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ORIGINAL ARTICLE

Computed Tomography in Chronic Suppurative Otitis Media: Value in Surgical Planning

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Abstract The present study was conducted prospectively to evaluate how accurately high resolution computed tomography scanning could define the extent and severity of the underlying disease in patients with chronic suppurative ear disease, thus, helping convert a surgical exploration into a planned procedure. Sixty adult consecutive cases of chronic suppurative otitis media underwent a detailed high resolution computed tomography by a single radiologist. The recorded radiological findings in various heads were then compared to the surgical findings during mastoid exploration of these patients by a single otologist and the two statistically compared. The presence and distribution of soft tissue in the middle ear cleft and mastoid could confidently be predicted using this modality. The malleus, body and short process of incus were well visualized, but not the long process of incus and the stapes suprastructure. Lateral semicircular canal fistulae could be demonstrated with an acceptable degree of accuracy. It was possible to detect facial nerve dehiscence and defects in tegmen tympani in significant number of cases although, statistical values were low for these structures. High resolution scanning is a modality which can accurately image the pathological anatomy in unsafe chronic suppurative otitis media. Otologists should use it more often, especially in complicated cases as an adjunct to better preoperative assessment, and thus, the surgical outcome. Its accuracy is likely to improve with larger studies and better experience, wherein its routine use may become justifiable.

Keywords Cholesteatoma · HRCT · Surgery · CSOM

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Introduction

In the area of otology, imaging has until recently been of poor quality and could only be interpreted by a small number of highly experienced radiologists. Historically, mastoid surgery has been undertaken with otoscopy, audiometry and possibly plain X-rays as the only preoperative investigations. The advent of high resolution computed tomography (HRCT) scanning in the 1980, has allowed superb pre-operative imaging of anatomy, some evidence of the extent of the disease and a screen for asymptomatic complications. It has not, however, gained wide acceptance as an essential aid to planning surgery, most otologists reserving scans for selected cases such as patients with complications of chronic suppurative otitis media (CSOM) with suspected congenital abnormalities or with loss of land marks due to previous surgery.

HRCT is having a significant impact on the medical and surgical management of individuals with middle ear disease. It confirms and expands upon otoscopic findings, resolve clinical doubts, and in many circumstances play a significant role in determining surgical efficacy when surgery is necessary, the approach can be planned on the basis of HRCT findings [1]. However, routine HRCT scanning prior to all surgery of cholesteatoma can only be justified if it can be shown to influence clinical management [2].

To this objective, the present study was conducted to evaluate how accurately HRCT scanning could define the extent and severity of the underlying disease in patients with CSOM, thereby altering the surgical plan and outcome.

Materials and Methods

The present prospective study was conducted in the department of Otorhinolaryngology in collaboration with department of Radio diagnosis at VMMC & Safdarjang Hospital, New Delhi over a 2 year period. A total number of 60 consecutive adult cases of unsafe CSOM presenting to a single otologist were selected from outpatient Department of Otorhinolaryngology. These cases comprised of both males as well as females of different age groups.

A detailed history with regard to otorrhoea, deafness, tinnitus, otalgia and vertigo was taken and recorded in a systematic manner, paying attention to any associated symptomatology suggestive of impending or already established complications of unsafe chronic suppurative otitis media. A complete general physical examination was carried out followed by otorhinolaryngological examination which included otoscopic examination and examination under microscope. Assessment of hearing was done by tuning fork tests and pure tone audiometry. An attempt was made in every case to evaluate bacterial flora by sending the pus for culture and sensitivity.

Each of the selected cases of unsafe CSOM were subjected to HRCT of temporal bone. Thin sections (<2 mm) were obtained using a high spatial frequency algorithm with a 512 × 512 pixel matrix size and high spatial resolution (<0.8 mm), with 1.5 mm thin sections and 1.5 mm increments (Occasionally 1 mm increments were used for example through ossicular chain to minimize partial volume effects). Images were obtained both in the axial and coronal planes. Coronal scans were obtained with the patient supine or prone with the neck completely extended. Intravenous contrast was used only when evaluation was done for complications of the infective process. Following areas of interest were looked at the preoperative scans by a single experienced radiologist with considerable experience in reading temporal CT scans:

