Original Research Article

Evaluation of hearing loss in relation to tympanic membrane

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Abstract

Background: 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. The present study was an attempt to evaluate the hearing loss in tympanic membrane perforation based on size and site of perforation. **Material and Methods:** This study consisted of 50 randomly selected patients with dry unilateral or bilateral perforations of tympanic membrane. Each patient underwent complete ENT examination and hearing loss was assessed by pure tone audiometry. **Results:** All tympanic membrane perforations, irrespective of its size and location caused hearing loss (average 18 dB).Larger perforations caused more hearing loss than small perforations. The hearing loss increased as the size of perforation increased. Perforations in postero-inferior quadrants resulted in more hearing loss (25.7 dB average) as compared to the perforations in antero-inferior quadrants (14.2 dB average), whether they are malleolar or non-malleolar. **Conclusion:** The degree of conductive hearing loss increased statistically with increasing size of tympanic membrane perforation, as well as the posteriorly placed perforations resulted in more hearing loss than anteriorly placed perforations.

Key Words: Conductive hearing loss, tympanic membrane, perforation.

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INTRODUCTION

Loss of hearing is a national health problem with significant physical and psychosocial disability to the patient[1]. Chronic suppurative otitis media (CSOM), a wide spread disease of the developing countries like India, is one of the commonest causes of variable degree of hearing loss. CSOM mainly results due to a tympanic membrane perforation. 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[2].Perforation of the tympanic membrane is caused by variety of causes, the most common being Infection (acute otitis media, chronic otitis media, TB) and trauma (self-inflicted, Iatrogenic). It leads to varying degree of conductive hearing loss[3]. In routine otological practice, tympanic membrane perforations are very frequently met with, but the patients hardly ever present with deafness as the chief presenting complaint. Many of the patients deny any hearing loss even on questioning by the otologist and Free Field Hearing Tests may not reveal any appreciable hearing loss. It has been generally believed that the degree of hearing loss increases with the size of the perforation[4,5]. If the perforations are bilateral, hearing handicap becomes more evident. Correlation of the site of perforation to hearing loss is not very clearly established, Though few studies have shown postero-inferior perforation caused more hearing loss than others, because of the direct exposure of the round window to sound waves, and perforations at or near the site of tympanic membrane attachment to manubrium have more severe effects on hearing than those of comparable size at different sites[6]. However, some workers believe that there is no significant effect associated with location of the

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perforation[1,7]. Ears with perforation typically have additional pathological changes, so a better description of perforation effects on middle-ear function is needed so that clinicians know what magnitude and frequency of hearing loss to expect with perforations of various sizes. With such information, clinicians will be able to predict whether hearing loss is solely the result of a perforation or if additional pathologies are involved. Therefore, the present study was an attempt to correlate the size and site of perforation and the hearing loss. Accurate assessment of the TM perforation and its relationship with hearing loss is important as it enables the clinician to optimally assess the condition and offer an appropriate solution.

MATERIAL AND METHODS

Thiscross-sectional prospective observational study consists of 50 randomly selected patients with dry perforations of tympanic membrane, (unilateral or bilateral) who were attending Ear, Nose and Throat OPD at a tertiary care hospital in Maharashtra.

Inclusion Criteria

1. Presence of central perforation in pars tensa.
2. Absence of ear discharge (Patients having active ear discharge were treated, so as to make the ear dry and were taken up for the study subsequently)
3. Absence of any other pathology, like unhealthy middle ear mucosa, granulations, aural polyp, cholesteatoma, tympanosclerosis. Absence of any adjacent infective foci, like adenoid or tonsillar sepsis, gross DNS, nasal polypi or sinusitis. Absence of any history of ear surgeries in the past.
4. Sufficiently wide external auditory canal.
5. Cases having only pure conductive deafness were included in our series.
6. Age between 10 to 60 years. Patients of either sex and irrespective of cause of perforation.

Exclusion Criteria

1. Patients with other associated ear pathology, like otomycosis, acute and chronic otitis externa, etc.
2. Patients with sensorineural hearing loss or mixed hearing loss.
3. Active CSOM
4. Patients with ossicular chain pathology, Atticoantral disease- presence of cholesteatoma or granulation tissue.
5. Patients who cannot give a valid and consistent PTA response

A detailed history was taken in each case, followed by routine examination and investigations. Each patient underwent complete ENT examination by head mirror, otoscopic examination and microscopic examination of both ears according to standard guidelines. Other investigations, like pure tone audiometry done according to standard guidelines in a sound proof room[8,9].

