Section: Radiodiagnosis

Original Research Article

HIGH-RESOLUTION CT OF THE TEMPORAL BONE: A KEY TOOL IN ASSESSING CHOLESTEATOMA AND ITS COMPLICATIONS.

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ABSTRACT

Background: Cholesteatoma is a destructive middle ear condition characterized by keratinizing squamous epithelium that can spread into the mastoid air cells or the external auditory canal. It causes hearing deficits, erosion of the ossicles, facial nerve dysfunction, and potential inner ear damage. Hence, the need for prompt and accurate diagnosis is requisite in order to avoid lasting damage to the key structures. High-Resolution Computed Tomography (HRCT) of the temporal bone provides detailed images of the cholesteatoma's extent including bony erosion and related complications, which then influences clinical management.

Materials and Methods: Cholesteatoma is a destructive middle ear condition characterized by keratinizing squamous epithelium that can spread into the mastoid air cells or the external auditory canal. It causes hearing deficits, erosion of the ossicles, facial nerve dysfunction, and potential inner ear damage. Hence, the need for prompt and accurate diagnosis is requisite in order to avoid lasting damage to the key structures. High-Resolution Computed Tomography (HRCT) of the temporal bone provides detailed images of the cholesteatoma's extent including bony erosion and related complications, which then influences clinical management.

Results: All seven patients (mean age: 30.4±9.0 years) showed cholesteatoma-related changes on HRCT. Common features included ossicular chain erosion (100%), scutum erosion (86%), facial canal involvement (43%), and labyrinthine destruction (14%). One patient presented with an EAC cholesteatoma, a relatively rare entity. HRCT was instrumental in detecting extensive disease, localizing lesions, and identifying complications like facial nerve and labyrinthine involvement. These findings guided surgical decisions and correlated strongly with intraoperative and histopathological observations.

Conclusions: HRCT of the temporal bone is a highly effective tool for diagnosing cholesteatoma, delineating disease extent, and identifying critical complications that influence surgical planning. Although small or residual cholesteatomas may still pose a diagnostic challenge, HRCT significantly enhances preoperative evaluation and can reduce morbidity by aiding precise surgical interventions.

Keywords: Cholesteatoma, HRCT, Temporal Bone, Ossicular Erosion, Facial Nerve Involvement.

INTRODUCTION

Cholesteatoma is a destructive lesion of the middle ear and mastoid air cell system, with the presence of keratinizing squamous epithelium in an anatomical site where it is not normally located.[1] Its erosive potential is through persistent inflammation, enzymatic activity, and pressure from the expanding lesion. Cholesteatoma, although often congenital,

more commonly presents as an acquired lesion resulting from chronic eustachian tube dysfunction, tympanic membrane retraction pockets, or chronic otitis media.[2] Cholesteatoma, left untreated, may cause damage to the ossicular chain, erode the scutum and mastoid air cells, and may result in serious complications like hearing loss, facial nerve palsy, labyrinthine fistula, and even intracranial extension in extreme cases.[3]

Insidious onset and anatomical complexity in the management of cholesteatoma constitute a key challenge. Clinical manifestations, including otorrhea, hearing loss, and otalgia sometimes, are usually nonspecific; hence, the role of imaging studies in achieving an accurate diagnosis is very significant.[4] High-Resolution Computed Tomography of the temporal bone has become a significant tool in such cases. HRCT provides better spatial resolution than conventional CT, allowing for detailed visualization of both bony and soft tissue structures in the middle ear and mastoid. Such precision can easily determine subtle bony erosions, differentiate cholesteatoma from other inflammatory or neoplastic processes, and analyze the ossicles, scutum, and mastoid septations.[5]

