Original Article

Assessment of Hearing in Patients with Tympanosclerosis with Intact Tympanic Membrane

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Abstract

Background: Tympanosclerosis is a chronic sequela of middle ear inflammation characterized by hyalinization and calcification of connective tissue within the tympanic membrane and middle ear structures. Although tympanosclerotic plaques may remain asymptomatic, extensive involvement can impair the mobility of the tympanic membrane and ossicular chain, resulting in conductive hearing loss. The present study was conducted to assess hearing status in patients with tympanosclerosis involving an intact tympanic membrane and to evaluate the relationship between the site of tympanosclerotic plaques and audiological findings. **Material and Methods:** A cross-sectional study was conducted in the Department of ENT, Santosh Medical College & Hospital, Ghaziabad, from May 2024 to September 2025. A total of 90 patients with tympanosclerosis and an intact tympanic membrane were included. All patients underwent detailed otorhinolaryngological examination, otoendoscopy, tuning fork tests, pure tone audiometry (PTA), and impedance audiometry. The anatomical site of tympanosclerotic patches was documented and correlated with audiological findings. **Results:** The mean age of patients was 36.36 ± 9.23 years, with maximum patients belonging to the 41–50 years age group (36.67%). Female predominance was observed (58.89% females and 41.11% males). Unilateral involvement was present in 81.11% of patients, whereas bilateral involvement was observed in 18.89%. Hearing loss was the commonest presenting symptom, reported in 84.44% of patients. On otoendoscopy, posterosuperior involvement was the most frequent site in unilateral cases (24.66%), while circumferential involvement was predominant in bilateral cases (41.18%). Pure tone audiometry revealed mild conductive hearing loss in 56.16% of unilateral cases and 52.94% of bilateral ears. Type As tympanogram was the most common impedance finding, observed in 53.42% of unilateral and 52.94% of bilateral ears. A significant association was observed between the site of tympanosclerotic patch and PTA findings in unilateral ($p=0.004$) and bilateral involvement ($p=0.001$). Significant correlation was also observed between tympanosclerotic site and impedance audiometry findings ($p=0.001$ and $p<0.001$, respectively). **Conclusion:** Tympanosclerosis with an intact tympanic membrane is frequently associated with conductive hearing impairment, although some cases may remain asymptomatic. Posterosuperior and circumferential tympanosclerotic involvement showed greater association with hearing abnormalities. Otoendoscopy combined with pure tone audiometry and impedance audiometry provides valuable assessment of functional impairment and helps in appropriate management planning.

Keywords: Tympanosclerosis; Intact tympanic membrane; Conductive hearing loss; Pure tone audiometry; Impedance audiometry; Otoendoscopy; Tympanometry.

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Introduction

The tympanic membrane (TM) is a vital anatomical and functional component of the auditory system, acting as the primary interface between the external ear and the middle ear. It forms the lateral wall of the middle ear cavity and is positioned at the medial end of the external auditory canal. The TM plays a crucial role in the conversion of sound waves into mechanical vibrations, which are subsequently transmitted through the ossicular chain to the inner ear.[1] Anatomically, the tympanic membrane is divided by the anterior and posterior malleolar folds into two distinct regions: the superior pars flaccida (Shrapnell's membrane) and the larger inferior pars tensa.[2] The pars tensa constitutes the major portion of the tympanic membrane and is bounded by the anterior and posterior malleolar folds. Its peripheral thickening forms the fibrous annulus, which is firmly attached to the tympanic sulcus of the temporal bone.[3] In contrast, the pars flaccida is a smaller, relatively lax portion of the membrane located between the malleolar folds and the notch of Rivinus, superior to the lateral process of the malleus. The structural differences between these two regions contribute to their distinct mechanical properties and susceptibility to

