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Revision surgery for cholesteatoma: hints and pitfalls based on clinical experience and Literature Review.

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Revision surgery for cholesteatoma.

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Abstract

INTRODUCTION: This study aims to identify the most frequent causes of failure in ear surgery for cholesteatomatous chronic otitis media (CCOM), through a retrospective clinical analysis and a literature review. Audiometric outcomes before and after revision surgery were also evaluated.

EVIDENCE ACQUISITION: A retrospective study was conducted on 37 patients who underwent revision tympanoplasty with canal-wall-down (CWD) mastoidectomy for recurrent CCOM between 2017 and 2023. Intraoperative findings were analyzed to identify potential causes of failure from previous surgeries. Audiometric data, including pure-tone average (PTA) and air-bone gap (ABG), were assessed pre- and post-operatively. A literature review, following PRISMA guidelines, was also performed across major databases to identify studies reporting intraoperative findings and hearing outcomes in revision surgery for CCOM.

EVIDENCE SYNTHESIS: In our series, the most frequent causes of failure were residual epithelial cells (83.7%), recurrent/residual cholesteatoma (81.1%), bony overhangs (81.1%), tympanic membrane perforation (81.1%), and canal stenosis (78.4%). High facial ridge and absent meatoplasty were present in 65% of cases. Postoperative audiometry showed a slight improvement, with an average ABG gain of 2.3 dB. From the literature (13 studies, 1180 ears), the most commonly reported

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failures included residual cholesteatoma, inadequate meatoplasty, and high facial ridge. Audiometric gains ranged between +1.7 and +12 dB.
CONCLUSIONS: Surgical failures in CCOM are often due to technical issues, particularly incomplete disease removal and inadequate cavity management. Revision surgery helps achieve disease control and may offer modest hearing improvement. Greater attention to surgical detail can reduce the recurrence rate and the need for further interventions.

Keywords: Revision tympanoplasty, revision mastoidectomy, cholesteatoma, chronic otitis media, ear surgery.

INTRODUCTION

Chronic middle ear diseases are typically characterized by persistent inflammation and/or infection of the mastoid and/or middle ear, with or without cholesteatoma, often accompanied by conductive hearing loss and abnormalities of the tympanic membrane. In this context, chronic otitis media with cholesteatoma (CCOM) refers to the presence of keratinizing squamous epithelium within the middle ear and/or mastoid cavity, representing the focus of the present study. Tympanoplasty with mastoidectomy is often the standard treatment for CCOM. The surgical objective is to excise pathological tissues, achieve a dry ear, and restore or reconstruct middle ear function. One of the most objective parameters for assessing the efficacy of tympanoplasty is the condition of a "dry and safe ear," indicating a well-epithelialized ear with a closed tympanic membrane and the absence of otorrhea or residual/recurrent cholesteatoma [1].
In cases where patients continue to experience one of these conditions, the desired outcomes are not achieved and, in such circumstances, revision surgery becomes necessary. The objective of the revision procedure is to achieve a dry ear while simultaneously eradicating the disease [2].
Tympanoplasty with canal-wall down (CWD) Mastoidectomy stands out as the most utilized and well-established procedure for surgically addressing CCOM. The primary advantage of this technique lies in the enhanced exposure of the middle ear, resulting in an open mastoid cavity that facilitates better post-operative monitoring of the treated ear [3]. On the other hand, the canal-wall up (CWU) approach preserves the integrity of the external auditory canal and avoids creating a large cavity. However, CWU carries a relatively higher recurrence rate, as consistently reported in the literature, possibly attributed to inadequate visualization of the middle ear during surgery, particularly in the pre-endoscopic era.

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While widely established, the CWD technique involves steps that, if not executed correctly, can result in procedural failure over time, leading to recurrence or persistence of the pathology and its consequences [4].

Despite the general knowledge of CCOM features, comparative data between clinical case series and systematic literature are limited, and evidence regarding recurrence patterns remains fragmented. This gap underscores the need for integrating clinical experience with a structured literature review.

The aim of this study is therefore to systematically identify the most common technical and anatomical factors contributing to surgical failure in CCOM, by integrating our clinical experience with a structured review of the literature, and to provide an evidence-based framework to guide future surgical practice.

EVIDENCE ACQUISITION

We conducted a retrospective analysis of patients who underwent revision surgery for recurrent CCOM from 2017 to 2024 at the ENT Department of University Hospital of Palermo.