Several researchers have emphasized the utility of HRCT in evaluating cholesteatoma and its complications. Koelliker et al 33 reported that besides high sensitivity for detecting cholesteatoma, HRCT affects surgical planning based on extension into facial recess, lateral semicircular canal, or tegmen tympani. Additionally, HRCT has postoperative utility in identifying residual or recurrent cholesteatoma.[6] Despite these benefits, HRCT is not without limitations: it does not reliably make a distinction between cholesteatoma and other soft tissue pathologies, like granulation tissue or neoplastic processes. For small lesions or early disease, MRI—especially with diffusion-weighted MRI—is often used as a supplementary diagnostic tool.[7]

Considering the severe morbidity potential of cholesteatoma, it is of prime importance to establish an accurate and timely diagnosis.[8] The present study deals with the application of HRCT in diagnosing cholesteatoma by analyzing the pattern of bone erosion, specifically ossicular destruction and scutum erosion, as well as identifying complications like facial nerve and labyrinthine involvement.[9] Reliability of the findings from HRCT has been assessed by comparison with intraoperative and histopathological findings. By highlighting the imaging manifestations of cholesteatoma, this research aims to inform clinical decision-making and improve surgical outcomes, thereby minimizing complications and recurrence rates.[10]

MATERIALS AND METHODS

Study Design and Population: A retrospective observational study was conducted at Gian Sagar Medical College and Hospital from February 2024 to January 2025. Eligible participants were patients with clinical and/or radiological suspicion of cholesteatoma who underwent HRCT of the temporal bone. Inclusion criteria were: (1) clinical or radiological indication of cholesteatoma, (2) availability of HRCT temporal bone scans, and (3) complete clinical data for correlation. Patients with incomplete imaging studies or contraindications for CT were excluded.

Overall, seven patients (4 males, 3 females; mean age 30.4±9.0 years) met the inclusion criteria. Their demographic data, presenting symptoms (e.g., hearing loss, otorrhea), and results of HRCT were retrieved from the radiological and clinical archives.

Imaging Protocol

All scans were acquired using a multi-detector CT scanner (Somatom go. UP, Siemens, Munich, Germany) with a detector configuration optimized for high-resolution imaging of temporal bones. The following protocol was applied:

- Slice thickness: 0.6 mm
- Reconstructions: Axial, sagittal, and coronal planes in 0.6 mm slices
- Kernel: High-resolution (bone) algorithm
- Window settings: Bone window for detailed bony architecture; soft tissue window for identifying soft tissue densities

Two experienced radiologists, blinded to the final diagnoses and surgical outcomes, independently interpreted the scans. Discrepancies were resolved by consensus discussion.

Radiological Assessment

On HRCT, cholesteatoma was suspected or deemed likely if there was:

1. A soft tissue mass in the middle ear, mastoid, or external auditory canal (EAC).
2. Evidence of bony erosion affecting the scutum, ossicles (malleus, incus, stapes), mastoid septations, tegmen tympani, or facial nerve canal.
3. Signs of expansion, such as displacement of normal anatomic structures, labyrinthine erosions, or extension to the intracranial space.

Each HRCT scan was meticulously evaluated for:

- Presence and exact location of cholesteatoma.
- Erosion of ossicles, scutum, tegmen tympani, and facial canal.
- Soft tissue attenuation in the EAC, middle ear, or mastoid cavity.
- Additional complications: labyrinthine destruction, facial nerve involvement, and intracranial extension.

Diagnostic Confirmation: Intraoperative and histopathological findings served as the gold standard for confirming cholesteatoma in surgical cases. When surgery was performed, the extent of bone erosion, ossicular chain integrity, and the presence of cholesteatoma or granulations were recorded. Histopathological diagnosis was based on

hematoxylin and eosin (H&E) staining, showing stratified squamous epithelium with keratin debris.

Data Analysis

Descriptive statistics (frequencies, proportions) were used to summarize demographic and clinical data, as well as HRCT findings. Sensitivity, specificity, and accuracy were not quantitatively calculated due to the limited sample size but were qualitatively interpreted based on radiology-surgery correlation.

