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REVIEW ARTICLE



# Current concepts in the surgical management of chronic suppurative otitis media

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## ABSTRACT

**Introduction.** Chronic suppurative otitis media represents a major public health concern in both children and adults, particularly in developing countries. The condition poses not only a medical challenge requiring complex clinical management but also a public health issue with significant socioeconomic implications and costs.

**Material and methods.** A review of selected literature from the PubMed, Hinari, SpringerLink, National Center for Biotechnology Information, and Medline databases was conducted. Articles published between 2000 and 2025 were selected using the following keywords: "chronic otitis media" and "chronic suppurative otitis media," combined in various ways with the terms "surgical treatment," "mastoidectomy," "canal wall-down," "canal wall-up," "canal wall-intact," "canal wall reconstruction," "tympanoplasty," and "ossiculoplasty" to maximize search efficiency. Based on the search criteria, 325 full-text articles were initially identified. The final bibliography included 66 relevant sources considered representative of the published material related to the topic of this review article.

**Results.** There are four traditional surgical procedures for the treatment of chronic suppurative otitis media: 1) simple (cortical) mastoidectomy, 2) radical mastoidectomy, 3) modified radical mastoidectomy, and 4) mastoidectomy with tympanoplasty. These surgical interventions can be classified into two categories: open cavity (canal wall-down – CWD) and closed cavity (canal wall-up – CWU) or canal wall-intact (CWI). The CWD technique is the most effective method for cholesteatoma eradication, as it allows a wide-angle view of the mastoid and middle ear structures. Currently, radical CWD mastoidectomy is rarely performed but may be indicated when complete excision of the cholesteatoma is not possible. To prevent complications associated with the mastoid cavity following CWD, surgeons may opt for CWU mastoidectomy or CWD mastoidectomy with mastoid cavity obliteration and reconstruction of the external auditory canal wall.

**Conclusions.** The current concept of managing patients with chronic suppurative otitis media involves developing a personalized approach based on anatomical, biological, radiological, and social factors. The selection of the surgical technique should be tailored to each patient according to the location and extent of the cholesteatoma, defects of the posterior canal wall, associated lesions, presence of complications, degree of hearing loss, and the patient's overall medical condition.

**Keywords:** chronic suppurative otitis media, mastoidectomy, canal wall-down, canal wall-up, canal wall-intact, canal wall reconstruction, tympanoplasty, ossiculoplasty.

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## Key messages

### What is not yet known on the issue addressed in the submitted manuscript

The inconsistent clinical outcomes and frequent complications of chronic suppurative otitis media have hindered the standardization of its surgical management. At present, many questions remain regarding the optimal management, whether medical and/or surgical, of these patients.

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**The research hypothesis**

It is hypothesized that a systematic analysis and synthesis of contemporary literature will demonstrate a significant association between specific surgical techniques applied in the management of chronic suppurative otitis media and their corresponding clinical outcomes, enabling the establishment of evidence-based indications and contraindications for each surgical method.

**The novelty added by manuscript to the already published scientific literature**

This article includes an analysis of the most recent international publications addressing the characteristics and effectiveness of contemporary surgical treatment methods for chronic suppurative otitis media. The findings of this study will contribute to the improvement of treatment protocols, focusing on the management and optimization of therapeutic approaches for patients with chronic suppurative otitis media.

## Introduction

Chronic suppurative otitis media (CSOM) constitutes a major public health problem in both children and adults, particularly in developing countries. The condition represents not only a medical challenge requiring complex clinical management but also a public health issue with significant socio-economic implications and costs [1]. Globally, CSOM is one of the most common infectious diseases in childhood, likely due to an immature immune system and neglect of personal hygiene, and it is a frequent cause of hearing impairment, especially in resource-limited countries. According to the World Health Organization (WHO), approximately 3–4.7% of the population suffers from CSOM, with up to 60% presenting moderate to severe hearing loss [2]. Surgical intervention as a management strategy is considered a last-resort option and is performed in patients with CSOM who do not respond to systemic therapy for 3–4 weeks or to antimicrobial therapy for 3–4 days and otorrhea [2]. The primary goal of surgical management of CSOM with cholesteatoma is disease eradication and the creation of a dry, safe, self-cleaning ear with a low risk of recurrence. Secondary objectives include ossicular chain reconstruction to improve hearing and preservation of normal ear anatomy [3, 4]. A wide variety of surgical techniques exist for middle ear and mastoid diseases. Mastoidectomy and/or tympanoplasty (with or without ossicular chain reconstruction) are frequently used to achieve definitive healing of CSOM [1]. In this context, the aim of this article is a to provide a narrative synthesis of the most recent data regarding the characteristics and efficacy of modern surgical management methods for patients with chronic suppurative otitis media.

