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Original Research Article

ROLE OF HIGH-RESOLUTION COMPUTED TOMOGRAPHY (HRCT) IN EVALUATION OF PATHOLOGIES OF TEMPORAL BONE: A CROSS SECTIONAL STUDY

Kartik Singla[1], Mohd Talha[2], Mohit Gambhir[3], Pramod Kumar[4], Harsh Kumar[5], Pankaj Swami[6], Iman Ikram[7], Stuti Krishna[1], Upanshu Gupta[8]

[1]Junior Resident, Department of Radiodiagnosis, Rohilkhand Medical College and Hospital, Bareilly, Uttar Pradesh, India
[2]Assistant Professor, Department of Radiodiagnosis, Rohilkhand Medical College and Hospital, Bareilly, Uttar Pradesh, India
[3]Assistant Professor, Interventional Radiology, Department of Radiodiagnosis, Rohilkhand Medical College and Hospital, Bareilly, Uttar Pradesh, India
[4]Proffesor and Head, Department of Radiodiagnosis, Rohilkhand Medical College and Hospital, Bareilly, Uttar Pradesh, India
[5]Senior Resident, Department of Radiodiagnosis, Rohilkhand Medical College and Hospital, Bareilly, Uttar Pradesh, India
[6]Senior Resident, Department of Surgery, Lady Hardinge Medical College, Delhi, India.
[7]Doctoral Candidate, School of Communication Studies, Scripps College of Communication Ohio University, Ohio, USA
[8]Junior resident, Department of Internal Medicine, T. S. Misra Medical College, Lucknow, Uttar Pradesh, India

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Corresponding Author:
Dr. Kartik Singla,
Junior Resident, Department of Radiodiagnosis, Rohilkhand Medical College And Hospital, Bareilly, Uttar Pradesh, India.
Email: kartiksingla379@gmail.com

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ABSTRACT

Background: The temporal bone is one of the most complex anatomical structures in the human body and plays a vital role in hearing, balance and facial nerve function. The objective is to systematically evaluate the role of HRCT in the assessment of temporal bone pathologies, to analyse its accuracy in detecting disease extent, ossicular involvement, bony erosions & associated complications and to correlate HRCT findings with clinical observations.

Materials and Methods: This cross-sectional study was conducted after clearance from Institutional Ethics committee in the Department of Radiodiagnosis, Rohilkhand Medical college and Hospital, Bareilly, U.P. Duration of study was one-year period.

Results: Most patients in this study were young adults, with a slight predominance of males. The most common clinical symptoms—otalgia, otorrhea and hearing loss. HRCT reliably characterized these clinical entities by distinguishing traumatic disruptions from chronic disease-associated changes. In trauma cases, fractures most commonly involved the mastoid portion, while non-traumatic lesions frequently affected the mastoid antrum and middle ear cavity, supporting observations from earlier studies emphasizing these regions as primary sites of involvement. Ossicular erosion was identified in more than half of the study population. HRCT demonstrated high reliability in identifying scutum erosion—an early hallmark of attic cholesteatoma—as well as tegmen and mastoid cortex involvement, all of which are critical parameters influencing surgical planning. HRCT efficiently detected early and advanced complications.

Conclusion: HRCT stands as a reliable, non-invasive and highly informative imaging technique that plays an essential role in the timely diagnosis, effective management and prognostication of temporal bone diseases. Its integration into routine assessment protocols, especially in suspected cholesteatoma and unsafe CSOM, is strongly supported by the present findings as well as published literature.

Keywords: High-Resolution Computed Tomography (HRCT), Temporal Bone, Chronic suppurative otitis media (CSOM).

