THE CORRELATION OF THE HIGH-RESOLUTION CT SCAN WITH THE OPERATIVE FINDINGS IN PATIENTS WITH CHRONIC OTITIS MEDIA UNDERGOING TYMPANO-MASTOIDECTOMY: A DESCRIPTIVE STUDY

Muaid I. Aziz Baban [a]

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ABSTRACT

Background

The prior knowledge of the normal anatomy and disease extension in chronic suppurative otitis media (CSOM) is essential in the decision-making and planning of their surgical approach. Especially with the development of high-resolution computed tomography (HRCT), which provides good topographic viewing without the artefacts caused by the superimposition of structures.

Objectives

To point out the accuracy of the HRCT scan in correlation to intraoperative findings of CSOM diseases in predicting the disease's extent and taking surgical decisions.

Patients and Methods

A Prospective study conducted at the Department of Otolaryngology-Head & Neck Surgery (Sulaimani Teaching Hospital, College of Medicine – the University of Sulaymaniyah, Kurdistan Region –Iraq. Patients who had CSOM and were listed for mastoid surgery were included in the study. All included patients underwent HRCT preoperatively, and each image was analyzed on Osirix software to define the anatomical structures. Evaluation of pathologies of the temporal bone was recorded in a radiology proforma. A similar proforma itemized the intraoperative findings, compared them to the radiological records, and statistically analyzed them using the statistical package for social sciences (SPSS, version 19).

Results

Thirty-five patients were included in this study, and their findings showed the significance of sensitivity and specificity of HRCT in comparison to surgical findings as follows; scutum erosion was 88.9%, 96.9%, ossicle erosion was 100%, 96%, and 68.4%, 100% for malleus and incus erosion respectively. Moreover, facial nerve canal erosion with a sensitivity of 28.6% and 92.9% specificity. Lateral semicircular canal (LSSC) erosion with a sensitivity of 50% and specificity of 93.9%. Tegmen, posterior canal wall, and sigmoid sinus wall integrity with a sensitivity and specificity of 66.7%/ 96.9%, 83.3%/89.7%, and 100%/ 96%, respectively.

Conclusion

High-resolution computed tomography scan is a valuable modality in the preoperative assessment of temporal bone pathologies in patients with chronic suppurative otitis media with reasonable accuracy and precision for taking surgical decisions.

Keywords: *Chronic suppurative otitis media, High-resolution CT scan, Temporal bone, Tympano-mastoid surgery.*

[a] Department of Surgery, College of Medicine, University of Sulaimani, Kurdistan Region, Iraq.
Correspondence: muaid.aziz@univul.edu.iq

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INTRODUCTION

Despite the important role of antibiotics, Chronic otitis media (COM) remains a frequent disease worldwide. It is defined as chronic inflammation of the middle ear cleft with recurrent or persistent discharge through a perforated tympanic membrane for more than 12 weeks not responding to the medical treatment. Therefore, it is termed 'suppurative' otitis media (CSOM) [1-4].

Chronic otitis media (COM) may be further classified into mucosal disease (active/inactive), squamous disease (active/inactive), and healed COM. Although in most cases, the clinical findings, including history, micro-otoscopic examination, and audiological assessments, fundamentally influence the diagnosis, radiological investigations, especially in complicated and recurrent conditions, are warranted [5-9]. Since no effective medical treatment has been developed for COM, surgical intervention for clearance of the pathology and hearing reconstruction, extending from intact canal wall mastoidectomy to radical mastoidectomy, is advocated [10-14].

Radiological assessment of the complex temporal bone in the management of COM is a challenge for radiologists and otologists. The prior knowledge of the normal anatomy and disease extension is mandatory, not as it were within the setting of their decision-making but moreover for planning their surgical approach and weighing the anticipated benefits against the potential risks [15,16]. Godfrey and Allan McLeod developed the CT scan in 1972, receiving the Nobel Prize in medicine in 1979. In the last decades, a significant advance in the imaging system has occurred with the development of high-resolution computed tomography (HRCT), which allowed sectional images of significant detail to be obtained up to a spatial resolution of 0.45 to 0.65mm. HRCT offers the advantage of providing excellent topographic visualization free of artefacts caused by structural superimposition. However, because the various components of the temporal bone are often seen in only one projection, it is necessary to obtain scans in both planes of view, axial and coronal [1, 17].

Many authors, in their articles [14, 18-25], noted the uncertainty of the worthiness of the CT scanning of the temporal bone in the CSOM for the per-operative planning of the surgical approach and predicting the disease's extent. The aforementioned contradicted viewpoints in the literature motivated us to do this study and delineate the correlation between preoperative HRCT and intraoperative findings of CSOM diseases.

