

Role of High Resolution Computed Tomography of Mastoids in Planning Surgery for Chronic Suppurative Otitis Media

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Abstract Chronic suppurative otitis media (CSOM) presents with a typical history of recurrent otorrhoea with tympanic membrane perforation. The diagnosis of cholesteatoma is usually made on otologic examination. High resolution computed tomography (HRCT) is indicated to evaluate the extension and the complications of cholesteatoma. The aim of the work was to study the role of HRCT in detecting, evaluating diagnosing and managing CSOM. All patients presenting with CSOM who were planned for mastoid exploration surgery in department of ENT, Gauhati Medical College and Hospital within a period of 2 years—from 1st January, 2013 to 31st December, 2014, were taken up for the study. HRCT mastoids done routinely before cholesteatoma surgery, but with improved resolution, to characterize all middle ear structures and complications of the disease prior to surgery, might guide as road map during mastoid explorations for unsafe CSOM. The important role of HRCT lies on the early detection of cholesteatoma, and more conservative surgical procedures can be used to eradicate the disease.

Keywords Cholesteatoma · Unsafe CSOM · HRCT mastoid

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Introduction

Otitis media remains a significant international health problem in terms of prevalence, economics, and sequelae. Chronic suppurative otitis media is divided into two main clinical types: chronic suppurative otitis media without cholesteatoma that is recognized clinically as safe type, and chronic suppurative otitis media with cholesteatoma, or unsafe type.

Surgery is widely used to treat various pathological conditions of the middle ear such as chronic otitis media. The decision for the choice of surgical procedure is of particular importance to preserve a higher hearing rate and prevent complications such as infection, cerebral hernia, recurrence, and treatment failure. Imaging of the temporal bone, with CT and magnetic resonance imaging (MRI), is playing an increasingly important role for diagnosis, surgical decision, and follow up. Evidence of location and extent of disease and of asymptomatic complications, secondary to bony destruction should also influence management. Computerized tomography can undoubtedly provide reliable details of temporal bone anatomy and its congenital malformations. To date, temporal bone CT-scan is the preferred radiological exam to precisely determine, preoperatively, the extension of the disease and petrous bone complications.

However, there are concerns that CT cannot reliably distinguish cholesteatoma from mucosal disease and that it lacks guaranteed sensitivity for erosive complications. Such concerns have cast doubts on its value.

The aim of this study is to evaluate preoperative CT scanning and to determine the accuracy and the usefulness of this imaging method in patients with CSOM undergoing surgery.

Materials and Methods

All patients presenting with CSOM who were planned for mastoid exploration surgery in department of ENT, Gauhati Medical College and Hospital within a period of 2 years—from 1st January, 2013 to 31st December, 2014, were taken up for the study. A clinico-radiological study was conducted on the 167 patients by subjecting them to history, clinical examination and radiological investigation.

A detailed history with regard to otorrhoea, deafness, tinnitus, otalgia, vertigo, headache and fever was taken, and recorded in a systematic order, with special consideration of associated symptomatology suggestive of any impending or already established complication of unsafe chronic otitis media. Audiometry and pus culture and sensitivity was routinely performed. All the cases were thoroughly evaluated clinically and examined under operating microscope. Each of the selected case was subjected to HRCT mastoids. Following areas of interest were looked up in preoperative scans:-

1. Soft tissue mass
2. Pneumatisation of mastoid
3. Extent of disease
4. Tegmen tympani erosion
5. Sinus plate erosion
6. Facial canal dehiscence
7. Lateral semicircular canal dehiscence
8. Ossicular status
9. Disease outside middle ear cleft

Then a thorough review of the findings was done to demonstrate the anatomy and pathological process. All surgeries were performed depending upon intra-operative picture. All pre-operative and intra-operative findings were recorded and compared on basis of standard proforma. All data were statistically analysed and correlated to reach conclusion. Follow-up was done at a routine interval.

Results and Observation

A total of 167 patients were included in this study out of 99,208 patients attending ENT OPD in tertiary care institute during the 2 years study period. The results of our study showed age distribution of the patients ranges from 4 to 60 years with a mean age of 23.17 years. Commonest age group was 11–20 years with 66 patients followed by 21–30 years with 41 patients. Out of all, 115 cases were male and 52 cases were female, which gives a male: female ratio of 2.21:1. Chronic ear discharge with hearing loss was the main clinical presentation (60.7 %).

