



STUDY OF CANAL WALL UP (CWU) MASTOIDECTOMY COMBINED WITH TRANSCANAL ATTICOTOMY AND ATTIC RECONSTRUCTION APPROACH FOR CHOLESTEATOMA.

ENT

Dr. P. N. Singh	Department Of Otorhinolaryngology, B.r.d. Medical College, Gorakhpur, Uttar Pradesh, India
Dr. R. N. Yadav	Department Of Otorhinolaryngology, B.r.d. Medical College, Gorakhpur, Uttar Pradesh, India
Dr. Aditya Kumar Pathak	Department Of Otorhinolaryngology, B.r.d. Medical College, Gorakhpur, Uttar Pradesh, India
Dr. Vaibhav Srivastava	Department Of Otorhinolaryngology, B.r.d. Medical College, Gorakhpur, Uttar Pradesh, India
Dr. Archana	Department Of Otorhinolaryngology, B.r.d. Medical College, Gorakhpur, Uttar Pradesh, India
Dr. Devendra	Department Of Otorhinolaryngology, B.r.d. Medical College, Gorakhpur, Uttar Pradesh, India
Dr. Surendra Kumar Arya	Department Of Otorhinolaryngology, B.r.d. Medical College, Gorakhpur, Uttar Pradesh, India

ABSTRACT

Background And Aims: Chronic Otitis Media (COM) with cholesteatoma is a severe condition requiring surgical intervention to prevent complications and preserve hearing. This study aims to evaluate the effectiveness of canal wall up (CWU) mastoidectomy combined with transcanal atticotomy and attic reconstruction using cartilage in managing cholesteatoma, focusing on disease eradication, recurrence rate, and hearing outcomes. **Methods:** A prospective study was conducted in the Department of Otorhinolaryngology, B.R.D. Medical College, including 30 patients with COM and cholesteatoma. Ethical clearance and informed patient consent were obtained. Participants underwent ENT examinations, audiometry, and high-resolution CT scans. Surgical intervention involved CWU mastoidectomy, transcanal atticotomy, and cartilage-based attic reconstruction. Postoperative follow-ups were conducted over two year, assessing disease clearance, recurrence, and hearing improvement using air-bone gap (AB gap) measurements. **Results:** The study reported a low recurrence rate with no revision surgeries required within the follow-up period. Patients with intact ossicular chains achieved post-op AB gaps below 15 dB, while those undergoing ossiculoplasty with cartilage attained AB gaps under 30 dB. The procedure was not recommended for cases with grade 4 tympanic membrane retraction or narrow ear canals with limited access. **Conclusion:** CWU mastoidectomy combined with Transcanal atticotomy and attic reconstruction using cartilage is a reliable technique for selected cases of cholesteatoma. It demonstrates excellent hearing outcomes and minimal recurrence, emphasizing the importance of careful case selection and follow-up.

KEYWORDS

Cholesteatoma; Canal Wall Up Mastoidectomy; Transcanal Atticotomy;; Cartilage Reconstruction; Ossiculoplasty

INTRODUCTION

Chronic Otitis Media (COM) is a widespread infectious condition, especially among children, and a major cause of hearing loss globally.¹ A severe form of COM is Chronic Suppurative Otitis Media (CSOM) with cholesteatoma, which can lead to persistent ear discharge, progressive hearing loss, and potentially serious complications if not treated effectively. Cholesteatoma often arises from prolonged Eustachian tube dysfunction (ETD), where poor ventilation creates negative pressure in the middle ear.² This leads to retraction of the tympanic membrane, forming a pocket that traps skin and debris, resulting in cholesteatoma.

