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Diagnostic Accuracy of Preoperative High-Resolution Computed Tomography Compared With Intraoperative Findings in Active Squamous Chronic Otitis Media: A Cross-Sectional Study

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Abstract

Background and objective

High-resolution CT (HRCT) is widely used to map cholesteatoma before surgery, but its diagnostic performance differs across temporal bone structures. This study evaluated the diagnostic accuracy of preoperative HRCT and used paired analysis to determine whether HRCT systematically over- or underdetected operative findings in active squamous chronic otitis media.

Methods

This cross-sectional diagnostic accuracy study included 55 patients who underwent temporal bone HRCT followed by cholesteatoma surgery at Bangladesh Medical University from September 1, 2025, to August 29, 2026. Intraoperative findings were the reference standard. Patient-level 2 × 2 tables were used to calculate sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy with exact 95% confidence intervals (CIs). Two-sided exact McNemar tests were used for paired comparisons, with Holm adjustment as a multiplicity sensitivity analysis.

Results

The mean age of the cohort was 23.02 ± 11.33 years, and 39/55 patients (70.9%) were male. Scutum erosion was present in 55/55 patients (100.0%) on both HRCT and surgery. Overall accuracy was 52/55 (94.5%) for posterior meatal wall erosion and 51/55 (92.7%) for lateral semicircular canal (LSCC) fistula. Incus erosion was detected in 37/55 patients (67.3%) on HRCT and 50/55 (90.9%) at surgery; sensitivity was 36/50 (72.0%) and specificity 4/5 (80.0%) (exact McNemar $p = 0.00098$; Holm-adjusted $p = 0.0049$). Tegmen erosion was reported in 28/55 patients (50.9%) on HRCT versus 4/55 (7.3%) at surgery, and facial canal dehiscence in 38/55 (69.1%) versus 11/55 (20.0%); both were significantly overdetected and remained significant after Holm adjustment. Mesotympanic involvement was 48/55 (87.3%) on HRCT versus 39/55 (70.9%) at surgery ($p = 0.035$), but no disease-extension comparison remained significant after Holm adjustment.

Conclusions

HRCT is a useful preoperative surgical roadmap in cholesteatoma, but its diagnostic performance is structure-dependent. It performed well for posterior meatal wall erosion and lateral semicircular canal fistula, while incus erosion was significantly underdetected and tegmen erosion and facial canal dehiscence were significantly overdetected. Exact McNemar analysis appropriately accounts for the paired nature of HRCT and intraoperative observations and should be interpreted alongside structure-specific diagnostic accuracy measures.

Categories: Otolaryngology

Keywords: active squamous com, cholesteatoma, chronic otitis media, diagnostic accuracy, epitympanic cholesteatoma, high-resolution computed tomography, intraoperative findings, mcnemar test, ossicular erosion, temporal bone

Introduction

Active squamous chronic otitis media (cholesteatoma) is characterized by progressive keratin accumulation within the middle ear and mastoid, which can lead to local bone destruction [1,2]. The disease remains clinically important in developing countries. A nationwide Bangladeshi survey reported a prevalence of chronic suppurative otitis media of 6.2%, including 0.6% of cases involving atticotympanic disease (cholesteatoma) [3].

Cholesteatoma commonly presents with persistent otorrhea and hearing loss, but advanced disease may

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cause vertigo, facial nerve dysfunction, labyrinthine fistula, or intracranial complications [4]. Preoperative recognition of ossicular injury and disease extension matters because the incus may require reconstruction, a lateral semicircular canal (LSCC) fistula entails labyrinthine risk, facial canal dehiscence increases the risk of nerve injury, and tegmen defects may expose the dura. The scutum and posterior canal wall also help characterize the extent of bone erosion. Surgery remains necessary for disease eradication, with operative decisions guided by the underlying anatomy and disease extent [5].

High-resolution CT (HRCT) of the temporal bone provides detailed visualization of bony anatomy and can demonstrate scutum erosion, ossicular destruction, posterior canal wall defects, tegmen defects, facial canal abnormalities, and LSCC fistula [6,7]. Diagnostic performance varies across these structures. Very thin bony plates and small ossicular components are susceptible to partial-volume effects, while cholesteatoma, granulation tissue, edema, and fluid may exhibit similar soft-tissue attenuation on CT [7,8]. Diffusion-weighted MRI offers better tissue characterization, but HRCT remains central to preoperative assessment because of its detailed depiction of bony anatomy [8].

