ORIGINAL ARTICLE

Evaluating Mastoid Involvement in Chronic Suppurative Otitis Media: Diagnostic Accuracy of High-Resolution Computed Tomography in Southern Iraq

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Abstract- The study aimed to assess the diagnostic accuracy of high-resolution computed tomography (HRCT) in evaluating mastoid involvement in patients with chronic suppurative otitis media (CSOM) in southern Iraq. This multicenter study was conducted in three medical centers across southern Iraq from September 2023 to February 2024. A total of 120 patients diagnosed with attico-antral CSOM, scheduled for mastoidectomy across three medical centers, underwent HRCT scanning and subsequent intraoperative evaluation. The research compared HRCT findings with intraoperative results across various parameters, including soft tissue lesions, mastoid pneumatization, and erosion of the scutum, tegmen plate, sinus plate, ossicular chain, facial canal, and lateral semicircular canal (LSCC). The study found that HRCT and intraoperative findings showed good agreement in assessing soft tissue involvement in the mastoid, attic, middle ear, Eustachian tube, and facial recess (P>0.05). Mastoid pneumatization also noted a strong agreement (P=0.75). However, significant discrepancies were observed in scutum erosion (P=0.047), sinus plate positioning (P=0.036), and ossicular status, with HRCT being less sensitive for detecting stapes erosion (P=0.013). For facial canal erosion, no significant differences were observed (P=0.58), while HRCT identified fewer cases of LSCC erosion compared to intraoperative findings, though the difference was not statistically significant. The results demonstrate that while HRCT is a reliable tool for assessing most aspects of middle ear involvement in CSOM, certain areas such as scutum erosion and stapes erosion require careful intraoperative evaluation for comprehensive diagnosis and management.

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Introduction

Chronic suppurative otitis media (CSOM) is a persistent inflammation of the middle ear and mastoid cavity characterized by recurrent ear discharge through a perforated tympanic membrane (1). Among the various types of CSOM, the attico-antral type is particularly concerning due to its association with cholesteatoma, a destructive and expanding growth of keratinizing squamous epithelium within the middle ear and mastoid (2). This condition often leads to bone erosion, ossicular damage, and potentially severe complications like facial nerve paralysis and intracranial infections (3).

The mastoid process, an essential anatomical component of the temporal bone, plays a critical role in the pathophysiology of CSOM (4). The mastoid air cells, interconnected cavities within the mastoid process, are involved in the ventilation and drainage of the middle ear (5). CSOM often leads to changes in the mastoid air cells, such as sclerosis, opacification, and reduced pneumatization, indicative of chronic inflammation and infection (6). Evaluating these

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changes is crucial in understanding the extent and severity of the disease, planning appropriate surgical interventions, and predicting postoperative outcomes (7).

Accurate preoperative assessment is crucial for effective management of CSOM, especially in cases with suspected cholesteatoma (8). High-resolution computed tomography (HRCT) of the temporal bone has become a vital tool in this regard, providing detailed visualization of the complex structures within the middle ear and mastoid (9). HRCT aids in identifying the extent of disease, the involvement of critical structures, and the presence of complications, thereby guiding surgical planning and reducing the risk of postoperative complications (9).

Several studies have underscored the importance of mastoid HRCT scans in the management of CSOM (10-12). For instance, CT imaging has been shown to accurately depict the extent of mastoid sclerosis and pneumatization, which correlates with the chronicity and severity of the disease (11). Moreover, CT scans can reveal hidden cholesteatomas, ossicular chain disruptions, and labyrinthine fistulas—findings often undetectable through clinical examination alone (13). By providing a comprehensive overview of the middle ear and mastoid anatomy, HRCT scans enhance the surgeon’s ability to plan a tailored surgical approach, whether a canal wall up or a canal wall down mastoidectomy, thereby optimizing patient outcomes (11).

