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Research Article

DIAGNOSTIC ACCURACY OF PREOPERATIVE HRCT TEMPORAL BONE IN CHOLESTEATOMA PATIENTS UNDERGOING TYMPANOMASTOIDECTOMY

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Abstract: ***Introduction:*** Cholesteatoma is a locally destructive keratinizing lesion of the temporal bone associated with progressive ossicular erosion and potentially life-threatening extracranial and intracranial complications. High-resolution computed tomography (HRCT) of the temporal bone plays a pivotal role in preoperative assessment by delineating disease extent and identifying critical anatomical involvement. However, variability persists regarding its diagnostic accuracy for certain structures, particularly the facial nerve canal and labyrinthine fistula.**Objective:**To evaluate the diagnostic accuracy of preoperative HRCT temporal bone in patients with cholesteatoma by correlating radiological findings with intraoperative observations.**Methods:**This prospective observational study was conducted at Karnataka Institute of Medical Sciences and included 60 patients with clinically and/or radiologically diagnosed cholesteatoma who underwent tympanomastoidectomy. Thirteen anatomical parameters identified on preoperative HRCT were systematically compared with intraoperative findings. Diagnostic performance indices including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy were calculated using 2×2 contingency analysis. Statistical correlation was assessed using the chi-square test.**Results**:Most patients were aged ≤20 years (41.7%), with female predominance (61.7%). Ear discharge with hearing loss was the most common presentation (56.7%), and attic retraction pocket with cholesteatoma was the predominant otoscopic finding (85.0%). HRCT demonstrated 100% sensitivity, specificity, PPV, NPV, and diagnostic accuracy for detecting middle ear soft tissue density, aditus widening, scutum erosion, ossicular erosion (malleus, incus, and stapes), tegmen tympani erosion, mastoid cortex erosion, and intracranial complications. Tympanum erosion showed sensitivity of 98.2% and overall accuracy of 98.3%, while sigmoid sinus plate erosion demonstrated sensitivity of 85.7% and accuracy of 98.3%. Lower sensitivities were observed for lateral semicircular canal fistula (44.4%) and facial canal dehiscence (54.5%), although specificity and PPV remained 100% for both parameters. Overall radiological and intraoperative agreement was excellent across all cases ($p<0.001$). Canal wall down tympanomastoidectomy was performed in 93.3% of patients.**Conclusion**:HRCT temporal bone demonstrates excellent diagnostic accuracy and strong radio-surgical concordance in the preoperative evaluation of cholesteatoma. It remains an indispensable tool for disease mapping, surgical planning, and anticipating complications. Nevertheless, caution is warranted while interpreting facial canal dehiscence and lateral semicircular canal fistula, where intraoperative assessment continues to be essential.

Keywords: Cholesteatoma, Diagnostic Accuracy, HRCT Temporal Bone, Ossicular Erosion, Tympanomastoidectomy.

INTRODUCTION

Cholesteatoma is a destructive keratinizing lesion of the middle ear and mastoid characterized by the abnormal proliferation of squamous epithelium with progressive bone erosion. Owing to its locally aggressive nature, cholesteatoma can involve critical temporal bone structures including the ossicular chain, facial nerve canal, tegmen tympani, labyrinth, and sigmoid sinus plate, potentially resulting in serious extracranial and intracranial complications if left untreated.1 The disease process is mediated by pressure necrosis, osteoclastic activity, and enzymatic bone destruction, leading to progressive anatomical damage and functional impairment.

The reported annual incidence of cholesteatoma ranges from 3 to 15 cases per 100,000 population worldwide.2 Acquired cholesteatoma is more common than the congenital form and is frequently associated with Eustachian tube dysfunction, recurrent otitis media, and tympanic membrane retraction pockets.3 Clinically, patients commonly present with chronic ear discharge, hearing loss, and, in advanced disease, vestibular symptoms or facial nerve involvement. Early diagnosis and complete surgical excision remain the cornerstone of management.

