Orginal Article

Hearing results of type III tympanoplasty with or without cartilage augmentation after Canal Wall Down mastoidectomy.

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Background: To assess and compare the hearing results in patients undergoing canal wall down mastoidectomy with classical type III tympanoplasty using temporalis fascia alone and with cartilage augmented type III tympanoplasty.

Methods: Patients of 5 years of age or more with the diagnosis of Chronic otitis media (squamous) with conductive or mixed hearing loss, needing canal wall down mastoidectomy and with intact and mobile stapes suprastructure at surgery who underwent classical type III tympanoplasty with or without cartilage augmentation were included in the study. Pure tone audiometry (PTA) was performed and evaluated. Post- operative hearing was assessed in terms of average air bone gap (ABG) and size of ABG closure. Post-operative hearing results were compared in between classical type III and cartilage augmented type III tympanoplasty groups.

Results: Postoperative PTA–ABG ranged from 15–61.2 dB in classical type III tympanoplasty while the postoperative PTA–ABG ranged from 15–47.5 dB in cartilage augmented type III tympanoplasty. When comparing average post-operative ABG and size of ABG closure between classical and cartilage augmented type III tympanoplasty, cartilage augmented group showed marginally better results but this difference was statistically not significant.

Conclusions: Hearing results after type III tympanoplasty varied widely. There was no statistically significant improvement in post-operative hearing results in cartilage augmented when compared to classical type III tympanoplasty, suggesting possibility of the effects of multiple other factors.

Key words: Air bone gap, air bone gap closure, canal wall down (CWD) mastoidectomy, cartilage augmented type III tympanoplasty, classical type III tympanoplasty, chronic otitis media (squamous).

Introduction

Chronic otitis media (COM) is a common condition, affecting 0.5–30% of any community. Therefore, a conservative estimate of the number of people in the world suffering from COM is over 20 million.[1] The prevalence of squamous type of chronic suppurative otitis media (CSOM) is 3.5% in Nepal.[2]

The objective of tympanomastoid surgery for chronic otitis media, in decreasing order of priority are elimination of disease to produce safe and dry ear; alteration of anatomy to prevent recurrent disease, optimization of cleaning and otological monitoring; and reconstruction of the middle ear to achieve serviceable and stable postoperative hearing.[4]

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.[3] The modern era of tympanoplasty was ushered in by Wullstein and Zollner. Wullstein classified the operations as types I

through V.[4]

In classical type III tympanoplasty or myringostapediopexy, disease is removed from tympanomastoid compartment and advancement of the tympanic membrane (TM) or placement of tissue graft is done on top of the stapes capitulum. After this procedure, air-bone gap (ABG) range is around 10-60dB.

Merchant et al. in laboratory model demonstrated that improved hearing results could be achieved in myringostapediopexy by interposing a thin cartilage disc between the graft and stapes head.[4] For augmented type III tympanoplasty, either cartilage or sculptured cortical bone can be kept between the intact stapes and the fascial graft.[3] Cartilage disc was hypothesized to improve the "effective" vibrating area of the graft that was coupled to the stapes head.[3] Cartilage also offers the advantage of higher mechanical stability compared with membranous transplants thus preventing retraction of tympanic membrane in the long run but others argue that it may alter the acoustic transfer characteristics of the graft due to its increasing mass and stiffness of the reconstructed tympanic membrane.

Materials and methods

A Prospective study was performed in Ganesh Man Singh Memorial Academy of ENT and Head & Neck Studies, Tribhuvan University Teaching Hospital, Institute of Medicine, Maharajgunj, Kathmandu, Nepal from October 2006 to April 2008. Patients who were e" 5 years of both sexes with intact and mobile stapes suprastructure at Canal-wall-down (CWD) tympanomastoidectomy surgery for COM squamous type were included. Pure Tone Audiometry was performed within seven days prior to the operation by Hughson and Westlake method. The test was performed through Air Conduction and Bone Conduction mode. Air and Bone Conduction threshold 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 Air and Bone conduction threshold were recorded both pre and post-operatively. Postoperative ABG closure was calculated by taking the difference between preoperative and postoperative ABG of the average frequencies of 500, 1000, 2000 and 4000 Hz. Audiometry results were reported according to American Academy of Otolaryngology-Head and Neck Surgery guidelines, except for thresholds at 3kHz, which was substituted in all cases with thresholds at 4kHz.[5] For classical type III tympanoplasty, a temporalis fascia graft was used to bridge the middle ear air space and placed in contact with the stapes head. The graft was then draped over the facial ridge. 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 was performed after 10th week postoperatively. During follow up, ears with minimal discharge from the mastoid cavity but with healed middle ear were subjected to pure tone audiometry (PTA) assessment. Results were analyzed in terms of average postoperative ABG and ABG closure. The results between both 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 d" 0.05 was taken as significant.