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pathological changes.[4] Histologically, the tympanic membrane consists of three layers: an outer epithelial layer, a middle fibrous layer, and an inner mucosal layer. The epithelial layer is continuous with the skin lining the external auditory canal, while the mucosal layer is continuous with the middle ear mucosa.[5] The middle fibrous layer of the pars tensa contains an organized arrangement of collagen fibres, including radially oriented fibres in the superficial layer and circular, parabolic, and transverse fibres in the deeper layer. This complex arrangement provides the tympanic membrane with its unique vibratory characteristics required for efficient sound transmission. In contrast, the collagen fibres within the pars flaccida are arranged in a more random pattern, resulting in different biomechanical properties.[6] Normal hearing depends on the coordinated function of the tympanic membrane and the ossicular chain.[7] Vibrations generated by sound waves cause movement of the tympanic membrane and the attached malleus, incus, and stapes, transmitting mechanical energy from the external auditory canal to the cochlea. The resulting pressure changes within the perilymph stimulate movement of the basilar membrane, initiating neural transmission of sound signals. The middle ear functions as an impedance-matching mechanism, increasing the efficiency of sound transfer between the air-filled external ear and the fluid-filled inner ear.[8] The sound amplification provided by the middle ear is primarily attributed to two mechanisms: the area ratio between the tympanic membrane and stapes footplate and the ossicular lever action. The effective area ratio between the tympanic membrane and stapedial footplate is approximately 20:1. This anatomical advantage results in an increase in pressure at the oval window, contributing approximately 26 dB of sound amplification. Additionally, the lever action of the ossicular chain further enhances sound transmission.[9] The ratio between the length of the handle of malleus and the long process of incus is approximately 1.3:1, producing an additional gain of about 2 dB. Therefore, the combined transformer action of the middle ear provides an overall theoretical pressure gain of approximately 28 dB.4 Thus, an intact, mobile, and normally positioned tympanic membrane is essential for maintaining normal conductive hearing.[10] Tympanosclerosis is a chronic healing process characterized by abnormal deposition of dense collagenous tissue within the middle ear structures. It develops as a consequence of chronic inflammation, most commonly following recurrent otitis media or previous middle ear infections. During this process, collagen fibres undergo organization and transformation into homogeneous hyaline masses, with subsequent deposition of calcium and phosphate salts within the affected tissues. These pathological changes primarily occur in the submucosal layer of the middle ear cavity, involving the ossicles, bony walls of the middle ear, and the fibrous layer of the tympanic membrane.[11] The clinical impact of tympanosclerosis depends upon the extent and location of the lesions. While small tympanosclerotic plaques may remain asymptomatic and are often detected incidentally during otoscopic examination, extensive involvement of the tympanic membrane or ossicular chain may interfere with sound conduction and result in varying degrees of conductive hearing loss.[12] Tympanosclerotic changes involving an intact tympanic membrane may alter its compliance, vibratory capacity, and acoustic properties despite the absence of perforation or obvious structural defects. Patients with tympanosclerosis may present with symptoms such as ear heaviness, reduced hearing ability, or difficulty in sound perception. However, the degree of hearing impairment does not always correlate with the visible extent of tympanosclerotic changes, making objective assessment of hearing function essential. Pure tone audiometry and other audiological investigations provide valuable information regarding the functional consequences of tympanosclerosis and help determine the effect of pathological changes on sound transmission.[13] Although tympanosclerosis has been widely studied in relation to ossicular fixation and surgical outcomes, limited literature is available regarding the assessment of hearing function in patients with tympanosclerosis where the tympanic membrane remains intact. Understanding the impact of tympanosclerotic changes on auditory function in such patients may assist in early diagnosis, appropriate counselling, and individualized management strategies.[14] Therefore, the present study, titled "Assessment of Hearing in Patients with Tympanosclerosis with Intact Tympanic Membrane," aims to evaluate hearing status and audiological characteristics in patients affected by tympanosclerosis while maintaining an intact tympanic membrane.

Materials and Methods

This cross-sectional study was conducted in the Department of Otorhinolaryngology (ENT), Santosh Medical College & Hospital, Ghaziabad, from May 2024 to September 2025. The study population comprised patients attending the ENT outpatient department (OPD) during the study period. The study was undertaken to assess hearing status among patients with tympanosclerosis involving an intact tympanic membrane and to evaluate the relationship between the site and extent of tympanosclerotic plaques and audiological findings.