## Materials and methods

To achieve the stated objective, an initial search of scientific publications was conducted using the databases PubMed, Hinari (Health Internet Network Access to Research Initiative), and SpringerLink,. Selection criteria for articles included contemporary data on surgical procedures such as mastoidectomy, tympanoplasty, and ossiculoplasty in the surgical treatment of patients with CSOM. The following keywords were used: "chronic otitis media" and "chronic suppurative otitis media", in various combinations with "surgical treatment", "mastoidectomy", "canal wall-down", "canal wall-up", "canal wall-intact", "canal wall reconstruction", "tympanoplasty", and "ossiculoplasty" to maximize search yield.

To refine the selection of bibliographic sources, the following filters were applied: full-text articles, articles in English, and publications from 2000 to 2025. After preliminary screening of titles, original articles, editorials, narrative and systematic reviews, and meta-analyses were selected if they contained relevant and contemporary information regarding the effectiveness of different techniques of mastoidectomy, tympanoplasty, and ossiculoplasty in the surgical management of CSOM patients. Additionally, reference lists of identified sources were screened to identify supplementary relevant publications not captured in the initial database search.

Information from the included publications was selected, classified, evaluated, and analyzed to highlight key aspects of contemporary perspectives on surgical treatment methods for patients with CSOM.

To minimize the risk of systematic errors (bias) in the study, exhaustive database searches were conducted to identify the maximum number of relevant publications for the study's purpose, only studies meeting validity criteria were evaluated, and strict exclusion criteria were applied to eliminate unsuitable articles from the review.

After processing the information retrieved from the databases , 325 articles addressing the management of patients with CSOM were identified. Following a preliminary analysis of titles, 78 articles were deemed potentially relevant for the present review. After full-text assessment of these sources, 66 publications were ultimately selected as relevant to the stated objective. The final bibliography of the study included these 66 articles, which were considered

representative of the published material on the topic of this review.

**Results and discussion**

The surgical management of chronic suppurative otitis media (CSOM) includes several traditional approaches, such as simple mastoidectomy, radical mastoidectomy, modified radical mastoidectomy, and mastoidectomy combined with tympanoplasty. These procedures are generally categorized into open cavity (canal wall down, CWD) and closed cavity (canal wall up/intact wall, CWU/CWI) techniques. The CWD approach allows extensive visualization of the mastoid and middle ear structures, making it highly effective for cholesteatoma eradication; however, it results in a large mastoid cavity with associated structural deficiencies. In contrast, the CWU technique preserves the anatomy of the external auditory canal and generally provides better auditory outcomes, although it carries a higher risk of residual or recurrent disease.

While CWD mastoidectomy is now infrequently performed, it remains indicated in cases where complete cholesteatoma removal is not achievable. To mitigate postoperative complications associated with CWD, alternative strategies include CWU mastoidectomy, CWD with cavity obliteration, canal wall reconstruction, or cavity ablation. Revision surgery represents an effective approach for managing post-radical ear pathology, aiming both at complete disease eradication and at preventing recurrence through procedures such as meatoplasty, canalplasty, mastoid cavity obliteration, posterior canal wall reconstruction, tympanoplasty, and ossiculoplasty.

Tympanoplasty is classified into multiple types based on the extent of reconstruction, ranging from simple myringoplasty to more complex procedures involving the ossicular chain and middle ear space. Successful outcomes are defined by full graft integration and measurable hearing improvement one year postoperatively, with primary tympanoplasty success rates reported between 60–99% in adults and 35–94% in children with CSOM. Ossicular reconstruction is guided by the Austin-Kartush classification, which describes the presence or absence of the malleus, incus, and stapes. Functional results following ossiculoplasty show that non-titanium prostheses achieve an air–bone gap closure of ≤20 dB in 37–65% of cases, while titanium prostheses achieve similar outcomes in 60–73% of cases, with overall prosthesis extrusion rates ranging from 0–4%.

