HEARING OUTCOMES FOLLOWING TYPE III MAJOR COLUMELLA TYMPANOPLASTY IN CHOLESTEATOMA SURGERY

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ABSTRACT

Aims and Objectives: Chronic otitis media with cholesteatoma is a significant cause of hearing impairment. It is surgically treated by modified radical mastoidectomy. In patients with absent stapes suprastructure, type III major columella tympanoplasty can be performed. The aim of this study was to assess post-operative hearing outcomes after type-III major columella tympanoplasty in patients undergoing modified radical mastoidectomy.

Methods: This prospective, analytical study was conducted in the Department of ENT–Head & Neck Surgery, Maharajgunj Medical Campus, Tribhuvan University Teaching Hospital, Kathmandu, Nepal, over an 18-month period from March 2023 to August 2024 after an ethical approval. Twenty-seven patients aged over 14 years with diagnosis of chronic otitis media with cholesteatoma who underwent modified radical mastoidectomy with type III major columella tympanoplasty were included in the study. Pre-operative and three-month post-operative pure tone audiograms (Air conduction Threshold and Air Bone Gap) were analyzed. The paired-t test was used for normally distributed data, and Wilcoxon's signed-rank test for data which weren't normally distributed.

Results: The mean pre-operative air conduction threshold was 48.11 dB, and at three months post-operatively, it was 46.60 dB. The mean hearing gain was 1.51 dB which was not statistically significant (p=0.395). The mean air–bone gap decreased from 31.87 dB pre-operatively to 31.15 dB post-operatively, without statistically significant difference (p = 0.68).

Conclusion: The hearing outcomes at three months post-operative period was not significantly better than that in the pre-operative period, following modified radical mastoidectomy with type III major columella tympanoplasty.

Keywords: Cholesteatoma, Hearing, Modified Radical Mastoidectomy, Otitis media, Tympanoplasty

INTRODUCTION

Chronic Otitis Media (COM) refers to middle ear pathology persisting for more than three months in the presence of a permanent tympanic membrane defect.[1] Cholesteatoma is a benign keratinizing epithelial inclusion cyst containing desquamated keratin debris.[2] It causes progressive destruction of ossicles and surrounding structures through osteoblastic and osteoclastic remodeling, leading to hearing loss and other intra/extracranial complications.[3]

The World Health Organization (WHO) estimates that 65-330 million people worldwide suffer from COM, with nearly 50% experiencing hearing impairment, particularly in developing countries.[4] The treatment for cholesteatoma is mastoidectomy with hearing reconstruction. In patients with absence of stapes suprastructure with intact stapes footplate, ossicular reconstruction using type-III major columella tympanoplasty can be performed for hearing gain.[3] The post-operative closure of Air-Bone gap (ABG) below 20 dB is considered to be auditory success.[5] However, the hearing results are influenced by factors such as age of patient, extent of pathology, ossicular status, smoking, type of hearing reconstruction and type of mastoidectomy.[4,6] There is limited literature evaluating hearing outcomes with type-III major columella tympanoplasty in COM with cholesteatoma.[7]

However, this data is essential in patient counselling and to provide them realistic benefit with hearing reconstruction. This study aims to assess post-operative hearing outcomes after type-III major columella tympanoplasty in patients undergoing canal wall down mastoidectomy.

METHODS

This prospective, analytical study was conducted in the Department of ENT-Head & Neck Surgery, Maharajgunj Medical Campus, Tribhuvan University Teaching Hospital, Kathmandu, Nepal, over an 18-month period from March 2023 to August 2024. Ethical approval was obtained from the Institutional Review Committee, Institute of Medicine prior to study initiation with approval number- 465(6-11) E2. Written informed consent was obtained from all the participants.

Patients aged over 14 years with diagnosis of chronic otitis media with cholesteatoma and undergoing modified radical mastoidectomy with type III major columella tympanoplasty were included in the study. Patients with sensorineural hearing loss, fixed or absent stapes footplate, revision surgery, use of prosthesis or any other materials than autologous graft, perforation in the repaired tympanic membrane and patients with incomplete follow-up were excluded.

