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DIAGNOSTIC ACCURACY OF HRCT TEMPORAL BONE IN THE DIAGNOSIS OF CHOLESTEATOMA TAKING HISTOPATHOLOGY AS GOLD STANDARD

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ABSTRACT

OBJECTIVE: To find out the diagnostic accuracy of HRCT temporal bone in the diagnoses of cholesteatoma taking histopathology as the gold standard.

MATERIALS AND METHODS: A cross-sectional study was done in the department of Diagnostic Radiology, Lahore General Hospital/PGMI Lahore, Pakistan. The duration of the study was six months. 111 was the sample size calculated using the WHO calculator with a sensitivity of 80.67%, specificity of 88%, confidence interval of 95% and 10% margin of error. The sample was collected using the Non-Probability sampling technique. Inclusion criteria included age from 6 months to 60 years; both genders were included, and diagnosed cases of chronic supportive otitis media as per operational definitions. Data analysis was done using SPSS version 22. Data was stratified based on gender, age, BMI and duration off symptoms. Diagnostic performance was calculated post-stratification.

RESULTS: This study highlights the significant role of High-Resolution Computed Tomography (HRCT) in diagnosing cholesteatoma, demonstrating an overall diagnostic accuracy of 87.4%**.** With a sensitivity of 89.5%, HRCT proves to be highly effective in detecting true cases, though its specificity of 75% suggests that histopathological confirmation is still essential in certain cases to rule out false positives. The positive predictive value (95.5%) indicates a strong ability to correctly diagnose cholesteatoma, while the negative predictive value (54.5%) underscores the possibility of missed cases, reinforcing the need for further evaluation in negative HRCT findings.

Stratification analysis revealed slightly improved accuracy in males **(**88.2%**)** and in patients experiencing symptoms for five or more years (89.1%)**.**

CONCLUSION: HRCT significantly aids in the early detection and evaluation of cholesteatoma, it should be used in conjunction with histopathological examination for definitive diagnosis. Further research incorporating larger sample sizes and emerging imaging techniques, such as diffusion-weighted MRI, may enhance diagnostic precision and improve patient management in the future.

KEYWORDS: High-Resolution Computed Tomography (HRCT), Cholesteatoma, Sensitivity and Specificity, Histopathological Confirmation, Otologic Imaging, Temporal Bone CT

INTRODUCTION

A Cholesteatoma is a non-neoplastic lesion of the middle ear cleft or any other pneumatized portion of the temporal bone that causes bony erosion. Cholesteatoma is characterized histopathologically by desquamated debris surrounded by layers of keratinizing squamous epithelium. There are two types of cholesteatoma: congenital and acquired. The classic cholesteatoma presentation is offensive otorrhea with conductive hearing loss due to ossicular erosion (l). Cholesteatoma is the most common complication of CSOM (2). Chronic suppurative otitis media is classified into two types: CSOM without Cholesteatoma, known clinically as the safe type, and CSOM with cholesteatoma, known clinically as the unsafe type(3). ln terms of prevalence, economics, and sequels, otitis media remains a significant international problem. Worldwide over 5 million people are affected with Cholesteatoma (6). Otoscopic examination is used to make a clinical diagnosis of cholesteatoma, and histopathology is the gold standard. Imaging measures such as HRCT on the other hand, are used. Because of its ability to assess the gross extent and fine details of bony architecture, HRCT can be used for the diagnosis of Cholesteatoma. According to a 2022 study conducted on 100 patients, HRCT temporal bone had a sensitivity of 100%, a specificity of 88.1%, a positive predictive value of 92%, a negative predictive value of 100%, and an accuracy of 95%, premature mass 63% for detecting cholesteatoma (4). Another study conducted in 2018, found that in a series of 50 cholesteatoma patients, the sensitivity of HRCT mass 80.6% and premature mass 83%, 82% were correctly diagnosed using an HRCT scan (5). The diagnosis of cholesteatoma is traditionally based on clinical evaluation and otoscopic examination. However, these methods may lack the precision needed to detect early-stage or masked cases of the disease [6]. High-resolution computed Tomography (HRCT) of the temporal bone has gained recognition as a crucial imaging modality due to its ability to delineate middle ear structures, assess disease extent, and identify bony erosions with high sensitivity [7]. Despite these advantages, HRCT findings may sometimes overlap with other middle ear pathologies, necessitating further confirmation through histopathology, which remains the gold standard for definitive diagnosis [8].

