The Role of CT Scan in Preoperative Assessment of Ossicular Status in Chronic Otitis Media

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ABSTRACT

Background: Chronic otitis media is persistent inflammation of the middle ear cavity and mastoid for at least 12 weeks. Imaging is indicated if the long-term inflammation is unresponsive to medical treatment to evaluate hearing loss due to ossicular erosion, clinical suspicion of cholesteatoma or suspected intracranial or extracranial complications.

Objectives: To assess the accuracy of high resolution computerized tomography in evaluation of ossicular status by comparing high resolution computerized tomography results with intraoperative findings.

Methods: This was a retrospective study reviewed patients who had a computerized tomography prior to ear surgery for chronic otitis media. The computerized tomography findings were compared with the operative findings. This study was carried out in radiology department / Al-Imamein AlKadhimein Medical City, A total of 20 patients, aged more than 10 years, suffering from chronic otitis media with or without cholesteatoma that was resistant to treatment with systemic and local antibiotics were operated on during a 6-monthes period (June - December 2022).

Results: A total of 20 cases were included for this study showed mean age of 33.6 years, 13 cases were male (65 %) and 7 cases were female (35 %), which gives a male : female ratio of 1.8:1, The primary complaints of the patients were ear discharge, seen in 90% of the cases and hearing loss, seen in 75% of the cases.

The incidence of bilateral ear involvement was seen in 6 cases (30%) while 14 cases (70%) had unilateral ear involvement. Computerized tomography scan findings were compared with intraoperative findings; malleus erosion were encountered with (100%) sensitivity and specificity. incus erosion seen with 92.3% sensitivity and 100% specificity ,lastly the stapes erosion seen with 100% sensitivity and 88.23 % specificity .

Conclusion: Computerized tomography scan in preoperative assessment of ossicular status in chronic otitis media has a high sensitivity and specificity with operative findings. The incidence of ossicular erosion was found to be much greater in chronic otitis media with cholesteatoma than in chronic otitis media without cholesteatoma.

Keywords: Chronic otitis media, High resolution computerized tomography, Cholesteatoma.

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Chronic otitis media (COM) is a persistent inflammation of the middle ear cavity for at least 12 weeks with resultant tympanic membrane perforation[1]. Imaging in COM is indicated if the long-standing inflammation is unresponsive to medical treatment for evaluation of hearing loss (ossicular erosion), clinical suspicion of cholesteatoma or suspected intracranial or extracranial complications[1].

What the surgeon wants to know: there is a checklist for COM:

- Has there been any prior surgery?
- What is the degree of mastoid pneumatization, opacification or sclerosis? [1] (Knowledge of the mastoid pneumatization aids in the planning of surgical approach e.g. whether to do canal wall up or canal wall down surgery)[2].
- Anatomical variants that may pose a surgical risk, e.g. low tegmen tympani, laterally displaced sigmoid sinus, facial nerve canal dehiscence, high-riding and dehiscent jugular bulb with part of the

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internal jugular vein protruding into the middle ear cavity.
- Location of mass-epitympanum / mesotympanum / hypotympanum.
- Hidden areas-sinus tympani, facial recess, anterior epitympanum recess.
- Is the ossicular chain eroded?
- Osseous walls of the middle ear.
- Mastoid air cells, aditus.
- Tegmen tympani, sinodural plate, scutum.
- Facial canal.
- External auditory canal and tympanic membrane.
- Inner ear esp. lateral semi-circular canal
- Petrous apex, intracranial abnormality, postauricular soft tissue[3].

The aim of this study is to assess the accuracy of high-resolution CT (HRCT) in evaluation of ossicular status by comparing HRCT results with intraoperative findings.

Methods

This retrospective study was carried out at Radiology department in Al-Imamein AlKadhimein Medical City, from June to December 2022.

The inclusion criteria: every patient with chronic otitis media underwent mastoid exploration.