Ethical Considerations: The study was initiated after obtaining approval from the Institutional Ethics Committee. All eligible participants were informed about the nature and purpose of the study, and written informed consent was obtained before enrolment. Confidentiality of the participants and their clinical information was maintained throughout the study.

Study Population and Sample Size: Patients attending the ENT OPD who were diagnosed with tympanosclerosis involving an intact tympanic membrane were screened for eligibility. A minimum sample size of 88 patients was calculated and rounded off to 90 patients for the final study.

Inclusion Criteria: Patients were included if they were 15–50 years of age, of either sex, had tympanosclerosis involving an intact tympanic membrane, with or without a history of hearing loss, and provided written informed consent for participation in the study.

Exclusion Criteria: Patients younger than 15 years or older than 50 years were excluded. Patients with tympanic membrane perforation, sensorineural or mixed hearing loss, acute otitis media, or otitis media with effusion were also excluded. Patients who did not provide consent for participation were not included in the study.

Data Collection and Clinical Evaluation: All eligible participants underwent detailed clinical evaluation. Demographic information, presenting complaints, relevant otological history, history of hearing impairment, and other pertinent clinical details were recorded using a predesigned study proforma.

A comprehensive otorhinolaryngological examination was performed in all participants. Particular attention was given to examination of the external auditory canal and tympanic membrane. Otoscopic examination was performed to identify tympanosclerotic plaques and to confirm the integrity of the tympanic membrane.

Bedside assessment of hearing was performed using tuning fork tests with 256 Hz, 512 Hz, and 1024 Hz tuning forks, as appropriate. The findings were documented for subsequent comparison with audiological investigations.

Otoendoscopic Assessment: Patients in whom tympanosclerosis involving an intact tympanic membrane was identified on otoscopic examination underwent otoendoscopic examination for confirmation and detailed assessment. The location and extent of the tympanosclerotic plaque were carefully documented. The site of involvement of the tympanic membrane was recorded according to its anatomical distribution, including the relevant quadrants or combinations of quadrants.

Audiological Assessment: All patients with tympanosclerosis involving an intact tympanic membrane underwent Pure Tone Audiometry (PTA) to objectively assess hearing thresholds. Air-conduction and bone-conduction thresholds were evaluated at standard audiometric frequencies, and the presence and degree of conductive hearing loss were documented. Patients found to have sensorineural or mixed hearing loss were excluded according to the predefined eligibility criteria.Participants also underwent impedance audiometry (tympanometry) to evaluate middle ear function and tympanic membrane compliance. Tympanometric findings were recorded and correlated with the site and extent of tympanosclerotic involvement.The principal audiological findings obtained from pure tone and impedance audiometry were subsequently compared with the anatomical location and extent of tympanosclerotic plaques to determine whether the pattern of tympanic membrane involvement was associated with the presence or severity of hearing impairment.

Outcome Assessment: The primary outcome of the study was the assessment of hearing status in patients with tympanosclerosis and an intact tympanic membrane. The presence and degree of conductive hearing loss on pure tone audiometry were evaluated. Secondary assessments included the distribution of tympanosclerotic plaques according to their site and extent, impedance audiometry findings, and the association of these anatomical characteristics with audiological abnormalities.

Statistical Analysis: Data were entered into a Microsoft Excel spreadsheet and subsequently analysed using Statistical Package for the Social Sciences (SPSS), version 16.0. Continuous variables were summarized as mean ± standard deviation (SD), while categorical variables were expressed as frequencies and percentages. Appropriate tables and graphical representations were used to present the findings.Associations between categorical variables, including the site or extent of tympanosclerotic involvement and hearing-related outcomes, were assessed using the Chi-square test, wherever applicable. A p-value <0.05 was considered statistically significant. All statistical analyses were performed using a two-sided level of significance.

