Section: Radio-diagnosis

Original Research Article

TEMPORAL BONE CHOLESTEATOMA: TYPICAL FINDINGS AND EVALUATION OF DIAGNOSTIC UTILITY ON HIGH RESOLUTION COMPUTED TOMOGRAPHY

Sourabh Bhave[1], Amlendu Nagar[2], Sheetal Singh[3], Bhushita Lakhkar Guru[4]

[1]3rd Year Junior Resident, Department of Radio-diagnosis, Index Medical College, Hospital and Research Center, Indore, Madhya Pradesh, India
[2]Hod and Professor, Department of Radio-diagnosis, Index Medical College, Hospital and Research Center, Indore, Madhya Pradesh, India
[3]Professor, Department of Radio-diagnosis, Index Medical College, Hospital and Research Center, Indore, Madhya Pradesh, India.
[4]Professor, Department of Radio-diagnosis, Index Medical College, Hospital and Research Center, Indore, Madhya Pradesh, India.

Received *: 04/09/2024*
Received in revised form *: 23/11/2024*
Accepted *: 06/11/2024*

Corresponding Author:
Dr. Sourabh Bhave,
3rd Year Junior Resident, Department of Radio-diagnosis, Index Medical College, Hospital and Research Center, Indore, Madhya Pradesh, India.
Email: drsourav2011@gmail.com

DOI: 10.70034/ijmedph.2024.4.89

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2024; 14 (4); 464-470

ABSTRACT

Background: Chronic otitis media (COM) is a persistent ear disease characterized by middle ear infection, often resulting in a ruptured tympanic membrane and drainage. Cholesteatoma, a severe complication of chronic suppurative otitis media (CSOM), requires timely diagnosis for effective management. High-resolution computed tomography (HRCT) is a crucial tool for diagnosing cholesteatoma, assessing disease extent, and identifying bony erosions in the temporal bone. **Objective:** This study aimed to evaluate the diagnostic accuracy of HRCT in detecting cholesteatoma and its associated complications in patients with CSOM.

Material and Methods: A descriptive observational study was conducted at Index Medical College Hospital and Research Centre, including 50 patients with suspected primary or recurrent cholesteatoma. All patients underwent HRCT, and findings were correlated with intra-operative and histopathological examination results. Sensitivity, specificity, positive predictive value and negative predictive value of HRCT were calculated.

Results: Of the 62 temporal bones identified as diseased, HRCT demonstrated a sensitivity of 100%, specificity of 88.2%, PPV of 92.2%, and NPV of 100% in detecting cholesteatoma. HRCT findings included soft tissue density in the epitympanum in 95.2% of cases, with common bony erosions of the incus (61.2%), malleus (58.1%), and scutum (54.8%). False positives were observed in five cases, with granulation tissue, cholesterol granuloma, and wax misdiagnosed as cholesteatoma.

Conclusion: HRCT provides excellent sensitivity and high specificity for diagnosing cholesteatoma and associated bony erosions, making it an invaluable tool in the pre-operative assessment and management of CSOM. However, its inability to differentiate between cholesteatoma and similar soft tissue lesions poses some diagnostic challenges.

Key Words: Chronic otitis media, cholesteatoma, high-resolution computed tomography (HRCT), temporal bone, bony erosion, temporal bone cholesteatoma.

INTRODUCTION

Chronic otitis media (COM) represents a phase of ear disease marked by a prolonged infection of the middle ear cleft, encompassing the Eustachian tube, middle ear, and mastoid. This stage is characterized by a perforated tympanic membrane and associated discharge.[1] Clinically, there are two main types of chronic suppurative otitis media: one without cholesteatoma, known as the "safe" type, and one

with cholesteatoma, referred to as the "unsafe" type.[2]

Cholesteatoma can be understood as "skin in the wrong place." It is composed of an outer layer of stratified squamous epithelium, keratin debris within the sac produced by the epithelium, and an external peri-matrix that releases proteolytic enzymes responsible for bone destruction.[3]

