Study of Outcome of Tympanoplasties in Relation to Size and Site of Tympanic Membrane Perforation

Sudhakar Vaidya · J. K. Sharma · Gurchand Singh

Received: 12 May 2014 / Accepted: 23 May 2014 / Published online: 8 June 2014
© Association of Otolaryngologists of India 2014

Abstract There are not many studies on the effect of the site and size of the perforation on the hearing loss. This study is set to investigate the relationship between the size and site of perforation and hearing loss. This study was carried out between September 2011 to September 2013, at a tertiary care centre during which 100 cases of chronic otitis media tubotympanic type having central perforation were selected. All patients underwent, tympanoplasty using temporalis fascia/cartilage graft, underlay technique with or without simple mastoidectomy/modified radical mastoidectomy and followed up for 3 months and evaluated for graft uptake and hearing improvement with respect to size and site of TM perforation. To measure the size of perforation intra-operatively, thin transparency sheet was used, on which a graph paper of $1 \times 1 \text{ mm}^2$ size was printed. Significant relationship was observed between size and site of tympanic membrane perforation with hearing loss. Perforations which were involving all four quadrants (AS + AI + PS + PI) are having maximum residual perforations after the surgery. In relation with size, subtotal perforation were having more residual perforations post-operatively, followed by medium sized perforations. An inherent relationship noted between ossicular involvement and hearing loss, maximum average hearing loss was observed in those cases, where all three ossicles (malleus, incus & stapes) were involved, also more hearing loss was noted in posterior perforations.

Keywords Tympanic membrane · Tympanoplasty · Ossiculoplasty

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. It plays a major role in middle ear transformer mechanism. Chronic suppurative otitis media has been an important cause of middle ear disease, since prehistoric period and it is the most important cause of hearing loss in developing countries like ours.

It is acknowledged fact that size and site of tympanic membrane perforation is proportionate to degree of hearing loss [1], larger the perforation, greater the hearing loss [2]. The site of perforation in the tympanic membrane and the duration of ear discharge have significant effect on the magnitude of hearing loss [1]. For instance, posterior quadrant perforations are having poorer hearing than the anterior ones, because there is direct exposure of the round window to sound [1]. However, some workers believed that there is no significant effect associated with location of the perforation [3]. Persistent ear discharge is also supposed to deteriorate hearing level with passage of time [4]. This study was done to find out the relation between hearing loss with size and site of tympanic membrane perforation.

Methods

The present study was done between September 2011 to September 2013, at R.D. Gardi Medical College Ujjain during which 100 cases of chronic otitis media tubotympanic type having central perforation (age group 10–60 years) (both sexes) were selected. All the 100 patients underwent, tympanoplasty using temporalis fascia/cartilage graft, underlay technique with or without simple

S. Vaidya (✉) · J. K. Sharma · G. Singh
Department of Otolaryngology, RD Gardi Medical College,
Ujjain, MP, India
e-mail: drsvaidya@hotmail.com

mastoidectomy/modified radical mastoidectomy. These patients were followed up for a period of 3 months and were evaluated for graft uptake and hearing improvement with respect to size and site of tympanic membrane perforation. Average hearing loss was calculated through the pure tone average taken at 500, 1,000, and 2,000 Hz (Tables 1, 2).

Methodology to Measure the Size of Perforation

To measure the size of perforation, we have used pre-sterilized (cidex) thin transparency sheet, on which a graph paper of $1 \times 1 \text{ mm}^2$ size was printed. The measurement of size was done intra-operatively under operating microscope after doing posterior canal wall meatotomy, before starting the tympanoplasty procedure.

Results of our study were compared with other two studies. The other study 1 by Kumar et al. [5] have also measured the size of perforation by thin plastic paper (graph of $1 \times 1 \text{ mm}^2$ was drawn on it) under operating microscope. The study 2 (by Nepal et al. [2]) have assessed the size of perforation only by otoscope and perforations were classified as pinhole (1–2 mm), small (1 quadrant), medium (2–3 quadrants), large (subtotal).

