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ORIGINAL ARTICLE

A Study to Assess the Effect of Size & Site of Tympanic Membrane Perforation on Hearing Loss

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Abstract The objective of the study was to assess the effect of size & site of tympanic membrane perforation on hearing loss. The study was carried out in ENT department of a tertiary health care hospital, between October 2018 and March 2020 (a total of 18 months). Patients aged 15–50 years having chronic otitis media with dry central perforation were included in the study after taking informed written consent and were evaluated with detailed history, clinical examination including otomicroscopy, tuning fork tests and pure tone audiometry. The patients were then posted for Tympanoplasty and just prior to the procedure, the tympanic membrane perforation size was measured using the Castroviejo caliper and site was noted using otomicroscopy. The status of the middle ear mucosa and ossicles were also analyzed to ensure normal middle ear mucosa and normal ossicular mobility and continuity and only then were these patients included in the study. All the patients in the study were evaluated for hearing loss using air conduction measurements in pure tone audiometry done at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz and 4000 Hz. Hearing loss was found to be directly proportional to the size of perforation in our study. The site of the perforation has a significant association with the degree of hearing loss. Those perforations with posterior quadrant involvement and multiple quadrant involvement had a higher hearing loss. From our study, we concluded that there is a significant relationship between size and site of the perforation and the amount of hearing loss.

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Keywords Size of perforation · Site of perforation · Tympanic membrane

Abbreviations

dB	Decibels
SD	Standard deviation
Hz	Hertz

Introduction

The hearing mechanism is one of the most intricate system of the human body. Environmental sound undergoes transduction into several forms from acoustic to mechanical to neural in process of hearing. Auditory system is high fidelity transducer & processor.

Tympanic membrane has very important function in impendence matching transformer action of middle ear. It transmits sound through ossicular chain to cochlea.

Otitis media is inflammation of a part or all of the mucoperiosteal lining of the middle ear cleft which can result in permanent perforation in the tympanic membrane [1].

Surface area of tympanic membrane is 55 mm^2 which is responsible for amplification of sound by 22 dB [2]. Therefore, decrease in the surface area of tympanic membrane leads to loss of or decrease in amplification. Perforations of the tympanic membrane reduce the efficiency of the drum component of the middle ear impedance matching transformer [3].

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 [3].

The degree of hearing loss will also depend on the location of the tympanic membrane perforation and the middle ear status. Large perforations will generally cause greater hearing loss compared to smaller defects. In addition, perforations overlying the posterior part of mesotympanum and thus the round window niche, usually cause more severe degrees of conductive hearing loss because the tympanic membrane is no longer protecting the round window membrane from direct sound energy transfer. As a result, there is reduction in the "baffle" effect, leading to a change in cochlear mechanics [4].

Objective

To assess the effect of size & site of tympanic membrane perforation on hearing loss.

Methods

- *Study type* Prospective Observational.
- *Sample size* Sample size is 81 as per calculation.

It was conducted in ENT department at a Tertiary health care hospital.

All the data were entered on Excel sheet® and analyzed. All the quantitative data were summarized in the form of Mean ± SD. The difference between mean value of all groups was analyzed using ANOVA test in Open EPI software. All the qualitative data were summarized in the form of number and percentage. Data presented in the form of charts wherever applicable. The levels of significance and α error were kept 95% and 5% respectively, for all statistical analysis. P value < 0.05 was considered as Significant (S) and > 0.05 as Nonsignificant (NS).

Inclusion Criteria

- All patients belonging to both genders in the age group of 15–50 years with chronic otitis media with dry central perforation having good cochlear reserve and healthy middle ear mucosa.

Exclusion Criteria

- Patients below 15 years and above 50 years of age, having active (wet) central perforation, retraction pockets and cholesteatoma or patients with mixed hearing loss.

Patients aged 15–50 years having chronic otitis media with dry central perforation were included in the study after taking informed written consent in vernacular language. All the patients included in the study were evaluated with detailed history, clinical examination including otomicroscopy, tuning fork tests and pure tone audiometry. The patients were then posted for Tympanoplasty and just prior to the procedure, the tympanic membrane perforation size was measured using the Castroviejo caliper and site was noted using otomicroscopy. The status of the middle ear mucosa and ossicles were also analyzed to ensure normal middle ear mucosa and normal ossicular mobility and continuity and only then were these patients included in the study.

