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Correlation of size of tympanic membrane perforation & degree of hearing loss and frequency specific hearing gain following tympanoplasty

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***Abstract*---**Introduction: The tympanic membrane (TM) serves as a key component of the tympano-ossicular system. Chronic otitis media is known to cause mild to moderate conductive hearing loss. Material & Methods: The proposed study was conducted on 50 patients of either sex in age group of 15-50 years having unilateral or bilateral chronic inactive (mucosal) otitis media after obtaining their consent. Pure tone audiogram was done to confirm the degree, type and frequency specific hearing loss from frequency 250Hz to 8000Hz for air conduction and 250Hz to 4000Hz for bone conduction. TM perforations were divided into Group I (small), II (medium), III (Large) according to size of perforation. Results: Average Hearing loss in Group I, II, & III was 33.86, 43.84 & 46.75 dB respectively. Hearing improvement following tympanoplasty at 250, 500, 1000, 2000, 4000, 8000 Hz was 20.50, 18.1, 16.7, 14.3, 12.0, 1.6 dB respectively. Conclusion: Hearing threshold level depends on size of the tympanic membrane perforation. Hearing improvement following tympanoplasty is frequency-dependent also.

***Keywords*---**correlation, tympanic membrane, hearing loss, tympanoplasty.

Introduction

Chronic suppurative otitis media represents one of the most common infections of the ear. It is a worldwide health problem which is still prevalent in the modern antibiotic era.[1] Chronic suppurative otitis media is characterized by intermittent or persistent chronic purulent discharge through a perforated tympanic membrane and can be associated with cholesteatoma.[2] 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. The tympanic membrane (TM) serves as a key component of the tympano-ossicular system. Chronic otitis media is known to cause mild to moderate conductive hearing loss.[3] Larger TM perforation is thought to be unlikely to heal with conservative management and probably require surgical intervention. However, there is debate in the literature over whether the size of TM perforation is predictive of surgical success.[4-6] In addition, it has been established that the larger the perforation, the greater the decibel loss in sound perception.[7] Frequency-specific hearing studies are important because the average pure tone threshold does not directly correlate to pattern of hearing perceptions.[8] In view of high incidence of chronic suppurative otitis media in our country and lack of studies on frequency specific hearing gain in myringoplasty and correlation of size of tympanic membrane on graft uptake, we have undertaken a prospective study to assess these parameters.

Aims and objectives

- To study the correlation of size of tympanic membrane perforation with degree of hearing loss.
- To study the post-operative frequency specific hearing gain.

Material and Methods

The proposed study was conducted on 50 patients of either sex in age group of 15-50 years having unilateral or bilateral chronic inactive (mucosal) otitis media with dry ear over a period of at least 4 weeks without use of topical or systemic antibiotics after obtaining their consent. All patients underwent a detailed evaluation based on history, general physical examination as well as complete ear, nose and throat examination. Tunning fork test and pure tone audiogram were done for preoperative assessment and to confirm the degree and type and frequency specific hearing loss from frequency 250Hz to 8000Hz for air conduction and 250Hz to 4000Hz for bone conduction.

Inclusion criteria

Patients in the age group of 15-50 years, uncomplicated perforation of pars tensa, that has remained dry for at least 4 weeks prior to surgery, good cochlear reserve and air bone gap more than 25 db on pure tone audiogram were included in the study.

Exclusion criteria

Patients with history of ear surgery in the past, age <15 years and >50 years, patients with hearing loss >60dB, actively discharging ear, presence of cholesteatoma, tortuous or narrow external auditory canal, marked deviated nasal septum and active sinus disease were excluded from the study. All selected patients (n=50) underwent underlay myringoplasty with temporalis fascia graft. Patients were taken up for surgery after the routine investigations were reported normal. All patients underwent pre-anaesthetic checkup. Anaesthesia preferred was local anaesthesia and all cases were operated under local anaesthesia.

Measurement of size of perforation

In the present study, the size of the perforation was measured by using measuring hooks specially prepared using dental wires. These hooks were of different sizes measuring from 2-7 mm in length. Two diameters vertical and horizontal were recorded for the tympanic membrane perforation. The area of the tympanic membrane perforation was calculated by using the formula:

Formula for the surface area = $\pi \times r_1 \times r_2$

Here, $\pi = 22/7$

r_1 is the radius along the vertical axis

r_2 is the radius along the horizontal axis.