Results

Total number of patients enrolled during the study were 77, out of which CWD mastoidectomy and classical type III tympanoplasty were 41 (53.2%) and CWD mastoidectomy and cartilage augmented type III tympanoplasty were 36 (46.8%). Among these patients, those with CWD mastoidectomy and classical type III tympanoplasty, 39 (95.1%) came for follow up and 2(4.9%) patients were lost in the follow up. Among those with classical type III tympanoplasty with adequate follow up, one was excluded from the study because of graft failure. Among those with cartilage augmented type III tympanoplasty, all 36 (100%) patients had adequate follow up. Among them, 2(5.5%) were excluded from the study because of graft failure. (Table I)

Table 1. Total distribution of patients in 2 groups.

Groups	Total cases*	Included	Excluded	Lost follow up
CWD mastoidectomy and classical type III tympanoplasty	41	38(92.7%)	1(2.4%)	2(4.9%)
CWD mastoidectomy and cartilage augmented typeIII tympanoplasty	36	34(94.4%)	2(5.6%)	-

*(n=77)

The difference in post-operative ABGs between classical type III tympanoplasty and cartilage augmented type III

tympanoplasty at different frequencies (500Hz, 1000Hz, 2000Hz, and 4000Hz) were analyzed and found to be statistically not significant. The difference in four frequency average post-operative ABG between these two groups was also found to be statistically not significant with p value of >0.001. However, the post-operative ABG was better by 2.5dB and 1.6dB at frequencies 500Hz and 2000Hz in cartilage augmented type III tympanoplasty as compared to classical type III tympanoplasty but it was worse by 1.4dB and 2.3dB at frequencies 1000Hz and 4000Hz in cartilage augmented type III tympanoplasty as compared to classical type III tympanoplasty. On an average, there was 0.1dB improvement in cartilage augmented type III tympanoplasty as compared to classical type III tympanoplasty, which was statistically not significant. (Table 2)

Table 2. Comparison of frequency wise post-operative PTA-ABG between patients with classical type III tympanoplasty and cartilage augmented type III tympanoplasty.

Parameters	Group	n	Mean	Std. Deviation	Min.	Max.	P value
Post-operative	cartilage augmented						
ABG 500Hz	type III tympanoplasty	34	35.44	10.10	15	60	0.385
	classical type III tympanoplasty	38	37.89	13.74	15	75	
Post- -operative	cartilage augmented						
ABG 1000Hz	type III tympanoplasty	34	31.47	11.25	10	60	0.660
	classical type III tympanoplasty	38	30.13	14.12	10	65	
Post- operative							
ABG 2000Hz	cartilage augmented						
	type III tympanoplasty	34	20.44	8.74	5	35	0.542
	classical type III tympanoplasty	38	21.97	12.00	5	55	
Post- operative							
ABG 4000Hz	cartilage augmented						
	type III tympanoplasty	34	31.47	12.76	0	70	0.491
	classical type III						
	tympanoplasty	38	29.21	14.73	10	80	
Post- operative							
ABG Average	cartilage augmented						
	type III tympanoplasty	34	29.71	7.69	15	47.50	0.965
	classical type III tympanoplasty	38	29.80	10.72	15	61.25	

The ABG closure between CWD mastoidectomy and classical type III tympanoplasty and cartilage augmented type III tympanoplasty at different frequencies (500Hz, 1000Hz, 2000Hz, and 4000Hz) was analyzed and average of them was plotted and found to be statistically not significant. However, in CWD mastoidectomy and cartilage augmented type III tympanoplasty, ABG closure was good at frequencies of 1000Hz, 2000Hz, and 4000Hz and was average as compared to CWD mastoidectomy and classical type III tympanoplasty whereas it was worse in 500Hz. (Table. 3).

The ABG closure was again divided into different categories like 0-5dB, 0-10dB, 0-20dB, 0-30dB and 0-40dB. It was noted that 9(26.5%) cases fell within 0-5dB and 24(70.6%) cases within 0-20dB in CWD mastoidectomy and cartilage augmented type III tympanoplasty whereas 7(18.4%) cases within 0-5dB and 23(60.5%) within 0-20dB in CWD mastoidectomy and classical type III tympanoplasty. (Table 4).

Discussion

The objectives of this study were to assess, analyze and compare post-operative hearing results in terms of average ABG and the size of ABG closure in patients undergoing

Table 3. Comparison of frequency wise ABG closure mean in classical type III tympanoplasty and cartilage augmented type III tympanoplasty.