Published studies have reported variable agreement between HRCT and operative findings, particularly for the stapes, facial canal, tegmen, and hidden recesses [9-12]. This study provides patient-level, structure-specific accuracy estimates and paired comparisons in a prospectively enrolled cohort from a tertiary center in Bangladesh. The primary objective was to estimate HRCT sensitivity, specificity, and predictive values for specific temporal bone findings against documented intraoperative observations. Secondary objectives were to describe paired discordance and findings related to disease extension.

Materials And Methods

Study design and setting

This prospective, observational, cross-sectional diagnostic accuracy study was conducted in the Department of Otolaryngology-Head and Neck Surgery, in collaboration with the Department of Radiology and Imaging, at Bangladesh Medical University (BMU), Dhaka, from September 1, 2025, to August 29, 2026. Fifty-five eligible patients presenting consecutively with active squamous chronic otitis media were prospectively enrolled. All included patients underwent temporal bone HRCT followed by surgery. The study was prepared with reference to the STARD 2015 guidelines [13].

Eligibility

Patients with active squamous chronic otitis media (cholesteatoma) who underwent preoperative temporal bone HRCT followed by surgery were eligible for inclusion. Patients undergoing revision surgery, those unfit for surgery, and those with incomplete imaging or surgical data were excluded.

Sample-size calculation

The sample size was calculated using Buderer's formula for diagnostic accuracy studies [14]. Based on previously published estimates, the anticipated sensitivity and specificity of HRCT for detecting incus erosion were 97% and 95%, respectively, with an estimated prevalence of 60%. Assuming a 95% confidence level and an absolute precision of 10%, the minimum required sample sizes were 19 based on sensitivity and 46 based on specificity. After allowing an additional 10% for potential dropout or incomplete data, the target sample size was 51 patients. A total of 55 eligible patients were prospectively and consecutively enrolled and included in the final analysis.

Imaging and operative assessment

All patients underwent detailed history-taking, clinical examination, including microscopic and otoendoscopic examinations, and relevant investigations. All HRCT examinations were performed in the Department of Radiology and Imaging at BMU using a 128-slice Philips spiral CT scanner (Philips Healthcare (Suzhou) Co., Ltd., Suzhou, China) with an 18-24 cm field of view. Axial images were acquired at a slice thickness of 0.5 mm, with coronal and sagittal multiplanar reconstructions. HRCT examinations were reviewed in Digital Imaging and Communications in Medicine (DICOM) format by a single radiologist specializing in head and neck imaging. The original clinical HRCT reports were prepared by the radiologist before surgery, without knowledge of the subsequent intraoperative findings.

All surgical procedures were performed by a single experienced otologic surgeon (KLS). The intraoperative findings were systematically assessed and documented, with particular attention to ossicular erosion, scutum erosion, posterior meatal wall erosion, tegmen defects, facial canal dehiscence, and LSCC fistula and involvement of the epitympanum, mesotympanum, sinus tympani, facial recess, aditus ad antrum, and mastoid antrum. The tegmen and facial canal were exposed and directly inspected in all 55 patients to assess the presence or absence of bony defects. These intraoperative observations served as the reference standard for comparison with the preoperative HRCT findings.

Statistical analysis

The finalized patient-level dataset contained 55 analyzable cases. Continuous variables were summarized as mean and standard deviation (SD), and categorical variables as counts and percentages. Intraoperative findings were treated as the reference standard. For each binary structural endpoint, patient-level 2 × 2 tables were reconstructed and sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy were calculated. Exact 95% binomial confidence intervals were calculated using the Clopper-Pearson method [15]. Because HRCT and intraoperative findings were paired observations in the same patients, two-sided exact McNemar tests were used to compare paired marginal proportions [16].

A nominal two-sided p-value < 0.05 was considered statistically significant. To assess robustness to multiple comparisons, Holm-adjusted p-values were calculated separately for the testable structural endpoints and disease-extension endpoints [17]. Scutum erosion was positive in all patients by both methods; therefore, specificity and NPV were not estimable, and McNemar testing was not informative for this endpoint. Analyses for the manuscript were performed using Python 3.13.5 (Python Software Foundation, Wilmington, DE), SciPy 1.17.0 (SciPy Developers), and statsmodels 0.14.6 (statsmodels Developers).

Ethical approval

The study protocol (Protocol No. 5601) was approved by the Institutional Review Board of Bangladesh Medical University (Approval No. BMU/2025/12245). Written informed consent was obtained from participants or their legal guardians, and confidentiality was maintained.

Results

Participant characteristics

A total of 55 patients were included (mean age: 23.02 years, SD: 11.33; range: 2-54 years). Thirty-nine (70.9%) were male, and 16 (29.1%) were female. The right ear was affected in 32 patients (58.2%), while the left ear was affected in 23 (41.8%).