Sample size was calculated using the pre-/post-formula, $n = (z\alpha+z\beta)^2 \times d^2/\sigma^2$, Where: $z\alpha$ = level of confidence interval (at 95 %, it is 1.96), For α = 0.05, Zα =1.96, $z\beta$= power of the test (for 80% power, it is 0.84), For ß = 0.80, Zß = 0.84, σ =*standard deviation of the population being studied =13, d =pre and post difference= 12.*[8] and the total sample size calculated was 27 for the total duration of study of 18 months. A non-probability convenience sampling method was applied.

The pre-operative hearing evaluation with Pure tone audiometry was performed a week prior to surgery. Modified radical mastoidectomies were performed under general anesthesia using a post-auricular approach. Cholesteatoma was completely removed from the middle ear cleft before hearing reconstruction. In patients with absent stapes suprastructure and mobile footplate, type-III major columella tympanoplasty was performed using either the sculptured incus remnant, cortical bone or conchal cartilage (figure 1 and 2).

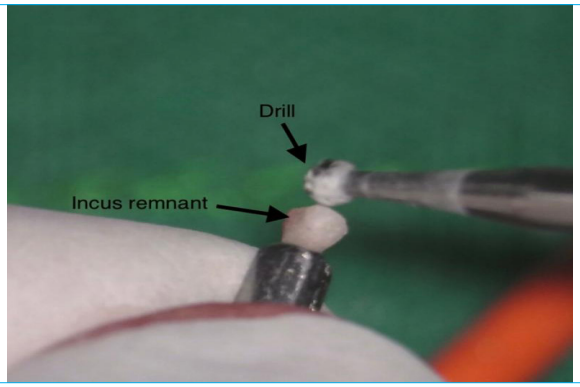

Figure 1. Incus remnant being sculptured using a drill.

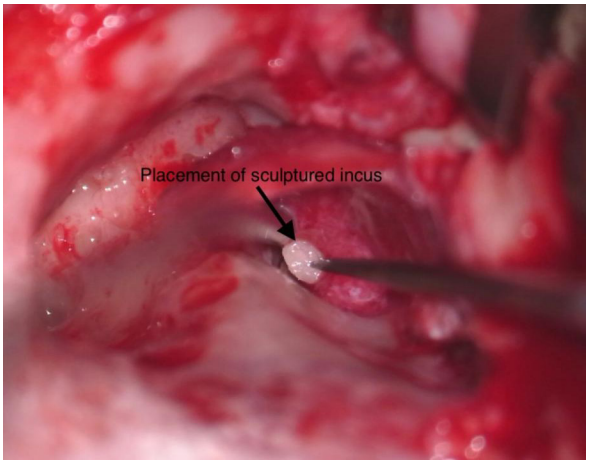

Figure 2. Sculptured incus placed on stapes footplate.

The post-operative Pure tone audiometry was performed at three months. The pre-operative and post-operative Air conduction thresholds (ACT) and air-bone gaps (ABG) were compared using average values at 0.5, 1, 2, and 4 kHz. Data were entered in Microsoft Excel and analyzed using SPSS version 26. Data normality was assessed using Kolmogorov-Smirnov test. Parametric data were expressed as mean ± SD, non-parametric data as median with interquartile range. Paired t-test was applied for parametric comparisons, with $p < 0.05$ considered statistically significant and similarly Wilcoxon signed-rank test was applied for non-parametric comparisons, with $p < 0.05$ considered statistically significant.

RESULTS

The hearing outcomes of 27 patients were evaluated. The age of patients ranged from 15 to 61 years, with a median age of 20 years and an interquartile range of 24 years. There were 16 females and 11 males. Sixteen ears were left sided while 11 ears were right sided. Cartilage was the most frequently used material for ossicular reconstruction, employed in 20 (74.1%) of patients.

The mean pre-operative air conduction threshold was 48.11 dB, and at three months post-operatively, it was 46.60 dB. The mean hearing gain was 1.51 dB which was not statistically significant (p=0.395) as shown in table 1. The pre-operative and post-operative ACT in different frequencies are shown in figure 3. Paired t and Wilcoxon tests showed no statistically significant differences at any frequency ($p > 0.05$).