1. Soft tissue mass
2. Aeration mastoid
3. Extent of disease
4. Tegmen tympani erosion
5. Sinus plate erosion
6. Facial canal dehiscence
7. Lateral semi-circular canal (LSC) dehiscence
8. Malleus
9. Incus
10. Stapes
11. Disease outside middle ear cleft

All patients were seen by one author to discuss the management options and they were seen in a dedicated otology clinic, where all patients were allocated a 15-min review appointment. A thorough review of the findings allowed demonstration of the anatomy and pathology and formulation of the surgical plan. All surgery was performed by, or under, direct supervision of one consultant. Depending upon the pathological process, extent of disease, status of ossicular chain, facial canal, LSC and extension of disease outside middle ear in the mastoid, canal wall up procedure or canal wall down procedure was carried out. Attempts were made to restore the hearing mechanism using various reconstructive procedures like tympanoplasty, ossiculoplasty, canal wall reconstruction and cavity obliteration using various graft materials. The operative findings were recorded on a standard proforma including all the findings mentioned above and compared to the CT scan findings. In each of the above mentioned areas, sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) was calculated of HRCT findings as compared to peroperative findings.

Results

All the patients included in the present study underwent mastoid exploration. On exploration out of 60 patients, in 32 patients (53.33%) cholesteatoma was found, 16 cases (26.67%) had granulation without any evidence of cholesteatoma, and 10 cases (16.67%) had cholesteatoma along with granulations. In 2 cases (3.33%) no disease was seen.

The type of surgery performed is given in Table 1. In 2 patients (3.33%) Atticotomy with type 1 tympanoplasty was done as no significant disease was found in HRCT as well as per operatively. Ten patients had complications in the form of brain abscess as diagnosed on HRCT, and these underwent drainage of the abscess followed by the definitive procedure (Modified Radical Mastoidectomy in 6 Cortical Mastoidectomy in 4).

In the present study, in identifying soft tissue mass in a case of unsafe CSOM, HRCT was found to be extremely effective in those without the mass (specificity 100%), but not so much in those with the mass (sensitivity 89.65%), with a 100% PPV (Table 2). It's accuracy as a diagnostic test in this regard was thus acceptable. HRCT was found to

Table 1 Surgery performed

Surgery done	No.of cases	Percentage
Modified radical mastoidectomy	8	13.33
Modified radical mastoidectomy with tympanoplasty	26	43.33
Intact canal wall mastoidectomy	2	3.33
Intact canal wall mastoidectomy with tympanoplasty	10	16.67
Cortical mastoidectomy	2	3.33
Abscess drainage f/b modified radical mastoidectomy	6	10
Abscess drainage f/b cortical mastoidectomy	4	6.67
Atticotomy with type 1 tympanoplasty	2	3.33

be extremely effective in identifying those with sclerosis of mastoid (sensitivity 100%) but less effective in those with a cellular mastoid (specificity 66.67%). HRCT proved to be helpful in correctly picking out the extent of the disease (sensitivity 96.3%). Its role in spotting areas free from the disease was found to be less satisfactory (specificity 66.67%). Our study demonstrated that HRCT cannot be used as a diagnostic method for detecting erosion of the tegmen tympani in unsafe CSOM in view of both low sensitivity and specificity. In pinpointing patients with sinus plate erosion in unsafe CSOM, HRCT was highly effective, with both specificity and NPV above 90%. However, it's utility in spotting out those with a normal sinus plate was limited (low sensitivity and PPV). In identifying facial nerve dehiscence, HRCT emerged as a poor test in our study. However, its importance in singling out those with an intact nerve was significant (95% specificity). In our series of patients, the status of HRCT as a diagnostic investigation for LSC integrity was shown to be below acceptable standards, as only the NPV approached 90%. In recognizing malleus erosion or intactness, HRCT in our study was demonstrated to be within satisfactory norms with high sensitivity, specificity and NPV. In singling out incus erosion, HRCT was found to be a poor investigation, as well as in patients with an intact incus, considering that all values were below 90%. For stapes erosion demonstration, HRCT was shown to have no role at all, in view of its inability in correctly picking out those with or without erosion. HRCT proved to be an excellent investigation in our study in spotting patients with no disease outside middle ear cleft with no false positives. Its efficacy in identifying those with disease outside middle ear cleft was however borderline.