Measurement of Size of Perforation

Size of the perforation was measured using a Castroviejo caliper with measurement scale from 0–20 mm with a minimum measure of 1 mm. On otomicroscopy, this caliper is introduced in the external canal and the vertical and horizontal diameters of the perforation are measured. The area of the perforation is calculated using the formula:

$$\text{Area of perforation} = \pi R1R2$$

where R1 is the radius along the horizontal axis and R2 is the radius along the vertical axis (Figs. 1, 2).

- Patients will be divided into 3 groups depending upon size of perforation

Group I 0–9 mm^2 (Small).
Group II 10–30 mm^2 (Medium)
Group III > 30 mm^2 (Large)

Fig. 1 Castroviejo caliper to measure the size of perforation

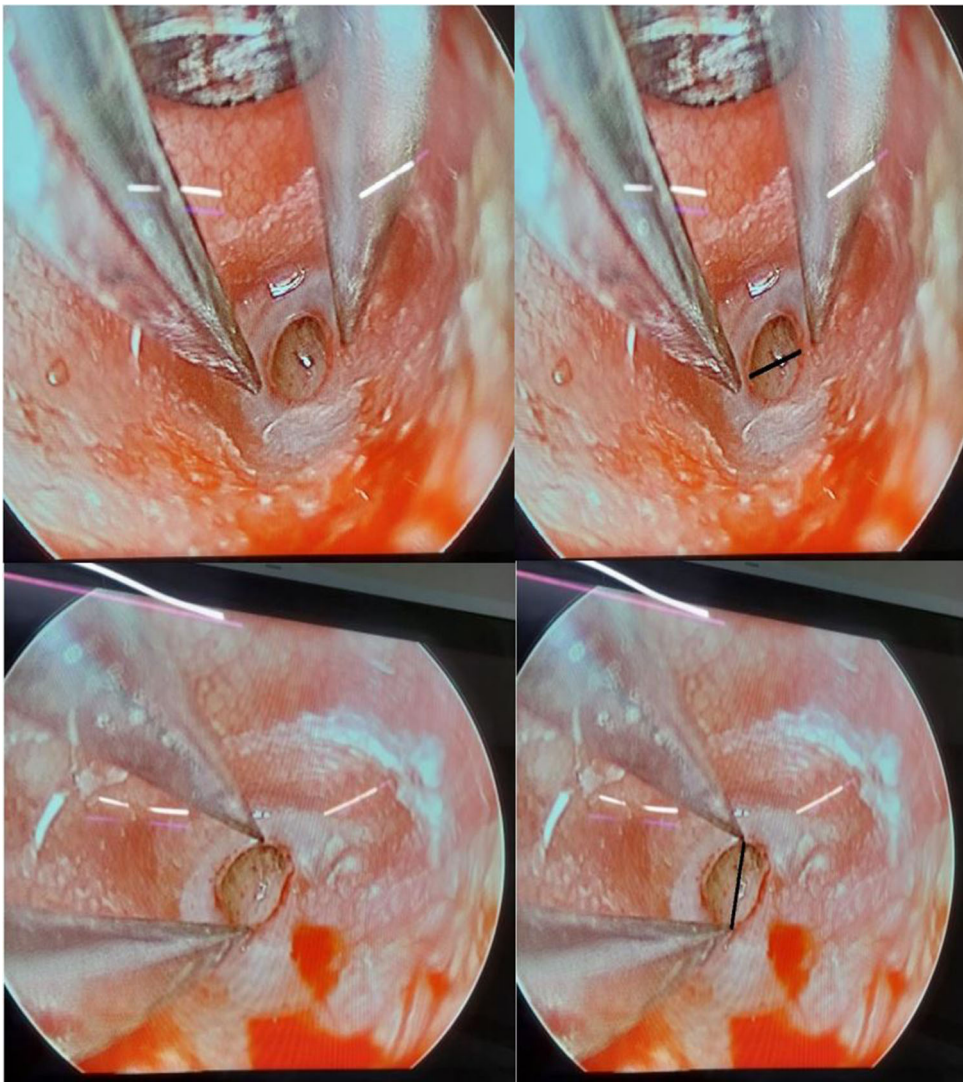

Fig. 2 Measurement of horizontal and vertical radius of perforation using Castroviejo caliper

Assessment of the Site of Perforation

Tympanic membrane (pars tensa) will be divided in four quadrants by two imaginary lines, one passing through manubrium of malleus anteroinferiorly & another line passing through umbo, perpendicular to first line thus dividing tympanic membrane in anterosuperior, anteroinferior, posterosuperior and posteroinferior quadrants [5].