The mean air-bone gap decreased marginally from 31.87 dB pre-operatively to 31.15 dB post-operatively, yielding a gain of 0.71 dB. Paired t-test revealed no statistically significant difference between pre- and post-operative ABG ($p = 0.68$), shown in table 2. No statistically significant improvement in hearing outcomes was observed at three months following surgery.

Table 1. Comparison of pre-operative and post-operative Average Air conduction Threshold (ACT) (n=27)

Average Air Conduction Threshold	Minimum (dB)	Maximum (dB)	Mean (dB)	Std. Deviation	Mean difference (95% CI)	Paired t-test		
						t	df	p-value
Pre-operative	26.25	73.75	48.11	12.90	1.51 -2.08 to 5.10	0.865	26	0.395
Post-operative	28.75	68	46.60	10.36				

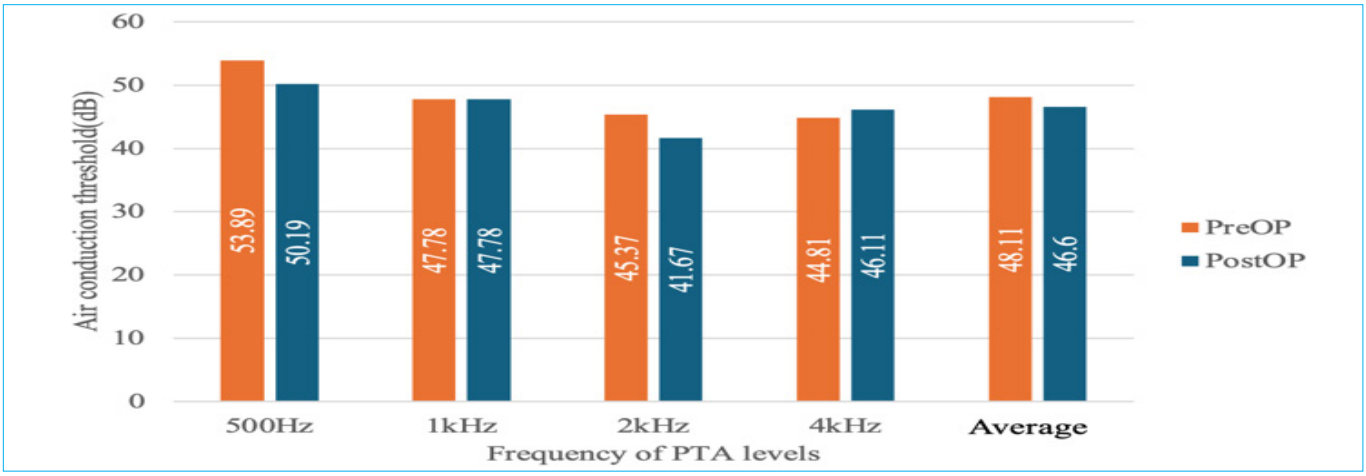

Figure 3. Average pre-operative and post-operative Air Conduction Threshold at different frequencies (n=27)

Table 2. Comparison of pre-operative and post-operative mean Air-Bone Gap (n=27)

ABG	Minimum (dB)	Maximum (dB)	Mean (dB)	Std. Deviation	Paired t-test		
					t	df	p-value
Pre-operative	16.25	50	31.87	8.79	0.417	26	0.68
Post-operative	16.25	51.25	31.15	8.21			

DISCUSSION

The main objective of cholesteatoma surgery is complete eradication of disease and establishment of a safe, dry ear, with hearing restoration as a secondary goal. The type III major columella tympanoplasty aims to re-establish sound transmission by directly coupling the tympanic membrane or graft to the stapes footplate. In the current study, no significant hearing improvement was achieved with major type III columella tympanoplasty. These functional outcomes might have been influenced by multiple anatomical and physiological factors.

