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ORIGINAL ARTICLE

Is Routine Use of High Resolution Computerized Tomography of Temporal Bone in Patients of Atticoantral Chronic Suppurative Otitis Media without Intracranial Complications Justified?

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Abstract Role of high resolution computerized tomography (HRCT) of temporal bone is established in cases of atticoantral chronic suppurative otitis media (CSOM) with intracranial complications. Routine use of HRCT in management of patients of atticoantral CSOM without intracranial complications has been an issue of debate. The aim of this study was to evaluate the routine use of HRCT of temporal bone in such cases. This study was a prospective study done at LG hospital, AMC MET Medical College, Ahmedabad to evaluate and compare the temporal bone findings in HRCT and intraoperative findings in 100 patients with atticoantral CSOM. All patients underwent HRCT screening followed by surgical exploration of middle ear cleft. In extent of disease HRCT showed very high sensitivity and specificity for epitympanum (100, 94%) and mesotympanum (98, 98%) areas. It gave valuable information of disease extent in hidden areas like sinus tympani and facial recess of mesotympanum. HRCT satisfactorily delineated malleus and incus erosion but had 75% sensitivity for detecting erosion of stapes suprastructure, though specificity was of 97%. For bony anatomical landmarks HRCT showed very high sensitivity and specificity for detecting erosion of lateral semicircular canal, tegmen tympani and sinus plate. Detection of facial canal erosion on HRCT had moderate sensitivity of 75%. We concluded that routine use of HRCT is justified as a reliable preoperative tool in patients with atticoantral CSOM without intracranial complications and it helps to plan type of surgical intervention. HRCT has limited role to distinguish between granulations and cholesteatoma and also to delineate stapes supra structure and facial nerve canal.

Keywords CSOM · HRCT · Atticoantral · Cholesteatoma

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Introduction

Cholesteatoma is a sac of keratinizing squamous epithelium in the middle ear cleft. Acquired middle ear cholesteatoma, which is more common than congenital variety has been recognized clinically and radiologically for many years [1]. Acquired cholesteatoma often arises from a postero-superior retraction pocket of the tympanic membrane or as an attic cholesteatoma [2]. The natural history of untreated cholesteatoma is progressive expansion at the expense of the bony structures and confines of the middle ear cleft [3]. Two predominant mechanisms are believed to account for the osteolysis seen in middle ear cholesteatoma: pressure induced bone resorption and enzymatic dissolution of bone by cytokine mediated inflammation [4].

The lack of the effective non-surgical management for cholesteatoma and the risk of potential complications if untreated, make surgical exploration almost mandatory [5]. In actual clinical situations, the management of cholesteatoma is surgical. It is rare that an otologist will treat cholesteatoma medically [6]. The fore knowledge of the extent of the disease and anatomical landmarks of the mastoid air system is helpful in deciding the technique used for mastoid surgery [5].

The role of X-rays in the assessment of a cholesteatoma is very limited. Subtle changes like ossicular erosion, involvement of hidden areas and erosion of the facial canal and the lateral semicircular canal (LSCC) are extremely difficult to assess using an X-ray. HRCT scan of the temporal bone is one of the imaging modalities used to evaluate the extent of a cholesteatoma prior to surgery. A HRCT scan can show the subtle details of a small cholesteatoma [2].

CT scanning is of vital importance in the detection of intracranial complications of CSOM [7–9]. Routine computed tomography scanning prior to cholesteatoma surgery can only be justified if it influences clinical management [10–12]. It not only displays internal bony architecture of the skull base, but also evaluates the soft tissue pathology associated with a bone disease process, which helps in deciding the approach to surgery and also the expected intra-operative and post-operative complications [10, 13]. This inspired us to do this study to evaluate whether routine use of HRCT of temporal bone in atticoantral CSOM without intracranial complications is justified.

