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## Comparison of Pre and Postoperative Hearing Results after Cartilage Augmentation Type III Tympanoplasty

### Objective:

To compare the hearing results of cartilage augmentation type III tympanoplasty with canal wall down (CWD) mastoidectomy pre and post-operatively.

### Materials and Methods:

It is a prospective, analytical, comparative and longitudinal study carried out from 1st October 2006 to 30th April 2008 in Ganesh Man Singh Memorial Academy of ENT and Head & Neck Studies, Institute of Medicine, Maharajgunj, Kathmandu, Nepal. Patients included were having >5years, both gender and diagnosis of chronic otitis media (squamous) with conductive or mixed hearing loss, needing canal wall down mastoidectomy in which stapes suprastructure present and no mastoid surgery was performed previously. Patients with sensorineural hearing loss and post-operative graft failure were excluded. Analysis of 34 ear surgeries was performed. Cartilage from conchal area and graft from temporal fascia was harvested. Pre and post-operative average air bone gap (ABG) at frequencies 500Hz, 1000Hz, 2000Hz and 4000Hz were compared. The post-operative hearing was assessed in terms of ABG closure.

### Results:

The comparison of pre and post-operative ABG in cartilage augmentation type III tympanoplasty at 500Hz was 46.6dB and 37.9dB ( $p<0.001$ ), at 1000Hz it's 39.7dB and 30.1dB ( $p=0.001$ ), at 2000Hz it's 29.9dB and 22dB ( $p=0.003$ ) and at 4000Hz it's 35dB and 29.2dB ( $p=0.062$ ). The mean pre and post-operative ABG was 37.4dB and 29.7dB, which was statistically significant ( $p<0.001$ ). The post-operative ABG ranges from 15-47.5dB. Similarly, the ABG closure was within 30dB in 26 (76%) patients.

### Conclusion:

Hearing results after cartilage augmentation type III tympanoplasty showed improvement at individual and mean post-operative ABG and also significant improvement in ABG closure suggesting thin cartilage disc increased the effective vibrating area of tympanic membrane graft but there was a great variation, suggesting possibility of effect of multiple other factors.

### Keywords:

Air bone gap, chronic otitis media (squamous), canal wall down mastoidectomy, cartilage augmentation type III tympanoplasty.

### INTRODUCTION:

Chronic otitis media (COM) is a chronic inflammatory disease of the middle ear and mastoid. It is complicated as partial or total loss of the tympanic membrane (TM) and ossicles which leads to conductive hearing loss in severity up to 60-70 dB.<sup>1</sup> COM is a common condition, affecting 0.5-30% of any community. A conservative estimate of the number of people in the world suffering from COM is over 20 million.<sup>2</sup> Chronic otitis media (COM) is still one of the commonest ear diseases in many of the developing countries among which the prevalence of squamous type of COM is 3.5% in Nepal.<sup>3</sup> The goal of tympanoplasty is to restore sound pressure transformation at the oval window by coupling an intact tympanic membrane with a mobile stapes footplate via an intact or reconstructed ossicular chain and to provide sound protection for the round window membrane by a closed, air containing, mucosa lined middle ear.<sup>4</sup>

Merchant et al in laboratory model demonstrated that improved hearing results by 5-10dB for frequencies below 1500Hz could be achieved in myringostapedioplasty by interposing a thin cartilage disc between the graft and stapes head.<sup>1</sup> For augmented type III tympanoplasty either cartilage or sculptured cortical bone can be kept between the intact stapes and the fascial graft.<sup>4</sup> The cartilage disc was hypothesized to improve the "effective" vibrating area of the graft that was coupled to the stapes head.<sup>5</sup> The aim of our study is to compare pre and post-operative hearing results after cartilage augmented type III tympanoplasty since such study was not done previously.

### MATERIALS AND METHODS:

This is a prospective, analytical, longitudinal and comparative study performed in Ganesh Man Singh Memorial Academy of ENT and Head & Neck Studies, Institute of Medicine, Maharajgunj, Kathmandu, Nepal from 1st October 2006 to 30th April 2008. The patients who were > 5 years, both gender, intact and mobile stapes suprastructure at CWD tympanomastoidectomy surgery for COM squamous type and with conductive or mixed hearing loss were included. Patients with sensorineural hearing loss and post-operative graft failure were excluded.