The exclusion criteria:

1. Previous mastoid surgery.
2. Congenital cholesteatoma.
3. Temporal bone malignancy.

High-resolution CT was done in axial sections and reformatted coronal sections with 0.6 section thickness by (Siemens Somatom Definition Edge 256) at the CT scan unit, in Al-Imamain AlKadhimain Medical city.

High-resolution CT examination was done in supine position. Head is kept in neutral position and true axial native study was obtained in bone algorithm. The raw data from each ear are separated and reconstructed into 0.6 mm (slice thickness) axial images in bone algorithm; the raw data are displayed in three orthogonal planes, then scrolls through the sagittal data to find an image where the anterior and posterior limbs of the lateral semicircular canal are displayed in cross section. An axial dataset is then made in a plane parallel to the lateral semicircular canal (LSCC). Connects the two dots of the LSCC and makes a 0.6 mm (slice thickness) parallel to the LSCC, (Figure 1). Then 0.6 x 0.5 mm coronal images are made in a plane perpendicular to the axial images. All the ossicles were analyzed in terms of health, erosion, and total loss, the presence of soft tissue mass and the presence of cholesteatoma is also checked, (Figure 2).

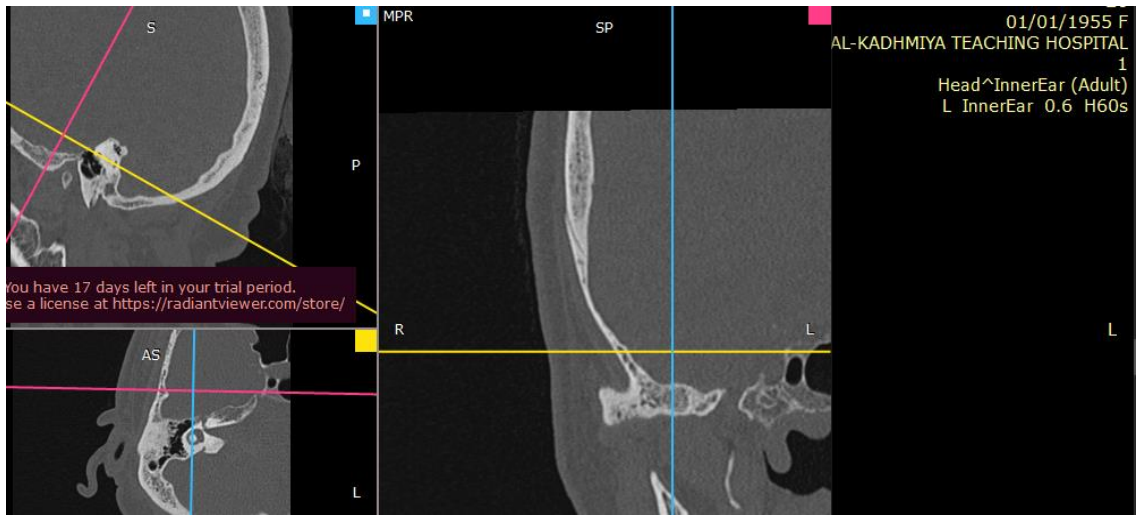

Figure 1: Axial reconstruction.