Materials and Methods

This study was a prospective study carried out in 100 patients having atticoantral CSOM at LG hospital; AMC MET Medical College, Ahmedabad from Jan'2012 to Dec'2014. Detailed history was taken and thorough otological examination was done in all patients. All patients were subjected to microscopic examination to confirm the diagnosis. The criteria for diagnosis were chronic intermittent ear discharge associated with cholesteatoma with either of the findings of—attic perforation; attic or posterosuperior pars tensa retraction pocket with or without granulations; marginal perforation; polyp obscuring the attic or posterior pars tensa [3, 9, 14–16]. Hearing assessment was done by pure tone audiometry (PTA). PTA with air and bone conduction thresholds with appropriate masking was done by 'conventional' method (5 up 10 down method). Hearing levels were calculated by pure tone average that is average of hearing threshold level at 500, 1000, 2000 and 3000 Hz [17]. All patients underwent HRCT screening followed by surgical exploration of middle ear cleft. Written informed consent was obtained from all patients for HRCT and surgery after counselling of patient and a relative regarding nature and prognosis of the disease. Patients with revision surgery, intracranial complications and those who were unsuitable for surgery or scanning such as patients with severe Ischemic heart disease or pregnancy were excluded.

All the HRCT scans were performed by Philips 16 slicer CT scan. Spiral acquisition of non-contrast volumetric data of bilateral temporal bones was done in the axial plane (1 mm thick sections) parallel to the orbito-meatal plane from the lower margin of mastoid to the arcuate eminence of the superior semicircular canal. Thereafter images were reconstructed with bone algorithm. Reformatted coronal images were obtained (1 mm thickness) perpendicular to the axial plane from the cochlea to the posterior semicircular canal. Parameters applied included 768 matrix, 200 mm field of view, 1 mm thick sections, 120 kv and 300 mA exposure.

Operative findings were compared with pre-operative HRCT scan in order to correlate following features:

- Extension of cholesteatoma or granulation tissue in middle ear cleft
- Erosion of ossicles
- Integrity of facial nerve canal
- Integrity of lateral semicircular canal
- Status of mastoid air cells
- Status of dural and sinus plates

Type of the surgery was determined by the clinical examination, CT scan findings and intraoperative findings.

Results

Out of 100 patients 52 were males and 48 were females. Age of patients varied from 11 to 60 years. Maximum number of patients was seen in second and third decade. Patients came with wide spectrum of symptoms like otorrhoea, hearing loss, earache, tinnitus, postaural swelling, giddiness and facial asymmetry. Majority of patients had otorrhoea (80 cases) and decreased hearing (85 cases) as predominant symptoms. Otoscopic and microscopic examinations were key to clinical diagnosis. On otoscopic examination 50% cases had cholesteatoma, 30% cases had retraction pocket with granulations, 12% had marginal perforation and 8% presented with ear polyps. When examined under microscope, squamous debris (cholesteatoma) was found in all patients with retraction pocket with granulations, marginal perforation and ear polyps. 40% of the patients presented with moderate (41–55 dB) and 28% with moderate to severe (56–70 dB) conductive hearing loss, which was suggestive of ossicular erosion in most of the cases. Patients with mild (26–40 dB) conductive hearing loss (20%) suggested limited disease in epitympanum. 12% of the patients presented with severe to profound hearing loss.

HRCT and intra-operative findings were correlated and sensitivity, specificity and accuracy were calculated.

True positive	Disease present in HRCT as well as intra operatively (cholesteatoma)
True negative	Disease not present in HRCT as well as intra operatively

Table 1 Extent of disease in middle ear cleft (comparison of HRCT and surgical findings)

No.	Extent	HRCT (soft tissue mass)	Surgery (cholesteatoma)	Cases in agreement (true positive)	True negative	False positive	False negative	Sensitivity (%)	Specificity (%)	Accuracy (%)
1	Epitympanum	70	68	68	30	02	00	100	94	98
2	Mesotympanum	45	45	44	54	01	01	98	98	98
3	Protympanum	10	08	06	88	04	02	75	96	94
4	Facial recess	20	20	17	78	02	01	94	98	95
5	Sinus tympani	06	06	06	94	00	00	100	100	100
6	Hypotympanum	06	05	04	93	02	01	80	98	97
7	Antrum	80	78	76	18	04	02	97	82	94
8	Aditus	76	65	58	17	18	07	89	49	75

False positive — Disease present in HRCT but not intra operatively

False negative — Disease absent in HRCT but present intra operatively

Extent

Majority of patients had disease involvement in more than one areas but delineation of different areas has been done in the interest of simplification of the data analysis.