For hearing assessment, the pure tone audiometry (PTA) test performed within seven days prior to the operation by Hughson and Westlake method. The test was performed through air conduction and bone conduction mode. The air and bone conduction threshold was recorded both pre and post-operatively. The air conduction

threshold and the bone conduction threshold averages were calculated by taking the averages of 500, 1000, 2000 and 4000 Hz frequencies. The ABG was calculated by taking differences between air conduction and bone conduction threshold. The audiometry results were reported according to American Academy of Otolaryngology-Head and Neck Surgery guidelines,<sup>6</sup> except for thresholds at 3kHz, which were substituted in all cases with thresholds at 4kHz.

For cartilage augmentation, thin disc of conchal cartilage of partial thickness and of 4-6 mm in diameter was interposed between the stapes head and temporalis fascia graft. Cartilage disc did not touch the external auditory canal or facial nerve canal.

The follow up of patients were performed at /or after 10<sup>th</sup> week postoperatively. During follow up period, ears with minimal discharge from the mastoid cavity but with healed middle ear were subjected to PTA assessment. The results were analyzed in terms of average postoperative ABG and ABG closure. The pre and postoperative results were compared. The data analysis was performed with the help of SPSS 11.5 software package. p value was calculated using the independent samples test and p value of < 0.05 was taken as significant.

### RESULTS:

The total number of patients enrolled during the study period was 36. All 36 (100%) cases had adequate follow up. Among them, 2 (5.5%) cases were excluded from the study because of graft failure as shown in Table-1.

Table-1. Total distribution of patients

Groups	Total cases	Included	Excluded
CWD mastoidectomy and cartilage augmented type III tympanoplasty	36	34 (94.4%)	2 (5.6%)

The patients were divided into different groups of age. Patients of <10 years were 2 (5.9%), 11-20 years were 11 (32.4%), 21-30 years were 15 (44.1%), 31-40 years were 4 (11.8%) and >40 years were 2 (5.9%). The average age was  $24.88 \pm 5.82$  years as shown in Table-2. Among 34 patients, 21 (61.8%) were male and 13 (38.2%) were female as shown in Table-3. The pre-operative ABG at frequencies 500Hz, 1000Hz, 2000Hz, and 4000Hz were found to be 46.6 dB, 39.4

Table 2. Age distribution of patients

Age (Years)	Number of patients (%)	Average age
<10	2 (5.9%)	
11-20	11 (32.4%)	
21-30	15 (44.1%)	
31-40	4 (11.8%)	24.88 ±
>40	2 (5.9%)	5.82

Table 3. Gender distribution of patients

Male	Female	Total
21 (61.8%)	13 (38.2%)	34 (100%)

dB, 27.7 dB and 35.7 dB respectively as compared to post-operative ABG of 35.4 dB, 31.5 dB, 20.4 dB and 31.5 dB in these respective frequencies. These differences were statistically significant except at 4000Hz as shown in Table- 4.

Table 4. Evaluation of the pre and post operative PTA-ABG

Parameter	Group	n	Mean	Std. Deviation	Min.	Max.	P value
CWD mastoidectomy and cartilage augmented type III tympanoplasty	Pre - Operative ABG 500Hz	34	46.6	13.75	20	70	<0.001
	Post - Operative ABG 500Hz		35.4	10.10	15	60	
	Pre - Operative ABG 1000Hz		39.4	15.61	5	70	0.003
	Post - Operative ABG 1000Hz		31.5	11.25	10	60	
	Pre - Operative ABG 2000Hz		27.7	14.15	0	55	0.002
	Post - Operative ABG 2000Hz		20.4	8.74	5	35	
	Pre - Operative ABG 4000Hz		35.7	11.42	15	60	0.111
	Post - Operative ABG 4000Hz		31.5	12.76	0	70	
	Pre - Operative ABG Average		37.4	11.84	16.2	61.2	<0.001
	Post - Operative ABG Average		29.7	7.69	15	47.5	

