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HIGH RESOLUTION COMPUTED TOMOGRAPHY IN THE EVALUATION OF TEMPORAL BONE PATHOLOGY

Hari Ram Jat[1], Sheena Daswani[2], Mark Sheldon[3], Neel Patel[4]

[1],2,3,4 Geetanjali Medical College and Hospital, Udaipur

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Corresponding author: Hari Ram Jat
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Abstract

Introduction: The temporal bone is a complex anatomic structure that contains the organs of hearing and balance and has direct contact with brainstem, cerebellum and temporal lobe of brain. Radiographic assessment of temporal bone is difficult owing to complicated anatomical structure of middle and inner ear. High resolution computed tomography (HRCT) - a modification of routine CT produces images with higher contrast and a better spatial resolution. HRCT has the advantage of topographic visualization, devoid of artifacts from superimposition of structures. It provides information not only about bony outline but also soft tissue changes making it possible for the accurate assessment of pathology prior to surgical exploration regarding location, extent and complication of the disease.

Material and methods: This was a cross sectional study of 50 patients who were clinically suspected of having symptoms related to the temporal bone like hearing loss, otorrhea, otalgia, tinnitus, vertigo, ear bleed, cranial nerve palsies, fever, ataxia etc were referred and subjected to HRCT of the temporal bone at Geetanjali Medical College and Hospital (Udaipur) between Nov 2017 and June 2019.

Results: CSOM and Cholesteatoma were the most common diseases found by HRCT and Intra-op/Follow-up scan followed by Fractures, acoustic neuroma, Glomus tympanicum and Atretic EAC. Almost all the lesions were correctly detected by HRCT when confirmed with Intra-op/follow up findings.

Conclusion: HRCT can very accurately detect Temporal bone pathology.

Keywords: HRCT, CSOM, CT

Introduction

The temporal bone is a complex anatomic structure that contains the organs of hearing and balance and has direct contact with brainstem, cerebellum and temporal lobe of brain. Radiographic assessment of temporal bone is difficult owing to complicated anatomical structure of middle and inner ear.

Earlier, in majority of the cases, a diagnosis was made by clinical examination alone. However, with an increase in the prevalence of infective pathologies of the ear, it was suggested that the current approach to preventing and treating these conditions was not adequate. Therefore, especially in complicated and recurrent conditions, imaging plays an important role, as imaging findings may fundamentally influence the treatment.

Imaging of temporal bone was revolutionized in 1980 by development of high-resolution computed tomography. It gives the highest structural definition of any currently available imaging modalities. Before computed tomography (CT), imaging modalities available for the evaluation of temporal bone were plain radiograph, polytomography, angiography, and cisternography. Plain radiograph though inexpensive tool has major limitations due to complex anatomy and overlapping of various bony structures.

High resolution computed tomography (HRCT) - a modification of routine CT produces images with higher contrast and a better spatial resolution[1]. HRCT has the advantage of topographic visualization, devoid of artifacts from superimposition of structures. It provides information not only about bony outline but also soft tissue changes making it possible for the accurate assessment of pathology prior to surgical exploration regarding location, extent and complication of the disease. In fact HRCT has revolutionized the method of imaging the temporal bone with its special algorithms and multiplanar reformats. It gives minute structural details of complex anatomy of temporal bone which consist of tiny structures like ear ossicles, cochlea and semi-circular canals - organs of hearing and balance. It depicts the detailed anatomy and course of the carotid canal, jugular fossa and other bony canals & major vessels and nerves traversing through them. Middle cranial fossa and posterior cranial fossa with its important brain structures are located anterior and posterior to temporal fossa respectively. These fine details help us to localise the disease, its extent, bony erosion or destruction and intracranial complications precisely. This study was done to evaluate the extent of chronic middle ear infections and their complications, temporal bone trauma, neoplasms involving temporal bone

and the congenital anomalies of the ear according to compartment involvement.

In a non-traumatic setting of middle ear opacification, imaging mostly reflects chronic inflammatory/ infectious disease. Underlying cholesteatoma is diagnosed in some of the cases. Status of the ossicular erosion and its suspensory apparatus, status of the tympanic and mastoid wall is best delineated by HRCT of temporal bone. When ossicular erosion is visualized the probability of cholesteatoma is 90%[2]. MRI is used as a problem-solving tool in these cases.

Most of the middle ear pathologies appear as soft tissue attenuation on HRCT.[3,4] The final diagnosis is usually a combination of radiological and clinical findings.[1,5]

HRCT excels in the evaluation of the middle ear disease process and adjacent bone. In certain cases, routine and contrast-enhanced Magnetic Resonance Imaging (MRI) scores over HRCT in the evaluation of middle ear soft tissue; however, in most instances, it acts as a next step for confirmation and further characterization.