On HRCT scan, soft tissue density mass was delineated in decreasing order of frequency in antrum (80%), aditus (76%), epitympanum (70%), mesotympanum (45%) and hypotympanum (6%). Involvement of hidden areas of mesotympanum like sinus tympani and facial recess was seen on HRCT with good accuracy. Intraoperatively presence of soft tissue mass could be appreciated in respective areas, but differentiation between these masses as granulations or cholesteatoma in HRCT was not possible. This differentiation between cholesteatoma and granulations was easily confirmed during surgery. This is reflected in false positive interpretation.

HRCT showed high sensitivity and specificity in diagnosing cholesteatoma in epitympanum (100, 94%) and mesotympanum (98, 98%). Specificity in case of antrum and aditus was 82 and 49% respectively. HRCT is quite accurate to evaluate extent in all areas except aditus (Table 1).

Ossicular Erosion

Ossicular erosion was found in 73% of cases. Incus was the most commonly involved ossicle in atticoantral CSOM (Table 2). HRCT showed 95% sensitivity and 100% specificity in detecting incus erosion (Figs. 1, 2). HRCT showed 100% sensitivity and 100% specificity in detecting malleus erosion. Delineation of stapes erosion had a

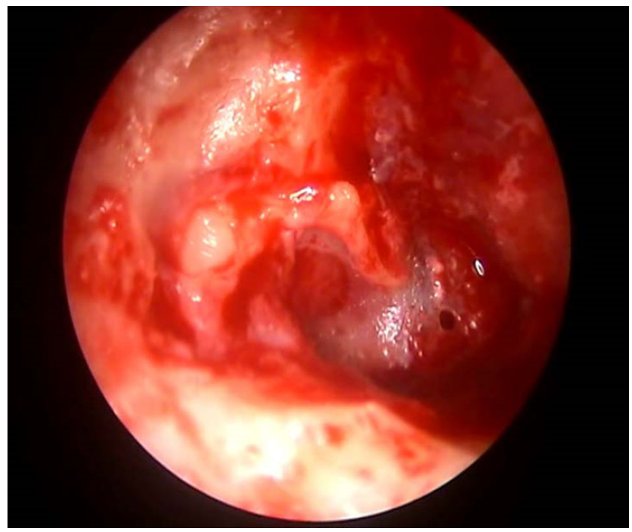

Fig. 1 Showing necrosed incus in attic cholesteatoma

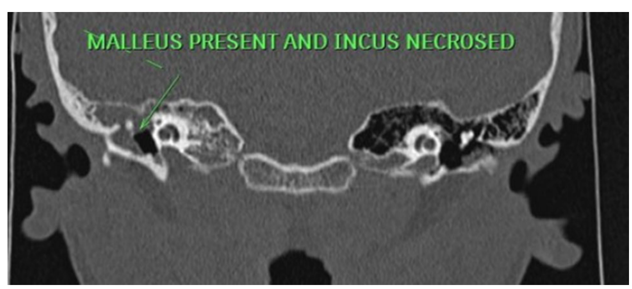

Fig. 2 Showing soft tissue density in *right side* with necrosed incus

Table 2 Ossicular erosion (surgical findings)

No.	Ossicular erosion	Intra-operative findings
1	Malleus + Incus	16 cases
2	Stapes suprastructure + Incus	24 cases
3	Incus only	17 cases
4	All ossicles absent	16 cases
5	None (normal ossicles)	27 cases

Table 3 Ossicular erosion (Comparison of HRCT and surgical findings)