Results

The present cross-sectional study titled "Assessment of Hearing in Patients with Tympanosclerosis with Intact Tympanic Membrane" was conducted among 90 patients attending the ENT outpatient department of Santosh Medical College & Hospital, Ghaziabad, from May 2024 to September 2025. All enrolled patients underwent detailed clinical evaluation, otoscopic examination, otoendoscopy, tuning fork tests, pure tone audiometry (PTA), and impedance audiometry. The findings were analysed statistically to assess hearing status and to evaluate the association between the anatomical site of tympanosclerotic patches and audiological outcomes.The mean age of the study participants was 36.36 ± 9.23 years, with an age range of 15–50 years. The majority of patients belonged to the 41–50 years age group (36.67%), followed by 31–40 years (33.33%) and ≤30 years (30.0%). Female predominance was observed in the study population, with 53 (58.89%) females and 37 (41.11%) males [Table 1, Figure 1].

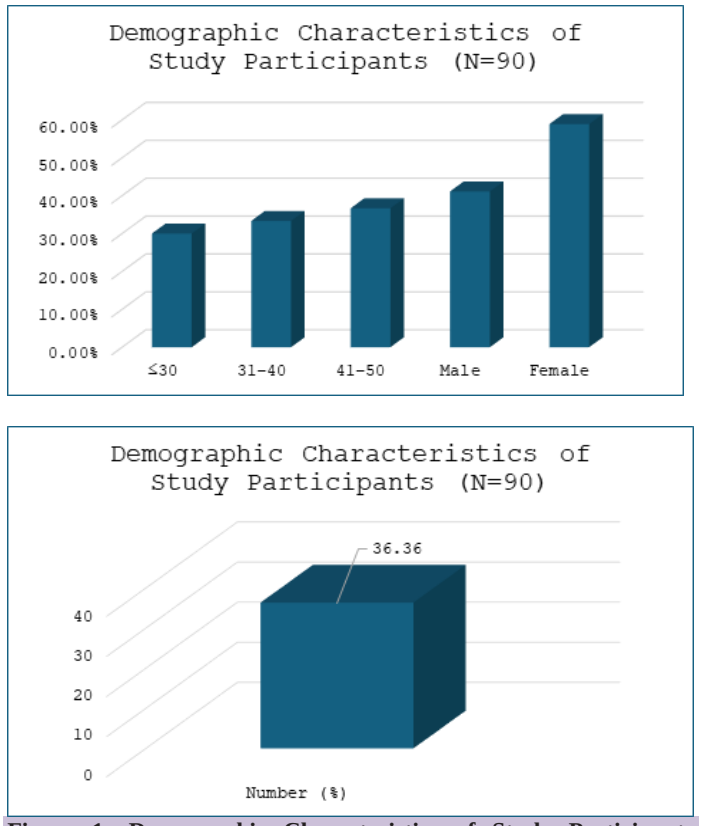

Figure 1: Demographic Characteristics of Study Participants (N=90)

Among the 90 patients, unilateral tympanosclerotic involvement was observed in 73 patients (81.11%), whereas bilateral

involvement was present in 17 patients (18.89%).

Ear-related complaints were the most common presenting symptoms, reported in 82 patients (91.11%). Hearing loss was the predominant ear symptom, present in 76 patients (84.44%), followed by earache and tinnitus (4.44% each) and ear blockage (2.22%). Right ear involvement was observed in 45.56% of patients, left ear involvement in 35.56%, and bilateral involvement in 18.89%.

Nasal complaints were reported in 43.33% of patients, with nasal blockage being the commonest symptom (38.89%). Throat complaints were uncommon and were reported in only 4.44% of patients [Table 2, Figure 2].

Table 1: Demographic Characteristics of Study Participants (N=90)

Parameter	Number (%)
Age group (years)	
≤30	27 (30.0%)
31–40	30 (33.33%)
41–50	33 (36.67%)
Mean age ± SD	36.36 ± 9.23
Gender	
Male	37 (41.11%)
Female	53 (58.89%)

Table 2: Clinical Characteristics and Presenting Symptoms (N=90)

Clinical parameter	Number (%)
Ear complaints	82 (91.11%)
Hearing loss	76 (84.44%)
Earache	4 (4.44%)
Tinnitus	4 (4.44%)
Ear blockage	2 (2.22%)
Nasal complaints	39 (43.33%)
Nasal blockage	35 (38.89%)
Excessive sneezing	16 (17.78%)
Nasal discharge	2 (2.22%)
Throat complaints	4 (4.44%)

