

**COMPARISON AND CORRELATION OF HIGH RESOLUTION COMPUTERIZED
TOMOGRAPHY WITH CLINICAL AND INTRA-OPERATIVE FINDINGS IN
CHOLESTEATOMA**

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ABSTRACT

Aim of the study: To study the correlation between high resolution computed tomography (HRCT) scan and intraoperative findings during surgery in cases of clinically diagnosed chronic otitis media with cholesteatoma.

Materials and methods: This was a descriptive study conducted on 72 patients with acquired cholesteatoma at Govt TD Medical College, Alappuzha for a period of 18 months. All the patients were subjected to high resolution computed tomography scans. Radiological correlation was done with the intra-operative findings. Sensitivity, specificity, positive and negative predictive values were calculated. Histopathological findings were noted.

Results: 24 (33.3%) patients had holotympanic cholesteatoma, 21 (29.2%) had involvement of the attic alone and 16 (22.2%) had attic and antrum involved. 100% correlation was found with bony wall erosions, whereas 96.9% and 75% sensitivity were noted in incus and stapes erosions respectively. 100% specificity was obtained in facial canal and sinus plate erosion, while a specificity of 96.9% in tegmen erosion and 98% in were seen in malleus erosion. By chi square test the difference in correlation was not significant (p-value >0.01). Good correlation was seen for lateral semicircular canal fistula. Contrast CT is more specific, but MRI with diffusion weighted sequences is the best in imaging cholesteatoma, especially residual lesions. **Conclusion:** Good correlation was found between HRCT scan and intra-operative findings in cases of COM with cholesteatoma in relation to bony wall erosion of the surrounding structures. CT scan alone cannot differentiate soft tissue masses.

KEYWORDS: cholesteatoma, computed tomography scan, correlation, sensitivity, specificity.

INTRODUCTION

The term cholesteatoma was coined by the German physiologist Johannes Muller in 1838, though it does not contain cholesterol (chole) or fat (steat) but keratinised squamous epithelial debris and that the term keratoma described by Schuknecht in the year 1974 is more appropriate to name this lesion. "Cholesteatoma" is derived from two Greek words chole (bile) and steatoma (fatty tumour) and the older terminologies were steatoma by De Verney in 1683 and pearly tumour of the temporal bone by Cruveilhier in 1829.^{[1],[2],[3]} Schuknecht defined this lesion as keratinised exfoliation. He also put it as "skin on the wrong side".^[2]

In a study by Olszenska et al. incidence of cholesteatoma was around 3 in 100,000 in children and 9.2 in 100,000 in adults annually, with a male predominance. Dornelles et al. noted in his study that 45% of the patients were below the age of 18 years.^[3] Incidence is higher among

Caucasians and Africans, lower among the Asians and least among the Eskimos.^[3]

Cholesteatoma can be classified generally into congenital and acquired.^[2]

The classification of the acquired type is based on otomicroscopic appearance of the growth pattern and extension of cholesteatoma.^{[2],[4]}

Jackler classified the growth pattern of cholesteatoma.

1. Attic or posterior epitympanic
2. Tensa or posterior mesotympanic
3. Anterior epitympanic.^[4]

These are the more common sites of cholesteatoma although it may be found in other parts of the temporal bone.^[5] Cholesteatoma tends to erode the surrounding bone.^[6] Several factors like inflammation, local pressure, granulation tissue etc contribute to this. Hydrolases and

collagenolytic enzymes like tumour necrosis factor, interleukins, prostaglandins etc. lead to bone resorption rather than necrosis.^[3]

On clinical examination by otoscopy and by the binocular microscope, foul smelling ear discharge, granulation tissue and polyps that accompany the epithelial debris mostly in the attic region and over the posterosuperior quadrant of the tympanic membrane can be made out, while very early lesions are well made out by doing high resolution computerised tomography (HRCT) scan of the temporal bone.^[6]

Presence of soft tissue opacification, blunting or erosion of the scutum, erosion of the ossicles, tegmen and sinus plates, facial canal, lateral semicircular canals etc. are the classical findings in acquired cholesteatoma on HRCT. Moreover, any anomalies of the facial nerve course and the ossicles and any impending intracranial complication associated with bone erosion are clearly demonstrated by HRCT.^[7]

The purpose of the study was to correlate between the preoperative HRCT evaluation with the intraoperative findings in cases of chronic otitis media (COM) with cholesteatoma. Also, histopathological correlation of cholesteatoma with other soft tissue density masses on HRCT can be studied.

