Original Article

High-resolution computed tomography (HRCT) in pediatric and adult patients with unsafe chronic suppurative otitis media (CSOM) and its surgical correlation

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Abstract

Background and Aim: Atticoantral, alias unsafe type of CSOM affects the posterosuperior part of the middle ear cleft and is frequently coupled with complications and bony erosions. This study aimed to correlate the high-resolution computed tomography (HRCT) temporal bone and intraoperative findings in the patients with the unsafe type of CSOM. **Methods:** This prospective study included 50 patients (28 males: 22 females; mean age 24 ± 14 years) who presented with clinically suspected unsafe CSOM. All patients underwent HRCT of the temporal bone and subsequent surgical procedure. The intraoperative and histopathological findings were compared with HRCT findings. Descriptive statistics, sensitivity, specificity, and positive and negative predictive value for HRCT were calculated. Student's *t*-test and Chi-square test were performed. **Results:** Out of 50 patients, left, right, and bilateral ear involvement were seen in 42% (21/50), 38% (19/50), and 20% (10/50) patients, respectively. Ear discharge was the most common symptom (100%) followed by earache (66%), vertigo (16%), and tinnitus (14%), respectively. Cholesteatoma was reported in 82% (49/60) of ears on HRCT while histopathological and intraoperative evaluation confirmed the diagnosis in 40 out of 49 ears. In 18% (11/60) ears, the cholesteatoma was not diagnosed on HRCT evaluation; however, the intraoperative and histopathological assessment revealed cholesteatoma in six patients while the rest had granulation tissue. For detection of ossicular erosions, tegmen erosions, erosions of facial nerve canal, erosions of sigmoid sinus plate, and erosions of lateral/posterior semicircular canals; HRCT had high sensitivity (86.44%–100%) and specificity (93.33%–100%). **Conclusion:** HRCT has a superb correlation with intraoperative findings and is a valuable tool for preoperative assessment of temporal bone pathologies.

Keywords: Cholesteatoma, CSOM, ear discharge, HRCT, temporal bone

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Received: 24-03-2020 **Revised:** 25-04-2020
Accepted: 19-06-2020 **Published:** 25-08-2020

Access this article online

Quick Response Code:

Website: www.jfmpc.com

DOI: 10.4103/jfmpc.jfmpc_455_20

Introduction

The middle ear is a narrow cavity separating the inner and external ear and is divided into mesotympanum or tympanum proper, epitympanic recess or attic, and hypotympanum. The

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How to cite this article: Singh R, Rai R, Singh P, Sethi S, Ahluwalia AP, Choudhary G. High-resolution computed tomography (HRCT) in pediatric and adult patients with unsafe chronic suppurative otitis media (CSOM) and its surgical correlation. J Family Med Prim Care 2020;9:4067-73.

roof of the tympanic cavity is formed by tegmen tympani thus separating it from the temporal lobe of the brain.[1,2] Chronic suppurative otitis media (CSOM) is a pathology of the middle ear and often involves the mastoid, insidious in onset, and is capable of causing severe destruction and irreversible sequelae.[3] The global burden of illness from CSOM involves 65–330 million individuals with draining ears, 60% of them (39–200 million) suffer from significant hearing impairment. CSOM accounts for 28,000 deaths and a disease burden of over 2 million disability-adjusted life years. India is one of the high endemic areas with a prevalence of 7.8%.[4] It is clinically categorized into two types: tubotympanic and atticoantral. Tubotympanic, also called safe or benign type, involves the anteroinferior part of middle ear cleft and is associated with central perforation. Atticoantral, also called unsafe or dangerous type, involves the posterosuperior part of middle ear cleft, namely, the attic, antrum, and mastoid, and is associated with an attic or marginal perforation. Compared to tubotympanic CSOM, atticoantral poses a higher risk of complications. Cholesteatoma, granulation tissue, or osteitis are found to occur in the atticoantral type of CSOM.[5-7] The complicated anatomical spatial arrangement of middle ear structures and petrous bone makes it difficult to assess them radiologically. In conventional radiological procedures, there exist several special projections for optimal representation of particular structures, but they are often diagnostically insufficient and additional tomographs in one or more planes are necessary.[8-11]

CSOM along with its complications forms an important and challenging disease spectrum, both diagnostically as well as therapeutically. Therefore, it becomes imperative to demarcate the extent of involvement of petrous temporal bone radiologically, to aid in the best therapeutic approach towards disease management. We hypothesized that high-resolution computed tomography (HRCT) might guide the ideal approach for surgery by revealing the extent of pathology and help avoid unnecessary interventions. The purpose of this analysis was to assess the role of HRCT in unsafe CSOM and compare the intraoperative and preoperative HRCT findings.

