Am J Transl Res 2025;17(1):308-319
www.ajtr.org /ISSN:1943-8141/AJTR0161459

Original Article

Open cavity mastoidectomy improves audiological outcomes for cholesteatomatous chronic otitis media patients compared to closed cavity mastoidectomy

Hongya Geng, Lina Han, Yongtao Tian, Gaifang Zhang, Xiuyun Wu, Chunhua Wang, Zhitao Fan, Ranran Liu, Ling He

Department of Otolaryngology, Head and Neck Surgery, Hebei Eye Hospital, Hebei Provincial Key Laboratory of Ophthalmology, Hebei Provincial Clinical Research Center for Eye Diseases, Xingtai 054001, Hebei, China

Received October 25, 2024; Accepted December 25, 2024; Epub January 15, 2025; Published January 30, 2025

Abstract: Objectives: There is ongoing debate regarding the effectiveness of open cavity mastoidectomy (OCM) versus closed cavity mastoidectomy (CCM) in patients with chronic otitis media (COM). This study aimed to compare audiological outcomes of OCM and CCM in cholesteatomatous COM (CCOM) patients. Methods: Clinical data were collected from 102 patients with middle ear cholesteatomas who underwent OCM or CCM for CCOM at our hospital between February 2018 and May 2022. A retrospective analysis was conducted on audiological outcomes for patients with CCOM receiving either OCM or CCM. Air conduction (AC), bone conduction (BC), and air-bone gap (ABG) were compared between the two surgical methods. Further, recurrence, complications, pathological types, and the impact of prior ossiculoplasty were analyzed both before surgery and at three months post-ossiculoplasty. Results: No significant differences in demographic features were observed between the OCM and CCM groups, including gender, age, complications, pathological types, and the use of ossiculoplasty. All cases presented with hearing loss and otorrhea. Both OCM and CCM significantly reduced AC, BC, and ABG thresholds, with OCM showing greater effectiveness in decreasing AC and BC thresholds compared to the CCM method. In patients with different pathological types, OCM did not result in a significantly greater reduction in AC, BC, or ABG thresholds compared to CCM. Further, there were no significant differences in hearing outcomes between OCM and CCM, regardless of whether patients underwent ossiculoplasty. Conclusions: Both OCM and CCM are effective in improving hearing in patients with CCOM. However, OCM demonstrates superior therapeutic effects compared to CCM, particularly in terms of effectiveness, although complications and drying time should be considered.

Keywords: Chronic otitis media, cholesteatoma, mastectomy, hearing gain

Introduction

Active squamous type of chronic otitis media (COM) is typically associated with the presence of cholesteatoma [1, 2]. In a large study by Osma and colleagues, it was found that 78% of subjects with complications secondary to COM had cholesteatoma [3]. This condition typically presents with a perforation of the tympanic membrane, accompanied by intermittent or continuous otorrhea. As chronic otomastoiditis and eustachian tube dysfunction persist, the tympanic membrane weakens, increasing the risk of atelectatic ear or cholesteatoma formation [4]. Once established in the middle ear, mastoid, or petrous bone, cholesteatoma is a destructive lesion that gradually expands, destroying adjacent structures thus leading to complications [5, 6]. Cholesteatomatous COM (CCOM) is characterized by recurrent infections that cause pain and purulent otorrhea, potentially resulting in severe complications, such as facial nerve paralysis, meningitis and labyrinthitis [7, 8]. The resulting hearing loss, which can be conductive (CHL) and sensorineural (SNHL) or both, may have significant long-term effects on language development and educational process [9, 10].

Surgical removal is essential for the effective management of cholesteatoma and to minimize potential complications. Historically, the

https://doi.org/10.62347/DPOF4232

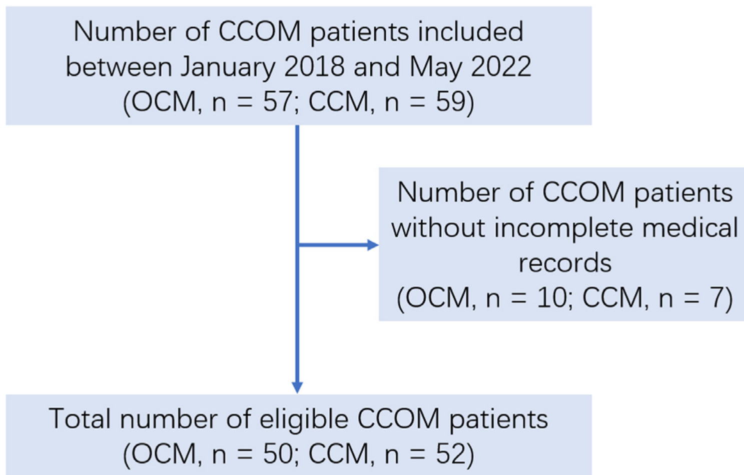

Figure 1. Flow diagram illustrating the inclusion and exclusion of patients with cholesteatomatous chronic otitis media (CCOM) undergoing open cavity mastoidectomy (OCM) and closed cavity mastoidectomy (CCM).

primary goal of surgery for COM has been to eradicate the disease and achieve dry, safe ears [11]. However, over the past decade, the focus has expanded to include hearing protection and recovery. Currently, mastoidectomy is the most commonly employed surgical method [12]. There are two main types of mastoidectomy: open cavity mastoidectomy (OCM) and closed cavity mastoidectomy (CCM). Clinical research indicates that OCM procedures have lower rates of residual and recurrent disease compared to CCM procedures. The advantages of OCM include better exposure of the surgical field and the elimination of potential spaces where the squamous epithelium could be trapped. However, one drawback is that the natural self-cleansing mechanism of the external ear may be disturbed.