INTRODUCTION

The temporal bone exhibits a high prevalence of anatomical diversity, which poses a notable problem in otologic procedures.[1]

For the assessment of various regions of the temporal bone, a variety of imaging modalities are available, such as computed tomography (CT), angiography, air and non-ionic contrast catheterization, cerebrospinal fluid (CSF) measurement and magnetic resonance imaging (MRI). Nevertheless, the most used methods today are CT and MRI, which have essentially supplanted the earlier modalities. Patients suspected with temporal bone pathology typically have a clinical examination first, frequently including audiology tests.[2] When paired with imaging results, the information gathered in this manner yields a precise and trustworthy diagnosis, helps prevent misunderstandings and guarantees an adequate course of treatment.[3]

The temporal bone as a whole can be effectively screened using conventional radiography. Currently, though the assessment of mastoid pneumatization is the only application for traditional radiography.[4]

High-Resolution Computed Tomography (HRCT) provides excellent visualization of the temporal bone anatomy and the location and extent of disease, along with the detection of asymptomatic complications and bony destruction.[5] It complements otoscopic and clinical findings, resolves diagnostic uncertainties and assists in determining surgical necessity and approach.[6] Owing to its high spatial resolution and cost-effectiveness, HRCT is widely used as a preoperative imaging tool in chronic ear disease. However, its major limitation lies in the inability to reliably differentiate between cholesteatoma, granulation tissue or fluid, emphasizing the need for cautious interpretation and when indicated, adjunctive use of MRI for accurate soft-tissue characterization.[7]

HRCT is a simple way to evaluate congenital abnormalities, normal variations of temporal bone and intracranial problems. Identifying different pathological alterations in temporal bone in cases of chronic suppurative otitis media (CSOM), patients with chronic otitis media (COM), with or without cholesteatoma, may exhibit erosion of the facial canal, lateral semi-circular canal and dural plate.[8]

Diseases affecting the temporal bone are associated with significant morbidity due to their close relationship with critical structures such as the ossicular chain, facial nerve, labyrinth and intracranial compartments. Clinical examination alone is often insufficient to accurately assess the full extent of disease, particularly in conditions like chronic suppurative otitis media, cholesteatoma and temporal bone trauma. Many pathological changes occur deep within the temporal bone and may remain clinically occult until advanced stages, making timely radiological evaluation essential.

High-Resolution Computed Tomography (HRCT) of the temporal bone has emerged as the imaging modality of choice for evaluating these conditions because of its exceptional spatial resolution and ability to demonstrate fine osseous details. HRCT enables precise visualization of the middle ear cleft, ossicular chain, mastoid air cells, facial nerve canal, semi-circular canals and tegmen plate. This detailed anatomical depiction is crucial for identifying subtle bony erosions, ossicular discontinuity and early complications that may not be detected clinically.

HRCT plays a pivotal role in surgical planning by guiding the choice of surgical approach, anticipating facial nerve exposure, predicting ossicular damage and detecting intracranial or extracranial extensions. In traumatic cases, HRCT is indispensable for characterizing fracture patterns and identifying associated complications such as hemotympanum, ossicular disruption and facial nerve injury.

Therefore, the present study was undertaken to systematically evaluate the role of HRCT in the assessment of temporal bone pathologies, to analyse its accuracy in detecting disease extent, ossicular involvement, bony erosions & associated complications and to correlate HRCT findings with clinical observations.

MATERIALS AND METHODS

This cross-sectional study was conducted after clearance from Institutional Ethics committee in the Department of Radiodiagnosis, Rohilkhand Medical college and Hospital, Bareilly, U.P. Duration of study was one-year period.

Sample Size: The sample size was determined according to the article authored by Mohammed A. Gomaa et al., (2013) 9 (Sensitivity of HRCT in detecting cholesteatoma = 92.8%). The sample size calculation performed using the following formula 4pq/L2 formula

N = 106.9

Rounded off Sample size =110

Sampling Technique: Simple random sampling method was used to include the sample in the study.

Inclusion Criteria:

- Clinically presenting with ear discomfort, otorrhea and decreased hearing.
- Patient suspected of unsafe chronic serous otitis media.
- Patient with tinnitus or vertigo.
- Patient suspected with temporal bone fracture and tumors of temporal bone.
- Patients of all age groups and of both genders are included.

Exclusion Criteria:

- Pregnant patients.
- Patients who cannot give a valid consent.