The four frequency average pre-operative ABG which was 37.4 dB was reduced to 29.7 post- operatively with a net gain of 7.7 dB. This observed difference was found to be statistically highly significant with p value of <0.001. It was observed that the ABG was the smallest at 2000 Hz as compared with other frequencies in both pre and post-operative audiograms. The details are shown in Table- 4 & Fig-1. The ABG closure was divided into different categories like 0-5 dB, 0-10 dB, 0-20 dB, 0-30 dB and 0-40 dB. Around 26.5% cases fell within 0-5 dB and 24 (70.6%) cases within 0-20 dB as shown in Table-5.

Table 5. ABG Closure in different bins (n=34)

Groups	0-5dB	0-10dB	0-20dB	0-30d	>30dB
CWD mastoidectomy and cartilage augmented type III tympanoplasty	9 (26.5%)	15 (44.1%)	24 (70.6%)	26 (76%)	1 (2.9%)

**DISCUSSION:**

This study was performed to compare the pre and post-operative hearing results in terms of average ABG and ABG closure. The average age of the patients was 24.88, the range being 7 to 50 years. But most of the similar studies done in the literature have included patients in their fourth or fifth decade and the range also shows patients of younger and older age groups.<sup>5,7</sup> This variation may be attributed to the socio-cultural context that in our country older adults are a bit hesitant to undergo surgical treatment as compared to patients of younger age. Similarly in our study, there were total 21 (61.8%) males and 13 (38.2%) females with a male female ratio of 1.6:1. Gender wise distribution of patients of our study compare favorably with all other

studies published in the literature.<sup>5,7</sup>

We reported only short-term hearing results, because the long-term success of any ossicular repair is largely dependent on factors outside the control of the surgeon, i.e. patient follow-up rates; eustachian tube function; middle-ear stability; and the condition of the mucosa. The short-term results are hence a more accurate reflection of the actual reconstructive procedures. In each case, post-operative air-bone gaps were calculated using post-operative air conduction and

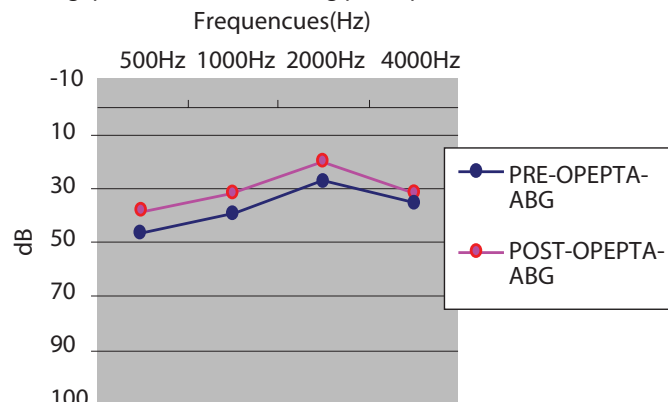


Fig : 1. Pre-post PTA-ABG

post-operative bone-conduction thresholds at frequencies 500, 1000, 2000 and 4000 Hz. None of the patient in the whole group had an acute worsening of bone conduction post-operatively. During the length of follow up there were no cases of cartilage extrusion.

Different methods have been used by different authors to report the pure tone audiometric post-operative hearing results in middle ear surgery in the literature. Among them, the ABG closure, the post operative ABG presented in 10 dB bins and air conduction threshold gain are commonly reported indicators of tympanoplasty outcome. We had applied average PTA-ABG and ABG closure for audiological assessment.