Parameters	Group	n	Mean	Std. Deviation	Min.	Max.	P value
ABG CLOSURE	cartilage augmented						
500Hz	type III tympanoplasty	34	11.18	12.50	-10	40	0.423
	classical type III tympanoplasty	38	8.68	13.64	-20	50	
ABG CLOSURE							
1000Hz	cartilage augmented						
	type III tympanoplasty	34	7.94	14.57	-25	45	0.624
	classical type III tympanoplasty	38	9.74	16.23	-35	45	
ABG CLOSURE							
2000Hz	cartilage augmented						
	type III tympanoplasty	34	7.21	12.74	-15	40	0.836
	classical type III tympanoplasty	38	7.89	15.14	-30	45	
ABG CLOSURE							
4000Hz	cartilage augmented						
	type III tympanoplasty	34	4.26	15.18	-35	30	0.706
	classical type III tympanoplasty	38	5.79	18.55	-40	55	
AVERAGE	cartilage augmented						
	type III tympanoplasty	34	7.65	10.38	-13.75	35	0.889
	classical type III tympanoplasty	38	8.03	12.39	-17.50	40	

Table 4. ABG closure in classical type III tympanoplasty and cartilage augmented type III tympanoplasty. (n=72)

Groups	0-5dB	0-10dB	0-20dB	0-30dB	>30dB
CWD mastoidectomy and classical type III tympanoplasty	18.4%(7)	36.8%(14)	60.5%(23)	73.7%(28)	2.6%(1)
CWD mastoidectomy and cartilage augmented type III tympanoplasty	26.5%(9)	44.1%(15)	70.6%(24)	76%(26)	2.9%(1)

CWD mastoidectomy with classical type III tympanoplasty using temporalis fascia alone and with cartilage augmented type III tympanoplasty.

In our study, only short-term hearing result is reported. Long-term success of any ossicular repair is largely dependent on factors outside the control of the surgeon, such as; patient follow-up rates, eustachian tube function, middle-ear stability and the condition of the mucosa. Short-term results are hence more accurate reflection of the actual reconstructive procedures. In each case, post-operative air-bone gaps were calculated using post-operative air conduction and 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 these ABG closure, 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 size of the ABG closure for audiological assessment. For calculation of the size of the post-operative PTA- ABG closure ABGs were divided into different bins of 0-5dB,0-10dB,0-20 dB,0-30 dB, and >30 dB.

In our study, while comparing the average post operative air bone gaps between classical type III tympanoplasty and cartilage augmented type III tympanoplasty at various frequencies the differences were found to be statistically not significant (P>0.001). The difference in four frequency average post-operative air bone gap between these two groups was also found to be statistically not significant with a p value of 0.965. However, the post-operative ABG was better by 2.5 dB and 1.6 dB at frequencies 500Hz and 2000Hz in cartilage augmented type III tympanoplasty as compared to classical type III tympanoplasty but it was worse by 1.4 dB and 2.3 dB at frequencies 1000Hz and 4000 Hz in cartilage augmented type III tympanoplasty as compared to classical type III tympanoplasty. Our findings are to some extent in agreement with those of Merchant et al who observed a 5 dB improvement at 250Hz, 500Hz and 2000Hz with interposition of thin disc of cartilage between the graft and the stapes head in both of their temporal bone model as well as in their clinical study.[6] In their clinical study, cartilage augmentation was done after canal wall reconstruction and cavity obliteration. Variation in functional hearing results between the two studies may also have occurred due to this difference in the technique used. Moreover, PTA in our setting is done in a sound treated room rather than a sound proof room.

While analyzing the frequency wise post-operative average PTA-ABG in both the groups it was seen that ABG was the smallest at 2000 Hz as compared to other frequencies. Similar findings were also noted by Merchant et al in 2003.[6] 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 in their review article state that a canal "wall-down" mastoidectomy poses several considerations from an acoustical and mechanical perspective when compared to a canal "wall-up" procedure.[4] Firstly, the canal wall-down procedure i.e., radical or modified radical tympanomastoidectomy results in significant reduction in the size of residual middle ear air space. Secondly, a canal wall down procedure results in the creation of a large air space lateral to the 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.[7] Thirdly, 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 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.[1] Twenty (52.6%) cases in classical type III tympanoplasty of our study fall within 30 dB ABG closure. Our result following classical type III tympanoplasty compare well with myringostapediopexy as a tympanoplasty procedure in canal wall down mastoid surgery as reported by Cheang et al (n =22) who observed PTA-ABG closure within 30 dB in 61.9 % of his patients.[8] Our results however are different from those of natural myringostapediopexy (n=15) and surgical canal down myringostapediopexy (n=35) as reported by Dawes who observed PTA ABG closure within 30 dB in 87.0 % and 90.0% of his cases in these two groups respectively.[9] Moustafa and Khalifa observed hearing results of simple myringostapediopexy technique (n=145) and showed that only 10 % of these cases achieved PTA-ABG closure of less than 30 dB.[10] Another study performed by Cook et al showed that the ABG closure in CWD mastoidectomy with cartilage from stapes to drum technique were 30% within 10 dB, 69% within 20 dB and 75% within 30 dB which are close to our results.[11]