Methodology: The entire procedure was explained in detail to each patient and/or attendant and

informed written consent was obtained prior to the scan. A detailed clinical history was recorded for every patient; including duration and type of ear discharge, hearing loss, tinnitus, vertigo, trauma or any prior ear surgeries. A complete examination was also carried out before imaging. The evaluation of patients was carried out with the assistance of a GE Bright-speed Computed Tomography (CT scan) 16-slice, patients were positioned supine with the head immobilized to avoid motion artifacts. Axial scans were obtained parallel to the infra-orbitomeatal line with thin contiguous sections (0.6–1.0 mm). Coronal and sagittal multiplanar reconstructions (MPR) were generated for better evaluation of bony details. High-resolution bone algorithm was used for image reconstruction with appropriate window settings.

- Bone window: Width 4000 HU, Level 700 HU.
- Soft tissue window: Width 350 HU, Level 50 HU

A current of 300 milliamperes and a voltage of 140 kilovolts were utilised. Two seconds was the cycle time that was utilised. Reconstruction of the images was performed using a high frequency bone method. Scanning was performed in the axial plane and the field of view was 180 millimetres. 14 x 17-inch films were used for the documentation process. For the purpose of making comparisons easier, images of each temporal bone were enlarged and recorded on different films. Following the recording of the findings in a tabular format, a differential diagnosis was developed based on the findings of the HRCT.

Statistical Analysis: After entering the data into Excel, the statistical software SPSS version 25.0 was used to conduct the analysis. The mean and standard deviation were used to display numerical data, while the percentage and frequency of each category were used to display categorical data. To compare the two groups' means, we utilised the student t-test; to look for differences in frequency, we used the chi-square test. Statistical significance is indicated by a p-value that is less than 0.05.

RESULTS

The highest number of cases were observed in the 21–30 years age group, followed by 11–20 years. This indicates that temporal bone pathologies predominantly affect young adults. Very few cases were noted in the extremes of age groups (0–10 and >60 years).

The study population consisted of a nearly equal distribution of male and female patients, with a slight male predominance. This suggests that temporal bone pathologies affect both sexes almost equally, though marginally higher in males.

The most common presenting symptom was otalgia, followed by otorrhea and headache. Hearing loss and vertigo were also frequently reported, while tinnitus, nausea and vomiting and facial nerve palsy symptoms were less common. This distribution highlights the predominance of inflammatory and infective manifestations in temporal bone pathologies.

A subset of study participants reported a positive history of trauma. The majority, however, did not have any traumatic history, suggesting that while trauma is an important etiological factor, non-traumatic inflammatory and infectious causes remain more predominant in temporal bone pathologies.

Table 1: Site of Temporal Bone Fracture in Trauma Patients (HRCT Findings)

Site of Temporal Bone Fracture	Frequency	Percentage
Squamous part	6	16.1%
Mastoid part	21	67.7%
Tympanic plate	4	12.9%

On HRCT evaluation of 31 trauma patients, the mastoid part was the most frequently fractured, followed by the squamous part and tympanic plate. This distribution aligns with the expected fracture propagation pattern following lateral skull trauma, where the mastoid and squamous portions of the temporal bone are most susceptible.

Table 2: Distribution of Study Participants as per percentage distribution of sites of involvement among non-traumatic cases on HRCT.

Site of Involvement	Frequency	Percentage
Mastoid antrum	62	43.1%
Entire middle ear cavity	46	32.0%
Mesotympanum	15	10.4%
Prussack's space	6	4.2%
Epitympanum	6	4.2%
External auditory canal	6	4.2%
Other / Unspecified	3	2.1%

On HRCT evaluation of 79 non-traumatic cases, the mastoid antrum was the most frequently involved site (43.1%), followed by the entire middle ear cavity (32.0%) and mesotympanum (10.4%). Other regions such as the Prussack's space, epitympanum and external auditory canal were less commonly affected. This distribution highlights the posterior extension of inflammatory and cholesteatomatous

disease into the mastoid antrum and middle-ear spaces.

On HRCT evaluation of 110 participants, the right side showed the highest frequency of involvement (41.0%), followed closely by the left side (37.0%), while bilateral involvement was seen in 22.0% of cases. The distribution indicates that most cases exhibit unilateral disease, with only a mild right-sided predominance. However, the notable proportion of bilateral cases suggests that advanced or chronic pathologies frequently extend to both temporal bones.

