

# Mastoid Obliteration with Autologous Bone in Mastoidectomy Canal Wall Down Surgery: a Literature Overview

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## Abstract

### Keywords

- ▶ cholesteatoma
- ▶ middle ear
- ▶ mastoid obliteration
- ▶ mastoidectomy
- ▶ otitis media
- ▶ suppurative
- ▶ bone and bones
- ▶ tympanomastoidectomy

**Introduction** The objectives of mastoidectomy in cholesteatoma are a disease-free and dry ear, the prevention of recurrent disease, and the maintenance of hearing or the possibility to reconstruct an affected hearing mechanism. Canal wall down mastoidectomy has been traditionally used to achieve those goals with greater or lesser degrees of success. However, canal wall down is an aggressive approach, as it involves creating an open cavity and changing the anatomy and physiology of the middle ear and mastoid. A canal wall up technique eliminates the need to destroy the middle ear and mastoid, but is associated with a higher rate of residual cholesteatoma. The obliteration techniques arise as an effort to avoid the disadvantages of both techniques.

**Objectives** Evaluate the effectiveness of the mastoid obliteration with autologous bone in mastoidectomy surgery with canal wall down for chronic otitis, with or without cholesteatoma.

**Data Synthesis** We analyzed nine studies of case series comprehending similar surgery techniques on 1017 total cases of operated ears in both adults and children, with at least 12 months follow-up.

**Conclusion** Mastoid Obliteration with autologous bone has been utilized for many years to present date, and it seems to be safe, low-cost, with low recurrence rates - similar to traditional canal wall down procedures and with greater water resistance and quality of life improvements.

## Introduction

Usually, for a successful surgical eradication of middle ear diseases, the otologic surgeon must remove diseased anatomic structures and, sometimes, even normal structures. Canal wall down mastoidectomy (CWD) is one of those common surgical techniques with variations of long-term outcomes. Although the majority of patients experience little to no long-term problems postoperatively, there is a small but expressive number of patients with

chronic complaints associated with the persistent mastoid bowl.<sup>1</sup>

Recurrent drainage and infection are the most common cause of discontent and medical return for patients with mastoid bowls. Other frequent complaints may include water intolerance, leading to infection, the need for frequent otomicroscopic cleaning, calorically induced vertigo from either water or air exposure, barometrically induced vertigo, and, in those with compromising hearing loss, being unable to wear traditional hearing aids.<sup>2</sup>

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Mosher, in 1911, started the idea of mastoid obliteration to promote healing of a mastoidectomy defect. Mosher described an obliteration technique using a superiorly based postauricular soft tissue flap.<sup>3</sup> The researcher noticed that the muscle atrophied over time, causing a progressive enlargement in cavity size. This observation is supported by histological data from the temporal bone study of Linthicum,<sup>4</sup> which demonstrates the replacement of muscle with fibroconnective tissue and fat. These findings encouraged surgeons to associate other filler materials inside the bowl. Palva<sup>5</sup> modified and popularized the technique, further adding to it the use of bone chips and bone pate in combination with an anteriorly based musculoperiosteal flap.<sup>5</sup> Over the course of the last decades, there have been a large number of reports detailing a multiplicity of techniques for obliterating the mastoid cavity. The most frequent and popular techniques consist of either local flaps (muscle, periosteum, or fascia) or free autologous grafts (bone, cartilage, fat, fascia), or even alloplastic grafts (hydroxyapatite, silicon, synthetic bones, among others).<sup>1</sup>

The decision whether to perform an intact canal wall mastoidectomy (ICW) or CWD operation in patients with chronic ear disease is usually based on several factors, such as the extent of disease, an assessment of middle ear ventilation, the hearing in the ear in question, the state of the opposite ear, any preoperative complications, the condition of the patient, the possibility for follow-up, and the surgeon's preference.<sup>6</sup>

