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Original Research Paper

"A study on HRCT of temporal bone in evaluating chronic otitis media and its correlation with surgical findings in a tertiary care hospital"

Dr Harishkiran N Elukoti[1], Dr Abhinay A C[2], Dr Bharat M P[3]

1. 2. Associate Professor, Department of Radiodiagnosis, Subbaiah Institute of medical sciences, Shivamogga, Karnataka.
3. Professor, Department of Radiodiagnosis, Subbaiah Institute of medical sciences, Shivamogga, Karnataka.
*Corresponding Author: Dr Abhinay A C, Associate Professor, Department of Radiodiagnosis, Subbaiah Institute of medical sciences, Shivamogga, Karnataka.

ABSTRACT: Background: Otitis media (OM), also known as middle ear inflammation, is classified into three types: acute otitis media (AOM), otitis media with effusion (OME; "glue ear"), and chronic otitis media. OM can be caused by bacteria or viruses; during "colds," viruses can move from the eustachian tube to the middle ear, creating a pathway for bacteria in the nasopharynx

OBJECTIVES:

• The aim of the work is to study the radiological findings of the temporal bone in patients with chronic otitis media with or without cholesteatoma.

• Assessing extent of the disease, ossicular destruction and other potential complications.

MATERIAL & METHODS: Study Design: A prospective hospital-based observational study.**Study area:** Department of Radio Diagnosis, Subbaiah Institute of Medical Sciences, Karnataka. **Study Period:** 1 year.**Study population:** patients attending/referred to the department of Radiodiagnosis for High resolution computed Tomography of temporal bone. **Sample size:** The study consisted of 40 subjects. **Sampling method:** Simple random technique.

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Results: Of the 30 cases of atticoantral disease studied, 27 (90%) patients had imaging findings of cholesteatoma whereas 3 (10%) patients had no findings suggestive of cholesteatoma. Surgery showed cholesteatoma in 26 (86.6%) patients and no cholesteatoma in 4 (13.3%) patients

CONCLUSION: HRCT of the temporal bone is promising in the pre-operative assessment of cholesteatoma since it shows the extent of the disease and the integrity of most middle ear structures. The scan notifies the surgeon to any potential surgical risks or disease consequences.

Keywords: semicircular canal, temporal bone, hrct, ossicular erosion, chronic otitis media

INTRODUCTION:

Otitis media (OM), also known as middle ear inflammation, is classified into three types: acute otitis media (AOM), otitis media with effusion (OME; "glue ear"), and chronic otitis media. OM can be caused by bacteria or viruses; during "colds," viruses can move from the eustachian tube to the middle ear, creating a pathway for bacteria in the nasopharynx [1]. COM is a significant contributor of hearing loss in impoverished countries. These consequences are especially dangerous in low-income countries, where an estimated 21,000 individuals die each year as a result of OM. The prevalence of OM-related hearing loss is estimated to be 30 (with a range of 0.7-95) per 10,000 people globally [1]. The meninges, brain, internal carotid artery, jugular bulb, and facial nerve surround the temporal bone, where the middle ear is located. The anatomical complexity raises the likelihood of COM-related issues, which already complicates the surgical procedure [2].

Early detection of COM is critical for preventing hearing loss, developmental delays, or learning issues. Radiological testing is critical in the diagnosis of COM, supplementing clinical and audiological examinations. Traditional X-rays have little utility in examining the

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temporal bone, but computed tomography (CT) scans have emerged as the gold standard imaging modality for the ear, nose, and throat (ENT). CT scans provide extensive information on the skull base's bony architecture as well as the ability to diagnose soft tissue disorders related to bone. They provide good clarity of anatomical landmarks, aiding in surgical planning by determining the approach to be used and forecasting potential intraoperative difficulties. The transition to a less invasive surgical approach emphasizes the necessity of reliable radiological imaging in guiding surgical decisions.

Conventional radiography does not allow for comprehensive examination of the middle ear and mastoid. CT offers the advantage of providing images with higher contrast and greater spatial resolution. Thin slices and a particular bone algorithm are used to produce high resolution CT (HRCT) pictures with fine detail. HRCT, a variation of standard CT, gives a direct visual window into the temporal bone, revealing minute structural details. It aids in the appropriate assessment of pathology prior to surgical investigation, particularly in terms of disease location, extent, and complications. HRCT has substantially improved the ability to assess bone architecture as well as soft tissue condition. HRCT temporal bone clearly displays the anatomy of several minor but significant structures in the middle and inner ear cavities.

Understanding the condition and extent of middle ear illness can assist surgeons in planning appropriate surgery and effectively removing the disease. The preoperative assessment increases the surgeon's awareness of the complicated anatomy and its variances, allowing him to take the necessary precautions to protect crucial structures. However, there is much debate about the efficacy of preoperative radiological evaluation in the treatment of chronic otitis media. Thus, a study is required to determine the accuracy of HRCT of the temporal bone in detecting the numerous pathological alterations associated with chronic otitis media.

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OBJECTIVES:

• The aim of the work is to study the radiological findings of the temporal bone in patients with chronic otitis media with or without cholesteatoma.