PATIENTS AND METHODS

A Prospective descriptive cross-sectional study was conducted at the Department of Otolaryngology-Head & Neck Surgery (Sulaymaniyah Teaching Hospital - College of Medicine - University of Sulaymaniyah, Kurdistan Region –Iraq) in the period between December 2018 – December 2020. The institutional review board approved the study of the university's Committee on Human Research. The study sample was taken depending on a previous report by Rogha M. et al. [26]; patients who had CSOM with consistent or intermittent discharge that lasted more than three months were listed for typmano-mastoid surgery were included in the current study after taking informed consent. Exclusion criteria were as follows; patients who presented with intracranial complications of CSOM, revision mastoid surgeries, history of temporal bone trauma, systemic disease which may affect the ear (e.g., collagen vascular or granulomatous diseases), temporal bone and skull base malignancies, and those with a history of head and neck radiotherapy. All included patients underwent careful clinical assessment through a detailed history, otomicroscopic examination, audiological evaluation through (pure tone audiometry with or without speech audiometry, tympanometry) and HRCT.

HRCT scan technique has been done, utilizing Siemens Somatom sensation 64 detectors, where the patient is in the supine position, the axial views were obtained with coronal reformatting by serial 0.6-1 mm thin sections of the temporal bone with the line joining the infra-orbital rim and external auditory meatus perpendicular to the table. The images were reconstructed with a bone algorithm to obtain excellent visibility of the bony detail and related soft tissue. All HRCT scans were analysed and interpreted in detail on Osirix software (version 8.0.2, manufactured by Pixmeo SARL Geneva, Swiss) to characterize highlights related to the anatomical structure and assessment of pathologies of temporal bone recorded in a radiology proforma. Following each tympano-mastoid exploration, a similar proforma was completed, which itemized the intraoperative findings, and, later on, compared to the radiological records. The listed radiological and operative proforma findings are as follows;

Development/cellularity of the mastoid bone. Site of soft tissue mass and opacification. Ossicular chain integrity. Lateral semicircular canal integrity.

Facial nerve canal integrity. Tegmen integrity. Erosion of the scutum.

Posterior canal wall. Sigmoid sinus plate integrity and position. Types of surgery.

Collected data were analyzed using the statistical package for social sciences (SPSS, version 19). Frequencies and percentages were calculated. McNemar's test was used to compare the same patient's CT scan and operative findings. McNemar's test could be a well-known numerical test to analyze the statistical significance of the differences in classifier exhibitions. The test is a Chi-square ($\chi2$) test for goodness of fit comparing the dissemination of sums anticipated under the useless hypothesis to the observed counts [27].

RESULTS

Thirty-five patients were enrolled in the current report. The mean age of the patients was (33 years) with an age range between (7–76 years). Eighteen patients were male 18/35 (51.4%), and the rest were females 17/35 (48.6%).

The presenting symptoms were as follows; aural discharge 25/35 (71.4%); the second one was hearing loss 10/35 (28.6%), tinnitus 8/35 (22.8%), vertigo 5 /35 (14.2%) & pain 3/35 (8.5%). Clinical and micro-otoscopic findings of the examined series noted different CSOM pathologies, which were distributed as follows; 22 (62.8%) active mucosal, 8 (22.8%) active squamous, 3 (8.5%) inactive mucosal, and 2 (5.7 %) inactive squamous CSOM.

The surgical approaches were distributed into 18 CWD vs 17 CWU, performed for the middle ear cleft pathologies as follows; CWD: 15 for active and 3 for inactive COSM, CWU: 8, 7, 2 for active mucosal, squamous, and inactive squamous type respectively.

In our study, the mastoid pneumatization was defined in the CT scan review and intraoperatively as follows; 29 (82.9%) patients were sclerotic (hyperdense), and 6 (17.1%) patients were with pneumatized mastoids (hypodense) with 100% sensitivity and specificity. On HRCT, 2/35 (5.7%) patients had clear (no soft tissue opacification in middle ear and mastoid), and 4/35 (11.4%) had middle ear disease and mastoid involvement, respectively. In 19/35 (54.3%) patients, both mastoid and middle ear opacity were noted, and in 6/35 (17.1%) patients with EAC, mastoid, and middle ear involvement. The matching between CT scan and the surgical finding was (27/35= 77.1%), which is significant, Table 1.