Structural findings on HRCT and surgery

Scutum erosion was present in 55/55 patients (100.0%) on both HRCT and intraoperative assessment. Among the ossicles, intraoperative erosion was most frequent in the incus (50/55, 90.9%), followed by the malleus (34/55, 61.8%) and stapes (21/55, 38.2%). HRCT identified malleus erosion in 37/55 patients (67.3%), incus erosion in 37/55 (67.3%), and stapes erosion in 32/55 (58.2%). HRCT also reported substantially more tegmen defects and facial canal dehiscence than were confirmed at surgery. Posterior meatal wall erosion and LSCC fistula had similar frequencies on imaging and at surgery (Table 1).

Anatomical structure	HRCT, n (%)	Intraoperative, n (%)
Malleus erosion	37 (67.3)	34 (61.8)
Incus erosion	37 (67.3)	50 (90.9)
Stapes erosion	32 (58.2)	21 (38.2)
Scutum erosion	55 (100.0)	55 (100.0)
Posterior meatal wall erosion	6 (10.9)	5 (9.1)
Tegmen erosion	28 (50.9)	4 (7.3)
Facial canal dehiscence	38 (69.1)	11 (20.0)
LSCC fistula	9 (16.4)	7 (12.7)

TABLE 1: Comparison of preoperative HRCT and intraoperative structural findings (n = 55)

HRCT: high-resolution computed tomography; LSCC: lateral semicircular canal

Diagnostic accuracy of structural findings

Patient-level analysis showed that HRCT performance varied substantially across structures. Posterior meatal wall erosion had a sensitivity of 4/5 (80.0%), specificity of 48/50 (96.0%), and overall accuracy of 52/55 (94.5%). LSCC fistula had a sensitivity of 6/7 (85.7%), specificity of 45/48 (93.8%), and accuracy of 51/55 (92.7%). Malleus erosion had a sensitivity of 29/34 (85.3%) and specificity of 13/21 (61.9%). For incus erosion, sensitivity was 36/50 (72.0%) and specificity was 4/5 (80.0%). Given the high prevalence of incus

erosion at surgery, the PPV was 36/37 (97.3%), whereas the NPV was 4/18 (22.2%). Tegmen erosion had a sensitivity of 3/4 (75.0%), specificity of 26/51 (51.0%), and PPV of 3/28 (10.7%). Facial canal dehiscence had a sensitivity of 9/11 (81.8%), specificity of 15/44 (34.1%), and PPV of 9/38 (23.7%), suggesting frequent radiological overestimation of these findings (Table 2).

Structure	Sensitivity, n/N (%) (95% CI)	Specificity, n/N (%) (95% CI)	PPV, n/N (%) (95% CI)	NPV, n/N (%) (95% CI)	Accuracy, n/N (%) (95% CI)
Malleus erosion	29/34 (85.3) (68.9-95.0)	13/21 (61.9) (38.4-81.9)	29/37 (78.4) (61.8-90.2)	13/18 (72.2) (46.5-90.3)	42/55 (76.4) (63.0-86.8)
Incus erosion	36/50 (72.0) (57.5-83.8)	4/5 (80.0) (28.4-99.5)	36/37 (97.3) (85.8-99.9)	4/18 (22.2) (6.4-47.6)	40/55 (72.7) (59.0-83.9)
Stapes erosion	16/21 (76.2) (52.8-91.8)	18/34 (52.9) (35.1-70.2)	16/32 (50.0) (31.9-68.1)	18/23 (78.3) (56.3-92.5)	34/55 (61.8) (47.7-74.6)
Scutum erosion	55/55 (100.0) (93.5-100.0)	N/A	55/55 (100.0) (93.5-100.0)	N/A	55/55 (100.0) (93.5-100.0)
Posterior meatal wall erosion	4/5 (80.0) (28.4-99.5)	48/50 (96.0) (86.3-99.5)	4/6 (66.7) (22.3-95.7)	48/49 (98.0) (89.1-99.9)	52/55 (94.5) (84.9-98.9)
Tegmen erosion	3/4 (75.0) (19.4-99.4)	26/51 (51.0) (36.6-65.2)	3/28 (10.7) (2.3-28.2)	26/27 (96.3) (81.0-99.9)	29/55 (52.7) (38.8-66.3)
Facial canal dehiscence	9/11 (81.8) (48.2-97.7)	15/44 (34.1) (20.5-49.9)	9/38 (23.7) (11.4-40.2)	15/17 (88.2) (63.6-98.5)	24/55 (43.6) (30.3-57.7)
LSCC fistula	6/7 (85.7) (42.1-99.6)	45/48 (93.8) (82.8-98.7)	6/9 (66.7) (29.9-92.5)	45/46 (97.8) (88.5-99.9)	51/55 (92.7) (82.4-98.0)