Preoperative imaging plays a crucial role in determining disease extent, identifying anatomical involvement, and planning the surgical approach. High-resolution computed tomography (HRCT) of the temporal bone is currently considered the imaging modality of choice because of its superior spatial resolution and excellent delineation of bony anatomy.4 The advent of multidetector CT scanners with submillimeter slice thickness and multiplanar reconstruction capabilities has further enhanced the utility of HRCT in evaluating middle ear pathology.5

Typical HRCT findings in cholesteatoma include non-enhancing soft tissue density within the middle ear or mastoid cavity, often associated with scutum erosion, ossicular destruction, aditus widening, tegmen defects, labyrinthine fistula, or facial canal dehiscence.6 However, despite its diagnostic utility, HRCT has limitations in differentiating cholesteatoma from granulation tissue or inflammatory soft tissue changes. Previous studies have reported variable sensitivity and specificity for HRCT in detecting cholesteatoma and associated complications, particularly involving the facial nerve canal and lateral semicircular canal.7

Accurate preoperative identification of disease extent is essential, as discrepancies between radiological and intraoperative findings may alter surgical planning and influence operative outcomes. Rogha et al. reported high accuracy of HRCT for ossicular erosion but lower sensitivity for facial canal dehiscence, highlighting the need for continued intraoperative vigilance despite advanced imaging.8 Reliable preoperative assessment may reduce surgical uncertainty, improve patient counseling, and optimize operative strategies.

Although diffusion-weighted magnetic resonance imaging has emerged as a useful adjunct for soft tissue characterization, HRCT remains indispensable because of its ability to demonstrate fine bony details and anatomical variations relevant to surgery.9 With ongoing advances in imaging interpretation and evolving surgical techniques, evaluating the diagnostic performance of HRCT against intraoperative findings remains clinically important.

Therefore, the present study was undertaken to evaluate the diagnostic accuracy of preoperative HRCT temporal bone in patients with cholesteatoma by comparing radiological findings with intraoperative observations during tympanomastoidectomy.

Aim

To evaluate the diagnostic accuracy and reliability of preoperative high-resolution computed tomography (HRCT) of the temporal bone in patients with cholesteatoma by comparing radiological findings with intraoperative findings during tympanomastoidectomy.

Objectives

1.To assess the effectiveness of preoperative HRCT temporal bone in evaluating the extent of cholesteatoma and associated temporal bone involvement.

2.To compare preoperative HRCT temporal bone findings with intraoperative findings in patients undergoing surgery for cholesteatoma.

3.To evaluate the utility of HRCT temporal bone in preoperative surgical planning and patient counseling.

MATERIALS AND METHODS

Study Design and Setting

This prospective observational study was conducted in the Department of Radio-Diagnosis in collaboration with the Department of Otorhinolaryngology at Karnataka Institute of Medical Sciences from June 2024 to June 2026 after obtaining approval from the Institutional Ethics Committee.

Study Population

A total of 60 patients with clinically suspected cholesteatoma who were scheduled for tympanomastoidectomy were included in the study. All patients underwent detailed clinical evaluation including history, otoscopic examination, and audiological assessment before HRCT temporal bone imaging.

Inclusion Criteria

Patients aged ≥10 years with clinically diagnosed unsafe chronic suppurative otitis media with cholesteatoma who were willing to participate and undergo surgery were included.

Exclusion Criteria

Patients with acute otitis media, previous ear surgery, pregnancy, contraindications to radiation exposure, unfitness for general anesthesia, or unwillingness to participate were excluded.

HRCT Imaging Protocol

HRCT temporal bone was performed using a 128-slice multidetector CT scanner (Siemens SOMATOM Definition Edge). Imaging was obtained with 0.6 mm slice thickness in axial sections with multiplanar reconstruction in coronal and sagittal planes. Images were analyzed using bone and soft tissue algorithms.

Image Analysis

HRCT images were independently evaluated by two experienced radiologists blinded to surgical findings. The evaluated parameters included soft tissue density, scutum erosion, ossicular erosion, tegmen tympani erosion, facial canal dehiscence, sigmoid sinus plate erosion, mastoid cortex erosion, lateral semicircular canal fistula, and intracranial complications.