Discussion

In past studies [3–6] HRCT was found to be up to 100% sensitive in detecting a soft tissue mass preoperatively. Our data showed a slightly lower sensitivity of 89.65%. However, the specificity and PPV in this regard were both 100%, indicating that it was an excellent investigation for those without the disease and that if HRCT said that a mass was present, then it was always so. However, we could not distinguish cholesteatoma from other soft tissue diseases, and this again was the experience of most authors [1, 7, 8]. The differential diagnosis of soft tissue mass is often quite difficult with HRCT. We have been unsuccessful for the most part in differentiating pathologic processes on the basis of HRCT numbers. Acquired cholesteatomas, granulation tissue (in the absence of hemorrhage) and middle ear effusions, all share HRCT numbers ranging from 40 to 65. We therefore must rely on secondary findings to help in differential diagnosis, like ossicular destruction and tendency to gravitate [1]. Thus, after clinical examination, otoscopy and diagnosis of cholesteatoma, HRCT can determine its extent by revealing the combination of a soft tissue mass and bone erosion with 80% specificity [3, 5].

Table 2 Correlation between HRCT and surgical findings

	Feature	Perop. ($n = 60$)	On CT ($n = 60$)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
1.	Soft tissue mass present	58 (96.67%)	52 (86.67%)	89.65	100	100	25
2.	Aeration mastoid absent	48 (80%)	52 (86.67%)	100	66.67	92.3	100
3.	Presence of Disease	54 (90%)	54 (90%)	96.3	66.67	96.3	66.67
4.	Tegmen tympani eroded	22 (36.67%)	22 (36.67%)	54.54	73.68	54.54	73.68
5.	Sinus plate eroded	6 (10%)	8 (13.33%)	66.67	92.6	50	96.15
6.	Facial N. dehiscent	20 (33.33%)	10 (16.67%)	40	95	80	76
7.	Lateral semi-circular canal fistula	12 (20%)	16 (26.67%)	66.67	83.33	50	90.9
8.	Malleus erosion	22 (36.67%)	24 (40%)	90.9	89.47	83.33	94.44
9.	Incus erosion	46 (76.67%)	34 (56.67%)	65.21	71.42	88.23	38.46
10.	Stapes erosion	30 (50%)	34 (56.67%)	40	26.67	35.29	30.76
11.	Disease outside middle ear	12 (20%)	10 (16.67%)	83.33	100	100	96

Although, cholesteatoma is said to show a lower attenuation than granulation tissue, the difference is subtle and only Magnetic Resonance Imaging can differentiate the two [4].

In studies on efficiency of HRCT in defining the extent of disease preoperatively, O'Donoghue et al. [3] and Mafee et al. [4] independently found HRCT to be highly accurate. O'Reilly et al. [5] in his study corroborated the above studies with a 100% sensitivity of HRCT in defining the extent of disease. In our study, the sensitivity and PPV were both 96.3% which is in agreement with the aforementioned studies.

O'Donoghue et al. [3] reported a sensitivity of 50% in identifying tegmen tympani erosion but did not report his false positives. O'Reilly et al. [5] showed sensitivity of 46% and specificity of 84%. Jackler et al. [8] reported a sensitivity of 100% but a PPV of 33.33% in this regard. Mafee et al. [4] showed a sensitivity of 50%, and a PPV of 100% for detecting tegmen erosion. In our study, the sensitivity and PPV were both 54.54%. These non-correlating values can be explained partly by the very small number of patients with tegmen erosion in these studies, and also on the fact stated by O'Reilly et al. [5]. He commented that it is not possible to demonstrate reliably a dehiscence in the tegmen on axial scan alone but even using coronal cuts they found that the effect of partial volume averaging with adjacent soft tissues could give a false impression of tegmen erosion.

In detecting sinus plate erosion on HRCT our study showed sensitivity of 66.66%, specificity of 92.6%, PPV of 50% and NPV of 96.15%. Hence in our study, we demonstrated that, in pinpointing patients with sinus plate erosion in unsafe CSOM, HRCT was highly effective. However, it's utility in spotting out those with a normal sinus plate was limited.

In previous studies, the sensitivity of HRCT in detecting facial canal dehiscence varied widely with values of 0 [4], 25 [9], 44 [5], and 100% [3]. The specificity has been reported only by O'Reilly [5] as 85%. In our study, the sensitivity was 40% and specificity was 95%, which was comparable to the O'Reilly study. These non-compliant results can be explained on the fact that the visualization of thin bony structures like facial nerve canal may be misleading due to errors in computer reconstruction of their images. These structures may appear eroded due to the fact that the computer averages their density with adjacent soft tissue and air [10].