Results

1. We studied 100 patients, majority of them (44 %) belonged to the age group ranging from 10 to 20 years, and females (61 %) were slightly predominated over males.
2. Unilateral discharging ear patients (59 %) outnumbered bilateral discharging ear patients (41 %).
3. Otorrhea was the commonest complaint (in all 100 cases) (100 %). Next to otorrhea, hearing loss was noted in 93 % patients.
4. It was observed that maximum pure tone average hearing loss (49.31 dB) was found in subtotal perforations, which lies in between size ($42\text{--}55 \text{ mm}^2$) and maximum average hearing loss (48.88 dB) was noted in the perforations involving all four quadrants (AS + AI + PS + PI).
5. Ossicular chain had a direct link with hearing loss; we found that hearing loss increases with the number of ossicles involvement. A hearing loss of 42 dB was noted in perforation, where malleus alone was eroded. 44 dB hearing loss was found in ear, where incus alone was eroded. When both malleus and incus (M + I) were involved, average hearing loss was 47.80 dB and where all three (M + I + S) were involved; average hearing loss was 56.8 dB.
6. With relation to size and site of perforation, post-operative graft intactness results were excellent in small size perforation, as compared to larger size of perforation where residual perforations were leading.
7. Graft was intact in 86 (86 %) patients, maximum of them (91.11 %) were having small size perforation ($1\text{--}14 \text{ mm}^2$) at the end of 3 months follow up and residual perforation was found in 14 (14 %) patients, maximum (37.5 %) were noted in subtotal type ($42\text{--}55 \text{ mm}^2$) perforations.
8. Maximum graft intactness was observed in single quadrant perforations average (93.22 %) and maximum residual perforations (33.33 %) were noted in those cases, where all four quadrants were involved.
9. After surgical treatment, in relation to size, we observed that subtotal perforation ($42\text{--}55 \text{ mm}^2$) had maximum hearing improvement (16.25 dB), in which (type I tympanoplasty + cortical mastoidectomy) surgery had been performed. Minimum average hearing improvement (14.93 dB) was noted in (type I tympanoplasty) where size of perforation was small in between (1 and 14 mm^2).
10. After surgical treatment, in relation to site of perforation, we observed that single quadrant (AI) had maximum hearing improvement (30 dB), in which (type III tympanoplasty + cortical mastoidectomy) surgery had been performed along with incus remodeling & repositioning. Minimum hearing improvement (6 dB in each group) was noted in (type IV tympanoplasty + MRM = PS + PI quadrants) and (type III tympanoplasty + MRM = AI quadrant).

Table 1 Hearing improvement in respect to the size of perforation

Size of perforation (mm^2)	Average of TM involved by perforation (mm^2)	No. of ears	Pure tone average (dB) improvement	Air bone gap (dB) improvement
1–14	7.46	45	14.93	10.86
15–27	19.59	37	16.08	13.29
28–41	38	2	15	11.50
42–55	48.06	16	16.25	14.43
Total		100		

Table 2 Hearing improvement in respect to the site of perforation

	Site of perforation according to quadrant	No. of ears	Percentage (%)	Pure tone average (dB) improvement	Air bone gap (dB) improvement
Single quadrant	AI	22	22	17.04	10.54
	PI	19	19	12.94	11
	AS	1	1	15	8
	PS	0	0	0	0
Two quadrant	AS + AI	8	8	13.12	9.75
	PS + PI	18	18	17.22	14.72
	AI + PI	13	13	15.38	14.15
Three quadrant	AS + AI + PI	0	0	0	0
	PS + PI + AI	1	1	16	15
Four quadrant	AS + AI + PS + PI	18	18	16	13.70
Total		100	100		

Discussion

CSOM, with tubotympanic perforations forms a large proportion of patients presenting to the ENT clinics with hearing impairment. The aim of management in such cases is to provide a safe and dry ear and restore the hearing. Following are the two studies in the literature, found in the literature, who had observed the relationship of size and site of tympanic membrane perforation with hearing loss. These are:

- Study 1—by (Kumar et al. [5])
- Study 2—by (Nepal et al. [2])

Size of Perforation and Hearing Loss

In our study, perforation size in between 1 and 14 mm² (small) had shown average hearing loss of 34.26 dB. In the study 1 (by Kumar et al. [5]), 1–14 mm² size perforation had shown average hearing loss of 28.23 dB.

In our study, perforation size in between 15 and 27 mm² (medium) had shown average hearing loss of 44 dB. In the study 1 (by Kumar et al.), 15–27 mm² perforations had shown average hearing loss of 32.42 dB.

