Modified intact canal wall mastoidectomy – long term results in hearing and healing

A. Mahadevaiah · Bhavin Parikh

Abstract

Introduction The classic intact canal wall (ICW) mastoidectomy with tympanoplasty (combined approach tympanoplasty) [1, 2] has anatomic constraints for clearance of disease from the anterior attic and sinus tympani leading to high recidivism. Farrior [3, 4] described the modification of this technique and senior author (AM) has been using it with further modifications since 1973.

Materials and methods We report our long-term experience in hearing and healing in 126 cases with special reference to the age (pediatric versus adults), ossicle status (presence or absence of stapes suprastructure) and type of cholesteatoma (Attic versus posterior-superior versus secondary acquired cholesteatoma).

Results All the patients had unsafe CSOM and underwent Modified ICW mastoidectomy with primary ossiculoplasty except five where the procedure was staged.

Conclusion Modified ICW technique is a one-stage procedure with the lowest recidivism rate when compared to various other ICW techniques. There is no significant difference in relation to age of the patient or type of cholesteatoma if the operative cases are selected judiciously.

Keywords Modified intact canal wall mastoidectomy · Closed cavity mastoidectomy.

A. Mahadevaiah · B. Parikh
Basavanagudi ENT Care Centre,
Basavanagudi, Bangalore,
India.

A. Mahadevaiah (✉)
E mail: bent@bgl.vsnl.net.in

Introduction

The limitation of the original ICW technique which includes posterior transmastoid facial recess approach with posterior thinning of canal wall have been reported by various authors [5–9] as early as 1970 with regard to high rates of residual and recurrent cholesteatoma. This incidence has not reduced substantially over the years and staging the operation has become routine by the authors advocating the original ICW technique. Various modifications have been published since then sensing the need for improvement in results and prevention of second stage operations with intact posterior canal wall. As early as 1969, Farrior had suggested his modification of anterior atticotomy with anterior thinning of the canal wall. This was further modified by Tos [10] who described transmeatal atticotomy with anterior drilling of canal wall with bony rim (which he termed “otosclerosis drilling”) with post-auricular mastoidectomy with maximal thinning of posterior and superior bony canal wall. However, Tos performs atticotomy leaving behind the bridge of bone over medial part of scutum. We hereby describe our technique with its results over long term with regards to hearing and healing in 126 cases.

Materials and methods

A retrospective study was carried out by analysis of records of patients who underwent modified ICW mastoidectomy with tympanoplasty for cholesteatoma over the 16-year period from 1989 to 2004. Modified ICW technique was performed in cases of cholesteatoma confined to the middle ear, attic and antrum with an intact sac. It was not performed in cases of invasive cholesteatoma, recurrent cholesteatoma after ICW technique or in sclerosed mastoids with anteriorly placed lateral sinus and low-lying tegmen plate. The senior author had performed modified ICW procedure on 435 patients with 360 patients having follow-up up to 1 year out of which 126 cases were available for more than one

year of follow up (average follow up of 37.4 months). Since the patients were referred from far off places, not all of them were available for follow up examination and audiometry at our center and were managed by referring ENT surgeons. These 126 patients form the core sample of the present study. Details of these patients were recorded for age, date of operation, period of follow up, type of cholesteatoma, status of ossicles, details of ossiculoplasty, staging of operation and presence of residual or recurrent cholesteatoma over this period.

Hearing evaluation was done by recording air (AC) and bone conduction (BC) of all these patients for 0.5, 1, 2 and 4 kHz pre-operatively, in immediate post-operative period (3 months to one year) and in late post-operative period (more than one year). Air conduction for 3 kHz was calculated as an average of 2 and 4 kHz [11]. Hearing results are reported using the guidelines recommended by Committee on Hearing and Equilibrium of the American Academy of Otolaryngology-Head and Neck Surgery for the evaluation of results of treatment of conductive hearing loss [11]. This includes reporting of the mean, standard deviation and range of the post-operative air-bone gap (AB gap), the number of decibels of change in the air-bone gap and the change in high-tone bone conduction level. Statistical analysis of these results was done by Z test. The hearing result was further classified into bins of 0–10, 11 to 20, 21 to 30 and more than 30 dB based on post-operative AB gap. Specific analysis was made for hearing results with variables in age (pediatric versus adults), ossicle status (presence or absence of stapes suprastructure) and type of cholesteatoma (Attic versus Posterior-superior versus Secondary Acquired cholesteatoma). The healing results comprised of evaluating all the patients requiring revision surgery during the observation period. The causes for revision were divided into those with residual or recurrent cholesteatoma, residual perfora-

tion or those requiring revision ossiculoplasty. Patients undergoing planned second stage ossiculoplasty were not considered as primary cases and the hearing results were reported from the time of ossiculoplasty.