Cholesteatoma is typically diagnosed through otoscopic examination, with histopathology or surgical exploration considered the gold standard. Imaging methods such as high-resolution computed tomography (HRCT) and magnetic resonance imaging (MRI) are commonly used. HRCT is the preferred imaging technique for detecting cholesteatoma, as it effectively reveals the extent and erosion of the intricate bony structures in the temporal bone. Thus, HRCT is an essential pre-operative requirement.[3]

On HRCT, cholesteatoma typically manifests as a soft-tissue "mass-like" density within the middle ear cavity and mastoid antrum. It is often accompanied by signs of mass effect, such as smooth bony erosions and expansion of surrounding cavities.[4] The probability of cholesteatoma is higher when the soft tissue opacity is non-dependent.[5] The absence of soft tissue density within the middle ear and mastoid complex can effectively rule out cholesteatoma. However, HRCT is unable to differentiate between soft tissue densities, making it difficult to distinguish cholesteatoma from inflammatory or granulation tissue, as well as scar tissue.[6] This study aims to outline the characteristic signs of cholesteatoma on HRCT and evaluate its effectiveness in diagnosing temporal bone cholesteatoma.

MATERIALS AND METHODS

Following approval from the institutional ethical committee, this descriptive observational study was conducted in the Department of Radiodiagnosis at Index Medical College Hospital and Research Centre in Indore over an 12 -month period (September 2023 to August 2024). Fifty patients of varying ages, who were referred from the Department of Otorhinolaryngology due to suspected primary cholesteatoma or recurrent cholesteatoma in post-operative cases, were evaluated based on their clinical presentation, otoscopic examination, and audiometric assessments. Informed consent was obtained from each patient after a thorough explanation of the study protocol, and enrolment was completed accordingly. Patients displaying soft tissue density in the temporal bone, suspected to indicate cholesteatoma based on HRCT, subsequently underwent surgical intervention, with the definitive diagnosis confirmed through surgical findings and histopathological examination.

Inclusion Criteria

- Suspected and already diagnosed cases of cholesteatoma of both genders in the any age group referred to radiodiagnosis department, willing to give informed consent were included in the study.

Exclusion Criteria

- Patients with history of ear surgery, previous head trauma, and known history of sensory neural hearing loss;
- Patient with any contraindication to the HRCT examination; and
- Non-consenting patients

Methodology

A comprehensive clinical history was obtained for each patient, followed by a thorough ear, nose, and throat (ENT) examination, which included meticulous otoscopic and microscopic ear assessments. Additionally, a complete audiological evaluation was conducted, encompassing pure tone audiometry, tympanometry, speech discrimination scores, and stapedial reflex testing. Pre-operatively, high- resolution computed tomography (HRCT) imaging of the temporal bone was performed for all cases.

Imaging protocol

HRCT imaging was performed using a 128-slice CT scanner. High-resolution CT images were acquired with a collimation of 20 × 0.625 mm and a thickness of 0.8 mm, utilizing 320 mAs and 120 kVp. Ultrathin image reconstruction was conducted using a high-resolution bone algorithm applied in the axial plane, with a section thickness of 0.5 mm, 0.01 mm increments, and a field of view (FOV) of 100, along with a matrix dimension of 512 × 512. This isotropic image data facilitated the generation of coronal and sagittal reformatted images, which were interpreted using a 3D workstation.

Imaging evaluation

In our study involving 50 patients, both bilateral temporal bones were thoroughly assessed, resulting in a total of 100 high-resolution temporal bone evaluations across the axial plane and the reformatted coronal and sagittal planes. The HRCT findings for each temporal bone were documented under several categories: the aeration status of the mastoid, extent and location of the soft tissue lesion, sclerosis of mastoid air cells, bony expansion (such as a widened aditus ad antrum or mastoid cavity), ossicular chain status (comprising the malleus, incus, and stapes), bony erosions (including those of the scutum, middle ear walls, and mastoid air cells), erosion of tegmen tympani and sinus plate, dehiscence of facial canal and any additional findings. All HRCT studies were reviewed by an experienced single radiologist, specializing in neuroradiology and imaging of head and neck.