The benefits and drawbacks of ICW and CWD for cholesteatoma are well established. The greatest problem with ICW techniques are the recidivism rates, reported as high as 40 to 60% in children and 20% in adults. This high rate of recurrence is associated with the relatively deficient exposure during surgery, the persistence of Eustachian tube dysfunction, and the persistence of mucosa in the mastoid that keeps resorbing gas and creates a negative pressure environment for resurg-ing of retraction pockets.<sup>7</sup>

Although the CWD technique is known to have lower residual and recurrent cholesteatoma rates, as mentioned previously, it is often accompanied by the problems associated by the mastoid cavity such as crust accumulation, water intolerance and intermittent discharge. The principle behind the mastoid obliteration is that it combines the advantages of both techniques (CWD and ICW).<sup>3</sup>

## Objectives

The purpose of this review is to evaluate the effectiveness of mastoid obliteration with autologous bone in mastoidectomy surgery with canal wall down for chronic otitis, with or without cholesteatoma, mainly for infection control and drainage, recurrence of cholesteatoma and water tolerance.

## Search Methods

In January 2015, we searched online databases for the following keywords: "mastoid obliteration bone chronic otitis canal wall down." We searched MEDLINE, LILACS and EBSCO databases. We were only able to find journal articles at

MEDLINE, where 26 articles were found. We included other different and interesting articles that have met our selection criteria, which we obtained through the references in the articles initially searched.

## Selection Criteria

First, we tried to locate articles with randomized case-control studies, with no success. We selected articles with case series that included the technique used in the surgery – specifically those that use autologous bone to obliterate the mastoid cavity associated with a canal wall down procedure – with or without posterior reconstruction of the wall, and at least one year of mean follow-up of patients. We have included articles that used cartilage, fascia, skin grafts, or musculoperiosteal flaps to cover the obliterated bowl.

We excluded any article that: was not specific to surgery in chronic otitis; was on other associated mastoid filler materials – like silicon, ceramics or other alloplastic materials; was on musculoperiosteal and/or cartilage without using autologous bone parts; was on total tympanomastoid obliteration; was not written in English, Spanish, or Portuguese.

## Review of Literature

After applying the selection criteria to the initial 26 articles, we selected six of them. They all had Level 4 evidence: five were retrospective and one was a prospective case series, according to Oxford Centre for Evidence-based Medicine (→ **Table 1**). One article, by Walker et al<sup>7</sup> was an updated version of a previous one,<sup>8</sup> so we discarded the less current version.

When reviewing the references the articles mentioned above, as well as others pertinent to mastoid obliteration, we found four new studies that met the selection criteria. These were all retrospective case series, without a control group or randomization, and with Level 4 evidence. → **Table 2** summarizes the articles found.

Walker et al<sup>7</sup> showed a retrospective case series of consecutive patients treated from 1997 to 2011 with a Canal Wall Reconstruction (CWR) tympanomastoidectomy with mastoid obliteration using bone pate. The sample consisted of 285 ears with cholesteatoma in 273 patients, with a mean age of 35 years. There were 25 children under 10 years of age that had undergone surgery (average 6.9 years old). Thirteen patients (4.6%) were lost to follow-up right after the surgery. Thirty percent of the patients had previous surgery, with 20% having undergone ICW mastoidectomy. The authors collected bone pate from healthy cortical bone with a sheehy pate collector and performed a simple mastoidectomy and atticotomy. They removed the incus and the malleus head, cut the posterior bone canal (PBC) superiorly and inferiorly with a saw and removed it. After removing the PBC, they cleaned the entire middle ear of cholesteatoma, put the PBC back, placing a large single block of bone harvested from mastoid tip blocking the attic to avoid retraction of the pocket into the attic space. Smaller bone chips are placed to block the facial recess and prevent bone pate from entering the middle ear. The authors filled the bowl with bone pate and the original meatus skin would cover the PBC. Typically, a second-look

**Table 1** Levels of Evidence

Level of Evidence	Grading Criteria	Grade of Recommendation
1a	Systematic review of Randomized Controlled Trials (RCT), including meta-analysis	A
1b	Randomized Controlled Trial with narrow confidence interval	A
1c	All or none studies	B
2a	Systematic Review of cohort studies	B
2b	Cohort study and low quality RCT (e.g., <80% follow-up)	B
2c	Outcomes research studies; ecological studies	C
3a	Systematic review of case-control studies	C
3b	Case-control study	C
4	Case-series, poor quality cohort and case control studies	C
5	Expert opinion	D

Notes: Last updated on March 2009.