Surgical technique

All the cases (except children and non co-operative adults) were operated under local anesthesia with proper sedation by post-aural approach. In all the cases of unsafe CSOM surgery is initiated in similar pattern and the decision to perform ICW mastoidectomy with tympanoplasty is made intra-operatively depending on the extent of disease. The closed cavity technique is performed in cases of cholesteatoma confined to the attic, the antrum with an intact sac, and the middle ear.

We follow the following steps in that order.

1. Harvesting of temporalis fascia through a postauricular incision.
2. Post-auricular cortical mastoidectomy and removal of polypoid mucosa, diseased cellular system and delineation of cholesteatoma with its sac in the antrum.
3. Transcanal elevation of posterior meatal and superior and inferior tympanomeatal flaps (figure 1) and securing the tympanomeatal flaps in anterior sulcus.
4. Transcanal atticotomy until the disease in anterior attic and supratubal recess are directly visualized (figure 2).
5. Widening the bony canal by thinning of posterior canal wall from anterior aspect including removal of the posterior bony rim to expose the sinus tympani and facial recess.

Fig. 1 Showing incisions for transcanal elevation of superior and inferior tympano-meatal flaps

6. Total clearance of cholesteatoma and granulations from the attic, antrum and middle ear including sinus tympani area along with the involved malleus and incus (Fig. 2).
7. Reconstruction of tympanic membrane (TM) by underlay grafting.
8. Short or long columella ossiculoplasty with autogenic or allogenic ossicles or septal spur cartilage depending on the condition of stapes suprastructure in that particular case (Figs. 3 and 4).
9. Reconstruction of lateral attic wall with autogenic

conchal cartilage. The small defects remaining in the attic after the reconstruction with conchal cartilage is filled with free fibro-periosteal tissue (Fig. 5).

10. Opening of the facial recess by posterior tympanotomy is not required since the disease clearance especially from the sinus tympani area can be achieved by removal of posterior bony wall and the rim.

Fig. 2 Showing transcanal atticotomy with thinning of posterior bony canal wall, removal of posterior bony rim and total clearance of cholesteatoma and granulations from the attic, antrum and middle ear

Results

The study group consisting of 126 patients who underwent modified ICW technique range from 6 to 65 years in age (Mean-28.4 and Median- 28 years) with a follow up of 12 to 120 months (Mean-37.4 and Median-36 months). All the patients had unsafe CSOM and underwent modified ICW mastoidectomy with primary ossiculoplasty except five where the procedure was staged. Intra-operative ossicular status was showing ossicular defect of M⁺I⁻S⁺ in 57 and M⁺I⁻S⁻ in 69 patients. It is the policy of senior author (AM) to do either short or long columella ossiculoplasty independent of presence of malleus as the malleus oval window relationship is highly variable and unfavorable or the malleus is diseased with pathological destruction. The stapes footplate was fixed in one and dehiscent with exposed endosteum in one patient each. Autogenic or allogenic ossicle (incus for short columella and malleus for long columella) or septal spur cartilage was used for ossiculoplasty. The cholesteatoma type included 42 patients with attic, 50 with postero-superior (sinus) and 34 with secondary acquired cholestea-

Fig. 3 Showing short columella ossiculoplasty (myringostapediopexy) with allogenic cartilage

Fig. 4 Showing long columella ossiculoplasty (myringoplastinopexy) with allogenic cartilage

Fig. 5 Showing reconstruction of lateral attic wall with autogenic conchal cartilage and fibro-periosteal tissue

toma. 11 (8.7%) patients required revision surgery due to recidivism, residual perforation or revision ossiculoplasty (Table 1). There was recurrence of cholesteatoma in three of these patients, three had recurrent cholesteatoma and one of them required revision myringoplasty for residual perforation. Revision ossiculoplasty was performed in four cases due to worsening of initially improved AB gap. There was no extrusion of either autogenic or allogenic ossicle/cartilage during the follow up period.