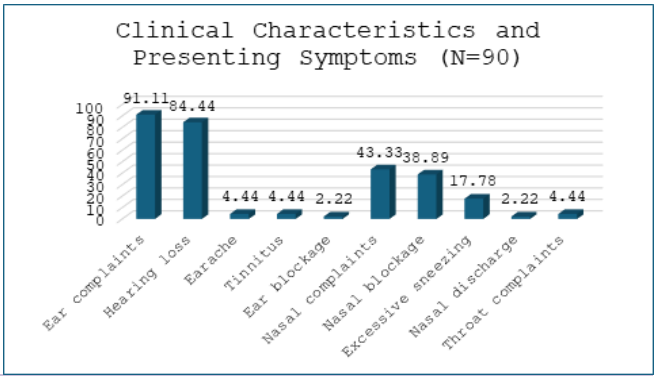

Figure 2: Clinical Characteristics and Presenting Symptoms (N=90)

A history of recurrent upper respiratory tract infection/allergy was present in 21 patients (23.33%), while previous ear surgery was reported in 5 patients (5.56%). The majority of patients (76.67%) did not have any significant previous history.

On otoendoscopic evaluation, among patients with unilateral involvement (73 ears), the most frequent site of tympanosclerotic plaque was the posterosuperior quadrant (24.66%), followed by circumferential involvement of pars tensa (21.92%). In patients with bilateral involvement (34 ears), circumferential involvement was the most common finding (41.18%), followed by combined posterosuperior and posteroinferior involvement (17.65%) [Table 3, Figure 3].

Table 3: Distribution of Tympanosclerotic Patch According to Site of Involvement

Site of TS patch	Unilateral (n=73)	Bilateral ears (n=34)
Posterosuperior	18 (24.66%)	2 (5.88%)
Circumferential	16 (21.92%)	14 (41.18%)
Posteroinferior	2 (2.74%)	0
PS + PI	8 (10.96%)	6 (17.65%)
AI + PI	8 (10.96%)	4 (11.76%)
Other sites	21 (28.76%)	8 (23.53%)

On Rinne's test, among unilateral cases, using a 256 Hz tuning fork, 65 patients (89.04%) had a negative Rinne test, whereas only 8 patients (10.96%) had a positive result. With a 512 Hz tuning fork, 49 patients (67.12%) showed a positive Rinne test. All patients showed a positive Rinne test with a 1024 Hz tuning fork.Among bilateral cases assessed as 34 ears, similar findings were observed, with 28 ears (82.35%) showing negative Rinne test at 256 Hz and all ears showing positive results at 1024 Hz.Weber test showed lateralisation towards the right ear in 45.21% of unilateral cases and towards the left ear in 36.99%. In bilateral cases, left-sided lateralisation was observed in 52.94% of ears.Pure tone audiometry demonstrated conductive hearing impairment in the majority of affected ears. Among unilateral cases, mild

conductive hearing loss was present in 41 patients (56.16%), followed by moderate conductive hearing loss in 24 patients (32.88%). Normal hearing was observed in 8 patients (10.96%).Among bilateral cases (34 ears), mild conductive hearing loss was observed in 18 ears (52.94%), moderate conductive hearing loss in 10 ears (29.41%), and normal hearing in 6 ears (17.65%).Impedance audiometry revealed that Type As tympanogram was the most common pattern, observed in 39 unilateral cases (53.42%) and 18 bilateral ears (52.94%). Type A curve was the second most frequent pattern [Table 4, Figure 4].