Ethical Considerations

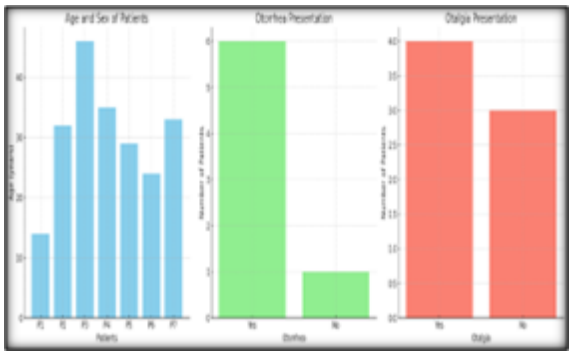
This study was approved by the Institutional Ethics Committee of Gian Sagar Medical College and Hospital. All patient-related information was anonymized. Written informed consent was obtained for clinical procedures and for the use of data in research, in accordance with the Declaration of Helsinki.

RESULTS

Overview of Patient Characteristics: Seven patients—four males and three females—aged 14 to 46 years (mean: 30.4±9.0 years) underwent HRCT for suspected cholesteatoma. All patients (100%) presented with conductive hearing loss, most had otorrhea (86%), and nearly three-quarters reported otalgia (71%). [Table 1] summarizes the demographic profiles and presenting symptoms.

Table 1: Demographic and Clinical Presentation of the Study Population

Patient	Age (yrs)	Sex	Hearing Loss	Otorrhea	Otalgia
1	14	M	Yes	Yes	Yes
2	32	F	Yes	Yes	Yes
3	46	M	Yes	Yes	No
4	35	F	Yes	Yes	Yes
5	29	M	Yes	No	No
6	24	F	Yes	Yes	Yes
7	33	M	Yes	Yes	No



HRCT Findings

All seven HRCT scans revealed findings consistent with cholesteatoma. The majority (six patients) demonstrated soft tissue masses predominantly within the middle ear. One patient had disease centered in the external auditory canal (EAC) that extended toward the middle ear—an example of the rarer EAC cholesteatoma.

Common HRCT features included

- **Ossicular Chain Erosion**: Noted in all 7 cases (100%). The incus and malleus were the most frequently eroded ossicles.
- **Scutum Erosion**: Present in 6 cases (86%), highlighting the aggressive potential of the lesion.
- **Facial Canal Involvement**: Identified in 3 patients (43%). Erosion or dehiscence of the facial nerve canal raises the risk of facial nerve palsy and underscores the need for careful surgical intervention.
- **Tegmen Tympani Erosion**: Observed in 3 cases (43%). This involvement indicates advanced disease and proximity to the middle cranial fossa.

Labyrinthine Involvement: One patient (14%) had erosions affecting the semicircular canal, suggesting labyrinthine fistula.