The comparison of hearing results that was obtained pre-operatively, in early post-operative period and on final follow up is summarized in Table 2. There is a highly

significant improvement in post-operative air conduction and air bone gap in early post-operative period, which was maintained over long term without any statistically significant difference. There was a mean improvement of 13 dB in air bone gap sustained over the long term. Only four of the patients had post-operative air bone gap worst than the pre-operative level. There was no statistically significant change in bone conduction in early post-operative period. However there was a mean rise in late post-operative bone conduction of 3.2 dB. Serviceable hearing was considered to be present when the air bone gap was less than 20 dB. Table 3 shows that only 17 patients (13.5%) had serviceable hearing before surgery, which increased to 87 (69.1%) after surgery over long term.

Table 4 shows comparison of hearing and healing (as denoted by requirement of revision surgery) based on the age of patient (pediatric versus adult) at the time of surgery. There was no significant difference among the two with regard to hearing and healing. Table 5 shows comparison of hearing and healing results based on the ossicular status (stapes suprastructure present or absent) during initial ossiculoplasty (primary or staged). Type of Ossiculoplasty and status of ossicles did not affect long-term healing results. However, presence of stapes suprastructure requiring short columella ossiculoplasty had significantly better post-operative air bone gap compared to long columella ossiculoplasty. Table 6 shows comparison of hearing and healing based on the type of cholesteatoma (Attic versus Posterosuperior versus Secondary Acquired) at the time of surgery. There was no significant difference among the three with regard to hearing and healing.

Table 1 Cause for revision surgery

	Number of patients (%)
Residual Cholesteatoma	3/126 (2.4)
Recurrent Cholesteatoma	3/126 (2.4)
Perforation	1/126 (0.8)
Revision Ossiculoplasty	4/126 (3.2)

Table 2 Comparison of pre- and post-operative hearing results

	Air conduction (0.5, 1, 2, and 3 kHz)			Bone conduction (0.5, 1, 2, and 3 kHz)			Air-bone gap (0.5, 1, 2 and 3 kHz)		
	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range
Preoperative (dB)	51	13	25-84	19.8	7.4	5-45	31	10	5-55
Early Post operative(dB)	40	11	18-70	20.6	8.2	0-52	19	8	5-40
Late Post operative(dB)	40	14.5	15-83	23	9	0-50	18	9	3-42
Change* (EarlyPostop)	12	12	-18-46	-1	5	-20-18	13	1	-7-43
Change# (LatePost- op)	36	22	-18-50	-3	6	-25-10	13	12	-4-32
Change \$ (Early- Late Post-op)	-1	10	-40-25	-2	7	-34-10	1	8	-25-19

*p value < 0.01 (highly significant) for AC and AB gap and >0.05 (not significant) for BC

#p value < 0.001 (highly significant) for AC and AB gap and <0.05 (significant) for BC.

\$p value < 0.001 (highly significant) for AC and AB gap and <0.05 (significant) for BC.

Table 3 Summary of post-operative hearing condition

	Post-op air conduction (In dB)				Post-op air-bone gap (In dB)			
	0 to 20	21 to 30	31 to 40	> 40	0 to 10	11 to 20	21 to 30	> 30
Pre-operative number (%)	0 (0)	4 (3.2)	17 (13.5)	105 (83.3)	1 (0.8)	16 (12.7)	40 (31.7)	69 (54.8)
Late post-operative number (%)	4 (3.2)	24 (19.1)	37 (29.4)	61 (48.4)	34 (27)	53 (42.1)	23 (20.6)	13 (10.3)

Table 4 Comparison of hearing and healing

	Air-bone gap for children (0.5, 1, 2 and 3 kHz)			Air-bone gap for adults (0.5, 1, 2 and 3 kHz)		
	Mean	SD	Range	Mean	SD	Range
Pre-operative (dB)	30	9	5-51	32	10	11-55
Late post-operative (dB)	16	9	5-40	19	9	3-42
Change (dB) *	SD 10, Mean 14			SD 12, Mean 13		
Number requiring revision surgery# (%)	2/28 (7.1)#			9/98 (9.2)#		
* p value	Not Significant					
# p value	Not Significant					

Discussion

The surgical approach for removal of cholesteatoma is dictated by location, type and extension of the cholesteatoma.