• Assessing extent of the disease, ossicular destruction and other potential complications.

• To study the correlation of High Resolution CT scan of temporal bone with intraoperative findings.

MATERIAL & METHODS:

Study Design: A prospective hospital-based observational study.

Study area: Department of Radio Diagnosis,Subbaiah Institute of Medical Sciences, Karnataka.

Study Period: 1 year.

Study population: patients attending/referred to the department of Radiodiagnosis for High resolution computed Tomography of temporal bone.

Sample size: The study consisted of 40 subjects.

Sampling method: Simple random technique.

Inclusion criteria: Patients who are clinically suspected of having symptoms related to chronic otitis media.

Exclusion Criteria:

1. Patients with electronic devices at the skull base, such as cochlear implants.

2. Patients with history of temporal bone fracture.

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3. Patients with temporal bone neoplastic diseases.

Ethical consideration: Institutional Ethical committee permission was taken prior to the commencement of the study.

Study tools and Data collection procedure:

HRCT temporal bone was performed by using Multidetector High Resolution Computed Tomography (GE BRIGHT SPEED 16 SLICE C T) scan with serial 0.625 mm cuts in axial and coronal planes and findings were correlated with surgical findings. Findings of HRCT temporal bone were recorded. Findings of mastoid exploration surgery were recorded. Report of HRCT of temporal bone was correlated with surgical findings and tabulated using percentages.

Technique for HRCT study: Routine lateral topogram of the skull base was initially taken in all patients in the supine position. The axial view was performed with the patients in the supine position and the coronal images were reformatted. Contiguous axial 0.6 mm thickness images were obtained from top of the petrous apex to the inferior tip of the mastoid, and coronal images were obtained from the anterior margin of the petrous apex to the posterior margin of the mastoid. The axial CT examinations were performed at 120 Kv and 240 mAs, the field of view was approximately 18 cm with an imaging matrix of 512 X 512 pixels and the slice increment was the same as slice thickness. Images were evaluated in both soft tissue and bone algorithm. HRCT findings were noted according to the proforma. Intraoperative findings of mastoid exploration surgery were recorded and were taken as standard for determination of sensitivity and specificity of HRCT scan for various study variables. The data were analyzed using sensitivity, specificity, positive predictive value and negative predictive value.

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Statistical analysis:

Data was analysed using SPSS 21.0 software. Descriptive parameters were represented as mean with SD or median. Continuous variables were compared using unpaired t-test/Mann Whitney u test. Chi-square or t-test will be used to determine significant outcome differences. Categorical data was represented as frequency with percentage. For all tests, a p-value of <0.05 was considered statistically significant.

OBSERVATIONS & RESULTS:

Table 1: Age distribution of study population.

Age(yrs.)	**No.ofpatient**	**Percentage(%)**
11-20	16	40
21-30	21	52.5
31-40	01	2.5
41-50	01	2.5
51andabove	01	2.5
Total	**40**	**100**

Table 2: Gender distribution of study population

Gender	**No.ofpatients**	**Percentage**
Male	24	60

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Female	16	40
Total	**40**	**100**

40 patients with clinical diagnosis of chronic otitis media were studied, out of which 16 were female and 24 were male, predominantly in the age group of 21-30years. Of 40 cases of chronic otitis media studied,30 patients had atticoantral disease (75%) and the remaining 10 patients had tubotympanic disease (25%).

Table 3: Frequency of clinical symptoms in the study population.

Clinicalfeatures	**No.ofpatients**	**Percentage**
Eardischarge	36	90
Ear ache	31	77.5
Hearingloss	25	62.5
Facial weakness	8	20
Giddiness,vomiting,others	7	17.5

Table 4: Distribution of type of chronic otitis media

TypeofCOM	**Frequency**	**Percentage**
Tubotympanicdisease	10	25
Atticoantraldisease	30	75

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Total	40	100

Table 5:Distributionwith respecttopresenceorabsenceof cholesteatoma.

HRCTFINDINGS	**SURGICALFINDINGS**	
	Cholesteatoma	NoCholesteatoma
Cholesteatoma	24	3
NoCholesteatoma	2	1

Out of 30 cases of atticoantral disease, HRCT showed findings of cholesteatoma in 27 cases. Surgically cholesteatoma was present in 26 cases. The findings were correlated with surgical outcome by diagnostic statistics.

Of the 30 cases of atticoantral disease studied, 27 (90%) patients had imaging findings of cholesteatoma whereas 3 (10%) patients had no findings suggestive of cholesteatoma. Surgery showed cholesteatoma in 26 (86.6%) patients and no cholesteatoma in 4 (13.3%) patients

Extent of Cholesteatoma:

 Epitympanum was involved in 27 (90%) patients in HRCT and 27 (90%) patients at surgery.

 Aditus was involved in 26 (86.6%) patients at both HRCT and at surgery.

 Mastoid antrum was involved in 24 (80%)patients in HRCT and 25 (83.3%) patients at surgery.

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 Facial recess was involved in 18 (60%) patients in HRCT and 14 (46.6%) patients at surgery.

