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Which technique is better for cholesteatoma surgery?

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Abstract. *Which technique is better for cholesteatoma surgery? Objective*: The objective of this study was to evaluate the long-term surgical outcomes and recurrence rates of three surgical techniques that are commonly used for cholesteatoma.
Patients and methods: The hospital records of 132 patients with primary cholesteatoma who underwent surgery between January 1996 and December 2006 were evaluated retrospectively. Twelve cases had bilateral disease, and a total of 144 ears were treated. The patients were divided into three groups according to surgical technique: modified radical mastoidectomy (MRM) (n=48 ears), radical mastoidectomy (RM) (n=42 ears), and intact canal wall mastoidectomy (ICWM) (n=54 ears). MRM and RM procedures are canal wall down (CWD) techniques, whereas the ICWM procedure is a canal wall up (CWU) technique. Postoperatively, all patients were followed up yearly for at least 6 years. The otomicroscopic features, cholesteatoma extension, surgical findings, and recurrence rates were compared in the groups.
Results: Preoperative otomicroscopic examination showed attic retraction or perforation in 32% of the cases and central perforation in 11%. There was a higher cholesteatoma recurrence rate in the ICWM group than in the MRM and RM groups ($p<0.05$), but there was also better hearing gain in the ICWM group ($p<0.05$).
Conclusion: There are several surgical techniques for eradicating cholesteatoma. Our study found that CWD procedures (RM, MRM) were more effective for the eradication of cholesteatoma, but hearing gain was better when a CWU technique was used. The choice of surgical technique should be individually tailored based on the pre-operative imaging and hearing examination findings.

Introduction

Chronic otitis media is inflammation of the middle ear and mastoid spaces that continues for more than 3 months. Its major findings are otorrhea, tympanic membrane perforation, hearing loss, and sometimes cholesteatoma. Cholesteatoma is a benign lesion of the middle ear that consists of squamous epithelium and keratin debris and which contains E-cadherin, an epithelial cell adhesion molecule. Cholesteatoma can invade other sides of the temporal bone and cranial cavity as well.[1,2] High-resolution computed tomography (HRCT) is the most widely used imaging tool for diagnosing primary cholesteatoma, but MRI is quickly becoming more important for both the pre-operative assessment of cholesteatoma and for postoperative follow-up screening for residual disease.[3,4]

Cholesteatoma can occur in patients with long-term untreated tympanic membrane perforation. It can also occur in patients with chronic serous otitis media due to negative pressure of the middle ear, which can lead to invasion of the epithelium into the middle ear.[5,6] Cholesteatoma can lead to conductive hearing loss due to ossicle displacement, erosion, and tympanic membrane perforation. It can also lead to sensorineural hearing loss due to otic capsule fistulas and to mediators that pass through the round window and damage cochlear hairy cells. The risk of sensorineural hearing loss increases with increasing duration of chronic otitis media.[7,8]

The main goals for successful treatment of cholesteatoma are complete disease eradication, having a dry middle ear, and hearing restoration as much as possible.[9] The best technique for cholesteatoma eradication has been debated for many years. Several factors must be taken into the consideration before the operation: the type of cholesteatoma (congenital or acquired), the patient's age (child or adult), cholesteatoma extension (involvement of the attic, antrum, mastoid

cavity, eustachian tube, labyrinth, middle fossa, and mesotympanum), and preoperative hearing levels. A 'second look' operation is sometimes needed when a canal wall up (CWU) technique is used to ensure that there is no residual disease within the mastoid cavity or the middle ear, and this is usually performed electively six months to approximately one year after the primary surgery.[10]An increasing number of surgeons are using magnetic resonance imaging (MRI) for postoperative evaluation rather than a second look operation when hearing is sufficient. A canal wall down (CWD) procedure is appropriate for patients who have problems with compliance with surgical aftercare due to personal, social, or geographical conditions. The majority of patients achieve a dry, self-cleaning mastoid cavity after CWD procedures.[11,12]

There are two main approaches to the surgical management of cholesteatoma. Some otological clinics advocate CWU procedures, while others offer CWD procedures. Although some studies report recurrence rates for both CWD and CWU surgeries, more long-term results data are needed. This is quite important for otolaryngologists because the surgical management of cholesteatoma isa day-in/day-out procedure in ENT surgery. Thoughtful reflection on the use of well known surgical procedures is just as important as investigating new techniques. Accordingly, this study retrospectively analyzed the advantages and disadvantages of three surgical techniques that are commonly used for cholesteatoma.