Concerning bony and structural integrity, Table 2 shows both HRCT scan and intraoperative findings, which showed the significance of sensitivity and specificity of HRCT in comparison to surgical findings as follows; For scutum erosion was 88.9%, 96.9%, ossicle erosion was 100%, 96% and 68.4%, 100% for malleus and incus erosion respectively as shown in table 2. For stapes, ossicle was not applicable ((Radiologically; four patients (4/35; 11.4%) were found to be intact stapes; in (31/35; 88.5%) patients could not be visualized. Intraoperatively, twenty-five patients (25/35; 71.4%) were found to be intact stapes; ten patients had eroded stapes (10/35; 28.6%).

Moreover, facial nerve canal erosion was detected radiologically with a sensitivity of 28.6% and specificity of 92.9%. LSSC erosion was detected on a CT scan with a sensitivity of 50% and specificity of 93.9% compared to intraoperative findings. Tegmen, posterior canal wall, and sigmoid sinus wall integrity were detected on CT scan compared to intraoperative findings with a sensitivity and specificity of 66.7%/ 96.9%, 83.3%/89.7%, and 100%/ 96%, respectively. Moreover, the sigmoid sinus position was noted with 100% / 96.9%, Table 2.

Further to the above findings, numerous other congenital anatomical variations and surgical risks have been detected within the course of reviewing the scans and included: a) Low lying dura; 4 cases were noted in our study b) High and dehiscent jugular bulb and dehiscent of the internal carotid canal were not recorded. Figure 1. A, B shows the malleuo-incudal ossicles integrity (Right ear); C, D shows intact facial nerve canal (Left ear); E, F illustrates the dehiscent facial nerve canal (Right ear); G, H illustrates the eroded SCC (Right ear). PCW (Posterior canal wall), ME (Middle ear cavity), SS (Sigmoid sinus), a red arrow (facial nerve), a yellow arrow (Malleulo-incudal joint), yellow arrowhead (Incus), blue arrowhead (Malleus), a red asterisk (Attic area), a yellow asterisk (Mastoid antrum), a black asterisk (Intact facial nerve canal), a blue asterisk (Dehiscent facial nerve canal), a white asterisk (Dehiscent SCC).

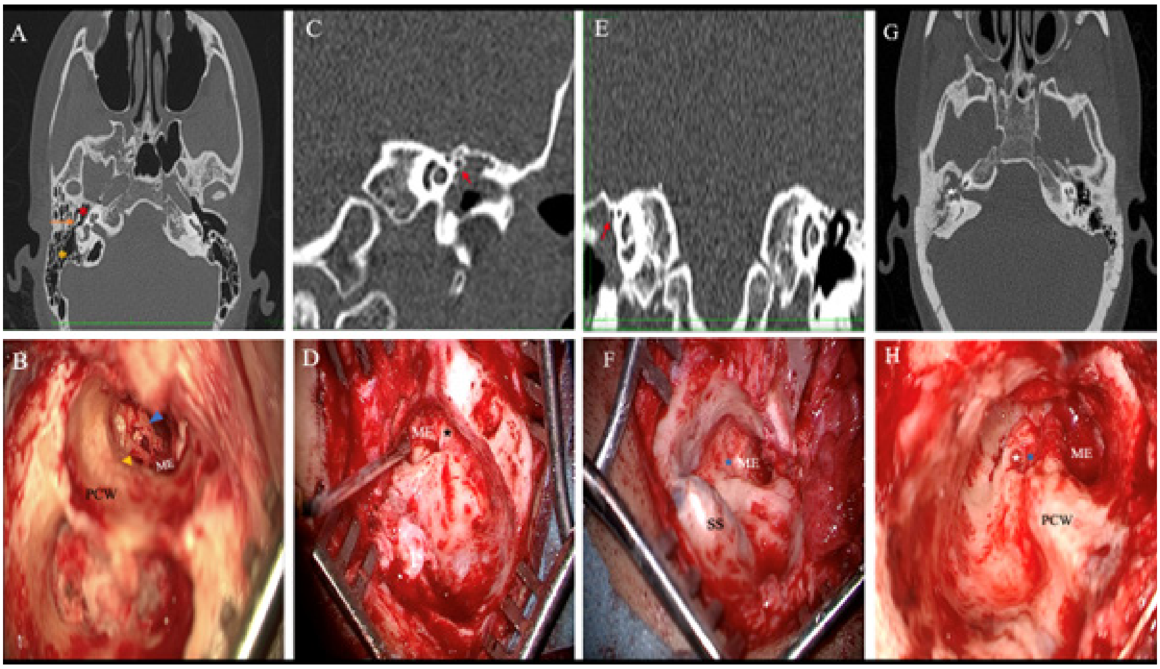

Figure 1. The preoperative HRCT scan of the temporal bone and their relative intraoperative findings.