In our study, perforation size in between 28 and 41 mm² (large) had shown average hearing loss of 45.50 dB. In the study 1 (by Kumar et al.), 28–41 mm² size perforations had shown average hearing loss of 36.26 dB.

In our study, subtotal perforation measuring size (42–55 mm²) had 49.31 dB average hearing loss, while this was 44.62 dB, in same sizes of perforation in the study 1 (by Kumar et al.).

The study 2 (by Nepal et al. [2]) has not measured the size of perforation microscopically, so its results could not be compared with our study.

Site of Perforation and Hearing Loss

The single quadrant anteroinferior (AI) perforations, whose average hearing loss was 30.36 dB in our study, while this was 26.6 dB in study 1 (by Kumar et al. [5]). Study 2 (Nepal et al. [2]) had reported 50 % of AI quadrant perforations with mild, 29 % with moderate & 21 % with minimal hearing loss.

Posteroinferior (PI) quadrant perforations had 39.10 dB average hearing loss in our study, while it was 32.4 dB in study 1 (by Kumar et al. [5]) and in study 2 (by Nepal et al. [2]) 50 % of these perforations had mild, 39 % moderate & 11 % had minimal hearing loss.

In single quadrant anterosuperior (AS) perforation (only 1 case) in our study had hearing loss of 25 dB, this was not studied in study 1 (by Kumar et al. [5]). In the study 2 (by Nepal et al. [2]) 50 % of these perforations had moderate, 25 % had mild & 25 % had minimal hearing loss.

Two quadrants perforations (anterosuperior + antero-inferior = AS + AI) in our study had shown 37.12 dB average hearing loss, which was 28.6 dB average hearing loss in study 1 (by Kumar et al. [5]). Study 2 by (Nepal et al. [2]) has not studied 2 quadrants perforations.

The posterosuperior & posteroinferior (PS + PI) perforations had shown 46.83 dB average hearing loss in our study, which was 36.6 dB in study 1 (by Kumar et al. [5]) and this was not studied in study 2 (by Nepal et al. [2]).

In antero-inferior & postero-inferior (AI + PI) in our study had shown 42.15 dB average hearing loss, while study 1 (by Kumar et al. [5]) noted 32 dB average hearing loss and it was not studied in study 2 (by Nepal et al. [2]).

Three quadrants perforation, posterosuperior, postero-inferior & antero-inferior (PS + PI + AI) had 46 dB hearing loss. In the study 1 (by Kumar et al. [5]) they had only studied anterosuperior, antero-inferior & postero-inferior

(AS + AI + PI) perforations and average hearing loss was 36.6 dB. Study 2 (by Nepal et al. [2]) has not included three quadrants perforations.

All four quadrants perforations (PS + PI + AS + AI) in our study had shown 48.88 dB average hearing loss, which was 44.6 dB average hearing loss in study 1 (by Kumar et al. [5]). Study 2 (by Nepal et al. [2]) had noted that 12 cases of all quadrant perforations which had moderate hearing loss, while two of these had mild hearing loss.

Comparison of Identical Size Perforation with Hearing Loss

In our study, we noted that identical size perforations (average perforation size 7.76 mm^2) which were lying posteroinferior are having more (40.07 dB) average hearing loss as compared to anteroinferior perforations in which average hearing loss was 29.30 dB. In study 1 (by Kumar et al. [5]) also observed similar results as posteroinferior perforations (average perforation size 6 mm^2) had 25.14 dB average hearing loss while it was 23.91 dB in anteroinferior perforations. Study 2 (by Nepal et al. [2]) had not studied relation of identical size perforation with hearing loss.

Relation of Ossicular Chain Status with Hearing Loss

Sakagami et al. [6], in their study of CSOM, observed tympanic membrane perforation with intact ossicular chain in 90.1 % (82 out of 91) cases and 9.89 % of their cases had ossicular involvement. In our study, we found that the tympanic membrane perforation with intact ossicular chain was in 76 cases (76 % cases) and 24 (24 %) of our cases had ossicular involvement (Table 3).

In our study, we observed involvement of each ossicle (malleus, incus and stapes) in relation with hearing loss, while study 1 (by Kumar et al. [5]) had only studied relation of malleus and incus with hearing loss. Study 2 (by Nepal et al. [2]) had not studied relation of ossicular chain status with hearing loss.

