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Original Research Article

DIAGNOSTIC UTILITY OF HIGH-RESOLUTION COMPUTED TOMOGRAPHY IN TEMPORAL BONE CHOLESTEATOMA: A RETROSPECTIVE STUDY

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ABSTRACT

Background: Temporal bone cholesteatoma is destructive pathology of the middle ear. It is known to have potential to cause significant morbidity by causing progressive bone erosion and intracranial complications. Early identification of disease extent in these cases is essential for optimal surgical planning as well as for prevention of complications. High-resolution computed tomography (HRCT) provides excellent depiction of temporal bone anatomy and is being widely used for preoperative assessment. The aim of this study was to evaluate the diagnostic utility of HRCT in detecting the extent, osseous involvement as well as complications associated with temporal bone cholesteatoma.

Materials and Methods: This retrospective observational study included 60 adult patients with temporal bone cholesteatoma who underwent HRCT of the temporal bone. CT images as well as clinical details were retrieved from electronic records and reviewed. Demographic details, clinical presentation, lesion size and disease laterality were documented. HRCT scans were analysed for the distribution of soft-tissue lesions within temporal bone compartments. Additionally bony erosions involving structures such as the ossicular chain, scutum, tegmen tympani, facial nerve canal, lateral semicircular canal, and sigmoid sinus plate were also noted. Associated complications were also recorded. Imaging findings were correlated with operative findings where available. Descriptive statistics and chi-square tests were used for Statistical analysis. P value less than 0.05 was considered statistically significant.

Results: Most common age group was between 21–30 years (33.3%). There was a male predominance (60%) and Right-sided disease was most common (60%). HRCT most frequently demonstrated disease in the mesotympanum (38.3%) and mastoid antrum/air cells (36.7%). Facial nerve canal dehiscence (70%), lateral semicircular canal fistula (53.3%), and ossicular erosion (51.7%) were the most frequent radiologic findings. The incus was the most commonly eroded ossicle (87.1%). Major complications included labyrinthine fistula (16.7%), sigmoid sinus thrombosis (16.7%) and intracranial extension (13.3%). Extensive multicompartment disease on HRCT showed a significantly higher rate of complications compared with limited disease (53.3% vs 13.3%, p = 0.002).

Conclusion: HRCT is a valuable imaging modality for the preoperative evaluation of temporal bone cholesteatoma. It reliably demonstrates disease extent, identifies critical osseous erosions and detects potentially life-threatening complications.

MeSH Keywords: Cholesteatoma, Temporal Bone, Computed Tomography, Middle Ear Diseases, Ossicular Chain.

INTRODUCTION

Temporal bone cholesteatoma remains a clinically important cause of persistent middle ear disease because, despite its histologically benign nature, it behaves in a locally destructive manner and may produce substantial morbidity when diagnosis or intervention is delayed. Progressive accumulation of keratinizing squamous epithelium within the middle ear cleft and mastoid can lead to chronic inflammation, osteolysis, ossicular chain destruction, labyrinthine fistula, facial nerve canal involvement, and, in advanced cases, intracranial spread. Contemporary evidence also emphasizes that cholesteatoma continues to impose a meaningful global health burden, with marked variation in disease prevalence, complication patterns, and access to surgical care across regions. This ongoing burden is especially relevant in routine otologic practice, where patients frequently present after prolonged symptoms and with disease that has already extended beyond the primary site of origin. In early radiologic characterization is important for identifying the true extent of disease.[1]

Cholesteatoma most often arises in association with chronic otitis media and Eustachian tube dysfunction, although congenital lesions also occur and may remain clinically silent until they enlarge sufficiently to affect hearing or erode surrounding structures. The patients usually present with persistent or intermittent otorrhea, conductive hearing loss, tinnitus, and otalgia. In patients with complications vertigo, facial weakness, severe headache or neurologic symptoms may be present. Yet clinical examination alone may underestimate disease burden, particularly when the lesion extends into anatomically complex recesses such as the epitympanum, aditus ad antrum, mastoid antrum, sinus tympani, facial recess, or hypotympanum. Because these hidden areas are frequently inaccessible to direct otoscopy, radiologic imaging has become a crucial extension of otologic evaluation. A detailed preoperative map of disease distribution is essential for selecting the operative approach, anticipating technical difficulty, counselling patients regarding risks, and reducing the likelihood of residual disease.[2]