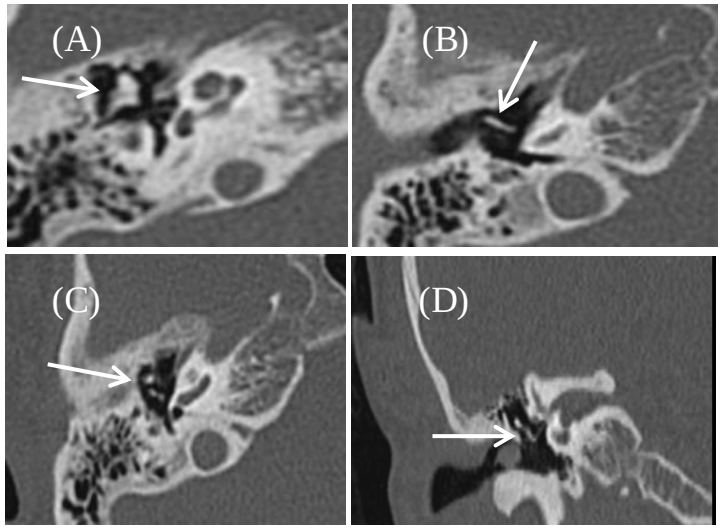

Figure 2: High-resolution CT scan of normal ossicles.
(A, B and C) axial sections. (A) demonstrates the ice cream cone configuration (the malleus head and incus body/short process), (white arrow). (B) demonstrates the handle of malleus (white arrow). (C) shows the two parallel dots (handle of malleus anteriorly and incudostapedial joint posteriorly), (white arrow). (E) coronal section demonstrates the vertical segment of the right angle (long process of incus/lenticular process), (white arrow).

Surgical procedure: Under general anesthesia and trans-oral endotracheal intubation with standard aural surgery position and preparations. Through post auricular incision, after identification of McEwan triangle the mastoid and middle ear was approached, the condition of ossicular chain were examined under the operating microscope in terms of health, erosion, and total loss. The presence of cholesteatoma was also checked. The surgery was carried out by two specialist surgeons. All the scans were reported or verified by two experienced radiologists.

A correlation between operative findings and radiological findings were performed by using Sensitivity (Se), specificity (Sp), negative predictive value (NPV), positive predictive value (PPV) were calculated. The parameters of comparison were ossicular status, extent of cholesteatoma or granulation tissue.

Results

Twenty cases were included in this study with age distribution ranges from 12 to 68 years and a mean age of 33.6 years. Commonest age group was 11-20 years accounted six cases (30%) followed by 21-30 years with five cases (25%), (Table 1). Out of all; 13 cases were males (65%) and seven cases were females (35%), which gives a male : female ratio of 1.8:1.

The primary complaints of the patients were ear discharge, seen in 90% of the cases followed by hearing loss, seen in 75% of the cases.

The incidence of bilateral ear involvement was seen in six cases (30%) while 14 cases (70%) had unilateral ear involvement. None of the patients with disease in the opposite ear were operated during the study period and were under regular follow-up (not included in this study).

Table 1: Age distribution of the studied patients.

Serial No.	Age group (Year)	Number of patients (n=20)	Percentage
1.	11-20	6	30
2.	21-30	5	25
3.	31-40	2	10
4.	41-50	2	10
5.	51-60	2	10
6.	>60	3	15
	Total	20	

In COM without cholesteatoma, 12 cases (80%) had an intact malleus; Erosion involved the handle of malleus in four cases (13.33%), and the whole malleus (head and handle) in one case (6.66%), (Table 2). In COM with cholesteatoma, the malleus was found intact in two cases (40%), and erosion involved the handle in two cases (40%) and the whole malleus (head and handle) in one case (20%), (Table 2). Malleus erosion was associated with incus erosion in all of the cases except one ear.

CT findings: Fourteen cases (70%) were found to have intact malleus and six cases (30%) were found eroded.

Surgical findings: Fourteen cases (70%) were found to have intact malleus and six cases (30%) were found eroded, (Figure 3).

Statistical analysis: Sensitivity was (100%) and specificity was (100%) of CT scan in detecting the eroded bone compared with results of surgery, (Table 5).

Table 2: Malleus status in chronic otitis media.

