ORIGINAL RESEARCH PAPER

Radio-Diagnosis

UTILITY OF HIGH-RESOLUTION COMPUTED TOMOGRAPHY IN TEMPORAL BONE PATHOLOGIES

KEY WORDS: Temporal bone, HRCT, Cholesteatoma, Inflammatory lesions, Diagnostic accuracy

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ABSTRACT

Background: Temporal bone pathologies present a wide array of diagnostic challenges due to their complex anatomical localization and nonspecific clinical presentations. Accurate imaging, particularly using High-Resolution Computed Tomography (HRCT), plays a pivotal role in evaluating these lesions and guiding surgical planning. The study aimed to assess the diagnostic accuracy of HRCT in identifying temporal bone pathologies and to correlate radiological findings with histopathological and intraoperative results. **Methods:** A prospective, observational cross-sectional study was conducted at the Department of Radiodiagnosis, Sri Aurobindo Medical College & PG Institute, Indore, over 18 months. A total of 40 patients with suspected temporal bone lesions underwent HRCT followed by surgical exploration or biopsy for histopathological confirmation. Data were analyzed to evaluate HRCT's sensitivity, specificity, predictive values, diagnostic accuracy, and agreement (kappa coefficient) across various pathologies. **Results:** The most frequent diagnosis was inflammatory lesions (40%), followed by cholesteatoma (25%), traumatic injuries (15%), benign neoplasms (7.5%), congenital malformations (7.5%), and malignant neoplasms (5%). HRCT demonstrated excellent diagnostic accuracy: sensitivity ranged from 60% to 100%, specificity from 92% to 100%, and overall accuracy above 92.5% in all categories. Kappa values showed strong agreement, particularly for cholesteatoma (= 0.931) and inflammatory lesions (= 0.842). **Conclusion:** HRCT is a reliable and highly accurate modality for diagnosing temporal bone pathologies, particularly in detecting inflammatory lesions and cholesteatoma. While histopathology remains the gold standard, HRCT significantly enhances preoperative assessment. Future studies should involve larger, multicentric cohorts with MRI correlation and long-term follow-up for improved diagnostic protocols.

INTRODUCTION

Temporal bone pathologies encompass a diverse spectrum of conditions, including congenital anomalies, infections, trauma, neoplasms, and inflammatory disorders. These pose considerable diagnostic challenges due to the region's intricate anatomy and variable clinical presentations [1]. Symptoms such as vertigo, hearing loss, tinnitus, or facial nerve dysfunction are often nonspecific and may overlap with other disorders, complicating clinical evaluation. Ear-related conditions represent the third most common reason for consultation in otorhinolaryngology, with middle ear infections being particularly prevalent in pediatric populations and frequently requiring antibiotics or surgical intervention [2].

The temporal bone houses vital structures such as the cochlea, vestibular apparatus, semicircular canals, facial nerve, inner auditory canal, and parts of the brainstem and cerebellum. Its connection to the upper respiratory tract via the Eustachian tube and mastoid air cells increases its vulnerability to infections and other diseases [4,5]. Clinical examination alone is often inadequate for accurate assessment due to the bone's complex anatomical configuration, necessitating advanced imaging techniques for detailed visualization.

Temporal bone lesions are radiologically and clinically diverse. Common neoplasms like facial nerve schwannomas, glomus tumors, and squamous cell carcinoma may be identifiable, but rarer lesions often remain underdiagnosed due to overlapping features and limited literature [6–8]. A 25-year review by Kim et al. emphasized the predominance of facial nerve schwannomas and glomus lesions but also stressed the need for greater insight into rare entities [9]. Similarly, Campion et al. advocated structured imaging protocols, especially for pediatric inflammatory lesions [10].
High-resolution computed tomography (HRCT) has revolutionized the evaluation of temporal bone diseases. It provides excellent spatial resolution, enables multiplanar reconstruction, and offers superior visualization of bony structures with reduced radiation compared to conventional techniques [11,12]. HRCT is invaluable in diagnosing chronic otitis media, evaluating postoperative ears, and identifying subtle erosions or fractures.

Given the scarcity of region-specific data, particularly in Indian populations, this study aims to evaluate the spectrum of temporal bone lesions using HRCT, correlate imaging findings with histopathological or intraoperative outcomes, and highlight the role of HRCT in enhancing diagnostic precision and surgical planning.