Bhushal CL et al and Pannu KK et al, also measured size of perforation in similar fashion.[9,10]

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

- Group I: Small perforation: upto 8 mm^2
- Group II : Medium sized perforation: 9-30 mm^2
- Group III: Large perforation: > 30 mm^2

This division of perforations into groups based on size of area was also done by Mehta RP et al.[11]

Final result was assessed at 3 months and following assessment were made:

- Graft taken up or rejected.
- Pure tone audiogram.

The data was entered in Microsoft excel spreadsheet and later cleaned for possible errors. The data was analysed using SPSS software for Windows version 20.0. For quantitative data involving two groups, independent sample t-test was applied. For paired data, paired t-test was applied. For normally distributed three or more groups, ANOVA test was applied. Quantitative data was presented as mean and standard data. Chi-square test was applied for quantitative and qualitative data was presented as proportions.

Observations and Results

All patients were subjected to detailed history and examination, the findings of which were tabulated. The clinical profile, pre- and post-operative pure tone audiograms and results of surgery were also tabulated as per the master chart. The observations and results obtained are as follows:

Age and Sex Distribution: (Table 1)

Out of 50 patients, there were 27 male (54%) and 23 female (46%). Patients ranged from 15 years to 50 years. Maximum patients belonged to age group 15-25 i.e. 32 cases (64%). (Graph 1)

Table 1
Age and Sex Distribution

	15-25 years	26-35 years	36-50 years	Total	%age
Male	20	06	01	27	54
Female	12	08	03	23	46
Total	12	05	03	20	100

On applying chi-square test, value is 2.98 with degree of freedom value 2. The p value is 0.225.

Size of Perforation (Table 2)

Table 2
Distribution of patients according to size groups

SIZE OF PERFORATION	Number of cases	%age
Group I	19	38
Group II	26	52
Group III	05	10
Total	50	100

Audiological Assesment (Table 3)

Based on the pure tone audiogram, hearing loss was classified as mild (25-40 dB), moderate (41-55dB), moderately severe (56-70dB), severe (71-90dB) or profound (>90 dB). The average of hearing levels of frequencies 500 Hz, 1 KHz, 2 KHz and 4 KHz was taken. Out of 50, 29 (58%) of the patients were having conductive hearing loss in the range of 25-40 dB. 20 (40%) of patients were having hearing loss in the range of 41-55 dB while 01 (02%) patients were having hearing loss of 56-70 dB. (Graph 2)

Table 3
Audiological assessment
(On the Mean of four frequencies from 500 hz to 4 khz)

Degree of Hearing Loss	Hearing Loss in dB	Number of patients	%age
Mild	25-40 dB	29	58
Moderate	41-55 dB	20	40
Moderately Severe	56-70 dB	01	02
Severe	71-90 dB	00	00
Profound	>90 dB	00	00
Total		50	100

Comparison of Size of Perforation with Hearing Threshold Levels: (Table 4)

On comparing the hearing thresholds levels between Group I, II & III (as per Table 6) ; it was observed that the overall p-value was statistically very significant (p-value <0.001) on comparison between Groups I, II & III. However on Intergroup comparison, it was observed that p-value was statistically very significant (p-value <0.001) on comparison between Groups I & II and between Group I & III., but it was statistically insignificant on comparison between Group II & III (p-value=0.198). It indicates that hearing threshold levels does depend on size of the perforations and difference is statistically significant between small & medium sized perforations and between small & large sized perforations. But the difference is not statistically significant between medium & large sized perforations. As the size of perforation increases, hearing loss also increase.

Table 4
Size of perforation and hearing threshold levels

Groups	SIZE OF PERFORATION (AREA IN mm^2)	Mean±SD	Intergroup p-value
I	Up to 8 mm^2	33.86±1.58	I-II=<0.001
II	9 - 30 mm^2	43.84±5.56	II-III=0.198
III	> 30 mm^2	46.75±6.28	I-III=<0.001
		p-value<0.001	

Frequency Specific Pre-Operative and Post-Operative Hearing Thresholds of All Patients: Table 5

On comparing pre-operative and post-operative hearing threshold at individual frequencies from 250 hz to 8 khz, it was observed that p-value is statistically highly significant (p-value <0.001) at frequencies from 250 hz to 2 khz, and insignificant at 8 khz (p-value 0.073). It indicates that at higher frequency (at 8 khz), there is no significant change occur between pre and post-operative hearing thresholds. (Graph 6 & 7)

Table 5
Frequency specific pre-operative and post-operative hearing thresholds

	Mean±SD (250 hz)	Mean±SD (500 hz)	Mean±SD (1 khz)	Mean±SD (2 khz)	Mean±SD (4 khz)	Mean±SD (8 khz)
Pre-op	42.00±6.70	41.10±7.01	40.60±7.73	39.30±6.85	40.40±7.87	41.60±10.17
Post-op	21.50±8.93	23.00±7.69	23.90±7.71	25.00±6.54	28.40±6.88	40.00±8.97
P value	<0.001	<0.001	<0.001	<0.001	<0.001	0.073

Relationship between Graft Take up and Size of Perforation (Table 6)

On comparing graft uptake rates with 3 groups, it was observed that the p-value is statistically highly significant (p-value <0.001). It indicates that the size of the perforation does affect the graft takeup rate, with more chances of graft failure in large sized perforations**.** Graft take-up rate was 100% in Group I & Group II, while it was only 40% in Group III.

