

Original Research Article

A CROSS-SECTIONAL DESCRIPTIVE STUDY ON TRAUMATIC TYMPANIC MEMBRANE PERFORATION AND ITS OUTCOME

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ABSTRACT

Background: Traumatic perforation of the tympanic membrane is a common otological emergency encountered in clinical practice, with its incidence rising due to increasing interpersonal violence and road traffic accidents. Understanding the etiological patterns, clinical presentation, and healing outcomes in the Indian population is essential for developing effective management strategies.

Aim: To evaluate the demographic profile, etiological factors, clinical presentation, audiological outcomes, and spontaneous healing rates of traumatic tympanic membrane perforation in patients attending a tertiary care hospital in Tamil Nadu.

Material and Methods: This cross-sectional descriptive study was conducted among 60 patients presenting with traumatic tympanic membrane perforation at a tertiary care hospital in Tamil Nadu over 18 months. Following informed consent, detailed clinical history, otological examination and pure tone audiometry were performed. Patients were managed conservatively and reviewed weekly. Sample size was calculated using the formula $n = Z^2pq/d^2$, assuming 85% spontaneous healing rate from previous Indian studies, with 95% confidence interval and 10% margin of error.

Results: The mean age was 30.2 ± 9.1 years with male predominance (63.3%). Assault (45%) emerged as the most common etiology, followed by road traffic accidents (18.3%). Left ear involvement was observed in 76.7% of cases. Aural Fullness (46.7%) was the predominant presenting symptom. The mean hearing loss improved from 27.8 ± 7.4 dB at presentation to 17.2 ± 4.3 dB at 3-week follow-up. Spontaneous healing occurred in 95% of cases, with mean healing time of 4.9 weeks. Significant associations were found between etiology and symptoms ($p < 0.01$) and between perforation size and healing time ($p < 0.01$).

Conclusion: Traumatic tympanic membrane perforation predominantly affects young adult males, with assault being the primary etiological factor. Conservative management with masterly inactivity yields excellent healing rates, supporting the watchful waiting approach in uncomplicated cases.

Keywords: Traumatic tympanic membrane perforation, hearing loss, assault, spontaneous healing, conservative management.

INTRODUCTION

The tympanic membrane, a delicate trilaminar structure approximately 0.1 mm thick, serves as the critical interface between the external auditory canal and the middle ear cavity, playing an indispensable

role in the conduction of sound waves through its vibratory properties.^[1] This anatomically sophisticated membrane contributes significantly to the impedance matching mechanism that facilitates efficient transmission of sound from the air-filled external environment to the fluid-filled inner ear

structures, while simultaneously providing a protective barrier against foreign bodies and pathogens.^[2] The integrity of this structure is essential for maintaining normal hearing function, and its disruption through trauma can lead to significant functional impairment and patient morbidity. Traumatic perforation of the tympanic membrane has emerged as an increasingly prevalent clinical concern in India, with its incidence estimated at approximately 6.80 per 1000 persons annually.^[3] The rising trend of traumatic injuries, particularly in developing nations like India, has positioned this condition as a significant contributor to preventable hearing impairment. In the Indian context, factors such as urbanization, changing socio-economic dynamics, increasing interpersonal violence and rising road traffic accidents have contributed to the growing burden of this condition.^[4] Recent studies from various Indian states have reported assault as the most common etiological factor, with male predominance and left ear involvement being consistent findings across different geographical regions.^[5]

The etiological spectrum of traumatic tympanic membrane perforations encompasses both direct and indirect mechanisms of injury. Compression injuries, often resulting from hand slaps or blows to the ear, represent the most common mechanism, followed by penetrating injuries from foreign objects, blast injuries, and iatrogenic causes.^[6] The clinical presentation typically includes symptoms such as otalgia, hearing impairment, tinnitus, and aural fullness, with varying degrees of severity depending on the size and location of the perforation.^[7] Understanding these etiological factors and clinical presentations is essential for developing effective prevention strategies and guiding appropriate clinical management in the Indian healthcare setting. The present study was undertaken to evaluate the demographic profile, etiological patterns, clinical presentation and healing outcomes of traumatic tympanic membrane perforation in a tertiary care setting in Tamil Nadu.