MATERIALS AND METHODS

Objectives of the study

1. To study the correlation between the HRCT scan and intra-operative findings in acquired cholesteatoma.
2. To study the sensitivity and specificity of the HRCT scan report with intra-operative findings.
3. To study the limitations of HRCT scan in evaluating soft tissue lesions of the temporal bone.

Study design

Descriptive study

Study setting

Department of Otorhinolaryngology, Govt TD Medical college, Alappuzha

Study period

1st of December 2016 to 31st of May 2018 (18 months)

Inclusion criteria

Patients between 6 and 65 years presenting with chronic otitis media (COM) of acquired type of cholesteatoma (active squamosal disease).

Exclusion criteria

1. Congenital cholesteatoma
2. Granulomatous or collagen disorders of the temporal bone
3. Post irradiated cases of head and neck malignancy
4. Previously operated ear.

5. Malignancy of the temporal bone

Sample size

72 patients between 6-65 years diagnosed of having chronic suppurative otitis media with acquired cholesteatoma were enrolled for the study.

Sampling method

Convenient Sampling

Study procedure

The aim and benefits of the study and the possible complications of the surgery were explained to all the patients. Informed consent was obtained for the study. Detailed examination of all cases was done by otoscopy and with the microscope. The tympanic membrane perforation, retraction pockets, presence of squamous epithelial debris, granulations, attic and canal wall erosions, etc were noted. Pure Tone Audiogram (PTA) and HRCT scan of the temporal bone were taken. All details were noted in the proforma.

HRCT scan of the temporal bone was taken in both axial and coronal sections which were reconstructed on sagittal sections also. The images were interpreted together with the help of the radiologist. Contrast was used if any complication was suspected. Scans were taken in 1mm thickness in the fast scan mode, at 120 KV and 150 mA. Bony erosion, soft tissue mass, ossicular integrity, labyrinthine fistula, anatomical variation and intracranial involvement were noted.^[6]

Mastoidectomy surgery was done (either canal wall up or canal wall down). Granulations, polyps and the epithelial debris were sent for histopathological diagnosis. Correlation between the radiological and intra-operative findings was done. Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of the assessment were calculated by statistical analysis.

Statistical analysis

Data were entered in Microsoft excel and analysed using SPSS software.

Ethical considerations

Permission to conduct the study was obtained from the Institutional Ethics Committee and Institutional Research committee.

RESULTS

The youngest patient studied was 7 years of age and the oldest was 65 years old. The maximum incidence of cholesteatoma occurred in the 2nd decade of life. 72.2 % of the cases studied were seen in the 16-30 years of age group as shown in table 1. The mean age in this series was 25.8.

Table 1-Age incidence.

Age in years	Number of patients	Percentage %
6-15	12	16.7
16-30	52	72.2
31-45	5	6.9
46-65	3	4.2
Total	72	100

There were 37 (51.4%) males and 35 (48.6%) females in this study with a male to female ratio of 1.06:1.

Table 2-Involvement of cholesteatoma in the middle ear cleft.

Location and extension	No. of patients	Percentage%
Extensive (holotympanic) extending to mastoid antrum	24	33.3
Attic	21	29.2
Attico-antral	16	22.2
Mesotympanum	11	15.3
Total	72	100

b. Sclerotic type of mastoid pneumatisation was noted in all the 72 patients, correlating well with the intra-operative findings. Sensitivity, specificity, PPV and NPV=100%.

c. The scutum and lateral attic wall erosion were the most common bony erosions on involving 46 patients (63.9%), followed by eroded Koerner's septum in 40 patients (55.6%), eroded superior and posterior meatal wall in 12 patients (16.7%), mastoid fistula in 3 patients (4.2%), thinning of the tegmen bone in 25 (34.7%) and erosion of the tegmen in 12 patients (16.67%), sigmoid sinus plate erosion in 11 patients (15.3%) which is shown in table 3. Intra-operative findings correlated well with CT findings except in tegmen erosion which was noted only in 10 patients.

Table 3- HRCT of the temporal bone of patients with cholesteatoma with bone erosion.

