COMPARATIVE STUDY OF HEARING LOSS WITH SITE AND SIZE OF PERFORATION

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ABSTRACT

Chronic otitis media leads to ear discharge, hearing loss and tympanic membrane perforation. Tympanic membrane perforation leads to hearing loss. Perforation in the tympanic membrane can be seen in different quadrants and of different sizes. Hearing loss varies in each individual depending on the perforation size, shape and position. This study is a comparative study of amount of hearing loss in the patients suffering from otitis media with Pars tensa perforation with size and position of the perforation.

KEYWORDS
Hearing Loss, Size of Perforation, Site of Perforation, Paper Patch Test.

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INTRODUCTION: Tympanic membrane perforations lead to recurrent ear infections and hearing loss. Persistent perforations occur either due to improper treatment of recurrent middle ear infections or infected traumatic perforations. The importance of this study is that it has been generally believed that the degree of hearing loss increases with the size of the perforation. Many prior clinical studies[1] have shown that hearing loss associated with perforation was more at low frequencies than at high frequencies and it increases with the size of perforation. Relation between the site of perforation to hearing loss is not very clearly established though a few studies have shown no significance of site of perforation. Similarly, the task of observing the site of the perforation of the tympanic membrane and its effect on the hearing loss was carried out. All the patients included in this sample, when subjected for otoendoscopy & recording were classified according to the site of the perforation and their hearing losses were charted and compared.

This study was possible only by the various infrastructural gadgets and helpful software which were used for the compiling and comparing. 0 degree Storz otoendoscope with viewing & recording facility was used, along with Image "J" software to compare the size of the perforation with the total area of the tympanic membrane, and report as a percentage. Audiological tests were done using a standard pure tone audiometer. The results were expected to be in line with whatever work has already been done, that is, the hearing loss to be proportionately increasing to the increase in the size of the perforation, that too, more so in lower frequencies.

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Glasscock and Shambaugh[2] state that "seemingly identical perforations in size and location produce different degrees of hearing loss. The reasons for the variations in the hearing effects of simple perforations are not easily defined." Mehta RP et al[3] documented that perforation of the TM is common and can result from various causes like trauma and Chronic otitis media, but TM perforations contribution to middle ear sound transmission were not well studied. Voss SE et al[4] in 2001 described middle ear function with perforations using measurements on normal cadaveric ears in which controlled perforations were made. These were simulated to resemble a perforation in a patient and various parameters were studied in detail, as acoustic measurements on cadaver ears have been shown to approximate the mechanical and acoustic properties of live ears, by various anatomists and physiologists. An earlier study by Anthony WP et al[5] in 1972, did a study in operated cases of myringoplasty, by comparing the preoperative and postoperative PTA readings; by using only those cases in which the air-bone gap was closed by myringoplasty, the variable of ossicular chain defects was controlled in the study. The most important finding of this study was that there was a greater loss in the low frequencies in the posteroinferior quadrant when compared to the anteroinferior quadrant; this particular finding was never encountered in any study.

In a study by Kumar UA and Bhat KV,[6] it was found that there was a relation between area of perforation and amount of hearing loss at 250 and 500 Hz, but not at other higher frequencies. Configuration and degree of hearing loss did not change with the site of the tympanic membrane perforation except in the anterosuperior quadrant. Kruger B and Tonndorf J[7] studied middle ear transmission in cats with experimentally induced perforations.

Kruger B and Tonndorf J[8] also studied tympanic membrane perforations in cats and determined the configurations of losses with and without ear canal extensions. The study made conclusions regarding flat audiometric losses in the mid frequency region as being due to pre-calibrated sound pressure levels in audiometers. Molvaer OI et al[9] measured the size of the middle ear and

the mastoid air cell by an acoustic method and found that the volume varied between 2»22 cm' with an average of around 6.5 cm. The size of the air cells, as proved earlier by many studies, affects the hearing of the patient by increasing/decreasing the size of the resonating chambers in and around the ear. Molvaer also postulated that a patient subjected to a mastoidectomy hears poorer than a patient subjected to plain myringoplasty/tympanoplasty. Bhusal CL et al[10] did a study to compare the level of preoperative hearing loss in different sizes of pars tensa perforation in patients with chronic suppurative otitis media undergoing myringoplasty. It was a prospective study. It was seen that the hearing loss was more at lower frequencies and less as the frequencies increase. It was also seen that the hearing loss increases with the increase in size of the perforation.

