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ORIGINAL ARTICLE

Evaluation of Hearing Loss in Tympanic Membrane Perforation

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Abstract To evaluate and analyse the hearing loss in tympanic membrane perforation based on size, site and duration of perforation. The material for this study was comprised of 100 patients of either sex and of age 15 years and above selected randomly. Size of tympanic membrane perforation was assessed under microscope using calibrated wire look. Patients were divided into three groups according to size; group I (0–9 mm^2), Group II (9–30 mm^2), Group III ($\geq$ 30 mm^2); according to site into anterior and posterior group; according to involvement of malleus into malleolar and non malleolar and according to duration into Group A (<1 year), Group B (1–5 years), Group C ($\geq$ 5 years). Hearing loss was measured in each case with pure tone audiometry. Data was analysed statistically using paired *t*-test. Hearing loss increased as the perforation size increased [I vs. II ($t - 4.23, p < 0.001$), II vs. III ($t - 8.19, p < 0.001$), I vs. III ($t - 11.68, p < 0.001$)]. Hearing loss was more in posterior quadrant perforation than anterior quadrant perforation but difference was not significant statistically ($t - 1.15, p > 0.05$). Hearing loss was more in malleolar perforation ($t - 5.74, p < 0.001$). Hearing loss increased as the duration of disease increased [A vs. B ($t - 2.01, p < 0.043$), A vs. C ($t - 5.49, p < 0.001$), B vs. C ($t - 4.14, p < 0.001$)].

Keywords Hearing loss · Perforation · Tympanic membrane

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Introduction

Tympanic membrane is a membranous partition separating the external auditory meatus from the tympanic cavity, measuring 9-10 mm vertically and 8-9 mm horizontally [1]. It plays a major role in middle ear transformer mechanism. Tympanic membrane perforation is caused by variety of causes, the most common being trauma and infections. Trauma (Barotrauma, temporal bone fracture), Infections (Acute otitis media, chronic otitis media, TB), Intragenic (ventilation tubes). Tympanic membrane perforation leads to varying degree of conductive hearing loss. Loss of hearing is a national health problem with significant physical and psychosocial problem. So it is important to diagnose and treat tympanic membrane perforation as early as possible as untreated tympanic membrane perforation leads to ongoing destructive changes in the middle ear, thus adding to further hearing loss. The incidence of otitis media and tympanic membrane perforation is high in our region; so we have undertaken this study.

Aims and Objectives

1. To assess the effect of size and site of tympanic membrane perforation, on degree of hearing loss.
2. To evaluate the effect of duration of tympanic membrane perforation on hearing.

Materials and Methods

For the study, 100 patients of either sex and of age 15 years and above presenting with dry perforations of tympanic membrane with no history of active middle ear disease, unilateral or bilateral, were selected randomly.

A thorough history was taken in each case, followed by detailed examination and investigations. Then, the evaluation of hearing loss was done in each case of dry tympanic membrane perforation with no history of active middle ear disease at the time of presentation, depending on the size, site and duration of perforation.

To estimate the diameter of perforation a 1 mm thin wire hook was taken. Readings were taken under microscope. Two diameters were taken for each perforation, one maximum vertical and the other maximum horizontal. Area was calculated as:

Area of perforation $= \pi R_1 R_2$

where π is the 3.14159 constant, R_1 is the radius along the vertical axis, R_2 is the radius along the horizontal axis.

Depending upon the area, perforations were divided into 3 groups:

Group I = Small perforation: 0–9 mm^2.
Group II = Medium sized perforation: 9–30 mm^2.
Group III = Large perforation: >30 mm^2.

The average surface area of intact tympanic membrane was taken as 64.3 mm^2 [2].

The location of each perforation was determined anterior or posterior with respect to an imaginary line drawn across the tympanic membrane at the level of manubrium.

Perforations were divided into malleolar or non-malleolar depending upon whether the malleus was involved or not.

Depending upon the duration of disease, perforations were divided into 3 groups:

- Group A = <1 year
- Group B = 1–5 years
- Group C = ≥5 years

Routine Investigations

- Hb
- TLC
- DLC
- X-ray both mastoids lateral/oblique view was done in every case to know the involvement of mastoid air cell system.

The type, degree and frequency of hearing loss was determined by:

1. Tuning fork test.
2. Pure tone audiometry.

The association of degree of hearing loss was matched with the characteristics of perforation and result thus obtained was evaluated.

