

Traumatic perforation of tympanic membrane in rural population: A clinical study

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Abstract

Background: Tympanic membrane is a thin, transparent white membrane that separates the external acoustic canal from the middle ear. It is oval in shape and measures 9 mm x 10 mm. It is positioned obliquely at a 55-degree angle with the meatus floor.¹ Tympanic membrane is a crucial component of sound conduction since its vibratory feature is required for sound transmission in humans. A defect in the tympanic membrane is termed as tympanic membrane perforation, which can occur due to various causes including trauma.

Objective: To study various etiologies of traumatic perforation of the tympanic membrane, their clinical presentation, extent of hearing loss and their response to the various treatment options.

Methodology: A Retrospective study of 100 cases of traumatic tympanic membrane perforation from rural areas was carried out. Data was collected from the ENT OPD Register, Audiology Register and OT Register of the patients who had presented to the Dept of ENT, CIMS Teaching Hospital, Chamarajanagar with features of Traumatic perforation of the tympanic membrane. Data was collected regarding the clinical profile of the patients, etiology, site, size of perforation, degree of hearing loss, treatment options utilized, time taken for healing and improvement in hearing after healing of the perforation.

Results: Of the 100 cases of traumatic perforation of the tympanic membrane, 59 were male and 41 were female. 49 patients presented with conductive hearing loss in the range of 26-40 dB, 29 patients with 16-25 dB hearing loss. Complete healing was observed within 2-8 weeks in 51 patients and within 8-12 weeks in 34 patients.

Conclusions: Assault was the most common cause of injury to the ear, majority of the patients presented with tinnitus, had small sized central perforation of the tympanic membrane with minimal hearing loss. In majority of the patients, perforation healed spontaneously without active intervention and only a few cases having required active surgical intervention.

Keywords: Traumatic perforation of tympanic membrane, central perforation of tympanic membrane, conductive hearing loss, myringoplasty, accidental tympanic membrane perforation

Introduction

Tympanic membrane is a thin, transparent white membrane that separates the external acoustic canal from the middle ear. It is oval in shape and measures 9 mm x 10 mm. It is positioned obliquely at a 55-degree angle with the meatus floor ^[1]. Tympanic membrane is a crucial component of sound conduction since its vibratory feature is required for sound transmission in humans. A defect in the tympanic membrane is termed as tympanic membrane perforation, which can occur due to various causes including trauma. Various causes of traumatic perforation of the tympanic membrane have been reported, including blunt trauma causing overpressure, which is the most frequent mechanism, penetrating trauma with a cotton swab (so-called "Q-tip injury") or other sharp instruments, barotrauma, and blast injuries ^[2, 3]. The antero-inferior quadrant of the Tympanic Membrane is the most prone to rupture owing to changes in air pressure. Atrophic segments are more likely to rupture when the pressure difference is at least 50% lower than that of a normal Tympanic Membrane. Temporal bone fracture is a significant cause, particularly when the fracture line involves the Tympanic Membrane attachment line. In some ways, the mode of injury received to the Tympanic Membrane by persons living in rural regions is comparable to that of people living in urban areas ^[4].

Tympanic membrane is more commonly injured than the middle or inner ear. The prevalence rate is estimated to be 6.80 cases per 1000 population ^[5]. The Pars tensa is the section of the tympanic membrane that perforates as a result of trauma. The diagnosis of traumatic tympanic membrane perforation is made based on the patient's medical history and physical examination. This is followed by an audiological assessment to determine the degree of hearing loss at the time of presentation. This also offers information regarding the patient's baseline hearing loss at the time of presentation, which is helpful in determining the degree of recovery in hearing when the perforation repairs ^[6].

The extent of the perforation and the presence of subsequent infection at the injury site determine how quickly it heals. Hearing loss, ear discomfort, aural fullness, ear buzzing, ear bleeding and vertigo are among symptoms that might occur. Because of the smaller drum size, a ruptured Tympanic Membrane causes hearing loss and puts the middle ear mucosa at risk of infection. These issues make it difficult for the patient to participate in water sports and to be recruited in several professions. Perforation of the tympanic membrane causes an increase in acoustic coupling due to the lack of the shielding effect of an intact Tympanic Membrane ^[7].