Site of perforation: The site of perforation was noted in the four quadrants of pars tensa viz. anterosuperior, anteroinferior, posterosuperior and posteroinferior with respect to an imaginary line drawn across the tympanic membrane at the level of manubrium, and perpendicular to this line at the level of umbo of manubrium.[10]

Size of Perforation: The size of the perforation was measured by using a calibrated 1 mm thin wire hook, graduated in ½ mm steps. Readings were taken under microscope. Two diameters were taken for each perforation, one maximum vertical and the other maximal horizontal. Area was calculated as:

Area of perforation = $\pi R_1 R_2$ (where π was the 3.14159 constant, R_1 was theradius along the vertical axis, R_2 was the radius along the horizontal axis).

Grouping of perforations were considered on the basis of diameter of the perforation and tympanic membrane loss in surface area as percentage.Based on diameter, perforations were divided into 'small' perforations (perforations upto 2 mms in diameter) and 'Large' perforations (perforations more than 2 mm in diameter).

Based on the surface area of tympanic membrane: The average effective surface area of intact tympanic membrane in adults was taken as 64.3 sq mm[10]. The perforations have been placed in the following groups depending on percentage of area involved as suggested by Ahmad and Ramani[11].

Group A: 10% of tympanic membrane surface area (up to 6.5 sq mm).

Group B: 10%-20% of tympanic membrane surface area (i.e. between 6.5 to 12.8 sq mm).

Group C: 20%-40% of tympanic membrane surface area (i.e. between 12.9 to 25.6 sq mm).

Group D: > 40% of tympanic membrane surface area (i.e. more than 25.6 sq mm).

Relation of Perforation with Handle of Malleus: With the use of microscope, the relation of perforation with handle of malleus was recorded and they were divided into:

1. Malleolar - perforations which were touching the handle of malleus.
2. Non-malleolar - perforations not touching the handle of malleus.

Degree of Hearing Loss: Tuning fork tests, free field hearing and pure tone audiometry were done to assess the nature and degree of hearing loss at the time of presentation, depending on the size, site of perforation. The patient's hearing levels in decibel were assessed with a biologically calibrated "Elkon eda-3-N-3 multi" diagnostic audiometer. Audiometry was done in sound proof room and records made for frequency 125, 250, 500, 1000, 1500, 2000, 3000, 4000, 6000 and 8000 Hz for air conduction and from 250-4000 Hz for bone conduction.

Other investigations such as X-ray mastoid- Schuller's view were also done.

Statistical Analysis: The collected data was tabulated and analyzed using appropriate and relevant statistical tests. Computer package Epi Info 3.5.3 and Vassarstats Statistical software was utilized for data management and analysis. The p-value were calculated to find out the significance of correlation of various parameters with hearing loss. p-value <0.05 was considered as significant. The result thus obtained were evaluated.

RESULTS

In this study maximum number of patients i.e., 22 (44%) were seen in age group of 21–30 years followed by 17 (34%) in 11-20 years and the lowest number of cases 2 (4%) were seen between age group of 51–60 years.The numbers of male and female patients were 27 (54%) and 23 (46%) respectively. The male to female ratio was 1.17:1. Table 1 shows the average conductive hearing loss of all the perforations (50 cases). In the present study, the maximum hearing loss in all the perforations at 125 Hz was 30 dB and gradually decreasing to a minimum of 8 dB at 8000 Hz. The hearing loss in all perforations was found to be fairly uniform between 1000 to 3000 Hz (18–15 dB). For small perforations i.e. ≤2 mm diameter (14 cases) the maximum of 20 dB hearing loss was seen over 125 Hz and minimum of 2 dB at 8 KHz. The hearing loss was fairly uniform between 1 KHz and 4 KHz (9–5 dB).We found strong relation between size of the perforation and degree of hearing loss. The relation between size of the perforation and degree of hearing loss at all the frequencies tested, was statistically significant with P-Value < 0.05, means the difference between hearing loss in small size perforations(≤2 mm diameter) and large perforations (>2 mm diameter) was statistically significant (p<0.05) in all frequencies. The larger the perforation, the more was the hearing loss. The hearing loss was seen more in the lower frequencies in both small and large perforations.