However, despite its high sensitivity and specificity, HRCT has limitations, particularly in differentiating between soft tissue types and detecting early bone erosions (14). Additionally, while CT is excellent for evaluating bony structures, it provides limited information on the disease's soft tissue involvement, which might necessitate additional imaging modalities like magnetic resonance imaging (MRI) for a more comprehensive assessment (15).

Therefore, our study aims to compare the preoperative HRCT findings with intraoperative observations in patients with CSOM of the attico-antral type, evaluating the accuracy of HRCT in predicting the extent of disease and guiding surgical interventions.

Materials and Methods

Patient selection

This study was conducted across three medical centers in southern Iraq from September 2023 to February 2024. The research was approved by the ALAYEN IRAQI University (AUIQ) ethics committee, and informed consent was obtained from all participants prior to their inclusion in the study. In our study, 120 patients were included, 72 females and 48 males diagnosed with chronic suppurative otitis media (CSOM) of the attico-antral type who were scheduled for mastoidectomy were included. The patients were distributed among the three centers: 68 from Al-Haboubi Teaching Hospital in Nasiriyah, 35 from Al-Fayhaa Teaching Hospital in Basra, and 17 from Al-Sadr Teaching Hospital in Misan.

The selection of patients was carried out randomly, adhering strictly to predefined inclusion and exclusion criteria.

The Inclusion Criteria were as follows:

1. Patients with a clinical diagnosis of the attico-antral type of CSOM present with symptoms such as offensive aural discharge, aural polyps, and marginal perforation.
2. Cases with suspicion of underlying pathology, such as malignancy.

The Exclusion Criteria included:

1. Patients with a history of previous ear surgery.
2. Individuals who had experienced ear trauma.
3. Patients who were considered unfit for surgery.
4. Patients with congenital ear anomalies.

Baseline high-resolution computed tomography (HRCT) scan protocol

HRCT scans were performed using a 64-section CT scanner (Sensation 64; Siemens, Forchheim, Germany) in zUHR mode with a 12×0.3 mm collimation. The scanning parameters included a tube potential of 120 kV, 400 effective mAs, 1-second rotation time, and 0.8 helical pitch. The automatic exposure control was turned off, and the volume CT dose index was 88 mGy. Images were reconstructed using a standard filtered back-projection algorithm with a specialized kernel designed for UHR mode (U70). The images were generated with a section thickness of 0.4 mm and increments of 0.3 mm, with both z-axis and in-plane flying focal spots employed for data acquisition.

Pre-operative assessment

All patients underwent a thorough pre-operative assessment, which included the following steps:

1. History Taking: A detailed medical history was recorded for each patient.
2. Oto-rhino-laryngological Examination: A

complete ENT examination was conducted.

3. Audiological Assessment: This included pure tone audiometry and tympanometry to assess hearing function.
4. Laboratory Investigations: Routine laboratory tests, including a complete blood picture, coagulation profile, blood sugar levels, liver function tests, and renal function tests, were performed.
5. Informed Consent: Written informed consent was obtained from all patients or their relatives.
6. HRCT Scan of the Temporal Bone: A cornerstone of the pre-operative assessment, the HRCT scan evaluates the extent of the disease.

Surgical procedure

The surgical procedures were performed under general anesthesia, with patients prepared and draped in a sterile fashion. Various mastoidectomy techniques were employed based on the pathology observed during ear exploration.

The following parameters were compared between HRCT and intra-operative findings:

1. Soft Tissue Lesions: Involving the middle ear, attic, and mastoid.
2. Mastoid Involvement: Classified as well-pneumatized (cellular), partially-pneumatized (diploic), or non-pneumatized (sclerotic).
3. Scutum: Evaluated for erosion.
4. Tegmen Plate: Assessed for erosion.
5. Sinus Plate: Evaluated for erosion and position (normal or anteriorly displaced).
6. Ossicular Chain: Checked for erosion.
7. Facial Canal: Assessed for erosion and position (normal or displaced).
8. Lateral Semicircular Canal (LSCC): Evaluated for erosion.
9. Facial Recess and Sinus Tympani (ST): Assessed for involvement.
10. Eustachian Tube (ET): Checked for involvement.