Objective: To study various etiologies of traumatic perforation of the tympanic membrane, their clinical presentation, extent of hearing loss and their response to the various treatment options.

Materials and Methods

The research was a retrospective study conducted at the Department of Otorhinolaryngology, Chamarajanagar Institute of Medical Sciences (CIMS) Teaching Hospital, Chamarajanagar. Data was collected from Hospital Registers such as Department of ENT Out-Patient/In-Patient Registers, Audiology (Pure Tone Audiometry) Register, Minor and Major Operating Room Registers. The Data collected from the Medical Records included details regarding demographic background of the patients, mode of trauma, clinical presentation, otoscopic findings, audiometric findings, treatment advised to the patients, its outcome and the hearing improvement after healing.

The research comprised of 100 individuals belonging to rural areas who presented to the Department of ENT at CIMS Teaching Hospital, Chamarajanagar from March 2016 to

December 2021, with recent history of trauma to the ear sustained by various means and without any prior history of ear disorders.

Various parameters such as age, sex of the patient, side of damage, presenting symptoms such as earache, hearing loss, tinnitus and vertigo that had been recorded at the time of presentation were obtained from the medical records and the same were tabulated. All patients had been examined by otoscopy/oto-microscopy and the size of perforation had been recorded which was tabulated.

The size of the perforation had been determined on the basis of the criteria that a defect involving less than one-fourth of the Pars Tensa of the Tympanic membrane had been categorized as a small perforation, a defect involving less than half of the Pars Tensa of the Tympanic Membrane was a medium sized perforation. A large sized perforation involved three fourths of the Pars Tensa. The patients had been assessed for hearing by tuning fork tests and Pure tone audiometry. Patients had been categorized as having minimal (16 dB to 25 dB), mild (26 dB to 40 dB), moderate (41 dB to 55 dB), moderately severe (56 dB to 70 dB), severe (71 dB to 90 dB) and profound hearing loss (more than 91 dB) on the basis of degree of hearing loss. The data regarding the same was collected and tabulated. A conservative care plan had been employed, with the exception of those with features of congestion or ear discharge who had been advised administration of oral/systemic antibiotics to prevent infection. Data regarding the treatments such as conservative management, surgical intervention advised to the patients were taken from the registers and tabulated.

Patients had been advised to come for follow-up visits at weekly intervals for the first month and then at intervals of every 15 days for the next 2 months to monitor the progress in healing of the tympanic membrane perforation. If the tympanic membrane perforation would have been healed completely then such patients had been subjected for pure tone audiometry to assess post-healing improvement in hearing. In cases where the traumatic perforation of tympanic membrane had failed to heal even after 3 months of trauma, surgical intervention was undertaken which consisted of freshening of the margins of perforation by chemical cautery using Trichloroacetic Acid or myringoplasty. Hearing had been assessed in these patients after the healing of the perforation. Percentage of patients who were managed by conservative approach and by surgical intervention was tabulated.

Results

Table 1: Distribution of study subjects based on the Age & Sex distribution

		Male (n=59)	Female(n=41)	Total
Age in Years	0-5	0	1	1
	6-10	4	5	9
	11-20	7	6	13
	21-30	12	9	21
	31-40	21	17	38
	41-50	7	1	8
	51-60	8	2	10
Laterality	Left	30	28	58
	Right	28	13	41
	Both	1	0	1

Data was collected regarding 100 cases of traumatic perforation of the tympanic membrane belonging to rural areas with history suggestive of trauma to the ear and without any previous history of ear diseases, 59 patients were male and 41 patients were female. It was seen in people belonging to all age groups, with the highest incidence in the age group of 31-40 years and then in the age group of 21-30 years. A total of 49 patients presenting with traumatic perforation of tympanic membrane were in the age group of 21 to 40 years. The incidence of

traumatic perforation of tympanic membrane was 10 in the age groups of 0-10 years, 13 in the age group of 11-20 years, 8 patients in the age group of 41-50 years, 10 cases being noted 51-60 years age group. The left ear was the most commonly injured ear, with involvement seen in 58 patients. Right ear involvement was seen in 41 patients, 1 patient had bilateral ear involvement.