Surgical Assessment

All patients underwent tympanomastoidectomy within two weeks of HRCT imaging. Intraoperative findings were documented using a standardized proforma and served as the reference standard for comparison.

Statistical Analysis

Data were analyzed using SPSS version 26.0. Sensitivity, specificity, positive predictive value, negative predictive

value, and overall diagnostic accuracy of HRCT were calculated for each parameter using intraoperative findings as the gold standard. Agreement between HRCT and surgical findings was assessed using Cohen's kappa coefficient. A p-value <0.05 was considered statistically significant.

Ethical Considerations

Written informed consent was obtained from all participants. Patient confidentiality was maintained throughout the study in accordance with the Declaration of Helsinki and Good Clinical Practice guidelines.KIMS:ETHICS COMM: 79:2023-24

RESULTS

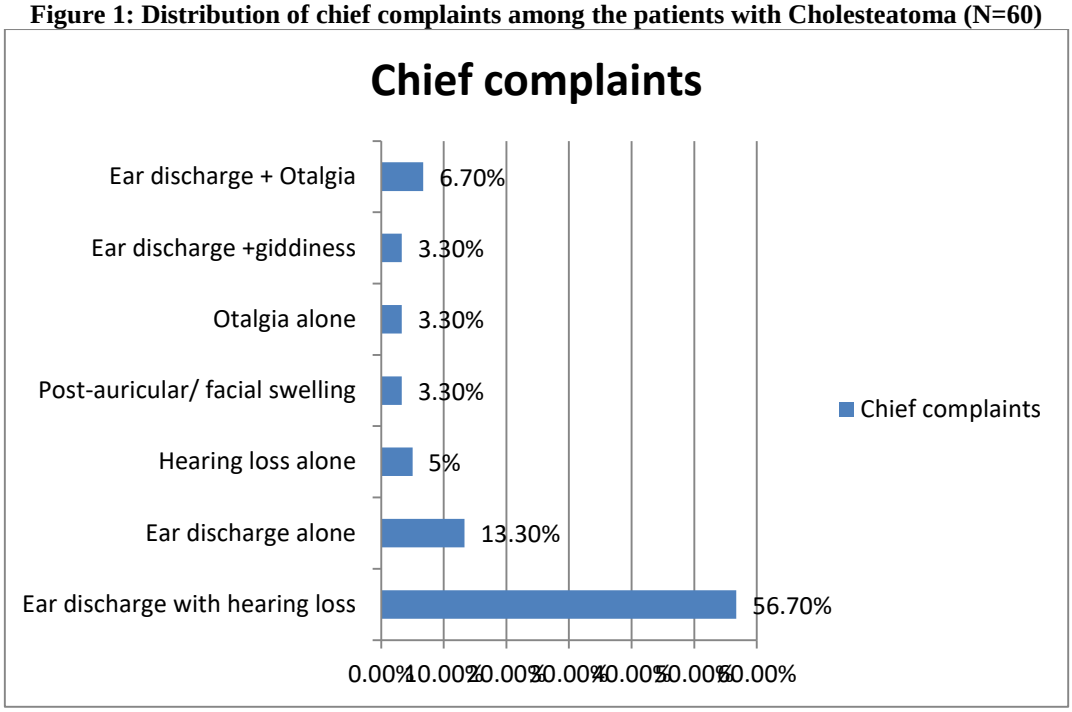
Sociodemographic characteristics and Clinical profile of the study participants

The majority of patients were aged ≤20 years (41.7%, n=25), followed by 31–40 years (21.7%, n=13), indicating a predominance of cholesteatoma in younger individuals. Females constituted 61.7% (n=37) of the cohort, with a female-to-male ratio of 1.6:1. Left-sided disease was most common (41.7%, n=25), while bilateral involvement was observed in 26.7% (n=16), suggesting advanced or longstanding disease. Nearly half of the patients (46.7%, n=28) presented after more than 5 years of symptoms, reflecting delayed healthcare-seeking behaviour. Attic retraction pocket with cholesteatoma was the predominant otoscopic finding (85.0%, n=51). Ear discharge associated with hearing loss was the most frequent presenting complaint (56.7%, n=34), while a small proportion presented with swelling or isolated hearing loss, indicating more advanced disease manifestations. (Table 1)