Table 6
Relationship between grafts take up and size of perforation

SIZE OF PERFORATION	No. of cases with Graft Takeup	No. of cases with Graft failure	Total
Group I (upto 8 mm^2)	19	0	19
Group II (9-30 mm^2)	26	0	26
Group III (>30 mm^2)	2	03	05
Total	47	3	50

Chi-square- 28.72, p-value <0.001

Follow-up examination and results (Table 7)

All patients were followed up on 10th day for suture and pack removal. Suture site and external ear were examined for any discharge or pus. In all patients, no discharge or pus was noticed on 10th day. Otoscopic findings are described as below in table.

Table 7
Follow-up examination and results

Otoscopic findings	10^{th} Day	4^{th} Week	2^{nd} Month	3^{rd} Month	6^{th} Month
1. Intact Graft	-	47 (94%)	47(94%)	47 (94%)	47 (94%)
2. Anterior sulcus blunting	-	-	-	-	-
3. Graft lateralization	-	-	-	-	-
4. Discharge	-	4(08%)	-	-	-
5. Residual perforation	-	-	-	-	-
6. Graft Rejection	-	-	-	3 (06%)	3(06%)

All patients presented themselves for regular follow up. Discharge was noted in four patients which resolved by change of antibiotic and three patients had graft rejection with residual perforation.

Relation between Sizes of the Perforation with the Hearing Gain: Table 8

When the mean hearing gain was studied between size groups (as per Table 8), it was found that the difference in hearing gain between Group I, II & III was statistically highly significant (p-value <0.001). It indicates that the amount of hearing gain does depend on the size of the perforation. In our study, it was noticed that amount of hearing gain in Group III was less as compared to the Group I & II. It was because out of 5 cases in group III, graft was rejected in 3 patients.

Table 8
Hearing gain in different size groups

Group	Size of the perforation	Mean HG±SD	Intergroup p-value
I	Up to 8 mm^2	13.66±1.59	A-B=0.001
II	9-30 mm^2	18.02±4.14	B-C=<0.001
III	> 30 mm^2	7.00±9.63	C-A=0.003
		p-value-0.001	

Frequency specific hearing gain: Table 9

On comparing the hearing gain at individual frequencies, it was observed that on ANOVA test, p-value between 6 frequencies was statistically highly significant (< 0.001). It indicates that the difference between hearing gain at individual frequencies is significant; which implies that with increase in frequencies from 250 hz towards 8khz, the amount of hearing gain at each frequency decreases. Maximum amount of hearing gain at 250 hz and minimum at 8 khz. (Graph 9)

Table 9
Frequency specific hearing gain

FREQUENCY (in hz)	Mean ±SD	N
250	20.5 ± 6.86	50
500	18.1 ± 6.69	50
1000	16.7 ± 6.74	50
2000	14.3 ± 5.53	50
4000	12.0 ± 5.53	50
8000	1.6 ± 6.18	50

p-value between groups is <0.001

Overall follow-up results (table 10)

Table 10
Overall follow-up results

	Number of cases	%age
1. Cases operated	50	100
2. Cases followed	50	100
3. Residual perforation	03	06
4. Graft rejection	03	06
5. Anterior sulcus blunting	-	-
6. Graft lateralization	-	-
7. Hearing improvement	Hearing gain in dB	
0-10	04	08
11-20	41	82
21-30	05	10
31-40	-	

Discussion

In the present study, age ranged from 15-50 years; patients younger than 15 years were excluded from the study. This age group was selected due to its likelihood of their proper and regular follow- up as well as to rule out failure of graft acceptance due to repeated upper respiratory tract infections as seen in children. In the elderly patients, presbycusis tends to blur the auditory functions. Maximum number of patients i.e. 64% were in the age group of 15-25 years, 28% of patients were in age group of 26-35 years and rest 08 % were in age group of 36-50. In our study, 54 % cases were males and 46% were female. This is because of the reason that male children usually in villages take bath in ponds and are more liable to suffer from CSOM as compared to females. Also males seek medical advice much more readily than females due to socioeconomic reason.