Malleus	COM without cholesteatoma No. (%) *n* = 15	COM with cholesteatoma No. (%) *n* = 5	COM No. (%) *n* = 20
Intact	12 (80)	2 (40)	14 (70)
Handel eroded	2 (13.33)	2 (40)	4 (20)
(Handle + head) eroded	1 (6.66)	1 (20)	2 (10)
Total	15 (100)	5 (100)	20 (100)

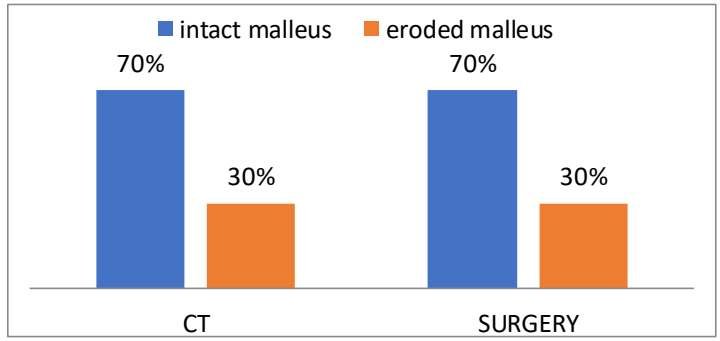

Figure 3: CT and surgical findings regarding the malleus erosion.

Incus was the ossicle most commonly found eroded in our study. We found the incus intact in eight cases (40%), eroded in 10 cases (50%) and absent in two cases (10%). The most commonly eroded parts of the incus were the lenticular process in 12 cases (60%) followed by the long process in 10 cases (50%). In COM without cholesteatoma, the incus was found intact in seven cases (46.66%), eroded in seven cases (46.66%), and absent in one case (6.66%). In COM with cholesteatoma, the incus was found intact in one case (20%), eroded in three cases (60%) and absent in one case (20%), (Table 3).

CT findings: Nine cases (45%) were found to have intact incus, nine cases (45%) were found eroded and absent in two cases (10%).

Surgical findings: Eight cases (40%) were found to have intact incus, 10 cases (50%) were found eroded and absent in two cases (10%), (Figure 4).

Statistical analysis: Sensitivity was 92.3% and specificity was 100% of CT scan in detecting the eroded bone compared with results of surgery, (Table 5).

Table 3: Incus status in chronic otitis media.

Incus	COM without cholesteatoma No. (%) *n* = 15	COM with cholesteatoma No. (%) *n* = 5	COM No. (%) *n* = 20
Intact	7 (46.66)	1 (20)	8 (40)
Absent	1 (6.66)	1 (20)	2 (10)
Absent of Lenticular process	2 (13.33)	--	2 (10)
Absent of Long + lenticular process	5 (33.33)	-	5 (25)
Erosion of (short process and body) + absent (long and lenticular process)	–	3 (20)	3 (15)
Total	15 (100)	5 (100)	20 (100)

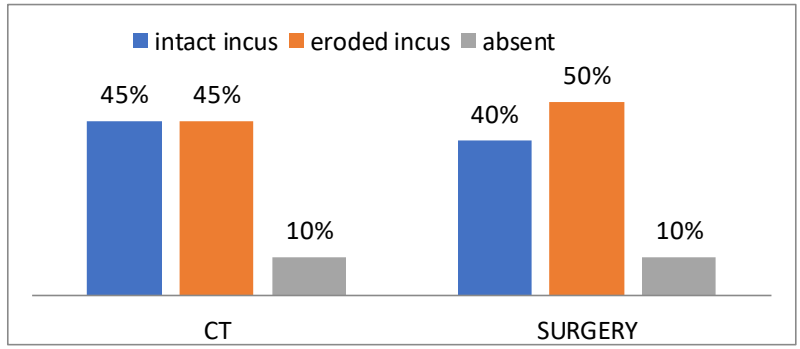

Figure 4: CT and surgical findings regarding the incus erosion.

Stapes was found intact in 15 cases (75%), while in five cases (25%) the superstructure of stapes was found eroded. In COM with no cholesteatoma, 13 cases (86.66%) had an intact stapes, and eroded in two cases (13.33%). In COM with cholesteatoma, two cases (40%) had an intact stapes and three cases (60%) showed erosion of the superstructure. The disease spared the footplate in all the cases and erosion was localized only to stapes superstructure and was associated with incus erosion in all of the affected cases, (Table 4).

CT findings: Thirteen cases (65%) were found to have intact malleus and seven cases (35%) were found eroded.