Table 1: Sociodemographic Characteristics, Clinical Presentation, and Otoscopic Findings among Patients with Cholesteatoma (N=60)

Sl. No.	Variable/Category	Frequency (n)	Percentage (%)
1	**Age distribution**		
	≤20 years	25	41.7
	21–30 years	11	18.3
	31–40 years	13	21.7
	41–50 years	10	16.6
	51–60 years	1	1.7
2	**Gender distribution**		
	Female	37	61.7
	Male	23	38.3
3	**Laterality of disease**		
	Left-sided disease	25	41.7
	Right-sided disease	19	31.7
	Bilateral disease	16	26.7
4	**Duration of symptoms**		
	6 months–1 year	19	31.7
	>5 years	28	46.7
	Other durations	13	21.6
5	**Otoscopic findings**		
	Attic retraction pocket with cholesteatoma	51	85.0
	Marginal/central perforation with cholesteatoma	9	15.0
6	**Presenting symptoms**		
	Ear discharge with hearing loss	34	56.7
	Ear discharge alone	8	13.3
	Hearing loss alone	3	5.0
	Post-auricular/facial swelling	2	3.3
	Other symptom combinations	13	21.7

Figure 1: Distribution of chief complaints among the patients with Cholesteatoma (N=60)



HRCT temporal bones v/s Intraoperative findings

Comparison of HRCT findings with intraoperative observations showed strong overall concordance across most anatomical parameters. HRCT demonstrated complete agreement for soft tissue density, aditus ad antrum widening, scutum erosion, ossicular erosion involving the malleus, incus, and stapes, tegmen tympani erosion, mastoid cortex erosion, and intracranial complications. However, HRCT underestimated lateral semicircular canal fistula (4 cases on HRCT vs. 9 intraoperatively) and facial canal dehiscence (6 cases on HRCT vs. 11 intraoperatively), indicating reduced sensitivity in detecting fine bony dehiscences. These findings highlight the key limitations of HRCT in preoperative cholesteatoma staging. (Table 2)

Table2: ComparisonofHRCTtemporalbonefindingswithintraoperativefindingsfor each anatomical parameter (n=60)

Parameter	**HRCT Present**		**Intraoperative Present**		**Difference (Intraop−HRCT)**	**χ^2**	**p-value**
	n	**%**	**n**	**%**			
SoftTissueDensity (Middle Ear)	60	100.0	60	100.0	0	N/A	—
AditusadAntrumWidening	51	85.0	51	85.0	0	60.000	<0.001
TympanumErosion	54	90.0	55	91.7	+1	60.000	<0.001
ScutumErosion	53	88.3	53	88.3	0	60.000	<0.001
MalleusErosion	49	81.7	49	81.7	0	60.000	<0.001
IncusErosion	49	81.7	49	81.7	0	60.000	<0.001
StapesErosion	49	81.7	49	81.7	0	60.000	<0.001
TegmenTympaniErosion	4	6.7	4	6.7	0	60.000	<0.001
LateralSCCErosion/ Fistula	4	6.7	9	15.0	+5	24.286	<0.001
FacialCanalDehiscence	6	10.0	11	18.3	+5	29.697	<0.001
SigmoidSinusPlateErosion	6	10.0	7	11.7	+1	50.476	<0.001
MastoidCortexErosion	57	95.0	57	95.0	0	60.000	<0.001

Intracranial Complication	3	5.0	3	5.0	0	60.000	<0.001

Diagnostic Accuracy of HRCT

Diagnostic accuracy analysis demonstrated that HRCT achieved 100% sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy for most parameters, including soft tissue density, aditus widening, scutum erosion, ossicular chain erosion, tegmen erosion, mastoid erosion, and intracranial complications. Reduced sensitivity was observed for lateral semicircular canal fistula (44.4%) and facial canal dehiscence (54.5%), although both parameters maintained 100% specificity and PPV, indicating absence of false-positive findings. Sigmoid sinus plate erosion showed a sensitivity of 85.7% with 100% specificity. Overall diagnostic accuracy for all evaluated parameters was ≥91.7%, highlighting the strong reliability of HRCT temporal bone in the preoperative assessment of cholesteatoma.