The Eustachian tube, a bony-cartilaginous structure, connects the middle ear to the nasal passages, regulating air pressure within the ear. When this tube malfunctions due to factors such as infections, allergies, or structural obstructions, ETD occurs, which impairs middle ear ventilation.^{3,4} If unresolved, this dysfunction can cause chronic inflammation and complications, including cholesteatoma formation. Treatments like myringotomy, pressure equalization tubes, or Eustachian tuboplasty are often required to restore ventilation and manage ETD.⁵

Cholesteatoma surgeries focus on eradicating disease while preserving hearing. Two widely used surgical techniques are Canal Wall Up (CWU) and Canal Wall Down (CWD).⁶ Although CWD ensures complete removal of disease, it leaves behind an open cavity, which demands lifelong care and imposes lifestyle restrictions.⁷ CWD procedure have some other inherent problems which are due to open cavity like need of cavity maintenance, risk of vertigo due to cold air caloric effect, hearing loss due to shallow middle ear cleft and difficulty in hearing aid fitting due to wide meatal opening. CWD

procedure left the patients unable to swim and make them unfit for army recruitment too. On the other hand, CWU preserves the natural structure of the ear, facilitating better hearing outcomes and eliminating the need for routine cavity maintenance. However, successful outcomes with CWU rely heavily on careful patient selection and surgical expertise.⁸

This study aims to assess the effectiveness of a CWU approach, combined with atticotomy with attic reconstruction, in completely excising cholesteatoma from areas such as the attic, sinus tympani, and mastoid keeping the intact posterior canal. The goal is to preserve the ear's natural anatomy with eradication of disease and optimize post-operative hearing outcomes. HRCT scans and intraoperative findings will guide surgical decisions, with the flexibility to switch to CWD if the disease is too extensive. This approach strives to achieve complete disease clearance while maintaining ear functionality and minimizing the need for post-surgical care.

MATERIALANDMETHODS

This prospective study was carried out in the Department of Otorhinolaryngology, B.R.D. Medical College, after obtaining informed consent from the participants. A total of 30 patients diagnosed with Chronic Otitis Media (COM) were included. Eligible patients presented with attic perforation or posterior-superior retraction pockets, intact pars tensa, and a healthy anterior middle ear space. Patients of all ages and genders were considered, provided they gave written consent. Individuals who declined consent or had known intracranial or intratemporal complications were excluded from the study.

Before surgery, each patient underwent a thorough ENT examination,

including otoscopic and microscopic evaluations. Hearing assessments were conducted using pure tone audiometry, and high-resolution CT (HRCT) scans of the temporal bone were performed to determine the extent of the disease and assess the ossicles' condition (Fig. 1, Fig. 2). General anesthesia fitness was confirmed, and all patients were counseled about the procedure. Informed written consent was obtained prior to surgery.

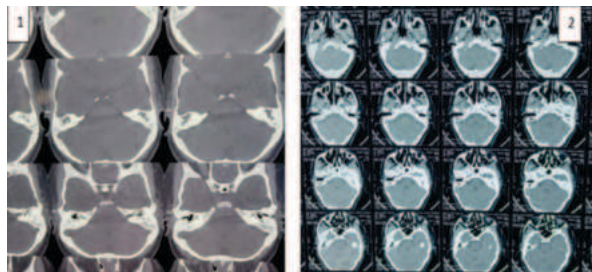


Figure: (1) shows B/L ear soft tissue density seen in middle ear with erosion of ossicles. **(2)** shows soft tissue density left ear mastoid with attic invasion likely cholesteatoma.

The surgical procedure commenced with proper patient positioning and the creation of a Wilde's incision, approximately 5-10 mm behind the retroauricular skin crease. The incision extended through the skin and subcutaneous tissue. The temporalis fascia was harvested, dried, and prepared for later use in reconstruction. A horizontal incision was made along the lower border of the temporalis muscle, and a vertical incision was made along the posterior edge of the external auditory canal (EAC). A posterior-based musculo-periosteal flap was elevated to expose the mastoid cortex (Fig. 3).

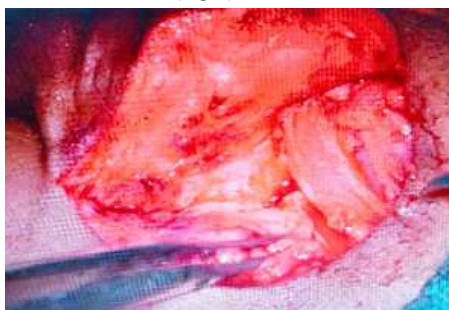


Figure 3: The posterior based Musculo-periosteal flap in left ear exposing the mastoid cortex.