Material and methods

The hospital records of 132 patients who underwent surgery for primary cholesteatoma between January 1996 and December 2006 at Haydarpaşa Numune Education and Research Hospital were evaluated retrospectively. The study included 63 women and 69 men with a mean age of 41 years (range, 18-72 years). Twelve patients had bilateral disease, so a total of 144 ears were treated surgically. Children younger than 18 years were excluded from the study; notably, postoperative results are often unsatisfactory in this population because of the high rate of cholesteatoma recurrence in children.[13,14]

In our clinic, CWD mastoidectomy is used for all large cholesteatomas, whereas CWU procedures are usually performed in patients with small cholesteatomas. The standard of care in our institution includes a visit the first week after the operation to remove sutures and packing material, an additional visit at 3-4 weeks for review and debridement, and a final visit the second month after surgery. These patients were asked to visit our clinic yearly after their operation, and all patients were followed up for at least 6 years postoperatively. Every follow-up visit included otomicroscopic examination and audiometric and radiologic investigations (temporal bone HRCT and diffusion MRI).

Patients were divided into 3 groups according to the surgical technique: modified radical mastoidectomy (MRM), radical mastoidectomy (RM), and intact canal wall mastoidectomy (ICWM). The MRM and RM procedures are called CWD techniques, and the ICWM procedure is called a CWU technique. In all cases, a post-auricular approach was performed using a 'front to back' technique. We tried to pay meticulous attention to fully clear the disease and totally remove the affected mastoid air cells. In the CWD techniques (MRM and RM), the surgeon removed the remnants of the posterior canal wall, and in the CWU technique (ICWM), the wall was saved or reconstructed. For the CWD technique, the tip of the mastoid process was removed and the hypotympanum, supratubal area, and sinus tympani were examined. The widened mastoid bowl was obliterated using 4 periosteal flaps based anteriorly, posteriorly, superiorly, and inferiorly. Continuous serum physiologic irrigation was performed to remove bone debris and to prevent thermal damage to the cochlea, vestibule, and facial nerve. Exploration of the tegmen, sinus, and vertical facial nerve is routine in our institution. The autologous temporalis muscle fascia was used for myringoplasty.[6]

Cholesteatoma extension was described based on intraoperative involvement of the attic, antrum, mastoid cavity, eustachian tube, labyrinth, middle fossa, and mesotympanum. The functional hearing results were calculated according to the guidelines of the Committee on Hearing and Equilibrium of the American Academy of Otolaryngology Head and Neck Surgery (AAO-HNS).[15] Air bone gaps (ABGs) were calculated from the air conduction (AC) and bone conduction (BC) thresholds. Finally, postoperative hearing gains were calculated by comparing the preoperative (one day before surgery) and the most recent follow-up results.

Statistical data analysis was performed using SPSS for Windows, version 13 (SPSS Inc., Chicago, IL, USA). The Kruskal-Wallis test (KW) was used to compare the groups. Dunn's multiple comparison test and the Tukey's range test were used to compare the subgroups, and the chi-square (χ^2) test was used to compare qualitative data. Results were considered significant for $p<0.05$.

Results

Of the 144 ears with cholesteatoma, 48 were operated with MRM, 42 with RM, and 54 with ICWM. At preoperative otomicroscopic examination, 46 ears (31.94%) had attic retraction or perforation, 19 (13.19%) had total perforation, 31 (21.52%) had subtotal perforation, 22 (15.27%) had marginal perforation, 16 (11.11%) had central perforation, and 10 (6.94%) had both marginal and attic perforation at their tympanic membrane. The percentage of ears with attic retraction or perforation was significantly higher than the percentage of ears with perforation of other areas of the tympanic membrane (KW = 24.61, p = 0.001) (p < 0.05) (Figure 1).