Table 3:Diagnostic Accuracy of HRCT Temporal Bone Findings Compared with Intraoperative Findings in Cholesteatoma (N=60)

Parameter	TP	FP	FN	TN	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)	χ^2	p-value
Soft Tissue Density (Middle Ear)	60	0	0	0	100.0	100.0	100.0	100.0	100.0	N/A	—
Aditus ad Antrum Widening	51	0	0	9	100.0	100.0	100.0	100.0	100.0	60.000	<0.001
Tympanum Erosion	54	0	1	5	98.2	100.0	100.0	83.3	98.3	60.000	<0.001
Scutum Erosion	53	0	0	7	100.0	100.0	100.0	100.0	100.0	60.000	<0.001
Malleus Erosion	49	0	0	11	100.0	100.0	100.0	100.0	100.0	60.000	<0.001
Incus Erosion	49	0	0	11	100.0	100.0	100.0	100.0	100.0	60.000	<0.001
Stapes Erosion	49	0	0	11	100.0	100.0	100.0	100.0	100.0	60.000	<0.001
Tegmen Tympani Erosion	4	0	0	56	100.0	100.0	100.0	100.0	100.0	60.000	<0.001
Lateral SCC Erosion/Fistula	4	0	5	51	44.4	100.0	100.0	91.1	91.7	24.286	<0.001
Facial Canal Dehiscence	6	0	5	49	54.5	100.0	100.0	90.7	91.7	29.697	<0.001

Canal Wall Down (CWD) tympanomastoidectomy was the predominant surgical approach, performed in 93.3% of patients (n=56), while Canal Wall Up (CWU) surgery was undertaken in 6.7% (n=4), reflecting the advanced extent of disease in most cases. Radio-surgical agreement was rated as good in all patients (100%, n=60), demonstrating excellent concordance between preoperative HRCT findings and intraoperative observations, and highlighting the high reliability of HRCT temporal bone in preoperative assessment and surgical planning for cholesteatoma.

DISCUSSION

The present study evaluated the diagnostic accuracy and radio-surgical correlation of High-Resolution Computed Tomography (HRCT) temporal bone in 60 patients with cholesteatoma. Cholesteatoma is a locally destructive lesion characterized by progressive accumulation of keratinizing squamous epithelium with a marked tendency for bony erosion involving the ossicular chain, scutum, tegmen tympani, facial nerve canal, lateral semicircular canal, and adjacent intracranial structures. Accurate preoperative assessment is therefore essential for determining disease extent, anticipating complications, and planning the appropriate surgical approach. HRCT temporal bone, owing to its excellent delineation of osseous anatomy, has become the imaging modality of choice in the preoperative evaluation of cholesteatoma.

In the present study, the ≤20 years age group constituted the largest proportion of patients (41.7%), indicating a predominance of cholesteatoma among younger individuals, likely related to early-onset Eustachian tube dysfunction and recurrent middle ear infections. Female

patients accounted for 61.7% of the study population, with a female-to-male ratio of 1.6:1. Left-sided disease was most common (41.7%), while bilateral involvement was observed in 26.7% of cases, suggesting advanced or longstanding disease. Delayed healthcare-seeking behaviour was evident, as 46.7% of patients presented after more than five years of symptoms. Ear discharge associated with hearing loss was the most frequent presenting complaint (56.7%), and attic retraction pocket with cholesteatoma was the predominant otoscopic finding (85%), consistent with the acquired pars flaccida subtype commonly described in literature.