TABLE 2: Calculated diagnostic performance of HRCT using intraoperative findings as the reference standard

Exact 95% CIs were calculated using the Clopper-Pearson method

HRCT: high-resolution computed tomography; CI: confidence interval; PPV: positive predictive value; NPV: negative predictive value; N/A: not estimable because no operative-negative cases were present for scutum erosion; LSCC: lateral semicircular canal

Paired McNemar analysis of structural findings

Exact McNemar testing identified significant systematic underdetection of incus erosion (p = 0.00098; Holm-adjusted p = 0.0049) and significant overdetec-tion of tegmen erosion (p < 0.000001; Holm-adjusted p < 0.00001) and facial canal dehiscence (p < 0.000001; Holm-adjusted p < 0.00001). Stapes erosion showed nominal overdetec-tion (p = 0.0266), but this did not remain significant after multiplicity adjustment (Holm-adjusted p = 0.106). No significant paired marginal difference was observed for malleus erosion, posterior meatal wall erosion, or LSCC fistula. Scutum erosion showed complete concordance with no discordant pairs, so McNemar testing was not informative (Table 3).

Structure	Exact McNemar p	Holm-adjusted p	Interpretation
Malleus erosion	0.581	1.000	No significant paired difference
Incus erosion	0.00098	0.0049	HRCT significantly underdetects
Stapes erosion	0.0266	0.106	Nominal HRCT over-detection only
Scutum erosion	N/A	N/A	Complete concordance; no discordant pairs
Posterior meatal wall erosion	1.000	1.000	No significant paired difference
Tegmen erosion	< 0.000001	< 0.00001	HRCT significantly overdetects
Facial canal dehiscence	< 0.000001	< 0.00001	HRCT significantly overdetects
LSCC fistula	0.625	1.000	No significant paired difference

TABLE 3: Exact paired comparison of HRCT with intraoperative structural findings

McNemar tests are two-sided exact tests. Holm-adjusted p-values are shown as a multiplicity sensitivity analysis across the seven testable structural endpoints; scutum erosion was excluded because there were no discordant pairs

HRCT: high-resolution computed tomography; LSCC: lateral semicircular canal

Disease extension: paired HRCT and intraoperative analysis

HRCT identified epitympanic involvement in 54/55 patients (98.2%) and aditus ad antrum involvement in 54/55 (98.2%), compared with 55/55 (100.0%) at surgery for each site. Mesotympanic involvement was identified in 48/55 patients (87.3%) on HRCT and 39/55 (70.9%) intraoperatively; the exact McNemar p-value was 0.035, but this did not remain significant after Holm adjustment (adjusted p = 0.211). Sinus tympani involvement was 39/55 (70.9%) on HRCT and 31/55 (56.4%) intraoperatively (p = 0.057), and facial recess involvement was 44/55 (80.0%) and 37/55 (67.3%), respectively (p = 0.092). After Holm correction, no disease-extension site showed a statistically significant paired difference between HRCT and surgery (Table 4).

Site	HRCT, n (%)	Intraoperative, n (%)	Exact McNemar p	Holm-adjusted p
Epitympanum	54 (98.2)	55 (100.0)	1.000	1.000
Mesotympanum	48 (87.3)	39 (70.9)	0.035	0.211
Sinus tympani	39 (70.9)	31 (56.4)	0.057	0.287
Facial recess	44 (80.0)	37 (67.3)	0.092	0.369
Aditus ad antrum	54 (98.2)	55 (100.0)	1.000	1.000
Mastoid antrum	53 (96.4)	51 (92.7)	0.688	1.000

TABLE 4: Disease extension on HRCT versus surgery using paired exact McNemar analysis

McNemar tests are two-sided exact tests. Holm-adjusted p-values were calculated across the six disease-extension endpoints

HRCT: high-resolution computed tomography

Discussion

The findings from this prospective cohort demonstrate marked structure-specific variation in the agreement between preoperative HRCT reports and intraoperative documentation. The primary clinical finding is that HRCT may fail to detect incus erosion. Fourteen of the 50 cases of operative incus erosion were not reported on HRCT, consistent with the small size of the ossicular components and their potential obscuration by adjacent soft tissue [7,9,18-21]. The high prevalence of incus injury in this cohort (90.9%) also contributes to the low NPV. Therefore, a normal-appearing incus on HRCT should not be considered evidence that the ossicles are intact.