Statistical Analysis

The raw data was recorded on a Microsoft Excel spreadsheet and analyzed using IBM Statistical Package for Social Sciences (SPSS), version 22.0.

The mean and standard deviation were used to compare continuous parametric data while meaning and interquartile range was used for continuous non-parametric data and percentages for categorical data. The sensitivity, specificity, PPV, NPV, and accuracy of HRCT in efficiently diagnosing cholesteatoma were calculated using a CI of 95%, correlating the results with the gold standard of histopathological examination (HPE) and intraoperative findings. The comparison of categorical data was conducted using Chi-square test, while that of continuous data was done using an independent t-test. A 'p' <0.05 was considered statistically significant.

RESULTS

In the present study, the average age was 26 ± 11.5 years, with a range from 10 to 60 years; the highest proportion of patients (25%) were between 30 and 40 years old. The cohort was balanced in terms of gender, comprising 25 males and 25 females, indicating no gender preference.

The most common clinical symptom observed was purulent ear discharge, observed in 40 patients (80%), followed by hearing loss 30 (60%) and otalgia 24 (48%). Furthermore, 31 patients (62%) had a history of recurrent upper respiratory tract infections, while just two patients (4%) reported experiencing ear trauma.

HRCT findings revealed that 36 patients (72%) exhibited unilateral soft tissue density and 13 patients (26%) showed bilateral soft tissue density in the temporal bones. Overall, 100 temporal bones from the 50 patients were assessed; among these, 62 were classified as diseased based on the presence of soft tissue density, while 38 were normal. Of the 62 diseased temporal bones, 56 (90.3%) were identified as primary disease, and 6 (9.7%) were recurrent cases post-surgery. Notably, one clinically symptomatic patient did not show any soft tissue on HRCT.

The most frequently affected site was the epitympanum/Prussak's space, with soft tissue density identified in 59 (95.2%) diseased temporal bones. This was followed by involvement of the aditus ad antrum and mesotympanum, present in 52 (83.9%) diseased temporal bones. Soft tissue density was identified in the mastoid antrum and air cells in 45 cases, accounting for 72.6%, while the hypotympanum was affected in 21 (32.3%) diseased temporal bones. The least commonly involved regions were the external auditory canal (EAC) [10 (16.1%)], sinus tympani [5 (8.1%)], facial canal recess [4 (6.5%)], and eustachian tube [1 (1.6%)]. [Table 1]

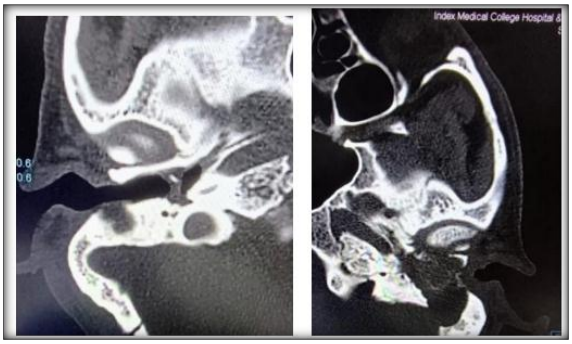

Figure 1: HRCT images demonstrating locations of cholesteatoma. HRCT image of the right temporal bone -(A) shows soft tissue density noted in proximal part of EAC, MAC with erosion and destruction of ossicles. Mastoid aircell sclerosed with soft tissue density noted in mastoid air cell with erosion of underlying bone. HRCT image of left temporal bone-(B) shows demonstrating soft tissue density lesion and bony erosions in the left EAC. soft tissue density seen in MAC with erosion and destruction of underlying bone and ear ossicles. Erosion of lateral wall of bony facial canal, deformed cochlea, erosion of superior semicircular canal. Soft tissue density seen in mastoid with erosion of underlying mastoid bone. Dehiscence of bony part of left sigmoid plate EAC: external auditory canal, HRCT: high-resolution computed tomography, MAC: middle air cavity

