

Original Research Article

Functional audiological outcomes of canal wall down mastoidectomy with type III tympanoplasty in middle ear and mastoid cholesteatoma

Abhishek Manjunath^{1*}, G. Prabhakar², S. Sathish Kumar²

¹Department of ENT and Head Neck Surgery, Sapthagiri Institute of Medical Sciences and Research Centre, Bangalore, Karnataka, India

²Department of ENT and Head Neck Surgery, Vydehi Institute of Medical Sciences and Research Centre, Bangalore, Karnataka, India

Received: 15 July 2026

Revised: 03 August 2026

Accepted: 05 August 2026

*Correspondence:

Dr. Abhishek Manjunath,

E-mail: mabhishek.m@gmail.com

Copyright: © the author(s), publisher and licensee Medip Academy. This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License, which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

ABSTRACT

Background: Cholesteatoma is a destructive middle ear disease requiring surgical intervention. Canal wall down mastoidectomy (CWDM) combined with type III tympanoplasty is commonly performed to eradicate disease and restore hearing. Objective of the study was to evaluate hearing outcomes and graft uptake in patients undergoing CWDM with type III tympanoplasty.

Methods: A prospective clinical study was conducted on 77 patients with attico-antral chronic suppurative otitis media. All patients underwent CWDM with type III tympanoplasty. Preoperative and postoperative hearing levels and air-bone gaps (ABG) were compared using the Wilcoxon signed-rank test.

Results: The median preoperative hearing loss improved from 43.75 dB to 31.25 dB postoperatively ($p < 0.001$). Median ABG reduced from 22.5 dB to 8.75 dB ($p < 0.001$). ABG closure of 10–19.9 dB was seen in 55.8% of patients.

Conclusions: CWDM with type III tympanoplasty provides significant hearing improvement along with effective disease eradication.

Keywords: Cholesteatoma, Canal wall down mastoidectomy, Type III tympanoplasty, Ossiculoplasty

INTRODUCTION

Cholesteatoma represents the end stage of squamous epithelial retractions of the pars tensa or pars flaccida that fail to self-cleanse, resulting in retention of epithelial debris and subsequent secondary inflammatory mucosal reactions. It continues to pose a significant challenge to otolaryngologists, particularly in developing countries, where patients often present at advanced stages with extensive disease, complications, and variability in the surgical expertise.¹

Tympanomastoid surgery for cholesteatoma aims to: eradicate disease and achieve a safe, dry ear, modify middle ear anatomy to prevent recurrence and facilitate

surveillance, and reconstruct the middle ear to restore functional and stable hearing.

For many years, canal wall down mastoidectomy (CWDM) has been considered the gold standard for cholesteatoma management due to superior disease visualization and low recurrence rates in single-stage procedures.¹ However, CWDM is associated with notable morbidity, including persistent otorrhea, keratin debris accumulation, caloric vertigo, suboptimal hearing outcomes, and difficulty with hearing aid fitting.²

To address these issues, modifications such as posterior canal wall lowering, mastoid obliteration, and reconstruction techniques have been introduced.³

Previous studies comparing canal wall up and canal wall down techniques have shown no significant difference in hearing outcomes for comparable ossicular pathology.³ Optimal hearing is achieved when the ossicular chain is intact and mobile; when diseased, preservation of the stapes yields better outcomes. In CWDM, stapes columella reconstruction provides superior hearing compared to major columella reconstruction by approximately 5 dB.⁴ Despite existing literature, there remains limited data specifically evaluating hearing outcomes following CWDM with type III tympanoplasty, which forms the basis of this study.

Objectives

The objectives of the study were: to compare preoperative and postoperative hearing outcomes in patients undergoing canal wall down mastoidectomy with type III tympanoplasty, to evaluate the impact of ossicular status on hearing outcomes following reconstruction using homologous septal spur cartilage, and to assess graft uptake (neo tympanum formation) following surgery.

METHODS

Study design

It was a prospective clinical study.

Study population

77 patients with an attico-antral type of CSOM presenting to Vydehi Institute of Medical Sciences and Research Centre (VIMS&RC), Bangalore from September 2017 to November 2019 were included in this study.

Inclusion criteria

Patients with squamosal type CSOM (active or inactive), and patients with willingness to provide informed consent were included.

