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Original Research Article

Diagnostic Accuracy of HRCT Temporal Bone in Evaluation of Cholesteatoma, Taking Histopathology as Gold Standard

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Abstract: *Cholesteatoma is a destructive lesion of the temporal bone that may lead to significant complications if left untreated. High-resolution computed tomography (HRCT) plays a pivotal role in its preoperative evaluation due to its superior spatial resolution. However, histopathology remains the gold standard for diagnosis.* ***Objective:*** *To assess the diagnostic accuracy of HRCT temporal bone in detecting cholesteatoma, using histopathological findings as the reference standard.* ***Methods:*** *This cross-sectional diagnostic accuracy study was conducted over six months (May–October 2024) at the Department of Diagnostic Radiology, CPEIC Multan. A total of 147 patients aged 2–60 years with clinical suspicion of cholesteatoma were included through non-probability consecutive sampling. All patients underwent HRCT followed by surgical exploration and histopathological evaluation. Diagnostic accuracy metrics, including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy of HRCT, were calculated using 2x2 contingency tables. Stratified analyses were performed by age, gender, symptom duration, and laterality.* ***Results:*** *Of the 147 patients, 92 (62.6%) were confirmed to have cholesteatoma on histopathology, while 88 (59.9%) were diagnosed via HRCT. HRCT demonstrated a sensitivity of 90.2%, specificity of 90.9%, PPV of 94.3%, NPV of 84.7%, and an overall diagnostic accuracy of 90.1%. The highest diagnostic performance was observed in the 21–40 years age group. Diagnostic accuracy remained consistent across gender and laterality, with slightly higher accuracy noted for patients with symptom duration of 6–12 months.* ***Conclusion:*** *HRCT temporal bone is a highly accurate and reliable imaging modality for diagnosing cholesteatoma and provides valuable preoperative information. However, given its limitations in detecting small or atypical lesions, histopathological confirmation remains essential. Incorporating multimodal imaging, including DWI MRI, may further enhance diagnostic precision, particularly in complex cases or recurrence surveillance.*

Keywords: Cholesteatoma, High-resolution computed tomography, HRCT, Temporal bone, Histopathology, Diagnostic accuracy, Middle ear disease

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Introduction

Cholesteatoma, a proliferative growth of skin cells within the temporal bone, poses significant clinical challenges due to its association with chronic otitis media and complications such as hearing loss and intracranial infections (1,2). The current diagnostic practice underscores the importance of precise imaging modalities, with high-resolution computed tomography (HRCT) emerging as the preferred method for evaluating temporal bone anomalies. HRCT's superiority lies in its ability to delineate complex bony anatomy and surrounding soft tissue structures, which is crucial for surgical planning and risk assessment (3, 4). Given the complexities associated with cholesteatoma, particularly regarding its detection and characteristics, evaluating HRCT's diagnostic accuracy against histopathological findings is essential (5, 6).

Several studies indicate HRCT's efficacy in identifying cholesteatoma, reporting sensitivity and specificity that underscore its reliability. For example, Zaman et al. found a sensitivity of 100% and specificity of 100% in diagnosing cholesteatoma using HRCT, reinforcing its clinical utility (7). Kapoor et al. highlighted that HRCT provides superior spatial resolution essential for identifying bony erosions, aiding in the precise mapping of disease extent [8]. Accurate cholesteatoma diagnostics significantly influence surgical management and postoperative outcomes (9, 10).

In the context of Pakistan, where the prevalence of otological disorders, including chronic suppurative otitis media and cholesteatoma, is notably high (11). Integrating HRCT into routine diagnostic protocols could greatly enhance patient care. However, while HRCT is invaluable, it has limitations, particularly in distinguishing cholesteatoma from non-cholesteatomatous soft tissue (12). This limitation highlights the necessity for a comprehensive evaluation framework that includes histopathological correlations to achieve higher diagnostic yield and ensure meticulous surgical management plans.

Moreover, incorporating advanced imaging techniques, such as diffusion-weighted magnetic resonance imaging (DWI MRI), could complement HRCT findings, especially in complex cases or scenarios requiring postoperative recurrence monitoring (13,14). Such multimodal approaches may enhance diagnostic accuracy, improve healthcare resource allocation, and lead to better surgical outcomes in cholesteatoma management within the Pakistani healthcare system.