MATERIAL AND METHODS

This hospital-based prospective, observational, cross-sectional study was conducted in the Department of Radiodiagnosis at Sri Aurobindo Medical College and PG Institute, Indore, over 18 months (1st June 2023 to 30th November 2024). A total of 40 patients of varying age and sex, presenting with clinical suspicion of temporal bone lesions, were included. The study received prior approval from the Institutional Ethics Committee, and written informed consent was obtained from all participants or their guardians. Ethical standards regarding confidentiality, autonomy, and the right to withdraw were strictly maintained.

The sample size was calculated using the formula for estimating proportions in diagnostic accuracy studies. Based on existing literature and prior studies (e.g., Pramod V et al., Thukral CS et al.) indicating approximately 85% diagnostic accuracy of HRCT in temporal bone pathologies, with an absolute precision (d) of 15%, the minimum required sample size was 22. However, to compensate for dropouts, incomplete follow-ups, or non-diagnostic scans, a final sample size of 40 patients was chosen. This target was feasible given the

institution's average case load of 2–3 temporal bone evaluations per month.

Inclusion Criteria

- Patients of all age groups presenting with clinical symptoms suggestive of temporal bone pathologies.
- Patients who underwent HRCT evaluation followed by histopathological confirmation.

Exclusion Criteria

- Patients who refused consent for participation.
- Patients with contraindications for CT imaging (e.g., pregnancy, allergy to contrast where applicable).
- Patients on life support or lost to follow-up before completing imaging and histopathological evaluation.

Imaging Protocol

All patients underwent HRCT using a Siemens Somatom Definition AS 64-slice CT scanner

- Axial thin-section scans of the temporal bone were acquired (slice thickness ≤ 0.6 mm).
- Coronal and sagittal reformats were generated using maximum intensity projection (MIP) techniques.
- Images were acquired with high-resolution bone window settings (Window Width: ~4000 HU; Window Level: ~700 HU) to ensure optimal visualization of osseous structures.
- Radiation safety measures and proper patient positioning were ensured for every scan.

Procedure

Following clinical evaluation and consent, all patients underwent HRCT scanning. Images were reviewed by an experienced radiologist for critical findings such as ossicular chain disruption, scutum erosion, tympanic cavity involvement, labyrinthine erosion, and mastoid pathology. When surgical management was indicated, intraoperative tissue specimens were collected and sent for histopathological analysis, which served as the reference standard. Radiological and histopathological findings were correlated on a case-by-case basis.

Data Collection and Statistical Analysis

A structured proforma was used to uniformly collect demographic, clinical, imaging, and histopathological data. Data were compiled in Microsoft Excel 2010 and analyzed using IBM SPSS Statistics version 26.0. Continuous variables (e.g., age) were expressed as mean ± SD, while categorical variables (e.g., sex, symptoms, imaging, and histopathology) were summarized as frequencies and percentages. HRCT diagnostic performance was evaluated against histopathology as the gold standard by calculating sensitivity, specificity, PPV, NPV, and accuracy. Bar and pie charts were used for visual data representation.

RESULTS

The present study, involving 40 patients with suspected temporal bone pathologies, revealed a diverse spectrum of clinical and radiological findings. The mean age was 33.8 ± 14.98 years, with the 31–40 years age group being the most commonly affected (32.5%). Males (57.5%) were more frequently involved than females.

Ear discharge (87.5%) and hearing loss (72.5%) emerged as the predominant symptoms, followed by ear pain (50%), tinnitus, vertigo, and facial palsy. Otoscopic evaluation commonly revealed central (42.5%) and marginal perforations (35%), with the right ear being more commonly affected (60%).

Radiologically, middle ear involvement was seen in 90% of cases, and ossicular erosion, particularly of the incus (57.5%) and malleus (55%), was frequently noted. Scutum erosion (32.5%) and facial canal dehiscence (22.5%) were significant findings. The epitympanum and mesotympanum were commonly involved regions within the tympanic cavity. Fractures were detected in 15% of patients, predominantly of the longitudinal type, while mastoiditis or mastoid abscess was seen in 55% of cases. Complications such as cochlear involvement, lateral semicircular canal erosion, and tegmen tympani erosion were seen in a subset of patients, suggesting disease extension. Notably, intracranial complications such as brain abscess (10%), meningitis (5%), and dural sinus thrombosis (2.5%) were also observed in some cases. [Table 1]

Table 1. Demographic, Clinical, Otoscopic Radiological, and Histopathological Findings (n = 40)