Surgical findings: Fifteen cases (75%) were found to have intact malleus and five cases (25%) were found eroded, (Figure 5).

Statistical analysis: Sensitivity was (100%) and specificity was (88.23%) of CT scan in detecting the eroded bone compared with results of surgery, (Table 5).

Table 4: Stapes status in chronic otitis media.

Stapes	COM without cholesteatoma No. (%) *n* = 15	COM with cholesteatoma No. (%) *n* = 5	COM No. (%) *n* = 20
Intact	13 (86.66)	2 (40)	15 (75)
Erosion of Superstructure	2 (13.33)	3 (60)	5 (25)
Total	15 (100)	5 (100)	20 (100)

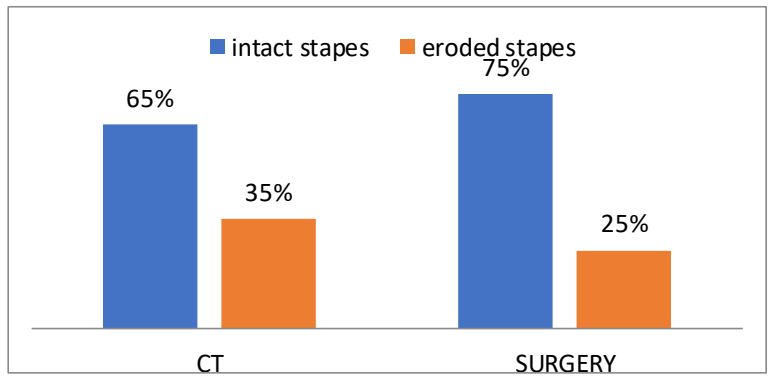

Figure 5: CT and surgical findings regarding the stapes erosion.

Table 5: Correlation between HRCT findings and operative features for ossicular erosions.

Feature	Finding in CT	Operative features	False negative	False positive	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Incus erosion	11	12	1	0	92.3	100	100	91.66
Malleus erosion	6	6	0	0	100	100	100	100
Stapes superstructure erosion	7	5	0	2	100	88.23	71.42	100

Abbreviations: HRCT, high-resolution computed tomography; NPV, negative predictive value; PPV, positive predictive value.

The ossicular chain was found intact in eight cases (40%) and eroded in 12 cases (60%). In COM with no cholesteatoma, seven cases (46.66%) had an intact chain, eight cases (53.33%) had ossicular damage. In COM with cholesteatoma only one case (20%) had an intact chain and four cases (80%) had ossicular damage, intact stapes with eroded lenticular and long process of incus were the most common site of erosion was seen in 11 cases (55%), followed by handle of malleus erosion, Stapes erosion was infrequent in COM when not associated with cholesteatoma; it was present in 13.33% of the cases only. Conversely, the presence of cholesteatoma was associated with stapes superstructure erosion in most (60%) of the ears.

On exploration out of 20 cases, in five cases (25%) cholesteatoma was found, nine cases (45%) had granulation tissue without any evidence of cholesteatoma, and three cases (15%) the middle ear cavity and mastoid antrum filled with fluid alone. In three cases (15%) no mass or fluid were seen.

All cases had soft tissue density on HRCT, the operative findings confirmed presence of soft tissue density in typical location

The following pictures show two cases from the current study.