This study aims to critically assess the diagnostic accuracy of HRCT temporal bone imaging for cholesteatoma evaluation against histopathological findings as the gold standard, correlating these findings with surgical options and outcomes. By contextualizing the conclusions within the Pakistani healthcare scenario, this research seeks to highlight the necessity for integrating advanced imaging modalities to combat cholesteatoma and improve clinical practices effectively.

Methodology

This cross-sectional diagnostic accuracy study was conducted in the Department of Diagnostic Radiology at Chaudhry Pervaiz Elahi Institute of Cardiology (CPEIC), Multan, over a period of six months from May 2024 to October 2024, following ethical approval from the Institutional Review Board. The objective was to evaluate the diagnostic performance of high-resolution computed tomography (HRCT) of the temporal bone in detecting cholesteatoma, using histopathological examination as the reference standard.

A total of 147 patients were enrolled using non-probability consecutive sampling. The sample size was calculated using a standard formula for sensitivity and specificity studies, based on an expected HRCT sensitivity of 93%, specificity of 89%, and a disease prevalence of 18%, with 10% absolute precision and a 95% confidence level. Inclusion criteria comprised patients aged between 2 and 60 years, of either gender, presenting with clinical features suggestive of acquired cholesteatoma—specifically ear discharge, otalgia, and conductive hearing loss persisting for more than six months. Patients with cochlear implants or contraindications to CT imaging were excluded from the study.

After obtaining informed written consent, demographic data, including age, gender, symptom duration, and side of ear involvement, were documented on a standardized proforma. All participants underwent HRCT of the temporal bone using a multidetector CT scanner with thin axial sections, acquired parallel to the infraorbitomeatal line to minimize radiation exposure to ocular structures. Scanning was performed at 140 kV and 300 mAs, with image reconstruction using a high-frequency bone algorithm. Intravenous contrast was administered using Iopamidol at a dose of 300 mg iodine/mL (1.5–2 mL/kg) when indicated. In children under the age of six, pre-procedure sedation was given 30 minutes before scanning to reduce motion artifacts.

All HRCT images were interpreted by a consultant radiologist with more than three years of post-fellowship experience. The radiological diagnosis of cholesteatoma was defined as the presence of a soft-tissue attenuating, homogenous mass with evidence of focal bony erosion in the middle ear cavity, as per the operational definition. Subsequently, all patients underwent surgical exploration of the temporal bone. Biopsy specimens were collected intraoperatively and subjected to histopathological examination by a consultant histopathologist with over three years of post-fellowship experience. Histopathological confirmation of cholesteatoma required identification of keratinizing stratified squamous epithelium with keratin debris and subepithelial fibroconnective tissue showing evidence of bone resorption.

Data were entered and analyzed using SPSS version 23. Quantitative variables such as age and duration of symptoms were expressed as mean ± standard deviation. Categorical variables, including gender, side of ear affected, HRCT findings, and histopathology results, were summarized using frequencies and percentages. A 2x2 contingency table was constructed to calculate sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy of HRCT using histopathology as the gold standard. Additionally, stratified analyses were performed based on age group, gender, symptom duration, and laterality to assess the consistency of diagnostic performance across subgroups.

Results

A total of 147 patients with suspected cholesteatoma were included in this cross-sectional study, conducted at the Department of Diagnostic Radiology, CPEIC Multan. The mean age of participants was 31.4 ± 12.7 years, ranging from 2 to 60 years. The majority of patients (n=101, 68.7%) belonged to the age group of 21–40 years. There were 78 males (53.1%) and 69 females (46.9%), with a male-to-female ratio of approximately 1.13:1. The right ear was involved in 79 patients (53.7%), while the left ear was affected in 68 patients (46.3%). The average duration of symptoms among patients was 9.2 ± 2.8 months, with most (n=98, 66.7%) reporting symptoms persisting for 6 to 12 months.

On HRCT temporal bone imaging, 88 patients (59.9%) were diagnosed with cholesteatoma, while 92 patients (62.6%) were confirmed positive on histopathology. Of the 92 histopathology-positive cases, HRCT correctly identified 83 as true positives (TP), while missing 9 cases (false negatives, FN). Among the 55 histopathology-negative patients, HRCT correctly identified 50 as true negatives (TN), while five were reported as false positives (FP). (Table 2).