***Mastoidectomy.*** Mastoidectomy is a surgical procedure of the temporal bone that opens the postauricular pneumatic cells by removing the thin bony septa between them. The method remains the cornerstone therapy for malignant/atticoantral CSOM [1, 5-7]. A systematic literature review indicates that, overall, the incidence of "dry" ears is reported between 70–95%, while the incidence of ears without recurrent or residual cholesteatoma ranges from 55% to 97% of surgical cases [5]. There are four traditional surgical procedures: 1) simple (cortical, complete) mastoidectomy; 2) radical mastoidectomy; 3) modified radical mastoidectomy; 4) mastoidectomy with tympanoplasty. The goals of the last procedure, in addition to disease eradication, include preservation or reconstruction of the posterior-superior wall of the external auditory canal (EAC), the tympanic membrane (tympanoplasty), and the ossicular chain (ossiculoplasty) [8]. These procedures can be classified into two categories: open cavity (canal wall-down, CWD) and closed cavity (canal wall-up, CWU) or canal wall-intact (CWI), with or without middle ear reconstruction, each having its advantages and disadvantages [8-12]. These two techniques are mainly distinguished by EAC preservation. CWD is considered the most effective method for cholesteatoma eradication, as it allows wide-angle visualization of mastoid and middle ear structures. However, a small self-cleaning cavity cannot be achieved. These problems are avoided in CWU, as the EAC anatomy is preserved. Nevertheless, residual disease and recurrences are more common, whereas auditory outcomes are better in CWU compared to CWD [13].

*Simple (cortical, complete) mastoidectomy* or antrostomy involves removal of the mastoid cortex and some pneumatic cells, depending on the extent of the disease [14, 15].

*Radical mastoidectomy is a CWD procedure* with exposure of the middle ear and includes removal of the superior and posterior walls of the EAC, the tympanic membrane, and the ossicular chain without attempting reconstruction [14].

*Modified radical mastoidectomy* refers to the procedure introduced by Gustave Bondy in 1910, in which the disease is confined to the epitympanum, which is exteriorized by removing the posterior and superior walls while preserving the lateral epitympanic wall in whole or in part, without disturbing the intact tympano-ossicular system (pars tensa and ossicular chain). The posterior wall of the EAC is lowered to the level of the facial nerve, and the mastoid cavity floor continues with the EAC floor, thus creating a common cavity from the mastoid, epitympanum, and EAC. This method is indicated for epitympanic cholesteatoma with intact ossicular chain, normal pars tensa, and good hearing, aiming to achieve a safe ear and prevent intracranial complications. Advantages of this technique include the ability to perform the procedure in a single stage, lower incidence of residual/recurrent cholesteatoma, fewer revision surgeries, and better functional outcomes [14-20].

The method provides relatively safe surgical access for the removal of chronic middle ear and mastoid disease and yields reproducible results. However, it has been suggested that hearing outcomes may not be as good as after CWU (CWI) [20, 21].

*Canal Wall-Down (CWD) Mastoidectomy***.** CWD mastoidectomy, which includes radical and modified radical mastoidectomy, involves complete removal of the mastoid pneumatic cells, cortical margins of the mastoid, and the superior and posterior walls of the external auditory canal (EAC), combined with a meatoplasty to create an open cavity. This creates a single cavity encompassing the mastoid, middle ear space, and EAC, altering the anatomy and physiology of the middle ear and mastoid. Mastoid obliteration and meatoplasty should also be considered routine parts