The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of Policlinico “Paolo Giaccone” of Palermo (11-22/04/2024).

Each participant underwent a comprehensive anamnesis, gathering personal information, symptoms onset, hearing complaints, and a review of any previous medical and/or surgical treatments.

A thorough otolaryngologic examination was performed, including micro-otoscopy and endoscopy of the upper airways. The audiometric examination, evaluating the pure-tone average (PTA) at frequencies of 0.5, 1, 2, and 4 kHz, and the air-bone gap (ABG), was performed in all subjects. Our study included patients of any gender, age and ethnicities who have undergone previous tympanoplasty with CWU or CWD mastoidectomy for CCOM, experiencing recurrent or relapsing symptoms. All subjects enrolled in the study underwent temporal bone computed tomography (CT).

All patients displaying clinical and/or radiological features indicative of recurrent CCOM were referred for revision surgery. Only cholesteatomatous forms of chronic otitis media were included in this study; non-cholesteatomatous cases were excluded. Recurrent CCOM was defined based on clinical findings (persistent or relapsing otorrhea), otoscopic evidence of residual or recurrent pathology, and/or radiological signs on temporal bone CT suggestive of cholesteatoma recurrence.

All patients underwent tympanoplasty with CWD mastoidectomy at our center following comprehensive counseling and obtaining written consent. The surgical procedures were performed under general anesthesia by the same expert surgeon. The surgical techniques were chosen based on the patient’s hearing status. In patients with good hearing (PTA ≤ 40 dB), a revision tympanoplasty

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with a modified radical mastoidectomy was performed. In this technique the mastoidectomy is followed by complete removal of the posterior bony wall of the external auditory canal with adequate lowering of the facial ridge, management of the tympanic cavity with removal of the pathology from the attic and eventually the middle ear, taking care to leave the ossicular chain remnants intact. The reconstruction is made by positioning temporalis fascia underlay the tympanic membrane remnants, medially to the malleus handle and laterally to the stapes, with or without ossiculoplasty. An option is the partial obliteration of the cavity with bone patè or cartilage.

In patients with poor residual hearing (PTA > 40 dB), for whom the primary goal of surgery was solely to achieve eradication of the pathology and a dry ear, a radical revision mastoidectomy was performed. This technique involves the removal of ossicular remnants except for the stapes (if present) and obliteration of the eustachian tube. The temporalis muscle fascia is then positioned above the medial wall of the tympanic cavity, beneath the tympanic remnants or external meatus skin, without leaving space medially. Consequently, this technique lacks a phase for reconstructing the structures of the middle ear. With both techniques, the primary outcomes assessed were intraoperative findings identified as potential causes of failure in the previous surgery.

Since all patients underwent CWD mastoidectomy, we performed a meatoplasty at the same time. This technique entails a full-thickness incision of the skin, conchal cartilage, and connective tissue extending from the posterior wall of the meatus to the antihelix. A portion of the skin and connective tissue overlying the meatal cartilage is then detached, and an appropriate portion of the cartilage is removed based on the size of the cavity created. The meatal skin flaps are subsequently sutured superiorly and inferiorly to the musculoperiosteal layer. In all cases, we administered antibiotic prophylaxis, and, following the surgical procedure, a compressive bandage was applied to the treated ear. Regardless of the surgical technique used, all patients were discharged within 24 to 48 hours post-surgery. Follow-up appointments were scheduled with weekly checks during the first month, followed by monthly checks for the subsequent three months, and then after six months. We documented the time required to achieve a stable and dry ear, as well as the resolution of recurrent pathology. Hearing outcomes were assessed by evaluating the PTA at frequencies of 0.5, 1, 2, and 4 kHz, and the ABG. During follow-ups, monitoring for the persistence or recurrence of pathology did not necessitate imaging, but rather meticulous cavity inspection using a microscope.

The literature review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-analyses group (PRISMA) guidelines [5]. Two independent authors conducted a comprehensive search by consulting the main scientific databases on the web, including PubMed, Google Scholar, Medline, EMBASE, Web of Science, and the Cochrane Library.

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Specific keyword pairs such as “Revision” AND “Tympanoplasty” (OR Mastoidectomy) were used for the search. Titles and abstracts were reviewed to screen out non-relevant articles, and the working group reviewed the full text of the remaining articles. The results of the studies were then combined, integrated, and analyzed. The criteria for considering studies for the review were based on the population, intervention, comparison, outcome, timing, and settings (PICOTS) framework.