Aim and Objective

To evaluate the demographic profile, etiological factors, clinical presentation, audiological outcomes and spontaneous healing rates of traumatic tympanic membrane perforation in patients attending a tertiary care hospital in Tamil Nadu.

Objectives

1. To assess the demographic profile and etiological factors associated with traumatic tympanic membrane perforation including age, gender distribution, laterality, and various mechanisms of injury.
2. To evaluate the clinical presentation and audiological status of patients with traumatic tympanic membrane perforation at presentation and at 3-week follow-up using pure tone audiometry.
3. To determine the spontaneous healing rate and healing time of traumatic tympanic membrane

perforation with conservative management and to identify factors influencing the healing outcome.

MATERIALS AND METHODS

Study Design and Setting: This cross-sectional descriptive study was conducted in the Department of Otorhinolaryngology at Government Medical College, Ariyalur, Tamil Nadu, India, over a period of 18 months from January 2024 to June 2025. The study protocol received approval from the Institutional Ethics Committee (IEC Reference No: GMCA-IEC-1/2024/PR-14 held on 26.02.2024), and all procedures were performed in accordance with the ethical standards outlined in the 1964 Helsinki Declaration and its subsequent amendments.

Sample Size calculation: The sample size was calculated using the formula for cross-sectional studies: $n = Z^2pq/d^2$, where $Z = 1.96$ for 95% confidence interval, $p = 0.85$ (anticipated proportion of spontaneous healing based on previous Indian studies),^[8] $q = 1-p$ (0.15), and $d = 0.10$ (margin of error). The calculated sample size was:

$$n = (1.96)^2 \times (0.85 \times 0.15) / (0.10)^2$$

$$n = 3.8416 \times 0.1275 / 0.01$$

$$n = 0.4898 / 0.01$$

$$n = 48.98 \approx 49 \text{ patients}$$

in the study included 60 patients to account for potential dropouts and to enhance the statistical power of subgroup analyses.

Study Population

Inclusion Criteria:

- Patients of both genders aged between 12 and 50 years
- Confirmed diagnosis of traumatic tympanic membrane perforation
- Presentation within 7 days of injury
- Willing to provide informed consent
- Willing to comply with follow-up protocol

Exclusion Criteria:

- Patients with pre-existing chronic suppurative otitis media
- Congenital ear anomalies
- Prior otological surgeries
- Temporal bone fractures or associated intracranial injuries
- Patients who had received active intervention elsewhere
- Immunocompromised patients or those with uncontrolled diabetes mellitus
- Pregnant women

Data Collection

After obtaining written informed consent from all participants, a comprehensive clinical history was elicited documenting demographic details, mechanism of injury, time elapsed since injury, and presenting symptoms. Thorough otological examination was performed using otoscopy and binocular microscopy (Zeiss Tivato 700, Germany) to assess perforation characteristics including size,

location, and marginal integrity. Tuning fork tests (Weber's and Rinne's tests) were conducted to determine the nature of hearing loss. Perforation size was categorized as small (<25% of tympanic membrane area), medium (25-50%), or large (>50%) based on the grading system used in previous Indian studies.^[9]

Audiological Assessment

Pure tone audiometry was performed using a standardized audiometer (ALPS Advanced Audiometer AD 2100) in a sound-attenuated room, following the guidelines of the American Speech-Language-Hearing Association. Air and bone conduction thresholds were measured at 250, 500, 1000, 2000, 4000, and 8000 Hz. The pure tone average hearing loss was calculated at 500, 1000, and 2000 Hz.^[10] Audiometric assessment was performed at initial presentation and repeated at the 3-week follow-up visit.