High-resolution computed tomography has long been regarded as the primary imaging modality for preoperative assessment of suspected temporal bone cholesteatoma because of its superb spatial resolution and excellent depiction of fine osseous anatomy. HRCT can define soft tissue opacification within the middle ear and mastoid and, more importantly, demonstrate erosion of key landmarks including the scutum, malleus, incus, stapes superstructure, tegmen tympani, lateral semicircular canal, facial nerve canal, and sigmoid sinus plate. Several surgical-radiologic correlation studies have shown that CT is particularly valuable in demonstrating the extent of bony destruction and in alerting the surgeon to hidden complications that may alter operative planning. It is therefore highly useful not only for diagnosis, but also for staging disease severity, anticipating the need for canal wall up versus canal wall down procedures, and identifying patients at higher risk of dural exposure, labyrinthine fistula, ossicular discontinuity or vascular plate erosion.[3]

At the same time, the strengths of HRCT must be interpreted alongside its recognized limitations. While CT is excellent for demonstrating erosive changes and mapping disease extent, it cannot reliably distinguish cholesteatoma from other nonspecific soft tissue such as granulation tissue, inflamed mucosa, effusion, or postoperative fibrosis when these entities share similar attenuation characteristics. This limitation becomes particularly important in patients with previously operated ears or equivocal soft tissue filling of the middle ear cleft. In such scenarios, magnetic resonance imaging, especially non-echo-planar diffusion-weighted imaging, has emerged as a valuable complementary technique with high diagnostic performance for detecting residual or recurrent cholesteatoma.[4] Even so, MRI does not replace HRCT in defining osseous anatomy and preoperative surgical landmarks. Rather, the two modalities serve different but complementary purposes: HRCT excels in anatomic delineation and complication mapping, whereas diffusion-weighted MRI improves tissue characterization in selected cases. Therefore, for primary preoperative evaluation of temporal bone cholesteatoma, HRCT continues to occupy a pivotal role.[5]

Despite the established utility of HRCT, clinically relevant questions remain regarding the spectrum of radiologic findings encountered in routine retrospective practice and the extent to which HRCT identifies disease distribution, bony erosions, and complications in patients with temporal bone cholesteatoma. Many published reports combine diverse chronic suppurative ear diseases, focus mainly on postoperative surveillance, or emphasize selected radiologic signs rather than providing a comprehensive clinicoradiologic profile in a defined cohort. Moreover, the pattern of disease at presentation may vary across institutions depending on referral pathways, duration of symptoms, and local disease burden. The present retrospective study of 60 cases was undertaken to evaluate the diagnostic utility of high-resolution computed tomography in temporal bone cholesteatoma by systematically analyzing demographic characteristics, laterality, anatomic extent, characteristic HRCT findings, and associated complications. By correlating these aspects within a real-world cohort, this study seeks to strengthen the evidence for HRCT as an indispensable preoperative tool and to clarify how effectively it contributes to comprehensive disease assessment and surgical decision-making in cholesteatoma of the temporal bone.

MATERIALS AND METHODS

This retrospective observational study was conducted in the department of radiology of a tertiary care hospital. The purpose of the study was to assess the diagnostic utility of high-resolution computed tomography in patients presenting with temporal bone cholesteatoma. This retrospective study was based on review of archived HRCT temporal bone examinations and corresponding clinical case records of 60 patients with cholesteatoma. Case identification was performed from radiology archives and clinical records and consecutive patients meeting the study criteria were included on the basis of predefined inclusion and exclusion criteria. The diagnosis of cholesteatoma was established on the basis of clinico-radiological assessment with operative confirmation wherever available. Because this was a retrospective record-based study, all eligible cases available during the study period were reviewed. For methodological adequacy, sample size estimation was assessed using the formula $n = Z^2pq/d^2$ at a 95% confidence level; assuming p = 50% for maximum variability and an absolute precision of 13%, the minimum required sample size was approximately 57 cases. The final cohort of 60 patients therefore satisfied the required sample size for descriptive and exploratory analysis.

Clinical data was obtained from IPD papers, OPD notes, operative notes and radiology request forms. Extracted variables included demographic details such as age, gender distribution, side of involvement, presenting symptoms and their duration, history of previous ear surgery, otoscopic findings and final clinical diagnosis. HRCT images were retrieved from the picture archiving and communication system and reviewed in a systematic manner. In patients with bilateral disease, each affected temporal bone was evaluated individually for radiologic extent, while patient-based demographic and clinical variables were recorded once. The imaging findings were interpreted in conjunction with the available clinical notes to determine the probable extent of disease and associated complications. In cases that underwent surgery, intraoperative findings were reviewed from operative records.