Ibekwe TS et al[11] took a sample of adult patients with a perforated tympanic membrane, in 2005-06 to investigate the relationship between the location of perforation on tympanic membrane and hearing loss. The authors concluded that the location of perforation has no effect on the magnitude of hearing loss in acute TM perforations, but has a significant impact in chronic TM perforations.

Jaisinghani VJ et al[12] used video otoendoscopy for a quantitative analysis of the perforated tympanic membranes. The ratio of the posterior angle to the anterior angle formed at the umbo seems to be a more reliable indicator of otitis media than the reduced length of the long process of malleus. Matsuda et al[13] conducted a quantitative analysis of tympanic membrane perforations using image analysis equipment. A significant correlation was found between the degree of sound conduction disturbance and the perforation area.

AIMS & OBJECTIVES:

1. To measure the size of the perforation in the tympanic membrane, as a ratio between the surface area occupied by the perforation and the surface area of the tympanic membrane; to record the site of the perforation with respect to the quadrant-division of the pars tensa.
2. To subject the patients fulfilling the study criteria to paper patch test and pure tone audiometry.
3. To correlate the size of perforation, and the site of the perforation with the audiological findings.

MATERIALS AND METHODS: Data for this study was collected from department of ENT, Andhra Medical College during the period of April 2015 to March 2016, sample size 112 cases.

Method of Study: All the patients presented to ENT Department with H/o of ear discharge and Hard of Hearing were taken proper History and Clinical, and local examinations were done. Tuning fork tests were done for hearing assessment. Patient was subjected to pure tone audiometry with a digital audiometer calibrated to ANSI standards. Air conduction and Bone conduction thresholds were recorded for the same frequencies. Paper patch test was done for ears having more than 20 dB hearing loss.

Inclusion Criteria:

1. Subjects with central tympanic membrane perforation due (tubotympanic disease).
2. Subjects with an intact ossicular chain- as confirmed by paper patch test.
3. Subjects aged between 10 to 60 years.

Exclusion Criteria:

1. Patients suffering from COM with squamosal disease (atticoantral disease).
2. Active chronic suppurative otitis media tubotympanic type.
3. Patients with ossicular chain pathology.
4. Patients who could not give a valid and consistent pure tone audiogram response.
5. Patients with Sensorineural hearing loss or mixed hearing loss.

The findings in otoendoscopy and audiometries were compared using "One-way analysis of variance (ANOVA), Tukey-Kramer Multiple Comparisons Test and Bartlett's test by using GraphPad software. The results obtained were incorporated in to the study as a documentary evidence for the credibility of the conclusions drawn from this study. Apart from ANOVA, Spearman's correlation and confidence levels were arrived at, using the same statistics proforma and the results were documented.

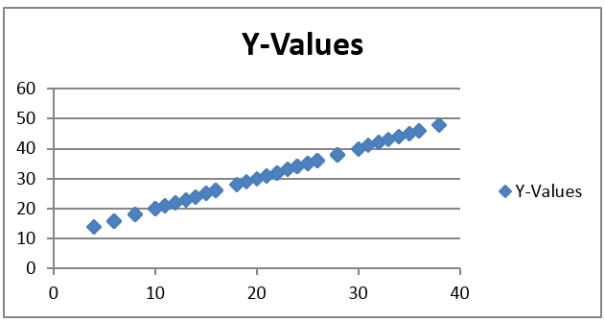
OBSERVATION AND RESULTS:

