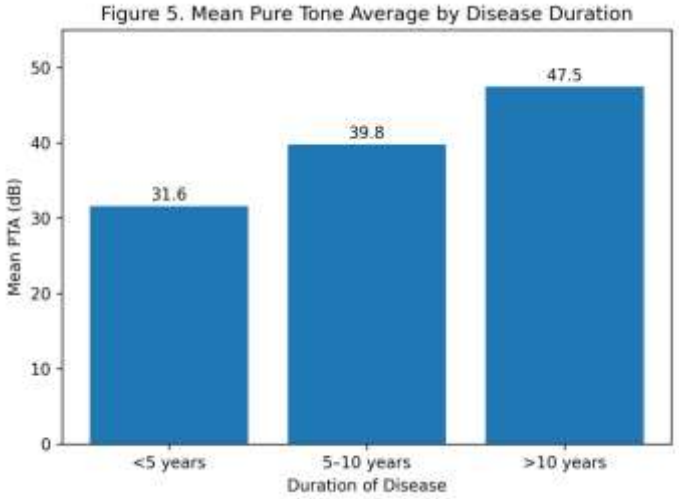

Figure 4: Mean Pure Tone Average by Disease Duration

The increase in hearing loss with disease duration was statistically significant (**p = 0.002**). There was a progressive increase in the mean pure tone average (PTA) with increased duration of the disease, from 31.6 ± 6.4 dB in those with less than 5 years of disease duration to 47.5 ± 10.3 dB in those with more than 10 years of disease duration.

Hearing Threshold According to Size of Tympanic Membrane Perforation

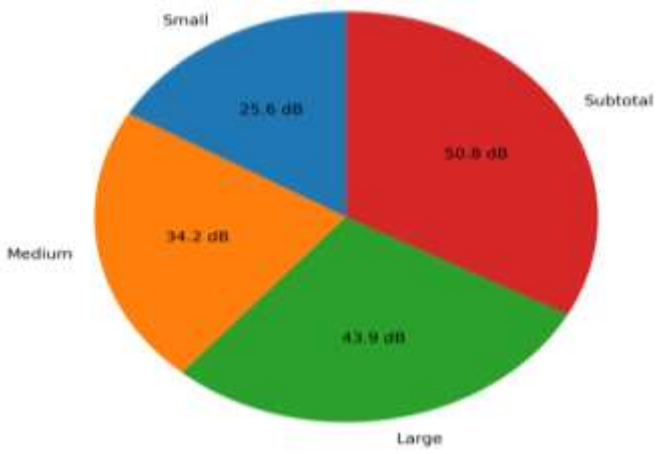

Figure 5: Mean Hearing Threshold by Perforation Size

The difference in hearing thresholds among perforation sizes was statistically significant (**$p < 0.001$**). The mean value of the PTA was found to be directly proportional to the size of the perforation, being 25.6 ± 5.8 dB for small perforations, 34.2 ± 9.2pannu dB for medium perforations, 43.9 ± 8.5 dB for large perforations, and 50.8 ± 9.4 dB for subtotal perforations. These results suggest that there is a positive relationship between the size of the perforation and the extent of hearing loss in inactive mucosal chronic otitis media.

Air-Bone Gap at Different Frequencies

Table 4: Frequency of ABG

Frequency	Mean ABG (dB)
500 Hz	24.2 ± 5.4
1000 Hz	27.6 ± 6.2
2000 Hz	30.9 ± 7.1

The ABG increased progressively with increasing frequency from 24.2 ± 5.4 dB at 500 Hz to 30.9 ± 7.1 dB at 2000 Hz, suggesting an increase in the degree of conductive hearing loss with increased frequency. This finding indicates that the degree of hearing loss worsens with an increase in test frequency in patients with inactive mucosal chronic otitis media.