Bony wall erosion based on HRCT findings	No. of patients	%
Eroded scutum and lateral attic wall	46	63.9
Eroded Koerner's septum	40	55.6
Eroded superior and posterior meatal wall	12	16.7
Mastoid fistula	3	4.2
Thinning of the tegmen	25	34.7
Eroded tegmen	12	16.67
Eroded sigmoid sinus plate	11	15.3

d. Erosion of the incus was seen in 64 patients (88.9%), handle of malleus in 25 patients (34.7%), head of malleus in 20 patients (27.8%) and suprastructure of the stapes in 8 patients (11.1%). Intra-operative findings showed incus erosion in 66

Comparison of the HRCT scan findings was done with the intra-operative findings.

a. On HRCT of the temporal bone, 24 (33.3%) patients had extensive involvement of the middle ear and mastoid (holotympanic), 21 (29.2%) patients had attic involvement alone, 16 patients (22.2%) with attic and antrum involvement and 11 (15.3%) patients had involvement of the mesotympanum (Table 2) which were similar to the intra-operative findings. Sensitivity, specificity, PPV and NPV=100%.

patients, malleus handle erosion in 24 patients, malleus head erosion in 19 patients and stapes supra structure erosion in 12 patients (Table 4).

Table 4- HRCT findings of ossicular involvement in cholesteatoma cases.

Integrity of the ossicles (HRCT)	No. of patients	%
Incus erosion	64	88.9
Malleus handle erosion	25	34.7
Malleus head erosion	20	27.8
Stapes suprastructure erosion	8	11.1

e. 28 patients (38.9%) showed involvement of the sinus tympani and 25 patients (34.7%) had involvement of the facial recess (Figure 1).

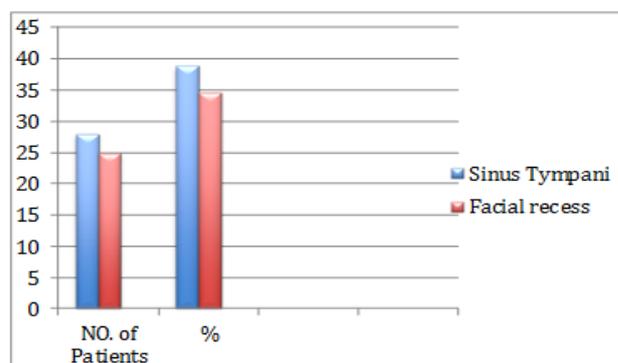


Figure 1-Involvement of facial recess and sinus tympani.

f. Lateral semicircular canal fistula (figure 2) was noted in 8 patients (9.7%).

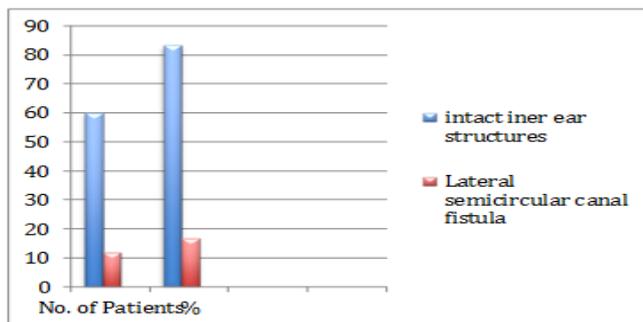


Figure 2- HRCT on involvement of lateral semicircular canal.

g. Involvement of facial nerve canal 52 patients (72.2%) had intact facial nerve canal and 15 patients (20.9%) had erosion of the facial canal. 15 patients had erosion of the tympanic segment of the facial nerve. 5 patients had dehiscence canal. Table 5 shows the involvement of the facial nerve canal. Intra-operatively, facial canal was intact in 50 and eroded in the tympanic segment in 17 patients.

Table 5- Facial canal involvement on HRCT in COM with cholesteatoma.

Facial nerve canal state	No. of patients	Percentage%
Intact	52	72.2
Dehiscent facial canal	5	6.9
Eroded facial canal tympanic segment	15	20.9
Total	72	100

Table 6-Correlation between HRCT findings and intra-operative findings.

Pathological features	CT findings	Surgery findings	False negative	False positive	Accu-racy	Sensiti-vity	Specific-ity
Tissue mass	72	72	0	0	100	100	100
Typical location	72	72	0	0	100	100	100
Scutum erosion /blunting	46	46	0	0	100	100	100
Superior &posterior canal wall erosion	12	12	0	0	100	100	100
Mastoid fistula	3	3	0	0	100	100	100
Koerner's septum erosion	40	40	0	0	100	100	100
Incus erosion	64	66	2	0	97.2	96.9	100
Malleus head erosion	20	19	0	1	98.6	100	98.1
Malleus handle erosion	25	24	0	1	98.6	100	98.3
Stapes erosion	8	12	4	0	94.4	66.7	100
LSC fistula	8	8	0	0	100	100	16.7
Tegmen erosion	12	10	0	2	97.2	100	16.7
Facial-Intact	52	50	0	2	97.2	100	90.9
Facial-eroded	15	17	2	0	97.2	88.2	100
Facial-dehiscence	5	5	0	0	100	100	100
Eroded sigmoid sinus plate	11	11	0	0	100	100	100
Mastoid abscess	10	10	0	0	100	100	100
Temporal lobe abscess	2	2	0	0	100	100	100