Table 2: Etiology and side of ear injured

Side of affected	Slap/ Assault	RTA	Attempts at ear cleaning	Accidental falls at home or at workplace	Foreign body (Insect removal attempts)	Impact by a ball/Sports injury	Cracker Bursting	No. of patients
Left	31	9	6	7	1	3	1	58
Right	14	12	5	4	4	2	0	41
Both	-	-	-	-	-	-	1	1

Table 3: Mode of trauma to the Ear and Sex of Patients

Etiology	Frequency		
	Male	Female	Total
Slap/Assault	16	29	45
RTA	17	4	21
Attempts at ear cleaning	8	3	11
Accidental falls at home or at workplace	8	3	11
Foreign body (Insect removal attempts)	3	2	5
Impact by a ball/Sports injury	5	0	5
Cracker Bursting	2	0	2
Total	59	41	100

The most common mode of injury was assault, which was seen in 45 patients. All the 45 patients had given history of trauma to the ear by bare hands. 21 patients had history of trauma to the ear during road traffic accident. Road Traffic Accident was seen to be the second most common cause of traumatic perforation of the tympanic membrane in our study followed by falls at home and workplace. Most of the falls involved two wheelers either in the form of falls from two-wheeler or due to getting hit by a two-wheeler.

11 patients had sustained trauma to the ear during attempts to clean one's own ear. Aural manipulation with an intention to clean the ear and to relieve irritation of the ear had led to traumatic perforation of the tympanic membrane in 11 patients. Attempts at cleaning of the ear were made by use of matchsticks, ear buds, safety pins, hair pins. Amongst them, three patients each were in the age group of 6 to 10 years and 11 to 20 years.

11 patients had sustained trauma to the ear during falls at home, agricultural fields. Three patients had accidental falls at home and 8 patients had falls at agricultural fields. Amongst them, one male patient gave history of trauma to the ear, during a bull attack. Trauma to the ear as a result of sports injury, impact by ball to the ear during play, falls in sports field, had led to traumatic perforation of tympanic membrane in 4 male patients and 1 male patient had injury following diving in a pond.

Unskilled attempts at removal of foreign body from the ear by family members or untrained individuals approached by the patients and their attendants had led to 5 cases of traumatic perforation of the tympanic membrane. In one case the child had inserted a broom stick into an ear. There was history of unskilled attempts at removal of foreign bodies like insects in 3 patients and pebble in a four-year old child by the caretakers of the child. 2 patients had exposure to cracker bursting.

Table 4: Clinical presentation of the patients

Presenting Symptoms	Frequency		
	Male	Female	Total
Tinnitus	19	24	43
Aural Fullness	14	22	36
Hearing loss	20	15	35
Bleeding	15	17	32
Earache	13	17	30

Tinnitus was the most common complaint seen in 43 patients, followed by aural fullness seen in 36 patients, hearing loss was seen in 35 patients, bleeding from the ear seen in 32 patients, 30 patients had symptoms of earache. 64 patients presented with more than one symptom, 12 patients presented with 3 symptoms, 52 patients presented with 2 symptoms.

Table 5: Distribution of study subjects based on the number of perforations

Number of perforations	Number of patients
Single	99
Multiple	1

Table 6: Size of perforation

Size of perforation	Number of TM Perforations in Male	Number of TM Perforations in Female	Total number of Tympanic Membrane Perforations seen	Total Patients
Small	27	20	47	47
Medium	20	13	33	33
Large	11	8	19	19
Multiple small perforations	2	0	2	1

Majority of the patients presented with a single perforation of the Tympanic Membrane. 47 patients had presented with small sized perforation with a defect involving one quadrant of the tympanic membrane. In 33 patients a medium sized central perforation was noticed. Only 1 individual had presented with multiple perforations, in whom 2 perforations of small size were seen.