Exclusion criteria

Patients with congenital cholesteatoma, previous ear surgery, tegmen or sinus plate erosion, intracranial complications, labyrinthine fistula, and dehiscent facial nerve were excluded.

Methodology

Following institutional ethical approval and informed consent, all patients underwent: all surgeries were performed by a single surgeon to minimize inter-operator variability.

Surgical technique

A standard postauricular approach was used. After cortical mastoidectomy and cholesteatoma clearance: the

traditional postauricular approach is used; the graft is harvested from the temporalis fascia; and post aural soft tissue dissected and the mastoid cavity is exposed, Mac Evans triangle identified.

Cortical mastoidectomy and attico-antrostomy is completed from the posterior cavity. A wide tympanomeatal flap is elevated. The fibrous annulus is detached from the tympanic sulcus posteriorly, and the tympanomeatal flap is elevated to explore the middle ear. The middle ear is entered, and the cholesteatoma matrix is removed.

The facial ridge is lowered up to the facial nerve. The cavity is always saucerised and gradually deepened. Bony overhangs are removed from the edges. A round-shaped cavity should be obtained at the end of the drilling. All the bone covering the middle fossa dura and the sigmoid sinus is thinned with large burrs moved parallel to these structures. Removal and exteriorization of all air cells posterior to the mastoid segment of the facial nerve and the sigmoid sinus are carried out. Removal of enough bone from the Sino Dural angle is also a part of the procedure.

The facial ridge is lowered evenly by drilling the posterior canal wall with a large diamond burr, with continuous suction irrigation.

Intra-operative findings with regards to the involvement of the various sites of the middle ear, the ossicular status and presence of any pathologies like tympanosclerosis, and dural invasion are noted.

The facial bridge and, subsequently, the anterior and posterior buttresses are removed. Removal of the anterior buttress produces a continuous plane between the middle fossa plate and the anterior canal wall (Figure 1).



Figure 1: Complete canal wall down procedure done.

The temporalis fascia is grafted by the underlay technique. The graft must have abundant extension superiorly to cover the attic and obliterated cells, and posteriorly onto the mastoid cavity especially as ossiculoplasty is performed at the same stage using homologous septal spur cartilage (Figure 2).

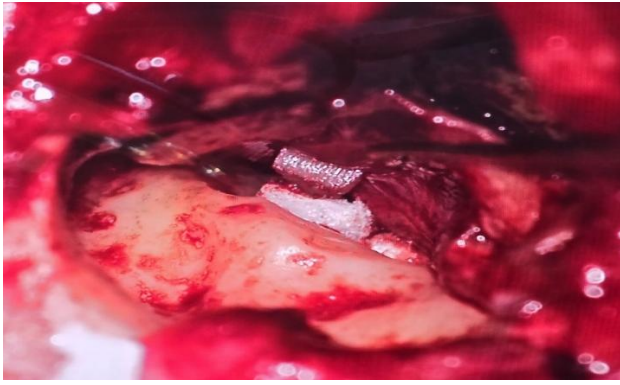


Figure 2: Cartilage ossiculoplasty done which is secured using gel foam.

Another piece of the graft may be placed to cover the exposed bone. Epithelialization is facilitated if the exposed bone is covered with the fascia.

Gel foam soaked with antibiotics and steroids is inserted medially and laterally to the new tympanic membrane.

A wide meatoplasty is performed by 3-flap technique. The canal is packed with gauze soaked with antibiotic ointment.

The wound is closed in two layers, and a standard mastoid dressing is applied. Patients are given oral antibiotics for 1 week.

The gel foam is removed after 15 days and antibiotic eardrops are advised for 4 weeks.

After 2 weeks, patients are asked to start performing the Valsalva manoeuvre to clinically assess drum mobility and to prevent tympanic membrane retraction.

Postoperative hearing is assessed by audiometry, while drum mobility is assessed by tympanometry after 3 months. Preoperative and postoperative average ABGs are calculated at 500, 1000, 2000, and 4000 Hz. Healing of the mastoid cavity and tympanic membrane, together with complications such as cholesteatoma recurrence, is observed and recorded clinically and by performing a CT scan if necessary.