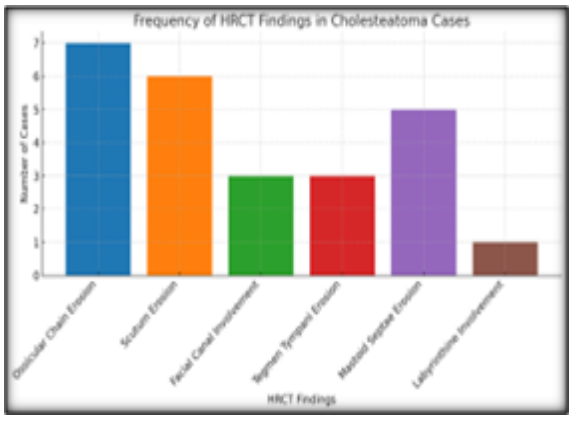


Table 2: HRCT Findings in Seven Cases of Cholesteatoma

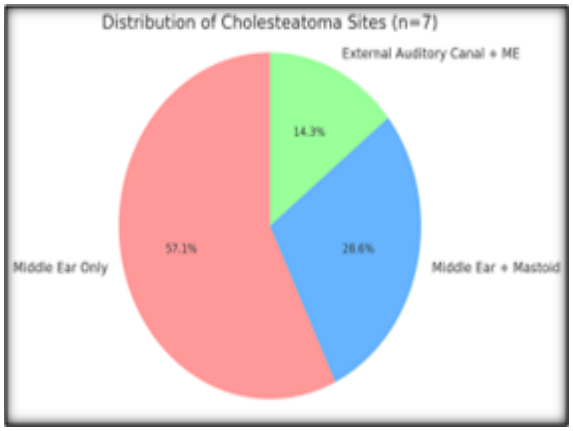
Finding	P1	P2	P3	P4	P5	P6	P7
Scutum erosion	+	–	+	+	+	+	+
Ossicular chain erosion	+	+	+	+	+	+	+
Facial canal involvement	–	+	+	–	–	–	+
Tegmen tympani erosion	–	–	+	+	–	–	+
Mastoid septae erosion	+	+	+	+	–	–	+
Sigmoid plate erosion	–	–	–	–	–	–	+
Labyrinthine involvement	–	–	–	–	–	–	+

In 5 out of 7 patients (71%), mastoid air cells were also affected, displaying partial or complete opacification and bony septal disruption. Figure below depicts the frequency of HRCT-detected erosive findings in cholesteatoma, illustrating the predominance of ossicular and scutum erosion.

Table 3: Distribution of Cholesteatoma Sites (n=7)

Cholesteatoma Location	Number of Patients (%)
Middle Ear Only	4 (57)
Middle Ear + Mastoid	2 (29)
External Auditory Canal (EAC) + ME	1 (14)

In our study, the prevalence of Hypomagnesemia was high among Group A (Vitamin D deficiency) patients i.e. 11(18.97%), compared to other two groups. (p =0.023).



Case 1: EAC Cholesteatoma

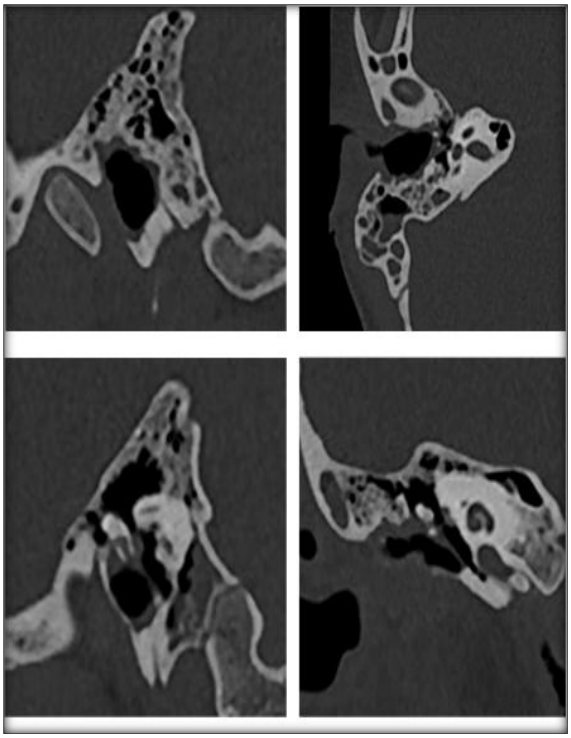


Figure 1: Sagittal (A) and axial images (B) of right temporal bone reveal erosions of bony boundaries of external auditory canal by abnormal soft tissue. Mastoid effusion is seen in (B). Sagittal (C) and Coronal (D) reformations reveal erosions in malleus and incus. Blunting and erosion of scutum is seen in (D)