Table 7: Location of the perforation

Location of perforation	Number of TM Perforations in Male	Number of TM Perforations in Female	Total number of Tympanic Membrane Perforations seen	Total Patients
Antero-inferior Quadrant	20*	15	49	48
Posteroinferior Quadrant	7	3		
Antero-superior Quadrant	2*	2		
Antero-superior and Antero-inferior Quadrants	16	11	33	33
Antero-inferior and Posteroinferior Quadrants	3	2		
Posteroinferior and Posterosuperior Quadrants	1	-		
Antero-superior, Antero-inferior and Posteroinferior Quadrants	11	8	19	19
Antero-inferior, Posteroinferior and Posterosuperior Quadrants	-	-		

*includes 1 patient who had multiple perforations (2 in number)

Majority of the patients presented with perforation involving the antero-inferior quadrant (35patients). 27 patients had perforation involving the antero-superior and antero-inferior quadrant.

Table 8: Hearing loss among patients at the time of presentation

Air-bone gap (dB)	Small sized Perforation	Medium sized Perforation	Large sized Perforation	Multiple small perforations	Number of Patients
16dB-25 dB	25	4	-	-	29
26 dB-40 dB	22	27	-	-	49
41 dB-55 dB	-	2	17	1	20
56 dB-70 dB	-	-	2	-	2
71 dB-90 dB	-	-	-	-	0
> 91 dB	-	-	-	-	0
Number of Patients	47	33	19	1	100

29 patients had minimal hearing loss with 25 amongst them having small sized central perforation.

49 patients had mild hearing loss amongst whom 27 patients had medium sized central perforation. 20 patients had moderate hearing loss, amongst them 17 had large sized central perforation. All the patients had conductive hearing loss with no evidence of sensorineural hearing loss or mixed hearing loss in any of the patients.

Table 9: Healing time among patients

Healing time (in weeks)	Number of patients
2-4	5
4-8	46
8-12	34

Table 10: Management strategy amongst patients

Management	Number of patients
Conservative management	85
Myringoplasty	6
Trichloroacetic acid cauterly	9

In 85 patients, there was spontaneous healing of perforation without any active intervention. In 5 patients, perforation had healed within 1 month of trauma. In 46 patients, perforation healed during 4-8 weeks following trauma. In 34 patients, perforation healed in 8-12 weeks following trauma. In 15 patients there was no evidence of healing even after observation for a period of 12 weeks. Amongst them, 2 patients with small sized perforation and 7 patients with medium sized perforation, were treated with freshening of the margins of perforation by chemical cauterization using Trichloroacetic Acid. After freshening of the margins, splintage was provided by placing gel foam and maintaining sterile environment for aiding in healing. These patients were further observed for a period 8 weeks and healing of the perforation was noticed in all the patients. 6 patients with large sized perforation were treated with myringoplasty, healing of the perforation was observed in all of these cases.

Table 12: Improvement in hearing after the healing of perforation

		Air-bone gap (dB) after the healing of perforation				
		<15 dB	16-25 dB	26-40 dB	41-55 dB	56-70 dB
Air-bone gap (dB) at the time of presentation	16 dB-25 dB	29	-	-	-	-
	26 dB-40 dB	49	-	-	-	-
	41 dB-55 dB	20	-	-	-	-
	56 dB-70 dB	2	-	-	-	-
	71 dB-90 dB	-	-	-	-	-
	> 91 dB	-	-	-	-	-
	Number of Patients	-	-	-	-	-

All the patients showed improvement in hearing after the healing of perforation. Hearing Assessment by Pure Tone Audiometry was done after the perforation had healed spontaneously or following intervention.

Discussion

Incidents of trauma are on a gradual and exponential rise in India. The etiology of trauma varies and it could be due to assault, road traffic accidents, domestic violence, industrial and sports injuries. This has an impact on the economic, psychological and social well-being of the individual, their dependents and also on the nation at large. Trauma to the ear can result in a wide variety of injuries ranging from blunt trauma, pinna laceration to pinna avulsion, tympanic membrane perforation, dislocation of ossicles, longitudinal and transverse fractures of temporal bone leading to loss of inner ear and facial nerve function.

Trauma to the ear can occur in isolation or in association with facial injuries and injuries to other parts of the body. In the ear, tympanic membrane is usually traumatized by direct impact or by changes in air pressure that are transmitted to the tympanic membrane either from the lateral aspect through the external auditory canal or from the medial aspect due to air pressure changes in the middle ear. Incidence of trauma can be expected to be higher amongst rural population because of the occupation of these people which involves manual work and the greater time they spend outdoors when compared to people of urban areas.