HRCT scans were performed with 1 mm sections in both axial and coronal planes, and findings were meticulously recorded and compared with intraoperative observations.

Statistical analysis

Data were analyzed using SPSS software (version 29.0). The paired sample t-test was employed to compare HRCT and intraoperative findings. Graphs were generated using Excel or SPSS. A *P* of less than 0.05 was considered statistically significant.

Results

Clinical and imaging characteristics

On examination, 64 patients had a posterosuperior quadrant retraction pocket with cholesteatoma flakes, 40 patients had attic cholesteatoma with pars flaccida perforation, and 16 patients had extensive cholesteatoma involving all the middle ear cleft with aural poly.

Soft tissue involvement in the middle ear cleft

In all observed regions (mastoid, attic, middle ear, Eustachian tube, sinus tympani, and facial recess), the findings from HRCT scans and intra-operative procedures suggest no statistically significant difference between the two methods (*P*>0.05) (Table 1).

Table 1. Comparison between HRCT and intra-operative findings regarding soft tissue involvement in the middle ear cleft

Variable	Finding	CT (120 cases) (%)	Intraoperative (120 cases) (%)	*P**
The soft tissue in mastoid	Absent (No. of cases)	40 (33.33)	40 (33.33)	
	Present (No. of cases)	80 (66.67)	80 (66.67)	0.05
	Undefined (No. of cases)	0	0	
The soft tissue in the attic	Absent (No. of cases)	8 (6.67)	8 (6.67)	
	Present (No. of cases)	112 (93.33)	112 (93.33)	0.05
	Undefined (No. of cases)	0	0	
The soft tissue in ME	Absent (No. of cases)	48 (40)	48 (40)	
	Present (No. of cases)	72 (60)	72 (60)	0.05
	Undefined (No. of cases)	0	0	
The soft tissue in ET	Absent (No. of cases)	96 (80)	96 (80)	
	Present (No. of cases)	24 (20)	24 (20)	0.58
	Undefined (No. of cases)	0	0	
Sinus tympani and facial recess involvement	Absent (No. of cases)	48 (40)	48 (40)	
	Present (No. of cases)	72 (60)	72 (60)	0.05
	Undefined (No. of cases)	0	0	

Pneumatization of mastoid

our findings illustrate that the difference between the HRCT and intraoperative findings was not statistically significant (*P*=0.75), suggesting a generally good agreement between the two methods in assessing mastoid pneumatization (Table 2).

Table 2. Comparison between HRCT and intra-operative findings regarding mastoid pneumatization

Variable	Finding	CT (120 cases) (%)	Intraoperative (120 cases) (%)	*P**
Mastoid Pneumatization	Well pneumatized (NO. of cases)	8 (6.67)	12 (10)	0.75
	Partially pneumatized (NO. of cases)	32 (26.66)	28 (23.33)	
	Not pneumatized (NO. of cases)	80 (66.67)	80 (66.67)	

Scutum erosion

The results demonstrated that the difference between the HRCT and intraoperative findings was statistically significant (*P*=0.047), indicating a notable discrepancy between the two methods in detecting scutum erosion (Table 3).

Table 3. Comparison between HRCT and intra-operative findings regarding scutum erosion

Variable	Finding	CT (120 cases) (%)	Intraoperative (120 cases) (%)	*P**
Scutum	Not eroded (No. of cases)	64 (53.33)	48 (40)	0.047
	Eroded (No. of cases)	56 (46.67)	72 (60)	
	Undefined (No. of cases)	0	0	

Tegmen and sinus plates (erosion & position)

For the tegmen plate, there was no statistically significant difference between HRCT scans and intra-operative procedures (*P*=0.85). Both methods agreed on a normal tegmen plate position in 116 cases, with a borderline significant difference (*P*=0.049). The findings of the sinus plate showed statistically significant differences between HRCT scans and intra-operative procedures (*P*=0.036). Both methods also agreed on sinus plate positioning in 112 cases, with a statistically significant difference for anterior displacement (*P*=0.045) (Fig.1).