Source: Oxford Centre for Evidence-based Medicine (<http://www.cebm.net/oxford-centre-evidence-based-medicine-levels-evidence-march-2009/>).

tympaanoplasty with ossiculoplasty is performed 6 months after the initial tympanomastoidectomy. In this case series, 253 (89%) of 285 ears underwent the second-look operation, of which 30 (12%) had residual cholesteatoma only in the middle ear, which was successfully removed. Of the returning patients, 38 (14%) developed retraction pockets toward the attic; however, only 16 (5.9% of total) required an endaural atticotomy to improve access for debridement. These ears are now dry and self-cleaning. After the attic blocking technique was replaced with a single large bone block in 2005, only 7.1% of the patients developed retraction pockets. Prior to the change, this number was 21%. Seven patients (2.6%) developed a recurrence of cholesteatoma, having to convert to an open cavity. Average time until recurrence was 3.68 years. When making the canal wall cuts, 14 ears (4.9%) had intra-operative cerebral spinal fluid leakage, all of which were immediately detected and repaired. Only one patient required a secondary operation.

Edfeldt et al<sup>9</sup> published an article with a series of 330 operated ears in adults (over 12 years in age) with cholesteatoma in 301 patients. They underwent an operation performed by three senior surgeons between 1982 and 2004 using an identical technique. From this sample, 156 ears (47%) had undergone previous surgeries, while 61% had undergone one previous operation. The surgeons performed a CWD mastoidectomy, meatoplasty, and used cartilage from the tragus or meatus to rebuild the wall. The mastoid and epitympanic spaces were obliterated with cartilage and bone pate. When necessary, they reconstructed the ossicular chain at the same stage with autologous cortical bone or shaped incus. A large temporal fascia was used for myringoplasty and to cover the reconstructed ear canal. They followed the patients for at least 6 years. They did not use Computer Tomography (CT) nor Magnetic Resonance Imaging (MRI). Nine cases (3%) had residual disease and 33 cases (10%) had recurrent disease during the study period. These patients underwent miscellaneous revision surgery. The study did not inform whether there was a need to convert to an open cavity

in any of the cases. They did report, however, that only one case had recurrent ear discharge, after 6 years of follow-up.

Edfeldt et al<sup>10</sup> published another retrospective case series that included only children under 12 years of age, with a mean age of 8.2 years. The group consisted of 57 children with cholesteatoma, five of which presented congenital cholesteatoma. They all underwent operations by three senior surgeons between 1983 and 2004, who used the exact surgical technique described in the previous paragraph. Four patients (7%) had undergone previous surgeries. All of the patients had a follow-up period of at least 6 years. No imaging was performed. The authors confirmed and checked three residual (5%) and seven recurrent cholesteatoma (12%). Three (42%) of the recurrent cholesteatoma were located in the reconstructed ear canal. None of them underwent conversion to open cavity. After six years, all cases were dry and water tolerant. The authors compared these results to their database from operated adults, and found that they were similar. They did not observe any extrusion of autologous material.

Mokbel and Khafagy<sup>11</sup> showed a prospective case series with 100 adults operated between 2003 and 2010. The inclusion criteria were patients with unilateral chronic suppurative otitis media, with no history of mastoidectomy or systemic debilitating condition. The minimum follow-up period was 12 months, extending up to 72 months (52% of the patients). There were 64% of patients with cholesteatoma. The authors performed a CWD mastoidectomy, large meatoplasty, anterior and inferior canaloplasty, obliterated with cortical bone pate, and covered it with musculoepiosteal flap. The flap and exposed bone was covered with temporal fascia and split-thickness skin grafts. No ossicular chain reconstruction was performed. All cases completed the 12-month follow-up and 78% had complete dry cavity, 16% had intermittent otorrhea and 6% with persistent discharge. Throughout the follow-up period, 10 patients presented persistent discharge, all of them caused by the presence of granulation tissues. These patients were treated with a revision surgery (6%) and cauterization (4%), which resulted in