 Sinus tympani was involved in 14 (46.6%) patients in HRCT and 10 (33.3%) patients at surgery.

 Hypotympanum was involved in 2 (6.6%) patients in HRCT and 4 (13.3%) patients at surgery.

 Eustachian tube was involved in 2 (6.6%) patients in HRCT and 3 (10%) patients at surgery.

 Extension beyond middle ear cleft was seen in 4 (13.3%) patients in HRCT and 5 (16.6%) patients at surgery.

Status of ossicular chain:

 Erosion of malleus noted in 25 (83.3%) patients in both HRCT and surgery.

 Incus erosion was seen in 17 (56.6%) patients in HRCT and 20 (66.6%) patients at surgery.

 Stapes erosion was seen in 10 (33.3%) patients in HRCT and 15 (50%) patients at surgery.

Integrity of facial canal:

 Labyrinthine segment of facial canal showed erosion in 4 (13.3%) patients in HRCT and 3 (10%) patients at surgery.

 Tympanic segment of facial canal was the most commonly involved, showing erosion in 10 (33.3%) patients in HRCT and 12 (40%) patients at surgery.

 Mastoid segment of facial canal showed erosion in 1 (3.3%) patient in HRCT and 4 (13.3%) patients at surgery.

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Detection of erosions in bony labyrinth:

 Lateral SCC was the most commonly involved in bony labyrinth seen in 4 (13.3%) patients in both HRCT and surgery.

 Posterior SCC erosion was seen in 1(3.3%) patient in both HRCT and surgery.

 Superior SCC erosion was not seen in any of the patients in our study.

Detection of erosions in scutum, dural, sinus plate:

 Erosion of scutum was seen in 23 (76.6%) patients in HRCT whereas 23 (76.6%) patients showed dural plate erosion at surgery.

 Erosion of dural plate was seen in 6 (20%) patients in HRCT whereas 9 (30%) patients showed dural plate erosion at surgery.

 Erosion of sinus plate was seen in 4 (13.3%) patients in HRCT and 3 (10%) patients at surgery.

Table 6: Sensitivity and specificity of HRCT with surgical findings.

EXTENT OF CHOLESTEATOMA	**SENSITIVITY**	**SPECIFICITY**	**POSITIVEPREDICTIVE VALUE**	**NEGATIVEPREDICTIVE VALUE**
EPITYMPANUM	100	100	100	100
ADITUS	96.1	75	96.1	75

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MASTOIDANTRUM	96	100	100	83.3
FACIALRECESS	92.8	68.7	72.2	91.6
SINUSTYMPANI	80	70	57.1	87.5
HYPOTYMPANUM	50	100	100	92.8
EUSTACHIAN TUBE	66.6	100	100	96.4
BEYOND MIDDL EEARCLEFT	80	100	100	96.1

Statusofossicles	SENSITIVITY	SPECIFICITY	POSITIVEPREDICTIVEVALUE	NEGATIVEPREDICTIVEVALUE
MALLEUS	84	20	84	20
INCUS	80	90	94	69
STAPES	66	100	100	75

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Integrityoffacialcanal	SENSITIVITY	SPECIFICITY	POSITIVEPREDICTIVEVALUE	NEGATIVEPREDICTIVEVALUE
LABYRINTHINESEGMENT	66.67	92.59	50	96
TYMPANICSEGMENT	66.6	88.8	80	80
MASTOIDSEGMENT	25	100	100	89.6

Erosionsofbonylabyrinth	SENSITIVITY	SPECIFICITY	POSITIVEPREDICTIVEVALUE	NEGATIVEPREDICTIVEVALUE
LATERALSCC	75	96.1	75	96.1
POSTERIORSCC	100	100	100	100

Erosions of scutum,dural/sinus plate	SENSITIVITY	SPECIFICITY	POSITIVEPREDICTIVEVALUE	NEGATIVEPREDICTIVEVALUE

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SCUTUM	100	100	100	100
DURAL PLATE	66.6	100	100	87.5
SINUSPLATE	100	96.2	75	100