Management Protocol

Patients were managed conservatively with emphasis on aural hygiene and avoidance of water entry into the ear canal. Oral antibiotics (amoxicillin 500 mg thrice daily for 5 days) were prescribed for prophylaxis in cases with evidence of contamination or associated infection, and symptomatic treatment with anti-inflammatory medications (ibuprofen 400 mg thrice daily for 3 days) was provided for pain relief.^[11] Patients were instructed to avoid nose blowing, straining, and any maneuvers that could increase middle ear pressure. No active intervention such as myringoplasty or patch application was performed during the study period.^[12]

Follow-up and Outcome Assessment

Patients were reviewed weekly until complete healing of the perforation was documented or until

the end of the 12-week study period. At each follow-up visit, otological examination was repeated to assess healing status and any complications such as infection or failure to heal were documented.^[13] The primary outcome measure was the rate of spontaneous healing and the time required for complete closure of the perforation.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics including mean, standard deviation, frequencies, and percentages were calculated for all variables. The association between categorical variables was assessed using Chi-square tests, and comparison of continuous variables was performed using independent t-tests. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Demographic Profile of Study Participants

The study included 60 patients with traumatic tympanic membrane perforation, comprising 38 males (63.3%) and 22 females (36.7%). The age distribution ranged from 12 to 50 years, with a mean age of 30.2 ± 9.1 years. The most commonly affected age group was 21-30 years, accounting for 38.3% of cases, followed by the 31-40 years age group (26.7%). Among males, the highest proportion of involvement was observed in the 21-30 years age group (25%), while among females, the 21-30 years age group also showed the highest prevalence (13.3%).

Table 1: Age and Gender Distribution of Study Participants

Age Group (Years)	Male (n=38)	Female (n=22)	Total (N=60)	Percentage (%)
12-15	1	0	1	1.7
16-20	6	2	8	13.3
21-30	15	8	23	38.3
31-40	11	5	16	26.7
41-50	5	7	12	20.0

The mean age of males was slightly higher at 30.7 ± 9.2 years compared to females at 29.4 ± 8.9 years, though this difference was not statistically significant ($p > 0.05$). The male-to-female ratio was 1.7:1, indicating a clear male preponderance in the study population. Analysis of the demographic data

revealed that the majority of patients (65%) belonged to the economically productive age group of 21-40 years, highlighting the potential socioeconomic impact of this condition.

Etiological Factors and Laterality

Table 2: Distribution of Etiological Factors

Etiology	Number of Cases	Percentage (%)
Assault	27	45.0
Road Traffic Accident	11	18.3
Self-cleaning	8	13.3
Explosion/Blast	5	8.3
Fall	4	6.7
Barotrauma	3	5.0
Iatrogenic	2	3.3
Total	60	100.0

Analysis of the etiological factors revealed assault as the predominant cause, accounting for 27 cases (45%), followed by road traffic accidents in 11 cases (18.3%). Self-cleaning attempts with cotton-tipped applicators or other objects contributed 8 cases (13.3%), while explosion / blast causes accounted for 5 cases (8.3%). Falls contributed to 4 cases (6.7%), barotrauma to 3 cases (5%), and iatrogenic to 2 cases (3.3%).

Clinical Presentation and Symptom Distribution

The most common presenting symptom was Aural Fullness, reported by 28 patients (46.7%), followed by aural fullness with Tinnitus in 22 patients (36.7%). Hearing impairment was noted in 5 patients (8.3%), while ear pain and ear bleeding were less frequent, each occurring in 4 patients (6.7%) and 1 patient (1.7%) respectively.

Table 3: Distribution of Presenting Symptoms

Symptom	Number of Cases	Percentage (%)
Aural Fullness	28	46.7
Aural Fullness with Tinnitus	22	36.7
Hearing Impairment	5	8.3
Ear Pain	4	6.7
Ear Bleeding	1	1.7
Total	60	100.0

The predominance of Aural Fullness as the presenting symptom 28 (46.7%) followed by 22 (36.7%) had Aural Fullness with Tinnitus, 5 (8.3%)

cases had hearing impairment, 4 (6.7%) had ear pain and one case (1.7%) had ear bleeding.

Table 4: Comparison Between Etiology and Symptoms

Etiology	Aural Fullness	Aural Fullness with Tinnitus	Hearing Impairment	Ear pain	Ear Bleeding	Total
Assault	15 (55.6%)	9 (33.3%)	2 (7.4%)	1 (3.7%)	0 (0%)	27
RTA	4 (36.4%)	5 (45.5%)	1 (9.1%)	1 (9.1%)	0 (0%)	11
Self-cleaning	5 (62.5%)	2 (25%)	1 (12.5%)	0 (0%)	0 (0%)	8
Explosion	1 (20%)	3 (60%)	1 (20%)	0 (0%)	0 (0%)	5
Fall	2 (50%)	2 (50%)	0 (0%)	0 (0%)	0 (0%)	4
Barotrauma	1 (33.3%)	1 (33.3%)	0 (0%)	1 (33.3%)	0 (0%)	3
Iatrogenic	0 (0%)	0 (0%)	0 (0%)	1 (100%)	1 (0%)	2
Chi-square value: 28.45, df: 18, p-value: 0.008						

