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Original Research Article

Comparative study of pre-operative high-resolution computed tomography in middle ear cholesteatoma with per-operative findings

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ABSTRACT

Background: Imaging plays an important role in the management of middle ear pathology. Temporal bone imaging is challenging and involves deep understanding of the anatomy, especially in relation to high resolution computed tomography (HRCT) imaging. An HRCT scan can precisely determine the site and extension of cholesteatoma and its sac, assessing the erosion of ossicles, evaluating the facial nerve in its entire course, tegmen and sinus plate, and determining Dural, sigmoid sinus, and jugular bulb positions.
Methods: This prospective descriptive study was performed from January 2018 to May 2019 in 60 patients with cholesteatoma who were referred to the Otolaryngology department of the Command Hospital Kolkata. Preoperative high-resolution temporal bone CT scans were carried out and compared with intraoperative findings.
Results: Evaluation of 60 patients and their CT scans revealed excellent correlation for presence of soft tissue mass and its extent into the middle ear and mastoid, erosion of scutum, erosion of ossicular chain and tegmen plate, good correlation for facial canal dehiscence, labyrinthine fistula and sinus plate erosions.
Conclusions: HRCT temporal bone is essential for anatomical determination of cholesteatoma and its complication. Careful and thorough evaluation is needed for the early diagnosis and treatment of the disease, to prevent complications and preserve hearing. The extent of disease and associated complications like facial nerve paralysis, labyrinthine fistula, and intracranial complications often will determine the aggressiveness of the surgical approach.

Keywords: High resolution computed tomography, Cholesteatoma, Ossicular chain, Labyrinthine fistula anf facial canal dehiscence

INTRODUCTION

Cholesteatoma, also known as an epithelioma, is a keratin-producing squamous epithelial cystic lesion of the middle ear or mastoid, results from the progressive accumulation of keratin protein debris enclosed by a layer of stratified squamous epithelium which is commonly characterized as "skin in the wrong place".[1,2] It may develop anywhere within the pneumatized portions of the temporal bone, most common location of cholesteatoma are the anterior attic, posterior attic and posterior mesotympanum. It grows and destroys the important structures within the temporal bone.

Cholesteatoma may be acquired or congenital, with a similar morphologic appearance.[2] Annual incidences of cholesteatoma in children and adults are 3 and 12.6 per 100,000 population, respectively.[3] Most common presentation of cholesteatoma is progressive hearing loss and scanty foul smelling otorrhea. Some patients present with symptoms of the complications of a cholesteatoma; these include vertigo, otalgia, facial weakness or

nystagmus.[4] Majority of patients also give history of childhood ear infections.

HRCT scan findings in cholesteatoma of the temporal bone consist of a homogenous soft tissue mass and middle ear opacification due to granulation tissue with local bone erosion and effusion with or without surrounding inflammatory changes.[5,6] Bone erosions can be better delineated on HRCT, which includes attic lateral wall (scutum) erosion, aditus and antrum widening and opacification, erosion and disruption of ossicular chain, labyrinthine fistula (erosion of semi-circular canal), facial nerve (fallopian) canal dehiscence, tegmen and sinus palate erosion, mastoid destruction (auto-mastoidectomy) and sigmoid plate dehiscence.[7,8]

Aims and objectives

The aim of the study was to compare and correlate the extent and sites of involvement of the middle ear and the mastoid air cell system and complications of cholesteatoma on HRCT temporal bone. with per-operative surgical findings (Gold Standard). The aim of HRCT temporal bone evaluation was to answer the decisive surgical questions before the surgical interference.

METHODS

After taking clearance from ethical committee of the institute, this prospective correlative study was conducted in the Department of Radiodiagnosis, Command Hospital (EC) Kolkata from January 2018 to May 2019 including 60 patients with cholesteatoma who were referred to the Otolaryngology department of the Command Hospital Kolkata. All the patients diagnosed with active squamosal chronic otitis media, on clinical examination with otoscope and oto-endoscope, referred for HRCT Temporal bone from Department of ENT were included in the study after taking a written informed consent. Patients with a history of previous ear surgery, Systemic disease which may affect the ear (e.g. Collagen vascular or granulomatous diseases), Malignancies of the temporal bone and skull base, Those with a history of head and neck radiotherapy, patients with known case of other middle ear pathology and pregnant women were excluded from the study.