Table 3: Distribution of Study Participants as per Ossicular Involvement on HRCT

Ossicular Involvement	Frequency	Percentage
Present	58	52.80%
Absent	52	47.20%
Total	110	100.00%

On HRCT evaluation of 110 participants, ossicular involvement was observed in 52.73% of cases, while 47.27% showed no ossicular erosion or disruption. The presence of ossicular involvement was most commonly associated with chronic suppurative otitis media and cholesteatoma, reflecting the destructive progression of middle-ear pathology.

Table 4: Distribution of Study Participants as per Type of Ossicular Involvement on HRCT

Ossicle Involved (HRCT)	Frequency	Percentage
Malleus	21	36.21%
Incus	18	31.03%
Stapes	12	20.69%
All three ossicles	25	43.10%

Among 58 HRCT-positive cases with ossicular involvement, the malleus was the most frequently affected (36.21%), followed by the incus (31.03%) and stapes (20.69%). Erosion of all three ossicles was seen in 43.10% of cases, suggesting extensive middle-ear disease and advanced cholesteatomatous destruction.

Table 5: Distribution of Study Participants as per Location of Bony Erosion in HRCT

Location of Bony Erosion	Frequency	Percentage
Scutum erosion	21	19.09%
Tegmen erosion	18	16.36%
Styloid part erosion	5	4.55%
Petrous part erosion	5	4.55%
Lateral SCC erosion	5	4.55%
Mastoid cortex erosion	7	6.36%
Sigmoid plate erosion	7	6.36%

The most common sites of bony erosion identified on HRCT were the scutum and tegmen, followed by mastoid cortex and sigmoid plate erosions. Lateral semicircular canal and petrous part erosions were less frequent but are important indicators of advanced middle-ear disease.

Table 6: Distribution of Study Participants as per Extracranial Complications on HRCT

Extracranial Complication	Frequency	Percentage
Extension in Eustachian tube	1	0.91%
Facial nerve palsy	11	10.00%
Hemomastoideum/tympanum	21	19.09%
Mastoiditis / Oto-mastoiditis	50	45.45%
Post-auricular abscess formation	2	1.82%

The most common extracranial complication detected on HRCT was mastoiditis / oto-mastoiditis, followed by Eustachian tube extension. Facial nerve palsy and post-auricular abscess formation were less frequent, while hemotympanum / hemomastoideum was mainly seen in trauma-related cases.

The most frequent intracranial complication detected on HRCT was sigmoid plate sclerosis, followed by labyrinthine fistula formation. EDH and SDH were fewer common findings, typically associated with traumatic etiologies.

DISCUSSION

In the present study, normal anatomical variations of the temporal bone were detected in a subset of patients during HRCT evaluation. A high jugular bulb was the most frequently observed variation followed by asymmetric mastoid pneumatization and anteriorly placed sigmoid sinus Although these are considered normal variants, their recognition is clinically important as they may alter surgical anatomy and increase the risk of intraoperative complications if not identified on preoperative imaging. Discussion: In the current study, the largest proportion of patients belonged to the 21–30-year age group (29.1%), followed by the 11–20-year group (17.3%). This pattern corresponds well with the findings of Mohammed A. Gomaa et al,[9] (2013)

and Sharma (2018), who reported that chronic otitis media (COM) and cholesteatoma frequently affect young adults. A slight male predominance (51.8%) was also observed, similar to trends described by Khan et al,[10] (2019), likely reflecting greater environmental exposure among males.

Otalgia was the most common presenting symptom (80.9%), followed by otorrhea (51.8%) and headache (44.5%). Hearing loss and vertigo were documented in 29.1% and 23.6% of patients, respectively. These findings are consistent with reports by Sreedhar et al,[11] (2015) and Thukral et al,[12] (2015), who noted that persistent ear pain, discharge and conductive hearing loss are hallmark features of chronic middle ear disease and cholesteatomatous pathology.

Trauma accounted for 28.2% of cases. Among trauma patients, fractures most frequently involved the mastoid part of the temporal bone (67.7%), followed by the squamous part (16.1%) and tympanic plate (12.9%). These patterns are in agreement with the fracture distributions reported by Juliano et al,[13] (2013), who highlighted the vulnerability of the mastoid and squamous components due to their anatomical configuration and exposure.