-*Population and inclusion criteria:* Studies in the English language on patients of all ages, genders, and ethnicities who have undergone previous tympanoplasty with CWU or CWD mastoidectomy for CCOM, experiencing recurrent or relapsing symptoms.

-*Intervention:* Studies in which patients underwent revision tympanoplasty with CWU or CWD mastoidectomy for recurrent CCOM.

-*Comparison and Outcome:* The primary outcomes assessed were intraoperative findings identified as potential causes of failure in the previous surgery, as well as pre- and post-operative PTA and ABG. These were compared with our case series.

-*Timing:* Studies published up to December 2023 have been included in this literature review.

-*Setting:* Randomized controlled trials (RCT), non-randomized controlled trials (NRCT), prospective or retrospective cohort studies, and case-control studies from community, private, and tertiary care university hospitals were included.

EVIDENCE SYNTHESIS

The retrospective analysis included 37 patients, comprising 17 males and 20 females (M:F ratio 0.85) with a mean age of 53 years (age range 18-82 years). All patients in our series reported various degrees of hearing loss, confirmed by audiometric examination with an average PTA of 52.8 dB and an average ABG of 27 dB. All patients also reported intermittent otorrhea along with persistent or recurrent ear infections. Fibroendoscopic examination of the nose, paranasal sinuses, and nasopharynx revealed no pathological findings in the anatomical areas assessed.

During the initial surgery, 17 patients underwent CWU mastoidectomy, while 20 underwent CWD mastoidectomy. Modified Radical Mastoidectomy was performed in 85.5% of patients (n=32), either as a conversion from a previous CWU mastoidectomy or as a revision of the previous open cavity. Radical Mastoidectomy was performed in 13.5% of cases (n=5) due to pre-operative sensorineural deafness or previous radical mastoidectomy with negligible residual hearing.

The presence of recurrent versus residual cholesteatoma was classified intraoperatively according to specific criteria: residual cholesteatoma was defined as epithelial remnants left behind from the initial surgery, typically in hidden anatomical recesses (e.g., sinus tympani, facial recess, anterior

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epitympanum), whereas recurrent cholesteatoma was defined as a new growth arising from retraction pockets or tympanic membrane dysfunction.

The presence of recurrent/residual cholesteatoma was found in 82.3% (14/17) of patients previously subjected to CWU mastoidectomy and in 80% (16/20) of those previously subjected to CWD mastoidectomy. Intraoperatively, all 37 cases presented some type of anatomical defect, mainly at the level of the mastoid cavity. A high facial ridge due to inadequate canal wall lowering was found in 65% (13/20) of patients who had previously undergone CWD mastoidectomy. Among these same patients, complete absence of meatoplasty was observed. Residual cellularity and bony overhangs at the level of the mastoid cavity were found in 83.7% (31/37) and 81.1% (30/37) of patients, respectively. A stenotic meatus or canal was observed in 78.4% (29/37) of patients. Tympanic membrane perforation was present in 81.1% (30/37) of cases. Table 1 summarizes the main intraoperative findings.

The post-operative audiometric examination allowed to detect an average PTA of 50.5 dB and an average ABG of 24.7 dB with an average ABG closure of 2.3 dB. Table 2 reports the pre- and post-operative audiometric characteristics of the study group.

Our initial search yielded 148 results. Following the PRISMA 2020 flow diagram (Figure 1), 121 studies (duplicates/non-relevant) were excluded, leaving 27 abstracts for examination. Subsequently, 2 articles were excluded based on the criteria outlined in the research protocol. Two authors independently reviewed the remaining 25 papers in detail. A discussion ensued before reaching a final decision regarding their inclusion or exclusion from the present study. Only 13 papers met the inclusion and exclusion criteria (Table 3). Most of the studies were excluded due to insufficient description of the main intraoperative findings encountered, a parameter to which we attributed significant importance and focused our attention on.

Overall, data from 1180 ears (287 CWU and 893 CWD) were analyzed. Each study reported the incidences of various intraoperative findings, along with data on preoperative and postoperative audiometric findings.

The presence of any recurrent/persistent cholesteatoma was recorded in each study, along with data pertaining to notable intraoperative findings, applying the same criteria used in our clinical series to distinguish residual from recurrent cholesteatoma, thus allowing direct comparison between our data and the literature (Table 4). Regarding the pre- and post-intervention audiometric results, only 4 studies comprehensively reported such data, including at least the average ABG pre- and post-intervention (Table 5).