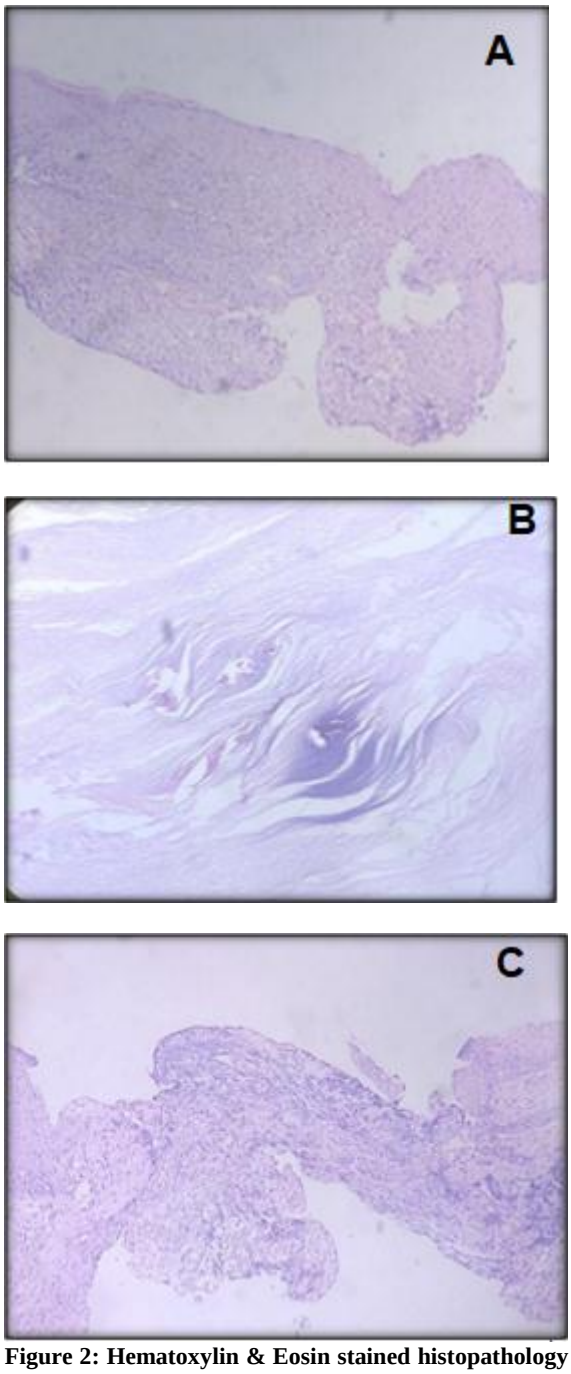


Figure 2: Hematoxylin & Eosin stained histopathology sections of EAC cholestatoma: (A) shows stratified squamous epithelium notable for a granular cell layer, absent rete pegs yielding an atrophic appearance, and no significant atypia. Laminated keratin seen in (B) consists of exfoliated anucleated squames arising from the keratinizing stratified squamous epithelium. (C) reveals inflamed fibrous connective tissue comprising of predominantly lymphocytes and plasma cells

Case 2: Epitympanic Cholesteatoma

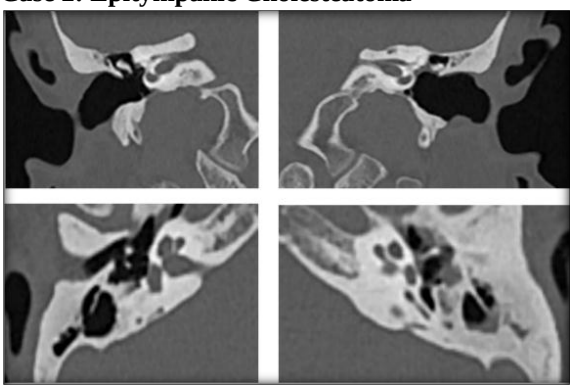


Figure 3: As against a normal incus in right middle ear (A), Coronal HRCT image of left temporal bone (B) reveals erosion of long process of incus (green arrow) by the cholesteatoma (soft tissue). Axial HRCT image of left temporal bone (D) reveals erosion of the long process of incus by a soft tissue mass in epitympanum, as against the right temporal bone (C) showing normal relation of handle of malleus and long process of incus.