Material and Methods

This study received ethical approval from the Institutional Research Board (Faculty of Medical Sciences) of the Baba Farid University of Health Sciences (BFUHS) Faridkot, India vide letter no. BFUHS/2k11/p-TH/8228; dated 26th September 2011. All participants were recruited in this cross-sectional study from October 2011 to December 2012. Written informed consent was acquired from all the adult study patients. For pediatric patients, the consent was taken from the parents.

Patients

This study enrolled 50 (28 M: 22 F; mean age 24 ± 14 years; age range 4–50 years) patients with clinical findings suggestive of unsafe CSOM such as scanty foul-smelling ear discharge and referred for HRCT scan. Out of these 21 patients were less than 18 years of age (13M: 8F; mean age 11 ± 4 years). Patients with suspected or diagnosed malignant pathology, history of trauma, previous ear surgery, or those who were found unfit for surgery or anesthesia were excluded from the study. All included patients were clinically evaluated and then underwent HRCT. A proforma was filled up for each patient incorporating the details regarding particulars of the patient, symptoms, clinical examination, and investigations including hearing tests. The patient was then scheduled for an HRCT scan. Before starting the scan, the procedure was portrayed to the patient in their vernacular language. Out of 50, left, right and bilateral ear involvement was present in 42% (21/50), 38% (19/50), and 20% (10/50) patients, respectively. The most frequent presenting symptom was otorrhea (100%) followed by hearing loss (96%), earache (66%), vertigo (16%), tinnitus (14%), post-aural abscess (6%), and facial nerve palsy (2%). Conductive hearing loss was seen in 88% (53/60), mixed type of hearing loss (both conductive and sensorineural) in 8% (5/60), and no hearing loss in 4% (2/60).

Sample selection and sample size

We employed the convenience sampling method to recruit consecutive patients who satisfied the inclusion criteria. The following formula was employed for computing the sample size of the present study at a 95% confidence level, which was calculated from the formula below.[12]

$$n = \frac{t^2 p (1 P)}{d^2}$$

where,

n = the sample size

t = the standard normal deviation equivalent to 95% level of confidence. The value attained from the normal distribution is 1.96.

p = 90% (0.9) (proportion of patients with unsafe CSOM presenting with temporal bone pathologies on HRCT in previous Indian study[13])

$(1 – p) = (1 – 0.9) = 0.1$

d = degree of accuracy desired (i.e. precision) is set at 10% (0.1).

$n = 1.96^2 \times 0.9 (1\text{-}0.9)$

0.1^2

Therefore, the desired sample size comes out as; $n = 35$.

Scanning technique

All patients were scanned using a non-contrast HRCT technique on Siemens SOMATOME motion 6 CT scanner (Siemens Healthcare, Erlangen, Germany). The axial sections were acquired in a supine, neutral position, parallel to the superior

orbital-meatal line consecutively. Scanning was done extending from the petrous pyramid to the mastoid in spiral mode. All scans were performed with 130 kV and 120 quality reference mAs using automatic exposure control with CARE Dose 4D system and CTDIvol 33 mGy. The gantry rotation time was 1 s and acquisition parameters were 6 × 1 mm with slice collimation of 1 mm, slice thickness of 2 mm, and increment of 2 mm. The kernels used for the image reconstruction were H90s for adult and C60s for pediatric patients with square matrix (512 × 512). Multiplanar reconstruction in axial, coronal, and sagittal planes was performed at a slice thickness of 1.25 mm and an increment of 0.8 mm.

Surgical procedures

In patients with cholesteatoma, modified radical mastoidectomy with canal wall down procedure was performed for the eradication of disease as well as for facial nerve decompression. For patients who presented with complications, the surgical approach was tailored depending on the nature of complications. On the other hand, tympanoplasty (myringoplasty), with or without mastoidectomy, was the main surgical procedure for uncomplicated CSOM without cholesteatoma.

Preoperative and intraoperative findings

Data were recorded in Microsoft EXCEL (Microsoft Inc., Redmond, Wash). The recorded HRCT temporal bone findings included the presence and location of soft tissue in middle ear cleft, tympanic membrane status bony erosions of the scutum, middle ear ossicles, tegmen, semicircular canals, sigmoid plate, lateral cortical wall, facial canal, carotid canal, and jugular canal walls. Cholesteatomas were identified intraoperatively by their typical appearance of white, compressible, greasy, or cheese-like keratinaceous debris that was confirmed on postoperative histopathological analysis in all the cases. The intraoperative and histopathological findings were recorded and correlated with the preoperative HRCT findings.