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Given the relatively limited size of our clinical cohort, we acknowledge that some comparisons may be influenced by sample size, and future studies with larger populations are warranted to confirm these findings.

In cases of canal wall down (CWD) mastoidectomy, revision surgery is typically required when a cholesteatoma recurs or when the inflammatory and hyperplastic processes persist or become self-sustaining. It is important to remember that revision surgery is generally more complex than primary surgery, due to the absence of key anatomical landmarks and/or the exposure of previously covered structures, which may have become more fragile. The primary reason for requiring revision tympanoplasty is often suboptimal execution of the initial surgical technique [19]. Although numerous studies evaluate the outcomes of middle ear surgery, relatively few offer a detailed analysis of intraoperative findings in failed mastoidectomy cases. The studies included in our review provide an integrated dataset that allows comparison of intraoperative findings between our series and previously published literature. The studies included in our review offer the most comprehensive data available on this topic. While not all studies analyze the same parameters, it is possible to assess the incidence of overlapping features. Figures 2 and 3 present the incidence rates of intraoperative findings both from the reviewed literature and from our clinical series, respectively. There are several critical phases during a mastoidectomy—whether CWD or canal wall up (CWU)—where surgical errors can occur.

Our review reveals that the most common intraoperative finding following a failed CWD mastoidectomy is a high facial ridge, with an average incidence of 44.8% [6,7,9–14,16–18]. This condition is typically the result of technical error. Creating a proper communication between the auditory canal and the mastoid cavity requires removal of the posterior bony canal wall and lowering the facial ridge to the canal floor, forming a smooth, self-cleansing neocavity. However, due to concerns about facial nerve damage, surgeons often leave the ridge too high. This can lead to the accumulation of epithelial debris or secretions, thereby increasing the risk of recurrence. In our series, the facial ridge could be lowered by at least 2–3 mm in 65% of revision cases, while maintaining a safe margin from the nerve and achieving a smooth, regular neocavity. In our experience, preoperative CT scans were essential for determining the distance from the facial nerve and detecting any anatomical variations. Another common error observed in failed CWD procedures is the absence or inadequacy of meatoplasty.

A stenotic external auditory canal can lead to retention of epithelial debris and poor aeration, contributing to infections and recurrence of cholesteatoma. This issue was found in only 12.1% of

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cases in the literature [9–11,13,17], but in our series, inadequate meatoplasty was observed in 65% of revision cases, highlighting a significantly higher incidence.

When considering both CWD and CWU techniques, residual or recurrent cholesteatoma is the most common finding, with an average incidence of 44.7% [6–18]. Residual and recurrent cholesteatomas are distinct but critical complications following middle ear surgery.

Residual cholesteatoma refers to epithelial remnants left behind during the initial procedure, often in hidden anatomical recesses like the sinus tympani, facial recess, or anterior epitympanum. The extent of the initial disease is a major risk factor—larger cholesteatomas are more likely to leave residual tissue [20].

In contrast, recurrent cholesteatoma develops from new retraction pockets or tympanic membrane dysfunction, typically driven by persistent Eustachian tube dysfunction or poor middle ear ventilation. The surgical technique plays a key role: while CWU surgery preserves the posterior canal wall and offers better hearing outcomes, it provides less exposure, increasing the risk of residual disease. According to Gyo et al., residual cholesteatoma occurred in 34% of CWU surgeries compared to 12% in CWD procedures [21]. Similarly, Tomlin et al., in a meta-analysis of over 5,000 patients, reported residual disease rates of up to 36% in CWU versus 8–17% in CWD cases [22].

In our series, however, the type of surgical technique had little effect on residual disease rates (82.3% in CWU vs. 80% in CWD).

Other recognized risk factors for recurrence include inadequate ossicular chain reconstruction, persistent tympanic membrane perforation, and unresolved chronic middle ear infection. Among the various reconstructive factors, the type of ossiculoplasty performed is significant. Partial ossicular replacement prostheses (PORPs) generally yield better outcomes than total prostheses (TORPs), which are associated with more extensive disease and higher recurrence rates. Yung et al. found a recurrence rate of 14.5% with TORPs, compared to 6.8% with PORPs, suggesting that greater ossicular erosion is associated with more aggressive disease [23]. This is further supported by Bovi et al., who identified ossicular erosion itself as an independent predictor of recurrence [24]. The choice of reconstructive material also plays a role. Autologous materials (e.g., remodeled incus, cartilage, cortical bone) are generally preferred in unstable or infected environments due to superior biocompatibility and lower risk of extrusion or reinfection. However, if autologous ossicles are eroded or contaminated with keratinizing epithelium, they may increase recurrence risk. Neudert et al. stressed the importance of sculpting, sterilizing, and thoroughly inspecting autologous materials before reimplantation [25]. When in doubt, titanium prostheses are considered safer despite the risks of extrusion or instability. Mishiro et al. reported a recurrence rate of 7.5% with autologous incus