of CWD mastoidectomy to achieve a complete surgical outcome [7-9, 11, 14, 16, 22, 23]. The CWD technique is usually performed in the presence of extensive infection, extensive cholesteatoma involving the mastoid and tympanic cavities, severe-to-profound hearing loss, ossicular chain erosion, and complications [24]. The main advantages of CWD procedures are excellent intraoperative exposure with access to the mesotympanum and epitympanum, facilitating more effective eradication of middle ear cholesteatoma, lower recurrence rates (2–17%), easy detection of recurrence, and reduced postoperative complication rates [6, 7, 11, 21-23, 25, 26]. A meta-analysis comparing recurrence cases (recurrent and/or residual cholesteatoma) found recurrence rates ranging from 5–17% for CWD techniques versus 9–70% for CWU techniques [27]. However, CWD tympanomastoidectomy has several well-known disadvantages, including cosmetic issues caused by an enlarged meatus, suboptimal functional outcomes, water intolerance and restrictions to prevent complications, vertigo (caloric or barometric), difficulty in fitting conventional hearing aids, absence of a self-cleaning mechanism (persistent otorrhea and granulation), which necessitates regular specialist visits for recurrence monitoring, mastoid cavity care, and medication for infection control [9, 11, 18, 22, 23, 26, 28, 29]. Even with proper care, a significant proportion of patients (20–60%) develop a defective mastoid cavity with persistent otorrhea, predisposing them to recurrent infections and additional complications, significantly impacting quality of life [11, 23]. Currently, CWD mastoidectomy is rarely performed but may be indicated in cases where cholesteatoma cannot be completely removed [14]. To avoid mastoid cavity issues after CWD, surgeons employ CWU mastoidectomy or CWD mastoidectomy with mastoid cavity obliteration, canal wall reconstruction (CWR), or cavity ablation (decavitation) [12]. Thus, the practice of performing an open cavity procedure without reconstruction, regardless of disease severity, is outdated. Optimal management should be determined on a case-by-case basis, influenced by the patient's goals and priorities, the surgeon's experience and technical skills, careful preoperative disease assessment, and intraoperative findings [25].

*Mastoid Obliteration.* Mastoid obliteration, introduced by Mosher in 1911, was proposed as an effort to avoid the disadvantages of both CWD and CWU mastoidectomy techniques. The main advantages of mastoid cavity obliteration are: (1) reduction of nitrogen-absorbing mucosa in the mastoid cavity, which prevents cholesteatoma recurrence in patients with Eustachian tube dysfunction, and (2) elimination of the mastoid cavity, preventing accumulation of squamous epithelium and mastoid cavity infection [9, 23, 28]. Currently, mastoid obliteration is the preferred treatment for eliminating mastoid cavities and can be performed during primary CWD mastoidectomy or as a secondary procedure during revision surgery [9, 11]. Various materials have been used for mastoid obliteration, including soft tissues (granulation methods, free soft tissue grafts), cartilage (autologous or homografts), bone (autografts, homografts, and heterografts), and biocompatible, non-resorbable synthetic materials (cement—hydroxyapatite, silicone, proplast, calcium phosphate, bioactive glass - Ceravital). Since no perfect solution exists for mastoid reconstruction or obliteration, a combination of different techniques is often used to achieve the most favorable outcome [9, 11, 23, 28, 30]. Several studies have reported acceptable outcomes with mastoid obliteration, with a high proportion (82%) of ears being dry, safe, and self-cleaning, with a small mastoid cavity. The most controversial aspect of mastoid obliteration is the risk of "silent" cholesteatoma recurrence within the obliterated cavity. Following CWD mastoidectomy with canal wall reconstruction, recurrence rates have been reported at 0–16.7%. Currently, imaging modalities such as diffusion-weighted MRI facilitate the detection of cholesteatoma in obliterated or reconstructed cavities [11].

*CWU Mastoidectomy (Canal Wall-Up / Canal Wall-Intact Mastoidectomy).* CWU mastoidectomy, also known as canal wall-intact (CWI) mastoidectomy, was introduced by Jansen in 1958. It is performed by removing pathological tissue while preserving the posterior and superior bony walls of the external auditory canal (EAC) [7, 8, 11, 14, 16, 19, 31]. The goals of this procedure are: (1) to avoid opening the mastoid cavity whenever possible, (2) to allow a staged procedure, if necessary (approximately 70% of patients), and (3) to enable re-exploration of the mastoid and middle ear for residual cholesteatoma when indicated [1, 7, 11, 31]. CWU mastoidectomy is indicated for patients with chronic suppurative otitis media (CSOM) with limited cholesteatoma confined to the epitympanum, an intact ossicular chain, good drainage of the mastoid and tympanic cavities, and no intracranial complications [24, 31]. As part of the CWU technique for attic cholesteatoma, procedures may include atticotomy, reconstruction of the lateral epitympanic wall, tympanoplasty using cartilage/perichondrium with or without ossiculoplasty, canalplasty, and cortical mastoidectomy [31, 32]. The major advantages of CWU mastoidectomy are preservation of the normal anatomical structure of the EAC, reduced structural damage, improved potential for hearing reconstruction, elimination of open cavity-related problems, facilitation of wound healing, and easier use of postoperative hearing aids. However, CWU mastoidectomy is associated with residual disease in 20–39% of cases and cholesteatoma recurrence in 3.8–50% of cases, predominantly located in the anterior attic, which is difficult to inspect. Therefore, a second-look surgery is typically planned, ideally 6–12 months after the initial procedure, to ensure complete disease removal and, when necessary, reconstruction of the conductive hearing mechanism [6, 8, 11, 21, 25, 26, 31, 33]. Contraindications for CWU mastoidectomy include revision or residual cholesteatoma, intracranial complications, non-reconstructible posterior EAC wall defect, poor patient compliance, and an unresectable matrix involving the labyrinth, facial nerve, dura mater, or tympanic sinus [31].