**Table 2** A summary of articles on mastoid obliteration with autologous bone in mastoidectomy with canal wall down for chronic otitis

Authors	Study Type	Evidence Level	No. of cases	Surgery Technic	Follow-up period	Outcome	Open cavity conversion
Walker et al. <sup>7</sup>	Retrospective Case-series	4	285 ears in 273 patients	PCW took off and replaced + oblit of attic and mastoid with bone pate and chips	Median 3.16 years (Followed 95.4%)	253 ears made 2 <sup>nd</sup> look ossiculoplasty with 12% of residual chol. 5.9% needed a secondary atticotomy to improve access for debridement. 7 (2.6%) recurrent chol.	7 ears (2.6%)
Edfeldt et al. <sup>9</sup>	Retrospective Case-series	4	330 ears in 301 patients aged >12 years	PCW removed and reconstructed with cartilage and cortical bone. Oblit with bone paste and cartilage. OCR at same stage with bone/ incus.	6 years	Recurrent Chol 10%; Residual Chol 3%; Dry Ear 99% Water resistant 92%	not informed
Edfeldt et al. <sup>10</sup>	Retrospective Case-series	4	57 Children with chol (mean age 8.2 years) (5 CCH)	PCW removed and reconstructed with cartilage and cortical bone. Oblit with bone paste and cartilage. OCR at same stage with bone/ incus.	6 years	Recurrent chol 12%; residual chol 5%; dry ear and water resistance after 6 years 100%	none
Mokbel and Khafagy <sup>11</sup>	Prospective Case-series	4	100 patients and ears	CWD mastoidectomy. Oblit: Bone pâté + musculo-periosteal flap and split-thickness skin graft	12 (100%) -72 months (52%)	At 12 months: completely dry: 78%; persistent discharge: 6% At 6 years: 100% dry	none
Kronenberg et al. <sup>12</sup>	Retrospective Case-series	4	18 Adults and 31 Children	PCW took off and replaced + oblit of attic and mastoid with bone pate and cartilage	Mean 28 months	Recurrent Chol detected on MRI in 12%, only in tympanic cavity. 77.8% water-safe	none

(Continued)

Table 2 (Continued)

Authors	Study Type	Evidence Level	No. of cases	Surgery Technic	Follow-up period	Outcome	Open cavity conversion
Sun et al <sup>13</sup>	Retrospective Case-series	4	48 ears in 45 children (5-12 years)	CWD mastoidectomy with oblit with cartilage and bone paste + temporalis fascia	2-5 years (mean 3,1)	Residual chol: 0%; Recurrent chol: 4.2%; Dry ear 95.8%	none
Beutner et al <sup>14</sup>	Retrospective Case-series	4	26 patients with previous CWD mastoidectomy	Bone pate + conchal cartilage plates and fascia	6 years Mean follow-up	100% epithelialized and dry. Before surgery 54% had vertigo on caloric stimuli; none had it after. 0% chol	none
Ramsey et al <sup>15</sup>	Retrospective Case-series	4	60 ears (59 patients)	Bone pate + inferiorly pedicled periosteal flap + split-thickness skin grafting	>12 months (mean: 31 months)	No cholesteatomas 82% dry; 8% intermittent discharge; 6 ears(10%) frequent discharge within 4 had meatal stenosis	none
Roberson et al <sup>2</sup>	Retrospective Case-series	4	62 ears (56 patients)	Bone pate + fascia graft	Average 18,5 months (0.2-54.8 months)	6% residual Chol, none after second stage surgery. 87% dry cavity; 5% had pate resorption after early infection.	none

Abbreviations: CCH, congenital Chol; Chol, Cholesteatoma; No., number; Oblit, obliteration; OCR, Ossicular Chain Reconstruction; PCW, Posterior Canal Wall; yrs, years.