Regarding the intraoperative extension of disease in all 3 groups, cholesteatoma was more often located in the attic region than in other areas. A total of 41 of 48 ears (85.41%) in the MRM group, 37 of 42 ears (88.09%) in the RM group, and 46 of 54 ears (85.18%) in the ICWM group had cholesteatoma in the attic region (KW = 19.74, p = 0.003, p < 0.05). The sites invaded by cholesteatoma in the 3 groups are shown in Table 1.

The incidence of intra-operative findings of ossicular chain status was different in each group. The percentage of ears with erosion or absence of the malleus, incus,or stapes was 52.08% (25/48), 79.16% (38/48), and 10.41% (5/48), respectively, in the MRM group; 64.28% (27/42), 83.33% (35/42), and 16.66% (7/42), respectively, in the RM group; and 59.25% (32/54), 75.92% (41/54), and 12.96% (7/54), respectively, in the ICWM group. In all 3 groups, erosion or absence of the incus was significantly higher than for the other ossicles (KW = 16.51, p = 0.002, p < 0.05) (Figure 2).

Postoperative audiometric investigation for a minimum of 6 years showed differences in hearing gain or loss in the 3 groups (Figure 3). One day before primary surgery, a pure-tone audiogram was performed and compared with the last available postoperative audiogram; the audiological evaluations were performed according to the guidelines of the Committee on Hearing and Equilibrium.[15]

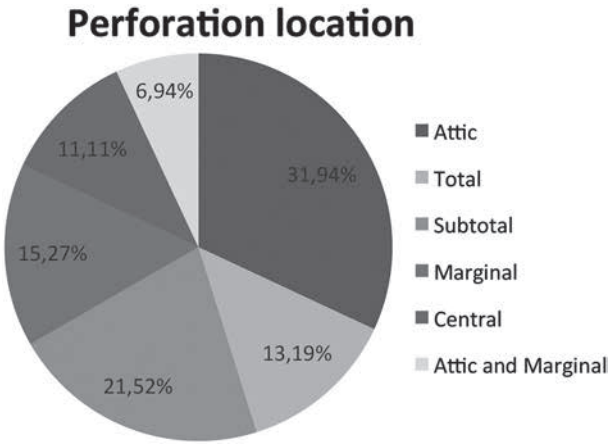
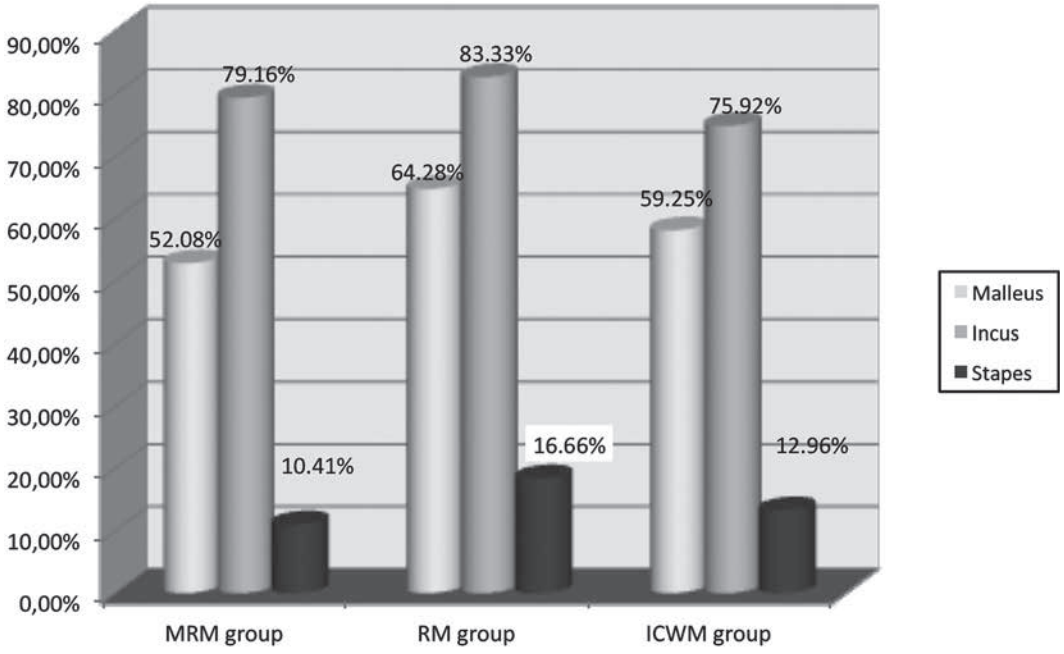


Figure 1
Location of tympanic membrane perforations in the ears with cholesteatoma in this study (n = 144).