Following a meatotomy, vertical canal incisions were placed at 12 and 6 o'clock positions in the right and left ears, respectively, extending from the anterior margin of the attic perforation to the lateral end of the bony canal. A curvilinear inferior incision was made 6 mm lateral to the annulus, extending to the canal's lateral border. The tympanomeatal flap was carefully rolled down, leaving the annulus and any remaining tympanic membrane (TM) intact. To protect these structures during drilling, the posterior canal wall flap was secured with aluminum foil from a suture wrapper (Fig. 4).

A small horizontal canal incision is made in anterior canal skin superiorly 10 -12 mm lateral to annulus and canal skin elevated inferiorly to expose the bony canal, anterior notch of rivinus.



Figure 4: Tympanomeatal flap protected with aluminum foil, exposing the middle ear and attic region.

An atticotomy was performed using 3 mm and 2.5 mm burs to expose the sinus tympani and attic regions (Fig. 5).



Figure 5: Removal of soft tissue from attic region along with exposure of sinus tympani and attic region by using inside out Atticotomy technique.

According to the extent of cholesteatoma sac in attic, partial or complete removal of the lateral attic wall is done to expose the posterior and anterior attic area (Fig- 6 A). The mesotympanum is observed carefully for any involvement by the disease. If the sac is not involving and not extending into the mastoid region, the whole of the sac can be exteriorized with meticulous dissection. A cortical antrostomy is done in all cases to check the disease in antrum and mastoid region.

If the cholesteatoma extended into the mastoid or antrum, cortical mastoidectomy was performed, exposing anatomical landmarks such as the tegmen, sinus plate, sinodural angle, and digastric ridge. The aditus was widened, the incus remnant removed, and the cholesteatoma sac carefully dissected from all surrounding areas and pushed back into the attic for complete removal (Fig. 6A, Fig. 6B). In cases where the sac extended deep into the malleus head, the head was excised to enhance surgical access.

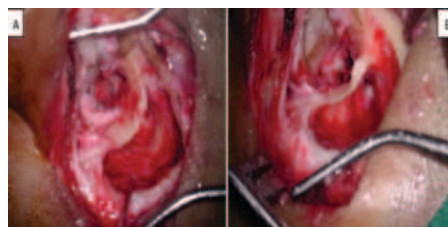


Figure 6: (A) Partial removal of the lateral attic wall and mastoidectomy during cholesteatoma excision. (B) Cholesteatoma sac repositioned into the attic for complete removal through the aditus.

Thinning of the posterior canal wall was performed cautiously to ensure full visualization of the cholesteatoma sac, avoiding unnecessary thinning. Magnification was increased from 0.4x to 1x during inspection of the anterior attic. Drilling of the anterior scutum and buttress further improved visualization. Irrigation with saline ensured removal of any remaining debris from the middle ear cavity, attic, and mastoid.

Reconstruction of the attic was achieved using conchal cartilage or ossicular remnants. The cartilage piece was carefully shaped to fit the defect, supported by the malleus head or a groove created in the bone. Small residual defects were filled with additional cartilage, periosteum, or perichondrium (Fig. 7A). Temporalis fascia was placed over the reconstructed areas, beneath the TM remnant, and over the handle of the malleus (Fig. 8). Ossiculoplasty was performed using an incus remnant as a partial ossicular replacement prosthesis (PORP), ensuring continuity in the ossicular chain (Fig. 7B).

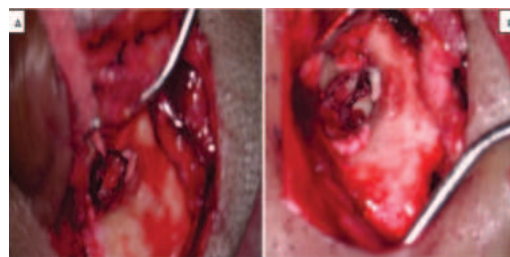


Figure 7: (A) Reconstruction of the attic using conchal cartilage. (B) Ossicular reconstruction with the incus remnant used as a PORP.