The attico-antral region was the most common area of soft tissue density involvement, detected in 31 out of 62 diseased temporal bones (50%). This was followed by extensive holotympanic involvement in 19 out of 62 cases (30.6%) and attic involvement in 10 out of 62 cases (16.1%). Conversely, the isolated mesotympanum and external auditory canal (EAC) were the least frequent locations, with each being observed in 1 out of 62 diseased temporal bones (1.6%). [Table 2]

The most common imaging finding associated with chronic suppurative otitis media (CSOM) among the 62 diseased temporal bones was the loss of aeration and sclerosis of the mastoid air cells, identified in 60 (96.7%) diseased temporal bones. A considerable number of soft tissue lesions were non- dependent, representing 42 (67.7%) of the soft tissue density lesions in the affected temporal bones. Other significant findings suggestive of CSOM with cholesteatoma included bony erosions, observed in 53 (85.5%) of the diseased temporal bones, and bony expansion, which was noted in 34 out of 62 (54.8%) affected temporal bones. Additionally, lateral semicircular fistula and petrous apicitis were detected in 3 out of 62 (4.8%) and 1 out of 62 (1.6%) of the diseased temporal bones, respectively. [Table 3]

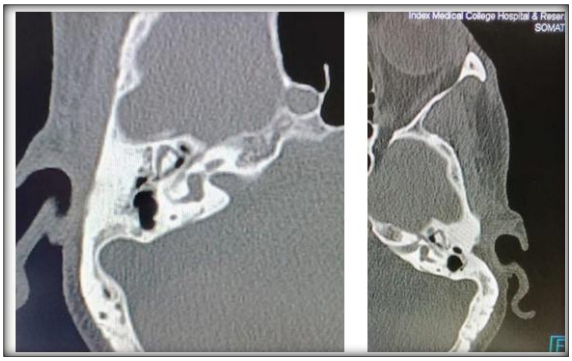

Figure 2: HRCT images demonstrating locations of cholesteatoma. HRCT image of the right temporal bone -(A) shows soft tissue density noted in MAC. HRCT image of left temporal bone-
(B) shows demonstrating soft tissue density seen in MAC. EAC: external auditory canal, HRCT: high-resolution computed tomography, MAC: middle air cavity

In context of location of the bony erosions, the incus was the most commonly eroded structure, identified in 38 (61.2%) diseased temporal bones, followed by the malleus in 36 (58.1%), scutum in 34 (54.8%), stapes in 29 (46.7%), tegmen tympani in 23 (37.1%), and facial canal in 21 (33.8%) of the affected temporal bones. The least commonly affected structures were the mastoid cortex dehiscence with 4(6.5%), lateral semicircular canal and bony external auditory canal, each seen in 3 (4.8%) diseased temporal bones. [Table 4]

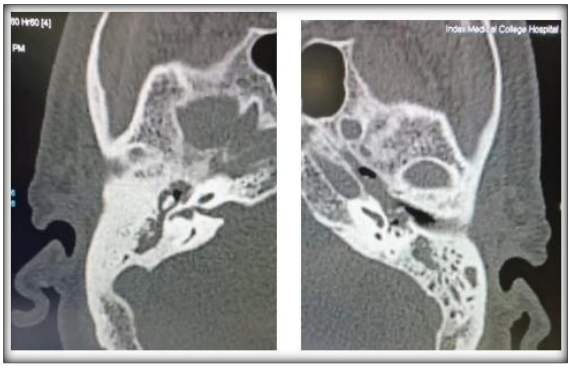

Figure 3: HRCT images demonstrating locations of cholesteatoma. HRCT image of the right temporal bone -(A) shows soft tissue density noted in MAC, additus, and antrum. Refraction of ear ossicles. Thining of horizontal part of right facial nerve canal. Near complete sclerosis of mastoid air cell. HRCT image of left temporal bone-(B) shows demonstrating soft tissue density seen in MAC, additus and antrum. Thining of horizontal part of facial nerve canal. Partial sclerosis of left mastoid air cell. EAC: external auditory canal, HRCT: high-resolution computed tomography, MAC: middle air cavity