All patients had undergone HRCT of the temporal bone using a standard and dedicated thin-section temporal bone protocol. Images were acquired in the axial plane using submillimetre collimation and reconstructed was done in coronal and sagittal planes using a bone algorithm. Each examination was analysed for the presence and location of abnormal soft tissue attenuation within the external auditory canal. Additional epitympanum, mesotympanum, hypotympanum, aditus ad antrum, antrum and mastoid air cells were also assessed on HRCT images. Particular attention was paid to bony erosions involving the scutum, ossicular chain, tegmen tympani, facial nerve canal, lateral semicircular canal, posterior canal wall, sigmoid sinus plate, and adjacent labyrinthine structures. Associated radiologic features such as mastoid sclerosis or opacification, extension into hidden recesses, auto mastoidectomy, labyrinthine fistula, facial canal dehiscence, intracranial extension, and other extracranial or intracranial complications were also documented. All CT examinations were reviewed by radiologists experienced in temporal bone imaging to maintain uniformity of interpretation.

Statistical analysis was performed using SSPS 23.0 software. Categorical data was presented as frequencies and percentages, while continuous data were summarized using mean with standard deviation. The association between HRCT findings and clinico-radiological variables was analysed using the chi-square test or Fisher's exact test, as appropriate.

To evaluate the diagnostic performance of HRCT, imaging findings were compared with operative findings wherever available. Sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy were calculated for important parameters such as ossicular erosion, scutum erosion, facial canal dehiscence, tegmen erosion, and lateral semicircular canal fistula. A p value <0.05 was considered statistically significant.

Inclusion Criteria

- Patients with clinically suspected or confirmed temporal bone cholesteatoma who underwent HRCT temporal bone examination.
- Patients with adequate CT image quality for detailed evaluation of middle ear and mastoid anatomy.
- !8 years of age or above.
- Patients whose clinical records and radiology data were available for review.
- Patients with primary, recurrent, or residual cholesteatoma included in the retrospective database.

Exclusion Criteria

- Age less than 18 years.
- Patients with incomplete clinical records or unavailable CT image data.
- Patients with postoperative temporal bone changes in whom cholesteatoma could not be assessed reliably on the available scan.
- Patients with nondiagnostic or severely motion-degraded HRCT examinations.
- Patients with middle ear soft tissue lesions other than cholesteatoma without adequate clinico-radiological confirmation.
- Patients with isolated inflammatory middle ear disease without radiologic or clinical evidence of cholesteatoma.

RESULTS

The study included 60 adult patients with temporal bone cholesteatoma. The most common affected age group was between 21–30-year age group (33.3%). There was a male predominance (60.0%) in studied cases. Right-sided disease was more common than

left-sided disease whereas bilateral involvement was seen in a smaller proportion of patients. [Table 1]

Table 1: Demographic profile of adult patients with temporal bone cholesteatoma (n = 60)

Parameter	Category	Number of cases	Percentage (%)
Age group (years)	18–20	6	10.0
	21–30	20	33.3
	31–40	14	23.3
	41–50	10	16.7
	51–60	6	10.0
	>60	4	6.7
Gender	Male	36	60.0
	Female	24	40.0
Laterality	Right	36	60.0
	Left	18	30.0
	Bilateral	6	10.0

Most patients had no prior history of ear surgery (73.3%). The duration of symptoms was less than 6 months in 41.7% of cases, and the most common lesion size on HRCT was 10–19 mm (46.7%). [Table 2]

Table 2: Clinical profile and HRCT lesion characteristics of adult patients with temporal bone cholesteatoma (n = 60)

Parameter	Category	Number of cases	Percentage (%)
Previous ear surgery	Yes	16	26.7
	No	44	73.3
Symptom duration	<6 months	25	41.7
	6–12 months	19	31.7
	>12 months	16	26.7
Lesion size on HRCT	<10 mm	23	38.3
	10–19 mm	28	46.7
	≥20 mm	9	15.0

On HRCT, the mesotympanum (38.3%) and mastoid antrum/air cells (36.7%) were the most frequently involved sites. Epitympanic and external auditory canal involvement were also commonly observed, indicating frequent extension of disease into multiple temporal bone compartments. [Table 3]