Comparable findings have been reported in previous studies. Rajesh Kumar et al.[10] reported a predominance in the 31–40 years age group with female predominance, while Khale A et al.[11] observed the highest incidence in the 21–40 years age group. Jain SK et al.[12] similarly demonstrated a high incidence in the second to fourth decades of life, and Aljehani M et al.[13] reported female predominance in their series. These variations likely reflect differences in study population, referral patterns, and healthcare accessibility.

The present study demonstrated excellent diagnostic performance of HRCT temporal bone for most evaluated parameters. HRCT achieved 100% sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy for soft tissue density, aditus ad antrum widening, scutum erosion, ossicular erosion involving the malleus, incus, and stapes, tegmen tympani erosion, mastoid cortex erosion, and intracranial complications. Tympanum erosion showed sensitivity of 98.2% and accuracy of 98.3%, with only one false-negative case. These findings emphasize the high reliability of HRCT in delineating disease extent and identifying bony erosions critical for surgical planning.

Similar observations have been documented in earlier studies. Kapoor AA et al.[14] reported sensitivity exceeding 90% for scutum erosion and mastoid sclerosis with specificity greater than 90% for facial canal and sinus plate erosion. Manik S et al.[15] demonstrated perfect correlation for sigmoid sinus plate erosion, mastoid cortex dehiscence, and scutum erosion, while good correlation was observed for ossicular and tegmen erosion. Dashottar S et al.[16] reported sensitivities ranging from 82–100% for scutum, tegmen, and incus erosion. Aljehani M et al.[13] observed perfect diagnostic indices for ossicular and sigmoid plate erosion, whereas Uz Zaman S et al.[17] demonstrated an overall HRCT accuracy of 95% in cholesteatoma evaluation.

Despite excellent overall performance, HRCT showed reduced sensitivity for lateral semicircular canal (SCC) fistula and facial canal dehiscence. In the present study, lateral SCC fistula was detected in 6.7% on HRCT compared with 15.0% intraoperatively, yielding a sensitivity of 44.4% and accuracy of 91.7%. Similarly, facial canal dehiscence was identified in 10.0% on HRCT versus 18.3% intraoperatively, with sensitivity of 54.5% and accuracy of 91.7%. However, specificity and PPV remained 100% for both parameters, indicating absence of false-positive findings. These results suggest that HRCT is highly reliable when positive findings are present but may underestimate subtle bony dehiscences due to the thin osseous covering and adjacent soft tissue masking effects.

These findings are consistent with existing literature. Dashottar S et al.[16] reported only 50% sensitivity for facial canal erosion, while Manik S et al.[15] found moderate correlation for facial canal dehiscence. Ram B et al.[18] similarly described good rather than excellent correlation for labyrinthine fistula and facial canal involvement. Lahel RS et al.[19] reported the lowest agreement for facial canal erosion and attributed discrepancies to partial volume averaging effects. Nevertheless, Rajesh Kumar et al.[10] demonstrated excellent sensitivity for SCC erosion, suggesting that diagnostic performance may vary based on disease severity, imaging protocols, and observer expertise.

Tegmen tympani erosion and sigmoid sinus plate erosion demonstrated excellent radio-surgical correlation in the present study. Tegmen erosion showed 100% sensitivity, specificity, and accuracy, while sigmoid sinus plate erosion demonstrated sensitivity of 85.7%, specificity of 100%, and accuracy of 98.3%, with only one false-negative case. Similar excellent correlations have been reported by Ram B et al.[18], Manik S et al.[15], and Aljehani M et al.[13], reinforcing the utility of HRCT in identifying critical skull base erosions and potential intracranial extension.

Mastoid cortex erosion was identified in 95% of patients with complete agreement between HRCT and intraoperative findings, reflecting the advanced and chronic nature of disease in this cohort. Intracranial complications were present in 5% of patients and demonstrated perfect HRCT correlation. Previous studies by Jain SK et al.[12] and Ram B et al.[18] similarly reported excellent accuracy of HRCT in detecting mastoid involvement and intracranial complications.