All HRCT temporal bone scans were performed with a 16-channel MDCT scanner (PHILIPS BRILLIANCE 16 SLICE). The CT scan protocol of 120 kVp, 300 mA, section thickness 0.8 mm were taken. Axial section were acquired with patient in supine position, Spacing of 0.3 mm with overlap; Helical pitch of 1.75, Table speed 35 mm/s (17.5 mm per rotation with two rotations); Gantry speed 0.5 s per rotation and Rotation time 0.8 second and field of view 240 mm.

Raw data was reconstructed using a bone algorithm in multiplanar reformats to provide optimal visualization of the bony anatomy of the temporal bone. All obtained images were evaluated by an experienced radiologist.

Data collection was done under taking different parameters like the nature and location of non-dependent soft tissue opacity, located in the attic region lateral to the ossicles, occupying the tympanic space medial to the ossicles with involvement of the facial recess and sinus tympani and cholesteatoma occupying the attic and tympanic region with filling of almost entire middle ear cavity (Figure 1a, b and c). Mastoid extension of the soft tissue opacity. The status of the middle ear ossicles (malleus, incus and stapes) and its erosions (Figure 2). Associated complications: facial canal dehiscence and lateral semicircular canal dehiscence (labyrinthine fistula). Sinus plate erosion (Figure 3) and tegmen plate erosion (Figure 1b), with or without any associated intracranial complication such as meningitis, cerebritis, brain abscess or sigmoid sinus thrombophlebitis.

Intra-operative findings were considered as gold standard. HRCT findings and intra operative findings were compared. Data was subsequently analyzed by appropriate statistical test as well as by descriptive statistics, sensitivity, specificity, positive predictive value negative predictive value and diagnostic accuracy were calculated.

Statistical analysis

For statistical analysis data were entered into a Microsoft excel spreadsheet and then analyzed by SPSS (version 20.0; SPSS Inc., Chicago, IL, USA) and Open EPI (version 3.01). Data had been summarized as mean and standard deviation for numerical variables, count and percentages for categorical variables.

Categorical variables are expressed as Number of patients and percentage of patients and compared using Pearson's Chi Square test for independence of attributes/ Fisher's exact test as appropriate. An alpha level of 5% has been taken, i.e. if any p value is less than 0.05 it has been considered as statistically significant.

RESULTS

Evaluation of 60 patients and their CT scans revealed excellent correlation for presence of soft tissue mass and its extent into the middle ear and mastoid, erosion of scutum, erosion of ossicular chain and tegmen plate, good correlation for facial canal dehiscence, labyrinthine fistula and sinus plate erosions.

In this study, 31 (52%) out of 60 of the patients were in the age group of more than 40 years with mean age 39.1±16.0 years. Out of total 60 patients, 37 (62%) were males and 23 (38%) were females.

In our study middle ear mass was accurately detected on HRCT scan in all patients 60 patients which was found

intra-operatively. Extension of cholesteatoma into the mastoid was found in 57 patients in HRCT whereas intra-operatively it was observed in 56 patients with 01 false positive on HRCT scan likely due to associated inflammatory changes. (Kappa = 0.9 (Excellent agreement); p-value: <0.001).

Table 1: Age distribution of study subjects.

Age group (years)	N	Percentage
<10 years	02	03
10 -19 years	07	12
20 - 29 years	02	03
30 - 40 years	18	30
> 40 years	31	52
Total	60	100
Mean ± SD	39.1±16.07	

HRCT was able to detect all patients (38) with malleus intactness. However, it was wrongly positive in 2 patients in HRCT scan. HRCT was also able to correctly identify 20 out of 22 patients (91%) in whom malleus was eroded. The kappa value of 0.926 indicates excellent agreement between HRCT and intra operative finding.

HRCT was able to detect 24 (92.3%) patients with incus intactness. However, it was wrongly positive in 1 patient. HRCT was also able to correctly identify 33 out of 34 patients (97%) in whom incus was eroded. The kappa value of 0.897 indicates excellent agreement between HRCT and intra operative finding.