The labyrinthine fistula continues to be one of the most common complications of CSOM. Its frequency varies approximately from 4 to 12%. In nearly 90% of patients the labyrinthine fistula is located in LSC. An extensive clinical examination supported by imaging studies is essential for the preoperative diagnosis of LSC fistula. O'Reilly et al. [5] stated that axial scans are more satisfactory as they depict LSC in its entirety and are less likely to produce false positives. Nevertheless, useful information can also be obtained from coronal scans and hence both sections should be employed. In previous studies, the sensitivity of HRCT in detecting LSC fistula was approximately 55% [11–14]. In one study, however, Fuse et al. [15] showed a sensitivity of 97% for the same. The results of our study showed a sensitivity of 66.67% which was comparable. The specificity, PPV and NPV of our data in this regard was 83.3, 50, and 90.9%, respectively. In conclusion, sensitivity of HRCT in diagnosing LSC fistulas was moderate.

It is relatively easy to visualize the bodies of the malleus and the incus on HRCT but this has little clinical value unless the whole ossicular chain can be demonstrated. The long processes of the malleus and incus, and the stapes suprastructure are the components most at risk in CSOM but are also the most difficult to demonstrate on HRCT [5]. Mafee et al. [4] were able to demonstrate the state of ossicular chain in 89% of cases scanned. On the other hand, Jackler et al. [8] were able to predict the state of ossicular chain in only 7% of their cases. Phleps and Wright [7] doubted that HRCT could demonstrate the ossicular chain reliably because of partial volume averaging and tissue silhouetting. The malleus was the ossicle whose presence was predicted with the greatest accuracy with the sensitivity of 100% on HRCT [3]. In our study, the sensitivity, specificity and PPV were 90.9, 89.47, and 83.33%, respectively. O'Donoghue et al. [3] reported a sensitivity of 81.4% in identifying incus erosion whereas in our study its sensitivity was 65.21%. He also reported sensitivity of 85.71% and specificity of 23.25% in detecting absence of stapes suprastructure. However, in our study, its sensitivity was 40% and specificity was 26.67%. In our study we were not satisfactorily able to detect ossicular chain integrity or disruption due to failure in identifying long process of incus and/or the stapes suprastructure.

On comparing our results with previous studies in literature we found that HRCT proved to be a necessary tool for planning surgery in every case where disease spreads outside middle ear cleft. In a study conducted by Migirov [16], HRCT showed sensitivity of 97% and a PPV of 94% in diagnosis of disease outside middle ear cleft. In our study, the sensitivity was 83.33%, specificity was 100%, and PPV was 100%. The sensitivity in our study was not comparable probably because of small sample size.

Conclusion

The following conclusions can be reliably reached by means of this study:

1. Ideally all cases should be scanned in both axial and coronal planes but, when considerations of time or cost prohibit this, coronal scans are preferable to axial scans, except when a LSC fistula is suspected.
2. The presence and distribution of soft tissue in the middle ear cleft and mastoid could confidently be predicted using this modality. Indeed, it was observed, that a scan showing no evidence of soft tissue essentially excluded the presence of a cholesteatoma.
3. The malleus, body and short process of incus are well visualized, even when surrounded by disease. However, the long process of incus and the stapes suprastructure cannot be reliably imaged on these scans. Thus, visualizing the entire ossicular chain was unsatisfactory
4. The visualization of thin bony structures (facial nerve canal, tegmen, LSC) may be misleading due to errors in computer reconstruction of their images.
5. Despite these reservations we feel that fistulae in LSC can be demonstrated with an acceptable degree of accuracy using a combination of axial and coronal scans.
6. We believe that it is possible to detect facial nerve dehiscence and defects in tegmen tympani in significant number of cases.

In conclusion, the present study pointed that high resolution HRCT scanning is a modality which can accurately image the pathological anatomy in unsafe CSOM and represents a major advance in the diagnostic imaging of this disease. Its use by otologists is encouraged, especially in patients who have or are suspected of having complex problems and in whom the maximum information is desirable, as an adjunct to better preoperative assessment, and thus the surgical outcome. Its accuracy is likely to improve with larger studies and better experience, wherein its routine use may become justifiable.

Conflicts of interest The authors declare that they have no conflict of interest.

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