Table 3: Anatomical distribution of cholesteatoma on HRCT in studied cases (n = 60)

Site involved*	Number of cases	Percentage (%)
Mesotympanum	23	38.3
Mastoid antrum/air cells	22	36.7
Epitympanum	18	30.0
External auditory canal	18	30.0
Hypotympanum	17	28.3
Aditus ad antrum	16	26.7
Sinus tympani	11	18.3
Facial recess	9	15.0

Among radiologic findings facial nerve canal dehiscence was the most frequent abnormality (70.0%). It was followed by lateral semicircular canal fistula (53.3%) and ossicular erosion (51.7%). Erosion of Scutum (31.7%) and tegmen tympani erosion (36.7%) were also notable findings. [Table 4]. [Figure 1,2]

Table 4: Major HRCT findings in adult patients with temporal bone cholesteatoma (n = 60)

HRCT finding	Number of cases	Percentage (%)
Facial nerve canal dehiscence	42	70.0
Lateral semicircular canal fistula	32	53.3
Ossicular erosion	31	51.7
Soft tissue mass in middle ear/mastoid	29	48.3
Tegmen tympani erosion	22	36.7
Sigmoid sinus plate erosion	22	36.7
Scutum erosion	19	31.7
Mastoid opacification/sclerosis	18	30.0
Posterior canal wall erosion	14	23.3
Automastoidectomy	7	11.7

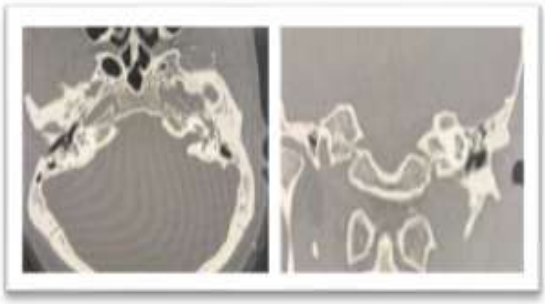

Figure 1: Axial and coronal high resolution multi detector CT images of the left temporal bone shows partial opacification of left epitympanum, mesotympanum and hypotympanum with focal erosions of tegmen tympani

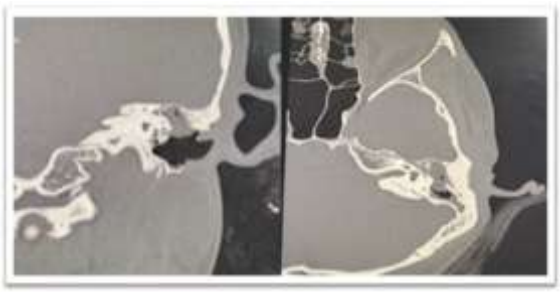

Figure 2: CT images of left temporal bone shows soft tissue density in the left middle ear cavity extending via aditus ad antrum into the mastoid cavity with erosion of scutum. Note the non-visualisation of left stapes and handle of malleus. There is also dehiscence of lateral wall of horizontal part of facial canal and lateral semicircular canal

Among patients with ossicular erosion, the incus was the most commonly affected ossicle (87.1%), followed by the malleus (67.7%). Complete ossicular chain erosion was present in 29.0% of these cases, suggesting advanced disease in a considerable proportion of patients. [Table 5]

Table 5: Antibiotic Sensitivity Pattern of Gram-Positive Bacteria (n = 32)

Ossicle involved*	Number of cases	Percentage among ossicular erosion cases (%)
Incus	27	87.1
Malleus	21	67.7
Stapes superstructure	16	51.6
Complete ossicular chain erosion	9	29.0

Regarding complications, labyrinthine fistula and sigmoid sinus thrombosis were each seen in 16.7% of patients. Intracranial extension was found on CT in 13.3% of cases. Facial nerve involvement, meningitis and brain abscess were each observed in 11.7% indicating substantial morbidity in cases of advanced cholesteatoma with intracranial complication. [Table 6]

Table 6. Complications associated with temporal bone cholesteatoma on HRCT in adult patients (n = 60)

Complication	Number of cases	Percentage (%)
Sigmoid sinus thrombosis	10	16.7
Labyrinthine fistula	10	16.7
Intracranial extension	8	13.3
Facial nerve involvement	7	11.7
Meningitis	7	11.7
Brain abscess	7	11.7
Mastoid abscess	5	8.3
Extradural abscess	4	6.7