Materials and Methods

Methodology

This study evaluating the role of HRCT in the diagnosis of temporal bone pathologies was done on 50 cases. This study was conducted during the period between Nov, 2017 to June,2019 in the Department of Radiodiagnosis, Geetanjali medical college and hospital, Udaipur. The study was conducted with aim to study the radiological features of HRCT in pathologies of temporal bone like:-

- Extent of middle ear infections and their complications,
- Neoplasms involving the temporal bone,
- Congenital anomalies of the ear,
- Temporal bone trauma
- Normal structural variations in the temporal bone.

Selection of patients:

Patients who were clinically suspected of having symptoms related to the temporal bone like hearing loss, otorrhea, otalgia, tinnitus, vertigo, ear bleed, cranial nerve palsies, fever, ataxia etc were referred and subjected to HRCT of the temporal bone and correlation is done with surgical findings wherever performed.

CT Machine:

All the HRCT scans were performed at our institute on the SIEMENS SOMATOM 64 SLICE CT system.

Preparation of patients:

Prior to performing the scan particularly in infants and children less than six years, sedation was usually required. The purpose of sedation was to avoid motion artifact and to ensure a CT scan of diagnostic quality.

From six years onwards the need for sedation generally decreased. Sedatives used in our institution were Ketamine(1-1.5mg/kg) or Midazolam(1-2mg/kg).Patients were kept nil orally 4 hours prior to the procedure to avoid complications of contrast. In infants the last feed before the procedure was omitted.

HRCT Technique:

CT excels in the evaluation of disorders that primarily affect air spaces or cortical bone. If the goal of a temporal bone CT study is to focus on the otic capsule, cortical plates, ossicles and the air spaces alone, then high resolution bone algorithm techniques may be adequate. However, if it is also important to evaluate the soft tissues, as in the case of a patient with cancer of external auditory canal, then it may be necessary to use intravenous contrast and techniques similar to those used for a brain or soft tissue neck study.

For contrast enhancement, a bolus injection of contrast was administered (100ml of Iohexol 1.5mg/kg body weight with a power injector at a rate of 1ml/s)

This was given just before the contrast enhancement CT was to be performed.

Statistical analysis: All the data were analysed by standard statistical methods.

Observations and Results

Table 1: Age Distribution

Sl. No	Age distribution	No. of cases	Percentages (%)
1	0-10	3	6%
2	11-20	9	18%
3	21-30	13	26%
4	31-40	13	26%
5	41-50	6	12%
6	51 & above	6	12%
7	Total(n)	50	100%

Maximum prevalence of temporal bone pathologies was found in 21-30 yrs and 31-40 yrs age group (26%) each. Out of 50 patients 30 were male and 20 were female.

Table 2: Clinical Presentations

Sl.no	Signs & Symptoms	No. of cases
1	Hearing loss	37(74%)
2	Otalgia	28(56%)
3	Otorrhoea	30(60%)
4	Cranial nerve palsies	3(6%)
5	Ataxia	3(6%)
6	Headache	20(40%)
7	Tinnitus	4(8%)
8	Ear bleed	5(10%)
9	Nausea with Vertigo	7(14%)
10	Trauma	8(16%)
11	Fever	11(22%)

Maximum patients presented with Hearing loss, Otalgia, Otorrhoea and Headache.

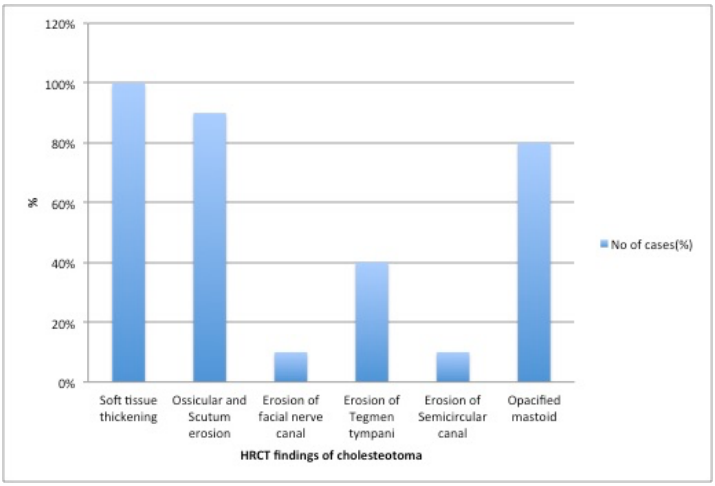
Table 3 Etiopathological distribution of cases

Sl. no	Etiology	No. of cases (%)
1	Inflammatory	31(62%)
2	Traumatic	8(16%)
3	Congenital	4(8%)
4	Neoplastic	6(12%)
5	Normal	1(2%)
	Total	50(100%)

Among 50 patients, maximum patients presented with inflammatory disease (64%), followed by Traumatic (16%), Neoplastic (12%) and Congenital diseases (8%).