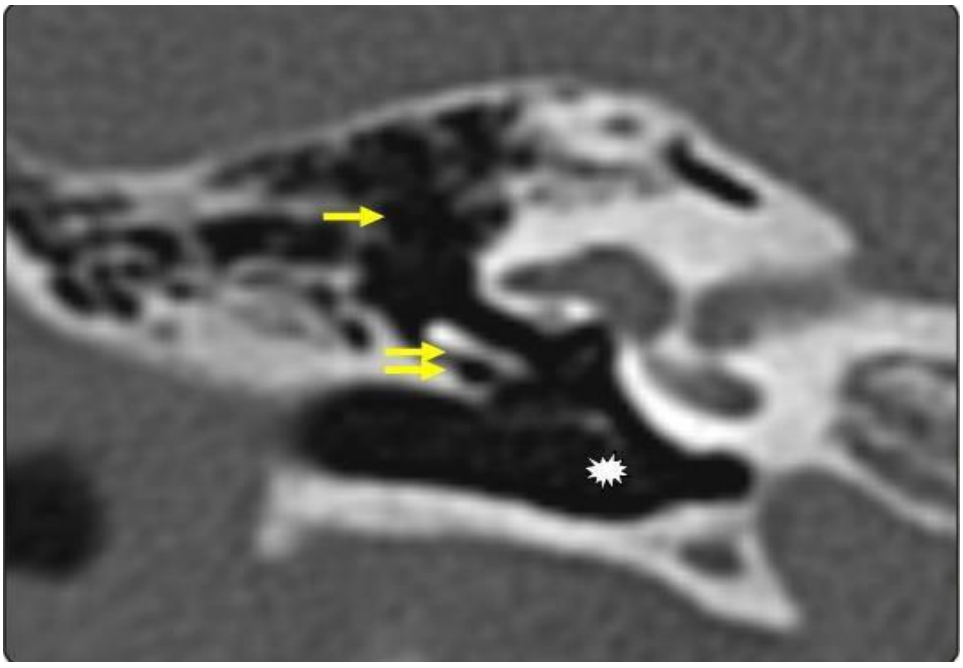

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FIGURE1: CoronalHRCTimageshowingnormalepitympanum(arrow),mesotympanum(double arrows)andhypotympanum(asterix).

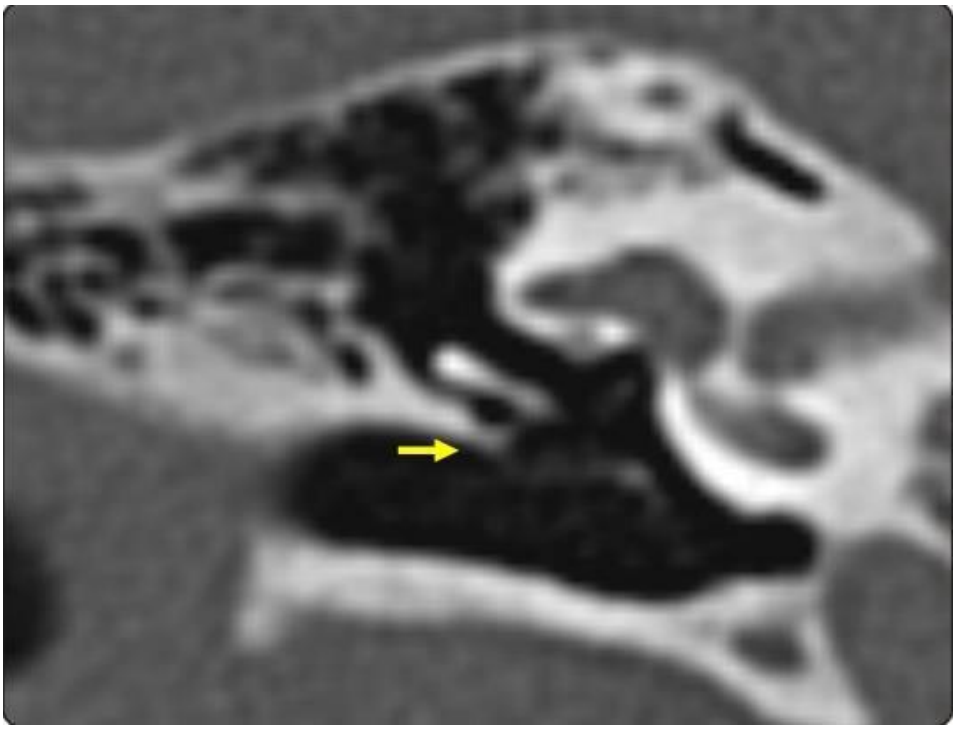

FIGURE2:Coronalimageshowingnormalscutum(arrow)andPrussak'sspace medial toscutum.

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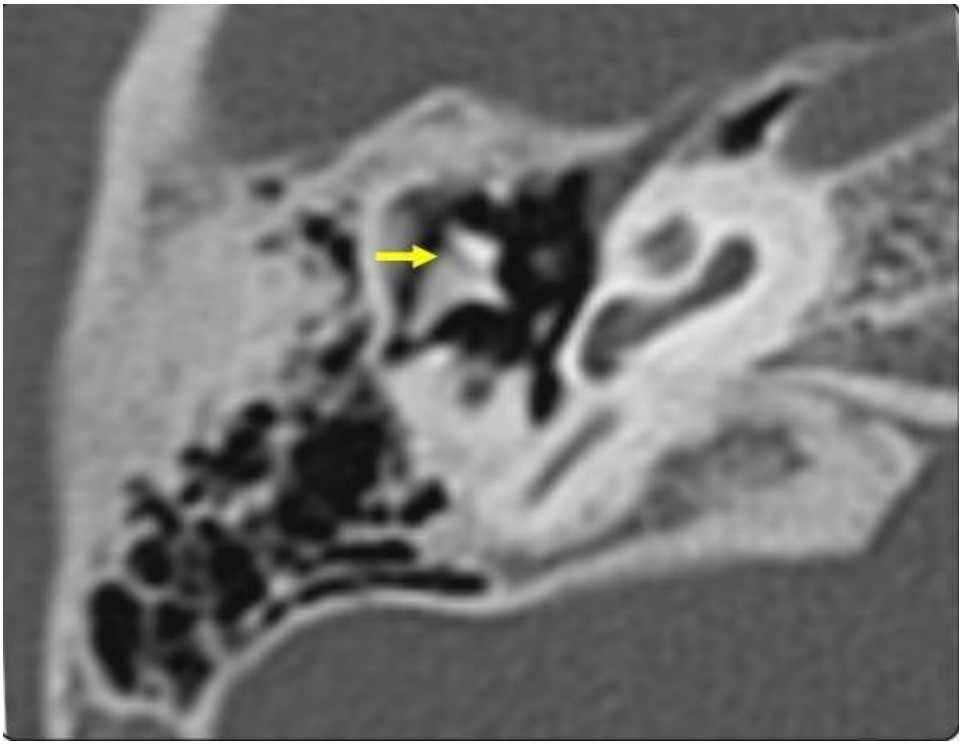