- Patients will be divided into 3 groups depending upon site of perforation

Group A–Perforation anterior to manubrium of malleus.

Group B–Perforation posterior to manubrium of malleus.

Group C–Multiple quadrant perforation- In our study, multiple quadrant perforation refers to both anterior and posterior perforation combined.

All the patients in the study were evaluated for hearing loss using pure tone audiometry done at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz and 4000 Hz. The hearing loss in terms of air conduction for each patient in the three groups according to their sizes of perforation was calculated in Decibels for each of the above-mentioned frequencies. The mean was calculated and compared.

Results

Total 81 patients were enrolled for this study. All of these patients with dry central pars tensa perforations of the tympanic membrane due to COM were divided into three groups based on the size of perforation:

Group I–0–9 mm^2

Group II–10–30 mm^2

Group III– $> 30\ mm^2$

Each group consists of 27 patients.

Further, all the 81 patients were divided into 3 groups based on the site of perforation:

Group A–Anterior quadrant
Group B–Posterior quadrant
Group C–Multiple quadrant

Highest number of patients were in the younger age group (15–20 years). The mean age at presentation was 29.50 years. Out of total 81 patients, 21 patients were male and 60 patients were female. The male to female ratio was 1:2.85. most common complaint was ear discharge in the past, complained by 90.12% of patients, followed by decreased hearing found in 58.02% patients, earache in 56.79% and tinnitus was found in 6.17% patients.

All the patients in the study were evaluated for hearing loss using pure tone audiometry done at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz and 4000 Hz. The hearing loss in terms of air conduction for each patient in the three groups according to their size and sites of perforation was calculated in Decibels for each of the above-mentioned frequencies. The mean was calculated and compared (Tables 1, 2).

Correlation of Size of Tympanic Membrane Perforation with Mean Hearing Loss on PTA

The 81 patients in this study were divided into three groups based on the size of perforation consisting of 27 patients in each age group. For Group I with size of perforation 0–9 mm^2, the mean hearing loss on PTA was 30.93 dB +/−3.78 dB. For Group II with size of perforation from 9–30 mm^2, mean hearing loss on PTA was 36.94 dB +/−3.76 dB. For Group III with size of perforation > 30 mm^2, the mean hearing loss on PTA was 48.98 dB +/−3.45 dB. Hearing loss was found to be directly proportional to the size of perforation ($p < 0.05$, significant) (Table 3).

Correlation of Site of Tympanic Membrane Perforation with Mean Hearing Loss on PTA

The 81 patients under the study were divided into three groups based on the site of perforation Group A with anterior perforation had 38 patients and the mean hearing loss on PTA was 32.41 dB +/−3.73 dB. Group B with posterior perforation had 16 patients and the mean hearing loss on PTA was 37.55 dB +/−5.27 dB. Group C with multiple quadrant perforation had 27 patients and the mean hearing loss on PTA was 48.98 dB +/−3.45 dB. In this study, hearing loss was more in posterior and multiple perforations than in anterior perforations. ($p < 0.05$, significant) (Table 4).

Discussion

Tympanic membrane central perforation is a condition as old as the evolution of the human species. Tympanic membrane perforation is the most common sequelae of middle ear infection. It is reported in approximately 10% of episodes where perforations tend to occur in the pars tensa [6]; other causes of tympanic membrane perforation include trauma; direct trauma, acoustic trauma, barotrauma, iatrogenic causes and middle ear tumors. Tympanic membrane perforation is an identifiable cause of hearing loss. The incidence is high in the developing countries due to malnutrition, overcrowding, frequent upper respiratory tract infections encouraged by poverty and ignorance. The incidence is 6.8/1000 persons [7]. In our study, the predominant age group was mainly the young population. This reflects a higher disease burden in the younger population.

Hearing loss was found to be directly proportional to the size of perforation in our study. ($p < 0.05$, significant). In our study, it was observed that the hearing loss increases with the increasing size of perforation. This confers to the general belief that the larger the perforation; the greater the hearing loss and is comparable to other studies done globally by Kharadi et al. [5], Gupta S et al. [8], Ahmad et al. [9], Bhusal et al. [10], Nahata et al. [11], Kumar et al. [12], Risotovska et al. [13], Gudepu et al. [14], Rafique et al. [15], Vaidya et al. [16] and Nepal et al. [17] (Table 5).