Statistical analysis

Data were analysed using statistical package for the social sciences (SPSS) version 19.0. The Wilcoxon signed-rank test was applied to compare pre- and postoperative hearing

outcomes. A p value <0.05 was considered statistically significant.

RESULTS

A total of 77 patients were included, with 57% (n=44) were male and 43% (n=33) were female, and a mean age of 33.5 years (Figure 3); most patients were aged 31–50 years (48.1%) and presented with otorrhea (100%) and hearing loss (85.7%) (Figure 4).

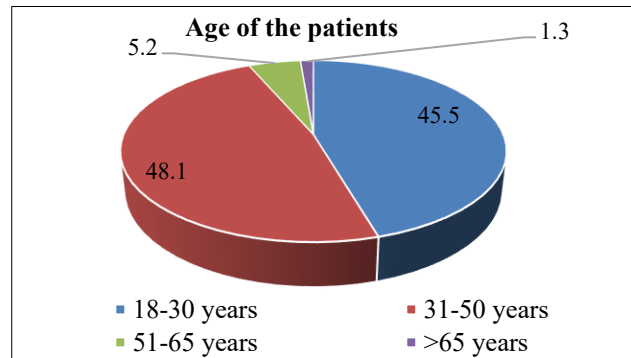


Figure 3: Distribution of age of the patients (n=77).

Right ear involvement was seen in 51% of cases 45% (n=35) of the patients had left ear involvement and 4% (n=3) of the patients had bilateral ear involvement.

In this study, 41.6% of the patients had symptoms for 4-7 years, followed by 33.8% of patients having symptoms for 0-3 years and 18.2% of patients with symptoms from 8-11 years and 6.5% of patients having symptoms for 12-15 years.

Posterior-superior quadrant retraction was the most common finding (42.9%) (Figure 5). Ossicular erosion predominantly involved the incus (53.2%), followed by combined malleus and incus erosion (31.2%), and complete ossicular loss (15.6%).

Preoperatively, most patients had hearing levels between 21–40 dB. The median hearing loss improved significantly from 43.75 dB (IQR 16.25) to 31.25 dB (IQR 15.63) (Figure 6 and Table 1), and the median air-bone gap (ABG) reduced from 22.5 dB (IQR 7.5) to 8.75 dB (IQR 7.5) (Figure 7 and Table 2) postoperatively (p<0.001).

ABG closure of 10–19.9 dB was achieved in 55.8% of patients, with 27.3% achieving <10 dB closure (Figure 8), demonstrating statistically and clinically significant hearing improvement following surgery.

Table 1: Comparison between pre-operative and post-operative hearing loss.

Variable	N	Median	Inter quartile range	P value
Pre-operative hearing loss	77	43.75 db	16.25 db	<0.001
Post-operative hearing loss	77	31.25 db	15.63 db	

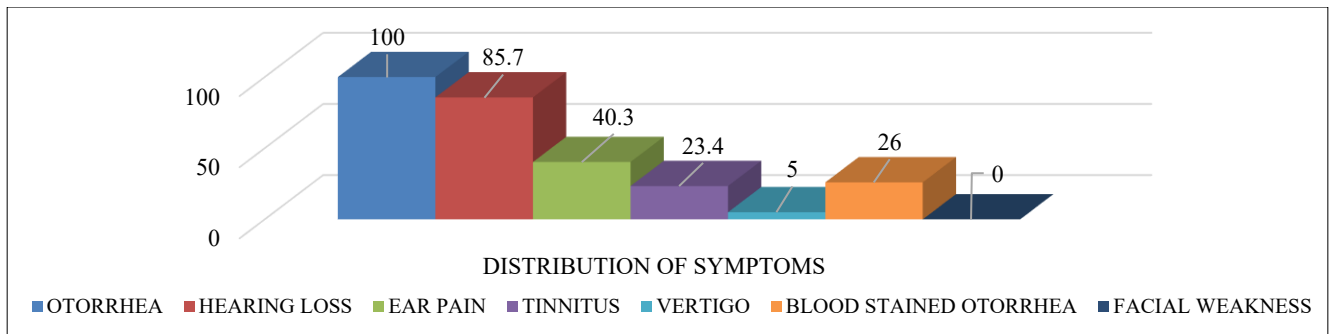


Figure 4: Distribution of symptoms (n=77).