FIGURE3:Axialimageshowingnormalincudo-malleolarjoint(arrow)

FIGURE4:Axialimageshowing

normalstapes(arrow)andovalwindo

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w(asterix).

CASE1

A 13yearoldgirlpresented withotorrhea,hearinglossandpainfor2months.

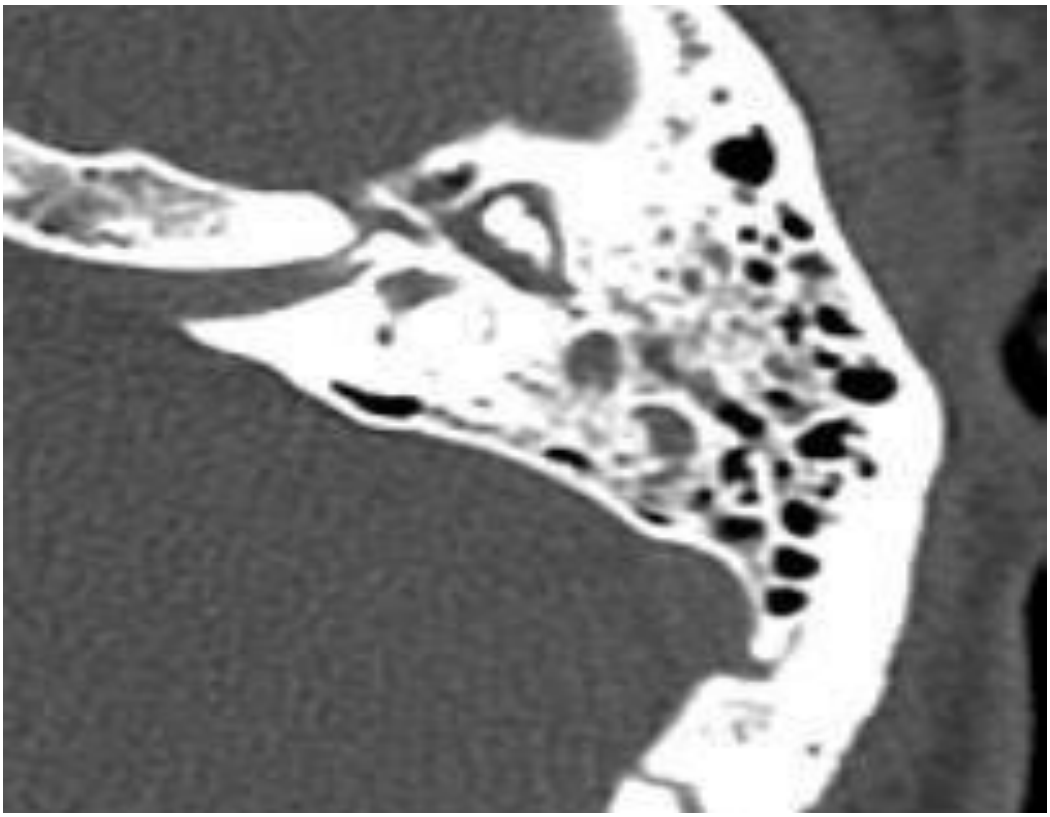

FIGURE5:AxialCTimageshowingopacificationofmiddleearandmastoid. Head of malleus and body of incus are seen intact. Chronic otitismedia.

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CASE2

A25yearmalepresentedwithearache,hearinglossfor3months,eardischarge for2 months onandoff.