Statistical analysis

The differences between the findings of HRCT temporal bone and intraoperative findings were scrutinized in numbers and proportions, and the dissimilarities between these two categories were statistically analyzed. Descriptive statistics, mean, and standard deviation were calculated. For comparative assessment, sensitivity, specificity, and positive and negative predictive values were computed. Student's *t*-test and Chi-square test were performed. A P value of < 0.05 was deemed statistically significant.

Results

The soft tissue density lesion was present in all the ears pre and intraoperatively [Figure 1, Image 1]. Cholesteatoma was reported in 49/60 (82%) ears on HRCT, which was confirmed in 40/49 ears on histopathology and intraoperative evaluation. In the rest of the 11 ears where the cholesteatoma was not diagnosed on HRCT, the intraoperative and histopathological assessment disclosed cholesteatoma in six patients while five had granulation tissue. Tables 1 and 2 show the correlation between HRCT findings and intraoperative (Sx) features.

Bony erosions: ossicles

Preoperative complete malleus, incus and stapes erosions reported in 14/60 (23%), 25/60 (42%), and 36/60 (60%) ears on HRCT were confirmed intraoperatively [Figure 2, Images 2 and 3]. Malleus and incus erosions were missed in 6/60 (10%) and 4/60 (7%) ears on HRCT that were seen intraoperatively. Partial erosions of malleus handle were more common (HRCT: 18; Sx:

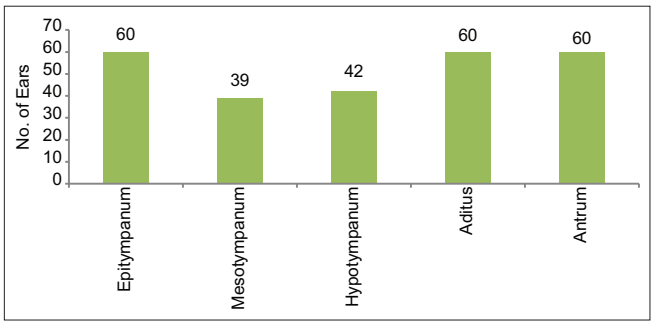

Figure 1: Bar diagram showing the distribution of soft tissue on HRCT

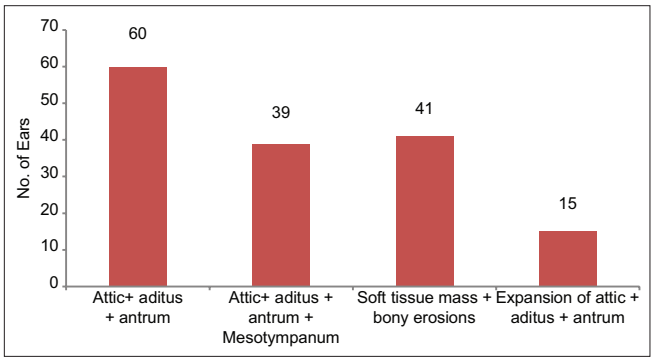

Figure 2: Bar diagram showing regions involved in HRCT

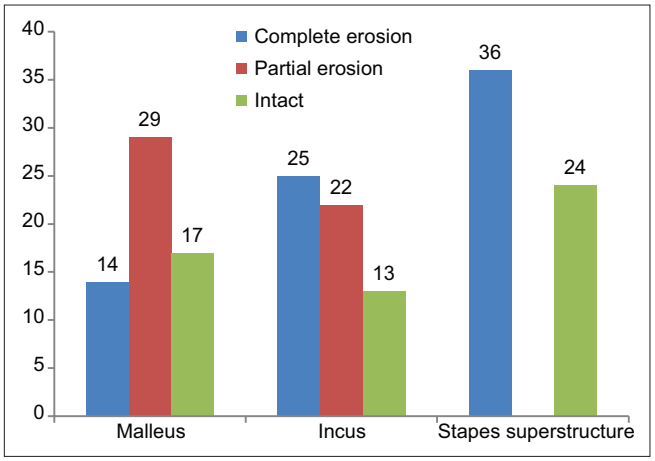

Figure 3: Column diagram showing ossicular erosion on HRCT

20 ears) followed by the head of the malleus (HRCT: 11; Sx: 15 ears). Partial erosions of the long process of incus (HRCT: 14; Sx: 16 ears) were more common than the body of incus (HRCT: 8; Sx: 10 ears) [Figure 3].