Assault-related injuries showed a predominance of aural fullness (55.6%), while RTA-related injuries were more commonly associated with aural fullness with tinnitus (45.5%). Explosion injuries were more common with aural fullness with tinnitus (60%). This association has clinical relevance, as the symptom profile may provide clues about the

underlying mechanism of injury and guide appropriate management.

Audiological Outcomes

Audiometric assessment at initial presentation revealed a mean hearing loss of 27.8 ± 7.4 dB. At the 3-week follow-up, significant improvement was observed, with the mean hearing loss reducing to 17.2 ± 4.3 dB ($p < 0.001$).

Table 5: Audiometric Thresholds at Presentation and Follow-up

Parameter	Mean Hearing Loss (dB)	Standard Deviation
At Presentation	27.8	± 7.4
At 3 Weeks	17.2	± 4.3
Mean Difference	10.6	± 5.8

The improvement in hearing thresholds from presentation to the 3-week follow-up was statistically significant ($p < 0.001$). This improvement was observed across all frequencies, though the most pronounced improvement was noted in the lower frequencies (250-1000 Hz),

which are particularly dependent on tympanic membrane integrity (21). The degree of hearing improvement showed correlation with the size of the perforation, with smaller perforations demonstrating better functional recovery.

Table 6: Cross-tabulation of Perforation Size and Healing Time

Perforation Size	<2 Weeks	3-5 Weeks	6-8 Weeks	9-11 Weeks	Unhealed	Total
Small (<25%)	4 (80%)	20 (60.6%)	3 (23.1%)	1 (16.7%)	0 (0%)	28
Medium (25-50%)	0 (0%)	11 (33.3%)	8 (61.5%)	3 (50%)	2 (50%)	24
Large (>50%)	0 (0%)	2 (6.1%)	2 (15.4%)	2 (33.3%)	2 (50%)	8
Chi-square value: 32.67, df: 12, p-value: 0.001						

The chi-square test revealed a statistically significant association between perforation size and healing time ($\chi^2 = 32.67$, $p = 0.001$). Small perforations (<25% of tympanic membrane area) showed the most favorable healing outcomes, with 80% healing within 2 weeks and 60.6% healing within 3-5 weeks. In contrast, large perforations (>50%) demonstrated delayed healing, with 33.3% healing in 9-11 weeks and 50% remaining unhealed at the end of the study period. Medium-sized perforations showed intermediate healing patterns.

Healing Outcomes

The majority of patients (55%) achieved spontaneous healing within 3-5 weeks of injury, while 21.7% healed between 6-8 weeks and 10% between 9-11 weeks. Notably, 8.3% of patients demonstrated healing within less than 2 weeks, reflecting the remarkable regenerative capacity of the tympanic membrane in favorable conditions (23). Three patients (5%) failed to achieve spontaneous healing by the end of the 12-week study period.

Table 7: Healing Time Distribution

Healing Time (Weeks)	Number of Cases	Percentage (%)
< 2	5	8.3
3-5	33	55.0
6-8	13	21.7
9-11	6	10.0
Unhealed	3	5.0
Total	60	100.0

The overall spontaneous healing rate was 95%, with a mean healing time of 4.9 weeks. Analysis of healing outcomes in relation to presenting symptoms revealed that patients with ear pain showed the most favorable healing patterns, with 60.7% healing within 3-5 weeks. Among patients with aural fullness, 50% healed within the same timeframe. The three patients with unhealed perforations included two with large perforations (>50% of tympanic membrane surface area) and one with evidence of secondary infection.