HRCT was able to detect 43 (95.5%) patients with stapes intactness. However, it was wrongly positive in 1 patient. HRCT was also able to correctly identify 14 out of 15 patients (93.3%) in whom stapes was not intact. The kappa value of 0.869 indicates excellent agreement between HRCT and intra operative finding.

HRCT was able to detect 11 (84.6%) patients with facial canal dehiscence. However, it was wrongly positive in 3 patients. HRCT was also able to correctly identify 44 out of 47 patients (93.7%) in whom facial canal dehiscence was not present. The kappa value of 0.761 indicates excellent agreement between HRCT and intra operative finding.

Table 2: Facial canal dehiscence on HRCT in relation to intra op finding.

Facial canal dehiscence on HRCT	Intra op finding of facial canal dehiscence		
	Present	**Absent**	**Total**
Present	11(84.6%)	3 (6.3%)	14 (23%)
Absent	2 (15.4%)	44 (93.7%)	46 (77%)
Total	13 (100%)	47 (100%)	60 (100%)

Kappa = 0.761 (Excellent agreement); Chi-square value: 30.6, df 1; p-value: <0.001

Table 2 depicts that HRCT was able to detect 11 (84.6%) patients with facial canal dehiscence. However, it was wrongly positive in 3 patients. HRCT was also able to correctly identify 44 out of 47 patients (93.7%) in whom facial canal dehiscence was not present. The kappa value of 0.761 indicates excellent agreement between HRCT and intra operative finding.

Table 3: Bony erosion on HRCT in relation to intra op finding.

Bony erosion on HRCT	Intra op finding of Bony erosion		
	Present	**Absent**	**Total**
Present	35 (94.5%)	2 (8.7%)	37 (62%)
Absent	2 (5.5%)	21 (91.3%)	23 (38%)
Total	37(100%)	23 (100%)	60 (100%)

Kappa = 0.859 (Excellent agreement); Chi-square value: 44.2718, df 1; p-value: <0.001

Table 3 depicts that HRCT was able to detect 35 (94.5%) patients with bony erosion. However, it was wrongly positive in 2 patients. HRCT was also able to correctly identify 21 out of 23 patients (91.3%) in whom bony erosion was not present. The kappa value of 0.859 indicates excellent agreement between HRCT and intra operative finding.

Table 4: Tegmen erosion on HRCT in relation to intra op finding.

Tegmen erosion on HRCT	Intra op finding of Tegmen erosion		
	Present	**Absent**	**Total**
Present	10 (18%)	0 (0%)	10 (17%)
Absent	0 (0%)	50 (100%)	50 (83%)
Total	10 (100%)	50 (100%)	60 (100%)

Kappa = 1 (complete agreement); chi square value- 53.02, df 1; p value <0.001

Table 4 depicts that HRCT was able to detect all patients (10) with tegmen erosion. HRCT was also able to correctly identify all patients in whom tegmen erosion was not present. The kappa value of 1 indicates complete agreement between HRCT and intraoperative finding.

Table 5: Labyrinthine fistula on HRCT in relation to intra op finding.

Labyrinthine fistula on HRCT	Intra op finding of Labyrinthine fistula		
	Present	**Absent**	**Total**
Present	3 (42.8%)	0 (0%)	3 (5%)
Absent	4 (57.2%)	53 (100%)	57 (95%)
Total	7 (100%)	53(100%)	60 (100%)

Kappa = 0.733 (Excellent Agreement), chi square value - 23.25, df 1, p value <0.001

HRCT was able to detect 3 (42.8%) patients with labyrinthine fistula. However, it was wrongly negative in

2 patients. HRCT was also able to correctly identify all 55 (100%) patients in whom labyrinthine fistula was not present.

Table 5 depicts that HRCT was able to detect 3 (42.8%) patients with labyrinthine fistula. However, it was wrongly negative in 2 patients. HRCT was also able to correctly identify all 55 (100%) patients in whom labyrinthine fistula was not present. The kappa value of 0.733 indicates excellent agreement between HRCT and intra operative finding.

HRCT could detect sinus plate erosion in 03 out 04 patients in whom it was found eroded intra-operatively.