Age groups	Number
10-20	14
20-30	22
30-40	49
40-50	27
Total	112

Table 1: Age Distribution

Percentage of the tympanic membrane occupied by the perforation	Average hearing loss in dB
<10%	22(18-28)
10-20%	30(25-36)
20-30%	42(28-51)
>30%	50(43-58)

Table 2: Average Hearing Loss as per the Size of the Perforation



Average Hearing Loss as per the Size of the Perforation

Spearman Rank Correlation - Number of points = 112. Spearman r = 1.000 (corrected for ties).95% confidence interval: 1.000 to 1.000. Test: Is r significantly different than zero? The two-tailed P value is < 0.0001, considered extremely significant. The P value is approximate because exact calculations would have taken too long. Multiple groups: for the calculation of "p" value.

Size of the Perforation	Number of Patients	Average Hearing Loss
<10%	22	22(18-28)
10-20%	26	30(25-36)
20-30%	48	42(28-51)
>30%	16	50(43-58)

Table 3

The P value is <0.0001, considered extremely significant. Variation among column means is significantly greater than expected by chance. Tukey-Kramer Multiple Comparisons Test.

If the value of q is greater than 3.958 then the P value is less than 0.05.

Comparison	Difference	q	P value
Column A vs Column B	-7.333	2.850 ns	P>0.05
Column A vs Column C	-19.167	7.449	*** P<0.001
Column A vs Column D	-27.000	10.493	*** P<0.001
Column B vs Column C	-11.833	4.599	* P<0.05
Column B vs Column D	-19.667	7.643	*** P<0.001
Column C vs Column D	-7.833	3.044 ns	P>0.05

Difference	Difference	95% Confidence Interval From	To
Column A - Column B	-7.333	-17.518	2.851
Column A - Column C	-19.167	-29.351	-8.982
Column A - Column D	-27.000	-37.184	-16.816
Column B - Column C	-11.833	-22.018	-1.649
Column B - Column D	-19.667	-29.851	-9.482
Column C - Column D	-7.833	-18.018	2.351

Assumption Test: Are the standard deviations of the groups equal?

ANOVA assumes that the data are sampled from populations with identical SDs. This assumption is tested using the method of Bartlett. Bartlett statistic (corrected) = 2.599. The P value is 0.4576.

Bartlett's test suggests that the differences among the SDs is not significant.

Assumption Test: Are the data sampled from Gaussian distributions?

ANOVA assumes that the data are sampled from populations that follow Gaussian distributions. This assumption is tested using the method Kolmogorov and Smirnov:

Group	KS	P Value	Passed normality test?
Column A	0.2837	>0.10	Yes
Column B	0.2204	>0.10	Yes
Column C	0.1673	>0.10	Yes
Column D	0.2440	>0.10	Yes

Intermediate calculations. ANOVA table

Source of Variation	Degrees of freedom	Sum of squares	Mean square
Treatments (Between columns)	3	2607.5	869.15
Residuals (Within columns)	20	794.50	39.725
Total	**23**	**3402.0**	

F = 21.879 = (MS treatment/MS residual) Summary of Data Number Standard of Error.

Group	Points	Mean	Deviation	Mean	Median
Column A	6	22.167	3.920	1.600	20.500
Column B	6	29.500	5.992	2.446	29.000
Column C	6	41.333	8.477	3.461	42.500
Column D	6	49.167	5.981	2.442	47.000

Group	Minimum	Maximum	95% Confidence Interval From	To
Column A	18.000	28.000	18.052	26.281
Column B	22.000	36.000	23.211	35.789
Column C	28.000	51.000	32.435	50.231
Column D	43.000	58.000	42.889	55.444

So, according to the Spearman's correlation curve, the distribution of the patients is along a linear curve depicting the patients so that there is a linear progression between the patients' size of the perforation and their hearing losses.

According to the various statistical procedures used, ANOVA, Tukey-Kramer Multiple Comparisons Test, Bartlett statistic test; "p" value was found to <0.0001; proving the study and its results to be statistically significant.