Table 1 Demographic profile of patients

Age	Range (mean ± SD)	15–55 years (28.27 ± 11.59)
Sex	Male	52
	Female	48
Socio economic status	Urban	38
	Rural	62
Ear involved	Right	30
	Left	50
	Both	20
Mode of onset disease	Chronic otitis media	84
	Trauma	16

Results

The study comprised of 100 patients. 20 cases had bilateral involvement. So total number of ears involved in our study were 120.

Demographic profile of the patients is as shown in Table 1.

Symptoms

The most common symptoms were hearing loss in 91(91%), 84(84%) had presented with on and off discharge from ear in past. Other symptoms like tinnitus 46(46%) and itching were present in 58 (58%) patients.

Duration of Disease

33 (28%) patients had disease for less than <1 year. In this group most of the patients had trauma as the cause of discharge and hearing loss.

42 (35%) patients had disease in the range of 1–5 years, and 45 (37%) patients had disease for ≥5 years.

Size of Perforation

On the basis of surface area of tympanic membrane involved, all the ears with perforation were divided into three groups.

Maximum number of patients were found in group I that is 56 (47%) and followed by 41 (34%) in group II. Minimum number of patients were in group III, that is 23 (19%).

This trend shows that people are becoming more and more aware of their health related problems and so they seek the medical advice as early as possible. As with long standing disease the perforation size increases.

Site of Perforation

Based on the site of perforation, they were divided into anterior, posterior and involving multiple quadrants. 45

(38%) ears had perforation in the anterior quadrant which were further subdivided into superior and inferior, thus they were classified as AS 6 (5%), AI 32 (27%), AS + AI 7 (5.8%). 35 (29%) had perforation in the posterior quadrant which were further subdivided into PI 24 (20%), PS 10 (8%), PS + PI 1 (0.8%). 40 (33%) had perforation involving the multiple quadrant. In this group those perforations had been taken which had either involved both the anterior and posterior quadrants together like AI + PI 2 (1.7%) or had involved more than 2 quadrants like PI + AI + AS 8 (6.7%) and involving all the 4 quadrants i.e. AS + AI + PS + PI 30 (25%) ears.

Malleolar/Nonmalleolar

In the present study, 21 (18%) cases were having malleus involved in the disease process and 99 (82%) cases were having perforation in which handle of malleus was intact. Handle of malleus get involved in long standing disease and in case of large subtotal perforation of long duration.

Tuning Fork Test

Rinne's test was negative in all diseased ears 120 (100%) cases. Weber's test was lateralised to worse ear in 106 (89%) cases while, 14 (11%) cases had indeterminate Weber's. This is because in those cases both ears were having almost equal degree of hearing loss.

X-Ray Findings

X-ray mastoids lateral oblique view of 100 patients revealed sclerosis in 59% patients and cellular mastoid in 41% patients.

Sclerosis of mastoid air cells can be congenital or the result of longstanding otitis media. Nevertheless, the process of sclerosis is more pronounced in a diseased ear than a healthy ear. Hence, the cases with sclerosed mastoid air cells outnumbered the cellular mastoid air cell system in our study.

Hearing Loss According to Size of Perforation

In our study hearing loss increased with increase in size of perforation at each frequency. In group I (0–9 mm^2) the mean hearing loss at 250 Hz was 31.43 ± 11.59 and at 4000 Hz was 19.91 ± 11.54. In group II (9–30 mm^2), the mean hearing loss at 250 Hz was 39.88 ± 11.43 and as the frequency increased hearing loss declined to 28.05 ± 10.50. In group III (≥30 mm^2), the mean hearing loss at 250 Hz was 55.22 ± 7.15 and 32.61 ± 6.01 at 4000 Hz.

On comparing the average hearing loss of one group with the other difference was found to be significant statistically as shown in Table 2. Average hearing loss increased as the perforation size increased.