Bony erosions: canals

Facial nerve canal erosions were seen in 6/60 ears on HRCT and 5/60 ears on surgery. All erosions were present in the horizontal (tympanic) part. Out of 6/60 ears with the erosion of the lateral semicircular canal (LSCC), only 3/60 were reported intraoperatively. The posterior semicircular canal (PSCC) and sigmoid sinus plate were eroded in two ears and six ears, respectively on HRCT and were confirmed on surgery. No anterior semicircular canal, carotid canal wall, and jugular canal wall erosions were reported [Figure 4].

Bony erosions: other structures

The erosion of scutum was seen in 36/60 (60%) ears on HRCT and confirmed intraoperatively. Tegmen was found eroded in eight (13%) ears on HRCT and four (7%) ears on surgery. On HRCT temporal bone, the lateral cortical wall of the mastoid (LCW) was seen eroded in 16 ears and was confirmed intraoperatively [Figures 5 and 6].

Discussion

Chronic inflammatory ear disease, especially the unsafe/atticoantral type can cause life-threatening complications and clinical examination is often not sufficient to rule out underlying pathology in the temporal bone.[3] Computed tomography (CT) is essential in those patients, especially children whose tympanic membrane is not discernible due to external ear pathologies or those with suspected intracranial complications.[3,5] With the introduction of modern HRCT scanners, it has been made possible to identify many important structures not previously demonstrated by X-ray radiography. HRCT has thus transformed temporal bone imaging and has substituted the earlier modalities.[8-11]

Family physicians are essential contributors to the management of children and adults with an earache and ear discharge. Primary care physicians have an important role to play in guiding patients who present with an earache and ear discharge; by designing and implementing awareness programs, by discussing complications of CSOM, and by focusing on timely treatment. Further, family physicians can coordinate the management of CSOM patients among different specialties, which can eventually lead to improved outcomes.

This study was done to evaluate the role of HRCT in unsafe chronic suppurative otitis media and to correlate the preoperative HRCT findings with the surgical findings. In this prospective study, we evaluated 50 patients with 60 ears involved by unsafe chronic suppurative otitis media. We documented the occurrence and extent of abnormal soft tissue, ossicular chain erosions, erosion of tegmen, facial canal dehiscence, semicircular canals dehiscence, and the HRCT findings were correlated with surgical findings.

Table 1: Correlation of HRCT findings and operative/histopathology findings for soft tissue density masses

Findings	HRCT	Intraoperative/histopathology	Cases in agreement
CSOM with cholesteatoma	49	40	40
CSOM without cholesteatoma	11	6	6

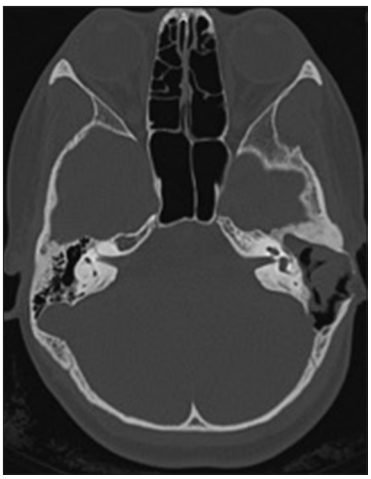

Image 1: Axial HRCT image shows soft tissue density mass in the left middle ear cavity, aditus, and antrum with the erosion of the sigmoid sinus plate and lateral cortical wall of the mastoid. Mastoid septae are eroded forming single cavity on left side

Table 2: Comparison between high-resolution CT findings and intraoperative findings regarding erosions of various structures

HRCT findings	HRCT findings *n* (%)	Intraoperative findings *n* (%)	Sensitivity	Specificity	Positive predictive value	Negative predictive value
Malleus erosion	43 (78%)	49 (82%)	89.09%	100.00%	100.00%	64.71%
Incus erosion	43 (72%)	51 (85%)	86.44%	100.00%	100.00%	52.94%
Stapes superstructure erosion	36 (60%)	36 (60%)	100.00%	100.00%	100.00%	100.00%
Tegmen erosion	8 (13%)	4 (7%)	100.00%	93.33%	50.00%	100.00%
LSCC erosion	6 (10%)	3 (5%)	100.00%	95.00%	50.00%	100.00%
PSCC erosion	2 (3%)	2 (3%)	100.00%	100.00%	100.00%	100.00%
Sigmoid plate erosion	6 (10%)	6 (10%)	100.00%	100.00%	100.00%	100.00%