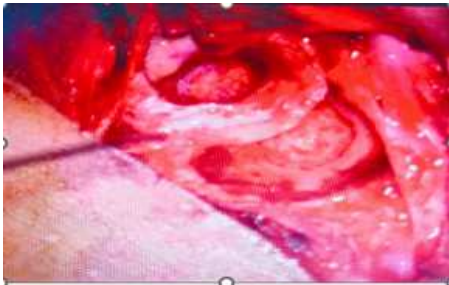


Figure 8: Temporalis fascia placed over cartilage and ossicular remnants during reconstruction.

Postoperatively, patients were monitored through a follow-up schedule extending over two year, with the first follow-up conducted six weeks after surgery. Each follow-up involved microscopic and otoscopic evaluations to assess healing and monitor for recurrence. Photographs taken during these follow-ups were documented for future reference and analysis (Fig. 9).

This surgical approach aimed to achieve complete removal of the cholesteatoma while preserving the ear's natural structure. The strategy focused on restoring auditory function and minimizing the need for long-term care, ensuring a favorable outcome for the patients.



Figure 9 – Postoperative after 6 month endoscopic image of left ear with repaired TM and better hearing outcome shown in audiometry.



Figure 10: (A) 1.5 year postop follow up pic showing infection of attic area before antibiotics medication. (B) Resolved infection after antibiotic course.

RESULTS

Table 1 Demographic Characteristics of Patients

Demographic Characteristic	Category	Number of Patients
Gender	Male	12
	Female	18
	Total	30
Age Group	20-50 years	30
	Other	0
	Total	30

This table shows the gender and age distribution of patients. The majority of the patients (30) were between the ages of 20 to 50 years, with a higher proportion of females (18) compared to males (12).

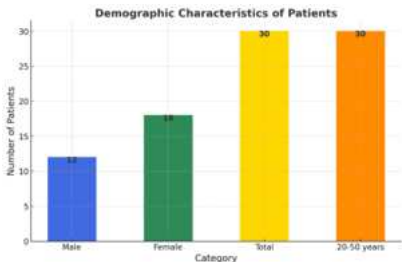


Table 2: Ossicular Condition and Ossiculoplasty Procedures

Condition / Procedure	Number of Patients
Ossicular Condition	
All three ossicles intact and mobile	5
Partial erosion of incus long process	18
Full erosion of incus and malleus	6
Absence of all ossicles (only footplate present)	1
Ossiculoplasty Procedure	
Cartilage used between stapes head and incus remnant	18
Type III cartilage shield tympanoplasty	6
No ossiculoplasty performed (All ossicles absent)	1

This table shows the ossicular conditions and corresponding ossiculoplasty procedures performed. Among the patients, partial erosion of the incus was observed in 18 cases, while 18 procedures involved cartilage placement between the stapes and incus. Additionally, 6 cases required Type III cartilage shield tympanoplasty for optimal reconstruction.

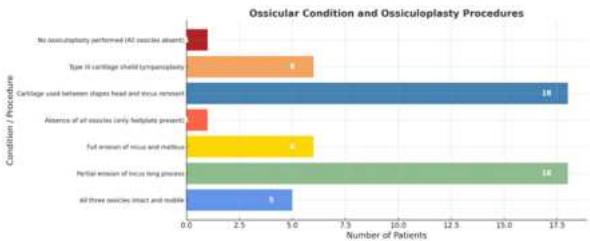


Table 3: Cholesteatoma Location and Extent

Location / Extent	Number of Patients
Location of Cholesteatoma	
Cholesteatoma in attic, aditus, and antrum	12
Cholesteatoma only in attic	10
Intact Pars Tensa with Retraction Pocket in PSQ	8
Extent of Cholesteatoma	
Lateral to head of malleus and incus	23
Deep to incus	7

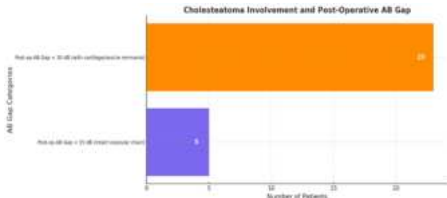
This table shows the distribution of cholesteatoma based on its location and extent. The majority of cases involved cholesteatoma lateral to the head of the malleus and incus (23 patients), with 12 patients exhibiting the disease across the attic, aditus, and antrum.