Parameter	Category / Finding	No. of Subjects (N)	Percentage (%)
Age Distribution	1–10 years	4	10.0
	11–20 years	4	10.0
	21–30 years	6	15.0
	31–40 years	13	32.5
	41–50 years	9	22.5
	51–60 years	3	7.5
	61–70 years	1	2.5
Gender	Male	23	57.5
	Female	17	42.5
Presenting Symptoms	Discharge from ear	35	87.5
	Hearing loss	29	72.5
	Ear pain	20	50.0
	Tinnitus	11	27.5
	Vertigo	10	25.0
	Headache	10	25.0
	Facial palsy	7	17.5
	Fever	6	15.0
Otoscopic Findings	Attic perforation	4	10.0
	Central perforation	17	42.5
	Marginal perforation	14	35.0
	Non-visualization	5	12.5
Side Involved	Right	24	60.0
	Left	11	27.5
	Bilateral	5	12.5
Fracture Type	Longitudinal	3	7.5
	Complex	1	2.5
	Transverse	2	5.0
	No fracture	34	85.0
Bony Ossicle Involvement	Malleus	22	55.0
	Incus	23	57.5
	Stapes	12	30.0
Scutum Erosion	Present	13	32.5
	Absent	27	67.5
Middle Ear Involvement	Present	36	90.0
	Absent	4	10.0
Tympanic Cavity Involvement	Epitympanum	27	67.5
	Mesotympanum	25	62.5
	Hypotympanum	17	42.5
Facial Canal Dehiscence	Present	9	22.5
	Absent	31	77.5
Tegmen Tympani Erosion	Present	7	17.5
	Absent	33	82.5
Cochlear Involvement	Present	4	10.0

	Absent	36	90.0
Lateral Semicircular Canal Erosion	Present	4	10.0
	Absent	36	90.0
Aditus Involvement	Present	21	52.5
	Absent	19	47.5
Antrum Involvement	Present	21	52.5
	Absent	19	47.5
Mastoiditis / Mastoid Abscess	Present	22	55.0
	Absent	18	45.0
Intracranial Complications	Meningitis	2	5.0
	Brain abscess	4	10.0
	Dural sinus thrombosis	1	2.5
	No intracranial complication	33	82.5

In this study, inflammatory lesions were the most common HRCT-diagnosed pathology, seen in 40% of patients, followed by cholesteatoma (25%) and traumatic lesions (15%). Less frequent findings included congenital malformations (7.5%), benign neoplasms (7.5%), and malignant neoplasms (5%). These results highlight HRCT's effectiveness in diagnosing both common and complex temporal bone conditions, aiding in accurate and timely clinical decision-making. [Figure 1]

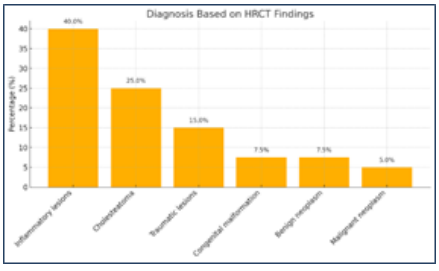


Figure 1. Diagnosis Based on HRCT Findings

For the histopathological and intraoperative correlation, inflammatory lesions were the most commonly confirmed diagnosis, observed in 37.5% of cases. This was followed by cholesteatoma (22.5%) and traumatic lesions (20.0%), which were consistent with HRCT findings in most cases. Benign neoplasms were confirmed in 12.5%, while congenital malformations and malignant neoplasms accounted for 5.0% and 2.5% respectively. These findings reinforce the diagnostic value of HRCT in preoperative assessment, while also highlighting the importance of histopathology for definitive confirmation, especially in differentiating neoplastic and congenital lesions. [Figure 2]

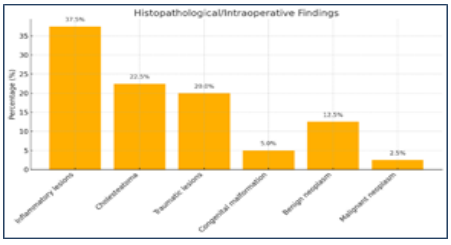


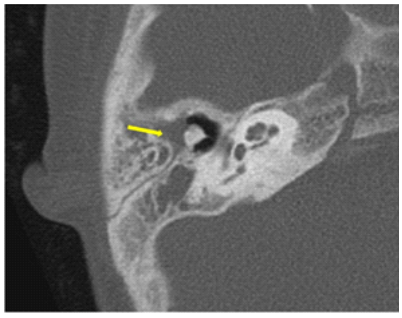
Figure 2. Diagnosis Based on

Histopathological/Intraoperative Findings

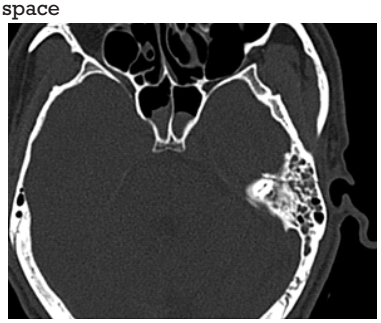
HRCT demonstrated high diagnostic accuracy across most pathologies, especially for cholesteatoma (97.5%), congenital malformations (97.5%), and malignant neoplasms (97.5%). Sensitivity was 100% in diagnosing cholesteatoma, congenital, and malignant lesions. However, benign neoplasms showed relatively lower sensitivity (60%), despite excellent specificity. The Kappa coefficients in all categories showed strong agreement, particularly for cholesteatoma (= 0.931), supporting HRCT as a reliable diagnostic tool when confirmed with histopathological outcomes. [Table 2]