Table 1: Average conductive hearing loss of all the perforations

Frequencies (Hz)	Hearing Loss (dB) Small Perforations (N- 14) [Mean]	Large Perforations (N- 36) [Mean]	All Perforations (N- 50) [Mean]	ANOVA One Way (F Statistic, p value)
125	20	34	30	37.97, < 0.05
250	17	31	27	27.64, < 0.05
500	14	28	24	23.02, < 0.05
1000	9	21	18	25.17, < 0.05
1500	8	20	16	18.50, < 0.05
2000	8	19	16	16.38, < 0.05
3000	6	18	15	23.98, < 0.05
4000	5	15	13	14.34, < 0.05
6000	4	12	10	19.54, < 0.05
8000	2	10	8	25.88, < 0.05

The hearing loss for each group A to D (four groups of perforation sizes expressed as percentage of tympanic membrane area loss are shown in Table 2.

Table 2: Hearing Loss – Percentage of Tympanic Membrane Loss

Frequencies (Hz)	Hearing Loss (dB) GroupA (N – 14) [Mean]	Group B (N – 14) [Mean]	Group C (N – 15) [Mean]	Group D (N – 7) [Mean]	ANOVA One Way (F Statistic, p value)
125	20	29	35	44	34.30, < 0.05
250	17	24	31	43	35.82, < 0.05
500	14	20	28	43	39.49, < 0.05
1000	9	14	22	34	38.57, < 0.05
1500	8	13	20	34	31.22, < 0.05
2000	8	13	19	31	22.28, < 0.05
3000	6	13	19	30	25.40, < 0.05
4000	5	6	18	27	43.31, < 0.05
6000	4	7	12	21	28.92, < 0.05
8000	2	8	10	16	17.88, < 0.05

In group A (<10% tympanic membrane surface area loss i.e. up to 6.5 sq.mm perforation area) the maximum hearing loss at 125 Hz was 20 dB and at 8000 Hz it was 2 dB. The hearing loss was fairly uniform between 1– 4 KHz i.e. (9– 5 dB). In group B (10-20% tympanic membrane surface area loss i.e. 6.5-12.8 sq.mm perforation area) the hearing loss at 125 was 29 dB and at 8000 Hz was 8 dB, and between 1– 4 KHz it was 14–6 dB. In group -C (20-40% area loss i.e. 12.9-25.6 sq.mm perforation area) the maximum hearing loss at 125 Hz was 35 dB and at 8 KHz was 10 dB, and between 1-4 KHz it was 22–18 dB. In group D (>40 % tympanic membrane area loss i.e. >25.6 sq.mm perforation area) hearing loss at 125 Hz was 44 dB, at 8 KHz was 16 dB and between 1– 4 KHz was 34–27 dB. Table 3 shows the comparative hearing loss in all malleolar perforations (29 cases) and all non-malleolar perforations (21 cases). In this study, all cases of non-malleolar perforations (21 cases) showed average hearing loss at 125 Hz maximum of 25 dB, which gradually decreased to 5 dB at 8 KHz frequency. Hearing loss was fairly uniform between 1– 4 KHz i.e. 12–6 dB.

Table 3: Hearing loss in all malleolar and Non-malleolar perforations

Frequencies (Hz)	Hearing Loss (dB)		ANOVA One Way (F Statistic, p value)
	All Non-malleolar Perforations (N-21)[Mean]	All Malleolar Perforations (N-29)[Mean]	
125	25	34	14.97, < 0.05
250	20	31	17.59, < 0.05
500	18	28	15.12, < 0.05
1000	12	22	16.70, < 0.05
1500	11	21	14.29, < 0.05
2000	10	19	14.11, < 0.05
3000	9	19	20.03, < 0.05
4000	6	17	24.01, < 0.05
6000	5	13	21.06, < 0.05
8000	5	10	11.52, < 0.05

In all malleolar perforations (29 cases), average hearing loss at 125 Hz was 34 dB and at 8 KHz was 10 dB. Between 1– 4 KHz average hearing loss was between 22–17 dB. The difference between hearing loss caused by large malleolar perforations and the large non-malleolar perforations was statistically significant at all the frequencies with p value < 0.05.Large malleolar perforations caused more hearing loss than the large non-malleolar perforations. Hearing loss was more in lower frequencies than higher frequencies in both groups. In the present study, the average hearing loss at 125 dB was maximum, i.e., 17 dB in small antero-inferior perforations and 30 dB in large antero-inferior perforations. The minimum hearing loss was seen at 8 KHz, 0 dB in small and 6 dB in large antero-inferior perforations. Fairly uniform hearing loss of 7–4 dB and 16–11 dB was seen between 1– 4 KHz frequencies in small antero-inferior and large antero-inferior perforations respectively. There was a statistically significant difference found between hearing loss caused by small antero-inferior perforations and large antero-inferior perforations at all the frequencies (p value < 0.05), except at 2 and 4 KHz, at which it was not significant (p value > 0.05). The hearing loss was more in the large antero-inferior perforations group, especially at low frequencies than small antero-inferior perforations.