In our study, majority of the patients to be affected by traumatic perforation were male and belonging to the age group of 31-40 years. In a study by Majumder JA *et al.*, adults in their 20s and 30s were the most affected and the incidence was common in men [8]. Also in studies by Rabbani, Dawood and Onotai the incidence of traumatic perforation of tympanic membrane was more in the 3rd decade of life [1, 9, 10].

Most of the studies conducted were not in the rural population. Our study was conducted amongst patients belonging to rural areas, who are likely to continue working as manual laborers in the outdoor, in their 4th decade of life and thus exposing themselves to risks of falls and trauma. And also due to the lower socio-economic background, they tend to be involved in domestic violence and physical assault against one another to a greater extent. However, in the urban population the incidence is likely to be higher in the 3rd decade of life as the people in their 4th decade of life are likely to spend lesser time outside and are more involved in earning their livelihood through indoor jobs. Males are involved more than females due to the greater time spent by males outside their homes and a tendency to be exposed to trauma due to falls and assaults due to aggression.

In studies by Lindeman P *et al.* and Lou ZC *et al.*, a higher prevalence of traumatic perforation of the Tympanic Membrane was noted in females [3, 11]. This was in contrast to the findings of our study. In our study, tympanic membrane of left ear was involved in majority of the cases. Similar findings were noted in the studies conducted by Lindeman *et al.*, Berger *et al.* and Sarojamma *et al.* [11, 12, 13]

In our study, the most common etiology for ear trauma was assault. The likely cause for greater involvement of right ear could be that the majority of individuals are right-handed and during assault, they tend to use their right hand to inflict trauma on the person facing them such that the left side of victim's body is traumatized. Hence, injuries to the left ear seem to be greater. In our study, most common etiology for the perforation was assault followed by Road Traffic Accidents. This was similar to a study by Lou ZC *et al.*, Yamazaki K *et al.* [3, 14]. The incidence of assault cases was higher amongst females when compared to males due to the physical abuse which occurs as a result of domestic violence, which is greater in people of rural areas with lower socio-economics status and educational background. Slaps were commonly inflicted on females by the males of their homes. The cause of assaults in males were fights outside homes. Road traffic accidents also resulted in 21 cases as the usage of vehicles especially two-wheelers for the purpose of transportation has increased amongst the rural population. But, there is no use of head protection gear amongst these individuals due to lack of education, further increasing their risks to facial and head trauma following falls. Ear picking was a major cause for traumatic perforations of the tympanic membrane in a study conducted by Yamazaki K *et al.* [14] In several studies, aural manipulation was found to be a leading cause for traumatic perforation of the tympanic membrane. Aural manipulation was found to have been carried out for various purposes such as attempts to remove foreign bodies or wax, cleaning of the ear in an unskilled manner by self, family members or untrained individuals approached by the patients [4, 15, 16, 17].

In our study, irrespective of the cause of tympanic membrane perforation, tinnitus was the most common presenting feature, followed by Aural fullness and hearing loss. These findings were similar to a study by Wani *et al.* where most common complaint was tinnitus followed by aural fullness and reduced hearing [6]. Tinnitus occurs as a result of passage of air from the external auditory canal into the middle ear through the defect in the tympanic membrane leading to hissing sound and was more commonly seen in patients having small central perforation. Traumatic tympanic membrane perforation results in decrease in the vibratory area of tympanic membrane leading to hearing loss. In the studies by Berger *et al.*, da Lilly-Tariah and Somefun hearing loss was the commonest complaint followed by tinnitus and otalgia [12, 13].

Majority of the patients had single perforation except one patient who had multiple perforations that were 2 in number and both these perforations were small in size. This was similar to the findings in a study by Wani *et al.* [6]. This was the patient who had history of exposure to bursting of a cracker in close proximity. Sudden increase in air pressure in the vicinity of bursting of cracker could be transmitted through the external ear on to the tympanic membrane resulting in multiple perforations. A similar consequence could result from incidents which cause sudden increase in air pressure such as bursting of tyres due to overpressure or exposure to blasts. Incidence of multiple perforations was relatively rare in most of the studies.