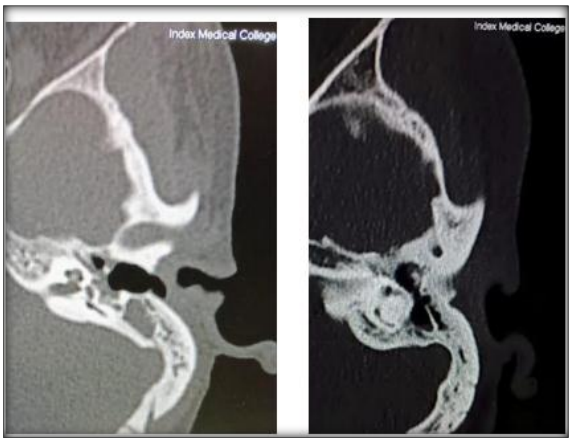

Figure 4: HRCT images demonstrating locations of cholesteatoma. HRCT image of the left temporal bone -(A) shows soft tissue density noted in MAC aditus and antrum. Eroding the middile ear ossicles. Near to comlete resorption of incus and stapes. Complete sclerosis of mastoid air cell. Thining of tegman tympani. HRCT image of left temporal bone-(B) shows soft tissue density seen in MAC, aditus and antrum. Middle ear ossicles are resorped and eroded. near complete sclerosis of the mastoid air cell . Horizontal part of facial canal shows thining. Rarefaction of tegmen tympani. EAC: external auditory canal, HRCT: high-resolution computed tomography, MAC: middle air cavity

Among the 62 temporal bones exhibiting soft tissue density, 57 were confirmed to be cholesteatoma, while five cases were identified as false positives based on intraoperative and histopathological examination. The false-positive cases included granulation tissue (two instances), cholesterol granuloma (one instance), non-cholesteatomatous otitis media (one instance), and cerumen (one instance).

In the present study, HRCT temporal bone demonstrated a 100% sensitivity (CI: 93.5%-100%), 88.2% specificity (CI:74.5%-95.6%), 92% PPV (CI: 81.8%-96.2%), 100% NPV (CI: 90.2%-100%), and an
accuracy of 95% (CI 88.6%-97.2%) for diagnosing cholesteatoma based on intra-operative and histopathological examination correlation.

Table 1: Soft tissue density at different locations in diseased temporal bones on HRCT

Involvement of individual parts	Number	Percentage
Epitympanum/Prussak space	59	95.2
Mesotympanum	52	83.8
Hypotympanum	21	32.3
Aditus ad Antrum	51	80.9
Mastoid Antrum and air cells	45	72.6
Sinus Tympani	5	8.1
Facial canal recess	4	6.5
Eustachian Tube	1	1.5
EAC	10	16.1

Table 2: Typical locations of soft tissue density in the diseased temporal bones on HRCT

Involvement	Number	Percentage
Attico-antral	31	50
Holotympanic	19	30.6
Attic	10	16.1
Mesotympanum only	1	1.6
EAC	1	1.6

Table 3: HRCT signs of CSOM and cholesteatoma in diseased temporal bones

HRCT signs	Number	Percentage
Loss of aeration and sclerosis of mastoid air cells	60	96.7
Bony erosions	53	85.5
Non-dependent soft tissue density lesions	42	67.7
Bony expansion	34	54.8
Lateral semicircular canal fistula	3	4.8
Petrous Apicitis	1	1.6

Table 4: Location of bony erosions in the diseased temporal bones

Location of bony erosions	Number	Percentage
Incus	38	61.2
Malleus	36	58.1
Scutum	34	54.8
Stapes	29	46.7
Tegmen tympani thinning/erosion	23	37.1
Facial canal	21	33.8
Mastoid cortex dehiscence	4	6.5
Lateral semi-circular canal dehiscence	3	4.8
Bony EAC	3	4.8