Hearing loss in perforation is due to loss of aerial ratio between tympanic membrane and stapes footplate and is usually conductive in nature. We have selected a criteria of good cochlear reserve and had A-B gap of more than 25 dB. In the present study all cases had conductive hearing loss and Weber was lateralized to affected ear. In bilateral involvement, Weber was lateralized to worse ear. Based upon pure tone audiogram, the hearing loss is classified as mild (25-40dB), moderate (41-55dB), moderately sever (56-70dB), severe (71-90dB), and profound (more than 90dB).[12] In the present study maximum no of patients, i.e. 58% were in the range of 25-40 dB and 20(40 %) were in the range of 41-55dB. The average of hearing levels of frequencies 500 Hz, 1 KHz, 2 KHz and 4 KHz was taken.

Size of perforation

In our study, out of the 50 cases, graft was taken up in 47 cases. In 3 cases, there was graft rejection at 3 month follow-up. So, the overall graft take-up rate was 94%. On studying the correlation between size of the perforation and graft take-up among Group I, II and III, the p-value on chi-square test is <0.001 (as per

table 21). It shows that graft take-up does depend on size of the perforation. Our this observartion is in accordance to earlier study by Lee et al.[13] However, Wasson JD et al reported that the size of the perforation is not a statistically significant determinant factor for myringoplasty success.[14]

On studying the hearing loss pattern between different size groups, it was observed that the hearing threshold levels does depend on the size of the perforation and p-value was <0.001 when 3 size groups (Group I, II & III) were compared among themselves (as per Table 11). Our this observation was in accordance with the most of the earlier studies by Wasson JD et al[14], Ahmad and Ramani[15], Matsuda Y et al[16] and Saliba I et al[17]. However, on Intergroup comparison, difference was statistically significant between group I & II (p-value <0.001) and between Group I & III (0.001). The difference was not statistically significant between Group II &III, which indicates that the relation between the size of the perforation and hearing threshold is not linear.

In our study, the average preoperative hearing level was 40.34 dB while the average postoperative hearing level was 25.08 dB, giving an average postoperative gain of 15.26 dB. On applying t-test, p value was <0.001 which was statistically highly significant. In our study, it was found that the difference in hearing gain between Group I, II & III was statistically highly significant (p-value <0.001). It indicates that the amount of hearing gain does depend on the size of the perforation. It was probably because the amount of hearing loss also depend on size of perforation. It was also noticed that amount of hearing gain in Group III was less as compared to the Group I & II. It was because out of 5 cases in group III, graft was rejected in 3 patients. When the amount of hearing gain was studied at each frequency, it was observed that on ANOVA test, p-value between 6 frequencies was statistically highly significant (< 0.001). It indicates that the difference between hearing gain at individual frequencies is significant; which implies that with increase in frequencies from 250 hz towards 8khz, the amount of hearing gain at each frequency decreases. Maximum amount of hearing gain at 250 hz and minimum at 8 khz. This observation was partially in accordance to the study done by Kent DT et al in which they stated that in the surgical success group, AC improved at all frequencies except at 4000 and 8000 Hz.[18]

Hearing threshold level depends on size of the tympanic membrane perforation perforation. As size of TM perforation increases, hearing loss also increases. Success of Myringoplasty can be accessed on two outcomes, graft uptake rate and hearing improvement. Graft uptake rate depend on size of the TM perforation, chances of graft failure are more in large size perforation. This finding is clinically relevant and can also be useful during informed written consent prior to myringoplasty. Hearing improvement following Myringoplasty varies according to size of TM perforation and it is more for medium and large size perforation as compared to small size perforation. The reason for this finding can be because the amount hearing of hearing loss was also more for larger perforation. Hearing improvement following Myringoplasty is frequency-dependent also. It is more for lower frequency, being maximum at 250 Hz, and as the frequency goes higher, the amount of hearing gain also decrease. It is minimum at 80 00 Khz.

Summary and Conclusion

Success of Myringoplasty can be accessed on two outcomes, graft uptake rate and hearing improvement. Graft uptake rate depend on size of the TM perforation, and does not depend on site of TM perforation. Hearing improvement following Myringoplasty varies according to size of TM perforation and it is more for medium and large size perforation as compared to small size perforation. Hearing improvement following Myringoplasty is frequency-dependent also. It is more for lower frequency, being maximum at 250 Hz, and as the frequency goes higher, the amount of hearing gain also decrease. It is minimum at 80 00 Khz. Hearing threshold level depends on size of the tympanic membrane perforation perforation.

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