Site of the Perforation:

Site	Number
Anteroinferior	11
Anterosuperior	6
Posteroinferior	5
Posterosuperior	0
Total	**22**

Table 4a: Patients with Perforation Occupying <10% of the Tympanic Membrane

Site	Hearing loss
Anteroinferior	20 dB
Anterosuperior	18 dB
Posteroinferior	22 dB
Posterosuperior	0
Average	22 dB

Table 4b: Hearing loss Patients with Perforation Occupying <10% of the Tympanic Membrane Average Hearing Loss

Spearman Rank Correlation - Number of points = 4; Spearman r = 0.4000.

Test: Is r significantly different than zero? The two-tailed P value is 0.7500, considered not significant.

Regardless of what data you enter, it is impossible for this test to yield P < 0.05 with so few data points.

Site	Number
Anteroinferior	13
Anterosuperior	7
Posteroinferior	5
Posterosuperior	1
Total	26

Table 4c: Patients with Perforation Occupying 10-20% of the Tympanic Membrane

Site	Hearing loss
Anteroinferior	28 dB
Anterosuperior	32 dB
Posteroinferior	32 dB
Posterosuperior	28 dB
Average	30 dB

Table 4d: Hearing Loss Patients with Perforation Occupying 10-20% of the Tympanic Membrane

Spearman Rank Correlation - Number of points = 4; Spearman r = 0.000 (corrected for ties).

Test: Is r significantly different than zero? The two-tailed P value is > 0.9999, considered not significant. The P value may be inaccurate because of ties. Regardless of what data you enter, it is impossible for this test to yield P < 0.05 with so few data points.

Site	Number
Anteroinferior	23
Anterosuperior	17
Posteroinferior	6
Posterosuperior	2
Total	**48**

Table 4e: Patients with Perforation Occupying 20-30% of the Tympanic Membrane

Site	Hearing loss
Anteroinferior	42 dB
Anterosuperior	38 dB
Posteroinferior	46 dB
Posterosuperior	42 dB
Average	42 dB

Table 4f: Hearing loss Patients with Perforation Occupying 20-30% of the Tympanic Membrane

Spearman Rank Correlation - Number of points = 4; Spearman r = -0.3162 (corrected for ties).

Test: Is r significantly different than zero? The two-tailed P value is 0.7500, considered not significant.

The P value may be inaccurate because of ties. Regardless of what data you enter, it is impossible for this test to yield P < 0.05 with so few data points.

Site	Number
Anteroinferior	7
Anterosuperior	4
Posteroinferior	3
Posterosuperior	2
Total	**16**

Table 4g: Patients with Perforation Occupying >30% of the Tympanic Membrane

Site	Hearing loss
Anteroinferior	46 dB
Anterosuperior	52 dB
Posteroinferior	52 dB
Posterosuperior	50 dB
Average	50 dB

Table 4h: Hearing Loss Patients with Perforation Occupying >30% of the Tympanic Membrane

Spearman Rank Correlation - Number of points = 4; Spearman r = -0.3162 (corrected for ties)

Test: Is r significantly different than zero? The two-tailed P value is 0.7500, considered not significant.

The P value may be inaccurate because of ties. Regardless of what data you enter, it is impossible for this test to yield $P < 0.05$ with so few data points.

Anteroinferior perforations were more common in this study, followed by anterosuperior perforations. Posterosuperior perforations were least of all. So, as is evident from these observations, the site of perforation doesn't change the hearing loss in dB; whatever the quadrant the perforation occupies; save for a deviation of ±2 dB, which is considered insignificant. Taking into consideration the distribution of various perforations among different quadrants of the tympanic membrane, a part of observation bias is also possible, given the size of the sample in which posterior quadrant perforations were seen.

DISCUSSION: The tympanic membrane serves as a key component of the tympano-ossicular system for the transmission of sound into the inner ear. Perforation of tympanic membrane is commonly seen in various inflammations of the middle ear, called as otitis media, because of its thin nature (0.1 mm), and its proximity to the external world.