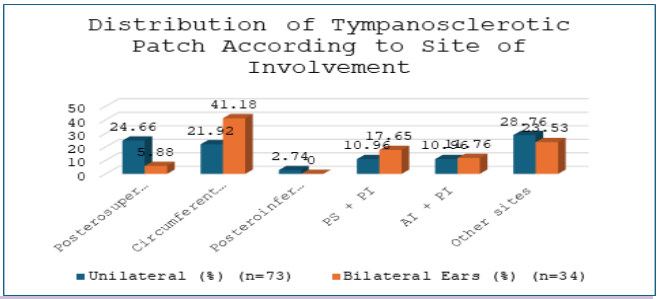

Figure 3: Distribution of Tympanosclerotic Patch According to Site of Involvement

Table 4: Audiological Findings in Patients with Tympanosclerosis

Investigation	Unilateral	Bilateral ears
PTA findings		
Normal	8 (10.96%)	6 (17.65%)
Mild CHL	41 (56.16%)	18 (52.94%)
Moderate CHL	24 (32.88%)	10 (29.41%)
Impedance findings		
Type A	20 (27.40%)	10 (29.41%)
Type As	39 (53.42%)	18 (52.94%)
Type C	10 (13.70%)	4 (11.76%)
Type AD	4 (5.48%)	2 (5.88%)

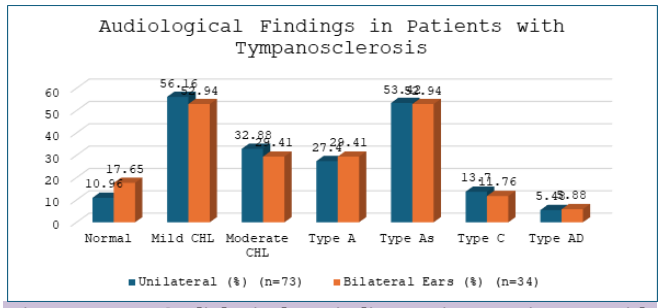

Figure 4: Audiological Findings in Patients with Tympanosclerosis

A statistically significant association was observed between the site of tympanosclerotic plaque and PTA findings. In unilateral involvement, the correlation between plaque location and degree of conductive hearing loss was significant (p=0.004). In bilateral involvement, a similar significant association was observed (p=0.001).

Patients with posterosuperior and circumferential plaques showed higher frequency of conductive hearing loss compared with other sites. Circumferential tympanosclerotic involvement was particularly associated with hearing impairment in bilateral cases [Table 5].

Table 5: Association Between Site of Tympanosclerotic Patch and PTA Findings

Parameter	p-value
Site of TS patch vs PTA (Unilateral)	0.004
Site of TS patch vs PTA (Bilateral)	0.001

A significant association was also observed between the site of tympanosclerotic plaque and impedance audiometry findings. In unilateral cases, the relationship was statistically significant (p=0.001), while bilateral cases also demonstrated significant association (p<0.001). Type As tympanogram was the predominant abnormality, particularly in patients with circumferential and posterosuperior plaques [Table 6].

A previous history of ear discharge was present in 15 ears (14.02%). Among these, posterosuperior involvement was most frequent (46.67%), followed by circumferential involvement (33.33%). A significant association was found between previous ear discharge and posterosuperior tympanosclerotic involvement (p=0.001).

Patients with previous ear discharge showed significantly higher grades of hearing impairment. Moderate conductive hearing loss was observed in 60% of ears with previous discharge compared with 27.17% among those without discharge (p=0.006).

Table 6: Significant Associations Observed in the Study

Association evaluated	p-value
Site of TS patch vs PTA findings (unilateral)	0.004
Site of TS patch vs PTA findings (bilateral)	0.001
Site of TS patch vs impedance findings (unilateral)	0.001
Site of TS patch vs impedance findings (bilateral)	<0.001
Previous ear discharge vs PS quadrant involvement	0.001
Previous ear discharge vs moderate CHL	0.006