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versus 15.2% with titanium prostheses, emphasizing the importance of material selection based on disease severity and intraoperative findings [26]. Unfortunately, the literature did not provide sufficient data to extract this specific information from the available case series.

Persistent or recurrent tympanic membrane perforation following primary tympanoplasty is another major cause of revision surgery. This finding was identified in 22.12% of the cases reported in the literature and in 81.08% of our case series.

A residual perforation compromises both hearing and middle ear health, promoting infection and underaeration both risk factors for recurrence. Studies have shown higher graft failure rates in ears with chronic otitis media and cholesteatoma, especially in the presence of ongoing inflammation or Eustachian tube dysfunction. Dornhoffer and Gardner linked tympanic membrane integrity directly to long-term surgical success, noting significantly higher recurrence rates in ears with persistent perforations [27].

Black and Kuo further demonstrated that inadequate control of chronic otitis media can double the risk of recurrence, with persistent inflammation observed in up to 35% of recurring cases [28,29].

Residual epithelial cells inadvertently left behind during initial surgery are another challenging cause of recurrence. These remnants, often located in hard-to-visualize areas such as the sinus tympani, facial recess, anterior epitympanum, or mastoid tip, were detected in 34.32% of the cases included in the literature review and in 83.78% of our case series. Badr-El-Dine found residual disease in up to 42% of revision cases, most commonly in the sinus tympani. Importantly, such remnants often reflect anatomical complexity rather than surgical inexperience [30].

Bony overhangs within the middle ear are another major barrier to complete cholesteatoma removal. This finding was identified in 8.81% of the cases included in the literature review and in 81.08% of our case series. These osseous protrusions often in the sinus tympani, facial recess, or retrotympanum—can obscure residual epithelium. Marchioni et al. highlighted the need for endoscopic assistance or careful drilling in these cases [31]. If not properly addressed, due to limited access or a conservative approach, revision surgery becomes necessary. Standard microscopic techniques often fail to fully visualize these recesses, especially in CWU procedures. Presutti et al. noted that even small epithelial nests left behind in poorly exposed areas can lead to recurrence [32], while Dornhoffer and Jassar found strong correlations between deep sinus tympani, overhanging canals, and recurrence [33-35]. In this context, second-look procedures or intraoperative endoscopy during the primary surgery are crucial strategies to reduce the need for revision.

As regards hearing results, as is known, the primary aim of revision surgery is not to improve hearing (already often compromised), but to obtain a clean and stable cavity. Although there were only 4

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studies that reported the hearing results in detail, a trend of improvement in the average ABG Gain from a minimum of + 1.7dB to a maximum of + 12 dB can be seen. Even in our series, a modest improvement in hearing was recorded despite the absence of ossiculoplasty with an average ABG gain of + 2.3 dB.

In our series (Figure 3), the most common finding was residual epithelial cells (83.7%), followed closely by recurrent/residual cholesteatoma (81.8%), bony overhangs (81.8%), tympanic membrane perforation (78.4%), and canal stenosis (78.4%). High facial ridge and absent meatoplasty were observed in 65% of cases. These findings suggest a greater frequency and co-occurrence of technical errors compared to literature reports, which could potentially be influenced by the limited number of specialized otologic surgeons in the Sicilian region and the referral of patients from centers with less routine expertise in ear surgery.

CONCLUSIONS

Revision surgery for cholesteatomatous chronic otitis media (CCOM) is a challenging but essential procedure in cases of persistent or recurrent disease following primary tympanoplasty and mastoidectomy. Rather than representing an unavoidable evolution of disease, many failures appear to be linked to potentially preventable technical factors during the primary procedure. The high prevalence of residual epithelial cells, inadequately lowered facial ridges, bony overhangs, tympanic membrane perforation, and insufficient meatoplasty observed both in our series and in systematic review suggests that meticulous surgical execution during the primary CWD mastoidectomy is crucial to reduce the need for revision. In particular, inadequate lowering of the facial ridge and poor meatoplasty compromise cavity self-cleaning and long-term surveillance, thereby favoring recurrence. These findings support the need for enhanced surgical training, careful preoperative planning with imaging guidance, and a more assertive management of critical anatomical areas such as the retrotympanum and facial ridge during the primary surgery.