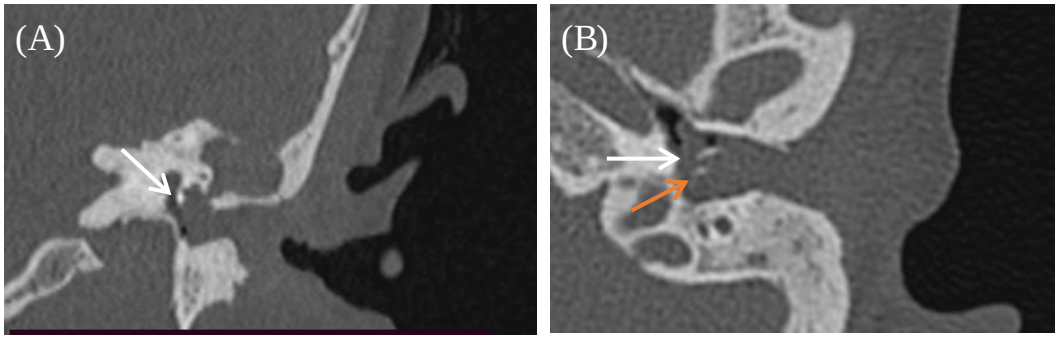

Figure 6: (A) coronal, (B) axial CT scan images of 20 years old female with left side COM.
CT scan shows background sclerosis and profound underpneumatization of the mastoid air cell are suggestive of long-standing inflammation. There is complete opacification of tympanic cavity and mastoid antrum extends to sinus tympani, facial recess and external ear cavity with erosion of scutum, tegmen tympani and tympanic segment of facial nerve canal. Intact sinodural plate and semicircular canal and lateral mastoid cortex. The incus body, short process, long process and lenticular process, stapes superstructure have been completely eroded, with remnant part from malleus (head and handle), (white arrow) and incus long process (red arrow). Picture of cholesteatoma confirmed by intra operative finding and histopathology.

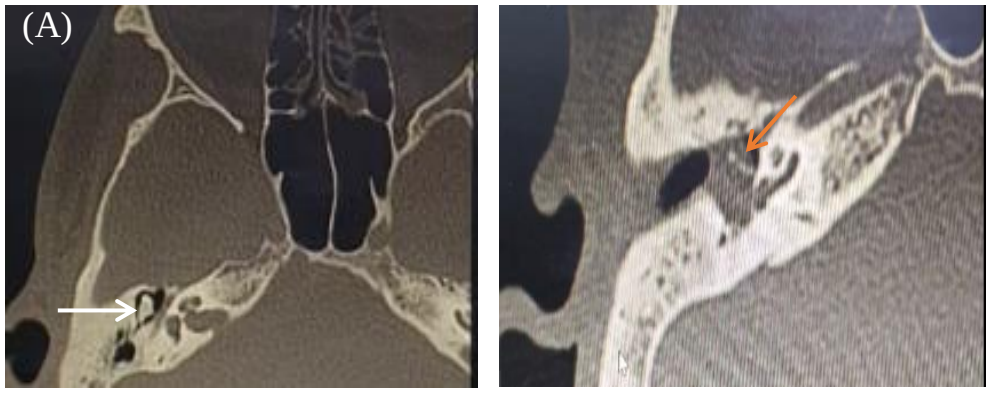

Figure 7: (A and B) axial CT scan images of 29 years old male with right side COM.
CT scan shows background sclerosis and profound underpneumatization of the mastoid air cell are suggestive of long standing inflammation. There is opacification of mesotympanic cavity, extend to sinus tympani, facial recess and external ear cavity. Intact scutum (not shown in this image), tegmen tympani, facial canal, sinodural plate, semicircular canal and lateral mastoid cortex. The incus long and lenticular process, have been completely eroded with partial erosion in mallear handle (red arrow), intact malleus head and incus body and short process (white arrow). Picture of COM with granulation tissue confirm by intra-operative finding.

Discussion

The most commonly affected group was between 11-20 years followed by 21-30 years. as observed by various other studies of Chatterjee et al[4] and Abdulridah MZ[5].

In the present study, majority of cases were males (n=13; 65%). Male to female ratio of study population was 1.85:1. Male to female ratio has been reported variedly in literature. Most of the studies show high male: female ratio[2,4,6-9]. Aljehani et al[10] study showed a low male to female ratio of 1:1.78.

In this study, the most common presenting symptom was ear discharge (n=18; 90%) followed by hearing loss (n=15; 75%) which is similar to Varshney S et al[11] that show the primary complaints of the patients were ear discharge, seen in 100% of the cases and hearing loss, seen in 88.67% of the cases.