No.	Ossicular erosion	HRCT	Surgery	Cases in agreement (true positive)	True negative	False positive	False negative	Sensitivity (%)	Specificity (%)	Accuracy (%)
1	Malleus									
	Head	10	10	10	90	00	00	100	100	100
	Handle	06	06	06	94	00	00	100	100	100
2	Incus	54	57	54	43	00	03	95	100	97
3	Stapes	20	24	18	74	02	06	75	97	92
4	Absent ossicles	14	16	12	82	02	04	75	98	94
5	None (normal ossicles)	32	27	26	67	06	01	96	92	93

moderate sensitivity of 75%. Normal ossicular chain was detected with high sensitivity (96%) and specificity (92%), though detection of absence of ossicles had moderate sensitivity (Table 3) (Figs. 3, 4).

Anatomical Landmarks Involved

Detection of facial canal erosion on HRCT had sensitivity of 75%, specificity of 99% and accuracy of 98%. This means HRCT has limited role for catching facial canal erosion but it excludes absence of erosion very accurately (Figs. 5, 6, 7, 8). Sensitivity and specificity of detection by HRCT was quite high for erosion of scutum, lateral semicircular canal, tegmen tympani, sinus plate and mastoid cortex (Table 4) (Figs. 9, 10, 11, 12).

In our study findings of HRCT to delineate the extent of soft tissue mass and to detect ossicular and bony erosion, guided us in planning the surgical procedure in a particular patient. 27 patients were planned for inside out mastoidectomy because of limited disease present in epitympanum. 61 patients were planned for modified radical mastoidectomy because of extensive disease in middle ear cleft. 12 patients who were having limited to moderate disease in middle ear cleft were planned for cortical mastoidectomy with tympanoplasty (Table 5) (Figs. 6, 13).

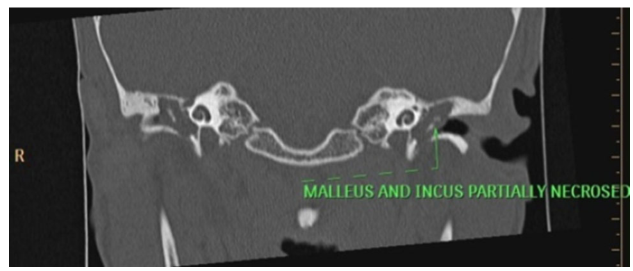

Fig. 3 Showing bilateral soft tissue density with partially necrosed incus and malleus

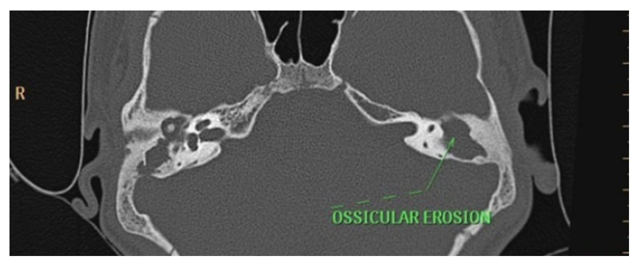

Fig. 4 Showing bilateral soft tissue density with complete ossicular erosion on *left side*

Discussion

In our study on HRCT and surgical exploration epitympanum, aditus and antrum were the commonest sites of involvement. HRCT detected disease in epitympanum (sensitivity 100%, specificity 94%) and mesotympanum (sensitivity 98%, specificity 98%) with high accuracy. This is in agreement with the other studies [2, 10, 18–20].

Though sensitivity of HRCT scan in cholesteatoma detection in antrum (97%) and aditus (89%) was good but it had low specificity (82, 49% respectively) for both the areas. Other studies had also similar observations [18, 19]. The reason for low specificity in antrum and aditus is that HRCT scan is less sensitive in differentiating cholesteatoma from granulation tissue and mucosal edema [3, 8, 9, 21]. This is in agreement with studies done by most of the authors [2, 5, 20, 22–25].