The systematic review by Finch et al. [22] synthesized 15 studies and reported the strongest HRCT-operative correlation for malleus erosion ($\kappa = 0.77$), followed by LSCC and tegmen findings ($\kappa = 0.69$), with weaker correlation for facial nerve dehiscence ($\kappa = 0.55$). Our findings are consistent with the broader message that CT performance differs across structures, although quantitative comparison is limited because our study reports diagnostic accuracy against documented surgical findings rather than study-level agreement coefficients. Previous reports by Manik et al. [9], Agarwal et al. [11], and Saha et al. [20] likewise address HRCT-surgical comparisons; differences in clinical spectrum and verification practice may account for heterogeneous estimates.

The substantially higher frequencies of HRCT-positive tegmen defects and facial canal dehiscence compared with intraoperative findings warrant careful interpretation. Both structures were exposed and directly inspected during surgery in all patients. The observed discrepancies suggest radiological overestimation of bony defects, potentially related to thin bony coverings, partial-volume effects, adjacent inflammatory tissue, and imaging interpretation thresholds [6,7,9]. Clinically, suspected tegmen defects and facial canal dehiscence on HRCT should heighten surgical caution without being regarded as definitive evidence of an actual bony defect.

For posterior meatal wall erosion and LSCC fistula, HRCT demonstrated high overall diagnostic accuracy (94.5% and 92.7%, respectively). However, the number of intraoperatively positive cases was limited (five and seven, respectively), resulting in wide confidence intervals for sensitivity. The positive predictive value was 66.7% for both structures, and the high overall accuracy was partly influenced by the predominance of negative cases. The findings for posterior meatal wall erosion and LSCC fistula were broadly consistent with previous studies reporting good agreement between HRCT and intraoperative observations [9,20]. Nevertheless, these results should be interpreted cautiously because of the limited number of positive cases.

Scutum erosion was noted by both sources in every patient, reflecting a cohort enriched for advanced disease but providing no specificity estimate or meaningful discrimination of structural erosion. Similar high agreement has been reported in previous studies, with near-perfect diagnostic accuracy [6,9]. For disease extension, apparent differences in recesses such as the mesotympanum did not persist after multiplicity adjustment, and CT soft-tissue attenuation cannot establish histological composition [8].

These results support using HRCT primarily as an anatomic surgical roadmap rather than as a substitute for intraoperative assessment. A positive finding may be highly informative for some hazards, such as LSCC fistula and posterior meatal wall erosion, whereas negative imaging may not exclude ossicular damage, and apparent defects in thin bony structures may be false positives. Selected cases may benefit from complementary diffusion-weighted MRI for tissue characterization, while ultrahigh-resolution CT may improve visualization of very small bony structures where available [8,23].

Limitations

This study has several limitations. It was conducted at a single tertiary center by a single surgeon and included 55 prospectively and consecutively enrolled patients. The study population predominantly represented advanced cholesteatoma, with scutum erosion present in all patients, potentially limiting the generalizability of the findings. The relatively small numbers of positive or negative cases for certain anatomical structures resulted in wide confidence intervals and reduced precision of the diagnostic accuracy estimates. Specifically, only five patients had no intraoperative incus erosion, limiting the precision of specificity estimates, while posterior meatal wall erosion and LSCC fistula were identified in only five and seven patients, respectively. Although the sample size was calculated a priori using anticipated diagnostic accuracy parameters for incus erosion, it did not ensure adequate precision across all anatomical endpoints.

The study relied on original preoperative radiology reports rather than standardized image reassessment, and interobserver and intraobserver agreement were not evaluated. Although key HRCT acquisition parameters were documented, the reconstruction interval and algorithm were unavailable. Additionally, the exact interval between HRCT and surgery was not systematically recorded, which precluded assessment of its potential effect on diagnostic concordance. Finally, ossicular erosion was evaluated for each ossicle as a whole, without separate analysis of individual ossicular substructures.

Conclusions

In this prospective study of 55 consecutively enrolled patients with active squamous chronic otitis media, the diagnostic performance of preoperative HRCT varied across anatomical structures. HRCT significantly underdetected incus erosion, whereas tegmen defects and facial canal dehiscence were more frequently identified on HRCT than confirmed intraoperatively, suggesting radiological overestimation. HRCT demonstrated high overall accuracy for posterior meatal wall erosion and LSCC fistula; however, these estimates should be interpreted cautiously because of the small numbers of positive cases. Scutum erosion was present in all patients by both methods, limiting assessment of its discriminatory performance. Although HRCT provides valuable anatomical information for preoperative surgical planning, its findings should be interpreted alongside clinical assessment and confirmed intraoperatively. Larger prospective studies are warranted to validate these structure-specific findings.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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Disclosures

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