Pars tensa being under relatively greater tension and being larger in area when compared to the pars flaccida is more likely to be damaged due to trauma. The changes in air pressure impact over the pars tensa which is under greater tension and hence offers higher resistance. Hence, perforations are predominantly central. However, size of the perforation varies which may depend on the extent of variation of air pressure in the external auditory canal and also on the size of the object used to manipulate the external auditory canal. The central portion of the tympanic membrane is more predisposed to rupture from pressure as the central portion of the pars tensa is the most dependent part of the tympanic membrane with poor blood supply [19].

Majority of the patients had small sized central perforation followed by medium sized central perforation. This was similar to a study by Rasool *et al.* where 72% of the cases had small sized central perforation [20]. In a study by Wani *et al.*, medium sized central perforation was

noticed in the majority of patient [6].

In our study, Tympanic membrane damage had occurred in the Antero-inferior quadrant in most of the cases. Similar findings were noted in a study where 59.4% of the patients had perforation in the antero-inferior quadrant [21]. However certain studies showed different results as in a study by Bhargava *et al.*, Posteroinferior quadrant was the commonly injured quadrant [22]. Due to perforation of the tympanic membrane, the effective vibratory area of the membrane is reduced. The sound waves are likely to impact over the oval window and the round window at the same time leading to cancellation of the mechanical energy that sets the basilar membrane in motion. Both these factors contribute to the hearing loss experienced by the patients with tympanic membrane perforations. The degree of hearing loss depends on the size and location of perforation. Hearing loss is likely to increase with an increase in the size of perforation. The size of the perforation is directly proportional to the decibel loss in sound perception. According to several authors the site of perforation is likely to have an effect on the magnitude of hearing loss. Perforations in the posterior quadrant are more likely to cause greater hearing loss as this leads to exposure of the round window leading to cancellation of any vibrations being transmitted to the inner ear. However, according to certain authors, the site of perforation has no significant effect on the extent of hearing loss in patients [23]. In a small perforation, the edges of the perforation present a certain amount of frictional resistance to the passage of sound and this friction increases with increase in frequency. Thus, in smaller perforation less sound will pass through and nullify the primary pressure and still less sound of higher frequency will pass through. Therefore, the hearing loss is less in smaller perforations than in larger ones and more for lower frequencies than for higher frequencies [24]. According to Thorburn hearing loss is lesser in anterior perforations and greater in posterior perforations due to loss of round window shielding effect in posterior perforations [25].

According to Simpson *et al.* larger perforations cause more deafness [26]. In our study, majority of the patients had mild hearing loss on pure tone audiometry, in the range of 26 dB to 40 dB, this was similar to a study by Wani *et al.* [6] As majority of the cases in our study had small perforations, the hearing loss in the cases was minimal to mild.

In our study, majority of the patients showed evidence of spontaneous healing without any active intervention within 8 weeks of injury. This was similar to a study by Wani *et al.*, Kristensen S *et al.*, Ijaduola [6, 20, 28].

In our study 15 patients required active intervention. There were 2 techniques of active intervention carried out. All the 15 patients had large sized central perforation. The patient who had multiple perforations underwent tympanoplasty. Majority of the perforations showed spontaneous healing underlining the importance of conservative wait and watch policy. In our study, significant improvement in hearing was noted in all the patients after healing of the perforation. It was evident from our study that even large sized perforations if provided with ideal environment showed good healing with conservative management. Tympanoplasty was done only in large sized perforations, showing that about one-thirds of the patients with failure of healing required surgical intervention.

Conclusion

Traumatic perforation of the tympanic membrane incidence in rural population is on a rise. The mechanism of trauma in rural population is comparable to the general population. People from rural areas need to be educated and this may result in their socio-economic improvement thus reducing the incidence of trauma due to assault both at home and outside home. Foreign body removals from ear should be attempted only by skilled professionals. The incidence of trauma is more in the middle-aged males. Prognosis is better in patients presenting with small sized perforation where spontaneous healing was noted. A large sized perforation needs more

meticulous management with continuous observation so that an intervention can be made at the right time. Improvement in hearing appears to be good in all the patients with traumatic perforation of tympanic membrane.

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