In our study, the sensitivity of HRCT for disease detection in hypotympanum and protympanum were moderate (80, 75% respectively) but the specificities were good for these areas. In contrast to our study, Sirigiri R R [18] and Rai T [10] showed high sensitivity and moderate specificities for these areas. In our study, detection of disease in hidden areas (facial recess and sinus tympani) by HRCT showed 94 and 100% sensitivity respectively.

Ossicular erosion was observed in 73% of cases. There was variation in the incidence of erosion of each ossicle in different studies [18, 22–24], involvement of incus in cases

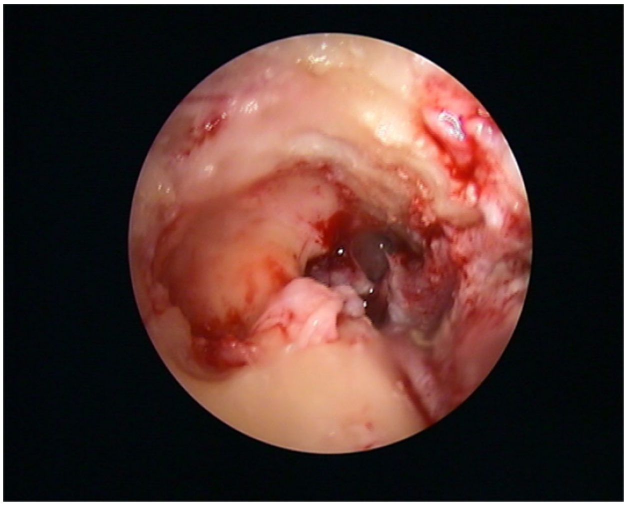

Fig. 5 Showing cholesteatoma sac dissected from mastoid cavity and intact *horizontal* facial canal during surgery

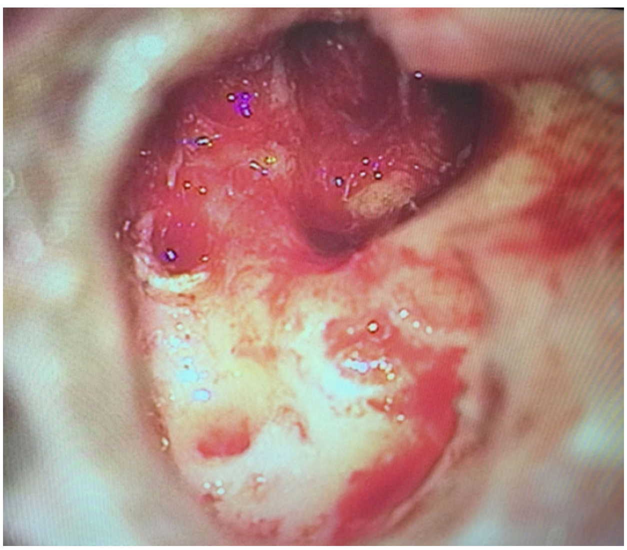

Fig. 6 Showing mastoid cavity and intact facial canal after complete removal of cholesteatoma sac

of cholesteatoma is almost universal [9, 18, 20, 23, 24]. In our study erosion of malleus and incus was detected with very high accuracy. This is in concordance with other studies [2, 5, 22, 23, 25]. Rai T [10] detected erosion of malleus with 100% sensitivity but incus with only 85% sensitivity. In our study, stapes erosion was not consistently visualized on HRCT. Similar observations were made in other studies [2, 5, 10, 26]. The presence of the soft tissue density around stapes made it difficult in identifying the erosion of this bone [2]. Pre-operative knowledge of the status of the ossicular chain would allow the surgeon to be ready for the ossicular chain reconstruction and to better advise the patient on the degree of hearing attainable after surgery [25].