Discussion

Tympanosclerosis is an irreversible, inactive reparative process of the middle ear characterized by fibrosis, hyalinization, and calcification following previous inflammatory injury. Although not an active inflammatory condition, it remains clinically significant as hyaline plaques may reduce tympanic membrane compliance and restrict ossicular mobility, leading to conductive hearing impairment. Early identification of hearing dysfunction is important to minimize morbidity associated with this condition. The present study, "Assessment of Hearing in Patients with Tympanosclerosis with Intact Tympanic Membrane," was conducted on 90 patients attending the ENT outpatient department of Santosh Medical College & Hospital, Ghaziabad, from May 2024 to September 2025. All patients underwent comprehensive evaluation including otoscopy, otoendoscopy, tuning fork tests, pure tone audiometry, and impedance audiometry. The study assessed hearing status and evaluated the relationship between tympanosclerotic plaque location and audiological findings. Patients in the present study ranged from 15 to 50 years, with the majority belonging to the 41–50 years age group (36.67%), followed by 31–40 years (33.33%). The mean age was 36.36 ± 9.23 years. Indranil Pal et al,[15] reported a predominance of cases in the 21–40 years age group, while B. Ramachandra Rao et al,[16] also observed higher occurrence among younger and middle-aged adults. K.S. Munish et al,[17] and Ramya Bandadka et al,[18] reported maximum cases in the 21–30 years age group. Variations may be related to differences in study population, healthcare-seeking behaviour, and inclusion criteria. Among the 90 patients, 37 (41.11%) were males and 53 (58.89%) were females, with a male-to-female ratio of 1:1.4. Indranil Pal et al,[15] reported nearly equal gender distribution, while B. Ramachandra Rao et al,[16] observed a slight female predominance similar to the present study. Conversely, Kamaljit Kaur et al.71 and K.S. Munish et al,[17] reported male predominance or equal distribution. These differences may reflect demographic variations and referral patterns rather than a true gender predisposition.

Unilateral tympanosclerosis was observed in 73 patients (81.11%), whereas bilateral involvement occurred in 17 patients (18.89%). Ramya Bandadka et al,[18] reported bilateral involvement in 23.33% of cases. The predominance of unilateral disease suggests that tympanosclerosis commonly develops as a localized sequela of previous middle ear inflammation rather than a progressive bilateral disorder. Ear-related symptoms were the most common presentation, observed in 91.11% of patients. Hearing loss was the predominant complaint (84.44%), followed by earache and tinnitus (4.44% each) and ear blockage (2.22%). Approximately 9% of patients were asymptomatic, with tympanosclerotic patches detected incidentally. Indranil Pal et al,[15] and B. Ramachandra Rao et al,[16] reported deafness as the commonest presenting symptom, whereas Ramya Bandadka et al,[18] observed a higher proportion of incidental cases. These variations may be due to differences in patient selection. The severity of symptoms depends on plaque extent, ossicular involvement, and impact on middle ear mechanics. Tympanosclerosis is frequently associated with previous inflammatory middle ear disease. In the present study, 21 patients (23.33%) had a history of recurrent upper respiratory tract infection and allergy, and 5 patients had previous ear procedures such as grommet insertion. Koch et al,[19] highlighted the association between recurrent upper respiratory infections and chronic otitis media. Jensen et al,[20] reported that healed chronic otitis media patients remain susceptible to recurrent inflammatory episodes, supporting the role of previous inflammation in tympanosclerosis development. Allergic rhinitis may contribute through Eustachian tube dysfunction and altered middle ear ventilation. Katiyar et al,[21] suggested that controlling allergic inflammation may reduce middle ear complications. Previous ventilation tube insertion has also been associated with tympanosclerosis. Lesser et al,[22] reported plaque formation at previous grommet sites, while Hampal et al,[23] demonstrated increased risk with heavier ventilation tubes.

Conclusion

Tympanosclerosis involving an intact tympanic membrane is frequently associated with conductive hearing impairment, although it may remain asymptomatic in some patients and be detected incidentally. In the present study, posterosuperior and circumferential tympanosclerotic patches were the most commonly observed sites and showed significant association with hearing loss and impedance audiometry findings. Pure tone audiometry and impedance audiometry were useful objective tools for assessing the functional impact of tympanosclerosis. Early identification of hearing impairment and detailed audiological evaluation can help in appropriate counselling and management of patients with tympanosclerosis.