Table 4: Post-Operative AB Gap

Post-Operative AB Gap	Number of Patients
Post-op AB Gap < 15 dB (intact ossicular chain)	5
Post-op AB Gap < 30 dB (with cartilage/ossicle remnants)	23

This table shows the post-operative air-bone gap (AB Gap) outcomes. Patients with an intact ossicular chain achieved a post-op AB gap of <15 dB in which preoperatively were moderate conductive hearing loss (CHL), while those with cartilage or ossicle reconstruction achieved <30 dB in which preoperatively were moderate to severe CHL.



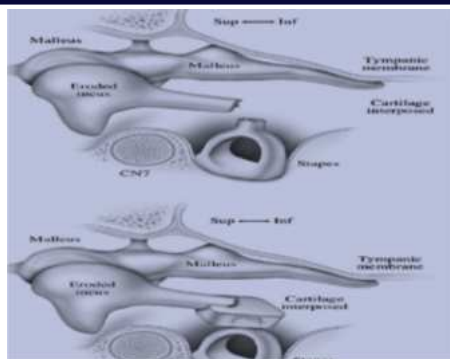


Figure 11: Cartilage bridge between stapes head and eroded incus.

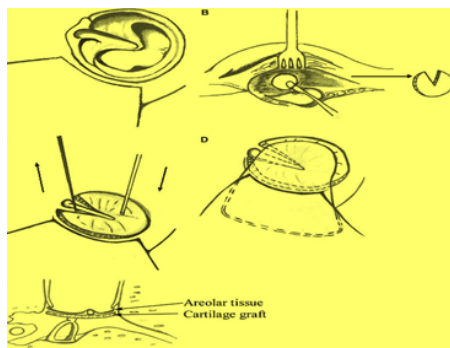


Figure 12: Type III cartilage “shield” tympanoplasty: An valuable procedure for hearing reconstruction.

DISCUSSION

With growing awareness of ear health, patients increasingly seek medical attention at earlier stages, particularly when there is limited involvement of the ear with attico-antral disease. Clinical examination plays a pivotal role in diagnosis, and CT scans of the temporal bone provide valuable insights into the extent of the disease. However, the ultimate decision to perform a canal wall up (CWU) or canal wall down (CWD) procedure is often made intraoperatively, after carefully evaluating the full extent of the disease and ensuring complete removal of pathological tissue.

Several techniques and modifications for the CWU procedure have been discussed in the literature. Farrior introduced the anterior-posterior mastoidectomy technique, which emphasizes thorough disease clearance. **Tos et al.**⁷ further refined the intact canal wall (ICW) technique, incorporating trans-canal atticotomy, post-auricular mastoidectomy, drilling of the anterior canal wall, and thinning of the superior and posterior bony canal walls. **Tos et al.**⁷ also concluded that treatment should be individualized based on the patient's condition, as no single technique is universally suitable for all cases. Furthermore, he stressed the importance of preserving the intact ossicular chain wherever possible for optimal outcomes.

Glasscock and colleagues³ predicted that the ICW tympanoplasty would gain wider acceptance and become a more frequently used technique in the future. Modern modifications of the ICW technique have further enhanced its effectiveness, with only a minimal number of patients requiring a second-stage surgery. **Mahadeviah and Parikh**⁴ advocated thinning the posterior canal wall rim to improve visualization of the sinus tympani, reporting that the majority of their patients did not need revision surgery.