In non-traumatic cases (71.8%), the most commonly involved site was the mastoid antrum (43.1%), followed by the entire middle ear cavity (32.0%). These findings reflect the disease behaviour described by Rogha et al,[14] (2014) and Bathla et al,[15] (2017), who observed that inflammatory disease and cholesteatoma frequently extend posteriorly toward the mastoid antrum.

Ossicular chain evaluation showed erosion in 52.7% of patients. The malleus was most commonly affected (36.2%), followed by the incus (31.0%) and stapes (20.7%). Complete ossicular chain erosion was seen in 43.1% of cases. These findings are comparable to those reported by Thukral et al,[12] (2015), confirming HRCT's high accuracy in detecting ossicular destruction. The malleus and incus are particularly susceptible to erosion because of their proximity to cholesteatomatous masses and their delicate structural features.

Among bony erosions, scutum involvement was most frequent (19.1%), followed by tegmen erosion (16.4%). Mastoid cortex and sigmoid plate involvement (6.4% each) were less common, while isolated styloid and petrous erosions accounted for 4.5% each. These results mirror findings from Manik et al,[16] (2021) and Kataria et al,[17] (2022), who emphasized that scutum erosion is typically the earliest radiological sign of attic cholesteatoma. HRCT clearly demonstrated these changes, supporting its use in differentiating localized attic disease from more advanced pathology with intracranial risk.

Extracranial complications were commonly identified, with mastoiditis/otomastoiditis representing the largest group (45.5%), followed by hemomastoideum or hemotympanum (19.1%) and facial nerve palsy (10%). These results correlate with study by Gomaa et al. [9] (2013) which highlighted HRCT's utility in assessing mastoid disease and facial canal involvement prior to surgery.

Intracranial complications were less frequently observed. Sigmoid plate sclerosis was the most common (6.4%), followed by epidural hematoma (3.6%), labyrinthine fistula (2.7%) and subdural hematoma (0.9%). These findings are in agreement with Kataria et al,[17] (2022), who underscored HRCT's importance in identifying intracranial extension, particularly sigmoid sinus plate irregularities and labyrinthine erosion.

Normal anatomical variations of the temporal bone were also detected during HRCT evaluation. Although these are considered normal variants, their recognition is clinically important as they may alter surgical anatomy and increase the risk of intraoperative complications if not identified on preoperative imaging.

Overall, HRCT demonstrated a high level of accuracy in visualizing the extent of disease, bony erosion and complications. The findings of this study closely parallel results reported by Thukral et al,[12] (2015), and Uz Zaman et al,[18] (2022), reaffirming that HRCT is a highly sensitive diagnostic modality for cholesteatoma, ossicular erosion, tegmen defects and semicircular canal involvement. However, consistent with the observations of Rogha et al,[14] (2014) and Manik et al,[16] (2021), HRCT remains limited in its ability to reliably differentiate cholesteatoma from granulation tissue or fluid, especially in early stages.

HRCT proved to be a crucial imaging tool in evaluating temporal bone pathologies. It accurately delineates disease involvement, assists in identifying complications and facilitates optimal preoperative planning. The results of this study support the continued use of HRCT as a non-invasive, reliable and indispensable modality in the management of inflammatory, traumatic and cholesteatomatous conditions of the temporal bone.

Conclusion: Overall, the findings of this study underscore HRCT's robust diagnostic accuracy, sensitivity and clinical relevance. When interpreted alongside clinical evaluation and surgical findings, HRCT significantly enhances diagnostic confidence, improves preoperative planning and reduces the likelihood of intraoperative surprises. Its ability to map anatomical variations, detect subtle erosions and identify complications reinforces its value as a frontline imaging modality for temporal bone disorders.

HRCT stands as a reliable, non-invasive and highly informative imaging technique that plays an essential role in the timely diagnosis, effective management and prognostication of temporal bone diseases. Its integration into routine assessment protocols, especially in suspected cholesteatoma and unsafe CSOM, is strongly supported by the present findings as well as published literature.

CONCLUSION

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