While revision surgery remains effective in achieving a dry and safe ear, its role should ideally be minimized through optimization of the initial intervention rather than relied upon as a corrective strategy. Audiological improvement, although possible, remains secondary to disease eradication and cavity stabilization. A major limitation emerging from our literature review is the marked heterogeneity in study design and outcome reporting. Many studies combine different surgical procedures without clearly stratifying results according to technique, extent of disease, or specific intraoperative findings. Furthermore, intraoperative anatomical and technical factors are inconsistently defined and reported, making meaningful comparison across studies difficult. To

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address this limitation, we propose the adoption of a standardized reporting model for future otologic studies, including: (1) clear differentiation between CWU and CWD procedures; (2) explicit classification of residual versus recurrent cholesteatoma; (3) systematic documentation of key intraoperative findings (e.g., facial ridge height, presence of bony overhangs, meatoplasty adequacy, retrotympanic involvement); and (4) uniform reporting of audiometric outcomes (PTA and ABG) with defined follow-up intervals. Such standardization would improve comparability between studies, enhance the quality of meta-analyses, and ultimately contribute to evidence-based refinement of surgical techniques. In conclusion, improving the quality and radicality of the primary surgical technique, together with adopting more rigorous and standardized reporting criteria in future research, represents the most effective strategy to reduce recurrence rates and the burden of revision mastoidectomy in CCOM.

DECLARATIONS

Registration and protocol: This review was not registered in any public database, and no protocol was prepared prior to conducting the review.

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Competing interest: The authors declare no conflicts of interest.

Availability of data, code and other materials: No data collection forms, extracted data, analytic code, or other materials used in this review are publicly available.

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Conflicts of interest

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Authors' contributions

Francesco Dispenza has given substantial contributions to the conception or the design of the manuscript. Angelo Immordino, Salvatore Alberto Di Vincenzo, Francesco Lorusso, Federico Sireci, and Salvatore Gallina to acquisition, analysis and interpretation of the data. All authors have participated to drafting the manuscript, Angelo Immordino revised it critically. All authors read and approved the final version of the manuscript.

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TABLES

Table 1: Main intraoperative findings

Findings	% (n)
Recurrent/residual cholesteatoma	82.3% of previous CWU (14/17) 80% of previous CWD (16/20) Tot 81,1% (30/37)
High facial ridge	65% of previous CWD (13/20)
Missing meatoplasty	65% of previous CWD (13/20)
Residual cells	83.7% (31/37)
Bony overhangs	81.1% (30/37)
Canal/Meatus stenosis	78,4% (29/37)
TM perforation	81.1% (30/37)

CWU= canal-wall up; CWD= canal-wall down; TM= tympanic membrane

Table 2: Average pre- and post-operative audiometric findings.

	Pre-operative	Post-operative
Average PTA	52.8 dB	50.5 dB

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Average ABG	27 dB	24.7 dB

PTA= pure-tone audiometry; ABG= air-bone gap

Table 3: Baseline characteristics of the patients included in the selected studies.

Author	Title	Year	Cases	Previous surgery
Nadol Jr. [6]	Causes of failure of mastoidectomy for chronic otitis media	1985	66	CWU (10) CWD (56)
Bhatia et al. [7]	Canal wall down mastoidectomy: causes of failure, pitfalls and their management.	1995	105	CWD (105)
Veldman et al. [8]	Revision surgery for chronic otitis media: a learning experience	1998	348	CWU (166) CWD (182)
Phelan et al. [9]	Intraoperative findings in revision canal wall down mastoidectomy	2008	37	CWD (37)
Faramarzi et al. [10]	Intraoperative findings in revision chronic otitis media surgery	2008	116	CWU (57) CWD (59)
Berçin et al. [11]	Results of revision mastoidectomy	2009	35	CWU (14) CWD (21)
Gluth et al. [12]	Patterns of failure in canal wall down mastoidectomy cavity instability	2012	130	CWD (130)
Kasenõmm [13]	Intraoperative findings of revision canal wall-down tympanomastoid surgery	2013	50	CWD (50)