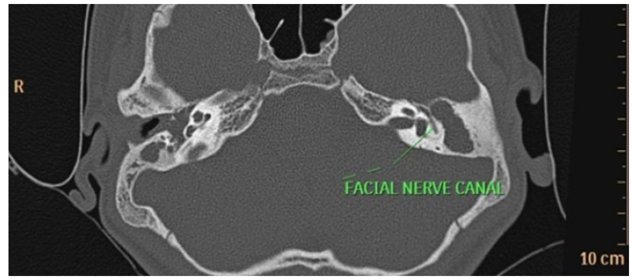

Fig. 7 Showing soft tissue density in both *middle* ear with intact facial canal on *left side*

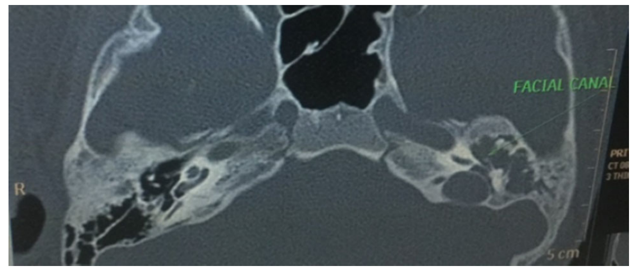

Fig. 8 Showing soft tissue density in *left middle* ear with facial canal erosion on *left side*

In our study facial canal erosion was observed on HRCT with moderate sensitivity (75%) but high specificity (99%). This is in consonance with other studies [10, 18, 22–24, 26]. The reason of low to moderate sensitivity is that, that in the area of tympanic portion of the facial nerve canal the bony floor is very thin and may not be visualized on coronal and axial C.T. images [21].

In our study lateral semicircular canal fistula was detected on HRCT with 100% sensitivity. Sirigiri R R [18], Muzeyyen [19] also similarly reported high sensitivity.

In our study HRCT showed 100% sensitivity in diagnosing destruction of mastoid cortex, tegmen tympani and sinus plate. Other authors [18, 19] showed high sensitivity in detection of erosion in these areas. Rai T [10] found HRCT to be 100% sensitive in detecting cortical erosion of mastoid but observed poor sensitivity in detecting sigmoid sinus plate and tegmen tympani erosion.

In our study, we observed that HRCT showed high sensitivity (96%) in detecting scutum erosion. This is in accordance with other studies [10, 25, 26]. This is one of the important signs of cholesteatoma in epitympanum. Osseous erosion involving the scutum or ossicles is key to distinguishing a cholesteatoma from benign debris or otitis media on CT, although absence of erosion does not exclude cholesteatoma [27].

CT is of most value when the otologist can be flexible in surgical technique, tailoring it to imaging findings [25, 28]. Pre-operative imaging can be justified if it can conclusively be shown to influence the surgical approach or result in a decrease in post-operative morbidity [3].

Table 4 Bony anatomical landmarks involved (Comparison of HRCT and surgical findings)

No.	Bony anatomical landmarks involved	HRCT	Surgery	Cases in agreement (true positive)	True negative	False positive	False negative	Sensitivity (%)	Specificity (%)	Accuracy (%)
1	Facial canal erosion	04	04	03	95	01	01	75	99	98
2	Lateral semicircular canal fistula	02	01	01	98	01	00	100	99	99
3	Scutum erosion	26	27	26	72	01	01	96	99	98
4	Tegmen tympani erosion	01	01	01	99	00	00	100	100	100
5	Sinus plate erosion	02	02	02	98	00	00	100	100	100
6	Mastoid cortex	03	03	03	97	00	00	100	100	100

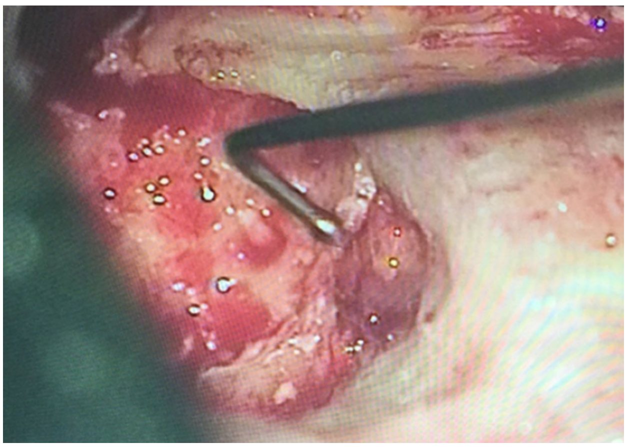

Fig. 9 Showing exposed sigmoid sinus

Fig. 10 Showing soft tissue density in bilateral *middle* ear and mastoid and erosion of sigmoid plate on *right side*