Table 1 Location and extent of soft tissue mass on HRCT

Location and extension	No. of patients
Attic	29
Attico-antral	20
Mesotympanum	29
Extensive (holotympanic) extended to mastoid antrum	89
Total	167

The incidence of bilateral disease was found in 38 cases in the studied sample. 167 ears were planned for intervention based on clinical, audiological and radiological findings and operated depending upon intra-operative picture. None of the patients with disease in the opposite ear were operated during the study period and are under regular follow-up.

Extensive holo-tympanic acquired cholesteatoma was the most common, found in 89 cases (53.7 %), and followed by attic cholesteatoma, found in 29 patients (17.4 %) (Table 1).

The scutum erosion was the most common finding, encountered in 112 patients, followed thinning of tegmen plate in 47 patients and eroded sigmoid sinus plate was found in 32 cases (Table 2).

The incus was the most commonly eroded, found in 120 patients, followed by malleus, found in 104. Sclerotic mastoid was the most common finding encountered in 79 %. The lateral semicircular canal fistula was the most common finding, encountered in 39 cases. Destruction of all inner ear structures were found in 7 cases. Intact facial nerve canal was encountered in 116 patients and eroded in 51 patients (Tables 3, 4).

Extracranial complication included complete ossicular erosion in 104 cases, mastoiditis alone in 84 cases, automastoidectomy in 70 cases, labyrinthitis in 47 cases, LSC fistula in 39 cases facial palsy in 14, abscesses and fistula in 34 and 16 cases (Table 3).

Among the intracranial complication, meningitis was seen in 35, cerebellar Abscess in 21, cerebral abscess in 5,

Table 2 Middle ear bony wall erosion on HRCT

Bony wall erosion	No. of patients
Eroded scutum	112
Eroded tegmen	34
Thinning of the tegmen	47
Eroded sigmoid sinus plate	32
Eroded superior and posterior meatal wall	25

Table 3 Extracranial and intracranial complications

Extracranial complications		Intracranial complications	
Types of Complication	No. of patients	Types of Complication	No. of patients
Complete ossicular erosion	104	Meningitis	35
Mastoiditis alone	84	Cerebellar abscess	21
Automastoidectomy	70	Cerebral abscess	5
Labyrinthitis	47	Epidural abscess	5
LSC fistula	39	Sigmoid sinus thrombosis	9
Facial palsy	14		
Abscesses	34		
Fistula	16		

epidural abscess in 5 and sigmoid sinus thrombosis in 9 cases (Table 3).

All cases had soft tissue density on HRCT, operative findings confirmed presence of soft tissue density in typical location, but characters of soft tissue were difficult to comment upon in HRCT. Cholesteatoma and granulations are easily confirmed under microscope; those with doubt were sent for histopathological diagnosis. (Table 3).

Discussion

Abnormal extension of the keratinizing epithelium of the external acoustic meatus into the middle ear cavity through tympanic membrane is considered to be the main cause of middle ear cholesteatoma [1, 5]. Ingrowths of cholesteatoma result in erosion of surrounding bony structures. Bony erosion is related to combined effects of cholesteatoma mass and collagenase activity [1]. The possible consequences of such an osteolysis are complications including ossicular destruction, automastoidectomy, meningitis, dural sinus thrombosis, facial nerve palsy, labyrinthine fistula, and extension to the petrous bone [5, 6] (Figs. 1, 2, 3, 4 and 5).

For several years, imaging of ear has been a routine test in preoperative workup of the disease and most recent reports recommend a CT-scan as part of preoperative workup in middle ear cholesteatoma [9, 13, 14]. 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 [15–17]. 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 otologic examination [11].