*Atticotomy and Canal Wall Reconstruction (CWR).* Atticotomy involves the removal of the lateral wall of the epi-

tympanum, improving access and visualization of the epitympanum and facilitating the removal of cholesteatoma or retracted tympanic membrane (TM). This technique allows excision of middle ear or attic space lesions without the need for mastoidectomy. Additionally, removal of the middle or lower portion of the medial aspect of the posterior EAC wall increases exposure to the hypotympanum and tympanic sinus [10]. Atticotomy techniques can also be performed during CWU mastoidectomy procedures if additional exposure is required to eradicate disease. Partial atticotomy, used during CWU, can significantly improve exposure and access to the middle ear, epitympanum, tympanic sinus, hypotympanum, and the round and oval windows. Furthermore, removal of cholesteatoma via attico-antrotomy with obliteration or reconstruction using bone or cartilage can significantly reduce recurrence rates [6, 32, 33]. The CWR technique (Canal Wall Reconstruction) combines the excellent exposure provided by CWD procedures with the preservation of the EAC wall seen in CWU, optimizing cholesteatoma eradication and obliterating the attic space, thereby reducing the risk of recurrence, complications, and retraction pocket formation. CWR was introduced by Mercke in 1987 and is performed with mastoid obliteration using osteoperiosteal flaps, alloplastic ceramic materials, bone cement grafts, and cartilage (tragal or costal) [1, 3, 11, 26, 30, 34]. CWR can be performed as a primary procedure in a single stage with CWD mastoidectomy, or secondarily during revision mastoidectomy [11]. Reconstruction of the EAC wall combined with tympano-ossicular allograft transplantation allows reconstruction of the mastoidectomy cavity, resulting in a near-normal ear with favorable outcomes: 76.25–85.0% anatomical surgical success, 9.5% functional surgical failure, and 67.0% improvement in overall hearing function [26, 34]. Thus, considering the above data, treatment of CSOM with cholesteatoma requires an individualized approach for each patient. The selection of the surgical technique should be based on anatomical, biological, radiological, and social factors. Currently, it is widely accepted that cholesteatoma surgery should be tailored to the location and extent of the cholesteatoma, defects of the posterior EAC wall, presence of complications, degree of hearing loss, and the patient's overall medical condition [15].

*Revision Mastoidectomy.* One of the most effective treatments for post-radical ear pathology is revision surgery. In addition to complete disease eradication, preventive measures are applied to reduce recurrence, including meatoplasty, canalplasty, mastoid obliteration procedures, wall reconstruction techniques, tympanoplasty, and ossiculoplasty [28, 29, 35-39]. Revision surgery is indicated after failure of any of the primary goals in CSOM surgery: (1) elimination of progressive disease to achieve a safe and dry ear, (2) modification of the tympanomastoid anatomy to prevent recurrent disease, and (3) reconstruction of the auditory mechanism. Additionally, revision mastoidectomy is performed in cases of recurrent cholesteatoma, recurrent suppuration, recurrent TM perforation, and residual or recurrent conductive hearing loss [29, 36-40]. According to several studies, the most common causes of previous surgical failure in CSOM were inadequately leveled facial ridge (43–98%), insufficient removal of mastoid cells (62–100%), recurrent or residual cholesteatoma (46–66%), inadequate meatoplasty with a narrowed meatus (24–84%), and the presence of the malleus head (40%) [40]. Specific surgical procedures relevant to revision mastoid surgery can be divided into: (1) procedures for complete disease removal and (2) modifications of soft tissue or bone to prevent future recurrence [37]. Surgical management in revision mastoid cavities initially focuses on removing recurrent and/or residual lesions, complications, and technical defects. When necessary, this is followed by meatoplasty, canalplasty, mastoid obliteration, posterior canal wall reconstruction, TM reconstruction, and ossicular chain reconstruction, all of which significantly improve patients' quality of life [28, 29, 26, 37-40].