CCM has become a widely used technique to address the challenges associated with cholesteatoma surgery. Studies suggest that CCM can improve patients' quality of life (QoL) by utilizing tragus cartilage to reconstruct the outer wall of the upper tympanic drum antrum, promoting the formation of self-cleaning, dry, and safe ears. However, the debate over which technique yields the best hearing outcomes continues into the 21st century. OCM can alter the ear canal's structure, potentially leading to diminished hearing. Furthermore, the cavity created by OCM often accumulates earwax, necessitating frequent cleaning and precautions to prevent water entry in order to maintain hearing function [13]. While CCM was developed to resolves the disadvantages of OCM, it has a higher recurrence rate [14]. Additionally, a notable drawback of CCM is the necessity for follow-up examinations to check for any residual or recurrent disease. This requirement can increase patient anxiety, raise healthcare costs, and cause potential delays in treatment if any issues are identified.

Galm et al. compared audiological outcomes in patients with middle ear clef pathology treated with either OCM or CCM [15]. They found that 41% of patients who underwent CCM had a postoperative air-bone gap (ABG) of 20 dB or less, compared to only 21% for those who underwent OCM. Despite this, there are limited studies comparing the audiological outcomes of these approaches in treating COM with cholesteatoma involving the mastoid process. Therefore, we conducted this retrospective analysis of the medical records of patients from the local population who underwent OCM or CCM for CCOM. This study also compared the hearing outcomes of OCM and CCM based on pathological types and the application of ossiculoplasty.

Materials and methods

Patient selection

A retrospective analysis of patient data was conducted by a single otologist at the Department of Otolaryngology, Head and Neck Surgery, Hebei Eye Hospital, focusing on patients who underwent OCM or CCM for CCOM involving the mastoid process. Between January 2018 and May 2022, a total of 102 patients with CCOM were identified.

The inclusion criteria were patients diagnosed with CCOM, while the exclusion criteria included incomplete medical records (**Figure 1**). Of the total cohort, 52 (50.98%) patients were male and 50 (49.02%) were female, with a mean age of 39.16 years, ranging from 2 to 80 years. All patients underwent surgical treat-

Table 1. Demographic profile of the study population

Variable	Total	OCM (n = 50)	CCM (n = 52)	*P*-value
Age (ys), mean ± SD	39.16 ± 19.20	37.80 ± 15.47	40.46 ± 22.29	0.487c
Gender				
Male, n	52	28	24	0.4259a
Female, n	50	22	28	
Complication				
Tinnitus (Yes), n	35	17	18	1a
Otalgia (Yes), n	13	5	8	0.6043a
Vertigo (Yes), n	9	5	4	0.7387b
Ear discharge (Yes), n	102	50	52	1b
Hearing loss, n	102	50	52	1b
Malleus absence, n	15	7	8	1b
Stapes footplate damage (Yes), n	9	5	4	0.7387
Incus damage (Yes), n	102	50	52	1b
Middle ear pathologies				
Squamous disease	90	43	47	0.7042a
Mucosal disease	12	7	5	
Ossiculoplasty				
No	78	39	39	0.6569b
Yes	24	11	13	
Post-time to dryness (wks), mean ± SD	3.02 ± 0.85	2.54 ± 0.72	3.40 ± 0.69	< 0.0001c
Recurrence (Yes), n	3	2	1	0.6139b

OCM, open cavity mastoidectomy; CCM, closed cavity mastoidectomy; ORP, ossicular replacement prostheses. Pearson Chi-square test (a) (n ≥ 5) and Fisher's exact test (b) (n < 5) were used to compare the frequency between the two groups; Independent samples t-test (c) was used to compare the quantitative data.

ment (tympanomastoidectomy) for CCOM. Data collected included middle ear pathologies (squamous and mucosal), recurrence, and ossiculoplasty (**Table 1**). Demographic data, including gender and age, were also recorded.

The diagnosis of CCOM was based on the clinical examination, audiometric testing, otomicroscopy, radiology examination, and pathological findings. All patients exhibited perforations in the tympanic membrane, with lesions confined to the middle ear and excluding any extensions beyond this region. Additionally, the preoperative *air*-bone gap (ABG) measured was more than 30 dB HL. Preoperative CT scan revealed that the lesions were restricted to the tympanic sinus and upper tympanic cavity. This study was approved by the Ethics Committee of Hebei Eye Hospital (No. 2018KY007). **Figure 2** presents the flowsheet of this study.

Surgical procedures

For OCM, the surgical procedures are as follows: 1) The patient was placed under general anesthesia and positioned supine with the head turned to provide access to the affected ear; 2) An incision was made in the postauricular area to access the mastoid process and the ear canal; 3) A canal tympanic membrane flap was created using an intraarticular incision to minimize trauma; 4) The tympanic nerve was identified and preserved; 5) The tympanic cavity was probed to evaluate the disease process and the condition of the ossicular chain; 6) The outer wall of the upper tympanum was excised to fully expose the upper tympanic cavity and anterior crypts, allowing complete access to the affected areas; 7) Cholesteatomas or infected tissue was carefully removed from the tympanic cavity; 8) The epithelium covering the malleus and incus was cleaned, ensuring the integrity of the ossicular chain; 9) Temporalis fascia was harvested to repair the tympanic membrane, and the fascia was placed over the incudostapedial joint to prevent exposure and maintain a closed middle tympanic cavity; 10) A common cavity was created by ensuring the upper tympanic sinus and external auditory meatus were interconnected; 11) The incision