Table 6 depicts that HRCT was able to detect 3 (75%) patients with bony erosion. HRCT was also able to correctly identify all patients in whom sinus plate erosion was not present. The kappa value of 0.848 indicates excellent agreement between HRCT and intra operative finding.

Table 6: Sinus plate erosion on HRCT in relation to intra op finding.

Sinus plate erosion on HRCT	Intra op finding of Sinus plate erosion		
	Present	**Absent**	**Total**
Present	3 (75%)	0 (0%)	3 (5%)
Absent	1 (25%)	56 (100%)	57 (95%)
Total	4 (100%)	56(100%)	60 (100%)

Kappa = 0.848 (Excellent Agreement); chi square value -29.83, df 1; P value <0.001

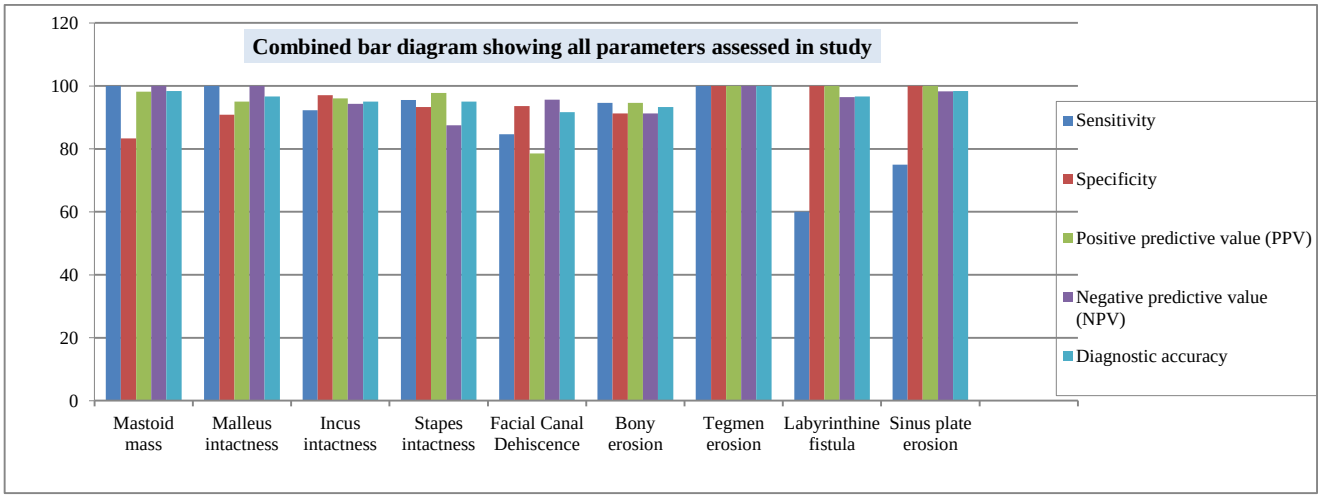

Figure 4: Combined bar diagram showing all parameters assessed in our study.

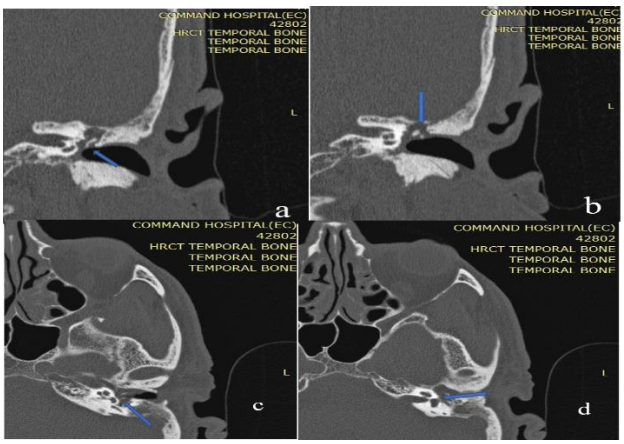

Figure 1: HRCT temporal bone coronal (a and b) and axial sections (c and d) in a 32 years old male patient with clinical suspicion of cholesteatoma. Image (a) erosion and sclerosis of scutum with soft tissue mass in prussak's space. Image (b) showing tegmen plate erosion. Image (c) showing soft tissue opacity in sinus tympani, the hidden site of cholesteatoma. Image (d) is showing facial canal dehiscence.