In our study, the average PTA-ABG was 37.4 dB pre-operatively & 29.7 dB post-operatively with a net gain of 7.7 dB. The postoperative PTA -ABG ranged from 15- 47.5 dB. The difference between the pre and post-operative PTA-ABG results was statistically significant (p<.001). These results are consistent with the study done by Kyrodimos et al<sup>7</sup> where pre and post-operative PTA-ABG were 35.41 and 24.33 dB respectively in type III cartilage shield tympanoplasty after CWD mastoidectomy. Similarly, Merchant et al<sup>5</sup> reported that cartilage augmented type III tympanoplasty in patients with mobile stapes and aerated middle ear result in mean ABG of 10-25 dB but large ABG of 40-50 are found in ears with mobile stapes and non-aerated middle ear. They had assessed the status of middle ear aeration either by post-operative computed tomography or by pneumatic otoscopy or by autoinflation. In our setting it was not possible to have post-operative computed tomography because of the cost factor.

While analyzing the frequency wise post-operative average PTA-ABG, it was seen that ABG was the smallest at 2000 Hz as compared with other frequencies. Similar findings were also noted by Merchant et al.<sup>5</sup> They explain that a combination of two factors are responsible for smaller ABG at 2000Hz. Bone-conduction threshold are not an exact measure of cochlear function and can be influenced by pathological condition of middle ear; the carhart's notch phenomenon in otosclerosis is an example. Similarly, there is no clear explanation for the cause of the air conduction thresholds showing to be the lowest at 2000Hz however; it could have resulted from resonances generated in the mastoid cavity and ear canal.

Merchant et al<sup>1</sup> in their review article state that a canal "wall-down" mastoidectomy poses several considerations from an acoustical and mechanical perspective. First, the canal wall-down procedure i.e., radical or modified radical tympanomastoidectomy results in a significant reduction in the size of the residual middle ear air space. Second, a canal wall down procedure results in the creation of a large air space lateral to the tympanic membrane (TM), i.e., the air space within the mastoid bowl including the external auditory canal. This

mastoid bowl and ear canal air space generates resonances that can influence middle ear sound transmission favorably or unfavorably.<sup>8</sup> Third, after a canal-wall down procedure, the TM graft comes to lie in a more medial position compared to normal, and the TM graft is made to couple to the stapes head or to prosthesis such as a total ossicular replacement prosthesis (TORP). The mechanics of such a TM graft and its coupling to the stapes/TORP are likely to be different from normal and also need to be characterized.<sup>1</sup>

In our study, it was found that 26 (76%) cases fell within 30 dB ABG closure and 24 (70.6%) cases fell within 20dB ABG closure. Similar studies with some modifications in the technique published in the literature report varying proportions of PTA-ABG. Like our study, Cheang et al<sup>9</sup> in his myringotomycartilage group (n= 20) achieved an ABG of less than 30 dB in 92 % and ABG of less than 20 dB in 64% of cases. Similarly, Moustafa and Khalifa<sup>10</sup> in their myringo-cartilago-stapedioplasty group (n= 95) achieved an ABG of less than 20 dB in 84%. Likewise, Kyrodimos et al<sup>7</sup> in their cartilage shield type III tympanoplasty (n=52) using a 0.8 mm thick cartilage piece with no capitulum for stapes head report that post-operative PTA-ABG of 25dB or less was achieved in 41 (79%) of patients and of 20 dB or less in 54% of patients. However, their study included both canal wall up and canal wall down procedures. Malafronte et al<sup>11</sup> in cases of both canal down and up procedures used modified folded double cartilage block with shallow acetabulum for stapes capitulum to augment their type III tympanoplasty procedure. One year after surgery, a post-operative ABG of 20 dB or less occurred in 84.3% (n = 27) of patients and this after a mean follow-up of 7 years, post-operative ABG of 20 dB or less occurred in 81% (n = 26) of patients which correlate with our study, however, we had only short term follow up as explained previously.

#### CONCLUSION:

The results concluded that mean pre and post-operative air bone gap were 37.4 dB and 29.7dB respectively with a net gain of 7.7 dB. These differences were statistically significant. The post-operative PTA-ABG ranged from 15- 47.5 dB, also the ABG closure was within 30 dB in 26 (76%) cases. Thus, hearing results after cartilage augmentation type III tympanoplasty showed improvement at individual and mean post-

operative PTA -ABG, and also improvement in ABG closure suggesting thin cartilage disc increased the effective vibrating area of tympanic membrane graft but there was a great variation, suggesting possibility of effect of multiple other factors.

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