Table 1. Correlation of the site of the pathology on the HRCT scan with the intraoperative findings

HRCT scan		**Site of soft tissue mass at the surgery**				**Matching %**
		Middle ear	**Mastoid cavity**	**Middle ear & mastoid cavity**	**EAC + Middle ear + Mastoid cavity**	
Site	No.	No. (%)	No. (%)	No. (%)	No. (%)	
No opacification	2	1 (50%)	0 (0%)	1 (50%)	0 (0%)	
Middle ear	4	4 (100%)	0 (0%)	0 (0%)	0 (0%)	
Mastoid cavity	4	0 (0%)	3 (75%)	1 (25%)	0 (0%)	77.1%
Middle ear & mastoid cavity	19	2 (10.5%)	1 (5.3%)	16 (84.2%)	0 (0%)	
EAC+ Middle ear + Mastoid cavity	6	0 (0%)	0 (0%)	2 (33.3%)	4 (66.7%)	
Total	**35**	**7 (20%)**	**4 (11.4%)**	**20 (57.1%)**	**4 (11.4%)**	**27/35**

Table 2. Sensitivity and Specificity of HRCT in comparison to surgical findings.

HRCT findings		Surgical findings				Total	HRCT scan Sensitivity / Specificity	P-value	Agreement
		Intact		Eroded					
	No.	No.	%	No.	%	%	%		
Malleus									
Intact	24	24	100	0	0	100	100 / 96	1	97.1
Eroded	11	1	9.1	10	90.9	100			
Incus									
Intact	22	16	72.7	6	27.3	100	68.4 / 100	0.031	82.8
Eroded	13	0	0	13	100	100			
LSCC									
Intact	32	31	96.9	1	3.1	100	50 / 93.9	1	91.4
Eroded	3	2	66.7	1	33.3	100			
FN canal									
Intact	31	26	83.9	5	16.1	100	28.6 / 92.9	0.453	80
Eroded	4	2	50	2	50	100			
Post CW									
Intact	27	26	96.3	1	3.7	100	83.3 / 89.7	0.625	88.5
Eroded	8	3	37.5	5	62.5	100			
Scutum									
Intact	26	25	96.2	1	3.8	100	88.9 / 96.9	1	94.3
Eroded	9	1	11.1	8	88.9	100			
SS									
Intact	31	30	96.9	1	3.2	100	100 / 96.9	1	97.1
Eroded	4	0	100	4	100	100			
Tegmen									
Intact	32	31	96.9	1	3.1	100	66.7% / 96.9%	1	94.3
Eroded	3	1	33.3	2	66.7	100			

DISCUSSION

Although the routinely performed CT scans before the middle ear surgery are not widely accepted in otology practice, and it is mainly advocated for CSOM with complications, suspected congenital abnormalities, and revision surgeries, all the pros and cons as examined within the current report, ought to be taken into considerations before a decision is taken. Some authors, however, recommend routine scanning before all mastoid surgery because the disease process may not be apparent in clinical findings alone.

In this study, the vast majority of mastoid cavities (82.9%) were found with loss of aeration and filled with soft tissue attenuation or sclerosis on CT scan images with 100% sensitivity and specificity. Because of the proximity of the mastoid air cells to the middle ear, sclerosis of the mastoid air cells is nearly usually associated with inflammatory disorders of the middle ear. Awareness of the mastoid pneumatization aids in making a surgical approach, e.g., canal wall up or down mastoidectomy (8, 28).

In the current study, the site of the disease involvement on HRCT & surgical exploration was noted mainly within the middle ear and mastoid cavity with a prevalence of 84.2% and good agreement of 77.1%, which is more or less in harmony with other reports [9, 17–19].

Although we did not investigate the different anatomical parts of the middle ear cavity separately, which is one of the limitations of this study, such observations might upraise any queries. Can we plan for CWD based on a preoperative CT scan that cannot assess the status of the different anatomical parts of the middle ear cavity without giving the details of the disease entity? The high incidence of soft tissue attenuation density in the middle ear and mastoid cavity in the same patient might define the disease process severity, which may need CWD, which is more evident in our results. The HRCT scan is less sensitive in distinguishing cholesteatoma from granulation tissue and mucosal oedema, which explains the low specificity in the antrum and aditus [2, 7, 8, 20]. This is by the findings of the majority of the authors' investigations [4, 19, 21–24].