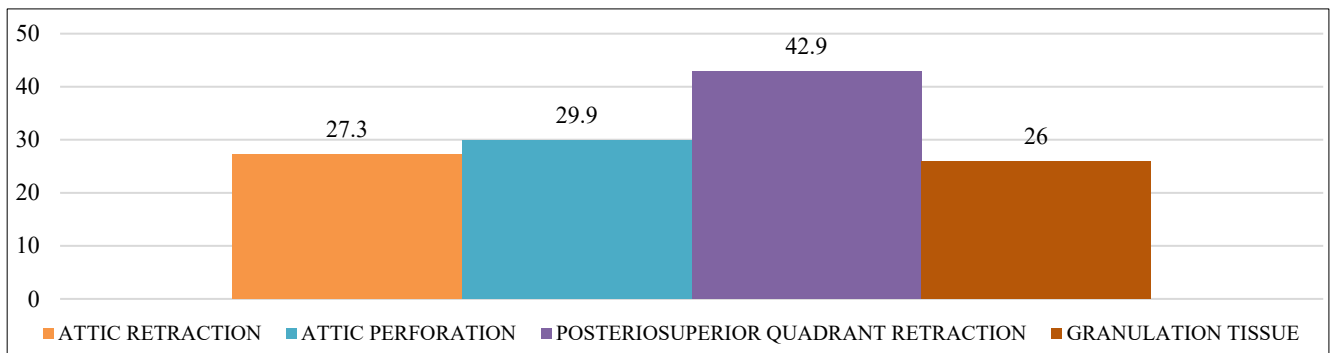


Figure 5: Otoscopic findings of involved ear.

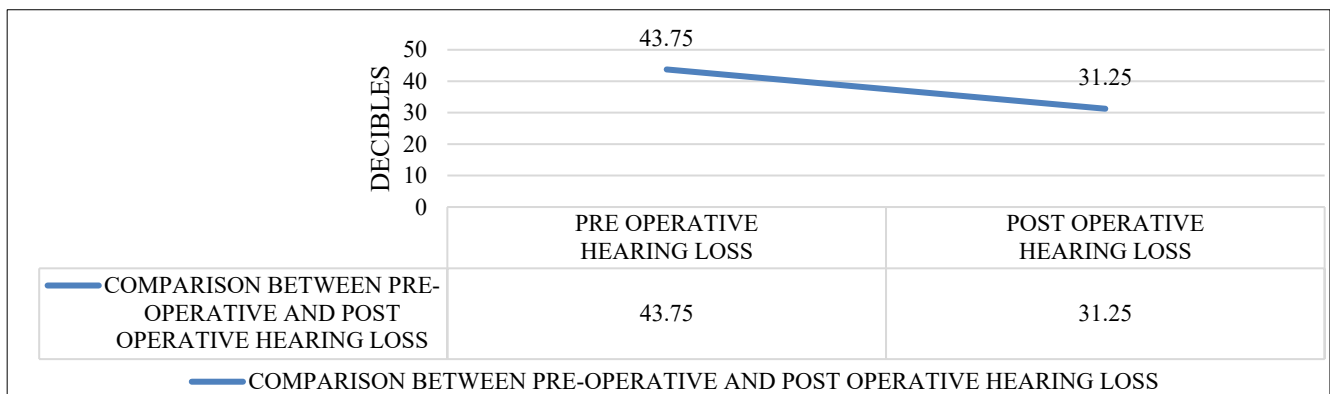


Figure 6: Comparison between pre-operative and post-operative hearing loss.