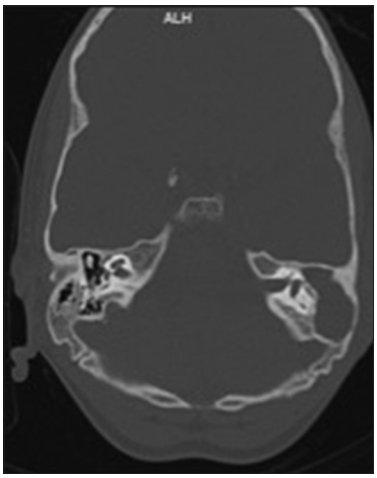

Image 2: Axial HRCT image showing soft tissue mass in the middle ear cavity, aditus, and antrum with the erosion of the left middle ear ossicles

Image 3: Axial HRCT image showing soft tissue density mass in the right middle ear cavity along with partial erosion of malleus and incus

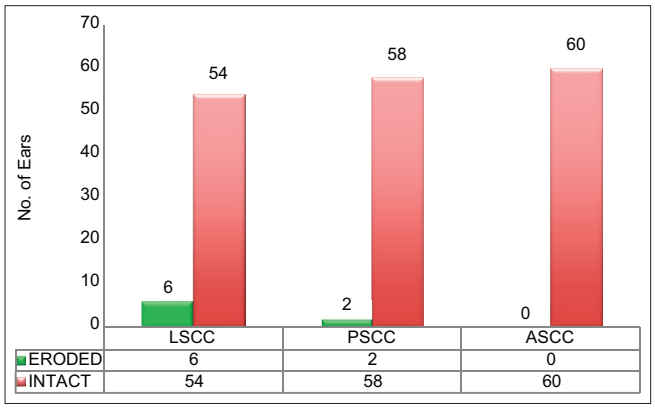

Figure 4: Bar diagram showing erosion of semicircular canals on HRCT

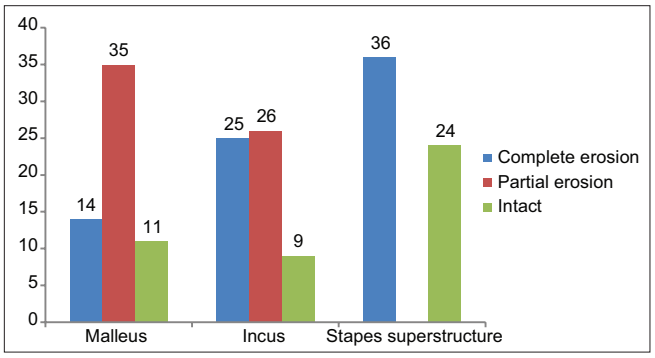

Figure 5: Column diagram showing ossicular erosions intraoperatively

In a recent study, the routine use of HRCT temporal bone has been justified even in patients without intracranial complications.[14] In another study done on the pediatric population, the authors have revealed that the preoperative HRCT temporal bone scan is a useful technique for the evaluation of the cholesteatoma surgery owing to a very good correlation between imaging and intraoperative findings.[15] Even one of the studies has revealed a specific sign (mass effect sign) for diagnosing cholesteatoma on HRCT.[16] Thus, similar to our study many papers have documented that HRCT scan findings correlate well with surgical findings for cholesteatoma and bony erosions,[14-23] however, few studies have disputed the above findings.[24,25] This may be due to the difference in the technical parameters used for the HRCT acquisition in different studies as well as the varying expertise of the radiologists involved in these studies.

Out of a total of 60 examined ears, in 49 ears HRCT indicated the presence of both abnormal soft tissue mass and definite signs of bony destruction while in 11 ears, HRCT indicated abnormal soft tissue density in the absence of osseous erosion. Intraoperative findings and postoperative histopathological evaluation revealed cholesteatoma in 40 of 49 and granulation tissue in 9 of 49 ears. Out of the remaining 11 ears, 6 ears along showed cholesteatoma while the rest of the 5 ears showed granulation tissue on histopathology and intraoperative evaluation. Thus even if a non-bone eroding mass is present, the possibility of cholesteatoma is still around 45% and these findings are in agreement with those of Jackler *et al.*[26]