We limit the use of Modified ICW technique to cases with intact sac in attic or antrum without invasion of mastoid air cells. We also use this technique in cases of chronic granulomatous disease of middle ear and mastoid, glomus

Table 5 Comparison of hearing and healing results based on the ossicular status

	Air-bone gap for intact stapes (0.5, 1, 2 and 3 kHz)			Air-bone gap for absent stapes (0.5, 1, 2 and 3 kHz)		
	Mean	SD	Range	Mean	SD	Range
Pre-operative (dB)	30	10	5-55	32	10	11-51
Late post-operative (dB)	16	7	5-33	20	10	3-42
Change (dB) *	Mean 14, SD 10			Mean 12, SD 13		
Number requiring revision surgery# (%)	4/57 (7) [#]			7/69 (10.1) [#]		
* p value	Not Significant					
# p value	Not Significant					

Table 6 Comparison of hearing and healing based on the type of cholesteatoma

	Air-bone gap for attic cholesteatoma (0.5, 1, 2 and 3 kHz)			Air-bone gap for sinus Cholesteatoma (0.5, 1, 2 and 3 kHz)			Air-bone gap for tensa retraction cholesteatoma (0.5, 1, 2 and 3 kHz)		
	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range
Pre-operative (dB)	29	10	5-55	31	10	14-49	35	9	15-51
Post-operative (dB)	16	10	3-40	19	9	5-42	20	9	4-37
Change (dB)*	Mean 13.95, SD 13			Mean 11, SD 11			Mean 15, SD 9.87		
Number of revision surgery (%)	3/42 (7.1)			4/50 (8)			4/34 (11.8)		
* p value	Not Significant								
# p value	Not Significant								

tympanicum (Glasscock Jackson Grade III and occasional cases of Grade IV) and congenital cholesteatoma localized to middle ear. However, our discussion is limited to its use in acquired cholesteatoma.

Modified ICW technique is an entirely different approach to critical areas in middle ear and anterior attic as compared to classic ICW technique. Sinus tympani and posterior tympanic sinus (the triangular space between facial nerve, stapedius tendon and posterior crus of stapes) are difficult or even impossible to view via classic facial recess approach and thus the classical technique becomes a blind technique when clearing disease in this area leading to risk of residual disease. In Modified ICW technique, the posterior bony rim is drilled under direct vision and facial recess opened till the base of the process pyramidalis bringing the sinus tympani and posterior sinus tympani into direct vision.

Clearance of disease from anterior attic in classical ICW technique requires extensive transmastoid epitympanotomy with narrow working space and inadequate visualization of supratubal recess especially its anterior end. Transmeatal atticotomy provides circumferential access to anterior attic with adequate working space and direct vision. Thus the chances of residual cholesteatoma decrease substantially and there is no need for second look procedure.

The disadvantage with this technique has been the higher probability of retraction due to atticotomy and increased gap between posterior bony wall and stapes suprastructure/footplate. However, it is prevented by the appropriate size of conchal cartilage with its perichondrium whose natural curvature makes it to snugly adapt to postero-superior bony wall. The retraction between posterior bony wall and stapes suprastructure/footplate is prevented by the ossiculoplasty graft (autogenic or allogenic ossicle or cartilage), which supports the neotympanum and prevent its retraction. If the eustachian tube is poor there might be retraction. But in most of these cases it is limited to shallow self-cleaning retraction. Thus the rate of recidivism is among the lowest (6/126 i.e. 4.8%) when compared to various other techniques where it ranges from 6 to 40% [6–10].

The rate of residual perforation is substantially reduced when underlay grafting is combined with skeletonization of malleus handle, extended superior and inferior tympanomeatal flaps and pulling of graft through anterior window made just above the anterior fibrous annulus [12].

The ossiculoplasty technique involves either short or long columella without any use of alloplastic material. The alloplastic material is more expensive and has higher rate of extrusion even if a cartilage is used as interposition

between it and neotympanum. The functional hearing results are equivalent with autograft/allograft and alloplastic TORP/PORP. The autogenic/allogenic ossicle graft is preferred over cartilage when stapes suprastructure is absent as it is more stable when the oval window is narrow [13]. The functional results are better with short columella compared to long columella and so the stapes suprastructure should be preserved in all possible cases.

The long-term hearing results achieved with our technique are comparable to other closed cavity techniques [6, 13, 14]. Serviceable hearing (AB Gap <20 dB) was achieved in 87/126 (69.1%) cases. The long-term hearing results were equivalent irrespective of the age of the patient or type of cholesteatoma with an average change in AB gap of 13 dB as compared to pre-operative levels and were achieved with single stage. Though there was an average of 3.2 dB increases in post-operative BC, it was not more than 10 db in any of the patients.