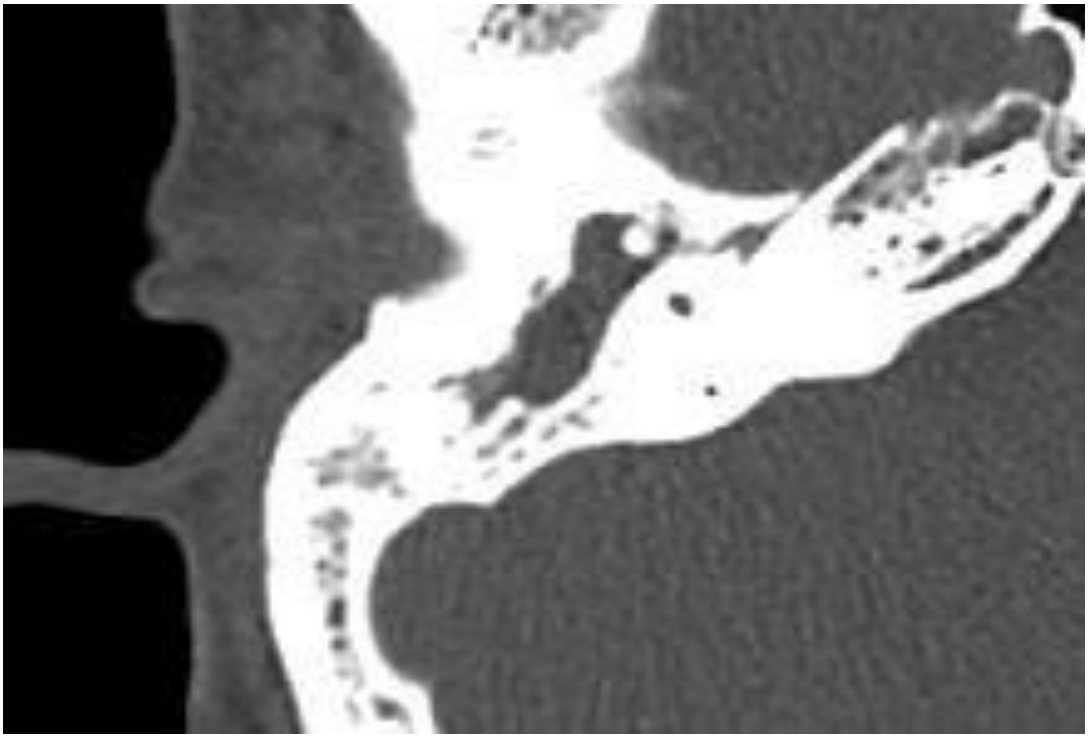

FIGURE 6: Axial imageshowing soft tissue attenuation in epitympanumandantrumwitherosionofincussuggestingcholesteatoma. Surgeryshowedcholesteatomain epitympanumand antrum.

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CASE3

A24yearoldfemalepresentedwithcomplaintsofeardischarge,earachesince3 months.

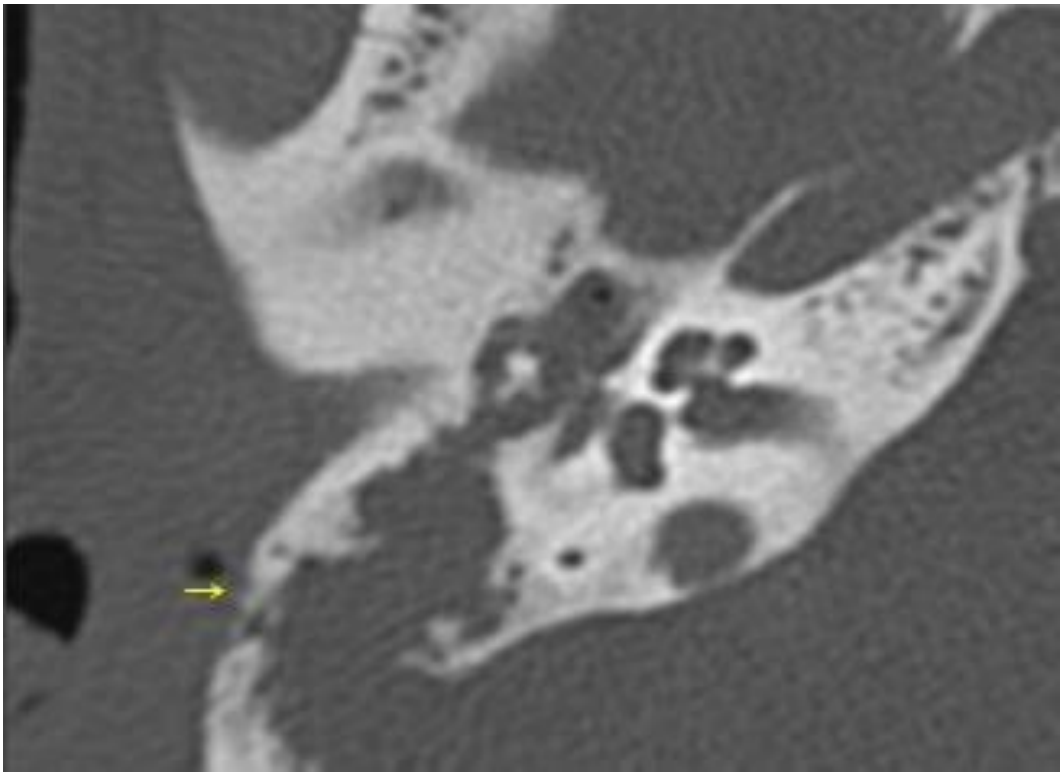

FIGURE17:Axialimageshowingcholesteatomaerodingthemastoidcortex(arrow).