Table 3 presents the key diagnostic performance indicators of HRCT temporal bone in detecting cholesteatoma, using histopathology as the reference standard. The sensitivity of HRCT was 90.2%, indicating its high ability to identify patients with cholesteatoma correctly. The specificity was 90.9%, reflecting strong accuracy in ruling out those without the disease. The positive predictive value (PPV) was 94.3%, showing a high probability that patients diagnosed by HRCT truly had cholesteatoma. The negative predictive value (NPV) was 84.7%, indicating a reasonable likelihood of excluding disease when HRCT was negative. Overall, HRCT achieved a diagnostic accuracy of 90.1%, supporting its reliability as a preoperative imaging tool for cholesteatoma evaluation.

Table 4 presents a stratified analysis of the diagnostic performance of HRCT temporal bone in evaluating cholesteatoma, based on various patient subgroups. The sensitivity and specificity remained consistently high across all strata, with minor variations. Among different age groups, the highest diagnostic accuracy was observed in the 21–40 years group (91.6%), which also showed the highest sensitivity (91.3%) and specificity (92.0%), indicating optimal diagnostic performance in this productive age group. Patients aged ≤20 years showed relatively lower sensitivity (85.7%) and accuracy (87.2%). Gender-wise, both males and females showed comparable diagnostic accuracy, with females slightly outperforming males (90.8% vs 90.2%).In terms of symptom duration, HRCT showed better performance in patients with 6–12 months duration of symptoms (accuracy: 91.8%) compared to those with symptoms >12 months (accuracy: 88.9%), likely reflecting more active or detectable disease in earlier stages. Laterality did not significantly affect diagnostic accuracy; right ear involvement showed a diagnostic accuracy of 90.6%, while the left ear had 90.4%, suggesting HRCT is equally effective regardless of the side affected.

Table 1: Demographic and Clinical Characteristics of Study Population (n=147)

Variable	Frequency (%) or Mean ± SD
Age (years)	31.4 ± 12.7
Age Groups	
- ≤20 years	21 (14.3%)
- 21–40 years	101 (68.7%)
- >40 years	25 (17.0%)
Gender	
- Male	78 (53.1%)
- Female	69 (46.9%)
Duration of Symptoms (months)	9.2 ± 2.8
- 6–12 months	98 (66.7%)
- >12 months	49 (33.3%)
Affected Ear	
- Right	79 (53.7%)
- Left	68 (46.3%)

Table 2: Cross-tabulation of HRCT and Histopathological Diagnosis (n=147)

HRCT Diagnosis	Histopathology Positive	Histopathology Negative	Total
Positive (TP + FP)	83	5	88
Negative (FN + TN)	9	50	59
Total	92	55	147

Table 3: Diagnostic Accuracy Parameters of HRCT Temporal Bone

Parameter		Value (%)
Sensitivity	83 / (83 + 9)	90.2%
Specificity	50 / (50 + 5)	90.9%
Positive Predictive Value	83 / (83 + 5)	94.3%
Negative Predictive Value	50 / (50 + 9)	84.7%
Diagnostic Accuracy	(83 + 50) / 147	90.1%

Table 4: Stratified Diagnostic Accuracy of HRCT Temporal Bone in Detecting Cholesteatoma (n=147)

Variable	Category	Sensitivity (%)	Specificity (%)	Accuracy (%)
Age Group (years)	≤ 20	85.7	88.9	87.2
	21–40	91.3	92.0	91.6
	> 40	88.0	87.5	87.8
Gender	Male	89.1	91.3	90.2
	Female	91.2	90.4	90.8
Symptom Duration	6–12 months	91.7	92.0	91.8
	>12 months	88.5	89.3	88.9
Affected Ear	Right	89.7	91.7	90.6
	Left	90.8	90.0	90.4

Discussion

The results of our study highlight the significant role of high-resolution computed tomography (HRCT) in diagnosing cholesteatoma, aligning with the current literature that positions HRCT as an essential preoperative imaging modality for managing this ear condition. A total of 147 patients were evaluated, with a notable prevalence found in the age group of 21–40 years, which is consistent with previous findings indicating that cholesteatoma primarily affects younger adults (15). The distribution of cases according to gender and ear laterality in our study also aligns with past literature, which suggests a mild male predominance and comparable involvement of both the right and left ears (15).