Clinically, otalgia was the most common presenting symptom (51.7%), followed by ear discharge (46.7%) and tinnitus (43.3%). Facial weakness was present in 40.0% of patients, reflecting the relatively high frequency of advanced disease in this adult cohort. [Table 7]

Table 7: Clinical presentation of adult patients with temporal bone cholesteatoma (n = 60)

Symptom	Number of cases	Percentage (%)
Otalgia	31	51.7
Ear discharge	28	46.7
Tinnitus	26	43.3
Facial weakness	24	40.0
Hearing loss	23	38.3
Vertigo	18	30.0
Aural fullness	15	25.0
Headache	11	18.3

A statistically significant association was observed between disease extent on HRCT and the occurrence of complications. Patients with multicompartment or extensive disease had a markedly higher rate of complications than those with limited disease (53.3% vs 13.3%, p = 0.002). [Table 8]

Table 8: Association between extent of disease on HRCT and occurrence of complications (n = 60)

Extent of disease	Complications present n (%)	Complications absent n (%)	Total	p value
Limited disease (single primary compartment involvement)	4 (13.3)	26 (86.7)	30	
Extensive disease (multicompartment involvement)	16 (53.3)	14 (46.7)	30	0.002

DISCUSSION

In the present retrospective adult cohort, temporal bone cholesteatoma was seen most often in younger adults, especially those aged 21–30 years, with a clear male predominance and predominantly unilateral disease. This overall profile is broadly consistent with the work of Gomaa MA et al,[6] and Gaurano and Joharjy,[7] both of whom described cholesteatoma as occurring commonly in younger patients and emphasized its characteristic unilateral destructive middle ear behavior on CT. Our findings therefore support the view that cholesteatoma remains a disease of relatively early adult life in many tertiary-care settings, although the persistence of cases into older age groups in our series also indicates that delayed presentation remains clinically important. Another notable feature of our cohort was that most patients had not undergone prior ear surgery and many presented within 12 months of symptom onset, yet a substantial proportion already demonstrated advanced radiologic changes. This suggests that symptom duration alone may underestimate biological aggressiveness or the true duration of occult disease. Clinically, otalgia, otorrhea, tinnitus, hearing loss, vertigo, and facial weakness were all frequent, with otalgia being the most common complaint in our series. While ear discharge and hearing loss are classically emphasized in the literature, the relatively high frequency of facial weakness and vertigo in our study points toward a more advanced disease spectrum than that seen in uncomplicated cholesteatoma cohorts. In this respect, the current series appears closer to tertiary referral populations in which patients often present after disease has extended beyond the attic or mesotympanum. The demographic and symptomatic pattern observed here therefore reinforces the need for early imaging evaluation in symptomatic adults, especially when the clinical picture suggests disease beyond what can be appreciated on otoscopy alone.

With regard to disease distribution, HRCT in our study demonstrated that the mesotympanum and mastoid antrum/air cells were the most commonly involved sites, followed by the epitympanum, external auditory canal, hypotympanum, aditus ad antrum, sinus tympani, and facial recess. This multicompartment pattern is important because it highlights the tendency of cholesteatoma to spread along the ventilation pathways and into surgically hidden recesses rather than remaining confined to a single cleft. The observations of Chee NW et al,[8] and Razek AA et al,[9] are particularly relevant here. Chee and Tan showed that preoperative HRCT is valuable for depicting the status of middle ear structures and alerting the surgeon to relevant anatomic details before cholesteatoma surgery, while Razek et al proposed a CT-based staging system that correlated well with operative findings and explicitly linked imaging-defined location, mastoid extension, and complications to surgical strategy. Our data support this concept strongly. The involvement of the aditus, mastoid, sinus tympani, and facial recess in a meaningful subset of cases underscores why cholesteatoma surgery should not be planned solely on the basis of otoscopic disease. These areas are precisely those in which residual disease may remain if the preoperative extent is underestimated. The predominance of mesotympanic and mastoid disease in our cohort may also reflect referral bias toward more established lesions, because limited attic disease can remain clinically silent for longer. From a practical standpoint, our results strengthen the argument that HRCT serves as a preoperative "anatomic map," especially in patients with suspected multicompartment disease, because it helps define whether the lesion is localized or extensive and therefore whether a more conservative approach is feasible or whether wider exposure is likely to be required.