The results of this study demonstrated a noticeable agreement between radiology and surgery in detecting the integrity of the anatomical structures, especially erosion of malleus, sigmoid sinus wall, tegmen, posterior canal wall, scutum, and LSCC. Erosion of malleus was detected with higher accuracy than incus (malleus 100% sensitivity and 68.4% incus erosion sensitivity), which is in concordance with Rai T [22], who detected erosion of malleus with 100% sensitivity but incus with only 85% sensitivity because the long process of the incus is the central part affected and eroded by CSOM, which might make it difficult to be identified radiologically.

Radiological interpretation of the stapes erosion was not applicable in this study which is in harmony with many previous reports' observations [4, 9, 25]. This is explained by the existence of the soft tissue density around stapes, which made the identification of the bone erosion challenges. Preoperative awareness of the ossicular chain status permits the otologist to plan for the ossicular reconstruction and inform the patient of the possible hearing gain after the surgery [24].

In the current study, high sensitivity/ specificity (88.9%/ 96.9%) was noted in detecting scutum erosion, which agrees with previous investigations [9, 24, 25]. In addition to the ossicle's erosion, this finding is a vital sign on a CT scan. It is worth considering the differentiation of the cholesteatoma CSOM from non-cholesteatoma CSOM (9, 24, 25). However, the absence of the erosion of scutum and ossicles does not exclude CSOM with cholesteatoma [27].

Although Rai T [22] observed poor sensitivity in detecting tegmen tympani and sigmoid sinus plate erosion, a noticeable disagreement reported by other authors [17, 18], were showed high sensitivity in detecting erosion in these areas. Our study results showed a high sensitivity for sigmoid sinus erosion and fair sensitivity in detecting tegmen tympani and LSCC erosion. This seems especially true when the latter (tegmen tympani and LSSC) were exposed during the operation. The tegmen tympani dehiscence and labyrinthine fistula can be accurately identified radiologically with a concurrent examination of both axial and coronal views. Mere dependence on either view alone may lead to increase specificity, and this might be due to volume averaging of these structures with adjacent soft tissue [8,15].

Our report delineates a strong settlement among the CT scan assessment and the surgical findings were observed in the tegmen tympani and LSCC, which is disharmony with Gerami et al. report [29], and this appears to relate to the intact condition of the aforementioned structures during the surgery in our series.

Only Alzoubi et al [30]. Asserted that all of their cases with actual tegmen tympani breach were correctly reported preoperatively and that preoperative CT scans accurately detect inner ear fistulas. However, most similar investigations, including this one, had far too few cases of LSCC fistulas or dura exposure to draw firm conclusions. Furthermore, when imaging is undertaken, the size of the fistula, or dura exposure in these instances, may have a major impact on their identification, Figure 1.

The current study noted facial canal erosion on CT scans with low sensitivity (50%) but high specificity (92.9%). This is in harmony with other reports [9, 17, 21, 22, 23, 25, 31]. The reason for low to moderate sensitivity is that in the area of the tympanic portion of the facial nerve canal, the bony floor is skinny and may be difficult to be visualized on either view of the CT images (20). Moreover, contiguous soft tissue oedema may be mistaken as bony dehiscence of the facial canal, Figure 1.

Limitations of the current study, as seen in other series, mainly relate to the need for other imaging modalities to differentiate the type of soft tissue density; thus, if the soft tissue density is due to pus or oedema, it can be medically treated and again resulting in a poor correlation with CT scan. Additionally, uneven distribution of the actual pathologies which affect the mastoid area is considered one of the main limitations which affect the CT scan sensitivity. FN dehiscence, SCC, and tegmen erosion are rare, thus reducing the sensitivity because this calculation is based on the few abnormal cases with the aforementioned pathologies. For those reasons, a larger sample is required to draw more robust conclusions.

In conclusion, the current study results points-out that a CT scan is a beneficial modality in the preoperative evaluation of temporal bone pathologies in patients with chronic suppurative otitis media with sensible accurateness for making surgical choices. The obtained images, however, need to be interpreted cautiously because of their limitations and numerous pitfalls. Therefore, ENT surgeons should be prepared to handle conditions not diagnosed preoperatively and adjust their operating strategy accordingly to minimize postoperative morbidity.

Compliance with ethical standards

Conflicts of interest

The authors declare that they have no conflict of interest.

Ethical approval

All procedures performed in studies involving human participants followed the institutional and national research committee's ethical standards and the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent

For this type of study, formal consent is obtained.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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