Table 2: Diagnostic Performance of HRCT Compared to Histopathology/Intraoperative Findings (n = 40)

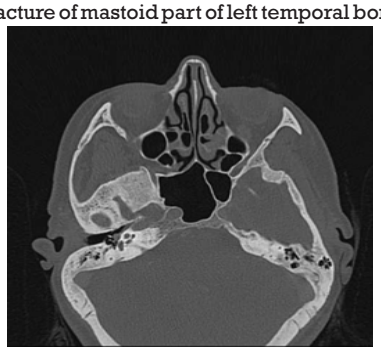
Diagnosis	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)	p-value
Inflammatory lesions	93.33	92.00	87.50	95.83	92.50	< .001
Cholesteatoma	100.00	96.77	90.00	100.00	97.50	< .001
Traumatic lesions	75.00	100.00	100.00	94.12	95.00	< .001
Congenital malformations	100.00	97.37	66.67	100.00	97.50	< .001
Benign neoplasms	60.00	100.00	100.00	94.59	95.00	< .001
Malignant neoplasms	100.00	97.44	50.00	100.00	97.50	< .001



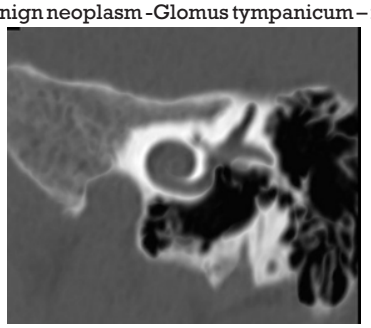
Case 1 Cholestatoma -Non-dependent soft tissue in the Prussack's space



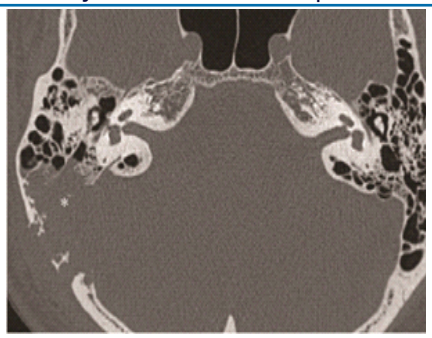
Case 2- Fracture of mastoid part of left temporal bone



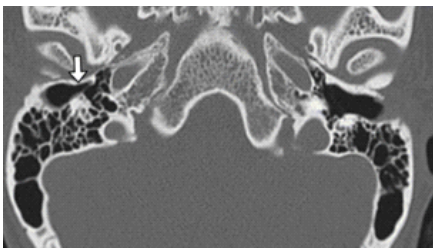
Case 3- Benign neoplasm -Glomus tympanicum – right side



Case 4-Cochlear malformation –cochlea showing 1 and ½ turn



Case 5- Malignant neoplasm (lymphoma) of right temporal bone



Case 6- Congenital malformation –congenital stenosis of medial aspect of right EAC.

Figure 3 (Case 1-6). Representative HRCT Images Depicting the Spectrum of Temporal Bone Pathologies

DISCUSSION

High-resolution computed tomography (HRCT) has become an indispensable tool in the diagnostic assessment of temporal bone pathologies, offering unparalleled resolution and anatomical detail, particularly for evaluating the fine bony structures of the ear. This study was conducted at Aurobindo Institute, Indore, and included 40 patients with clinically suspected temporal bone disorders. HRCT findings were systematically compared with clinical symptoms and histopathological diagnoses to evaluate its diagnostic accuracy and clinical relevance.

The mean age of the patients was 33.8 ± 14.98 years, with the majority in the 31–40-year age group (32.5%). Males accounted for 57.5% of cases, showing a mild male predominance (1.35:1), which aligns with previous studies such as Handi PS et al. (2018) [13] and Thukral CS et al. (2015) [2]. While some studies, including Patel AZ et al. (2021) [12], focused more on pediatric populations, others, such as Bagul M et al. (2016) [14], also reflected variable age distributions based on study demographics.