DISCUSSION

The capability of high-resolution computed tomography (HRCT) to delineate chronic suppurative otitis media (CSOM) and its associated complications, particularly cholesteatoma, prior to otologic surgery is well recognized.[7] HRCT is especially adept at identifying early erosive changes in the ossicular chain and detecting concealed soft tissue, particularly in smaller anatomical areas such as the sinus tympani and the recess of the facial canal. However, it falls short in accurately distinguishing cholesteatomatous soft tissue from other pathologies, including granulation tissue, scar tissue, cerumen, and granulomas.[6,8] Nonetheless, HRCT is superior to magnetic resonance imaging (MRI), positron emission tomography (PET) CT, and Technetium-99m imaging due to its greater accessibility, cost- effectiveness, and ability to furnish detailed insights into the bony structures of the middle ear in the context of CSOM.[3] Although MRI can assist in characterizing soft tissue, it does not provide the spatial resolution required for assessing bony alterations in the temporal bone.

Out of the 100 temporal bones examined from the 50 patients, 62 displayed soft tissue density and were categorized as diseased based on HRCT findings. Among these 62 diseased temporal bones, 56 (90.3%) were identified as primarily diseased, while 6 (9.6%) were suspected of postoperative recurrence.

In our study, unilateral disease was observed in 36 (72%) patients, while bilateral disease was present in 13 (26%) patients, aligning with the findings of Gomaa et al., who reported bilateral disease in 16 (28.5%) among 50 patients evaluated.[9]

In our study, the majority of soft tissue density lesions were non-dependent, representing 42 out of 62 (67.7%) of the diseased temporal bones, which is a significant indicator of cholesteatoma. Rai, in their study involving 50 patients, reported that 45 (90%) exhibited non-dependent soft tissue.[10] The difference in the percentage of non-dependent soft tissue between our findings and those of Rai may be due to the more extensive soft tissue progression and holotympanic involvement noted in 19 of the diseased temporal bones in our cohort.

In the current study, the epitympanum/Prussak space was identified as the most frequent site of soft tissue involvement, noted in 59 out of the 62 diseased temporal bones (95.2%). Other frequent locations included the mesotympanum and aditus ad antrum, seen in 52 (83.9%) and the mastoid antrum in 45 (72.6%) of the diseased temporal bones. Similarly, Jacob et al. conducted an HRCT study involving 30 cases of CSOM with cholesteatoma, which showed that soft tissue density was most commonly located in epitympanum i.e., 22 (73.3%) patients, followed by the mesotympanum with 17 (56.6%) patients and the aditus ad antrum in 16 (53.3%) patients. These findings align with the common locations of soft tissue involvement observed in CSOM cases with cholesteatoma.[11]

In the research conducted by Gomaa et al., the predominant locations of soft tissue density in chronic suppurative otitis media (CSOM) indicated that extensive holotympanic soft tissue density was present in 18 patients (32.1%), followed by attic involvement in 16 patients (28.5%), attico-antral in 12 patients (21.4%), and mesotympanum in 10 patients (17.8%).[9] In contrast, our study found that the most frequently identified site of involvement

was the attico-antral region, observed in 32 out of 62 diseased temporal bones (50.7%), followed by extensive holotympanic involvement in 19 (30.1%). Attic involvement was detected in 10 (15.8%) diseased temporal bones, while one case (1.5%) exhibited involvement of both the mesotympanum and external auditory canal. Notably, cholesteatoma in the external auditory canal, which is a rare location, was identified in one case, displaying surrounding bony erosion that distinguished it from keratosis obturans, its primary differential diagnosis.[3]

In our study, the most consistent finding associated with chronic suppurative otitis media (CSOM) was the loss of aeration and sclerosis of the mastoid air cells, observed in 60 out of 62 diseased temporal bones (96.7%). Similarly, Gaurano et al. conducted an HRCT evaluation of 64 patients with the unsafe type of CSOM and reported that all patients (100%) exhibited affected mastoid air cells.[12]