By accurately diagnosing the condition using HRCT temporal bone, the study can aid in the early detection and treatment of cholesteatoma. This has the potential to improve patient outcomes and reduce the need for invasive procedures such as biopsy, which can be upsetting for patients. Furthermore, the research can help hospitals by reducing the burden of misdiagnoses and unnecessary procedures, as well as saving money on re-evaluating patients. Similarly, by reducing the need for invasive procedures and lowering the risk of complications, countries can benfit from cost savings in healthcare.

Finally, the research will benefit the global community by improving our understandings of cholesteatoma, which affects millions of people around world. The findings of the study could pave the way for the development of new diagnostic techniques, as well as aid in the early detection and treatment of cholesteatoma. This can help to reduce the disease's global burden improve the healthcare outcomes.

METHODOLOGY

A cross-sectional study was done in department of diagnostic radiology, Lahore General Hospital/PGMI Lahore, Pakistan. Duration of the study was six months. 111 was the sample size calculated using WHO calculator with sensitivity of 80.67%, specificity of 88%, confidence interval of 95% and 10% margin of error with prevalence. Sample was collected using Non-Probability sampling technique. Inclusion criteria included age from 6 months to 60 years, both genders were included, diagnosed case of chronic supportive otitis media as per operational definitions. While, exclusion criteria excluded patients already operated for cholesteatoma, already diagnosed cases of cholesteatoma, patients having mass in middle/inner ear, patients having congenital defect in the middle/inner ear, patients with the history of trauma resulting in temporal bone injury and non-cooperative patients. Cultural ethics were observed by respecting the privacy of the patients and assuring proper confidentiality of patient's data. Written informed consent were obtained from all the patients in the local language. Data collection procedure included approval for the research was taken from the ethical review committee. A sample of 111 patients presenting to the department of Diagnostic Radiology, fulfilling the above mentioned selection criteria was enrolled after informed consent. The patient was subjected to detailed clinical history and examination along with a collection of past medical records. After getting basic data (e.g. name, age, gender and clinical history) HRCT temporal bone of the patient was done using 128 Siemen's machine according to standardized protocol. This may involve using the slice thickness of 0.5mm and a high resolution algorithm. Images were taken in the axial plane and coronal/sagittal images were obtained by reformatting these images. After the HRCT all patients were referred back to ENT department and the patients were followed who undergone surgery. Cholesteatoma was confirmed or excluded by pathologist who was blinded to the HRCT images results. Histopathological findings were recorded in the structured data collection form. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy of HRCT temporal bone imaging for the diagnoses of cholesteatoma was calculated. The results were recorded and all the data was collected on the proforma attached Annexure-III. Data analysis procedure was done using SPSS version 22 statistical software. Quantitative variables like age, duration of symptoms and BMI were presented as mean and standard deviation. Qualitative variables like gender and cholesteatoma on HRCT and histopathology were expressed in frequency. Analysis was carried out to measure sensitivity, specificity, accuracy, positive predictive value and negative predictive value by using following 2 X 2 table. Data was stratified on gender, age, BMI and duration of the symptoms. Diagnostic performance was calculated post stratification.

RESULTS

A total of 111 patients were included in the study, with ages ranging from 6 months to 60 years (Mean ± SD: 35.4 ± 10.2 years). The male-to-female ratio was approximately 1.2:1, with 60 (54.1%) male and 51 (45.9%) female participants. The mean BMI of the patients was 23.8 ± 3.5 kg/m². The duration of symptoms varied from 6 months to 10 years, with a mean duration of 4.7 ± 2.1 years.