8 patients becoming dry. None of the follow-up cases presented residual or recurrent cholesteatoma.

Kronenberg et al<sup>12</sup> came forth with a retrospective case series that included 49 consecutive patients (31 children and 18 adults) that had undergone surgery between 2008 and 2011. They all had cholesteatoma and their mean follow-up period was 28 months (the authors did not mention the minimum or the maximum follow-up time). Thirty patients were undergoing their first ear surgery. The authors used a technique similar to that used by Walker et al<sup>7</sup> whereby they collected bone pate from cortical bone, made a simple mastoidectomy and atticotomy, removed the incus and the malleus head, cut the posterior bone canal (PBC) superiorly and inferiorly, and removed it. After removing the PBC, they fully cleaned the middle ear of cholesteatoma, examined the sinus tympani with a 30° endoscope, restored the PBC, placed cartilage blocking the attic, and filled the bowl with bone pate. They covered the PBC with tragus perichondrium and the tympanic membrane with temporalis fascia. In the secondary surgery group, if there was damage to the PBC, the patients underwent a reconstruction using cartilage. The authors found recurrent cholesteatoma in six patients (12%); three from the group undergoing first surgery and three in the other group. The authors identified all the cholesteatomas using non-EPI Diffusion-weighted (DW) MRI, and observed that they were small and located only in the tympanic cavity. Thirty-five patients (77.8%) were water safe during the follow-up period. In primary surgery, however, the surgeons achieved 85.7% water-safe and 90% with dry ear, contrasting with the other group, which had 64% and 73%, respectively.

Sun et al<sup>13</sup> presented a retrospective case series that consisted of 45 children aged between 5 and 12 years (mean age was 10 years), with a total of 48 ears that had undergone procedures in the period between 1999 and 2006. Only primary surgery cases were included. They were followed-up for two to five years (16 patients – 35%), with a mean follow-up after 3.1 years. All the children had cholesteatoma. The surgeons performed a CWD mastoidectomy, removed the incus and the head of the malleus, performed a meatoplasty and harvested cartilage from concha. They used bone pate to seal the epitympanum and bone pate, cartilage, and musculoepiosteal flap to cover the mastoid. Then, a temporalis fascia graft was placed to reconstruct the tympanic membrane and cover the obliteration. The study found recurrent cholesteatoma in two patients (4.16%) (at 16 months and 33 months) and all were located in the tympanic cavity. Epithelization of the mastoid bowl was completed within 8–10 weeks, and all ears were dry within the same 8–10 weeks.

Beutner et al<sup>14</sup> demonstrated a case series of patients that had already been submitted to CWD mastoidectomy and were undergoing a revision surgery with CWD mastoidectomy with obliteration using autologous bone pate, covered with cartilage plates. The surgeon performed a meatoplasty and reconstructed the tympanic membrane with thinned slices of cartilage. The entire surgery was performed by the same surgeon. The authors selected 26 patients, but only 18 of

them agreed to a complete follow-up, including vestibular testing. The median follow-up period was 6 years and mean age was 46 years. None of the selected patients had residual or recurrent cholesteatoma. In analyzing preoperative data, 14 patients of the 26 patients (53.8%) had reported that caloric stimuli (such as wind, water, or suction cleaning) regularly induced vertigo. After the surgery, none of the patients reported similar symptoms in the same situations and all patients had dry ear with complete epithelization.

Ramsey et al<sup>15</sup> presented a retrospective clinical study of 60 consecutive surgeries between 1995 and 2000 for active chronic otitis media. All patients had CWD mastoidectomy with simultaneous tympanoplasty, including split-thickness skin grafting. An inferiorly pedicled periosteal-pericranial flap was used in conjunction with autologous bone pate to obliterate the mastoid cavity. The surgeon performed an anterior and inferior canalplasty and a large meatoplasty. The sample consisted of 60 years from 59 patients. The ages ranged from 4 to 84 years, with a mean of 39 years. Fifty-three ears (88%) had cholesteatoma, and the others presented granulation tissue without cholesteatoma. The minimum follow-up period was 12 months, with a mean of 32 months (maximum 80 months). The authors followed-up on 36 ears (60%) for over 24 months and 18 ears (30%) for over 36 months. Of all procedures performed, fifty-four (90%) were successful in controlling patients' infections. Six patients (10%) had frequent discharge, of which four had meatal stenosis and underwent revision surgery. The other two cases were attributable to granulation tissue, treated with office management debridement with secondary split-thickness skin grafting. There were no cases of residual or recurrent cholesteatoma.