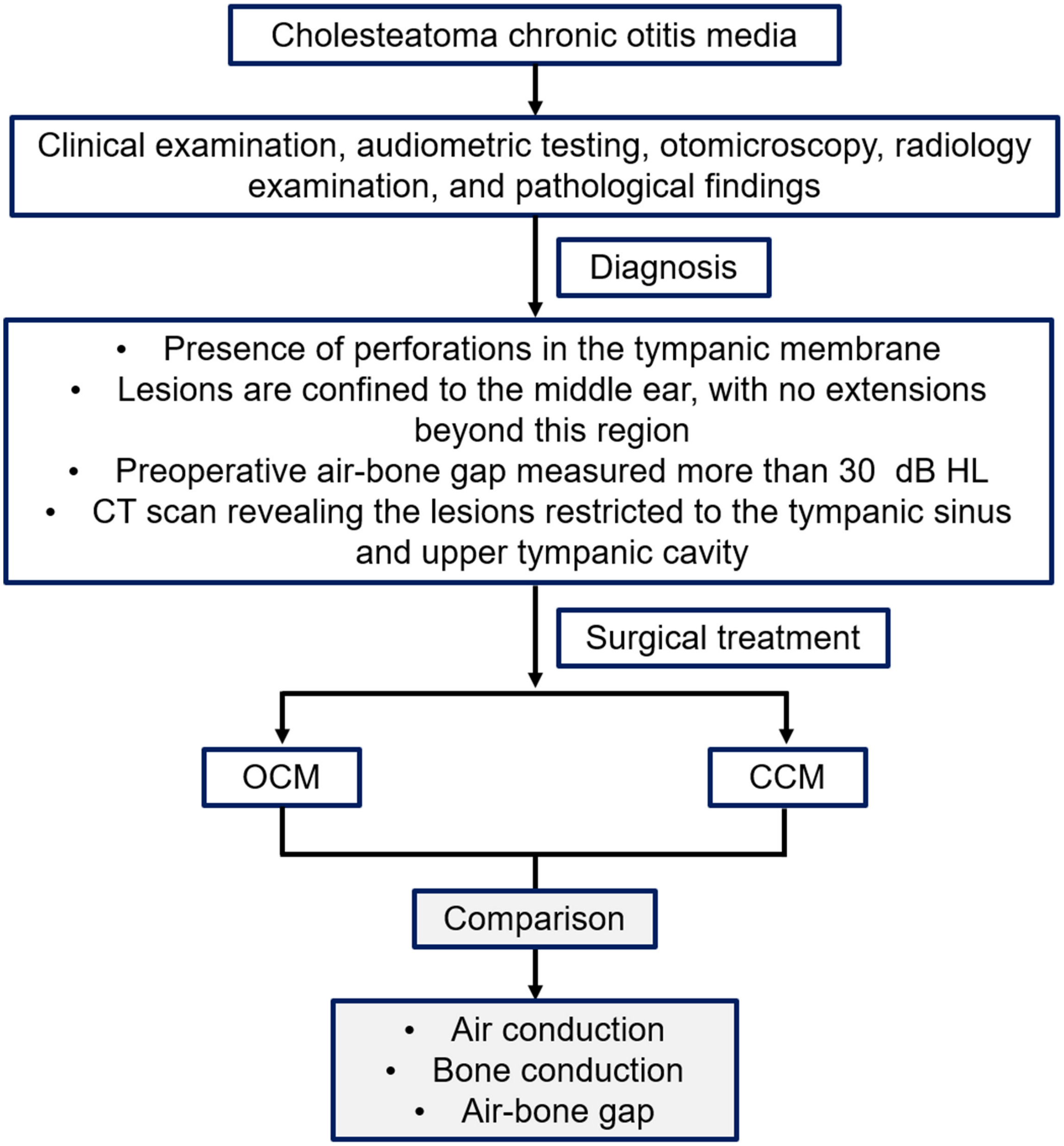

Figure 2. Flowsheet of the study. OCM, open cavity mastoidectomy; CCM, closed cavity mastoidectomy.

was closed, drains were placed, and the ear canal was packed with sterile gauze to aid healing.

For CCM, the surgical procedures are as follows: 1) A postauricular incision was made to provide access to the mastoid and middle ear, followed by an incision in the tympanic membrane to facilitate access to the middle ear; 2) The extent of disease was assessed, and any cholesteatomas or infected tissue was identified; 3) The tympanic nerve was identified and preserved; 4) Bone was removed from the mastoid air cells and the outer wall of the upper tympanum while ensuring the cavity remains closed; 5) Diseased tissue was excised; 6) The ossicular chain was assessed; 7) The tympanic membrane was repaired using temporalis fascia; 8) The tragus cartilage was trimmed to reconstruct the outer wall of the upper tympanic antrum; 9) The postauricular incision was closed.

Outcome measures

The primary outcome was the complete excision of cholesteatoma, verified by CT scans conducted three months after the surgery. The secondary outcomes included the duration of dryness, audiometric assessments, and postoperative complications, such as cholesteatoma recurrence, hearing loss, infection, dizziness or vertigo, facial nerve injury, persistent discharge, and tympanic membrane perforation. These outcomes were assessed three months after surgery.

Data extraction

Data collected for this study included audiometric assessment, patient demographics (gender and age), surgical details, pathologies (squamous and mucosal types), ossiculoplasty, and disease recurrence (cholesteatoma and granulation tissue).

Pure-tone audiometry was performed within seven days prior to the operation and three months after surgery. The test was performed through both air conduction (AC) and bone conduction (BC) mode. ABG was calculated by subtracting BC thresholds from AC thresholds, in line with the guidelines established by the Committee on Hearing and Equilibrium of the American Academy of Otolaryngology-Head and Neck Surgery (AAO-HNS). Pure-tone thresholds for AC and BC at 500, 1000, 2000 and 4000 Hz were recorded. Hearing outcomes were evaluated based on AC, BC and ABG values.

Statistical analysis

Data were analyzed using SPSS software version 20.0 (SPSS Inc., Chicago, IL, USA). Continuous variables were expressed as mean ± standard deviation. Independent sample t-tests were used to compare the two groups. Pearson Chi-square and Fisher's exact tests were utilized to compare the frequencies of categorical variables between the two or three groups. Univariate analysis involved cross-tabulation to generate odds ratios and their 95% confidence intervals. The variables were subsequently analyzed using multivariate logistic regression. Hypothesis testing for statistical significance was conducted with a 95% confidence interval. All *P*-values were two-tailed, with a value of < 0.05 considered statistically significant.

