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## **Influence of surgical technique on residual cholesteatoma location and prevalence**

P. Rayneau, MD <sup>1</sup>; C. Aussedat, MD <sup>1</sup>; TT. Trinh, MD <sup>1</sup>; C. Bobillier, MD <sup>1</sup>; E. Lescanne,  
MD, PhD <sup>1,2</sup>; A. Robier, MD, PhD <sup>1,2</sup>; D. Bakhos, MD, PhD <sup>1,2</sup>

1- CHRU de Tours, Service ORL et Chirurgie Cervico-Faciale, Boulevard Tonnelé, 37044  
Tours, France

2- Université François Rabelais de Tours, CHRU de Tours, UMR-S930, Tours, France

### \* Corresponding Author:

E-mail: [pierrerrayneau@wanadoo.fr](mailto:pierrerrayneau@wanadoo.fr) (Pierre Rayneau)  
Service ORL et Chirurgie Cervico-Faciale

CHU de Tours

2 Boulevard Tonnelé

37044 Tours

France

Tel.: 0033 632 354 839

Fax: 0033 247 473 600

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## **Abstract**

**Objective:** Compared to canal wall up (CWU) tympanoplasty, canal wall reconstruction (CWR) allows better visualization of cholesteatoma extension. The canal wall up approach provides good functional outcomes, but with higher rates of residual cholesteatoma. The aim of this study was to compare residual cholesteatoma prevalence and location between the two approaches.

**Method:** Subjects were adult patients with residual cholesteatoma following CWU or CWR surgery between January 1, 2010 and December 31, 2015. During this period, 94 patients underwent CWU and 71 CWR; 22 presented with residual cholesteatoma: 16 after CWU (R-CWU group) and 6 after CWR (R-CWR group).

**Results:** There was no significant inter-group difference in residual cholesteatoma prevalence: 17% after CWU, 8.4% after CWR. Locations comprised: 13 (81%) in the attic, 9 (56%) in the tympanic cavity and 4 (25%) in the mastoid in the R-CWU group, and 6 (100%) in the attic in the R-CWR group. There were significantly fewer tympanic cavity locations after CWR compared to CWU ( $p = 0.046$ ).

**Conclusion:** Residual cholesteatoma prevalence did not significantly differ between the CWU and CWR approaches. The most frequent location was the attic; significantly more locations were in the tympanic cavity with the CWU approach. These findings are important for surgeons and neuro-radiologists during follow-up.

**Key-words:** Cholesteatoma; residual; canal wall up; canal wall reconstruction.

## **Introduction**

The aims of cholesteatoma surgery are to prevent recurrence and residuals and to achieve optimal audiometric results. Recurrent cholesteatomas develop from a new postoperative tympanic membrane retraction pocket despite complete primary resection. Residual cholesteatomas develop from incomplete primary resection. The main techniques employed are canal wall up (CWU) and canal wall down (CWD) tympanoplasty. CWD shows lower rates of residual cholesteatomas (0-15%), as it provides good visualization of the sinus tympani and anterior attic [1-2]. However, it leaves a large, unesthetic cavity, impacting middle-ear anatomy and physiology. Such large meatoplasty, moreover, may lead to otorrhea, water intolerance, vertigo under sudden temperature change and difficulties in fitting hearing aids. CWU often provides good functional results, but with higher rates of residual cholesteatoma than CWD (3-35%) [3-6].

Given the pros and cons of these two techniques, canal wall reconstruction (CWR) was developed, obliterating then reconstructing the posterior wall of the outer ear canal and then filling the mastoidectomy cavity [3, 7-10]. CWR provides good visualization of the cholesteatoma after posterior wall obliteration, achieving resection quality comparable to that of CWD. The reconstruction conserves anatomy, as in CWU, while avoiding some of the drawbacks of CWD. Residual cholesteatoma rates range between 0 and 25%, depending on the team [1, 3, 5, 8, 11]. Residual locations, however, remain to be determined. Our hypothesis is that during CWR, better visualization of the tympanic cavity and mastoid filling affect residual locations and help to reduce residual prevalence as compared to CWU. The present study therefore sought to compare residual cholesteatoma prevalence and location following CWR versus CWU.

## **Patients and method**

### *Patients*

All over-18 year-old patients having undergone CWR or CWU surgery for primary of recurrent cholesteatoma, between January 1, 2010 and December 31, 2015 were included. Minimum follow-up was 1.5 years. During this study period, 165 patients underwent cholesteatoma surgery in our center: 94 CWU with posterior tympanotomy (mean age,  $42 \pm 17$  years; mean follow-up,  $3.8 \pm 1.5$  years), and 71 CWR (mean age,  $45 \pm 18$  years; mean follow-up,  $4 \pm 1.6$  years). Patients with history of mastoidectomy, congenital cholesteatoma and/or age <18 years were excluded. Patients operated on by CWD were also excluded, being too few in number (n=15).