In our study, the site of the perforation has a significant association with the degree of hearing loss ($p < 0.05$, significant). Those perforations with posterior quadrant involvement and multiple quadrant involvement had a higher hearing loss. This could be due the direct exposure

Table 1 Correlation of hearing loss at various frequencies on pure tone audiometry with the size of perforation

Frequencies on PTA	Mean hearing loss on PTA (dB)					
	250 Hz	500 Hz	1000 Hz	2000 Hz	3000 Hz	4000 Hz
Group I	33.52	34.81	31.48	28.33	28.89	28.52
Group II	39.07	39.26	36.67	36.48	35.74	34.44
Group III	48.52	49.44	51.11	48.89	48.52	47.41
Mean	40.37	41.17	39.75	37.9	37.72	36.79

Table 2 Correlation of hearing loss at various frequencies on pure tone audiometry with the site of perforation

Frequencies on PTA	Mean hearing loss on PTA (dB)					
	250 Hz	500 Hz	1000 Hz	2000 Hz	3000 Hz	4000 Hz
Group (A)	34.08	35.92	32.11	31.05	30.66	30.66
Group (B)	41.56	39.69	38.75	35.63	36.25	33.44
Group (C)	48.52	49.44	51.11	48.89	48.52	47.41
Mean	41.39	41.68	40.66	38.52	38.48	37.17

Table 3 Correlation of size of tympanic membrane perforation with mean hearing loss

Groups	Size of perforation	No. of patients	Mean hearing loss on PTA (dB)	Standard deviation	*P* value
I	0–9 mm^2	27	30.93	3.78	< 0.05
II	9–30 mm^2	27	36.94	3.76	
III	> 30 mm^2	27	48.98	3.45	

Table 4 Correlation of site of tympanic membrane perforation with mean hearing loss

Groups	Site of perforation	No. of patients	Mean hearing loss on PTA	Standard deviation	*P* value
A	Anterior	38	32.41	3.73	< 0.05
B	Posterior	16	37.55	5.27	
C	Multiple quadrant	27	48.98	3.45	

of the round window in the posterior perforations as shown in other studies. In case of multiple quadrant involvement hearing loss is even higher because of higher loss of surface area of tympanic membrane available for the normal hearing. This results in loss of the phase differential necessary for one to have perilymph movement [8, 11, 12]. The findings in our study are consistent with the below mentioned studies (Table 6).

Table 5 Comparison of hearing loss according to the size of perforation between different studies

Study	Mean hearing loss in dB on PTA		
	Small perforation	Medium perforation	Large perforation
Kharadi et al. [5]	27.1	31.4	43.5
Gupta et al. [8]	29.5	39.3	47.3
Ahmad et al. [9]	13	18.5	35
Nahata et al. [11]	29.41	34.69	38.79
Kumar et al. [12]	28.23	32.42	40.44
Rafique et al. [15]	22.9	30.7	44.51
Vaidya et al. [16]	28.23	38.42	40.44
Our study	30.93	36.94	48.98

Table 6 Comparison of hearing loss according to the site of perforation between different studies

Study	Mean hearing loss in dB on PTA		
	Anterior perforation	Posterior perforation	Multiple quadrant perforation
Pannu [3]	24.93	27.62	–
Gupta [8]	29.9	35.8	44.9
Ahmad [9]	13.5	20.7	–
Bhusal [10]	31	–	49
Nahata [11]	30.1	39.99	–
Kumar [12]	27.6	34.5	40.65
Rafique [15]	26.87	28.52	42.29
Vaidya [16]	31.06	42.96	45.51
Our study	32.41	37.55	48.98

Conclusion

Tympanic membrane perforations due to chronic otitis media are common in our setup and these could be attributed to risk factors such as low socioeconomic status which result in poor hygiene and overcrowding.

From our study, we concluded that there is a significant relationship between size and site of the perforation and the amount of hearing loss. Amount of conductive hearing loss increases with the increase in size of the perforation.

Similarly, perforation located in posterior quadrant of tympanic membrane with exposure of round window niche can cause more conductive hearing loss as compared to the perforation present in anterior part of tympanic membrane. Perforations involving multiple quadrants of the tympanic membrane have more hearing loss possibly because of the more loss of vibratory surface area of tympanic membrane.

Thus, this study is helpful to predict the amount of hearing loss based on the size and site of perforation. A thorough knowledge of these attributes would allow us to decide upon the most effective interventions for the patients of chronic otitis media at the correct time.

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Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Ethical Approval The study was approved by the Institutional Ethics Committee. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards."

Informed Consent Informed consent was obtained from all individual participants included in the study.

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