DISCUSSION

The demographic findings of this study provide important insights into the epidemiology of traumatic tympanic membrane perforation in the Tamil Nadu population. The male predominance observed in our study (63.3%) aligns well with the findings of Wani et al. (65.9% males) from their study in Jammu and Kashmir,^[10] Puttamadaiah et al. (61.36% males) from Karnataka,^[15] and Gulwade and Gandhi (69.53% males) from their pediatric study.^[1] This consistent male preponderance across multiple Indian studies likely reflects the greater exposure of males to occupational hazards, involvement in physical altercations, and participation in high-risk activities. The fact that men are more likely to be involved in interpersonal violence and workplace accidents explains the higher vulnerability observed across multiple studies.

The mean age of 30.2 years observed in our study is comparable to the mean age of 27.6 years reported by Lou et al. and the mean age of 29.5 years reported by Gupta and Jamwal. The predominance of the 21-30 years age group (38.3%) parallels findings from Puttamadaiah et al., who reported that 37.5% of patients were in the 21-30 years age group.^[15] This age-related vulnerability can be attributed to the active lifestyle characteristics of

this demographic, including workplace participation, engagement in sports and recreational activities, and increased social interactions that may lead to interpersonal conflicts. The substantial proportion of young adults in our study group underscores the need for targeted prevention strategies in this population.

Etiological Patterns and Mechanisms of Injury

The finding that assault constituted the most common cause of traumatic tympanic membrane perforation (45%) in our study is consistent with several other Indian studies. Wani et al. reported that physical assault was responsible for 69.42% of cases in their Kashmir-based investigation,^[10] while Puttamadaiah et al. found that slapping was the most common mode of injury (56.8%).^[15] Sannigrahi et al. from West Bengal also reported assault as a major etiological factor.^[9] The high prevalence of assault-related injuries reflects the growing burden of interpersonal violence in Indian society, particularly in urban and semi-urban areas.

The predominance of left ear involvement (76.7%) in this study is a notable finding that has been consistently reported across multiple studies. Puttamadaiah et al. reported left ear involvement in 62.5% of cases,^[15] Wani et al. in 71.14%,^[10] and Saimanohar et al. in 66% of cases. This consistent predilection for left-sided involvement is attributed to the fact that most assailants are right-handed; when facing the victim, a right-handed blow would strike the left side of the face, making the left ear more vulnerable to trauma.^[9] This observation has important medicolegal implications, as the pattern of injury can provide valuable information about the circumstances of the trauma.

Road traffic accidents accounted for 18.3% of cases in our study, emerging as the second most common cause. This finding is particularly relevant in the context of the high rate of road traffic accidents in Tamil Nadu. The mechanism of injury in RTA-related perforations typically involves either direct

trauma from impact or blast injuries from airbag deployment. Self-cleaning injuries constituted 13.3% of cases, a finding that underscores the widespread practice of inserting foreign objects into the ear canal for wax removal. This practice is particularly common in developing countries where access to professional ear care may be limited.^[10]

Clinical Presentation and Symptom Correlation

The study finding shows that aural fullness was the most common presenting symptom (46.7%) and some studies also reported where tinnitus with aural fullness was predominant complaint. Wani et al. reported tinnitus as the most common complaint (90.9%) followed by aural fullness (87.1%),^[1] while Gulwade and Gandhi reported ear block/hearing loss as the most common symptom (54.16%) in their pediatric study.^[11] The study by Puttamadaiah et al. reported deafness (75%) as the most common symptom,^[15] while our study found hearing impairment in only 8.3% of patients.

The significant association between symptom presentation and etiology ($p < 0.01$) observed in our study is an interesting finding that has clinical relevance. Assault-related injuries showed a predominance of aural fullness, while RTA-related injuries were more commonly associated with Aural Fullness with Tinnitus. This pattern may reflect differences in the mechanisms of injury, the presence or absence of associated middle ear damage, and the psychological context in which the injury occurred.^[9] Iatrogenic injuries were predominantly associated with ear pain and ear bleeding, which may relate to the specific mechanisms involved in these procedures.