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Li S. et al. [14]	Revision surgery for canal wall down mastoidectomy: intra-operative findings and results	2016	76	CWD (76)
Vercruysse et al. [15]	Long-term Results of Troublesome CWD Cavity Reconstruction by Mastoid and Epitympanic Bony Obliteration (CWR-BOT) in adults	2016	50	CWD (50)
Košec et al. [16]	Correlation of pre-operative computed tomography, intra-operative findings and surgical outcomes in revision tympanomastoidectomy	2020	42	CWU (28) CWD (14)
van der Toom et al. [17]	Revision surgery for chronically discharging mastoid cavities: mastoid obliteration with canal wall reconstruction versus non-obliteration surgery.	2022	79	CWD (79)
Li L. et al. [18]	Clinical outcomes of revision radical mastoidectomy surgeries to dry ears: A retrospective study.	2023	46	CWU (12) CWD (34)
Total cases			1180	CWU (287) CWD (893)

CWU= canal-wall up; CWD= canal-wall down.

Table 4: Intraoperative findings of the patients included in the selected studies.

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CWU= canal-wall up; CWD= canal-wall down; TM= tympanic membrane

Author	Recurrent/residual cholesteatoma	Residual cells	TM perforation	Canal stenosis	Bony overhangs	High facial ridge (only in CWD)	Missing meatoplasty (only in CWD)
Nadol Jr. [6]	30 (45%) (23 CWU - 7 CWD)	27 (41%)	-	7 (13%)	-	19 (34%)	-
Bhatia et al. [7]	67 (64%) (67 CWD)	-	-	67 (64%)	30 (29%)	70 (66,7%)	-
Veldman et al. [8]	105 (30%) (26 CWU - 79 CWD)	-	145 (42%)	-	-	-	-
Phelan et al. [9]	19 (51%) (19 CWD)	-	13 (35%)	-	-	16 (43%)	9 (24%)
Faramarzi et al. [10]	70 (60,3%) (28 CWU – 42 CWD)	-	17 (14,8%)	7 (15%)	-	26 (44,1%)	16 (30%)
Berçin et al. [11]	28 (80%) (11 CWU - 17 CWD)	23 (66%)	-	-	-	12 (57,1%)	17 (80,9%)
Gluth et al. [12]	58 (45%) (58 CWD)	113 (87%)	45 (34%)	-	-	70 (53,8%)	-
Kasenõmm [13]	23 (46%) (23 CWD)	50 (100%)	-	-	49 (98%)	49 (98%)	42 (84%)
Li S. et al. [14]	44 (58%) (44 CWD)	66 (87%)	-	-	-	66 (87%)	-
Vercruysse et al. [15]	4 (8%) (4 CWD)	-	-	-	-	-	-
Košec et al. [16]	31 (73,8%) (17 CWU – 14 CWD)	18 (42,8%)	28 (66,7%)	-	-	11 (78,6%)	-
van der Toom et al. [17]	14 (18%) (14 CWD)	73 (92%)	13 (17%)	27 (34%)	25 (32%)	37 (46.8%)	59 (74,7%)
Li L. et al. [18]	34 (74%) (either CWU or CWD)	35 (76%)	-	29 (63%)	-	24 (70,6%)	-
Total	527 (44,7%)	405 (34,3%)	261 (22,1%)	13 (11%)	104 (8,81%)	400 (44,8% of CWD)	143 (12,1%)

Table 5: Average pre- and post-operative audiometric findings of the patients included in the selected studies.

Author	Ossiculoplasty	Pre-operative PTA	Pre-operative ABG	Post-operative PTA	Post-operative ABG	ABG Gain
Faramarzi et al. [10]	No	-	39.4 dB	-	32.2 dB	7.2 dB
Gluth et al. [12]	Yes (88%)	61.7 dB	36.7 dB	60 dB	35 dB	1.7 dB
Kasenõmm [13]	Yes (34%)	56.4 dB	33.5 dB	48.3 dB	25.4 dB	8.1 dB
van der Toom et al. [17]	No	53.1 dB	36 dB	40.7 dB	23.5 dB	12.5 dB

PTA: Pure-tone audiometry; ABG: Air Bone Gap.

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TITLES OF FIGURES

Figure 1: PRISMA 2020 flow diagram

Figure 2: Intraoperative findings from the literature review case series

Figure 3: Intraoperative findings from our case series

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