Fig. 11 Showing soft tissue density in *left side* attic region with scutum erosion

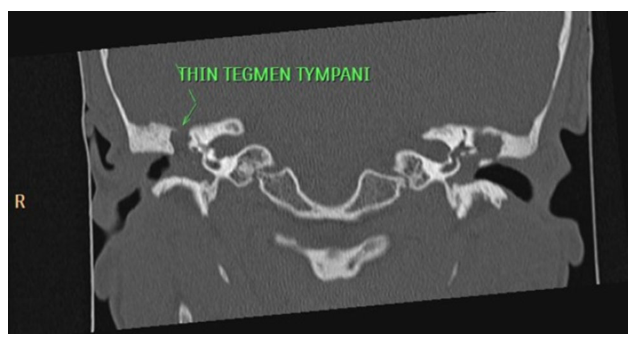

Fig. 12 Showing soft tissue density in bilateral *middle* ear and mastoid with thin tegmen tympani on *right side*

Conclusion

HRCT of temporal bone is an effective diagnostic modality to preoperatively assess the extent and sites of involvement, erosion of ossicles and other important bony anatomical landmarks in atticoantral CSOM without

Table 5 Decision of surgical procedure based on HRCT findings

No.	Surgery	No of cases
1	Modified radical mastoidectomy	61
2	Inside out mastoidectomy	27
3	Cortical mastoidectomy with tympanoplasty	12

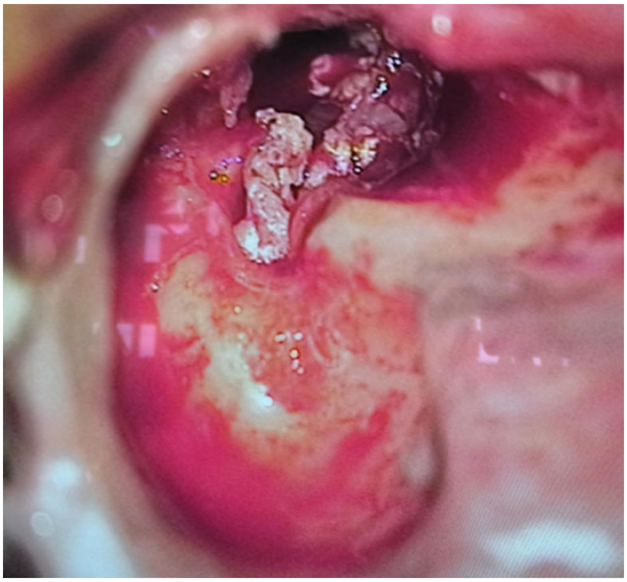

Fig. 13 Showing cholesteatoma sac dissected from the mastoid cavity and the *middle* ear

intracranial complications. High accuracy of HRCT in detecting cholesteatoma in middle ear cleft including hidden areas such as sinus tympani and facial recess; ossicular erosion and other bony anatomical structures helps in deciding surgical strategy and alerting the surgeon about intraoperative problems.

Few limitations observed with HRCT are

(a) The C.T. density findings are similar in cholesteatoma, granulations and mucosal edema making them indistinguishable on HRCT.
(b) Stapes and facial canal visualization is not very accurate.

So our study concludes that routine use of HRCT of temporal bone in patients of atticoantral CSOM without intracranial complications is justified, but role of knowledge and skill of an otologist cannot be undermined in diagnosis and surgical management of cholesteatoma.

Compliance with Ethical Standards

Conflict of interest The authors of this article declare that he/she has no conflict of interest.

Human and Animal Rights Animals were not involved in this study.

Informed Consent Informed consent was obtained from all individual participants included in the study.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and with the 1964 Helenski declaration and its later amendments or comparable ethical standards.

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