Results

Study population

A total of 102 CCOM patients were enrolled in this study. All patients completed follow-up, with no cases lost to follow-up. Demographic data are presented in **Table 1**. The average age of the enrolled patients was 39.16 ± 19.20 years. The male-to-female ratio was 52:50.

As for complications, tinnitus was reported in 35 patients (34.3%), 13 patients (12.7%) experienced earache, and 9 patients had vertigo. The most common complaints across all patients were ear discharge and hearing loss. 70 patients (76.5%) had an intact malleus, while 15 patients (14.77%) had malleus loss. Nine patients (8.8%) reported stapes footplate damage. All patients exhibited varying degrees of incus damage.

Among the patients, 90 (88.2%) had active squamous COM, while the remaining 12 (11.8%) had active mucosal COM characterized by granulation tissue filling the middle ear mucosa. Of these cases, 78 (76.5%) patients did not undergo ossiculoplasty, 15 (14.7%) patients had partial ossicular reconstruction (ORP), and 9 (8.8%) cases had total ORP. The average postoperative time to dryness was 3.0 ± 0.9 weeks. Cholesteatoma recurrence was found in 3 patients.

In this retrospective comparative analysis, the clinical data of patients who received OCM (n = 50) and patients who received CCM (n = 52) were compared. The male to female distribution was 28:22 in the OCM group, and 24:28 in the CCM group, with an average age of 37.80 years in the OCM group and 40.46 in the CCM group. No significant differences were observed between the two groups in terms of age, gender, complications (tinnitus, otalgia, vertigo, ear discharge, hearing loss), malleus absence, stapes footplate damage, incus damage, middle ear pathologies (squamous and mucosal), ossiculoplasty, and recurrence (all P > 0.05).

OCM significantly improved AC and BC thresholds of CCOM patients compared to CCM

The average preoperative AC and postoperative AC thresholds were calculated using values

Table 2. Comparison of preoperative and postoperative AC, BC, and ABG thresholds between OCM and CCM groups

	AC			
	OCM (n = 50)	CCM (n = 52)	t	*P*-value
Pre	54.24 ± 15.55	53.69 ± 11.51	6.64	0.8407
Post	31.22 ± 13.15	36.71 ± 10.57	-1.36	0.0226
t-value	8.96	7.24		
P-value	< 0.0001	< 0.0001		
	BC			
	OCM (n = 50)	CCM (n = 52)	t	*P*-value
Pre	23.86 ± 12.52	23.90 ± 11.13	1.5	0.9851
Post	14.88 ± 8.66	20.08 ± 9.56	-3.55	0.0049
t-value	4.74	0.606		
P-value	< 0.0001	< 0.0001		
	ABG			
	OCM (n = 50)	CCM (n = 52)	t	*P*-value
Pre	30.88 ± 14.45	29.79 ± 14.42	7.15	0.8253
Post	16.34 ± 12.39	16.63 ± 9.52	-2.32	0.8935
t-value	4.29	8.18		
P-value	< 0.0001	< 0.0001		

OCM, open cavity mastoidectomy; CCM, closed cavity mastoidectomy; AC, air conduction; BC, bone conduction; ABG, air-bond gap. Data are presented as mean ± standard deviation. Independent sample t-tests were used to compare the two groups.

obtained at frequencies of 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz. As shown in **Table 2**, the average preoperative AC threshold for the OCM group was (54.24 ± 15.55) dB, while for the CCM group, it was (53.69 ± 11.51) dB. There were no significant differences in preoperative AC thresholds between the OCM and CCM groups (P > 0.05). At three months post-operation, patients in the OCM group had average AC thresholds of (31.22 ± 13.15) dB, compared to (36.71 ± 10.57) dB in the CCM group. Both groups demonstrated significant reductions in AC thresholds (P < 0.0001), with patients in the OCM group showing a significantly lower post-operative AC threshold compared to the CCM group (P = 0.0226).

Next, the average BC thresholds for both groups across frequencies of 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz were analyzed. Preoperatively, the average BC thresholds were (23.86 ± 12.52) dB for the OCM group and (23.90 ± 11.13) dB for the CCM group (**Table 2**). Notably, both groups exhibited significant decreases in BC thresholds following surgery (P < 0.0001). Additionally, significant differences in BC thresholds between the two groups were observed post-surgery (P = 0.0049).

The average preoperative and postoperative ABG for the OCM group were (30.88 ± 14.45) dB and (16.34 ± 12.39) dB, respectively, indicating a significant reduction (P < 0.0001). Similarly, the CCM group showed a significant decrease in ABG thresholds, from (29.79 ± 14.42) dB to (16.63 ± 9.52) dB (P < 0.0001). However, no significant differences in ABG thresholds were noted between the OCM and CCM groups, either before or after surgery (**Table 2**).

OCM demonstrated an improvement in the degree of hearing loss for CCOM patients compared to CCM

Table 3 displays the distribution of AC and BC thresholds in the two groups. No significant differences were found between the OCM and CCM groups prior to the surgery (P = 0.2144). In contrast, after the surgery the OCM method demonstrated a more effective improvement in hearing for patients with CCOM compared to the CCM method, as indicated by significant improvements in AC (P = 0.0001) and BC (P = 0.0006) results. Regarding the ABG results, no significant difference was observed in the distribution of ABG thresholds between the OCM and CCM groups, either before (P = 0.9084) or after surgery (P = 0.9803) (**Table 4**).

Relationship between operation and middle ear pathologies or ossiculoplasty performance

We evaluated the impact of pathologies and ossiculoplasty performance on AC, BC, and ABG thresholds. The OCM method did not significantly improve hearing of patients with squamous or mucosal types, compared to the CCM method (P > 0.05) (**Table 5**). Additionally, regarding ossiculoplasty performance, neither the OCM nor CCM methods significantly altered the AC, BC, or ABG thresholds for patients with or without ossiculoplasty (P > 0.05) (**Table 6**).