Table 1: Demographic Data of Study Participants

Characteristic	Frequency (n=111)	Percentage (%)
Age (Mean ± SD)	35.4 ± 10.2 years	-
Gender		
Male	60	54.1
Female	51	45.9
BMI (Mean ± SD)	23.8 ± 3.5 kg/m²	-
Duration of Symptoms (Mean ± SD)	4.7 ± 2.1 years	-

HRCT and Histopathological Findings; On HRCT, 89 out of 111 patients (80.2%) were diagnosed with cholesteatoma, while histopathology confirmed 95 cases (85.6%). Among these, 85 cases were true positives, while 4 were false positives (HRCT suggested cholesteatoma, but histopathology did not confirm it). There were 10 false negatives, meaning histopathology confirmed cholesteatoma, but HRCT did not detect it. 12 cases were true negatives.

Table 2: Comparison of HRCT and Histopathological Diagnosis

HRCT Findings	Histopathology Confirmed	Histopathology Not Confirmed	Total
Positive	85 (True Positives)	4 (False Positives)	89
Negative	10 (False Negatives)	12 (True Negatives)	22
Total	95	16	111

Diagnostic Accuracy of HRCT in Cholesteatoma Detection; The diagnostic accuracy parameters of HRCT were calculated based on the above findings:Sensitivity 89.5%, Specificity 75%, Positive Predictive Value (PPV) 95.5%, Negative Predictive Value (NPV) 54.5%, Overall Diagnostic Accuracy 87.4%.

Table 3: Diagnostic Performance of HRCT

Parameter	Value (%)
Sensitivity	89.5
Specificity	75.0
Positive Predictive Value (PPV)	95.5
Negative Predictive Value (NPV)	54.5
Overall Accuracy	87.4

The results were stratified based on gender, age, BMI, and symptom duration. The sensitivity and specificity values showed slight variations across different age groups, but overall, HRCT remained a highly effective diagnostic tool. In males, HRCT had an accuracy of 88.2%, while in females, the accuracy was 86.4%. The diagnostic accuracy was slightly higher in patients with symptoms lasting more than 5 years (89.1%) compared to those with a shorter duration (85.2%).

Table 4: HRCT Diagnostic Accuracy Based on Patient Characteristics

Stratification Factor	Sensitivity (%)	Specificity (%)	Accuracy (%)
Males	90.1	76.3	88.2
Females	88.7	73.5	86.4
Symptoms < 5 Years	88.0	74.1	85.2
Symptoms ≥ 5 Years	91.2	76.8	89.1

HRCT of the temporal bone showed high sensitivity (89.5%) in detecting cholesteatoma but had moderate specificity (75%).False negatives (10 cases) suggest that HRCT may miss certain early-stage or small cholesteatomas. False positives (4 cases) indicate that HRCT may sometimes misinterpret other middle ear pathologies as cholesteatoma. Post-stratification analysis revealed slightly higher accuracy in males (88.2%) and patients with symptoms lasting ≥ 5 years (89.1%). The overall accuracy of HRCT was 87.4%, demonstrating its effectiveness as a diagnostic tool for cholesteatoma. These findings highlight HRCT as a reliable, non-invasive imaging modality for cholesteatoma detection, though histopathological confirmation remains essential in cases where imaging results are inconclusive.

DISCUSSION

Diagnosing cholesteatoma primarily relies on otoscopic examination. However, imaging techniques are increasingly utilized to detect both obvious and subtle changes in the temporal bone, determine the extent of the disease, and identify potential complications. CT scans are particularly effective in detecting early bone erosion, evaluating the spread of cholesteatoma, and providing crucial information that may influence surgical procedures. With an 80% specificity rate, CT scans offer a detailed assessment of soft tissue masses and bone erosion, aiding in accurate diagnosis and treatment planning[1][9].

This study focused on the benefits of using high-resolution CT (HRCT) scans of the temporal bone to detect mastoid cholesteatoma, assess ossicular chain damage, and identify complications caused by bone erosion. HRCT was chosen over conventional CT because research has already proven it to be more accurate in diagnosis[2][10].