Bone erosion was identified in 53 (85.5%) of the 62 diseased temporal bones. The incus was the most commonly eroded ossicle, found in 38 (61.2%) diseased temporal bones, followed by the malleus in 36 (58.1%) and stapes in 29 (46.7%) diseased temporal bones. A comparable trend was noted in a study by Manik et al., which involved HRCT analysis of 50 symptomatic patients. Their findings indicated that the incus was the most frequently eroded ossicle, affecting 35 out of 50 patients (70%). This was followed by erosion of the malleus in 21 patients (42%) and the stapes in 17 patients (34%).[13] In the current study, scutum erosion was detected in 35 out of 62 diseased temporal bones (55.5%). Conversely, Rai reported scutum erosion in 23 out of 35 patients (65%) in their research.[10] Tegmen tympani erosion was noted in 23 (37.1%) diseased temporal bones. An HRCT study by Jamal et al. in 50 symptomatic patients revealed tegmen tympani erosion in 13 (30%) patients.[14] No cases of dural sinus plate erosion were encountered in our study, as this complication is rare in CSOM/cholesteatoma.[9-13]

Bony expansion was observed in 34 (54.8%) diseased temporal bones in the present study. In contrast, the study by Gaurano et al. reported bony expansion in 59 (92%) cases.[12] We found facial canal dehiscence in 21 (33.8%) diseased temporal bones. The research conducted by Jamal et al. found facial canal dehiscence in 15 out of 50 patients (30%).[14] In our study, we noted mastoid cortex dehiscence in four out of 62 diseased temporal bones (6.5%), which corresponds with Rai's results, where mastoid cortex dehiscence was reported in four out of 50 patients (8%).[10] Furthermore, our findings included lateral semicircular canal fistula in three out of 62 diseased temporal bones (4.8%). This observation is consistent with an HRCT study by Dashottar et al., which identified lateral semicircular canal fistula in two out of 50 symptomatic patients (4%).[15]

In this study, HRCT successfully detected soft tissue lesions of all sizes, with no false-negative cases, leading to a sensitivity of 100%. However, five patients were incorrectly diagnosed with cholesteatoma, as HRCT was unable to clearly distinguish cholesteatoma from other pathologies such as granulation tissue (2 cases), cholesterol granuloma (1 case), and non-cholesteatomatous otitis media (1 case). These findings are consistent with common causes of false-positive results reported in the literature. Additionally, one case of soft tissue in a post-operative mastoid cavity initially suspected to be cholesteatoma was revealed to be impacted wax during surgery, a frequent issue in canal wall down procedures due to altered epithelial migration. The specificity of HRCT for diagnosing cholesteatoma in our study was 88.2%, based on intra-operative and histopathological examination (HPE) correlation. In a similar vein, Mitra et al,[17] reported a sensitivity and specificity of 100% in their HRCT evaluation involving 100 patients. Payal G et al. observed a sensitivity of 89.6% and a specificity of 100% in a cohort of 60 patients.[18] Additionally, Reddy et al. demonstrated a sensitivity of 92% and a specificity of 66% in their study of 25 patients with chronic suppurative otitis media (CSOM).[19]

The limitations of this study include its small sample size of 50 patients, which may have reduced the likelihood of observing complications related to CSOM, such as dural sinus thrombosis and intracerebral complications. Additionally, the correlation between HRCT findings and intra-operative results was not established, limiting the ability to assess the sensitivity and specificity of specific imaging signs. The presence of bilateral disease in 28% of patients confined the analysis to affected temporal bones rather than individual patients, making direct comparison with other studies difficult.

CONCLUSION

Advancements in radiological techniques have greatly improved the understanding of the tympanomastoid compartments and their relationship with adjacent neurovascular structures. High- resolution CT (HRCT) of the temporal bone is an invaluable tool for detecting early cholesteatoma, including small and hidden lesions. It allows for accurate assessment of bony integrity, identification of associated complications, and offers a surgical roadmap for cholesteatoma procedures. Additionally, HRCT is effective in evaluating recurrent disease in post-operative temporal bones, providing excellent sensitivity and high specificity in identifying cholesteatoma and evaluating the status of the temporal bone structures.