The majority of cases (n=14; 70%) had unilateral involvement and bilateral involvement was seen in (n=6; 30%). These finding are consistent with Balasubramanian C et al[12] study with incidence of bilateral ear disease was 33%
.

The present study confirmed that CT was substantially reliable in the determination of the status of the ossicular chain with high sensitivity and specificity. These results are in concordance with other studies Karki S et al[13] and Chatterjee P et al[4]. Pre-operative knowledge of the status of the ossicular chain would allow the surgeon to be ready for ossicular chain reconstruction and for better advise the patient on the degree of achievable hearing after surgery[14].

Correlation for ossicular erosion between CT and surgical findings is higher for the malleus, body and short process of incus when compared to the long process of incus and stapes as shown in Gulati M et al study[3].

Patients suffering from damage to all three ossicles also had extensive cholesteatoma in the tympanic, mastoid attic, and antrum cavities. As shown in Varshney S et al[11] and Balasubramanian C et al[12].

All cases had soft tissue density on HRCT, operative findings confirmed presence of soft tissue density in typical location this agree with Chatterjee P et al[4].

This study shows 100% sensitivity in detection of cholesteatoma with 93.75% specificity. These findings are consistent with the findings of Cihan MY et al[15] who observed sensitivity of 91.9% and specificity of 94.7%.

Although it's difficult by HRCT scan of temporal bone to differentiate cholesteatoma from granulation tissue, pus, or fluid[3]. Cholesteatoma can be accurately diagnosed by HRCT scan. The hallmark of cholesteatoma is bony destruction. Presence of soft tissue density in the middle ear cavity coexistent with ossicular and mastoid bony erosion is highly specific for cholesteatoma[3,14]. Also, mass effect on the ossicles is frequently seen in cholesteatoma, even in the absence of frank destruction[3]. Conversely, one should be aware of the limitations of CT to pick out early or limited disease, since it is difficult to diagnose cholesteatoma on the CT scan if the soft tissue mass is not associated with bone erosion. While a definitive diagnosis of cholesteatoma can only be made at the time of surgery[14,15].

In this study, we found the malleus head and stapedial foot plate to be the most erosion-resistant ossicular part in COM whereas incus (long and lenticular process) was found to be the most susceptible one. These finding are consistent with Aljehani M et al[10] and Abdulridah M Z[5]. Lenticular process of the incus is most prone to erosion, due to poor ligamentous support and precarious arterial supply by end arteries[3].

The incidence of ossicular erosion was found to be much greater in COM with cholesteatoma than in COM without cholesteatoma.

CT-scan imaging allows a comprehensive preoperative evaluation of the anatomic variations and bone details of the middle ear as well as ossicular chain and soft tissue. HRCT is most valuable for detection of early erosive changes in the ossicles, particularly in smaller parts, as well as in detection of non-dependent soft tissue opacification suggestive of cholesteatoma, usually made on otology examination[11].

Although the degree of ossicular erosion does not alter the need for surgery, it can help prognosticate the patient regarding recovery of hearing loss after surgery and aids in planning the reconstructive procedure[3].

It is relatively easy to visualize the bodies of the malleus and the incus on CT scan but this has little clinical value unless the whole ossicular chain can be demonstrated. The handle of malleus, (long and lenticular process) of incus, and the stapes superstructure are the components most at risk in COM but are also the most difficult to demonstrate on CT scan.

In conclusion, CT scan in preoperative assessment of ossicular status in COM has a high sensitivity and specificity with operative findings. The incidence of ossicular erosion was found to be much greater in chronic otitis media with cholesteatoma than in chronic otitis media without cholesteatoma.

We recommend doing HRCT for every patient prepared for mastoid exploration surgery using 0.6 mm slice thickness in examination of middle ear pathology and obtaining axial reconstructions in a plane parallel to the lateral semi-circular canal (LSCC), and coronal planes then reconstructed perpendicular to this acquired axial plane for better visualization of ossicular chain.

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