The extensive disease burden observed in the present study was reflected in the surgical management pattern. Canal Wall Down (CWD) tympanomastoidectomy was performed in 93.3% of patients, whereas Canal Wall Up (CWU) surgery was feasible in only 6.7% of cases. High rates of mastoid cortex erosion, aditus widening, scutum erosion, and ossicular chain involvement on HRCT strongly influenced the preference for CWD surgery. Similar conclusions regarding the role of HRCT in guiding surgical planning have been emphasized by Jain SK et al.[12], Rajesh Kumar et al.[10], and Pandey N et al.[20]

Overall radio-surgical agreement in the present study was rated as good in all cases, demonstrating excellent concordance between HRCT findings and intraoperative observations. These findings strongly support the role of HRCT temporal bone as an indispensable preoperative

imaging modality in cholesteatoma. Accurate mapping of disease extent by HRCT not only facilitates appropriate surgical planning and reduces intraoperative surprises but also aids in counselling patients regarding disease severity, surgical risks, and expected outcomes.

CONCLUSION

The present study demonstrates that HRCT temporal bone is a highly reliable and accurate imaging modality for the preoperative evaluation of cholesteatoma, showing excellent correlation with intraoperative findings for most anatomical parameters. HRCT accurately identified disease extent, ossicular erosion, mastoid involvement, and intracranial complications, thereby aiding effective surgical planning and reducing intraoperative surprises. Although its sensitivity was lower for facial canal dehiscence and lateral semicircular canal fistula, the overall diagnostic performance remained excellent, confirming HRCT as an indispensable tool in the management of cholesteatoma.

FIG 1: ATTIC CHOLESTEATOMA

FIG 2: TYMPANIC CHOLESTEATOMA

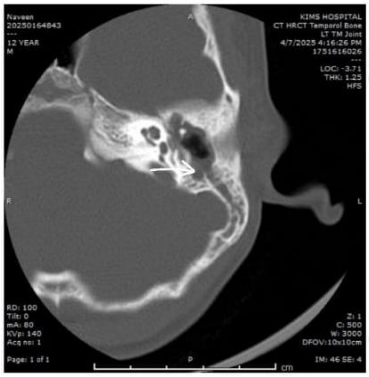
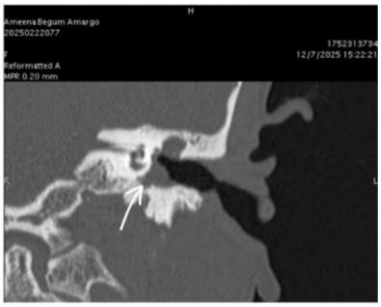


FIG 3: SCUTUM EROSION IN CHOLESTEATOMA



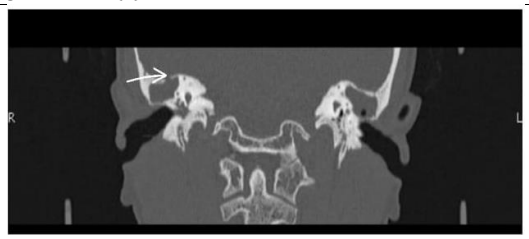
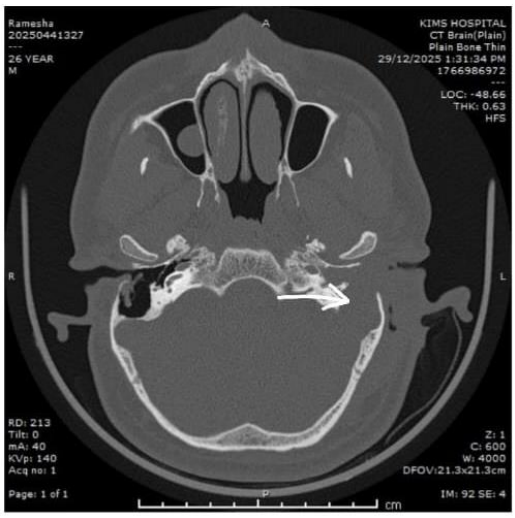


FIG 4: TEGMEN EROSION IN CHOLESTEATOMA

FIG 5: SIGMOID PLATE EROSION



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