Audiological Outcomes and Healing Patterns

The mean hearing loss of 27.8 dB at presentation in our study is comparable to findings from previous research. Wani et al. reported that the majority of patients (62%) presented with conductive hearing loss in the range of 20-35 dB,^[10] while Puttamadaiah et al. found similar results.^[15] The improvement to 17.2 dB at 3 weeks in our study demonstrates the rapid functional recovery associated with spontaneous healing of the tympanic membrane. The mean hearing improvement of 10.6 dB observed in our study is consistent with the findings of Puttamadaiah et al., who reported a mean hearing improvement of 13.18 ± 7.05 dB at 3 months.^[15]

The 95% spontaneous healing rate observed in our study is comparable to rates reported in other Indian studies. Wani et al. reported an overall spontaneous healing rate of 91.1%,^[10] Puttamadaiah et al. reported 90.9%,^[15] and Shinde et al. reported 75% in their conservative management group.^[14] The slightly higher healing rate in our study may reflect the relatively healthy population, the absence of associated infections at presentation, and the fact that most perforations were small to medium in size. The mean healing time of 4.9 weeks in our study is similar to the 5.3 weeks (37 days) reported by Puttamadaiah et al,^[15] and falls within the 3-6 weeks range commonly reported in the literature.

The factors influencing healing outcomes in our study included perforation size, presence of infection, and location of the perforation. The three patients with unhealed perforations included two with large perforations and one with secondary infection. These findings are consistent with previous studies that have identified perforation size and infection as negative prognostic factors for spontaneous healing.^[9] Sannigrahi et al. reported that perforation size $>50\%$ was a significant risk factor for non-healing with an odds ratio of 34.57.^[9]

Implications for Clinical Management

The findings of this study provide strong support for the "watch and wait" approach to the management of traumatic tympanic membrane perforations in the Indian context. As advocated by multiple authors including Wani et al,^[10] Puttamadaiah et al,^[15] and Sannigrahi et al,^[9] a period of observation for 3-6 months should be adopted before considering surgical repair. This approach is particularly justified in the Indian healthcare setting, where resources may be limited and where the majority of cases heal spontaneously with excellent functional outcomes.

Prevention of complications, particularly infection, is a critical aspect of conservative management. The dry ear precautions advocated in our study, combined with prophylactic antibiotics in selected cases, helped prevent the development of secondary suppurative otitis media, which could potentially delay or prevent healing. The use of oral antibiotics for contamination or associated infection is consistent with the approach recommended by previous Indian studies.^[10,15]

The medicolegal implications of traumatic tympanic membrane perforation, particularly in assault cases, require careful documentation and appropriate referral. As our study demonstrates, assault is the most common cause of these injuries and physicians should be aware of their role in documenting injuries and when appropriate, notifying authorities. The characteristic features of assault-related perforations, including their location, shape, and laterality, can provide important forensic evidence.^[9]

Study Strengths and Limitations

The strengths of this study include its prospective design, comprehensive clinical and audiological evaluation, and the inclusion of a well-defined study population from a tertiary care center in Tamil Nadu. The study provides valuable data on the epidemiology, clinical presentation, and healing outcomes of traumatic tympanic membrane perforation in this region. However, several limitations should be acknowledged. The relatively small sample size limits the statistical power of some subgroup analyses, and the single-center design may limit the generalizability of our findings to other populations. Additionally, the study did not incorporate advanced imaging modalities or tympanometry, which could have provided additional information about middle ear status and

ossicular chain integrity. Future research should focus on larger, multicenter studies with longer follow-up periods to better understand the long-term outcomes of conservative management.

CONCLUSION

This cross-sectional descriptive study of traumatic tympanic membrane perforation in a tertiary care center in Tamil Nadu has demonstrated that this condition predominantly affects young adult males, with assault being the most common etiological factor. The left ear is preferentially involved, and the majority of patients present with ear pain as their primary symptom. The study provides strong evidence supporting conservative management with masterly inactivity, as 95% of patients achieved spontaneous healing with an average healing time of 4.9 weeks. Audiological outcomes showed significant improvement in hearing thresholds at 3 weeks, reflecting the restoration of tympanic membrane function with spontaneous healing. The findings underscore the importance of public health interventions aimed at reducing interpersonal violence and road traffic accidents, as well as educational programs to discourage self-cleaning of ears and to promote appropriate healthcare-seeking behavior. Healthcare providers should be trained in proper ear examination and foreign body removal techniques to prevent iatrogenic injuries. The high rate of spontaneous healing observed in this study justifies the continued use of conservative management as the first-line approach in uncomplicated cases of traumatic tympanic membrane perforation in the Indian context.

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