Table 2 Comparison of average hearing loss of all the groups (according to size of perforation)

Groups	Average hearing loss (range in db)	Mean (in db)	±SD
Group I (0–9 mm^2) ($n = 56$)	11.67–61.67	23.90	10.05
Group II (9–30 mm^2) ($n = 41$)	15.00–48.33	32.07	8.44
Group III (≥ 30 mm^2) ($n = 23$)	31.67–56.67	45.51	7.32

Groups	't' value	'p' value	Significance
I vs. II	4.23	<0.001	Highly significant
I vs. III	11.68	<0.001	Highly significant
II vs. III	8.19	<0.001	Highly significant

Hearing Loss According to Site of Perforation

In our study, perforations were divided into three groups anterior (AI, AS, AS + AI), posterior (PI, PS, PS + PI), Multiple (AI + PI, PI + AS + AI, all 4). Hearing loss was calculated at each frequency. Hearing loss for anterior perforation at 250 Hz was 31.56 ± 13.77, for posterior perforation 36.29 ± 10.17 and for the perforation with multiple quadrant involvement was 49.39 ± 10.26. As the frequency increased hearing loss showed a decline trend.

Comparison revealed that posterior perforation caused more hearing loss than anterior perforation at all the frequencies. But the difference was not significant statistically as shown in Table 3.

So our study showed that effect of location, if any, on hearing was small.

Hearing Loss in Malleolar/Non-malleolar Perforation

Average hearing loss in malleolar perforation was 43.02 ± 9.70. Average hearing loss in non-malleolar perforation was 28.25 ± 10.90. Hearing loss in malleolar

Table 3 Comparison of average hearing loss of all the groups (according to site of perforation)

Groups	Average hearing loss (mean ± SD) (in db)
Anterior ($n = 45$)	24.93 ± 12.47
Posterior ($n = 35$)	27.62 ± 10.65
Multiple ($n = 40$)	40.29 ± 9.25

Groups	't' value	'p' value	Significance
Anterior vs. posterior	1.15	>0.05	Not significant
Anterior vs. multiple	6.38	<0.001	Highly significant
Posterior vs. multiple	6.65	<0.001	Highly significant

Table 4 Comparison of average hearing loss in malleolar and non malleolar perforation

Groups	Average hearing loss (mean ± SD) (in db)		
Malleolar ($n = 21$)	43.02 ± 4.70		
Non malleolar ($n = 99$)	28.25 ± 10.90		
Groups	't' value	'p' value	Significance
Malleolar vs. non malleolar	5.74	<0.001	Highly significant

Table 5 Comparison of average hearing loss of all the groups (according to duration of disease)

Groups	Average hearing loss (mean ± SD)		
<1 year ($n = 33$) Group A	23.89 ± 11.22		
1-5 year ($n = 42$) Group B	28.69 ± 9.62		
≥5 years ($n = 45$) Group C	37.93 ± 11.10		
Groups	't' value	'p' value	Significance
A vs. B	2.01	0.043	Significant
A vs. C	5.49	<0.001	Highly significant
B vs. C	4.14	<0.001	Highly significant

perforation was more than non-malleolar perforation. Difference was significant statistically ('p' value < 0.001) as shown in Table 4.

Hearing Loss According to Duration of Disease

In our study, hearing loss increased as the duration of disease increased at all the frequencies. Comparison of average hearing loss in all the three groups showed that average hearing loss increased, statistically significantly as the duration of disease increased as shown in Table 5.

All the perforations were divided into three groups according to duration of disease and hearing loss at each frequency was noted in all the three groups. Hearing loss at 250 Hz in group A (<1 year) was 32.58 ± 12.51 and in group B (1–5 years), it was 37.02 ± 12.55 and in group C (≥5 years) 45.22 ± 13.73.

Hearing loss was more in group C, followed by group B and group A in decreasing order. Hearing loss decreased as the frequency increased in each group.

Discussion

The study comprised of 100 patients. 20 cases had bilateral involvement of ears, so total number of ear involved in our study were 120.

Demographic Profile of Patients

It is as shown in the Table 1.

Age

The age of patient ranged from 15–55 years, the mean age of presentation being 28.27 ± 11.59.

Incidence of tympanic membrane perforation was found to be maximum (66%) in the age group of 11–30 years. The reason for more number of patients in this age group may be attributed to the patients becoming more cautious socially about their hearing at this age and because of professional necessities or due to marriageable age group.

The mean age of presentation in a study of Caye Thomasen et al. was 13.3 years [3].

Sex

In our study of 100 patients 52 patients were males and 48 were females. Male to female ratio was 1.14:1. The presentation of male patients slightly outnumber the female. This could be due to the male sex being more aware of their disease and the incapacity produced because of the disease, as they are the working members of our society.