Table 5: The significance of hearing loss with different quadrants

Site	ANOVA One Way (F Statistic, p value) at 125 Hz	Significance
Small AI Vs Large AI	19.06, < 0.05	Significant
Small PI Vs Large PI	35.09, < 0.05	Significant
Small AI Vs Small PI	09.67, < 0.05	Significant
Large AI Vs Large PI	23.69, < 0.05	Significant
All AI Vs All PI	15.49, < 0.05	Significant

In this present study, small postero-inferior perforations (3 cases) caused maximum hearing loss of 23 dB at 125 Hz and minimum of 3 dB at 8 KHz. Large postero-inferior perforations (15 cases) caused maximum hearing loss of 40 dB at 125 Hz and minimum of 15 dB at 8 KHz. But in these two groups the hearing loss was almost uniform at all frequencies (17 dB more at 125 Hz and 12 dB more at 8 KHz).There was a statistically significant difference between hearing loss caused by small postero-inferior perforations and large postero-inferior perforations at all the frequencies with p value < 0.05.Lower frequencies were affected more than higher frequencies in both the groups. And hearing loss was more in large postero-inferior perforations than small postero-inferior perforations. Comparisons have been made between hearing loss in all anterio- inferior perforations (24 cases) whether malleolar or non-malleolar and all perforations in postero-inferior quadrants (18 cases). In this study, the average hearing loss of 28 dB was seen at 125 Hz in all antero-inferior perforations and 37 dB in all postero-inferior perforations. The minimum of 5 dB hearing loss was seen at 8 KHz in all antero-inferior perforations and 13 dB in all postero-inferior perforations. Between 1– 4 KHz, a fairly uniform hearing loss of 14–9 dB was seen in antero-inferior and 26–20 dB in postero-inferior perforations. The hearing loss was more in postero-inferior quadrant perforations at all frequencies more marked at 250, 500 Hz (15–16 dB more). At other frequencies the difference remains almost uniform, around 10 dB. The statistically significant difference was seen between the hearing loss caused by all antero-inferior perforations and all postero-inferior perforations at all frequencies with p value < 0.05. The hearing loss was more at lower frequencies than higher frequencies in both group cases. In small antero-inferior perforations (5 cases), the hearing loss of 17 dB at 125 Hz and 0dB at 8 KHz was seen. In small postero-inferior perforations (3 cases) hearing loss was 23dB at 125 Hz and 3 dB at 8 KHz. The hearing loss between 1– 4 KHz was between 7–4 dB in small antero-inferior perforations and 12–7 dB in small postero-inferior perforations. Lower frequencies were affected more than higher frequencies in both groups. However, the difference between above groups was more marked in frequencies upto 1000 Hz. There was statistically significant difference found between hearing loss in small antero-inferior perforations and small postero-inferior perforations at 125, 250, 500 Hz and at 8 KHz frequencies only (p value < 0.05), however difference in hearing loss in both groups at 1, 1.5, 2, 3, 4, 6 KHz frequencies was statistically not significant (p value > 0.05). In the present study, the hearing loss at 125 Hz was 30 dB in large antero-inferior perforations and 40 dB in large postero-inferior perforations. At 8 KHz, hearing loss was of 6 dB in large antero-inferior perforations and 15 dB in large postero-inferior perforations. Between 1– 4 KHz hearing loss was fairly uniform i.e. between 16–11 dB in large antero-inferior perforations and between 29–22 dB in large postero-inferior perforations. The hearing loss in large postero-inferior groups of perforations was more than in large antero- inferior group and it is quite uniform at all frequencies except, at 6KHz and 8KHz (8–9 dB more) whereas, on other frequencies the hearing loss was 13–16 dB more in postero-inferior group. The difference in hearing loss caused by large antero-inferior perforations and large postero-inferior perforations was statistically significant at all frequencies tested with p value < 0.05. Hearing loss was more at lower frequencies than at higher frequencies in both group cases.