The mean hearing improvement in ACT was not significant in this study. Kara et al reported similar findings in a retrospective study of 203 patients undergoing ossiculoplasty with Total Ossicular Replacement Prosthesis (TORP), bone cement, and ossicular grafts, demonstrating no significant change in average AC values.[9] They emphasized the importance of intact stapes suprastructure for postoperative hearing gain and adequate surface tension between the tympanic membrane and mobile footplate.[9]

In the present study, ossicular erosion was reconstructed using type-III tympanoplasty. However, restoration of the normal lever mechanism might have been limited by graft uncoupling, middle ear atelectasis, postoperative footplate fixation, granulation tissue, fibrosis, adhesions, or compromised sound transmission following posterior canal wall removal in canal wall down mastoidectomy.[7] These factors likely contributed to the limited postoperative hearing improvement. Furthermore, few patients might have had reasonably good pre-operative hearing despite ossicular necrosis as cholesteatoma may serve as a medium for sound conduction.

In contrast, Corso et al demonstrated significant hearing improvement using TORP, with pre- and post-operative ACT of 50.97 ± 16.27 dB and 37.62 ± 15.41 dB, respectively ($p < 0.05$).[10] The superior outcomes were attributed to TORP's stability, low foreign body reaction and enhanced transmission when stabilized with cartilage, facilitating effective re-establishment of a single tympano-ossicular chain.[10]

In the current study, no significant improvement was observed in ABG closure. It is likely due to graft uncoupling from the footplate, altered ear canal and cavity acoustics, reduced

tympanic membrane surface area, and loss of the ossicular lever mechanism. After canal wall down mastoidectomy, reduced middle ear space, increased adhesions and unfavorable sound redistribution further compromise hearing results. Large lateral air spaces in the mastoid cavity can generate adverse resonances and poor middle ear aeration may cause conductive loss of 35-55 dB.[11]

Öçalan et al in 2013 found no statistically significant ABG improvement (33.96 dB to 28.22 dB) in type III reconstruction using reshaped incus, cartilage, or cortical bone, emphasizing the importance of graft shape, mass, and footplate coupling.[12] However, Shrestha et al reported significant ABG improvement (37.8 dB to 29.8 dB) after canal wall down mastoidectomy with type III tympanoplasty, likely due to intact stapes suprastructure.[13] Doshad et al showed marked improvement with canal wall up mastoidectomy (27.45 dB to 10.37 dB), attributed to better preservation of sound conduction mechanics compared to canal wall down mastoidectomy.[9]

Mehta et al noted wide ABG variability (10-60 dB), with better outcomes (15-30 dB) when the stapes suprastructure and middle ear aeration are preserved.[14] Merchant et al highlighted middle ear volume and round window niche as critical; volumes < 0.5 ml may reduce hearing by up to 10 dB, which can be mitigated by cartilage support.[15] Kyrodimos et al achieved post-operative ABG < 20 dB in a few patients using a conchal cartilage shield that increased middle ear volume and improved ossicular coupling.[16] In contrast, smaller graft materials and fascia medialization in our study may have reduced middle ear volume, contributing to poorer results; absence of stapes suprastructure can worsen hearing up to 60 dB.

These results imply the importance of realistic preoperative counseling regarding expected hearing outcomes in patients undergoing cholesteatoma surgery.

The study is limited by its small sample size and relatively short follow-up period which prevents commenting on long-term hearing results. The small sample size introduces sampling and selection bias. Multiple surgeons performing the surgery and multiple audiologists performing audiogram may have resulted in variable outcomes. Longer-term follow-up, greater sample size and comparative studies evaluating alternative reconstruction techniques may provide further knowledge into optimizing hearing outcomes.

CONCLUSION

Modified radical mastoidectomy with Type III major columella tympanoplasty did not result in a statistically significant improvement in hearing at three months postoperatively compared with preoperative hearing levels in this study. Given the small sample size, short follow-up duration, and potential inter-observer and inter-surgeon variability, these findings should be interpreted cautiously. Larger prospective studies with longer follow-up are required to determine the long-term hearing outcomes of this procedure.

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