Table 3. Comparison of AC and BC distribution between OCM and CCM groups before and after surgery (n = 102)

	Threshold (dB HL)	AC			BC		
		OCM	CCM	*P*-value	OCM	CCM	*P*-value
Pre	0-20 (normal range)	0	0	0.2144a	23	21	0.9301a
	20-35 (mild hearing loss)	7	2		20	22	
	35-50 (moderate hearing loss)	12	19		5	7	
	50-65 (moderate-severe hearing loss)	20	24		2	2	
	65-80 (severe hearing loss)	8	6		0	0	
	> 80 (profound hearing loss)	3	1		0	0	
Post	0-20 (normal range)	5	2	0.0001a	41	24	0.0006a
	20-35 (mild hearing loss)	17	22		8	23	
	35-50 (moderate hearing loss)	19	22		1	4	
	50-65 (moderate-severe hearing loss)	9	6		0	1	
	65-80 (severe hearing loss)	0	0		0	0	
	> 80 (profound hearing loss)	0	0		0	0	

AC, air conduction; BC, bone conduction; OCM, open cavity mastoidectomy; CCM, closed cavity mastoidectomy. a, Fisher's exact test (n < 5) was used to compare the frequency between the two groups.

Table 4. Comparison of ABG distribution between OCM and CCM groups before and after tympanoplasties (n = 102)

	Threshold (dB HL)	ABG		
		OCM	CCM	*P*-value
Pre	≤ 10 (normal range)	5	3	0.9084b
	10-20 (mild conductive hearing loss)	9	10	
	20-30 (moderate conductive hearing loss)	13	15	
	≥ 30 (severe conductive hearing loss)	23	24	
Post	≤ 10 (normal range)	17	17	0.9803a
	10-20 (mild conductive hearing loss)	18	18	
	20-30 (moderate conductive hearing loss)	8	10	
	≥ 30 (severe conductive hearing loss)	7	7	

ABG, air-bone gap; OCM, open cavity mastoidectomy; CCM, closed cavity mastoidectomy. Pearson Chi-square test (a) (n ≥ 5) and Fisher's exact test (b) (n < 5) were used to compare the frequency between the two groups.

Table 5. Comparison of the surgical results of CCOM patients with different pathologies after OCM or CCM

		OCM (n = 50)	CCM (n = 52)	*P*-value
AC	Squamous, n (%)	13 (30)	2 (4)	0.1177a
	Mucosal, n (%)	2 (29)	0 (0)	
BC	Squamous, n (%)	18 (42)	4 (49)	0.1645a
	Mucosal, n (%)	23 (57)	1 (20)	
ABG	Squamous, n (%)	14 (33)	3 (64)	0.3274a
	Mucosal, n (%)	30 (43)	3 (60)	

CCOM, cholesteatomatous chronic otitis media; OCM, open cavity mastoidectomy; CCM, close cavity mastoidectomy; AC, air conduction; BC, bone conduction; ABG, air-bone gap. Fisher's exact test (a) (n < 5) was used to compare the frequency between the two groups.

Analysis of risk factors for recurrence and post-time to dryness

Univariate logistic regression analysis showed that factors such as age, gender, complications (tinnitus, otalgia, vertigo), absence of the malleus, damage to the stapes footplate, middle ear pathologies, ossiculoplasty, surgical approach, and the duration until dryness were not significantly associated with recurrence (**Table 7**). Results shown in **Table 8** indicate that, compared to OCM, CCM significantly increased the post-time to dryness for patients with CCOM. This finding was supported by both univariate (OR = 14.909, 95% CI [5.704, 38.968]; P < 0.001) and multivariate analyses (OR = 20.903, 95% CI [6.932, 63.030]; P < 0.001).

Table 6. Comparison of the surgical results of CCOM patients with or without ossiculoplasty after OCM or CCM

		OCM (n = 50)	CCM (n = 52)	*P*-value
AC	No, %	10 (29)	1 (3)	0.4955b
	Yes, %	5 (33)	1 (7)	
BC	No, %	30 (86)	17 (46)	0.1645a
	Yes, %	11 (73)	7 (47)	
ABG	No, %	10 (29)	12 (32)	0.2492a
	Yes, %	7 (47)	5 (33)	

CCOM, cholesteatomatous chronic otitis media; OCM, open cavity mastoidectomy; CCM, close cavity mastoidectomy; AC, air conduction; BC, bone conduction; ABG, air-bone gap. Pearson Chi-square test (a) (n ≥ 5) and Fisher's exact test (b) (n < 5) were used to compare the frequency between the two groups.

Discussion

Acquired cholesteatoma frequently develops in the context of chronic otitis media (COM) and is often associated with tympanic membrane perforation [16, 17]. Surgical removal remains the primary treatment for cholesteatoma [18]. In this study, we retrospectively compared postoperative hearing improvement between the OCM and CCM groups. Our findings demonstrated that postoperative audiological outcomes and time to dryness improved in both groups, with the OCM showing statistically significant effectiveness compared to the CCM. However, there was no significant difference in hearing outcomes between the OCM and CCM groups, regardless of whether they had squamous or mucosal types, or underwent ossiculoplasty.

Various surgical methods are available for middle ear diseases, achieving stable ear conditions while retaining hearing and reducing long-term morbidity associated with persistent wet ears rate [11]. A modified radical mastoidectomy technique is the preferred technique for eradicating cholesteatoma. While OCM is often favored for ordinary cholesteatoma [19], some studies have indicated that long-term hearing outcomes of closed technology are at least as successful as those of open technology in treating cholesteatoma [20, 21]. However, the choice of surgical approach varies across departments, complicating comparisons of different methods. In this study, we compared the effects of the two commonly used mastoidectomy techniques, OCM and CCM, on hearing gain in patients with CCOM. We analyzed AC and BC thresholds at the average of four frequencies: 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz. Our findings revealed that both OCM and CCM effectively improved the hearing and reduced the time to dryness, with OCM demonstrating significantly better effectiveness compared to CCM.