DISCUSSION

The present study evaluated the association between hearing impairment and tympanic membrane perforation size, disease duration, and test frequency in patients with inactive mucosal chronic otitis media. Most participants had mild conductive hearing loss, while hearing thresholds tended to increase with increasing perforation size and disease duration.

Large central tympanic membrane perforations were the most common perforation type in the present study, accounting for 49% of cases. Patients with larger perforations demonstrated higher PTA values than those with smaller perforations. A larger tympanic membrane perforation reduces the effective vibrating area of the membrane and may impair the efficiency of sound transmission through the middle ear, thereby contributing to conductive hearing loss. These findings are consistent with the observations of Pannu et al. (2011), who reported a positive association between tympanic membrane perforation size and hearing loss.[12] Voss et al. (2001) also demonstrated that tympanic membrane perforations can alter sound pressure transmission within the middle ear and result in elevated hearing thresholds.[19] Lou et al. (2012) similarly reported an association between tympanic membrane perforation and impaired auditory function.[6]

Another important finding of the present study was the association between disease duration and hearing impairment. Patients with disease duration of more than 10 years had a mean PTA of 47.5 ± 10.3 dB compared with 31.6 ± 6.4 dB among those with disease duration of less than 5 years. The difference was statistically significant ($p = 0.002$). Prolonged middle-ear disease may be associated with structural changes including mucosal fibrosis, tympanosclerosis, ossicular-chain alterations, and other pathological changes that can adversely affect hearing. Lasisi et al. (2007) identified chronicity of otitis media as an important factor associated with hearing loss, while Orji and Agu (2008) reported an association between prolonged disease duration and greater conductive hearing loss.[5,11]

The frequency-specific analysis demonstrated progressively higher mean air-conduction thresholds with increasing frequency. Mean thresholds ranged from 24.5 ± 8.3 dB HL at 250 Hz to 52.3 ± 12.6 dB HL at 8000 Hz. The mean threshold was 28.4 ± 8.7 dB HL at low frequencies and 46.3 ± 11.5 dB HL at high frequencies, with a reported statistically significant difference between the two frequency ranges ($t = 12.48$, $p < 0.001$).

The mean ABG also demonstrated an increasing trend with frequency, from 24.2 ± 5.4 dB at 500 Hz to 30.9 ± 7.1 dB at 2000 Hz. The frequency-dependent behavior of hearing thresholds in patients with tympanic membrane perforation may reflect alterations in the acoustic properties and mechanical function of the tympanic membrane and middle-ear system. Merchant et al. (2010) described the pathophysiological mechanisms by which tympanic membrane perforations can affect middle-ear sound transmission.[7] Mehta et al. (2006) also demonstrated that perforation size and middle-ear volume can influence frequency-specific sound transmission.[10]

Overall, the findings of the present study support previous observations that tympanic membrane perforation size, disease duration, and frequency are important factors associated with hearing impairment in inactive mucosal chronic otitis media. The findings may have implications for audiological assessment and counseling of patients being considered for surgical management.

CONCLUSION

In this study of patients with inactive mucosal chronic otitis media, hearing impairment was predominantly conductive and was associated with tympanic membrane perforation size and disease duration. Large central perforations were the most common perforation type, and larger perforations were associated with higher PTA values. Patients with longer disease duration also demonstrated higher hearing thresholds.

Frequency-specific analysis demonstrated higher hearing thresholds at higher frequencies, with mean hearing thresholds of 46.3 ± 11.5 dB HL at high frequencies compared with 28.4 ± 8.7 dB HL at low frequencies. The mean ABG also showed an increasing trend from 500 to 2000 Hz.

These findings emphasize the importance of comprehensive pure-tone audiometric assessment across relevant frequencies in patients with inactive mucosal chronic otitis media. Assessment of tympanic membrane perforation size and disease duration may also assist in clinical evaluation, prognostic counseling, and planning of appropriate management.