h. Mastoid abscess was noted in 10 patients (13.9%) and temporal lobe abscess in 2 patients (2.8%) and the findings were similar to the intra-operative findings. The patients with mastoid abscess had associated sigmoid sinus plate erosion, while patients with temporal lobe abscess had tegmen plate erosion.

Table 6 shows the correlation between CT scan and intra-operative findings. Statistical correlation between the CT scan and intra-operative findings is given in table 7.

Table 7- Correlation between HRCT and intra-operative findings with statistical analysis.

Pathological features	CT findings	Surgery findings	Sens-itivity	Specifi-city	PPV	NPV	Chi-square test	p-value
Soft tissue mass	72	72	100	100	100	100		
Typical location	72	72	100	100	100	100		
Scutum blunting / erosion	46	46	100	100	100	100		
Superior & posterior canal wall erosion	12	12	100	100	100	100		
Mastoid fistula	3	3	100	100	100	100		
Koerner's septum erosion	40	40	100	100	100	100		
Incus erosion	64	66	96.9	100	97.2	96.9	.3165	.5737
Malleus Head erosion	20	19	100	98	95	100	.0352	.8513
Malleus handle erosion	25	24	100	98	96	100	.0309	.8604
Stapes erosion	8	12	75	100	100	92.6	.929	.3351
LSC fistula	8	8	100	100	100	100		
Tegmen erosion	12	10	100	96.9	83.3	100	.2146	.6432
Facial canal Intact	52	50	100	91.6	96.1	100	.1345	.7139
Facial canal Eroded	15	17	89.5	100	100	96.5	.1607	.6885
Facial canal Dehiscence	5	5	100	100	100	100	100	
Eroded sigmoid sinus plate	11	11	100	100	100	100	100	
Mastoid abscess	10	10	100	100	100	100	100	
Temporal lobe abscess	2	2	100	100	100	100	100	

On histopathology examination, all specimens except one were confirmed as cholesteatoma which turned to be tuberculosis.

DISCUSSION

With regard to the pathogenesis and spread of cholesteatoma, the pars flaccida retracts into the epitympanum in the pars flaccida cholestatoma, further leading to scutum erosion and ossicular damage. Posteriorly it can involve the aditus, antrum and cause tegmen and lateral semicircular canal erosion. In pars tensa cholesteatoma retraction pocket in the posterior quadrant invaginates medially. The stapes suprastructure, bony canal wall of the facial nerve are more commonly involved.

Radiological investigation is required to identify the pathology in hidden areas of the middle ear cleft and in complications of COM, HRCT scan remains to be the choice of imaging in cholesteatoma,^[8] the characteristic feature being bone erosion.^[9]

HRCT findings for cholesteatoma of the temporal bone include

(a) Non dependent soft tissue mass filling the attic, aditus, antrum or mesotympanum

(b) Blunting of the scutum, erosion of the scutum ossicles, tegmen, sigmoid sinus plate, facial canal, semicircular canals, erosion of the Koerner's septum, erosion of the posterior and superior meatal walls etc.

In case of clinically suspected complications, contrast CT scan or MRI should be taken.^{[10],[11]} Soft tissue mass behind an intact tympanic membrane is usually seen in congenital cholesteatoma on HRCT. So proper clinical examination is needed in such cases.^[11] CT scan of the involved ear should be compared with that of the normal ear as there can be anatomical variations. Erosion of the Koerner's septum and periantral cells indicate the presence of antral cholesteatoma. Widening of the aditus and antrum is made out by the loss of figure of eight appearance and attic involvement by the destruction of the scutum.^[10]

Ossicular erosion is more commonly associated with a pars tensa cholesteatoma than a pars flaccida one. Long process of the incus is mostly involved due to the weak ligamentous support and poor blood supply, while the ice cream cone configuration by the head of malleus and body of incus is disrupted in attic cholesteatoma. It is also difficult to detect stapes erosion by CT.^[5] Careful inspection of the stapes suprastructure, footplate and oval

window is important in predicting the hearing level and reconstruction of the hearing mechanism.^[6]