A single case in our study, where malleus alone was involved, had 42 dB hearing loss, while in study 1 (by Kumar et al. [5]) where alone malleus was involved in (4 cases) had 46.6 dB average hearing loss. Alone incus (single case) had 44 dB hearing loss in our study, in study 1 (by Kumar et al. [5]), where alone incus was involved in (3 cases) had 54.3 dB average hearing loss.

In our study, we found 47.80 dB average hearing loss, where both malleus & incus ($22 = 22 \%$ cases) were involved, while study 1 (by Kumar et al. [5]) and study 2 (by Nepal et al. [2]) had not studied these ossicles together.

Cases in which all ossicles where (malleus, incus and stapes) were involved (5 cases) had 56.8 dB average hearing loss in our study, study 1 (by Kumar et al. [5]) & study 2 (by Nepal et al. [2]) had not mentioned this finding.

Post-operative Follow Up: Graft Uptake and Residual Perforations

In our study, results of graft intactness among 100 cases were 86 (86 %). 14 (14 %) cases were having residual perforation at the end of our follow up of 3 months, whereas in study 1 (by Kumar et al. [5]) out of 50 patients, who underwent tympanoplasty during the study period, graft was accepted in 40 (80 %) patients and rejected in 10 (20 %) patients. Study 2 (by Nepal et al. [2]) had not studied about graft uptake.

In our study, we noted that residual perforations were more in 42 to 55 mm^2 size (subtotal) perforations and where all four quadrants (PS + PI + AS + AI) were involved. Study 1 (by Kumar et al. [5]) & study 2 (by Nepal et al. [2]) had not studied this relation.

Hearing Improvement After Surgery in Relation to Size of Perforation

In our study, perforation sizes between 1 and 14 mm^2 (small) had shown average hearing improvement of

Table 3 Hearing improvement in respect to status of Ossicular chain

	Erosion	Percentage (%)	Pre-operative hearing		Improvement	
			Pure tone average (dB)	Air bone gap (dB)	Pure tone average (dB)	Air bone gap (dB)
Malleus alone	1	1	42	30	24	18
Incus alone	1	1	44	24	31	12
Stapes alone	Not seen	Not seen	0	0	Not seen	Not seen
M + I	22	22	47.80	34.10	12.70	11.55
M + I + S	5	5	56.8	44.20	18	15.40
Intactness of ossicular chain	Nil	76	38.30	25.40	16.38	12.53

14.93 dB, perforation sizes between 15 and 27 mm² (medium) had shown average hearing improvement of 16.08 dB, between 28 and 41 mm² (large) had shown average hearing improvement of 15 dB, subtotal size (42–55 mm²) had 16.25 dB of average hearing improvement. Both study 1 (by Kumar et al. [5]) and study 2 (by Nepal et al. [2]) had not studied improvement of hearing after the surgery, so their results could not be compared with our study.

Hearing Improvement After Surgery in Relation to Site of Perforation

The single quadrant (anteroinferior = AI) perforations had average hearing improvement of 17.04 dB postoperatively in our study, (posteroinferior = PI) quadrant had 12.94 dB average hearing improvement, anterosuperior quadrant (AS) perforation (only 1 case) in our study had hearing improvement of 15 dB.

Two quadrants perforation (anterosuperior + antero-inferior = AS + AI) in our study had shown 13.12 dB average hearing improvement, (posterosuperior & posteroinferior = PS + PI) had shown 17.22 dB average hearing improvement, in (anteroinferior + posteroinferior = AI + PI) in our study shown 15.38 dB average hearing improvement.

Three quadrants perforation (a single case) (posterosuperior + posteroinferior + antero-inferior = PS + PI + AI) had 16 dB hearing improvement in our study.

All four quadrants perforations in our study had shown 16 dB average hearing improvement.

Both study 1 (by Kumar et al. [5]) and study 2 (by Nepal et al. [2]) had not studied improvement of hearing after the surgery, so their results could not be compared with our study.

Post-operative Hearing Improvement in Respect to Status of Ossicular Chain

In our study, we observed that (single case) where malleus alone was involved, 24 dB hearing improvement had noted after 3 months of follow up. Another (single case) where incus alone was involved, we noted 31 dB hearing improvement in the post-operative period.

In cases where both malleus & incus were involved, we noted 12.70 dB hearing improvement and where all three ossicles were involved; we found improvement of 18 dB at the end of follow up.