The exact role of CT in preoperative assessment of patients with chronic otitis media is controversial [10]. Some authors have reported a high degree of accuracy in pathological diagnosis of ossicular chain and inner ear conditions [11] and others have concluded that CT has poor ability to diagnose cholesteatoma and should not be relied on to visualize abnormalities of previously mentioned structures [12]. The results of this study suggest that cholesteatoma can be accurately diagnosed by computed tomography. The hallmarks of cholesteatoma on CT scan are the bone erosion and smooth expansion with soft tissue mass. Conversely, one should be aware of the limitations of

Table 4 Correlation between HRCT findings and operative features

Feature	Finding in CT	Operative features	False negative	False positive	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Tissue mass	167	167	0	0	100	100	100	100
Typical location	167	167	0	0	100	100	100	100
Scutum erosion	112	112	0	0	100	100	100	100
Tegmen erosion	47	44	0	3	100	97.56	93.62	100
Sigmoid erosion	32	36	4	0	88.89	100	100	97.04
Incus erosion	120	122	2	0	98.36	100	100	95.74
Malleus erosion	104	111	7	0	93.69	100	100	88.89
LSC fistula	39	38	0	1	100	99.22	97.44	100
Facial canal Erosion	51	54	3	0	94.44	100	100	97.41

Chi square test performed for all variables with degrees of freedom = 1, $p < 0.01$. All parameters are found statistically significant



Fig. 1 Left automastoidectomy cavity filled with soft tissue density post auricular fistula and thinning of tegmen



Fig. 2 Showing soft tissue density in middle ear with ossicular erosion and sigmoid plate erosion



Fig. 3 Automastoidectomy cavity filled up by cholesteatoma

CT to pick out early or limited disease, since it is difficult to diagnose cholesteatoma on the scan if the soft tissue mass is not associated with bone erosion [13].

While a definitive diagnosis of cholesteatoma can only be made at the time of surgery, the scan picture may at



Fig. 4 Cholesteatoma sac being dissected out

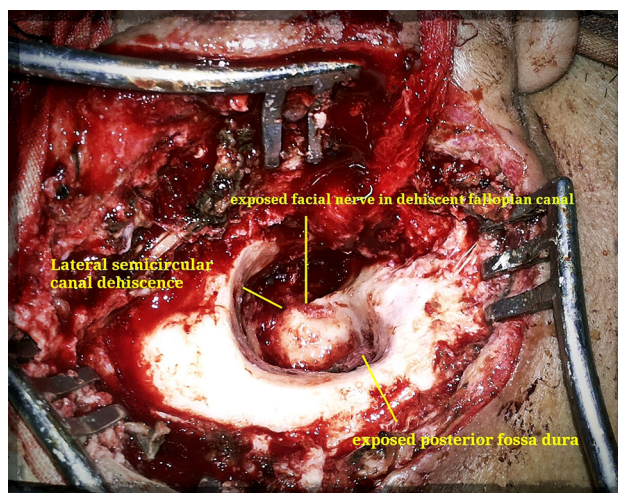


Fig. 5 Showing facial canal erosion, lateral semicircular canal erosion and exposed posterior fossa dura

times influence the decision and timing of surgical exploration. Scan evidence of cholesteatoma with significant bony destruction or other complications could prompt the surgeon to operate earlier, particularly if polyps or a tortuous bony canal obscures visualization of the tympanic membrane and hinders clinical diagnosis. On the other hand, the threshold to explore the ear may be higher when the scan is non-confirmatory, particularly if the patient has medical risk for surgery [14]. Therefore, CT findings enable the surgeon to be informed of the risk factors and to be prepared for the possibility of complications.

Our study confirmed that CT is substantially reliable in the determination of the status of the ossicular chain. These results are in concordance with other studies [8, 11, 14, 15, 19, 21]. Pre-operative knowledge of the status of the ossicular chain would allow the surgeon to be ready for ossicular chain reconstruction and to better advise the patient on the degree of hearing attainable after surgery.

According to the results of our study, CT gives a good idea about the dehiscence of the semicircular canal. Thus, it warns the surgeon to take more care during the operation. Preoperative CT can give the surgeon information about the possibility of bone fistula in the area of the cholesteatoma matrix to be dissected.

The most frequent radiological signs of cholesteatoma are middle ear mass and bony lysis [7]. Our comparison of radiological and surgical findings, it was found that CT-scan yields, overall, an adequate anatomical confirmation of the tympanomastoid cavities.

For the lysis of the tegmen tympani, which is a thin bony roof, radiological data seem imprecise, requiring thinner CT-scan slices on coronal sections [4, 7, 13].

In contrast, the lysis of the scutum, which represents a thick bony relief, is well visualized in frontal CT-scan images [4].

For middle ear content, CT seems to be the examination of choice for identifying areas of osteolysis and screening for the main complications associated with cholesteatoma [13]. The predictive value of CT-scan depends on the anatomic structure studied.