In the present study, all patients were advised to maintain strict follow-up for at least one year. Notably, none of the cases required revision surgery, demonstrating the effectiveness of the approach used. This result aligns with previous findings, underscoring that careful planning, appropriate modifications, and meticulous execution of the CWU technique can yield excellent outcomes without the need for additional surgical intervention.

Recommendations

Future studies should include larger sample sizes and multi-center trials to validate the findings and enhance generalizability. Long-term

follow-up beyond two year is recommended to monitor recurrence rates more accurately. Incorporating advanced imaging techniques like diffusion-weighted MRI could help in early detection of residual cholesteatoma. Further research on optimizing outcomes for complex cases, such as those with severe retraction or narrow ear canals, is encouraged.

Limitations

This study is limited by its small sample size and single-center design, which may restrict the generalizability of results. The follow-up period of two year may not be sufficient to capture all potential recurrences. Additionally, subjective variability in surgical expertise could influence outcomes, and no control group was included to compare alternative techniques.

CONCLUSION

Canal wall up mastoidectomy combined with Transcanal atticotomy, canaloplasty, and subsequent attic reconstruction using cartilage offers a dependable approach for managing cholesteatoma in carefully selected cases. Meticulous case selection and diligent postoperative follow-up are essential to ensure optimal outcomes. This technique has demonstrated a low recurrence rate, with significantly favorable postoperative hearing results. However, it is not suitable for cases with grade 4 tympanic membrane retraction lacking healthy ossicular mobility (HOM) or for ears with extremely narrow bony and cartilaginous canals, where the mastoid air cells are situated too close to the posterior external auditory canal (EAC), posing a higher surgical challenge.

Conflict of Interest: The authors confirm there are no conflicts of interest.

Funding: The study did not receive any financial support.

Consent: Written informed consent was obtained from all participants and securely archived.

Ethical Approval: The study received ethical clearance, adhering to the required institutional protocols.

REFERENCES

1. JB Farrior (1989) Surgical approaches to cholesteatoma. In: The otolaryngologic clinics of north America, vol 22/number 5. W.B. Sausnders company, Philadelphia p 1023
2. Ku D, Copson B, Fiorentino M, Gerrard JM, O'Leary S. A new "practical" plane for Eustachian tube measurements and its application in predicting middle ear dysfunction in patient with acquired cholesteatomas. *Eur Arch Otorhinolaryngol.* 2022 Oct;279(10):4917-4923. doi: 10.1007/s00405-022-07345-3. Epub 2022 Mar 31. PMID: 35355112; PMCID: PMC9474359.
3. Glasscock ME, Miller GW. Intact canal wall tympanoplasty in management of cholesteatoma. *Laryngoscope.* 1976;86:1639-1657. doi: 10.1288/00005537-197611000-00005.
4. Mahadeviah A, Parikh B (2008) Modified intact canal wall mastoidectomy—long term results in hearing and healing. *Indian J Otolaryngol Head Neck Surg* 60(4): 317–323
5. Cho SW, Cho YB, Cho HH. Mastoid obliteration with silicone blocks after canal wall down mastoidectomy. *Clin Exp Otorhinolaryngol.* 2012 Mar;5(1):23-7. doi: 10.3342/ceo.2012.5.1.23. Epub 2012 Mar 22. PMID: 22468198; PMCID: PMC3314801.
6. Pennings RJ, Cremers CW. *Ann Otol Rhinol Laryngol.* 2009 Mar;118(3):199-204. doi: 10.117716. Ridenour JS, Poe DS, Roberson DW. Complications with hydroxyapatite cement in mastoid cavity obliteration. *Otolaryngol Head Neck Surg.* 2008 Nov;139(5):641-645. [PubMed] [Google Scholar]
7. Tos M. Modification of combined approach tympanoplasty in attic cholesteatoma. *Arch Otolaryngol Head Neck Surg.* 1982;108:772-778. doi: 10.1007/s12070-015-0821-z. Epub 2015 Jan 9.
8. Vadiya S, Kedia A. *Indian J Otolaryngol Head Neck Surg.* 2015 Jun;67(2):128-31. doi: 10.1007/s12070-015-0821-z. Epub 2015 Jan 9.