Table 1
Cholesteatoma invasion location in the three treatment groups

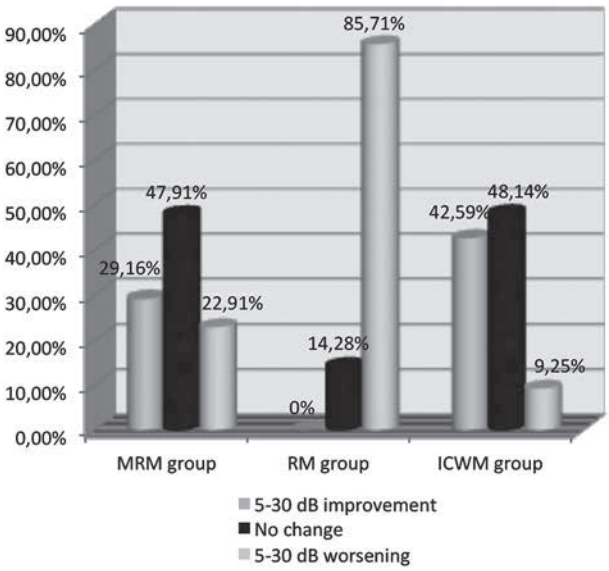
	MRM group	RM group	ICWM group
Attic	41/48 (85.41%)	37/42 (88.09%)	46/54 (85.18%)
Antrum	37/48 (77.08%)	33/42 (78.57%)	41/54 (75.92%)
Mastoid	32/48 (66.66%)	34/42 (80.95%)	39/54 (72.22%)
Middle ear	31/48 (64.58%)	29/42 (69.04%)	34/54 (62.96%)
Labyrinth	4/48 (8.33%)	5/42 (11.90%)	2/54 (3.70%)
Eustachian tube	5/48 (10.41%)	7/42 (16.66%)	3/54 (5.55%)

ICWM: intact canal wall mastoidectomy; MRM: modified radical mastoidectomy; RM: radical mastoidectomy.



ICWM: intact canal wall mastoidectomy; MRM: modified radical mastoidectomy; RM: radical mastoidectomy.

Figure 2
Ossicular chain involvement in the three treatment groups



ICWM: intact canal wall mastoidectomy; MRM: modified radical mastoidectomy; RM: radical mastoidectomy.

Figure 3
Post-treatment changes in hearing in the three treatment groups.

The outcome was based on the percentage of ears with a postoperative air-bone gap (ABG) <30 dB. In the MRM group, 14 of 48 patients (29.16%) showed 5-30 dB improvement, 23 (47.91%) showed no change, and 11 (22.91%) worsened by 5-30 dB; in the RM group, 6 of 42 patients (14.28%) showed no change and 36 (85.71%) worsened by 5-30 dB; and in the ICWM group, 23 of 54 patients (42.59%) showed 5-30 dB improvement, 26 (48.14%) showed no change, and 5 (9.25%) worsened by 5)-30 dB (Table 2). There was a statistically significant difference between the ICWM group and the other two groups in terms of hearing gain ($KW = 23.02$, $p = 0.034$, $p < 0.05$).

Analysis of cholesteatoma recurrence in the postoperative period (followed-up for at least 6 years after surgery) showed differences in the 3 groups. Based on the otomicroscopic examinations and radiological findings, we decided to perform revision surgeries on some patients. In the MRM group, 11 of 48 ears had revision surgery; 2 (4.16%) showed residual cholesteatoma, and 4 (8.33%) showed cholesteatoma recurrence. In the RM group, 7 of 42 ears had revision surgery; 1 (2.38%) showed residual cholesteatoma, and 2 (4.76%) showed recurrence. In the ICWM group, 16 of 54 ears had revision surgery; 5 (9.25%) showed residual cholesteatoma, and 8 (14.81%) showed recurrence (Table 3, Figure 4).