The optimal surgical treatment for cholesteatoma in children has been under controversy regarding ICW versus CWD technique. While some studies [7, 9, 14, 15] have shown higher recurrence rate in children others [16, 17] have found no correlation between age and recidivism. The various hypotheses behind the need for CWD treatment for pediatric cholesteatoma includes more aggressive biology, more chances of pneumatized mastoid and higher rate of eustachian tube dysfunction. If the intra-operative findings suit our indications for modified ICW technique, we found no difference with regard to hearing or recidivism when compared to long-term results of adult patients.

Tos and Lau [18] found different recurrence rates in different types of cholesteatoma, with attic cholesteatoma having lowest recidivism and tensa retraction cholesteatoma having highest recidivism and poorest hearing results. However, we did not find any significant difference in recidivism rates or hearing results when comparing the three groups of cholesteatoma i.e. Attic versus posterosuperior versus secondary acquired cholesteatoma.

Conclusion

Modified ICW technique is an entirely different approach to critical areas in middle ear and attic as compared to classic ICW technique. Modified ICW technique is a one-stage procedure (in majority of cases) with the lowest recidivism rate when compared to various other ICW techniques. There is no significant difference in relation to age of the patient or type of cholesteatoma if the operative cases are selected judiciously. Serviceable hearing can be achieved in 69% (87/126) cases over long term with an average improvement in post-operative AB Gap of 13 dB.

References

1. Sheehy JL, Patterson ME (1967) Intact canal wall tympanoplasty with mastoidectomy. *Laryngoscope* 77:1502–1542
2. Jansen C (1968) The combined approach for tympanoplasty. *J Laryngol Otol* 82:779–793
3. Farrior JB (1969) The canal wall in tympanoplasty and mastoidectomy. *Arch of Otolaryngol Head Neck Surg* 90: 706–714
4. Farrior JB (1973) Systematized approach to surgery for cholesteatoma. *Arch of Otolaryngol Head Neck Surg* 97: 188–190
5. Sheehy JL (1970) Tympanoplasty with mastoidectomy-A re-evaluation. *Laryngoscope* 80:1212–1230
6. Glasscock ME, Miller GW (1976) Intact canal wall tympanoplasty in management of cholesteatoma. *Laryngoscope* 86:1639–1657
7. Smyth GDL (1976) Post-operative cholesteatoma in combined approach tympanoplasty. *J Laryngol Otol* 90: 597–621
8. Abramson M, Lachenbruck PA, Press BHJ, Mc Cabe BF (1977) Results of conservative surgery for middle ear cholesteatoma. *Laryngoscope* 87:1281–1287
9. Brown JS (1982) A ten-year statistical follow-up of 1142 consecutive cases of cholesteatoma: the Closed versus Open technique. *Laryngoscope* 92:390–396
10. Tos M (1982) Modification of combined approach tympanoplasty in attic cholesteatoma. *Arch of Otolaryngol Head Neck Surg* 108:772–778
11. Guidelines of the Committee on Hearing and Equilibrium. Committee on Hearing and Equilibrium guidelines for the evaluation of results of treatment of conductive hearing loss. *Otolaryngol Head Neck Surg* 1995; 106: 865–867
12. Vijayendra H, Mahadevaiah A, Surendran K, Sangeetha R (2005) Micro-ear surgery-It's purpose and procedure for a tubotympanic pathology. *Indian J of Otolaryngol Head Neck Surg* 57:360–363
13. Vartiainen E, Nuutinen J (1992) Long-term hearing results of one-stage tympanoplasty for chronic otitis media. *Eur arch Otorhinolaryngol* 249:329–331
14. Vartiainen E (1995) Factors associated with recurrence of cholesteatoma. *J Laryngol Otol* 109:590–592
15. Stangerup S, Drozdiewicz D, Tos M, Trabalzini F (1998) Surgery for acquired cholesteatoma in children: long-term results and recurrence of cholesteatoma. *J Laryngol Otol* 112:742–749
16. Dodson EE, Hashisaki GT, Hobgood TC, Lambert PR (1998) Intact canal wall mastoidectomy with tympanoplasty for cholesteatoma in children. *Laryngoscope* 108: 977–983
17. Rosenfeld RM, Moura RL, Bluestone CD (1992) Predictors of residual-recurrent cholesteatoma in children. *Arch of Otolaryngol Head Neck Surg* 118:384–391
18. Tos M, Lau T (1989) Late results of surgery in different cholesteatoma types. *Oto-Rhino-Laryngology* 51:33–49