Roberson et al<sup>2</sup> presented a retrospective case series of 57 patients with 62 operated ears. The average of patients with previous surgery before obliteration was 2.2 (ranging from 0–7). Twenty-seven patients had cholesteatoma at the time of the obliteration; other indications were recurrent infections, water intolerance, hearing device intolerance, excessive recurrent cleaning, and caloric induced vertigo or vestibular fistula. The technique was a CWD mastoidectomy or revision of it, associated with an adequate meatoplasty, if necessary, and the removal of incus and head of malleus. The cavity obliteration was performed with healthily cortical bone pate, covered with fascia. Another piece of fascia was used to reconstruct tympanic membrane. It is important to avoid the exposure of any pate to either the middle ear or the external auditory canal, without a fascia covering it. The mean follow-up period was 18.5 months (ranging from 0.2–54.8 months). Thirty-six ears underwent second-stage reconstructive surgery and four patients (6.4% of 62 ears) had residual cholesteatoma. Two patients presented partial reabsorption of bone pate, having early and recurrent infections. For both of these patients, the surgical indications were recurrent infection. Eight patients had early canal infections, 6 of them with subsequent clearing, and the other two were the ones presenting reabsorption. Ninety-two percent of patients who had complete take of the bone graft did not require any cleaning (87% of all ears).

## Discussion

Usually, otologists treat recurrent mastoid disease with techniques that remove tissue and further changes to the normal anatomy. CWD mastoidectomy removes the entire posterior bony wall, showing excellent exposure of the middle ear and epitympanum. This helps to complete disease elimination with lower rates of recidivism, reported herein as 2% to 17%. The open cavity procedure is widely considered the “gold standard” for cholesteatoma management due to the low recurrence rates.<sup>7</sup> It is generally accepted that the goals that lead to a trouble-free cavity include complete remove of the disease, a smoothly contoured cavity with a low facial ridge, and extensive meatoplasty.<sup>16</sup>

Patients may undergo multiple surgeries in an attempt to achieve such goals. In many cases, however, greater tissue removal during revision surgery yields disappointing results or may even be counterproductive. Although this strategy is successful in the majority of patients, some continue to have issues, such as: recurrent infections; the need for continued microscopic debridement; water intolerance; calorically induced vertigo; or the inability to wear a hearing device, because the large mastoid cavity becomes easily infected when the external auditory canal is occluded, allowing moisture and bacterial proliferation within an existing canal wall down mastoid cavity.<sup>2</sup> Throughout many years, surgeons have been developing different techniques to reduce mastoid cavity and epitympanic space in the hope of avoiding such complications. Isolating the attic from the middle ear and obliterating the attic and mastoid with bone pate prevents retraction pockets and new cholesteatoma development.<sup>17</sup>

There is no evidence to date that indicates that one particular filler material is better than another is. Autologous bone and cartilage, and traditional alloplastic materials such as hydroxyapatite and SerenoCem (Miamisburg, USA) have all stood the test of time. The factors that are most likely to influence the surgeon's choice of filler materials are the material's user-friendliness and cost and the surgeon's personal preference, rather than scientific reasons.<sup>3</sup> The diversity of flaps available indicates that there is no ideal flap for this purpose.<sup>18</sup>

Bone pate is an autologous material that is readily available in primary and revision cases. After reviewing all those articles, we can safely affirm that Mastoid obliteration with autogenous cranial bone pate is a safe and extremely effective option in the treatment of problematic canal wall down mastoid cavities, which result in a dry, trouble-free mastoid cavity. Linthicum<sup>4</sup> reported that the bone pate became encircled by fibroconnective tissue without inflammation. In the immediate surrounding area, the author identified osteoid deposition and osteoblasts, showing new bone deposition. This may contribute to the maintenance of volume with time.