In an early study by Galm et al., the comparison of open and closed surgeries revealed no statistically significant difference in audiological outcomes between open cavity versus closed cavity mastoidectomy after one year [15]. This may be related to ineffective postoperative management, variability in patient hearing loss, and differences in rehabilitation protocols. Consistently, the percentage of patients achieving a postoperative ABG of 10 dB or less following open cavity procedures were comparable to those with closed cavity procedures. In detail, our findings reveal no significant difference in the rates of ABG closure across the ranges of ≤ 10, 10-20, 20-30, or ≥ 30. Generally, a surgery is considered successful when the ABG threshold is maintained below 10 dB. However, various factors influence postoperative hearing gain, including the presence of ear leakage, the type of perforation, osseous status, granulation tissue, and the presence of middle ear cholesteatoma [21-23].

Saroha et al. reported that patients with squamosal disease showed a significant improvement in average ABG closure postoperatively compared to mucosal disease [24]. The squamosal COM is an erosive condition often associated with cholesteatoma, which primarily affects the ossicular chain and results in varying degrees of hearing impairment [25, 26]. As the disease advances and involves surrounding vital structures, it can result in serious complications, necessitating prompt surgical intervention, typically mastoidectomy [23, 27]. Mucosal COM, on the other hand, is characterized by a permanent defect in the pars tensa, typically presenting as a central perforation [10, 28, 29]. It is generally considered to be less harmful, often resulting in intermittent ear discharge and mild conductive hearing loss [10]. These findings underscore the importance of assessing middle ear pathologies when deter-

Table 7. Multivariate logistic regression analysis of the associated risk factors for recurrent CCOM

Variable	Univariate		Multivariate	
	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value
Age (ys)	1.078 (0.994, 1.169)	0.071	2.655 (0.000, 1.45E+69)	0.990
Gender				
Male	-	-		-
Female	1.03E+08 (0.000, NA)	0.997	1.71E+42 (0.000, NA)	0.989
Complication				
Tinnitus (Yes), n	0.000 (0.000, NA)	0.998	0.000 (0.000, NA)	0.986
Otalgia (Yes), n	0.000 (0.000, NA)	0.999	1.40E+05 (0.000, NA)	0.999
Vertigo (Yes), n	5.687 (0.464, 69.768)	0.174	0.000 (0.000, NA)	0.990
Malleus absence, n	3.036 (0.258, 35.751)	0.377	3.47E+19 (0.000, NA)	0.986
Stapes footplate damage	0.000 (0.000, NA)	0.999	0.148 (0.000, NA)	1.000
Middle ear pathologies				
Squamous disease	-	-		
Mucosal disease	0.000 (0.000, NA)	0.999	0.000 (0.000, NA)	0.998
Ossiculoplasty				
No	-	-		
Total ORP	0.000 (0.000, NA)	0.998	0.000 (0.000, NA)	0.996
Surgery				
OCM	-	-	-	-
CCM	1.960 (0.172, 22.321)	0.588	1.20 (0.000, NA)	0.986
Post-time to dryness	0.942 (0.244, 3.634)	0.931	0.000 (NA, NA)	0.985

CCOM, cholesteatomatous chronic otitis media; OCM, open cavity mastoidectomy; CCM, close cavity mastoidectomy; OR, odd ratio; CI, confidence interval.

Table 8. Multivariate logistic regression analysis of the associated risk factors for post-time to dryness

Variable	Univariate		Multivariate	
	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value
Age (ys)	1.005 (0.985, 1.026)	0.634	1.005 (0.977, 1.034)	0.707
Gender				
Male	--	--	--	--
Female	0.855 (0.393, 1.859)	0.692	0.556 (0.192, 1.606)	0.278
Complication				
Tinnitus (Yes), n	0.914 (0.399, 2.097)	0.832	0.611 (0.206, 1.812)	0.374
Otalgia (Yes), n	0.838 (0.261, 2.692)	0.767	1.794 (0.392, 8.205)	0.451
Vertigo (Yes), n	1.277 (0.323, 5.057)	0.728	1.014 (0.177, 5.821)	0.988
Malleus absence, n	0.855 (0.285, 2.564)	0.780	0.983 (0.234, 4.123)	0.981
Stapes footplate damage	2.545 (0.620, 10.458)	0.195	5.034 (0.684, 37.030)	0.112
Middle ear pathologies	--	--		
Squamous disease	--	--	--	--
Mucosal disease	1 (0.300, 3.336)	1.000	1.264 (0.218, 7.338)	0.794
Ossiculoplasty				
No	--	--	--	--
Total ORP	1.208 (0.515, 2.836)	0.664	1.129 (0.311, 4.096)	0.854
Surgery				
OCM	--	--	--	--
CCM	14.909 (5.704, 38.968)	< 0.001	20.903 (6.932, 63.030)	< 0.001

OCM, open cavity mastoidectomy; CCM, close cavity mastoidectomy; OR, odd ratio; CI, confidence interval. Post-time to dryness, median = 3.43 wks.

mining surgical approaches. According to Galm et al., there is no significant difference in hearing gain between OCM and CCM, regardless of the underlying pathology of the middle ear [15]. In Melek Uyar's study, average postoperative hearing gains were reported as 11.9 dB for the OCM group and 3.8 dB for the CCM groups in cases involving squamous diseases [30]. This discrepancy may be related to variability in patient populations, including differences in the severity of disease. In our study, we found no significant improvement in the prognosis of squamous type patients after OCM compared to CCM, as indicated by the results of AC, BC and ABG thresholds.