Both study 1 (by Kumar et al. [5]) and study 2 (by Nepal et al. [2]) had not studied improvement of hearing after the surgery, so their results could not be compared with our study.

Relation of Size with Hearing Improvement in Respect to Different Tympanoplasties

In our study, subtotal perforation (42–55 mm²) had maximum hearing improvement (16.25 dB), in which group III (type I tympanoplasty + cortical mastoidectomy) surgery had been performed in maximum cases (7) and minimum hearing improvement was observed in small perforation (1–14 mm²), where group I (type I tympanoplasty) surgery was done in maximum cases (21).

Both study 1 (by Kumar et al. [5]) and study 2 (by Nepal et al. [2]) had not studied improvement of hearing after the surgery, so their results could not be compared with our study.

Relation of Site with Hearing Improvement in Respect to Different Tympanoplasties

In our study, single quadrant (AI) had maximum hearing improvement (30 dB), in which (type III + cortical mastoidectomy) surgery had been performed (a single case in which incus remodeling was done with cortical mastoidectomy). Minimum hearing improvement was observed in two quadrant perforation (PS + PI), where (type IV + MRM) surgery was done (1 case).

Both study 1 (by Kumar et al. [5]) and study 2 (by Nepal et al. [2]) had not studied improvement of hearing after the surgery, so their results could not be compared with our study.

Conclusion

This prospective clinical study of ears with TM perforations showed that:

1. Younger age group (10–20 years) was more involved in our study and females cases predominated over males. Unilateral discharging ear were observed more than bilateral discharging ears.
2. We observed significant relationship between size and site of tympanic membrane perforation with hearing loss, larger the size of perforation, more was average hearing loss and found same relation with site i.e. perforation involving all four quadrants were having more average hearing loss.
3. An inherent relationship exists between ossicular involvement and hearing loss, maximum average hearing loss was observed in those cases, where all three ossicles (malleus, incus & stapes) were involved, followed by those cases where only two ossicles (malleus & incus) were eroded.
4. There is definite difference in anterior and posterior perforations; more hearing loss was noted in posterior perforation.

5. Site of perforation does have relevance with graft take up. Perforations which were involving all four quadrants (AS + AI + PS + PI) are having maximum residual perforations after the surgery.
6. In relation with size, subtotal perforation were having more residual perforations postoperatively, followed by medium sized perforations.
7. In relation with size of tympanic membrane perforation, average hearing improvement was found more with larger perforations, after the surgical treatment as preoperative average hearing loss was also more in those cases.
8. In relation with site of tympanic membrane perforation, average hearing improvement was found more with posterior perforations than the anterior one (after the surgical treatment) as preoperative average hearing loss was also more in those cases.

Acknowledgment Authors are thankful to Dr. V K Mahadik, Medical Director, R D Gardi Medical College for giving permission to publish this article and for his kind encouragement and constant support.

References

1. Maharjan M, Kafle P, Bista M, Shrestha S, Toran KC (2009) Observation of hearing loss in patients with chronic suppurative otitis media tubotympanic type. *KUMJ* 7(28):397–401
2. Nepal A, Bhandary S, Mishra SC, Singh I, Kumar P (2007) Assessment of quantitative hearing loss in relation to the morphology of central tympanic membrane perforations. *Nepal Med Coll J* 9(4):239–244
3. Ibekwe TS, Nwaorgu OG, Ijaluola TG (2009) Correlating the site of tympanic membrane perforation with hearing loss. *BMC Ear Nose Throat Disord* 9(1):1
4. Bhusal CL, Guragain RP, Shrivastav RP (2007) Frequency dependence of hearing loss with perforations. *JNMA* 46(168): 180–184
5. Kumar N, Chilke D, Puttewar MP (2012) Clinical profile of tubotympanic CSOM and its management with special reference to site and size of tympanic membrane perforation, eustachian tube function and three flap tympanoplasty. *Indian J Otolaryngol Head Neck Surg* 64(1):5–12. doi:[10.1007/s12070-010-0114-5](https://doi.org/10.1007/s12070-010-0114-5)
6. Sakagami M, Maeda A, Node M, Sone M, Mishiro Y (2000) Long-term observation on hearing change in patients with chronic otitis media. *Auris Nasus Larynx* 27(2):117–120