A major strength of HRCT in our series was its demonstration of osseous destruction, particularly facial nerve canal dehiscence, lateral semicircular canal fistula, ossicular erosion, scutum erosion, tegmen erosion, sigmoid sinus plate erosion, and posterior canal wall erosion. The pattern of ossicular involvement was especially informative: among the 31 patients with ossicular erosion, the incus was the most commonly affected ossicle, followed by the malleus and stapes, and nearly one-third had complete ossicular chain erosion. This closely parallels the observations of Albera R et al,[10] and Mohammadi G et al,[11] both of whom reported that the incus is the most vulnerable ossicle in cholesteatoma because of its delicate structure and relatively tenuous blood supply. However, our relatively high frequency of facial canal dehiscence on HRCT should be interpreted with caution. Some of this may represent true advanced disease, but some may also reflect the known tendency of CT to overcall dehiscence when extremely thin bony covering is present. Thus, while HRCT is excellent for demonstrating the burden of bone erosion overall, the surgeon must still interpret selected findings—especially facial canal defects—in conjunction with clinical judgment and intraoperative vigilance.

In this study Labyrinthine fistula and sigmoid sinus thrombosis were each present in 16.7% of. These

rates are higher than in many general cholesteatoma series and strongly suggest that our cohort contained a substantial proportion of advanced disease. The reports of Magliulo G et al,[12] and Aw NMY et al,[13] are particularly helpful for contextualizing these findings. Magliulo et al showed that facial nerve dehiscence is a well-recognized accompaniment of cholesteatoma and that its likelihood increases in the presence of semicircular canal fistula, while Aw et al reported labyrinthine fistula in 15.6% of middle ear cholesteatomas and demonstrated high HRCT sensitivity and specificity for its preoperative detection. Our labyrinthine fistula rate is strikingly close to that reported by Aw et al, supporting the reliability of HRCT for identifying this surgically important complication. However, our facial nerve canal dehiscence frequency was considerably higher than the surgically documented prevalence reported by Magliulo et al, again suggesting that radiologic dehiscence in retrospective review may partly reflect overestimation in severely thinned bone or selection of more advanced ears. The presence of meningitis, brain abscess, and intracranial extension in our cohort also reaffirms that cholesteatoma remains potentially life-threatening when neglected. In such circumstances, HRCT is not simply diagnostic; it becomes essential for defining the relationship of disease to the labyrinth, tegmen, sigmoid sinus plate, and intracranial compartment, thereby enabling safer and more timely operative intervention.

Perhaps the most important analytic finding in our study was the statistically significant association between multicompartment/extensive disease on HRCT and the occurrence of complications (53.3% vs 13.3%, $p = 0.002$). This result is highly plausible biologically and is one of the strongest arguments for systematic preoperative imaging. Similar conclusions emerge from the studies of Rogha M et al,[14] and Manik S et al,[15] both of whom found that HRCT correlates well with operative disease extent and is particularly useful for identifying ossicular erosion, lateral canal fistula, tegmen or dural plate erosion, and other complications that influence the surgical plan. Our findings extend that practical message by showing that the radiologic burden of disease itself is a marker of complication risk within a real-world retrospective cohort. This has direct implications for surgical counseling and prioritization: a patient with isolated disease in one primary compartment is less likely to harbor serious complications than one with disease extending across the mesotympanum, epitympanum, aditus, antrum, mastoid, and hidden recesses. Nevertheless, our results also highlight the classic limitation of CT noted by multiple authors, namely its inability to reliably differentiate cholesteatoma from granulation tissue or other nonspecific soft tissue on attenuation alone. Accordingly, the true diagnostic utility of HRCT in cholesteatoma lies less in tissue characterization and more in anatomic delineation, mapping of extent, and detection of complications. Taken together, the present study supports HRCT as an indispensable preoperative investigation in temporal bone cholesteatoma, particularly in adults presenting with clinically suspected advanced disease, multicompartment extension, facial symptoms, vestibular symptoms, or possible intracranial spread. In such settings, HRCT transforms surgery from a largely exploratory procedure into one that is informed, anticipatory, and safer

CONCLUSION

High-resolution computed tomography plays an important role in the preoperative assessment of cases with temporal bone cholesteatoma. In this study HRCT effectively delineated disease extent, identified critical osseous erosions and reliably detected extracranial and intracranial complications. The significant association between multicompartment involvement and complication rates underscores its ability of risk stratification in cases with cholesteatoma. HRCT remains indispensable for surgical planning, improving operative precision and enhancing overall patient management outcomes in patients having cholesteatoma.

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