Ossiculoplasty is a viable surgical option for patients with COM, regardless of the presence of cholesteatoma, as it helps to restore hearing function [31]. We also compared the impact of ossiculoplasty on hearing between the two procedures. The results indicated a similar postoperative ABG in both closed and open cavity patients, regardless of whether ossiculoplasty was performed using ossicular replacement prostheses. This finding aligns with existing evidence, which reports no statistical difference in hearing gain between open and closed cavity groups, irrespective of middle ear pathology or the performance of ossiculoplasty [15]. However, alternative materials for ossiculoplasty, such as bioactive glass and bone cement, have been employed to reconstruct mastoid cavities and have demonstrated improved postoperative hearing gain [30, 32, 33]. In our study, patients received osseous prostheses, which may explain the differences in hearing gain observed compared to studies using alternative materials.

It is important to note that while the recurrence rate for both types of surgery is low, 12 patients (11.8%) required reoperation following closed cavity surgery. A further review of these cases revealed that 5 patients experienced infections in the external ear canal due to mold, 3 had issues related to the anterior sigmoid sinus, and 4 had complications involving the meninges. All of these patients initially underwent completely closed upper tympanic surgery but experienced relapse, necessitating successful open surgeries at our hospital. Closed procedures typically require a longer drying time, and infections, especially fungal infections in the external auditory canal, can prolong recovery [34, 35]. Our findings align with this observation. Closed procedures often involve less exposure of the middle ear to the external environment, which can impede the natural drying process. In contrast, open procedures offer greater exposure, facilitating drying. Additionally, the tympanic membrane is at risk of perforation during this period. In contrast, during the open upper tympanic surgery, the tympanic membrane is repaired, and the middle tympanic chamber is sealed off to create an independent small tympanic chamber [36]. This design minimizes exposure of the ossicular chain (hammer and anvil) to the external environment, thereby preventing restricted joint movement and potential hearing loss [37]. Given these considerations, we recommend OCM for patients with complications related to the anterior sigmoid sinus, the meningeal, or infections from mold in the external ear canal.

Limitations

The primary limitation of this study is the lack of assessment of long-term hearing outcomes for patients with cholesteatomatous COM. It remains challenging to determine whether the postoperative hearing gain observed at 3 months will be sustained and serve as a reliable indicator of disease-free hearing over a period of 5 years. However, it is important to note that these patients are currently being followed up to monitor their long-term progress.

Conclusion

Both OCM and CCM are effective in treating patients with CCOM, facilitating hearing recovery and reducing drying time. Our findings indicate that OCM is more effective in improving hearing compared to the CCM method. Factors such as middle ear pathologies and ossiculoplasty performance did not significantly influence the efficacy. One advantage of CCM is its ability to preserve anatomy close to normal. However, patients with complications such as anterior sigmoid sinus involvement, low meninges, or external ear canal mold infections are at a higher risk for recurrent cholesteatoma. Therefore, while the choice of surgical procedure ultimately depends on the surgeon's preference, we recommend OCM for patients with squamous type or with specific complications to minimize the risk of recurrence.

Acknowledgements

This work was supported by the Medical Science Research Project of Hebei (Grant No. 20190139).

Disclosure of conflict of interest

None.

Address correspondence to: Hongya Geng, Department of Otolaryngology, Head and Neck Surgery, Hebei Eye Hospital, Hebei Provincial Key Laboratory of Ophthalmology, Hebei Provincial Clinical Research Center for Eye Diseases, Xingtai 054001, Hebei, China. Tel: +86-15631901962; E-mail: zxhghy@163.com

References

[1] Dharanya GS and Raja K. Decision making in complicated chronic otitis media-squamous active disease on surgical approach: how it influenced the outcome? Indian J Otolaryngol Head Neck Surg 2024; 76: 2008-2012.
[2] Patel TR and Welch CM. The science of cholesteatoma. Otolaryngol Clin North Am 2025; 58: 1-27.
[3] Osma U, Cureoglu S and Hosoglu S. The complications of chronic otitis media: report of 93 cases. J Laryngol Otol 2000; 114: 97-100.
[4] Rebol J. Acute and chronic otitis. Otoscopy Findings. Springer; 2022. pp. 81-101.
[5] Phillips JS, Haggard M, Spencer H and Yung M. The chronic otitis media benefit inventory (COMBI): development and validation of a dynamic quality of life questionnaire for chronic ear disease. Otol Neurotol 2017; 38: 701-707.
[6] Cebeci S, Özbilen MS, Bayramoğlu I, Kemaloğlu YK, Uygur KK, Bayazit YA and Karamert R. Impact of the demographic and aetiological factors and intraoperative findings on postoperative outcomes in chronic otitis media surgery. Turk J Med Sci 2020; 50: 155-162.
[7] Sheehy JL, Brackmann DE and Graham MD. Cholesteatoma surgery: residual and recurrent disease. A review of 1,024 cases. Ann Otol Rhinol Laryngol 1977; 86: 451-462.
[8] Rebol J. Chronic otitis media with cholesteatoma. Otoscopy Findings. Springer; 2022. pp. 103-114.
[9] Subramaniam V, Ashkar A and Rai S. Cochlear dysfunction in chronic otitis media and its determinants. Iran J Otorhinolaryngol 2020; 32: 79-84.
[10] Soni S, Malhotra V, Sharma R and Passey JC. Sensorineural hearing loss in unilateral mucosal type of chronic otitis media. Indian J Otolaryngol Head Neck Surg 2023; 75: 2149-2154.
[11] Smith MCF, Huins C and Bhutta M. Surgical treatment of chronic ear disease in remote or resource-constrained environments. J Laryngol Otol 2019; 133: 49-58.
[12] Huang J, Li Z, Wu K and Wang W. Long-term outcomes after performing tympanoplasty without mastoidectomy for active and inactive noncholesteatomatous chronic otitis media. ORL J Otorhinolaryngol Relat Spec 2018; 80: 277-283.
[13] Mustafa SR. Comparison of efficacy of canal wall up mastoidectomy with canal wall down mastoidectomy in surgical management of otitis media with cholesteatoma. Journal of Islamabad Medical & Dental College 2017; 6: 78-82.
[14] Kerckhoffs KG, Kommer MB, van Strien TH, Visscher SJ, Bruijnzeel H, Smit AL and Grolman W. The disease recurrence rate after the canal wall up or canal wall down technique in adults. Laryngoscope 2016; 126: 980-987.
[15] Galm T, Martin TP and Raut V. Open and closed cavity mastoid operations: comparing early hearing results. Eur Arch Otorhinolaryngol 2013; 270: 77-80.
[16] Ji C, Zhang X, Yan X, Cao S and Fu T. Cholesteatoma in chronic otitis media secondary to pars tensa perforation. Acta Otolaryngol 2023; 143: 376-381.
[17] Barati B and Asadi M. Clinical and surgical features of acquired middle ear cholesteatoma: a 10 years population-based study. Shiraz E-Med J 2023; 24: e133899.
[18] Bovi C, Luchena A, Bivona R, Borsetto D, Creber N and Danesi G. Recurrence in cholesteatoma surgery: what have we learnt and where are we going? A narrative review. Acta Otorhinolaryngol Ital 2023; 43 Suppl 1: S48-S55.
[19] Vashishth A, Fulcheri A, Prasad SC, Dandinarasaiah M, Caruso A and Sanna M. Cochlear implantation in chronic otitis media with cholesteatoma and open cavities: long-term surgical outcomes. Otol Neurotol 2018; 39: 45-53.
[20] Jang JH, Choo OS, Kim H, Park HY and Choung YH. Comparison of surgical results between 'atticosinuplasty' and canal wall up mastoidectomy for early-stage cholesteatoma. Acta Otolaryngol 2022; 142: 259-264.
[21] Nikam S, Vedi J, Chandankhede V, Ekhar V and Shelkar R. Comparative study of various techniques of mastoid obliteration following canal wall down mastoidectomy. Indian J Otolaryngol Head Neck Surg 2023; 75: 3457-3460.
[22] Lim SJ, Jeon ET, Baek N, Chung YH, Kim SY, Song I, Rah YC, Oh KH and Choi J. Prediction of hearing prognosis after intact canal wall mastoidectomy with tympanoplasty using artificial intelligence. Otolaryngol Head Neck Surg 2023; 169: 1597-1605.