The most common presenting symptom was ear discharge (87.5%), followed by hearing loss (72.5%), ear pain (50%), tinnitus (27.5%), and vertigo (25%). These findings are consistent with other reports, such as Patel AZ et al. [12] and Handi PS et al. [13]. Less common symptoms included facial palsy and postaural swelling, which are indicative of advanced or complicated disease processes. Studies by Tyagi S et al. [15] and Haynes DS et al. [16] also emphasized otorrhea and headache as frequent complaints in CSOM.

Otoscopic evaluation revealed that central perforations were most common (42.5%), followed by marginal (35.0%) and attic perforations (10%). These findings are in line with Adegbiji WA et al. (2018) [17] and Ediale J et al. (2017) [18], who reported similar patterns. Marginal and attic perforations are often associated with cholesteatoma and a higher risk of complications, as discussed by Rao A et al. (2021) [19].

Unilateral involvement was predominant, with 60.0% affecting the right ear. Bilateral disease was seen in 12.5% of patients. These findings mirror the trends reported by Thukral CS et al. [2] and Gomaa et al. (2013) [20]. HRCT was particularly effective in evaluating the mastoid air cells, with mastoiditis observed in 76% of cases.

Temporal bone fractures were identified in 15.0% of patients. Longitudinal fractures were most frequent (7.5%), followed by transverse (5.0%) and mixed types (2.5%). These results correspond with studies by Bagul M et al. [14] and Jyothi AC et al. (2016) [21], which confirm the predominance of longitudinal fractures due to their anatomical vulnerability to lateral trauma.

HRCT detected ossicular erosion in the malleus (55.0%), incus (57.5%), and stapes (30.0%). Scutum erosion (32.5%), facial canal dehiscence (22.5%), and tegmen tympani erosion (17.5%) were other significant findings. The middle ear cavity was involved in 90% of cases, primarily the epitympanum and mesotympanum. Inner ear erosion (10%) and mastoid involvement (55.0%) were also notable. Intracranial complications were observed in 17.5% of patients, with brain abscess being the most common (10%). These findings are consistent with those reported by Handi PS et al. [13] and Thukral CS et al. [2], reaffirming HRCT's diagnostic accuracy in delineating the extent of disease and its complications.

Inflammatory lesions were the most common histological diagnosis (37.5%), followed by cholesteatoma (22.5%), fractures (20.0%), benign neoplasms (12.5%), congenital malformations (5.0%), and malignant neoplasms (2.5%). These trends are similar to those observed by Handi PS et al. [13].

For inflammatory lesions, HRCT achieved a sensitivity of 93.33%, specificity of 92.00%, and kappa value of 0.842 ($p < 0.001$), indicating strong agreement with histopathology. These results closely parallel those of Pokhrel et al. (2024) [22] and Shankhwar et al. (2016) [23].

In cases of cholesteatoma, HRCT showed a sensitivity of 100%, specificity of 96.77%, and kappa of 0.931, which is supported by findings from Thukral CS et al. [2], Jackler et al. [24], and Pramod V et al. (2020) [25]. Studies by Khan MT et al. (2019) [26] and Rogha et al. (2014) [27] also report high diagnostic accuracy for cholesteatoma.

For traumatic lesions, HRCT achieved a sensitivity of 75.00% and specificity of 94.12%, with a kappa value of 0.828, suggesting substantial agreement. While HRCT showed high specificity for congenital anomalies and benign neoplasms, its sensitivity was lower, indicating the need for correlation with clinical and surgical findings. Similar patterns were seen in the work of Kundra CL et al. (2016) [28] and Mukerji et al. (2009) [29].

In malignant neoplasms, HRCT achieved substantial agreement (kappa = 0.655), with high specificity and NPV, aligning with data from Pokhrel et al. [22] and Shankhwar et al. [23].

Although the study highlights HRCT's diagnostic utility, it is limited by a small sample size, single-center data, absence of MRI correlation, and lack of long-term follow-up. Future studies should be multicentric, include MRI (especially DWI) for better soft tissue characterization, and incorporate follow-up to evaluate outcomes and recurrence.

CONCLUSION

This study confirms that HRCT provides high diagnostic accuracy across a wide spectrum of temporal bone pathologies. It is especially effective for inflammatory lesions and cholesteatoma, with near-perfect histopathological correlation. Although less sensitive for benign neoplasms, HRCT remains a cornerstone modality for detecting structural

abnormalities, planning surgical interventions, and minimizing complications. When used in conjunction with clinical and histopathological assessments, HRCT significantly enhances diagnostic precision and improves patient outcomes in otologic practice.

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