HRCT of the temporal bone was found to be inaccurate in some of the cases with erosions of tegmen tympani, facial nerve canal, and lateral semicircular canal. Tegmen was found eroded in eight ears (13.33%) and undamaged in 52 (86.67%) ears on HRCT. However, on surgical evaluation out of the eight ears reported with erosive changes the Tegmen was found eroded in four ears and intact in four ears. The tympanic part of the facial nerve canal was intact in 54 (90%) ears and eroded in six (10%) ears on HRCT. However, out of the six ears showing facial canal erosion on HRCT, only three were found to have erosions of facial nerve canal intraoperatively. Out of 54 ears with HRCT showing the intact second part of the facial nerve canal, two showed erosions intraoperatively. Lateral semicircular canal (LSCC) was eroded in six (10%) ears and intact in 54 (90%) ears on HRCT. Out of the six ears reported of LSCC erosion on imaging, only three showed erosions intraoperatively, and in the other three ears, LSCC was found to be undamaged. The volume averaging artifact can explain these discrepancies as it can

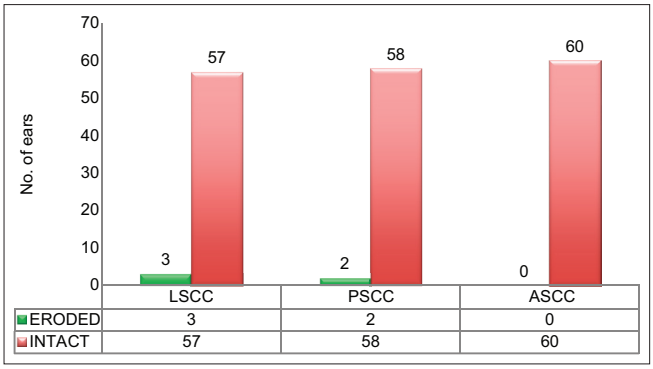

Figure 6: Bar diagram showing semicircular canals erosions intraoperatively

produce apparent dehiscence in the bony structures. This artifact results from a computer averaging of the density of the thin bone plate with that of adjacent soft tissue structures within the same 2 mm slice. For this reason, HRCT scans may occasionally give misleading impressions of bone erosion involving the tegmen tympani, lateral semicircular canal, and horizontal part of the facial nerve.[27-30] However, most of these pitfalls could be avoided by studying views in more than one projection and by familiarity with the normal radiographic variation of these structures.

There has been a recent shift of focus towards fusion imaging and the concurrent usage of CT and MRI for the assessment of temporal bone. Few of the latest studies have revealed that HRCT and diffusion-weighted magnetic resonance imaging (DW-MRI) images complement each other and both techniques must be used together for the preoperative evaluation of cholesteatoma.[31,32] In a study done by Jang *et al.*, the authors concluded that in the patients having CSOM with cholesteatoma though CT is adequate to show bony damage of the cranial fossa, MRI is needed to better delineate intracranial extension in such patients.[33] In a recent study done by Songu *et al.*[34], the authors have pointed out that preoperative Echo-planar DW-MRI is more dependable than HRCT in envisaging the existence and localization of cholesteatoma while literature has also documented that HRCT is more useful in evaluating intratemporal complications while MRI is more valuable in assessing intracranial extension.[35] Therefore, it appears that the fusion imaging may replace individual imaging modalities soon. However, due to financial constraints, the concomitant use of both modalities was not possible during the present study.

Following are the key recommendations based on the findings of this study:

- For the assessment of middle-ear infections, a close clinical correlation is essential to evaluate the nature of middle-ear soft tissue masses, as cholesteatoma is mimicked by many other middle-ear pathologies.
- HRCT is far more advantageous than clinical assessment in assessing the complications of middle ear infections. HRCT also lays down an anatomical roadmap for the surgeon and can predict certain normal variants of surgical significance preoperatively. Therefore, HRCT temporal bone should be routinely done in all preoperative patients with CSOM.

Summary and Conclusion

With the advent of modern HRCT scanners, a detailed demonstration of temporal bone anatomy has become a practical reality. HRCT has revolutionized temporal bone imaging and has replaced the earlier modalities. In the present study, the HRCT was found to have a high sensitivity and specificity in diagnosing ossicular erosions, tegmen erosions, erosions of lateral/posterior semicircular canals, and erosions of sigmoid sinus plate. Therefore, HRCT of the temporal bone is a valuable procedure for precise outlining of the pathological involvement of temporal bone as it has an excellent correlation with the intraoperative findings.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient (s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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