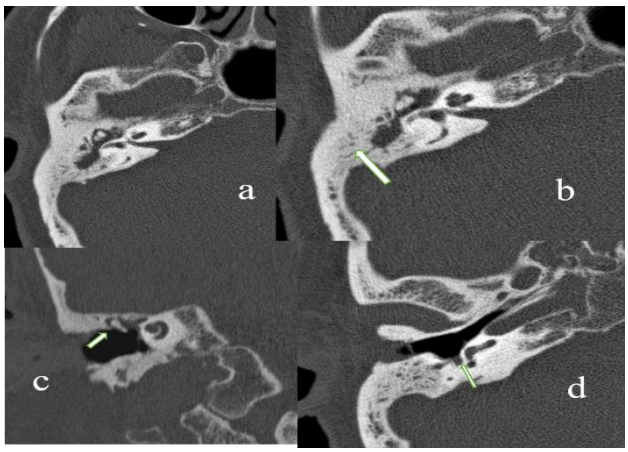

Figure 2: Axial (a, b) and coronal (c, d) images HRCT Temporal bone at epitympanum level, showing soft tissue mass surrounding the ossicles extending into the epi, meso and hypotympanum and opacification of the mastoid air cells (shown by arrow). Image c shows scutum erosion, soft tissue is also seen in sinus tympani (hidden site for cholesteatoma) shown by arrow in image d.

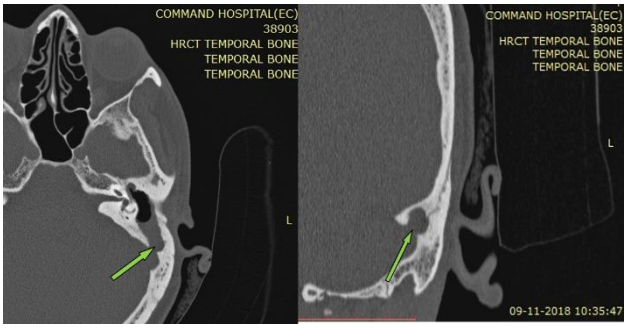

Figure 3: HRCT temporal bone, axial and coronal sections images showing sinus plate erosion (shown by green arrow).

DISCUSSION

Present study was conducted in the department of Radiology and ENT in Command Hospital (EC), Kolkata, West Bengal. 60 patients with clinical diagnosis of cholesteatoma were selected using above defined criteria.

In this study, 31 (52%) out of 60 of the patients were in the age group of more than 40 years with mean age 39.1±16.0 years (Table 1), similar study done by Kanotra et al with age ranging from 16 to 59 years and the mean age being 36.4 years.[9]

Out of total 60 patients, 37 (62%) were males and 23 (38%) were females Similar study done by Chavada PS et al 58% patients were females while 42% were males.[10] The study done by Dutta et al, also reported the similar results at par with our study, 56% were females and 44% were found males.[11]

In our study middle ear mass was accurately detected on HRCT scan in all patients which was found intra-operatively with 100% sensitivity and 100% PPV. (Figure 1a, b and c) Middle ear mass on CT in all the 60 (100%) patients and was similar to the intra-operative findings. Therefore, when statistically tried, the results of the 2 categories were at par with no difference. Sensitivity and positive predictive value of HRCT = 100%. Nath RK et al found that sensitivity and specificity of 100% with regards to soft tissue masses in mastoids and middle ears.[12]

Extension of cholesteatoma into the mastoid was found in 57 patients in HRCT whereas intra-operatively it was observed in 56 patients with 01 false positive on HRCT scan likely due to associated inflammatory changes (Figure 2). Sensitivity, specificity, PPV NPV and diagnostic accuracy in detection of mastoid extension 100%, 83.1%, 98.2%, 100%, 98.3%, respectively. P value <0.001 which was statistically significant in our study. Nath RK et al found that sensitivity and specificity of 100% with regards to soft tissue masses in mastoids and middle ears.[12] Gomaa et al in a comparative study including 56 patients reported accuracy and sensitivity of HRCT in detecting cholesteatoma (92.8%), its location and extension (96.4%).[13]

HRCT was able to detect all patients (38) with malleus intactness. However, it was wrongly positive in 2 patients in HRCT scan. HRCT was also able to correctly identify 20 out of 22 patients (91%) in whom malleus was eroded. Kappa value of 0.926 indicates excellent agreement between HRCT and intra operative finding. P value was <0.001 which is statistically significant.