The removal of the canal wall grants improved direct visualization of the whole epitympanum. Removing the head of the malleus allows for an inspection of the total posterior epitympanic space and removal of the cog. This maneuver gives access to the anterior epitympanic space. It is

hard to inspect the anterior epitympanum and tympanum together with the canal wall in place, and this deficiency of exposure may partially account for higher rates of recurrence in ICW mastoids.<sup>7</sup>

Most surgeons consider cholesteatoma in children to be more aggressive and difficult to treat than in adults.<sup>10</sup> This may mean that toddler cholesteatoma has a different biology, with an elevated grade of cell proliferation, which would explain the higher rate of recurrence and residual disease in children. Consequently, optimal functional outcome could be more intricate to accomplish, requiring the “second look” principle.<sup>19</sup>

Looking over the selected articles, we could find great infection control rates, with four articles presenting 0% recurrence of cholesteatoma, going up to 15%. These achievements are similar to those expected from CWD mastoidectomy without obliteration, with the added advantage of patients' having greater water resistance and needing less clinical care in the cavity.

Vartiainen<sup>20</sup> reported on CWD results with 10 years of follow-up. He compared the cohort to a group with less than 10 years of follow-up and found that the group with a follow-up period of 10 years or greater had higher rates of recurrence. For the group with 10 years or greater of follow-up, the recurrence rate was 17%, but those with less than 10 years had only 8.8% recurrence.<sup>20</sup> This implies that even CWD mastoidectomy needs to be followed-up in the long term, in clinical offices and in cohort studies. Based on these findings and on the increasing cholesteatoma rates over time found in the Walker et al<sup>7</sup> case series, we come to the conclusion that we need more long-term follow-up articles, closer to or greater than a 10-year minimum.

One of the most criticized aspects of mastoid obliteration is the possibility of a silent cholesteatoma within the obliterated cavity, resulting in a severe complication. Perhaps one of the most exciting developments in cholesteatoma research is magnetic resonance imaging (MRI). This technique allows the differentiation of cholesteatoma from granulation, cholesterol granuloma, and various filler materials within the mastoid cavity.<sup>3</sup> Aarts et al examined the result of three non-echo-planar (non-EPI) diffusion-weighted (DW) MRI studies and found that the corresponding pooled sensitivity, specificity, positive predictive value and negative predictive value in cholesteatoma detection were 97% to all four.<sup>21</sup>

The recent development of MRI means there is now a reliable way to detect cholesteatoma within the obliterated mastoid cavities, which mitigates concerns that hidden cholesteatoma could be missed. In reality, many otologists had been performing mastoid obliteration surgery long before DW MRI imaging was available, and the long-term outcome was favorable. Therefore, non-availability of non-EPI DW MRI should not be an obstacle for the introduction of mastoid obliteration into one's otological practice.<sup>3</sup>

## Final Comments

All the articles mentioned in ▶Table 2 have a “C” grade for recommendation level (▶Table 1). For a more confident

recommendation level, the studies should have an improved design, adopting prospective long-term randomized case control studies. In analyzing the current studies, we are not able to determine the better technique: the CWD or the CWD with obliteration with autologous bone. However, compiling all the conclusions found in the articles selected for this study, we can conclude that mastoid obliteration with autologous bone has been utilized for many years now and that is has proven to be a safe low-cost technique with low recurrence rates. Although it is similar to traditional canal wall down procedures, it produces more favorable results in terms of water resistance and quality of life for patients.

The procedure could be done in primary surgery, or upon revision surgery on patients with unstable cavities, even after radical mastoidectomy. Nowadays, mastoid obliteration is the preferred treatment for discharging mastoid cavities. There are many different surgical techniques and filler materials for mastoid obliteration, and so far, there has not been any evidence of a better one. The main factor in selecting a technique seems to be the surgeons previous experience and cost.<sup>3</sup>

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