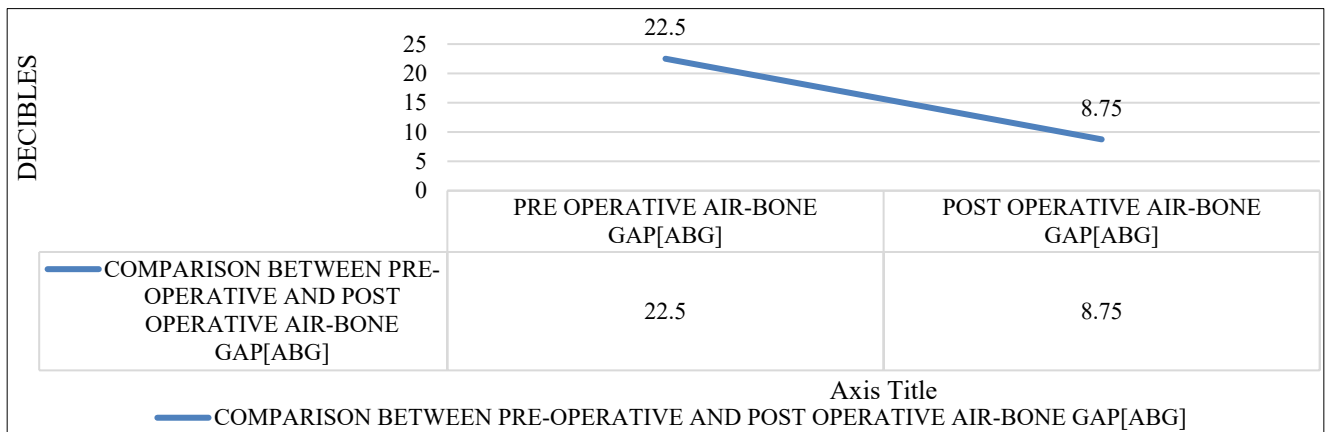
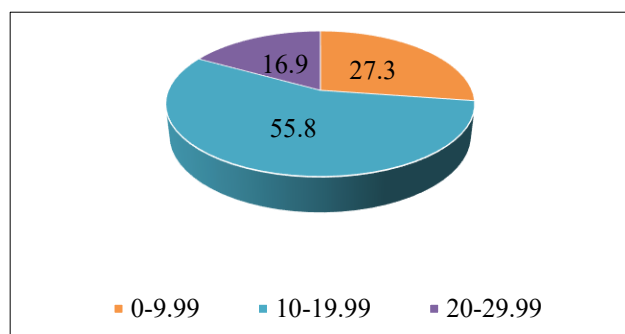


Figure 7: Comparison between pre-operative and post-operative air bone gap.

Table 2: Comparison between pre-operative and post-operative ABG.

Variable	N	Median	Inter quartile range	P value
Pre-operative air-bone gap	77	22.5 db	7.5 db	<0.001
Post-operative air-bone gap	77	8.75 db	8.75 db	

**Figure 8: Distribution of post-operative ABG closure (in decibels).**

DISCUSSION

The central challenge in cholesteatoma surgery lies in achieving complete disease eradication while preserving or restoring hearing function.⁵ Although surgical techniques have evolved from radical mastoidectomy to more conservative tympanoplasty-based approaches, the balance between disease control and functional outcome remains complex.⁶

Intact canal wall (ICW) tympanoplasty has historically been favoured for its superior hearing outcomes; however, this advantage is offset by significantly higher recurrence rates, often necessitating staged or revision procedures.⁷ Reported recurrence rates in ICW techniques vary widely from 5% to 71%, reflecting differences in follow-up duration and surgical expertise.^{8,9} In contrast, canal wall-down mastoidectomy (CWDM) offers more reliable disease clearance, with lower recurrence rates reported between 5.7% and 9.7% in the short term, although long-term recurrence may still reach up to 41%.⁹⁻¹¹ This highlights that while CWDM improves disease control, it does not entirely eliminate recurrence risk, particularly in extended follow-up.

The present study demonstrates that CWDM combined with type III tympanoplasty can achieve not only effective disease eradication but also meaningful hearing improvement. The demographic distribution, with a predominance of younger adults and male patients, is consistent with previously reported epidemiological patterns.¹² Clinical presentation was dominated by otorrhea and hearing loss, in agreement with studies by Parisier et al and Goyal et al, underscoring the chronic and symptomatic nature of attico-antral disease.^{13,14}

A key finding of this study is the significant improvement in ABG, from a median of 22.5 dB preoperatively to 8.75 dB postoperatively. Notably, 58.4% of patients achieved

an ABG of <10 dB, corresponding to an “excellent” outcome as per Kartush classification.¹⁵ This represents a clinically meaningful restoration of conductive hearing and compares favourably with existing literature. Kyrodimos et al reported ABG <20 dB in 79% of patients, while Harvey reported a higher mean postoperative ABG of 23.8 dB.^{16,17} Similarly, Goyal et al reported a mean ABG of 18.03 dB.¹⁴ The superior proportion of excellent outcomes in the present study may be attributable to the high rate of preserved stapes suprastructure and the use of cartilage ossiculoplasty, which provides mechanical stability and resistance to resorption.