Ossicular status

The findings for the malleus were consistent between the two methods, with no significant differences observed (*P*=0.07). A slight discrepancy was noted for the incus, but it was not statistically significant (*P*=0.5). In contrast, there was a significant discrepancy between HRCT and intraoperative findings for the stapes, with the intraoperative examination identifying more cases of erosion, and this difference was statistically significant (*P*=0.013) (Table 4).

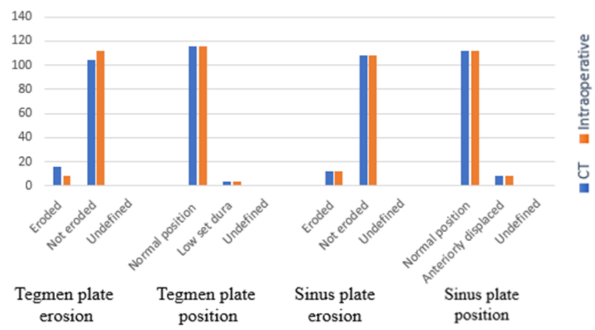

Figure 1. Comparison between HRCT and intra-operative findings regarding tegmen and sinus plates (erosion and position)

Table 4. The ossicular status of the malleus, incus, and stapes as determined by HRCT imaging and intraoperative examination

Variable	Finding	CT (120 cases)	Intraoperative (120 cases)	*P**
Malleus	Eroded (No. of cases)	96 (80)	96	0.07
	Not eroded (No. of cases)	24 (20)	24	
	Undefined (No. of cases)	0	0	
Incus	Eroded (No. of cases)	104 (86.67)	112 (93.33)	0.5
	Not eroded (No. of cases)	16 (13.33)	8 (6.67)	
	Undefined (No. of cases)	0	0	
Stapes	Eroded (No. of cases)	16 (13.33)	52 (43.33)	0.013
	Not eroded (No. of cases)	56 (46.67)	68 (56.67)	
	Undefined (No. of cases)	48 (40)	0	

Facial canal erosion and position

HRCT and intraoperative findings were largely consistent regarding the facial nerve canal's position, with no displacement observed. However, there was some discrepancy in detecting facial canal erosion, with intraoperative examination revealing fewer cases of erosion in the tympanic segment than initially indicated by HRCT and identifying additional erosion in the vertical segment not seen on HRCT. Despite these differences, the findings were not statistically significant (*P*=0.58) (Table 5).

Lateral semicircular canal (LSCC) erosion

HRCT imaging detected LSCC erosion in fewer cases than intraoperative examination, which identified additional instances of erosion. Despite this discrepancy, the difference between the two methods was not statistically significant, indicating that while HRCT may miss some cases of LSCC erosion, the overall variation is not statistically meaningful (Table 6).

Table 5. Comparison between HRCT and Intra-Operative Findings regarding facial nerve canal (erosion and position)

Variable	Finding	CT (120 cases)	Intraoperative (120 cases)	*P* *
Facial canal erosion	Eroded (No. of cases)	8	4	**.561**
	Not eroded (No. of cases)	112	116	
	Undefined (No. of cases)	0	0	
Facial canal position	Normal position (No. of cases)	120	120	**0.58**
	Displaced (No. of cases)	0	0	
	Undefined (No. of cases)	0	0	

Table 6. Comparison between CT and Intra-Operative Findings regarding LSCC erosion

Variable	Finding	CT (120 cases)	Intraoperative (120 cases)	*P**
LSCC erosion	Eroded (No. of cases)	12	20	**0.456**
	Not eroded (No. of cases)	108	100	
	Undefined (No. of cases)	0	0	

Discussion

Preoperative imaging of the temporal bone is essential for evaluating patients with suppurative COM and cholesteatoma, as it provides critical insights into the complex structures of the middle ear. Despite the challenges posed by the intricate anatomy of the middle and inner ear, HRCT has significantly improved the ability to detect early bone erosions and soft tissue changes, key indicators of COM and cholesteatoma (16).