In our study HRCT sensitivity was 100%, specificity 90.9 %, positive predictive value 95%, and negative predictive value 100% and diagnostic accuracy 96.6%. Our results were at par with the study conducted by Karki S et al.[14] In a prospective, analytical study conducted including 65 patients they reported sensitivity of 100% and specificity 95.2% in detecting malleus erosion on HRCT temporal bone.

HRCT was able to detect 24 (92.3%) patients with incus intactness. However it was wrongly positive in 1 patient. HRCT was also able to correctly identify 33 out of 34 patients (97%) in whom incus was eroded. The kappa value of 0.897 indicates excellent agreement between HRCT and intra operative finding. P value was <0.001 which is statistically significant.

HRCT sensitivity in detecting incus erosion was 92.3%, specificity 97%, positive predictive value 96% and negative predictive value 94.3% and diagnostic accuracy 95%. Kanotra et al reported the sensitivity of 95.7% and positive predictive value of 100% in detecting incus erosion on HRCT.[9] Karki S et al reported the sensitivity and specificity in incus erosion was 100% and 80.5%, respectively.[14]

HRCT was able to detect 43 (95.5%) patients with stapes intactness. However, it was wrongly positive in 1 patient. HRCT was also able to correctly identify 14 out of 15 patients (93.3%) in whom stapes was not intact. The kappa value of 0.869 indicates excellent agreement between HRCT and intra operative finding.

Therefore, HRCT sensitivity was 95.6%, specificity 93.3%, positive predictive value 97.7%, negative predictive value 87.5% and diagnostic accuracy 95%. Kanotra et al reported stapes superstructure erosion in 09 patients and intact in 38 patients out of total 47 patients, intra-operatively, it was found to be eroded in 10 patients and intact in the 37 patients.[9] Performance of HRCT temporal bone in detection stapes erosion was reported with sensitivity of 90%, specificity of 100%, positive predictive value of 100%, and negative predictive value of 97.4%. Gomaa et al in a comparative study including 56 patients reported accuracy and sensitivity of HRCT in detecting ossicular chain erosion (98%).[13] Karki S et al reported that the performance of HRCT in detecting stapes erosion was excellent with sensitivity and specificity of 96.6% and 71.4%, respectively.[14]

HRCT was able to detect 11 (84.6%) patients with facial canal dehiscence (Figure 1d). However, it was wrongly positive in 3 patients. HRCT was also able to correctly identify 44 out of 47 patients (93.7%) in whom facial canal dehiscence was not present. The kappa value of 0.761 indicates excellent agreement between HRCT and intra operative finding (Table 2). Therefore, HRCT sensitivity was 84.6%, specificity 93.6%, positive predictive value 78.6%, negative predictive value 95.6% and diagnostic accuracy 91.7%. Datta et al reported the sensitivity, specificity, positive and negative predictive value 75, 95.2, 95, 95.2 and 92, respectively which is comparable to our study.[11] Magliulo et al in their study, observed a sensitivity and specificity of 69% and 87%, respectively.[15]

HRCT was able to detect 35 (94.5%) patients with bony erosion. However, it was wrongly positive in 2 patients. HRCT was also able to correctly identify 21 out of 23 patients (91.3%) in whom bony erosion was not present. The kappa value of 0.859 indicates excellent agreement between HRCT and intra operative finding (Table 3). Therefore, HRCT sensitivity was 94.59%, specificity 91.3%, positive predictive value 94.59%, negative predictive value 91.3% and diagnostic accuracy 93.33%. Rogha et al reported the sensitivity, specificity, positive and negative predictive value 94.4, 96.4, 87.5, 96.4, and 87.5 respectively, which was comparable to our study.[16]