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DISCUSSION:

Chronic otitis media (COM) is a long-term inflammation of the middle ear cleft with no known cause or pathophysiology. Otitis media has the potential for cerebral extension due to its strategic location in the tympanomastoid compartment, which is separated from the middle and posterior cranial fossas by the thinnest of bony sections. As a result, it is critical to understand the location and degree of the condition before undergoing surgery. A radiological evaluation of the temporal bone can assist us reach this goal.It is crucial to distinguish between the two forms of COM. Chronic mucosal illness and chronic otitis media with cholesteatoma are associated with an increased risk of complications, which can lead to life-threatening situations. Early detection of the condition is critical for performing a surgical operation to salvage the patient's hearing and avoid serious intracranial consequences.Cholesteatoma is an acquired buildup of desquamated keratin epithelium in the middle ear or mastoid[3]. "Cholesteatoma" is a well-defined non-neoplastic lesion in the temporal bone that is often described as "skin in the wrong place." Cholesteatoma is a non-neoplastic keratinizing lesion characterized by increased proliferation of epithelial cells with abnormal morphology.[4]

In present study of 40 patients with chronic otitis media, the maximum percentage of patients was in age group of 21 to 30 years (52.5%), followed by 11 to 20 years (40%). Similar results were found in the studies conducted by Nanjaraj et al.[5] in which fifty patients with COM were evaluated and it was found thatmajority (40%) of patients were aged between 21-30 years. The mean age was 26.9 years. According to the study conducted by Tripthi Rai, the youngest patient was 5 years and the eldest was 56 years. 20 patients (40%) between 21 years and 30 years. The mean age was about 26.88 years.[6]

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In the present study, there was a male preponderance (60%) when compared to females (40%) which is in agreement with other case studies such as, in the study conducted by Gaurano LJ[7]on retrospective review of CT scan and surgical and histopathological reports in 64 patients with middle ear cholesteatoma.In this study 35 patients were male and 29 patients were female. A Comparative Study conducted by Pramod Menon et al[8]., between Preoperative HRCT Scan Findings of Temporal Bone &Peroperative Findings in CSOM Unsafe ear on 45 patients. There were 18 (40%) females and 27(60%) were males.

The common clinical features were ear discharge, otalgia and hearing loss which is in agreement with other studies. Ear discharge was seen in 90% of patients, otalgia was seen in 77.5%. Hearing loss was seen in 62.5%. According to the study conducted by Barath K et al[9] chronic discharge of the ear is present in 33%–67%, and some form of hearing loss, in 60%–87% of patients. In present study, facial nerve paralysis occurs in 20% patients, with middle ear cholesteatomas but can be present in 20%–64% of extensive cholesteatoma cases. Giddiness, tinnitus and headache are less common manifestations. The present study shows that these symptoms constitute 17.5% which is in accordance with study conducted by Barath K et al.[9]

In the present study, a moderate radio-surgical correlation was noted for differentiating cholesteatoma and granulation tissue in the middle ear cavity using soft tissue mass and bony erosions as the radiologic criteria. At surgery, cholesteatoma was present in 26 out of 30 patients (86.6%) whereas it was reported in 27 of the 30 CT scans (90%) thereby giving a sensitivity of 86.6%, specificity of 92.3%, positive predictive value of 88.8% and negative predictive value of 33.3% for HRCT in detecting cholesteatoma preoperatively. Similar findings were also noted in the study conducted by Leighton et al.[10] reported that CT scan of temporal bone had an excellent predictive value for diagnosing cholesteatoma and in another

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study by Gaurano and Joharjy[7] reported that correlation of CT with surgical and histopathological findings was 97%.

N W C Chee & T Y Tan[11] also showed that cholesteatoma can be accurately diagnosed by HRCT scan in the vast majority of cases. They considered tissue mass, typical location (epitympanum and mastoid antrum) and bone erosion as the radiographic criteria for diagnosis of cholesteatoma and showed that using at least 2 of the 3 features, cholesteatoma could be diagnosed in 94.4% of cases. High specificity in detecting cholesteatoma may be due to the accuracy of HRCT in detecting soft tissue mass with bone erosion. However, inability of HRCT to differentiate fluid and soft tissue mass based on the attenuation values and also due to the presence of ossicular erosion in some of the cases of chronic mucosal disease has to be considered.

In contrast, Firas Q et al[12] who found a sensitivity of 80% and specificity of 48% for HRCT in differentiating cholesteatoma from chronic mucosal disease. Jackler et al.[13] found cholesteatoma to be present in 30% of cases where soft tissue mass along with bone erosion was present.In present study, extent of cholesteatoma can be accurately detected. Among various parts of middle ear, epitympanum was common to be involved followed by aditus and antrum, facial recess. Epitympanum was involved in 27 (90%) patients in HRCT and 27 (90%) patients at surgery thereby giving a sensitivity of 100%, specificity of 100%, positive predictive value of 100% and negative predictive value of 100% for HRCT in detecting cholesteatoma in epitympanum preoperatively.