In our study, HRCT demonstrated a sensitivity and specificity of 100% in accurately predicting the extent of soft tissue mass in the middle ear cleft. These results are consistent with the findings of Walshe *et al*., (17), and Sirigiri *et al*., (18), who reported similar sensitivity rates. It is particularly important to assess areas such as the eustachian tube, sinus tympani, and facial recess, as these regions may harbor residual cholesteatoma, potentially leading to recurrence. Identifying these issues preoperatively allows surgeons to thoroughly inspect and ensure complete eradication of the disease, reducing the risk of recurrence.

While HRCT is highly sensitive, it has limitations in distinguishing between cholesteatoma, granulations, and pus when bone erosion is absent, as these conditions appear as opacifications in the middle ear. A study by Garber *et al*., (19) supports this limitation. However, bone erosion on CT can increase the suspicion of cholesteatoma (20).

Our study's findings related to mastoid pneumatization on HRCT were fully consistent with intraoperative results, showing 100% sensitivity but lower specificity. These results align with Rai *et al*., (21) and Datta *et al*., (22). However, HRCT detected scutum erosion, often an early sign of attic cholesteatoma, in fewer cases compared to intraoperative examination, suggesting that very early erosions might fall below the sensitivity threshold of CT (23).

HRCT demonstrated a high sensitivity of 100% for tegmen plate erosion and a specificity of 92.85%. However, Kataria *et al*., (24) pointed out the challenges in detecting tegmen dehiscence on CT due to partial volume effects. Accurate preoperative assessment of the tegmen and sinus plate is crucial to prevent injury during surgery. Similar challenges have been reported by Kucur *et al*., (25) and Jadia *et al*., (26), emphasizing the importance of careful intraoperative evaluation.

Ossicular erosion, a key indicator of cholesteatoma, was accurately predicted by HRCT in most cases, with the malleus showing a sensitivity of 92.3% and a specificity of 100%. These findings are consistent with the study of Zhang *et al*., (27), though some studies, such as Rogha *et al*., (28), reported even higher sensitivity. The incus exhibited similar sensitivity and specificity, but the stapes, a smaller and more delicate bone, had a much lower sensitivity of 30.76%, highlighting the challenges in accurately assessing it on HRCT.

HRCT detected facial canal erosion with 100% sensitivity and 96.55% specificity, findings are comparable to Rai *et al*., (21) and Alzoubi *et al*., (29). However, HRCT was less effective in detecting LSCC erosion, with a sensitivity of only 60%, highlighting the necessity of intraoperative confirmation, as emphasized by Datta *et al*., (22) and Gerami *et al*., (30).

While our study offers valuable insights into preoperative HRCT findings and intraoperative observations in patients with cholesteatoma, several limitations should be considered. HRCT has difficulty distinguishing between cholesteatoma, granulation tissue, and pus in the middle ear cleft, consistent with the findings of Elicker *et al*., Discrepancies in assessing mastoid pneumatization, scutum erosion, and erosions of the tegmen and sinus plates, as well as ossicular status, underscore the importance of intraoperative evaluation. Our study also underscores the challenges in detecting facial canal and LSCC erosion solely through HRCT, as previously noted by Wilson et al. and Dorjee et al. These limitations suggest that while HRCT is a valuable diagnostic tool, it should be complemented by a thorough intraoperative assessment to ensure optimal surgical outcomes.

HRCT is highly reliable for assessing mastoid pneumatization, cholesteatoma extension, and complications like sigmoid sinus plate and tegmen mastoideum erosion. It is recommended for all COM cases to determine disease extent, pneumatization variations, and anatomical differences, guiding surgical planning. HRCT serves as a valuable tool for surgeons managing CSOM with attico-antral disease, providing critical insights into the nature of the disease and potential complications and helping to inform the choice of surgical approach.

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