The study was approved by our center's IRB (2015-44).

The CWU procedure consisted in masto-antro-atticotomy with posterior tympanotomy (*Figure 1*).

CWR also comprised masto-antro-atticotomy with posterior tympanotomy (*Figure 2*). The posterior wall of the outer ear canal was then thinned and obliterated by sectioning the superior and inferior ends with a small-caliber (1 mm) diamond reamer, exposing the anterior attic and facial recess. After resecting the cholesteatoma, the posterior canal was reconstructed using cartilage fragments and the obliterated posterior wall. The reconstruction was reinforced by filling the mastoidectomy cavity with micro-macroporous biphasic calcium phosphate (MBCP<sup>TM</sup>) held in place by biologic glue, the attic having been previously filled with cartilage fragments. The reconstructed mastoid was then protected by the musculoperiosteal flap.

The choice between CWU and CWR was at the surgeon's discretion, and notably depended on cholesteatoma extension in the tympanic cavity. The choice was usually made

preoperatively, but patients were informed that the procedure might be adapted in the light of intraoperative findings.

Table 1 shows demographic data for the 2 groups. Student test found no significant inter-group differences in age at surgery ( $p = 0.6$ ) or follow-up ( $p = 0.26$ ).

Patients showing residual cholesteatoma during follow-up (until June 2017), suspected on MRI and confirmed on histology, constituted the residual-CWU (R-CWU) and residual-CWR (R-CWR) subgroups.

### *Method*

Patient demographics, primary cholesteatoma location and preoperative data were analyzed. All patients underwent MRI with T1, T1 gadolinium, T2 and diffusion-weighted sequences in axial and coronal slices at 18, 36, 60 and 96 months after CWU/CWR. In initially extensive cholesteatoma, the first MRI scan was taken at 1 year

Preoperatively, precise cholesteatoma location and involvement of the semicircular canals, facial nerve, ossicular chain and/or tegmen were noted. The cholesteatoma was located using the 4-zone PTAM middle-ear space division system of the Japan Otological Society [12]: protympanum (P), tympanic cavity (T), attic (A) and mastoid (M). Clinical and radiologic data were noted postoperatively.

### *Statistics*

Qualitative data were compared between groups on Fisher test, and quantitative data on Student test. The significance threshold was set at  $p < 0.05$ .

## Results

Twenty-two patients showed residual cholesteatoma: 16 (7 male, 9 female; mean age,  $40 \pm 16$  years) R-CWU, and 6 (4 male, 2 female;  $35 \pm 14$  years) R-CWR. Prevalence was 13% overall: 17% after CWU and 8.4% after CWR, with no significant difference.

Seven patients (4.2%) showed recurrence of cholesteatoma, with no significant intergroup difference: CWU, n=4 (4.3%), CWR, n=3 (4.2%).

### *Preoperative data*

Table 2 shows demographic data. In R-CWU, 10 patients had surgery for primary cholesteatoma and 6 for recurrence. Residual cholesteatoma was detected at a mean  $24.8 \pm 10$  months. In R-CWR, 3 patients had surgery for primary cholesteatoma and 3 for recurrence. Residual cholesteatoma was detected at a mean  $19 \pm 9$  months. Patients operated on for recurrence had no previous mastoidectomy. There were no significant inter-group differences in age at surgery ( $p = 0.459$ ), gender ( $p = 0.635$ ), operated side ( $p > 0.99$ ) or proportions of initial cholesteatoma location in the mastoid ( $p = 0.162$ ), tympanic cavity ( $p > 0.99$ ) or attic ( $p > 0.99$ ).

### *Intraoperative data*

Overall, residual cholesteatoma was located in the attic in 19 cases (86%), tympanic cavity in 6 (41%) and mastoid in 4 (15%). Table 2 shows locations according to technique. In R-CWU, 4 residual cholesteatomas were located in the mastoid (25%), 9 (56%) in the tympanic cavity (extending to the sinus tympani in 6 cases, oval window in 4, stapes in 1 and hypotympanum in 1), and 13 (81%) in the attic. Seven patients had residual cholesteatoma involving both attic and tympanic cavity, and 3 both attic and mastoid. In R-CWR, all 6 residual cholesteatomas were located in the attic (100%), and none elsewhere. There was thus

a significant inter-group difference in tympanic cavity location ( $p = 0.046$ ), but none for the mastoid ( $p = 0.541$ ) or attic ( $p = 0.532$ ). There were no significant inter-group differences in complications associated with residual cholesteatoma extension: ossicular ( $p > 0.99$ ), semicircular canal ( $p = 0.273$ ), tegmen ( $p = 0.169$ ), or facial canal involvement ( $p = 0.585$ ).