COMPARISON OF RESULTS: In the present study, the size of perforation and PTA showed a significant positive correlation showing that the average hearing loss increased with increase in size of the perforation. It was also found that perforation induced hearing loss was greater at low frequencies than at high frequencies. Many studies have attempted to reason why these effects are seen in TM perforation and to examine the fundamental conductive functions of the drum and the middle ear.

1. The sample size was mostly found to be concentrated in the age group of 30-40 yrs. (43.75); followed by 20-30 yrs. age group (24.1%). This incidence of patients presenting to the OPD was most probably due to the awareness levels of the patients.
2. All the patients included in this study were subjected to audiometry and their average hearing losses were recorded and tabulated.
3. When the size of the perforation was measured by the Image "J" software, taking the size of the perforation as a ratio of the total surface area of the tympanic membrane; perforations occupying 20-30% of the tympanic membrane were the commonest, comprising 42.8% of the total sample; followed by perforations occupying 10-20% of the tympanic membrane, comprising 23.21%. When the size of the perforation was measured by the Image J software, taking the size of the perforation as a ratio of the total surface area of the tympanic membrane; perforations occupying 20-30% of the tympanic membrane were the commonest, comprising 42.8% of the total sample; followed by perforations occupying 10-20% of the tympanic membrane, comprising 23.21%. The perforation was photographed by an otoendoscope, and the image was plotted on x-axis & y-axis. The different coordinates were then matched with the coordinates obtained for the tympanic membrane and a ratio of the areas was taken. All the ratios were grouped into four groups, taking them as a range.
4. The average hearing loss is more in lower frequencies, increasing in dB as the size of the perforation goes on increasing; but that increment also is more in the lower frequencies only; as evidenced from the tables and bar diagrams.
5. According to the Spearman's correlation curve, the patients came to be arranged as a linearly progressing curve increasing towards right-hand side of the curve denoting that as the size of the perforation increases, the hearing losses also increase, but only in the low frequency ranges. As the ratio of the tympanic membrane occupied by the perforation goes on increasing, the deafness of that particular patient also worsens.
6. When various statistical procedures were used, like, ANOVA, Tukey-Kramer Multiple Comparisons Test, Bartlett statistic test; "p" value was found to <0.0001; proving the study and its results to be statistically significant. Meaning that what the study implies- the hearing loss rises with the rise in the size of the perforation linearly, that too more so in lower frequencies. Confidence levels, correlation coefficients were also found to be in the range of significance, lending credibility to the study and proving that this hypothesis can well be converted into a theory, depending on the significant "p" value.
7. When the hearing loss of the patients was evaluated as per the site of the perforation, no significant correlation was found; according to the spearman calculation, "p" value was found to be insignificant at all the sizes of the perforation. So, the hearing loss never correlated significantly in our study with the site of the perforation.
8. Results of this study confirm to these findings. The degree & frequency of hearing loss depends only on the size of the perforation and not on the site of the perforation.

CONCLUSIONS & SUMMARY:

- This study aims to understand the relation between the size of the perforation as a percentage of the total area of the tympanic membrane and the average hearing loss at various frequencies, as assessed by a pure tone audiometry.
- An image of the affected tympanic membranes was visualised by a 0 degree Hopkins rod and analysed using "IMAGE J" software.
- Spearman's correlation co-efficient & Kruskal-Wallis ANOVA which was used to analyse the relationship between size of perforation and hearing loss.
- Tympanic membrane perforations produced a hearing loss that was more at lower frequencies than high; irrespective of the size of the perforation.

- The average hearing loss was more in patients with larger perforations when compared to smaller perforations, & it was directly proportional.
- Hearing loss at low frequencies had a high positive correlation with size of the perforation.
- Hearing loss produced by a perforated tympanic membrane doesn't depend on the site of the perforation.
- Tympanic membrane perforations produced a hearing loss that was more at low frequencies than high. The average hearing loss increased with the increase in size of the perforation. Hearing loss at low frequencies had a high positive correlation with size of the perforation.

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