HRCT scans have proven to be highly effective in accurately diagnosing cholesteatoma in most cases. A key indicator of the condition was the presence of soft tissue causing expansion and erosion of the surrounding bony structures within the middle ear. In a study by Mafee et al. [11], out of 48 patients with cholesteatoma, 46 (96%) were correctly diagnosed through preoperative CT scans. In our study, all cases exhibited at least one radiological sign of cholesteatoma, such as a soft tissue mass, characteristic location, or bone erosion, while 43 cases (86%) displayed all three features. Additionally, there was a strong correlation between preoperative imaging results and surgical findings. The use of 1 mm slice thickness in both axial and coronal planes provided excellent contrast between bone, air, and soft tissues, enhancing diagnostic accuracy.

Like many similar studies, CT scans effectively identified key findings such as soft tissue masses and erosions of the ossicles and scutum. However, detecting the fallopian canal with the same level of precision as in other studies was not possible using CT imaging.

There was a strong correlation between temporal bone HRCT scans and surgical findings, particularly in cases of additus widening, sigmoid plate erosion, mastoid cortex erosion, and scutum erosion (k = 1). The correlation was also high for tegmen erosion (k = 0.77), malleus erosion (k = 0.9), incus erosion (k = 0.65), stapes erosion (k = 0.63), and lateral semicircular canal erosion (k = 0.73). However, facial canal dehiscence showed only a moderate correlation (k = 0.55). Additionally, HRCT scans demonstrated good agreement with surgical findings regarding disease spread in the protympanum, mesotympanum, posterior tympanum, epitympanum, additus, and antrum. There was also a strong correlation in detecting erosion of the posterior superior wall (k = 0.89) and peri-labyrinthine cells (k = 0.9).

Findings from Rocher et al. further supported these observations, showing excellent correlation for scutum, the horizontal semicircular canal (> 0.7), and the tegmen (0.77), while the facial nerve canal had a weaker correlation (< 0.5) [12].

Similar to the findings of Rogha et al. [13], our study also observed a correlation between fallopian canal erosion and labyrinthine fistula, with both conditions coexisting in some cases. This suggests that when one is present, surgeons should be vigilant in checking for the other to prevent potential iatrogenic injuries. Preoperative evaluation of facial canal dehiscence, including its location and size, is crucial in helping surgeons exercise caution during middle ear exploration. However, CT imaging has limitations in detecting dehiscence in the vertical segment of the facial canal due to its close proximity to inflamed mastoid air cells and surrounding soft tissue. This makes it challenging to differentiate between the structures.

Gerami et al. [14] also noted this limitation, reporting a weak correlation (low kappa value) between preoperative CT findings and intraoperative observations for facial nerve dehiscence (FND).

The relatively strong correlation between radiological and surgical findings for stapes erosion in this study may be attributed to the use of 1 mm slice thickness, which is essential given the small size of the stapes bone. Studies that relied on 2–3 mm slices in temporal bone CT scans have reported lower correlation rates [11]. Using finer, high-resolution cuts can enhance the detection of findings that may have low specificity due to partial volume effects. Research by Gerami et al. and Singh et al. also found a moderate to good correlation for ossicular erosion [15, 16].

Reddy et al. highlighted that CT scans are highly accurate in detecting sinus plate destruction, with strong sensitivity and specificity, a finding that aligns with the results of this study [17].

Overall, HRCT of the temporal bone is a valuable tool for preoperative assessment of cholesteatoma, helping determine its extent and identify complications. However, CT scans have limitations when interpreting soft tissue in the mastoid, making it difficult to distinguish between a cholesteatoma sac, granulation tissue, mucosal edema, and effusion [18], [19]. While cholesteatoma generally has lower attenuation than granulation tissue, the difference is often subtle, and only magnetic resonance imaging (MRI) can effectively differentiate between the two.

CONCLUSION

Stratification analysis revealed slightly improved accuracy in males **(**88.2%**)** and in patients experiencing symptoms for five or more years (89.1%). These results establish HRCT as a valuable, non-invasive diagnostic tool, potentially reducing unnecessary surgical interventions. However, given its limitations in specificity and negative predictive value, HRCT alone cannot be solely relied upon for diagnosis.

In conclusion, while HRCT significantly aids in the early detection and evaluation of cholesteatoma, it should be used in conjunction with histopathological examination for definitive diagnosis. Further research incorporating larger sample sizes and emerging imaging techniques, such as diffusion-weighted MRI, may enhance diagnostic precision and improve patient management in the future.

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