Table 2
Postoperative improvement in the air-bone gap (ABG) according to surgical procedure

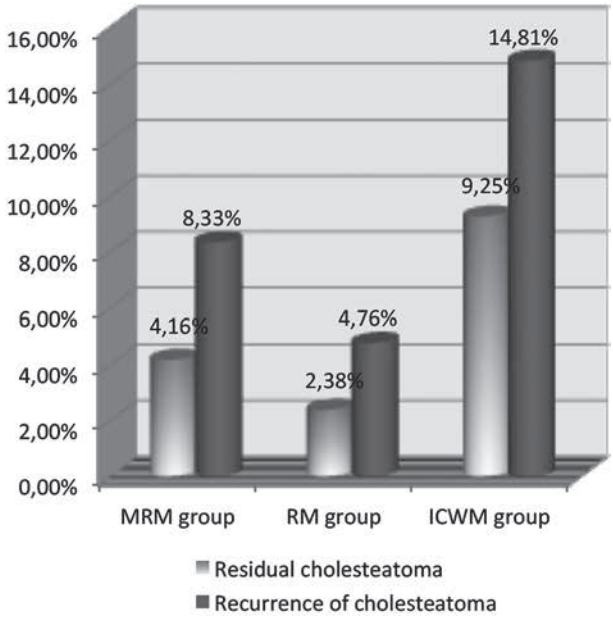
Group	≤ 10 dB	11-20 dB	21-30 dB	Total ≤ 30 dB
Modified radical mastoidectomy (MRM)	3.12%	11.63%	14.41%	29.16%
Radical mastoidectomy (RM)	0%	0%	0%	0%
Intact canal wall mastoidectomy (ICWM)	22.64%	18.33%	1.62%	42.59%

Table 3
Residual and recurrent cholesteatoma according to surgical procedure

Group	Residual cholesteatoma (%)	Recurrence of cholesteatoma (%)
Modified radical mastoidectomy (MRM)	2/48 (4.16%)	4/48 (8.33%)
Radical mastoidectomy (RM)	1/42 (2.38%)	2/42 (4.76%)
Intact canal wall mastoidectomy (ICWM)	5/54 (9.25%)	8/54 (14.81%)

Residual cholesteatoma is usually due to insufficient primary resection of the epidermal matrix, and it classically presents with a pearl-like aspect.[9,21,23] In this study, residual cholesteatomas were observed most often in the epitympanum (36.42%) followed by the sinus tympani (23.64%). We did not observe residual cholesteatomas in the mastoid cavity, protympanum, hypotympanum, or tympanic orifice of the eustachian tube. Residual cholesteatoma was observed significantly more frequently in the ICWM group than in the other groups ($KW = 23.14$, $p = 0.046$, $p < 0.05$) (Figure 4).

Recurrent cholesteatoma is usually due to attic retraction pockets, especially in ears with pre-operative discharge. Cholesteatoma recurrence was significantly higher in the ICWM group than in the other groups ($KW = 26.39$, $p = 0.0028$, $p < 0.05$).



ICWM: intact canal wall mastoidectomy; MRM: modified radical mastoidectomy; RM: radical mastoidectomy.

Figure 4
Residual and recurrent cholesteatoma according to treatment group.

Discussion

Cholesteatoma is a benign lesion of the middle ear that consists of squamous epithelium and keratin debris. The main goal of cholesteatoma treatment is eradication of the entire cholesteatoma, having a dry middle ear, and hearing restoration as much as possible.[9] In the literature, some authors prefer CWD procedures, while others favor CWU procedures. The cholesteatoma recurrence rates reported after surgery range from 7.6% to 57.0% and are related to the length of follow-up.[16]

Kim *et al*.[17] retrospectively analyzed 72 cholesteatoma surgeries and reported that 86% of patients with cholesteatoma were succesfully treated. They also stated that the average ABGs were satisfactory after CWD surgeries.