[23] Akula S, Reddy LS, Rani TM, Reshma B and Vaishnavi B. Surgical efficacy of mastoidectomy in chronic otitis media: squamosal type. Indian J Otolaryngol Head Neck Surg 2023; 75 Suppl 1: 250-254.
[24] Saroha N and Tomar N. Evaluating success of surgery in mucosal and squamosal chronic otitis media: a retrospective study. Bengal Journal of Otolaryngology and Head Neck Surgery 2018; 26: 99-104.
[25] Verma RB, Kumar R, Kapadia PB, Panchal AJ and Sheth S. Intra-operative ossicular chain status in patients with chronic otitis media. Indian J Otolaryngol Head Neck Surg 2024; 76: 1563-1568.
[26] Doddamani SA, Santhosh S, Divyashree M, ul Ameen SS and Archana M. Clinical profile of patients with chronic otitis media (mucosal) attending tertiary care hospital. Res J Med Sci 2024; 18: 91-95.
[27] Hidaka H, Ito M, Ikeda R, Kamide Y, Kuroki H, Nakano A, Yoshida H, Takahashi H, Iino Y, Harabuchi Y and Kobayashi H. Clinical practice guidelines for the diagnosis and management of otitis media with effusion (OME) in children in Japan - 2022 update. Auris Nasus Larynx 2023; 50: 655-699.
[28] Singer AEA, Abdel-Naby Awad OG, El-Kader RMA and Mohamed AR. Risk factors of sensorineural hearing loss in patients with unilateral safe chronic suppurative otitis media. Am J Otolaryngol 2018; 39: 88-93.
[29] da Costa SS and Paparella MM. Pathogenesis of chronic otitis media and the continuum: the basics, further and beyond. Textbook of Otitis Media: The Basics and Beyond. Springer; 2023. pp. 337-362.
[30] Uyar M, Acar A, Kılınç SB, Boynueğri S, Kaya A, Çavuşoğlu F and Eryılmaz A. Hearing outcomes after suppurative chronic otitis media surgery. Kulak Burun Bogaz Ihtis Derg 2015; 25: 131-136.
[31] Park S, Lim KH, Lim SJ, Park DH, Rah YC and Choi J. Functional outcomes of single-stage ossiculoplasty in chronic otitis media with or without cholesteatoma. J Int Adv Otol 2022; 18: 415-419.
[32] Sayyid ZN, Ding A and Creighton FX. Operative techniques and materials in ossiculoplasty. Operative Techniques in Otolaryngology-Head and Neck Surgery 2024; 35: 57-62.
[33] Della Santina CC and Lee SC. Ceravital reconstruction of canal wall down mastoidectomy: long-term results. Arch Otolaryngol Head Neck Surg 2006; 132: 617-623.
[34] Di Lella F, Bacciu A, Pasanisi E, Ruberto M, D'Angelo G and Vincenti V. Clinical findings and surgical results of middle ear cholesteatoma behind an intact tympanic membrane in adults. Acta Biomed 2016; 87: 64-69.
[35] Zhang C, Gao J and Cheng P. Analysis of risk factors of non dry ear after radical mastoidectomy for otitis media. Arch Clin Psychiat 2023; 50: 18-24.
[36] Qin X, Yin Y, Sun H, Feng G and Gao Z. Evaluation on the possibility of sound conduction independent of tympanic air cavity for severe tympanic adhesion patients by finite element analysis. Front Bioeng Biotechnol 2023; 11: 1212303.
[37] Luers JC and Hüttenbrink KB. Surgical anatomy and pathology of the middle ear. J Anat 2016; 228: 338-353.