From a mechanistic standpoint, the success of type III tympanoplasty is closely linked to the integrity of the stapes and the efficiency of sound transmission across the reconstructed columella. Short columella reconstruction, feasible in the majority of patients in this study, likely contributed to better acoustic outcomes by maintaining a more physiological ossicular coupling. In contrast, long columella reconstruction, which relies on footplate transmission, is inherently less efficient due to altered biomechanics and potential instability.

The observed improvement in median hearing thresholds (43.75 dB to 31.25 dB) further reinforces the functional benefit of this approach. While complete normalization of hearing is rarely achievable in cholesteatoma surgery, achieving a postoperative ABG <20 dB is widely accepted as a successful outcome. The majority of patients in this study met or exceeded this benchmark, indicating that CWDM does not necessarily compromise hearing when combined with appropriate ossicular reconstruction.

Recent literature supports these findings. Ferlito et al demonstrated that CWDM achieves satisfactory long-term disease control, with stapes superstructure preservation strongly predicting better hearing outcomes.¹⁸ A 2023 systematic review by Salem et al further confirmed that canal wall-down approaches provide reliable disease eradication with recurrence rates between 2% and 18%.¹⁹ More recently, Acke et al and Mahesh et al highlight that choice of ossiculoplasty technique significantly influences hearing recovery, with cartilage interposition yielding favourable and durable results.^{20,21} The 2025 multicentre study by Karkas et al further identified presence of the stapes superstructure as the single most significant predictor of postoperative hearing gain following ossiculoplasty in cholesteatoma surgery.²²

However, these results must be interpreted in the context of certain limitations. The relatively short follow-up period of three months precludes assessment of long-term outcomes such as recurrence, graft stability, and cavity-

related morbidity. Given the known propensity for delayed recurrence in cholesteatoma, longer follow-up is essential to validate the durability of these results. Additionally, the absence of a comparative group limits the ability to directly evaluate the relative efficacy of CWDM versus ICW techniques. The single-surgeon design, while reducing variability, may also limit generalizability to broader clinical settings.

In summary, the present study demonstrates that CWDM combined with type III tympanoplasty can achieve a favourable balance between disease eradication and hearing restoration. While traditionally associated with poorer hearing outcomes, CWDM, when complemented by effective ossiculoplasty, can yield results comparable to more conservative techniques. Future studies with larger cohorts, longer follow-up, and comparative designs are warranted to further refine patient selection and optimize surgical outcomes.

CONCLUSION

Canal wall down mastoidectomy remains an effective surgical option for cholesteatoma, ensuring disease eradication and a safe ear. Type III tympanoplasty provides significant hearing improvement when combined with ossiculoplasty. Homologous septal cartilage is a reliable graft material with low extrusion rates and good functional outcomes. Further long-term studies are recommended to evaluate durability and safety.