Generally there is a poor correlation between the radiological evaluation and intra-operative findings in case of the facial canal, as the canal can be very thin even in a normal ear and in the presence of soft tissue pathology it becomes difficult to assess any erosion.^{[5],[6]} Labyrinthine fistula commonly involves the lateral semicircular canal. Close contact with cholesteatoma should be reported as the labyrinth may get damaged during surgery.^{[6],[10]} Tegmen tympani and sigmoid sinus plate erosion may lead to intracranial complications.^[12]

Extensive destruction of the mastoid and ossicles can mimic post surgical change called as auto mastoidectomy and such a cholesteatoma is also known as mural cholesteatoma.^[6]

Our study was carried out on 72 patients with acquired cholesteatoma having a slight preponderance of males (51.4%) over females (48.6%) between 6 to 65 years of age. This was similar to a study by Sade *et al.* in Brazil where a male predominance (55.7%) over females (44.3%) was observed.^[3]

The highest incidence of cholesteatoma was noted in the second decade while the lowest incidence was noted in the sixth decade. Study by Kemppainen *et al.* showed that the incidence of cholesteatoma was higher among males under the age of 50 years.^[13]

Otorrhoea was noted in all the 72(100%) patients followed by hearing loss in 62 (86.1%) patients and vertigo in 3 (4.2%) patients. 2 patients (2.8%) had dull aching otalgia which was suggestive of impending intracranial complication. Similar symptoms were noted in the study by Agnieszka *et al.*^[14]

In this study 100% correlation between CT findings and intra-operative findings in cholesteatoma of the middle ear cleft was noted in mastoid pneumatization, status of the scutum, posterior canal wall, superior canal wall, koerner's septum, lateral semicircular canal, sigmoid sinus plate, presence of mastoid and temporal lobe abscess. Sensitivity, specificity, PPV and NPV were 100%.

Similar correlation was noted in interpreting the pneumatization of the mastoid by Sonika Kanotra *et al.*^[15] Jackler *et al.*^{[15],[16]}

Studies by Sonika Kanotra *et al.*^[15] Wlashe *et al.*,^[17] Sirigiri and Dwarakanath^[18] showed similar results in CT correlation with operative findings as in our study for extension and spread of cholesteatoma in the middle ear cleft.^[15]

Tegmen plate erosion was noted in 12 patients on HRCT but only in 10 patients during mastoid exploration

surgery. Sensitivity=100%, Specificity= 96.9%, PPV=83.3% and NPV=100%. Chi square statistics=0.2146 p-value=0.6432 which meant that there was no statistical difference between the HRCT report and intra-operative findings which was similar to the studies by Gerami *et al.*,^[19] and Datta *et al.*^[20] But Jackler *et al.* reported a poor sensitivity rate for HRCT in detecting tegmen plate erosion.^[16]

HRCT and operative findings were the same in case of sigmoid sinus plate erosion in the 12 patients. Sensitivity, specificity, PPV and NPV were 100% which was similar to the study by Datta *et al.*^[20] But Rai reported sigmoid sinus plate erosion in 12 patients during surgery, whereas erosion was noted in only 6 patients by HRCT.^[21]

Incus erosion was noted in 64 and 66 patients on HRCT and intra-operatively with a sensitivity= 96.9% and specificity=100% PPV=97.2%and NPV=96.9% Chi square test= 0.3165 p-value=0.5737 which was not significant at p-value<0.01. Similar observation was comparable to the study by Sonika Kanotra *et al.*^[15] Datta^[20] *et al.* and Rai,^[21] Chee and Tan.^[22] Malleus head erosion on HRCT was seen in 20 patients and intra-operatively in 19 patients giving a sensitivity of 100% and specificity of 98%. PPV=95% and NPV=100% Chi square test=.0352 p-value=0.8513, implying the difference was not significant.

Erosion of the handle of the malleus was noted in 25 patients on HRCT and 24 patients during surgery. Sensitivity=100% Specificity=98.3% PPV=96% NPV=100% Chisquare test=.0309 p value=0.8604 was not significant.