In our study, 20 (58.8%) cases in cartilage augmented type III tympanoplasty fell within 30 dB ABG closure. Similar studies with some modifications in the technique published in the literature report varying proportions of PTA-ABG closure. Cheang et al in his myringolenticulopexy group (n= 20) achieved an ABG of less than 30 db in 92 % and ABG of less than 20 dB in 64% of has cases.[8] Moustafa and Khalifa in their myringo-cartilago-stapediopexy group (n= 95) achieved an ABG of less than 20 dB in 84%.[10] Kyrodimos et al 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.[12] However their study included both canal wall up and canal wall down procedures. Malafronte et al 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.[13] 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. Another factor leading to failure of tympanoplasty is total or partial non-functional results which are often influenced by wide variability in the surgical techniques employed, criteria used to evaluate hearing results and a number of other anatomical, physiological

and pathological events that occur post-operatively in the middle ear as mentioned above. It must be remembered that fibrosis could be due to the underlying middle-ear or upper airway pathology that caused the disease – it may not be caused, in part or full, by surgery. Equally important may be the extent of destruction by the disease that may adversely affect the ultimate functional results. Such issues may be more relevant in an underdeveloped country like ours.

Conclusion

The post-operative PTA–ABG ranged from 15–61.2 dB in classical type III tympanoplasty while the post-operative PTA –ABG ranged from 15– 47.5 dB in cartilage augmented type III tympanoplasty, suggesting the possibility of effect of multiple other factors .The post-operative PTA-ABG was 2.5dB and 1.6dB less at frequencies 500Hz and 2000Hz in cartilage augmented type III tympanoplasty as compared to classical type III tympanoplasty but this difference was not statistically significant. In comparison of size of ABG closure between classical and cartilage augmented type III tympanoplasty, cartilage augmented group showed marginally better results. In classical type III tympanoplasty 28 (73.7 %) cases and 26 (76%) cases in cartilage augmented type III tympanoplasty fell within 30 dB ABG closure. But this difference was statistically not significant. However, cartilage augmentation type III tympanoplasty in canal wall down mastoid surgery is a worthwhile procedure.

References

1. Sadé J (1982) Introduction. In: Sade J (ed) Cholesteatoma and mastoid surgery. Kugler, Amsterdam,1–3.
2. Adhikari P, Sinha BK, Pokhrel NR, Kharel B, Aryal R, Ma J. Prevalence of chronic suppurative otitis media in school children of kathmandu district. Journal of institute of medicine 2007; 29**(3):**10-12.
3. Merchant SN, Rosowski JJ. Auditory physiology.Glassock-Shambough Surgery of the Ear, 5th edition. Elsevier India, New Delhi.2003, 64-78.
4. Merchant SN, McKenna MJ, Rosowski JJ. Current status and future challenges of tympanoplasty. Eur Arch Otorhinolaryngol 1998; **255:**221–228.
5. American Academy of Otolaryngology-Head Neck Surgery Foundation, Inc. Committee on Hearing and Equilibrium guidelines for the evaluation of results of treatment of conductive hearing loss. Otolaryngol Head Neck Surg 1995; **113:**186-7.
6. Merchant SN, McKenna MJ, Mehta RP, et al. Middle ear mechanics of type III tympanoplasty (stapes columella): II clinical studies. Otol Neurotol 2003; 24**(2):**186 –94.
7. Goode RL, Friedrichs R, Falk S. Effect on hearing threshold of surgical modification of the external ear. Ann Otol Rhinol Laryngol1977; **86:**441–451.
8. Cheang PP, Kim D, Rockley TJ. Myringostapediopexy and myringolenticulopexy in mastoid surgery. J Laryngol Otol 2008; 17**(3):**1-5.
9. Dawes PJ. Myringostapediopexy: surgical expectation The Journal of Laryngology & Otology March 2003; **117:**182–185.
10. Moustafa HM, Khalifa MA. Tympano-cartilago-stapediopexy: a method to improve hearing in open technique tympanoplasty. J Laryngol Otol 1990; **104:**942-4.
11. Cook JA, Krishnan S, Fagan PA. Hearing results following modified radical versus canal-up mastoidectomy. Ann Otol Rhinol Laryngol 1996; 105**(5):**379-83.
12. Kyrodimos E, Sismanis A, Santos D. Type III cartilage "shield" tympanoplasty: an effective procedure for hearing improvement. Otolaryngol Head Neck Surg. 2007; 136**(6):**982-5.
13. Malafronte G,Filosa B,and Mercone F. A new double – cartilage block ossiculoplasty: long term results. Otol Neurotol 2008; **29:**531-33.