Limitations

Single-center study, modest sample size, ear-based analysis

REFERENCES

1. Bhutta MF, Leach AJ, Brennan-Jones CG. Chronic suppurative otitis media. Lancet. 2024;403(10441):2339–2348. doi:10.1016/S0140-6736(24)00259-9.
2. Browning GG, Merchant SN, Kelly G, Swan IRC, Canter R, McKerrow WS. Scott-Brown's Otorhinolaryngology and Head and Neck Surgery. 8th ed. CRC Press; 2018.
3. Gelfand SA. Essentials of Audiology. 4th ed. Thieme Medical Publishers; 2016.
4. Hall JW. Handbook of Auditory Evoked Responses. Pearson; 2020.
5. Lasisi AO, Olaniyan FA, Muibi SA, Azeez IA, Abdulwasiu KG, Lasisi TJ, Imam ZO. Clinical and demographic risk factors associated with chronic suppurative otitis media. Int J Pediatr Otorhinolaryngol. 2007;71(10):1549–1554.
6. Lou Z, Tang Y, Chen Y. The effect of tympanic membrane perforation on hearing level in chronic otitis media. Acta Otolaryngol. 2012;132(9):990–995.
7. Merchant SN, Rosowski JJ, McKenna MJ. Pathophysiology of conductive hearing loss associated with tympanic membrane perforations. Otolaryngol Clin North Am. 2010;43(6):1079–1094.
8. Meyerhoff WL, Kim CS, Paparella MM. Chronic otitis media. In: Paparella MM, Shumrick DA, editors. Otolaryngology. 4th ed. Saunders; 2013.
9. Monasta L, Ronfani L, Marchetti F, Montico M, Vecchi Brumatti L, Bavcar A, et al. Burden of disease caused by otitis media: systematic review and global estimates. PLoS One. 2012;7(4):e36226.
10. Mehta RP, Rosowski JJ, Voss SE. Effects of tympanic membrane perforation on middle-ear sound transmission. Acta Otolaryngol. 2006;126(7):678–685.
11. Orji FT, Agu CC. Determinants of hearing loss in chronic suppurative otitis media. Clin Otolaryngol. 2008;33(6):594–598.
12. Pannu KK, Chadha S, Kumar D, Preeti. Evaluation of hearing loss in tympanic membrane perforation. Indian J Otolaryngol Head Neck Surg. 2011;63(3):208–213.
13. Paparella MM, Shumrick DA. Otolaryngology. 4th ed. Saunders; 2014.
14. Qureishi A, Lee Y, Belfield K, Birchall JP, Daniel M. Update on otitis media—prevention and treatment. Infect Drug Resist. 2014;7:15–24.
15. Rana AK, Upadhyay D, Yadav A, Prasad S. 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(2):187–193.
16. Rosowski JJ, Nakajima HH, Merchant SN. Clinical utility of laser-Doppler vibrometry in middle ear disorders. Ear Hear. 2008;29(1):3–19.
17. Singh R, Srivastava A, Mohan C. Comparative evaluation of hearing in different tympanic membrane perforations. Indian J Otol. 2016;22(4):258–261.
18. Sutton AE, Weimer AD. Tympanic membrane perforation. In: StatPearls. StatPearls Publishing; 2025.
19. Voss SE, Rosowski JJ, Merchant SN, Peake WT. How do tympanic membrane perforations affect hearing. Hear Res. 2001;153(1–2):50–60.
20. World Health Organization. Chronic Suppurative Otitis Media: Burden of Illness and Management Options. Geneva: World Health Organization; 2004.
21. World Health Organization. World Report on Hearing. Geneva: World Health Organization; 2021.
22. Yousaf M, Khan MA, Ahmed Z. Relationship of hearing loss and tympanic membrane perforation characteristics in chronic suppurative otitis media patients. Cureus. 2023;15(1):e33472.
23. Youssef M, El-Anwar MW, Elzayat S. 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. J Laryngol Otol. 2024.