The number of males to females in a study of 120 patients by Kurian et al. [4] were 55 and 45% respectively.

Socioeconomic Status

In our study 38 (38%) patients were from urban area and 62 (62%) were from rural area. This difference was due to illiteracy, poor sanitary conditions, poor personal hygiene and over crowding in rural population leading to more incidence of disease in rural people.

Ramanuj and Anoop [5] observed that most patients with chronic suppurative otitis media were from rural areas.

Side of Ear Involved

In our study, 80 (80%) patients had unilateral disease with 30 (30%) having right ear and 50 (50%) left ear. 20 (20%) patients had bilateral involvement.

Mode of Onset

Chronic otitis media was found to be the most common (84%) cause and trauma being the 2nd commonest cause.

Chopra and Chopra in a study found the cause of perforation was infection and Eustachian tube dysfunction in 62% cases, trauma in 28% and cholesteatoma in 10% cases [6].

Symptoms

The most common symptoms were hearing loss in 91%, followed by episodic discharge in 84%, itching in 58% and tinnitus in 46% patients.

Gulati et al. [7] in their study reported that main symptoms were hearing loss and discharge.

Chandra et al. [8] showed the distribution of the cause of perforation in tympanic membrane as follows

CSOM: 20
Trauma: 06
Post myringoplasty: 08

Hearing Loss According to the Size of Perforation

In our study hearing loss increased with increase in size of perforation at each frequency.

On comparing the average hearing loss of one group with the other difference was found to be statistically significant as shown in Table 2. Average hearing loss increased as the perforation size increased.

Ahmad and Ramani [9] stated that the hydraulic action arising from the difference in area of TM and of the stapedial footplate is the most important factor in impedance matching. When the surface area is decreased, there will be decrease in amplification and hearing loss will be proportionate to size of perforation. The average hearing loss in dB for each frequency according to their study was:

Frequency (in Hz): Hearing loss (in dB)	250	500	1000	2000	4000
Small perforation	19	18	17	18	8
Large perforation	27	27	17	17	13

Voss et al. [10] studied that hearing loss increased as the perforation size increases.

Gulati et al. [7] in a study of 21 patients with safe otitis media reported a linear relation between size of perforation and amount of hearing loss.

Frequency (in Hz): Hearing loss (in dB)	250	500	1000	2000	4000	Pure tone average
Anterior	31.56	27.78	24.44	21.56	19.67	24.93
Posterior	36.29	32.71	26.14	24.00	24.71	27.62
Multiple Quadrants	49.38	45.25	39.50	36.13	31.63	40.29

Voss et al. [10] stated that hearing loss does not depend on the location of perforation.

Shambaugh [11] in a study of 42 ears with tympanic membrane perforation classified group C perforation (size 20–30% of surface area of TM) into anterior and posterior groups and found that there was no statistically significant difference between two means at any frequency.

Mehta et al. [12] stated that hearing loss does not vary substantially with location of the perforation. Effects of location, if any, are small.

Our study is comparable with the study conducted by above authors.

Shah et al. [13] is his study observed that malleolar perforations had significantly greater hearing loss than non-malleolar perforations.

The study is also in agreement with Anthony and Harrison and Ahmad and Ramani, who also found greater hearing loss in malleolar perforation.

Conclusion

- Average hearing loss increased statistically significantly as the perforation size increased [I vs. II ($t - 4.23$, $p < 0.001$), II vs. III ($t - 8.19$, $p < 0.001$), I vs. III ($t - 11.68$, $p < 0.001$)].
- The mean hearing loss for anterior perforation was (24.93 ± 12.47) and for posterior perforation it was (27.62 ± 10.65). There is definitely a difference in mean hearing loss but the difference is not significant statistically ($t - 1.15$, $p > 0.05$). So effect of site, if any, on the hearing loss was small.
- The average hearing loss in malleolar perforation, (43.02 ± 9.70) was more than non malleolar perforation 28.25 ± 10.90 and the difference was statistically significant ($t - 5.74$, $p < 0.001$).
- The mean hearing loss at all the frequencies increased as the duration of disease increased and the difference was statistically significant [A vs. B ($t - 2.01$, $p < 0.043$), A vs. C ($t - 5.49$, $p < 0.001$), B vs. C ($t - 4.14$, $p < 0.001$)].

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