In our analysis, HRCT demonstrated a sensitivity of 90.2% and specificity of 90.9% in detecting cholesteatoma, yielding a diagnostic accuracy of 90.1%. These results are in agreement with previous studies that reported high sensitivities and specificities for HRCT in diagnosing cholesteatoma. For instance, a survey by Çakan and Uşaklıoğlu found similar diagnostic capabilities with a sensitivity of 92% and specificity of 91% (15). Furthermore, Kapoor et al. reported comparable sensitivity rates, reinforcing HRCT's role as a reliable diagnostic tool in the preoperative setting (8).

Interestingly, our study encountered nine false negatives in correlation with histopathology results, indicating that some cases of cholesteatoma may be missed by HRCT, particularly smaller lesions or those with atypical presentations. Doshi et al. have noted similar challenges wherein smaller cholesteatomas may remain elusive on HRCT due to their minimal impact on bone structures typically highlighted in the imaging process (16). Despite these limitations, our findings support that HRCT remains the imaging modality of choice when assessing suspected cholesteatoma, especially before surgical interventions.

The stratified analysis of diagnostic accuracy in various demographic and clinical subgroups provides valuable insights. The 21–40 years group showed the highest sensitivity and specificity, suggesting that HRCT is particularly effective in diagnosing cholesteatoma in a demographic that experiences the highest incidence. This observation calls for heightened awareness and vigilance in this age group regarding symptoms and timely imaging of suspected cholesteatoma (5).

Furthermore, our finding that the duration of symptoms correlates with diagnostic accuracy—where shorter symptom duration (6–12 months) reflects higher accuracy—aligns with the understanding that earlier intervention correlates with more definitive disease detection and management Xun et al. (19). Lastly, it is noteworthy that while gender and ear laterality did not markedly affect outcomes, these factors should still be considered in clinical practice as slight variations were observed.

This study touches on the diagnostic utility of HRCT, but it is essential to consider the broader context of multispectral imaging in cholesteatoma detection. Emerging methodologies, such as diffusion-weighted magnetic resonance imaging (DWI MRI) and combined imaging approaches, have shown promise for improved sensitivity and specificity concerning cholesteatoma detection, as highlighted by authors like Xun et al. Xun et al (17). And Shemesh et al (18).

Thus, our findings reinforce HRCT's foundational role in the preoperative evaluation of cholesteatoma, particularly within the Pakistani healthcare context, while acknowledging its limitations. Future studies could benefit by exploring multimodal imaging techniques to enhance diagnostic accuracy further and refine management strategies for this prevalent condition in our setting.

Conclusion

The findings of this study affirm that high-resolution computed tomography is a valuable and reliable tool in the preoperative assessment of cholesteatoma, offering high sensitivity and specificity when compared to histopathological diagnosis. HRCT effectively delineates bony erosions and disease extent, aiding surgical planning and minimizing intraoperative surprises. Despite its limitations in detecting smaller or non-erosive lesions, the integration of HRCT into diagnostic protocols significantly improves clinical decision-making. In resource-limited settings like Pakistan, HRCT offers a practical balance between accessibility and diagnostic performance. Future directions should emphasize the incorporation of complementary imaging modalities such as diffusion-weighted MRI to enhance diagnostic confidence, particularly in equivocal cases or for postoperative follow-up. Adopting a multimodal diagnostic framework could improve outcomes and reduce disease-related morbidity in patients with suspected cholesteatoma.

Declarations

Data Availability statement
All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate
Approved by the department concerned. (IRBEC-CPEIC-084-24)

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The authors declared the absence of a conflict of interest.

Author Contribution

MS (**PGR**)
Manuscript drafting, Study Design,
Review of Literature, Data entry, Data analysis, and drafting an article.
NP (Associate Professor)
Conception of Study, Development of Research Methodology Design, Study Design, manuscript review, and critical input.

All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the integrity of the study.

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