In the present study aditus was involved in 26 (86.6%) patients at both HRCT and at surgery. thereby giving a sensitivity of 96%, specificity of 75%, positive predictive value of 96% and negative predictive value of 75% for HRCT in detecting cholesteatoma in aditus preoperatively. Present study shows involvement of mastoid antrum in 24 (80%)patients in

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HRCT and 25 (83.3%) patients at surgery thereby giving a sensitivity of 96%, specificity of 100%, positive predictive value of 100% and negative predictive value of 83% for HRCT in detecting cholesteatoma in antrum preoperatively.

In present study facial recess was involved in 18 (60%) patients in HRCT and 14 (46.6%) patients at surgery thereby giving a sensitivity of 93%, specificity of 69%, positive predictive value of 72% and negative predictive value of 92% for HRCT in detecting cholesteatoma in facial recess preoperatively. Cholesteatoma extending into sinus tympani, hypotympanum, eustachian tube were less common sites. Sinus tympani was involved in 14 (46.6%) patients in HRCT and 10 (33.3%) patients at surgery. Hypotympanum was involved in 2 (6.6%) patients in HRCT and 4 (13.3%) patients at surgery. Eustachian tube was involved in 2 (6.6%) patients in HRCT and 3 (10%) patients at surgery.

According to study conducted Ranga Reddy Sirigiri et al[14]., CT was 100% sensitive for cholesteatoma in protympanum, posterior tympanum, hypotympanum and sensitivity varied from 95 to 86% for other regions. CT was 100% specific for cholesteatoma in epitympanum and mastoid air cells and specificity varied from 86 to 66% for other regions. This is comparable with our study which shows similar results.

Among various parts of temporal bone assessed for bony erosions, malleus was the most common structure to be involved followed by scutum, incus, facial canal, stapes, tegmen and semicircular canals. Mastoid cortex and sigmoid sinus plate were the least commonly involved sites. Gaurano and Joharjy[7] showed scutum and facial canal as the commonest site of erosion in CSOM followed by incus and tegmen. Scutum erosion was seen in 76% cases with cholesteatoma which is less than that seen by Gaurano et al.[7] (86%).But HRCT detected scutum erosion accurately in all cases. So HRCT is 100% sensitive and specific to detect scutum erosion as per this study. Ossicular chain erosion was the most common bony erosion

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in study conducted by Sandeep Berry-et al.[15] with incus being the most commonly involved ossicles. They also showed that sigmoid sinus plate was the least common site to be involved.

In the present study, for the assessment of status of various middle and inner ear structures, radiosurgical correlation was excellent for erosions of malleus and semicircular canals, moderate to good for erosions of incus, scutum, sigmoid plate, tegmen tympani, labyrinthine and tympanic segments of facial canal and poor for stapes and dehiscence of mastoid segment of facial canal.Pre-surgical knowledge of the status of the ossicular chain would allow the surgeon to better advise the patient on the degree of hearing attainable after surgery. For example, the hearing outcomes in patients with an intact stapes tend to be better than those where the stapes suprastructure is absent.[16]

Present study shows high sensitivity for HRCT in detecting erosions of epitympanum (100%), aditus (96%), mastoid antrum (96%), lateral SCC (75%), scutum(100%),malleus (83.3%) whereas sensitivity is low in depicting erosions of incus(80%), stapes (66%). Similar results were also noted in Gerami et al.[17] study with high sensitivity for ossicular erosions and low sensitivity for tegmen, semicircular canal and facial canal erosions.

HRCT showed 100% specificity for erosions of epitympanum, mastoid antrum, hypotympanum, eustachian tube, extension beyond middle ear cleft whereas it is relatively less specific for erosions of facial recess(69%) and sinus tympani (70%). So overall HRCT has got a P value <0.05 for all the parameters mentioned except for tegmen tympani and posterior fossa dural plate erosion. This is similar to studies by Ranga Reddy Sirigiri et al.[14]

Besides giving information on status of the middle ear structures, the HRCT scan can also delineate the extent and location of disease. Mastoid antrum was involved in most of the cases of attico-antral disease included in the study. Tympanic cavity was involved in 95% of cases and aditus in 90% of cases. Knowledge of the disease extent and information on the

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degree of mastoid pneumatization aid in planning the surgical approach, e.g. whether to keep the canal wall up or down. However, one should note that the scan may overestimate the extent of disease as it often cannot distinguish definitively between cholesteatoma and granulation tissue.[18] An enhanced MRI scan may be used to discern the two better if clinically indicated.[19]

CONCLUSION:

HRCT of the temporal bone is promising in the pre-operative assessment of cholesteatoma since it shows the extent of the disease and the integrity of most middle ear structures. The scan notifies the surgeon to any potential surgical risks or disease consequences. However, certain limitations of CT, such as incomplete volume averaging, can lead to incorrect interpretation of the disease process. Partial volume artifacts are best avoided by employing a narrow acquisition section width. Despite limitations, the HRCT scan is a valuable and useful investigative tool prior to cholesteatoma surgery.

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