Naclerio *et al*.[18] studied 60 cholesteatoma cases and found that patients with cholesteatoma undergoing intact canal wall tympanoplasty with mastoidectomy need to be re-explored because of high recurrence. They also stated that hearing levels were better after ICWM and that this finding merited further study to reach statistical significance.

Park *et al*.[19] investigated and compared outcomes of CWU versus CWD procedures for recurrent cholesteatoma after initial canal-preserving surgery and stated that the second recurrence rate was significantly higher in the CWU group than the CWD group. The authors added that postoperative air bone gap closure was significantly better in the CWU group than in the CWD group.

In a study of 52 cholesteatoma cases,Vercruysse *et al*.[20] found that recurrent cholesteatoma occurred in 1.9% of all cases and residual cholesteatoma in 15.4%, and that postoperative hearing results were satisfactory with a closed technique. Cho *et al*.[21] performed a retrospective chart review of 208 patients who underwent revision surgery and 51 patients who underwent primary CWD mastoidectomy (CWDM). They reported that as a result of revision surgery, a dry and safe ear was achieved in 88.5% of patients, and similar results were achieved in patients who underwent primary CWDM.

In this study, we compared the 3 techniques that are most widely used for cholesteatoma surgery. Analysis of recurrence of cholesteatoma in the postoperative period (6 years of follow-up) showed differences in results depending on the type of operation. CWD procedures showed more successful results for cholesteatoma eradication. There was cholesteatoma recurrence in 4 of 48 ears (8.33%) in the MRM group, in 2 of 42 ears (4.76%) in the RM group, and in 8 of 54 ears (14.81%) in the ICWM group. Recurrent cholesteatomas usually develop from attic retraction pockets that may result from irreversible poor eustachian tube function. We observed more frequent recurrence in ears showing pre-operative discharge than in dry ears. Reinfection may lead to infected attic cholesteatomas, and appropriate medical treatment prior to surgery may help decrease such infected recurrences.[20,21] Similarly, residual cholesteatoma was higher in the ICWM group than in the other groups: 9.25% in the ICWM group versus 4.16% in the MRM group and 2.38% in the RM group. Residual cholesteatomas were observed mostly in the epitympanum (36.42%); this was thought to be caused by inadequate surgical examination due to incomplete opening of the attic and incomplete cleaning around the head and neck of the malleus. Residual cholesteatomas were also observed in the sinus tympani (23.64%), and this was thought to be due to inadequate removal of the matrix under indirect surgical observation attributable to insufficient drilling into the facial ridge. We did not observe residual cholesteatoma in the mastoid cavity, protympanum, hypotympanum, or tympanic orifice of the eustachian tube. Therefore, surgeons, especially those with less experience, should pay attention to the epitympanium and sinus tympani in order to prevent residual cholesteatoma. Some authors advise the use of otoendoscopy or an angled mirror to prevent residual disease in the epitympanum and sinus tympani regions in order to obtain clear views of this region and to entirely remove the cholesteatoma.[22,23]

Although the average ABGs were satisfactory in the MRM group, hearing gain was better in the ICWM group. Nevertheless, the importance of having a dry ear without discharge versus the importance of having excellent hearing should be taken into consideration and should be explained to the patients. Despite the ongoing debate, the results of our study provide strong evidence that a CWU technique results in a higher rate of recurrence. However, according to the patients' pre-operative data, including the results of otomicroscopic examination and audiometric and radiologic investigations (i.e. temporal bone HRCT and diffusion MRI), the choice of surgical technique should be individually tailored to each patient. If CWU is considered feasible after taking into account the different parameters (especially the extent of the cholesteatoma), this technique may result in less morbidity and a reduced need for post-operative care.

Conclusion

There are several surgical techniques that can be used to remove cholesteatoma. This study showed that CWD procedures like RM and MRM are more effective than CWU procedure for eradicating cholesteatoma, but hearing gain is better after CWU. The choice of surgical technique should be tailored to each individual patient based on the pre-operative imaging and hearing examination findings.

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