*Tympanoplasty***.** Tympanoplasty, introduced by Zollner and Wullstein in 1952, is a surgical procedure performed to repair the TM with or without reconstruction of the ossicular chain (ossiculoplasty). The objectives of surgery for chronic otitis media are disease eradication, achieving a safe and dry ear with an intact TM, increasing the vibratory surface of the TM to restore hearing, and preventing reinfection [10, 41-47].

According to Wullstein's 1956 classification, types of tympanoplasty are distinguished based on the ossicular reconstruction method and rely on two parameters: 1) the remaining structures of the middle ear after disease eradication, and 2) the pathway by which sound is transmitted to the oval window [14, 43, 47, 48].

Currently, the most commonly used classification of tympanoplasty types is the modification of Wullstein's classical scheme by Nadol and Schuknecht, in which tympanoplasty types differ according to the method of ossicular reconstruction.

*Tympanoplasty Types*

- *Type I – Simple myringoplasty:* The middle ear and hearing are normal.
- *Type II – Tympanoplasty with minor ossicular reconstruction:* The TM graft or TM is in contact with the incus and stapes. This involves repair of the TM and middle ear due to small defects in the ossicular chain, which cause minimal hearing loss. The lever function is restored by placing a graft between the long process of the incus and the head of the stapes.
- *Type III – Myringostapediopexy:* The TM graft or TM is in direct contact with the stapes suprastructure (columella effect). It is divided into three subtypes of reconstruction:
  - *Columella stapes:* TM graft is placed on the intact stapes head.
  - *Minor columella:* A prosthesis is placed between the TM graft and the stapes head.
  - *Major columella:* A prosthesis is placed between the TM graft and the stapes footplate.
- *Type IV – Minor cavum:* The ossicular chain is ab-

sent, and the TM, in contact with the mobile stapes footplate, requires a CWD approach and a graft covering only the round window and auditory tube opening.

- *Type V – Fenestration:* A second-stage procedure following failure of Type III or IV tympanoplasty, in which the stapes footplate is fixed, a TM graft covers the hypotympanum, and a surgical window is created in the horizontal semicircular canal [14, 43, 47-49].
- *TM Perforation Size Classification:* Small (<50%), medium (50–75%), or large (>75%) [42].

The goal of tympanoplasty is to improve hearing by repairing the TM and/or ossicles and to prevent recurrent otorrhea. Any closure of the air–bone gap after surgery, which effectively measures conductive hearing loss, can be considered a clinical hearing improvement, although an air–bone gap closure to ≤10 dB is optimal [50-54]. Tympanoplasty is an effective procedure that can prevent middle ear infection, recurrent otorrhea, and cholesteatoma, while improving hearing function in 57–99% of cases [45, 55]. Since its introduction by Zollner and Wullstein in 1952, numerous techniques and graft materials have been described to reconstruct the TM: skin, fascia, vein, perichondrium, cartilage, and dura mater. Autologous graft material is readily available, biocompatible, cost-effective, stable, and well accepted by the body without extrusion. Among these, temporalis fascia, followed by tragal/conchal cartilage, remains preferred by surgeons due to availability, proximity to the surgical site, ease of harvesting and shaping, and handling, as well as acceptable hearing outcomes [14, 43, 44, 46, 56-58]. Over the years, various techniques have been proposed to improve tympanoplasty outcomes: overlay, underlay (subperforation), medio-lateral, cartilage shield, cartilage palisade, cartilage island, butterfly cartilage, and sandwich techniques [55, 58-60]. Each technique has its advantages and disadvantages, but two are fundamental in TM grafting: *overlay (lateral)* and *underlay (medial/substrate)* techniques [14, 41, 58].