DISCUSSION

The present study includes 50 patients presenting with tympanic membrane perforations. The age range included in this study was between 10 to 60 years and mean age was 26 years. The mean age of presentation in a study of Kulwant KP *et al*[12]was 28.3 years and in Mehta RP *et al*[5]study, it was 25.6 years. Out of 50 patients, 27 (54%) were male patients and 23 (46%) were females. The male: female ratio was found to be 1.17:1 in this study. The results were similar in the study of Lerut B *et al*[13] with 54% males and 46% females. In this study the average hearing loss in all frequencies was found to be 18 dB in all perforations, which compares well with, 19 dB by Anthony and Harrison *et al*[14] and 15 dB by Ahmad and Ramani[11]. This study showed that small perforations resulted in 17dB hearing loss in low frequencies (<1 KHz) as compared to 3dB hearing loss at high frequencies (>4 KHz) which compares well with Ahmad and Ramani[11], Anthony and Harrison *et al*[14] and Mehta RP *et al*[5]. Middle frequencies (1-4 KHz) showed fairly uniform hearing loss with average of 7dB. Larger perforations caused average hearing loss of 31dB in lower frequencies, 19dB in middle frequencies and gradually decreasing to 11dB at higher frequencies. The difference in hearing loss in small and large perforations was statistically significant (p < 0.05)[5,11,14]. From these observations, it was found that, hearing loss was seen to be higher in larger perforations as compared to smaller perforations. It was also found from these observations that, hearing loss was greater at lower frequencies than at higher frequencies in all the study including present study. So, the results of the present study are matching with these other previous studies. In our study, it was noticed that hearing loss varies between 22.5 to 12 dB in low to high frequencies in malleolar perforations as compared to the range of 16 - 6 dB in non-malleolar perforations. The average hearing loss of malleolar perforations in our study was 22 dB and in non-malleolar perforations it was 12 dB which was statistically significant (p < 0.05). In the study done by Kulwant KP *et al*[12], average hearing loss in all cases of malleolar perforations was found to be of 43dB and in non-malleolar perforations it was 28.25 dB irrespective of sizes of the perforations and frequencies studied. Shah *et al*[4], in his study observed that malleolar perforations had significantly greater hearing loss than non-malleolar perforations. It has been noticed that the hearing loss in malleolar perforations is higher than the non-malleolar perforations. Again, this was significantly seen in lower frequencies as compared to the higher frequencies. Besides the above observations, the larger perforations whether malleolar or non-malleolar, produced more hearing loss than the smaller perforations. Thus, the findings that the malleolar perforations cause more hearing loss than non-malleolar perforations were well substantiated. The average hearing loss of all antero-inferior perforations at all the frequencies and in all sized perforations was 14 dB and hearing loss of all postero-inferior perforations irrespective of the frequencies and size was 25 dB. The difference in hearing loss in antero-inferior perforations and postero-inferior perforations was statistically significant (p value < 0.05).The hearing loss of all antero-inferior perforations irrespective of the frequencies and size of perforation studied was 22 dB in Ibekwe TS *et al*[15] study and 25 dB in Kulwant KP *et al*[12] study. The hearing loss of all postero-inferior perforations irrespective of the frequencies and size of perforation studied was 35 dB in Ibekwe TS *et al*[15] study and 27.5 dB in Kulwant KP *et al*[12] study. The postero-inferior perforations caused more hearing loss than the antero-inferior perforations whether the perforations were small or large. Again the low frequencies were more affected than high frequencies and larger the perforation, greater was the hearing loss. Our findings in table no.20 shows a range of 16 - 7 dB in low to high frequencies in antero-inferior perforations whereas a range of 25 - 14 dB was noticed in postero-inferior perforations. This closely tallies with observations of Anthony and Harrison[14] and also of Ahmad and Ramani[11], particularly with respect to the postero-inferior perforations. Voss *et al*[7] stated that hearing loss does not depend on the location of perforation. This study is not matching the result of our study. Mehta RP *et al*[5] stated that hearing loss does not vary substantially with location of the perforation. Effects of location, if any, are small. Thus, we find that the degree of conductive hearing loss increased statistically with increasing size of tympanic membrane perforation, as well as the posteriorly placed perforations resulted in more hearing loss than anteriorly placed perforations.

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