Rai^[21] and Zhang *et al.*^[23] reported a 100% specificity rate which was higher than the present study. Excellent radio surgical correlation was noted by Chee and Tan.^[22]

Stapes suprastructure erosion in 8 patients was reported on HRCT, while intra- operative findings showed stapes erosion in 12 patients with a sensitivity of 75% and specificity of 100%. PPV%=100% NPV=75% Chisquare test=0.929 p-value= 0.3351, the difference was not significant. Rai^[21] also reported sensitivity of 75% for HRCT and 100% specificity which was comparable to our study.

Lateral semicircular canal fistula on HRCT and during surgery correlated well with a sensitivity and specificity of 100%. This was higher than the study by Sonika Kanotra^[16] and similar to the study by Chee and Tan,^[22] and Mafee *et al.*^[24]

Intact facial canal was reported on HRCT in 52 patients and in 50 patients during surgery. Sensitivity=100 Specificity =91.6% PPV=96.1% NPV=100% Chi square test= 0.1345 p-value=0.7139.

100% specificity and positive predictive values were noted by HRCT for erosion of the facial canal. PPV=100% NPV=96.5% Chi square test=0.1607 p-value=0.6885 which was not significant. Sonika Kanotra *et al.*^[16] reported only 33.3% sensitivity and 100% specificity. Mafee *et al.*^[24] considered HRCT to be accurate by 100%.

100% correlation was noted between HRCT and intra-operative findings in detecting intracranial and mastoid abscesses, similar to a study by V.Prasanth *et al.*^[25]

Involvement of sinus tympani was seen in 28 patients (38.9%) facial recess in 25 patients (34.7%). So HRCT scan are very useful in assessing the hidden areas of the middle ear.^[26]

Our study showed that all the 72 patients with cholesteatoma were accurately diagnosed with HRCT scans that correlated with surgical findings. Mafee *et al.* also reported in their series of 48 patients with cholesteatoma 46 of them (96%) had been diagnosed correctly with preoperative HRCT.^[24]

Chee *et al* concluded in their series of 36 patients, 34 patients (94.4%) had been correctly diagnosed by HRCT.^[22]

Joselito *et al* reported in their series of 64 patients that the preoperative HRCT scan correlated well with the surgical findings and histopathology reports (96.8%).^[10]

CT cannot always differentiate between soft tissue lesions.^{[1],[10]} Though HRCT remains the choice of investigation in cholesteatoma of the temporal bone there are still limitations^[8]

1. Difficulty to differentiate from lesions like cholesterol granuloma, facial nerve hemangioma, neuroma and schwannoma, paragangliomas, giant cell tumours, squamous cell carcinoma, metastasis, fluid, tuberculosis etc.^{[6],[28]}
2. Ossicular fixity cannot be made out.^[6]
3. Double oblique sagittal images taken along the plane of the tympanic segment may be required to study the facial nerve canal.^[6]
4. Lack of specificity in tegmen and sinus plate involvement in small areas of erosion.^[29]
5. Residual lesion in a previously operated ear cannot be made out.^[6]
6. High cost and effects of radiation by CT also limit its use.^[29]

In such cases MRI becomes a better tool. Cholesteatomas appears as hypointense on T1W1 and hyperintense on

T2W1 with a diffusion restriction (DW) sequences. This feature differentiates it from cholesteatoma and inflammation which are hyperintense on both T1W1 and T2W1 images and with no restriction on DW.

Delayed post gadolinium T1 weighted and non echo-planar diffusion weighted (Non-EPI DWI) sequences can differentiate inflammation or infection and also demonstrate the integrity of the membranous labyrinth and facial nerve canal. Using these two sequences together high sensitivity and specificity can be achieved in case of soft tissue lesions and in residual cholesteatoma even as small as 2 mm, and also in small lesions where bony erosion may not be seen, thereby making it an excellent screening tool.^{[8],[14]}

CONFLICT OF INTEREST

There is no conflict of interest among the authors.

CONCLUSION

High sensitivity and high negative predictive values make HRCT the radiological investigation of choice in suspected cases of cholesteatoma. Early diagnosis and surgical intervention can reduce the spread to surrounding tissues with its potential complications. HRCT is a major tool in predicting the outcome of surgery and also in reconstruction of the hearing mechanism.

HRCT is of limited use in soft tissue delineation, diagnosing recurrent /residual cholesteatoma and in an accurate interpretation of a previously operated ear, whereas MRI with T1, T2 images and DW1 sequences becomes the preferred choice of investigation in these situations.

Both HRCT and MRI are complementary to each other. The pivotal role played by them should be made use of to give the best outcome to patients in the management of cholesteatoma.

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