#### *Postoperative data*

There was no significant inter-group difference in follow-up ( $38 \pm 17$  months in R-CWU,  $30 \pm 13$  months in R-CWR;  $p = 0.286$ ). One R-CWR patient developed further recurrence, in the attic, revealed on MRI at 15 months after resection of the first residual cholesteatoma; after repeat resection, the patient showed no residual on MRI 24 months later.

## **Discussion**

In the present study, there was no significant difference between CWU and CWR for residual cholesteatoma prevalence, despite a lower absolute rate in the CWR group.

Residual cholesteatoma was most often located in the attic; tympanic cavity location was significantly more frequent after CWU.

The present residual cholesteatoma rates were comparable to previous reports for CWU [4, 6] and CWR [1, 5, 7-8, 11, 13]. Prevalence after CWR was higher than in a previous study in our center [1], probably due to a greater number of CWR procedures and longer follow-up ( $48 \pm 19$  versus  $24 \pm 9$  months).

Recurrence rates have fallen with the use of chondro-perichondral graft to reinforce the tympanic membrane. The main problem remaining is residual cholesteatoma. For this, some authors recommend 2-step surgery in extensive cholesteatoma, using either CWU [14]



or CWR [5, 7]. In the second step, anatomic landmarks are more easily visualized, as tympanic mucosa inflammation is lower. The 2-step technique enables early detection of residual cholesteatoma, ossiculoplasty performed under optimal conditions and better auditory results [5, 15]. Moreover, in case of intraoperative bleeding in step 1, due to cavity inflammation or superinfection, anatomic landmarks may be difficult to visualize, increasing the risk of residual cholesteatoma, especially in the tympanic cavity and the attic [16], and making ossiculoplasty more difficult and risky for the inner ear and facial nerve. Also, after step 1, changes in mastoid aeration and possible cartilage graft mobilization can lead to implant loosening. Further studies are, however, needed to compare complications rates and results between 1 and 2-step surgery.

In our center, MRI is usually performed 18 months after cholesteatoma resection. In very extensive cholesteatoma, it is performed at 12 months, for early detection of residual. Diffusion-weighted sequences are preferable to temporal bone CT, having better sensitivity (89.8%), specificity (94.6%) and positive predictive value (PPV) (96.5%) for residual cholesteatoma [17]. Moreover, temporal bone CT fails to reveal residual cholesteatoma developing within a mastoid cavity filled after CWR [18], especially when a muscle flap was used [19]. The strong specificity and PPV of MRI are particularly useful for differentiating between fibrous tissue, inflammatory tissue and cholesteatoma in a filled cavity [17]. MRI thus better guides indications for revision surgery, reducing the risk of operating on patients free of residual cholesteatoma. When audiometric results are poor, temporal bone CT can nevertheless effectively assess the position of an ossicular implant or myringostapedopexy performed in the initial operation [20], and can thus serve as a decision aid for surgical revision or auditory rehabilitation. Some studies suggested combining the advantages of diffusion-weighted MRI and CT, to improve cholesteatoma detection and location compared to MRI alone [21]. The fusion images can be used in primary surgery to facilitate

cholesteatoma detection and specify extension, especially in locations with high risk of residual.

In the present series, residual cholesteatoma was most often located in the attic, whichever the surgical technique, in agreement with the literature [5-6], without significant difference between CWR and CWU for attic or mastoid location. However, in contrast to Haginomori et al. [5], tympanic cavity locations were fewer after CWR. This confirmed the study hypothesis that obliterating the posterior wall of the outer ear canal improves visualization of the cholesteatoma in the cavity. This technique may thus reduce the rate of residual cholesteatoma, for example if posterior tympanotomy during CWU fails to provide sufficient exposure of the sinus tympani. Cholesteatomas in the sinus tympani, attic or oval window area can be difficult to visualize on CWU, increasing the risk of residual, although posterior tympanotomy does improve access to the sinus tympani [11]. In the present study, residual rates in the attic were comparable between CWU and CWR, suggesting that obliteration of the posterior wall of the outer ear canal is not always enough to allow complete resection of cholesteatoma in this location.

Although CWR provides better visualization, insufficient reaming or a very deep sinus tympani can lead to residual cholesteatoma, and the attic is always difficult to access. To improve visualization and thus reduce the risk of residual, some authors recommend endoscopy to facilitate resection [22], as it proves exposure while being less invasive. However, residual cholesteatoma rates, especially in the attic, are fairly variable in the literature [23-25].