Even if Ossicular chain lysis is frequent in cholesteatoma otitis, it remains nonspecific and can be found in other forms of chronic otitis media [4, 7]. Fine structures of the auditory ossicles could be delineated clearly in the images reconstructed using the multislice scan CT, which allows a slice thickness of 0.5 mm [18].

High-resolution computed tomography (HRCT) is most valuable for the detection of early erosive changes in the ossicles, particularly in the smaller parts such as the incudo-stapedial junction [18].

The erosion of the fallopian canal along its pathway through the temporal bone, especially of the tympanic segment of the canal, may be difficult to interpret [13].

High-resolution infra-millimetric CT slices and complete immobilization of the head of the patient during radiological exploration are necessary for an accurate and complete study of the facial nerve canal [16–18].

Labyrinthine fistulae because of LSCC erosion complicate cholesteatoma in 5–20 % of the cases [2, 16–18]. This canal is the most frequently eroded because of its close proximity to the medial wall of the attic anatomically. The bony lysis of the LSCC can be either cortical or total and necessitates the combination of coronal and axial infra-millimetric slices to appreciate it to avoid a false impression of a labyrinthine fistula [13, 18].

A comparative study with the contra-lateral temporal bone may be helpful to avoid false-positive results [16, 17].

For the assessment of all these variations and abnormalities, an adequate technique and a good radiologic interpretation of temporal bone CT-scan are needed.

Conventional CT-scans also have other limitations and usually cannot differentiate a cholesteatoma from granulation tissue, pus, and fluid, which are present in chronic otitis media without the presence of a cholesteatoma [23].

The middle ear structures are very small and fine; thus, a HRCT with infra-millimetric slices may offer a best topographic study [22]. HRCT has clearly shown its superiority in the evaluation of the temporal bone, particularly utilizing thin-section, high-resolution techniques. HRCT provides a more precise definition of the anatomic extent of the disease of the middle ear and the relationship of these cholesteatoma masses with the contiguous structures [20].

Financial cost, radiation dosage, the inability to differentiate between granulation, effusion or mucosal oedema, the lack of specificity to facial canal dehiscence, dural erosion, and sigmoid sinus thrombosis are all controversial points of CT scans. Despite the limitations, the results of this study suggest that radiological scanning is useful. Some studies have emphasized the importance of preoperative CT evaluation [17, 20]. They concluded that CT is sensitive to the presence of soft tissue disease and bone erosion, moderately sensitive to the presence of lateral canal fistulae but less sensitive to the presence of small areas of exposed dura, ossicular continuity and facial canal dehiscence.

Most cholesteatomas are associated with attic or marginal perforations and rarely with central perforations. An attic or pars flaccida perforation or invagination always means a cholesteatoma. Granulation tissue or polyp protruding through attic perforation indicates infected cholesteatoma. The size of attic defect bears little relation to the extent of the cholesteatoma in the attic, antrum, or mastoid. Preoperatively, the extent of the cholesteatomas can best be estimated by imaging studies non contrast computed tomography (CT) of the temporal bone provides excellent definition of erosion of vital structures including the semicircular canals, cochlea, fallopian canal, dural plates, and sigmoid sinus. Surgical planning is enhanced by identifying the degree of mastoid sclerosis and involvement of vital structures [23].

CT is of most value when the otologist can be flexible in surgical technique, tailoring it to imaging findings [3]. HRCT can be recommended not only in cases suspected with potential complications but also in all cases of COM to know the extent of disease, varied pneumatisation and the presence of anatomical variations, which should alert the clinician and guide in surgical approach and treatment plan. A skilful, aware, and alert surgeon still remains the key to successful diagnosis and surgical treatment of COM [24].

Conclusion

The results of this study suggest that preoperative HRCT imaging in cases of cholesteatoma, ossicular chain erosion, and SCC dehiscence have good correlation with intra-operative findings. However, there was weak specificity for preoperative HRCT in detecting facial canal dehiscence, dural plate erosion, and sigmoid plate erosion in COM patients. The role of HRCT lies on the early detection of cholesteatoma, and thereby using a more conservative surgical procedure (endoscopic) to eradicate the disease. HRCT can act as a guide to the nature of disease, potential dangers and possible complications, and this information can assist the surgeon in the choice of surgery to be performed and better advise the patient on the degree of hearing attainable after surgery.

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Compliance with Ethical Standards

Conflict of interest None.

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