Erosion of tegmen plate was reported in 10 patients on HRCT temporal bone while intra-operatively, same was found intra-operatively. (Figure 1b) HRCT was able to detect all patients (10) with tegmen erosion (Table 4). HRCT was also able to correctly identify all patients in whom tegmen erosion was not present. Therefore, HRCT sensitivity was 100%, specificity 100%, positive predictive value 100%, negative predictive value 100% and diagnostic accuracy 100%. The kappa value of 1 indicates complete agreement between HRCT and intra-operative findings. Findings of our study are consistent with the study conducted by Karki et al and they reported sensitivity and specificity of 100% for visualization of tegmen plate erosion.[14]

HRCT was able to detect 3 (42.8%) patients with labyrinthine fistula. However, it was wrongly negative in 2 patients. HRCT was also able to correctly identify all 55 (100%) patients in whom labyrinthine fistula was not present. The kappa value of 0.733 indicates excellent agreement between HRCT and intra operative finding (Table 5). Therefore, HRCT sensitivity was 60%, specificity 100%, positive predictive value 100%, negative predictive value 96.49% and diagnostic accuracy 96.67%. Our findings are consistent with study conducted by Karki et al in their study HRCT showed specificity of 100% for lateral semi-circular canal erosion but with low sensitivity of 53.8%.[14]

HRCT was also able to correctly identify all patients in whom sinus plate erosion was not present (Table 6), (Figure 3). The kappa value of 0.848 indicates excellent agreement between HRCT and intra operative finding. Therefore, HRCT sensitivity was 75%, specificity 100%, positive predictive value 100%, negative predictive value 98.2% and diagnostic accuracy 98.3%. Chavada PS et al reported sensitivity of HRCT for sinus plate erosion 86.4% while specificity 89.7%. Negative predictive value 95.9% and positive predictive value is 70.4%.[10] Nath RK et al found that sensitivity and specificity in respect to ossicular erosion, sinus plate erosion, SCC erosion, facial canal and tegmen plate dehiscence ranges from 70 to100%.[12]

Low sensitivity in detection of facial canal dehiscence, labyrinthine fistula and sinus plate erosions was noted in our study, compared to other parameters studied. This can be justified that the soft tissue covering the small defect, which was not so obvious on HRCT scan or it might have developed during progression of the disease over the period of time if the patient was not operated immediately. The correlation found among these three parameters in our study may alert the surgeon that detection of one may indicate the existence of the other, potentially leading to decrease iatrogenic complications.

HRCT temporal bone is essential and for anatomical determination of cholesteatoma and its complication. Careful and thorough evaluation is needed for the early diagnosis and treatment of the disease, to prevent complications and preserve hearing. The extent of disease often will determine the aggressiveness of the surgical approach. The various associated complications like facial nerve paralysis, labyrinthine fistula, and intracranial complications are well recognized preoperatively by careful interpretation of the appropriate imaging.[17]

Limitations of the study

In spite of every sincere effort our study has lacunae. The notable short comings of this study are:

The sample size (60) is insufficient for such a study. The study has been done at a single centre. The study was carried out at a tertiary care hospital, so hospital bias cannot be ruled out. There is substantial time lag between HRCT scan and surgery. So changes due to the progression of the disease could not be accurately assessed.

CONCLUSION

Imaging plays an important role in the management of middle ear pathology. Temporal bone imaging is challenging and involves deep understanding of the anatomy, especially in relation to HRCT imaging. Cross-sectional imaging has evolved rapidly and has surpassed the radiography and plain film tomography. Cholesteatoma of the middle ear appear as soft tissue attenuation on HRCT with or without osseous erosion

and related complication which can be accurately picked up pre-operatively on HRCT temporal bone. The final diagnosis is usually a combination of radiological and clinical findings.

HRCT imaging has an important role for early detection of cholesteatoma and its complications (Figure 4). It provides a good road map for planning of surgical procedures to eradicate the disease and reconstruction of ossicular chain erosion. Thus we can conclude that HRCT scanning was the most important part in restoration of hearing loss and good guide to the surgeon for planning and management of cholesteatoma.

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