In the present study, 6 of the 9 cases of residual cholesteatomas in the tympanic cavity extended to the sinus tympani. Otoendoscopy during CWU would probably have helped reduce the incidence of residuals here. A prospective study comparing tympanic cavity and/or

attic residual cholesteatoma rates between CWR and CWU with and without systematic otoendoscopy would doubtless be of interest.

In the present study, no residual cholesteatomas were found in the mastoid cavity after CWR, similarly to another study [5] using CWD and reconstruction by mastoid filling. This may have been due either to larger mastoidectomy or to mastoid filling with MBCP™. It would be interesting, however, to perform a prospective study properly comparing residual rates in the mastoid according to filling material.

In the present study, the rate of residual cholesteatoma in the mastoid space was 25% following CWU; no residual cholesteatomas were found in this location after CWR. There was no significant difference in the rate of mastoid location of residual cholesteatoma between CWU and CWR. Another study, using bone pâté as filling material in CWR, reported similar results [7]. Other studies could compare the impact of mastoid filling on residual cholesteatoma prevalence in the mastoid after CWU with and without mastoid filling.

The main limitation of the present study was the retrospective design. A multicenter prospective study comparing residual cholesteatoma prevalence and location according to surgical technique would have greater impact.

## **Conclusion**

The present study found no significant difference in residual cholesteatoma prevalence between CWU and CWR. In both techniques, the main location of residuals was the attic. The most notable finding was the residual rate in the tympanic cavity, which was significantly lower after CWR than CWU. This confirmed the study hypothesis that CWR reduces residual cholesteatoma rates, at least as concerns the tympanic cavity, by improving visualization of middle ear recesses. This is an important finding for otosurgeons and neuroradiologists, to improve screening for residual cholesteatoma according to surgical technique.

Future prospective studies with larger samples could better determine surgical indications for cholesteatoma, reducing the prevalence of residual cholesteatoma and avoiding unnecessary surgery. It would also be useful to compare costs between mastoid filling materials (biologic glue, synthetic bone, hydroxyapatite, etc.), efficacy in reducing prevalence of residual cholesteatoma in the mastoid cavity, and postoperative results.

**Disclosure of Interest:** The authors declare that they have no conflicts of interest concerning this article

**Table 1:** Demographic data for patients with primary of recurrent cholesteatoma according to surgical technique.

	<b>CWU</b>	<b>CWR</b>	<b>p</b>
N	94	71	
Age (years)	42 ( $\pm$ 17)	45 ( $\pm$ 18)	0.600
Follow-up (months)	45 ( $\pm$ 18)	48 ( $\pm$ 19)	0.260
<b>Indication</b>			
Primary	55	41	0.999
Recurrence	39	30	0.969
Residual	16	6	0.108
Recurrence	4	3	0.992

*CWU = canal wall up; CWR = canal wall reconstruction*

**Table 2:** Demographic and intraoperative data for patients with residual cholesteatoma.

		R-CWU	R-CWR	p
N		16	6	
Age (years)		40 ( $\pm$ 16)	35 ( $\pm$ 14)	0.459
Gender (F/M)		9/7	2/4	0.635
Side (L/R)		9/7	4/2	0.999
History of surgery (N)		0.9 ( $\pm$ 1.4)	0.5 ( $\pm$ 0.5)	0.379
Facial palsy		0	0	0.999
	Tympanic cavity	9 <sup>1</sup>	0	0.046*
Locations	Mastoid	4 <sup>1</sup>	0	0.541
	Attic	13 <sup>1</sup>	6	0.532
	Oval window	0	0	0.999
	Facial canal	3	2	0.585
Lysis	Ossicles	9 M+I, 7 M+I+S	3 M+I, 3 M+I+S	0.999
	Lateral SCC	0	1	0.273
	Tegmen	1	2	0.169

*Asterisk (\*): significant difference; F=female; M=male; L=left; R=right; M+I=malleus + incus; M+I+S=malleus + incus + stapes; SCC= semicircular canal; <sup>1</sup>: 10 patients with double location*

**Figure 1:**

Intraoperative view of a left ear. CWU tympanoplasty with posterior tympanotomy after cholesteatoma resection.

**Figure 2:**

Intraoperative view of a left ear during CWR tympanoplasty. (A) Left masto-antro-atticotomy and visualization of cholesteatoma via the atticotomy. (B) Section of outer ear canal posterior wall. (C) Visualization of cholesteatoma in the epitympanum.

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