*Definition of Tympanoplasty Success.* Correct anatomic placement of the graft, full integration, and hearing improvement one year after surgery [61]. Multiple studies report a primary tympanoplasty success rate of 60–99% in adults and 35–94% in children with CSOM [2, 45, 56, 59, 61]. However, complications after primary tympanoplasty may occur, the most common being graft failure (3.6–4.2%), conductive hearing loss (1.9%), TM perforation (1.0%), and the need for ventilation tube insertion [43].

*Ossiculoplasty.* Ossiculoplasty represents the reconstruction of the auditory mechanism (ossicular chain) using either an autologous graft (tragal cartilage or perichondrium) or a prosthesis, restoring the connection between the tympanic membrane (TM) and the oval window. The procedure can be performed with either partial ossicular replacement prosthesis (PORP) or total ossicular replacement prosthesis (TORP), depending on the status of the remaining ossicles after complete removal of diseased tissue [10, 41, 42, 48, 62-64]. A study on 279 ears after surgery for chronic suppurative otitis media (CSOM) found that the ossicular chain was eroded in 23.66% of cases. Erosion was more common in ears with cholesteatoma (69.3%) than in ears without cholesteatoma (13.9%). The most frequently affected ossicle was the incus (22.2%), followed by the stapes (11.1%) and the malleus (4.7%). The presence of cholesteatoma was associated with a higher prevalence of ossicular erosion (incus – 65.3%, stapes – 63.3%, malleus – 22.5%), including cases with two or more ossicles affected simultaneously [62].

*Austin-Kartush Ossicular Classification:*

- *Class 0*: Normal ossicles (M+I+S+)
- *Class A*: Absence of incus (M+S+)
- *Class B*: Absence of incus and stapes (M+S-)
- *Class C*: Absence of malleus and incus (M-S+)
- *Class D*: Absence of all ossicles (M-S-) [60]

Historically, ossicular chain reconstruction has been performed using various materials, including autologous bone grafts, ceramic, gold, hydroxyapatite, and polyethylene**.** Titanium prostheses were introduced in the early 1990s and quickly gained popularity. Cartilage and tragal perichondrium are recommended as graft materials due to easy availability, low toxicity, minimal extrusion, contraction, or lateralization, and cost-effectiveness for patients [48, 63]. A recent meta-analysis examining the impact of prosthesis material on outcomes did not find significant differences in audiometric results or extrusion rates between titanium and non-titanium prostheses. Nevertheless, titanium prostheses remain popular due to low weight, rigid profile, low acoustic impedance, small size, and design that facilitates visualization and accurate placement [63, 64]. In studies using non-titanium prostheses, the long-term mean postoperative air–bone gap ranges from 12 to 21 dB, with a success rate (air–bone gap ≤20 dB) of 37–65%. In studies using titanium prostheses, success is reported in 60–73% of cases. The overall prosthesis extrusion rate is 0–4%, indicating titanium's long-term stability in the middle ear [64]. Based on long-term outcomes (1–3 years), all four types of tympanoplasty improved hearing, measured by the mean reduction in the air–bone gap ($p<0.001$). Hearing improvement was less durable with PORP compared to TORP [65].

Long-term rates of significant complications (requiring further surgery) were reported as:

- 10.3% of patients experienced complications
- 8.2% required revision surgery
- 10.2% required secondary ventilation tube placement
- 3.6% had recurrent conductive hearing loss
- 4.1% experienced TM graft failure
- 1.5% had cholesteatoma recurrence [66].

## Conclusions

Surgical management of chronic suppurative otitis media should be individualized according to disease extent and patient anatomy. The choice between open- and closed-cavity techniques must balance complete eradication of pathology with preservation of auditory function. Advances

in cavity obliteration, canal wall reconstruction, and ossicular prostheses have improved both surgical outcomes and hearing restoration. Revision procedures remain essential for managing residual disease and optimizing functional results. Continuous refinement of surgical methods and materials contributes to better long-term disease control and quality of life. While preoperative planning is crucial, the definitive surgical approach or operative technique is often determined during the surgical procedure based on the specific pathology encountered.

### Competing interests

None declared.

### Authors' contributions

IN, ES, SV made substantial contributions to the conception and design of the study, as well as to the acquisition, analysis, and interpretation of the data. ES were responsible for drafting the manuscript and critically revising it for important intellectual content. IN, ES, SV provided final approval of the version to be published and take full responsibility for the integrity and accuracy of all aspects of the work.

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