REFERENCES

1. Head K, Chong LY, Bhutta MF, et al. Topical antiseptics for chronic suppurative otitis media. Cochrane Database Syst Rev. 2020; 1:0.
2. Seiden AM, Tami TA, Penssak ML, Cotton RT, Gluckman JL. Vol. 111. New York: Thieme; 2002. Otorhinolaryngology, The Essentials; pp. 44–58.
3. Baráth K, Huber AM, Stämpfli P, Varga Z, Kollias S. Neuroradiology of cholesteatomas. AJNR Am J Neuroradiol. 2011; 32:221–229. [PMC free article] [PubMed] [Google Scholar]
4. Mafee MF, Levin BC, Applebaum EL, Campos CF. Cholesteatoma of the middle ear and mastoid. Otolaryngol Clin North Am. 1988; 21:265–268.
5. Liu DP, Bergeron RT. Contemporary radiologic imaging in the evaluation of middle ear-attic-antral complex cholesteatomas. Otolaryngol Clin North Am. 1989; 22:897–909.
6. Jackler RK, Dillon WP, Schindler RA. Computed tomography in suppurative ear disease: a correlation of surgical and radiographic findings. Laryngoscope. 1984; 94:746–752.
7. Chee NC, Tan TY. The value of preoperative high resolution CT scans in cholesteatoma surgery. Singapore Med J. 2001; 2:155–159.
8. Mafee MF, Kumar A, Yannias DA, Valvassori GE, Applebaum EL. Computed tomography of the middle ear in the evaluation of cholesteatomas and other soft-tissue masses: comparison with pluridirectional tomography. Radiology. 1983; 148:465–472.
9. Gomaa MA, Abdel Karim AR, Abdel Ghany HS, Elhiny AA, Sadek AA. Evaluation of temporal bone cholesteatoma and the correlation between high resolution computed tomography and surgical finding. Clin Med Insights Ear Nose Throat. 2013; 6:21–28.
10. Rai T. Radiological study of the temporal bone in chronic otitis media: prospective study of 50 cases. Indian J Otol. 2014; 20:48.
11. Jacob A, Sreedhar S, Choolakkaparambu A, Anwar S, Bashir Bashir, Nalakath K. Utility of high resolution computed tomography in pre-operative evaluation of cholesteatoma. Int J Otorhinolaryngol Head Neck Surg. 2020; 6:1278.
12. Gaurano JL, Joharjy IA. Middle ear cholesteatoma: characteristic CT findings in 64 patients. Ann Saudi Med. 2004; 24:442–447.
13. Manik S, Dabholkar Y, Bhalekar S, Velankar H, Chordia N, Saberwal A. Sensitivity and specificity of high-resolution computed tomography (HRCT) of temporal bone in diagnosing cholesteatoma and its correlation with intraoperative findings. Indian J Otolaryngol Head Neck Surg. 2021; 73:25– 29.
14. Jamal S, Rahman A, Mohan C, Srivastava A. Is pre-operative HRCT temporal bone findings consistent with tympano-mastoid surgical findings. Int J Health Clin Res. 2020; 3:104–109.
15. Dashottar S, Bucha A, Sinha S, Nema D. Preoperative temporal bone HRCT and intra-operative findings in middle ear cholesteatoma: a comparative study. Int J Otorhinolaryngol Head Neck Surg. 2018; 5:77.
16. Khemani S, Singh A, Lingam RK, Kalan A. Imaging of postoperative middle ear cholesteatoma. Clin Radiol. 2011; 66:760–767.
17. Mitra M, Thakare P, Monteiro B, Amle D. The role of high-resolution computerized tomography as a diagnostic tool in the evaluation and planning of management of patients with chronic otitis media. Muller J Med Sci Res. 2021; 12:6.
18. Payal G, Pranjal K, Gul M, Mittal MK, Rai AK. Computed tomography in chronic suppurative otitis media: value in surgical planning. Indian J Otolaryngol Head Neck Surg. 2012; 64:225–229.
19. Sirigiri RR, Dwaraknath K. Correlative study of HRCT in attico-antral disease. Indian J Otolaryngol Head Neck Surg. 2011; 63:155–158.