DISCUSSION

The present tudy underscores the crucial role of HRCT in diagnosing cholesteatoma and delineating its complications. Despite the small sample size, our findings add to the growing body of evidence that HRCT is essential for preoperative assessment, particularly in complex cholesteatoma cases.[11]

Diagnostic Accuracy and Ossicular Erosion

All patients in our cohort exhibited ossicular chain erosion, with the incus and malleus being the most commonly affected.[12] These findings are consistent with earlier research that reported high rates of ossicular destruction in cholesteatoma, largely attributed to local inflammation, enzymatic degradation, and pressure necrosis.[13] HRCT's fine detail facilitates clear visualization of these bony changes, thus guiding the choice between ossiculoplasty, grafting, or prosthetic reconstruction during surgery.

Facial Nerve and Labyrinthine Involvement

A critical advantage of HRCT is its ability to assess the integrity of the facial nerve canal. In this series, facial nerve canal dehiscence was identified in nearly half of the patients, a significant consideration for surgeons aiming to preserve nerve function.[14] Similar observations were made by Koelliker et al. 33, who emphasized the high utility of HRCT in identifying nerve canal lesions.[15] Labyrinthine involvement in our cohort, though relatively uncommon, aligns with the reported risk of cholesteatoma invading the inner ear structures. Jafari et al. 55 similarly noted labyrinthine erosion to be a key finding that alerts clinicians to potential vestibulocochlear deficits.

External Auditory Canal Cholesteatoma

One patient had an external auditory canal cholesteatoma extending into the middle ear, illustrating a less common, yet clinically significant, disease pattern. This form of cholesteatoma can be under-recognized due to its lower incidence and atypical clinical presentation. HRCT successfully characterized the full extent of bony erosion in the EAC and facilitated timely surgical intervention.[16]

Surgical Correlation and Limitations

Surgical exploration remains the gold standard for definitive diagnosis, as histopathology confirms the presence of keratinizing squamous epithelium 66.[17] Yet, HRCT findings were highly congruent with intraoperative and pathological results, reaffirming the modality's reliability. Despite these strengths, HRCT alone may sometimes fail to distinguish small or early-stage cholesteatomas from granulation tissue or postoperative scarring 77. Hence, diffusion-weighted MRI can be a useful adjunct, especially when minimal residual disease or recurrent cholesteatoma is suspected.[18]

Implications for Clinical Practice

Early and precise imaging-based diagnosis is instrumental in preventing severe cholesteatoma complications. Our study demonstrates that HRCT provides a detailed roadmap for surgeons, particularly regarding facial nerve canal integrity and ossicular status. Furthermore, identifying high-risk features such as tegmen tympani erosion is vital for anticipating potential intracranial complications.[19]

In conclusion, although larger and multicenter studies are warranted, the current findings solidify HRCT's role as a key diagnostic and preoperative planning tool in cholesteatoma management. Adoption of standardized HRCT protocols and incorporation of advanced MRI techniques may further refine diagnostic accuracy and improve long-term outcomes.[20]

CONCLUSION

It points out the prime importance of high-resolution computed tomography in diagnosing cholesteatoma and all its complications, including ossicular erosion, facial nerve canal dehiscence, and labyrinthine involvement. The findings matched significantly with results obtained during intraoperative examination and histopathologically, thus improving surgical planning and possibly the prognosis. However, the limitation in the sensitivity of HRCT of very small lesions does provide an impetus to use additional imaging techniques like diffusion-weighted MRI to achieve a more comprehensive appreciation of the disease. Studies involving larger cohorts and uniform imaging protocols will further elucidate the most appropriate diagnostic and management approaches for cholesteatoma.

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