Funding: No funding sources

Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

- Kerckhoffs KGP, Kommer MJB, van Strien THL, Visscher SJA, Bruijnzeel H, Smit AL, et al. The disease recurrence rate after the canal wall up or canal wall down technique in adults. *Laryngoscope*. 2016;126(4):980-7.
- van der Toom HFE, van der Schroeff MP, Pauw RJ. Single-stage mastoid obliteration in cholesteatoma surgery and recurrent and residual disease rates: a systematic review. *JAMA Otolaryngol Head Neck Surg*. 2018;144(5):440-6.
- Tomlin J, Chang D, McCutcheon B, Harris J. Surgical technique and recurrence in cholesteatoma: a meta-analysis. *Audiol Neurotol*. 2013;18(3):135-42.
- Merchant SN, McKenna MJ, Mehta RP, Ravicz ME, Rosowski JJ. Middle-ear mechanics of type III tympanoplasty (stapes columella): II. Clinical studies. *Otol Neurotol*. 2003;24(2):186-94.
- Allema M, Paparella MM, Morris MS, da Costa SS. The flexible/intact-bridge tympanomastoidectomy technique. *Otolaryngol Clin North Am*. 1989;22(1):41-9.
- Filipo R, Barbara M. Rehabilitation of radical mastoidectomy. *Am J Otol*. 1986;7(3):248-52.
- Amendola S, Falcioni M, Caylan R. Recurrent cholesteatoma in open vs closed technique tympanoplasties and its surgical management. In: Sanna M, editor. *Cholesteatoma and Mastoid Surgery*. Rome: CIC Edizioni Internazionali; 1997;654-9.
- Sheehy JL, Brackmann DE, Graham MD. Cholesteatoma surgery: residual and recurrent disease. A review of 1024 cases. *Ann Otol Rhinol Laryngol*. 1977;86(4):451-62.
- Nyrop M, Bonding P. Extensive cholesteatoma: long-term results of three surgical techniques. *J Laryngol Otol*. 1997;111(6):521-6.
- Ikeda M, Yoshida S, Ikui A, Shigihara S. Canal wall down tympanoplasty with canal reconstruction for middle-ear cholesteatoma: post-operative hearing, cholesteatoma recurrence, and status of re-aeration of reconstructed middle-ear cavity. *J Laryngol Otol*. 2003;117(4):249-55.
- Kaylie DM, Gardner EK, Jackson CG. Revision chronic ear surgery. *Otolaryngol Head Neck Surg*. 2006;134(3):443-50.
- Salman AA, Azhar H, Muhammad EK, Muhammad M. Analytical study of ossicular chain in middle ear cholesteatoma. *Ann King Edward Med Coll*. 2009;15(3):134-7.
- Parisier SC, Edelstein DR, Han JC, Ahuja G. Management of labyrinthine fistulas caused by cholesteatoma. *Otolaryngol Head Neck Surg*. 1991;105(5):709-15.
- Goyal R, Mourya A, Qureshi S, Sharma S. Modified radical mastoidectomy with type III tympanoplasty: revisited. *Indian J Otolaryngol Head Neck Surg*. 2016;68(1):52-5.
- Kartush JM. Ossicular chain reconstruction: capitulum to malleus. *Otolaryngol Clin North Am*. 1994;27(4):689-715.
- Kyrodimos E, Sismanis A, Santos D. Type III cartilage shield tympanoplasty: an effective procedure for hearing improvement. *Otolaryngol Head Neck Surg*. 2007;136(6):982-5.
- Harvey SA, Lin SY. Double cartilage block ossiculoplasty in chronic ear surgery. *Laryngoscope*. 1999;109(6):911-4.
- Ferlito S, La Mantia I, Merlino F, Cocuzza S, Di Stadio A, Cammaroto G, et al. Long-term anatomical and hearing outcomes of canal wall down tympanoplasty for tympano-mastoid cholesteatoma: a 20-year retrospective study. *Life (Basel)*. 2022;12(11):1745.
- Salem J, Bakundukize J, Milinis K, Sharma SD. Mastoid obliteration versus canal wall down or canal wall up mastoidectomy for cholesteatoma: systematic review and meta-analysis. *Am J Otolaryngol*. 2023;44(2):103751.
- Acke F, Kostadinov F, Schlegel C, Linder T. Reconstructive ossiculoplasty options in primary

cholesteatoma surgeries with an intact stapes. *Eur Arch Otorhinolaryngol.* 2024;281(2):711-8.

21. Mahesh SG, Sapna M, Tantry D, Bhandary R. Canal wall down approach for tympano-mastoid cholesteatoma: long-term results and prognostic factors. *Indian J Otolaryngol Head Neck Surg.* 2025;77(1):202-6.
22. Karkas A, Tinquaut F, Asimakopoulos A, Grondier B, Bertholon P, Abounaidane I. Auditory outcomes and predictors following ossiculoplasty in

cholesteatoma surgery: a retrospective analysis. *Front Surg.* 2025;12:1630444.

Cite this article as: Manjunath A, Prabhakar G, Kumar SS. Functional audiological outcomes of canal wall down mastoidectomy with type III tympanoplasty in middle ear and mastoid cholesteatoma. *Int J Otorhinolaryngol Head Neck Surg* 2026;12:xxx-xx.