Limitations: The study was conducted at a single centre with a relatively limited sample size, which may restrict the generalizability of the findings. The cross-sectional design did not allow assessment of the progression of tympanosclerosis or long-term hearing outcomes. Advanced imaging modalities such as HRCT temporal bone and surgical exploration were not performed to evaluate the extent of hidden middle ear and ossicular involvement.

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Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Wright T, Valentine P. Anatomy and embryology of the external and middle ear. In: Scott-Brown's Otorhinolaryngology Head and Neck Surgery. 8th ed. CRC Press; 2018. p. 525-543.
2. Guinan JJ Jr, Peake WT. Middle-ear characteristics of anesthetized cats. J Acoust Soc Am. 1967;41(5):1237-1261.
3. Wever EG, Lawrence M. The function of the middle ear. In: Wever EG, Lawrence M, editors. Physiological Acoustics. Princeton, NJ: Princeton University Press; 1954. p. 69-78.
4. Kirikae I. The structure and function of the middle ear. Tokyo: University of Tokyo Press; 1960.
5. Slack RW, Maw AR, Capper JW, Kelly S. Prospective study of

tympanosclerosis developing after grommet insertion. J Laryngol Otol. 1984;98(8):771-774.
6. Cassebohm JF. Tractatus quatuor anatomici de aure humana. Magdeburgicae H: Sumtibus Orphanatrophei; 1734.
7. Von Troltsch AF. Lehrbuch der Ohrenheilkunde mit Einschluss der Anatomie des Ohres. 7th ed. Leipzig, Germany: FCW Vogel; 1881.
8. Pomeroy OD. The diagnosis and treatment of diseases of the ear. New York: Bermingham & Co; 1883.
9. Plester D. Tympanosclerosis. Aust J Otolaryngol. 1972;3:325-326.
10. Roosa DB. A practical treatise on the diseases of the ear: including the anatomy of the organ. New York: William Wood & Co; 1873.
11. Habermann J. Pathologische Anatomie des Ohres. In: Handbuch der Ohrenheilkunde. 1892;1:203-302.
12. Walb H. Krankheiten der Paukenhöhle und der Tuba Eustachii. In: Handbuch der Ohrenheilkunde. 1893;2:168-298.
13. Toynbee J. The diseases of the ear: Their nature, diagnosis, and treatment. Philadelphia: Blanchard and Lea; 1865.
14. Politzer A. A text-book of the diseases of the ear and adjacent organs. 1st ed. Henry C. Lea's Son & Co; 1883.
15. Pal I, Sengupta A. Clinicopathological and audiological study of tympanosclerosis. Indian J Otolaryngol Head Neck Surg. 2005;57(3):235-239.
16. Rao BR, Parasuram G, Rao SS. Clinico-pathological and audiological assessment of tympanosclerosis: a study. J Dent Med Sci. 2016;15(7):12-17.
17. Munish KS, Mamatha BS, Shivakumar AM. Hearing loss in tympanosclerosis. Int J Sci Res. 2015;4(10):811-812.
18. Bandadka R, Pai KM, Shenoy V, Prasad SC, Natarajan P, Bhat VS. Tympanosclerosis: clinical presentation and audiological evaluation. Int J Otorhinolaryngol Head Neck Surg. 2020;6(2):291-296.
19. Koch A, Homøe P, Pipper C, Hjuler T, Melbye M. Chronic suppurative otitis media in a birth cohort of children in Greenland: population-based study of incidence and risk factors. Pediatr Infect Dis J. 2011;30(1):25-29.
20. Jensen RG, Koch A, Homøe P. Long-term tympanic membrane pathology dynamics and spontaneous healing in chronic suppurative otitis media. Pediatr Infect Dis J. 2012;31(2):139-144.
21. Katiyar VH, Elango D, Prasanna V. Observational study of tympanic membrane changes in allergic rhinitis. Int J Res Med Sci. 2016;4:3977-3981.
22. Lesser TH, Williams KR, Skinner DW. Tympanosclerosis, grommets and shear stresses. Clin Otolaryngol Allied Sci. 1988;13(5):375-380.
23. Hampal S, Flood LM, Kumar BU. The mini-grommet and tympanosclerosis. J Laryngol Otol. 1991;105(3):161-164.