Table 4: HRCT findings of Cholesteatoma

Sl. no	HRCT findings	No of cases (%)
1	Soft tissue thickening	10(100%)
2	Ossicular and Scutum erosion	9(90%)
3	Erosion of facial nerve canal	1(10%)
4	Erosion of Tegmen tympani	4(40%)
5	Erosion of Semicircular canal	1(10%)
6	Opacified mastoid	8(80%)
	Total cases of Cholesteatoma	10(100%)



Graph 1: Most common HRCT findings of Cholesteatoma included Soft tissue thickening, Ossicular and Scutum erosion, Opacified mastoid. Other findings were erosion of Tegmen tympani, Erosion of facial nerve canal and Erosion of Semicircular canal

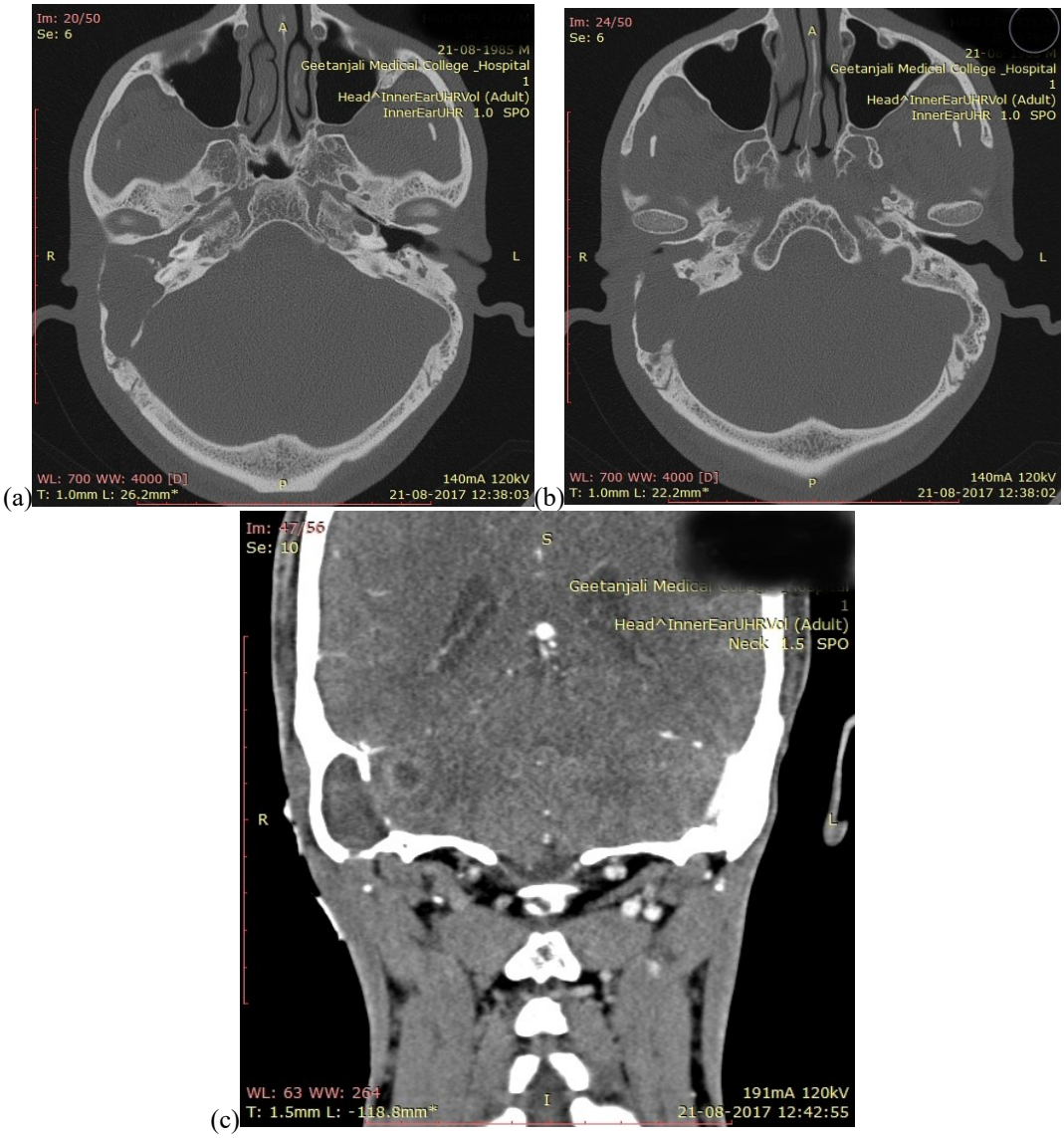


Figure 1: Cholesteatoma with Cerebellar abscess

Fig.(a),(b)axial noncontrast CT shows soft tissue density in right external and middle ear and extending into mastoid via aditus causing erosion of the ossicles, mastoid wall and tegmen tympani. (c) On coronal postcontrast CT shows well defined peripherally enhancing hypodense lesion in right cerebellum suggestive of abscess.

Table 5: Various complications of Cholesteotoma

Complications	No of cases (%)
Brain abscess	3(42.8%)
Post auricular abscess	1(14.2%)
Dural sinus thrombosis	2(28.4%)
Meningitis	1(14.2%)

7 cases out of 10 Cholesteatoma patients were associated with complication like brain abscess being the most common (3 cases) , post auricular abscess, Dural sinus thrombosis and Meningitis.

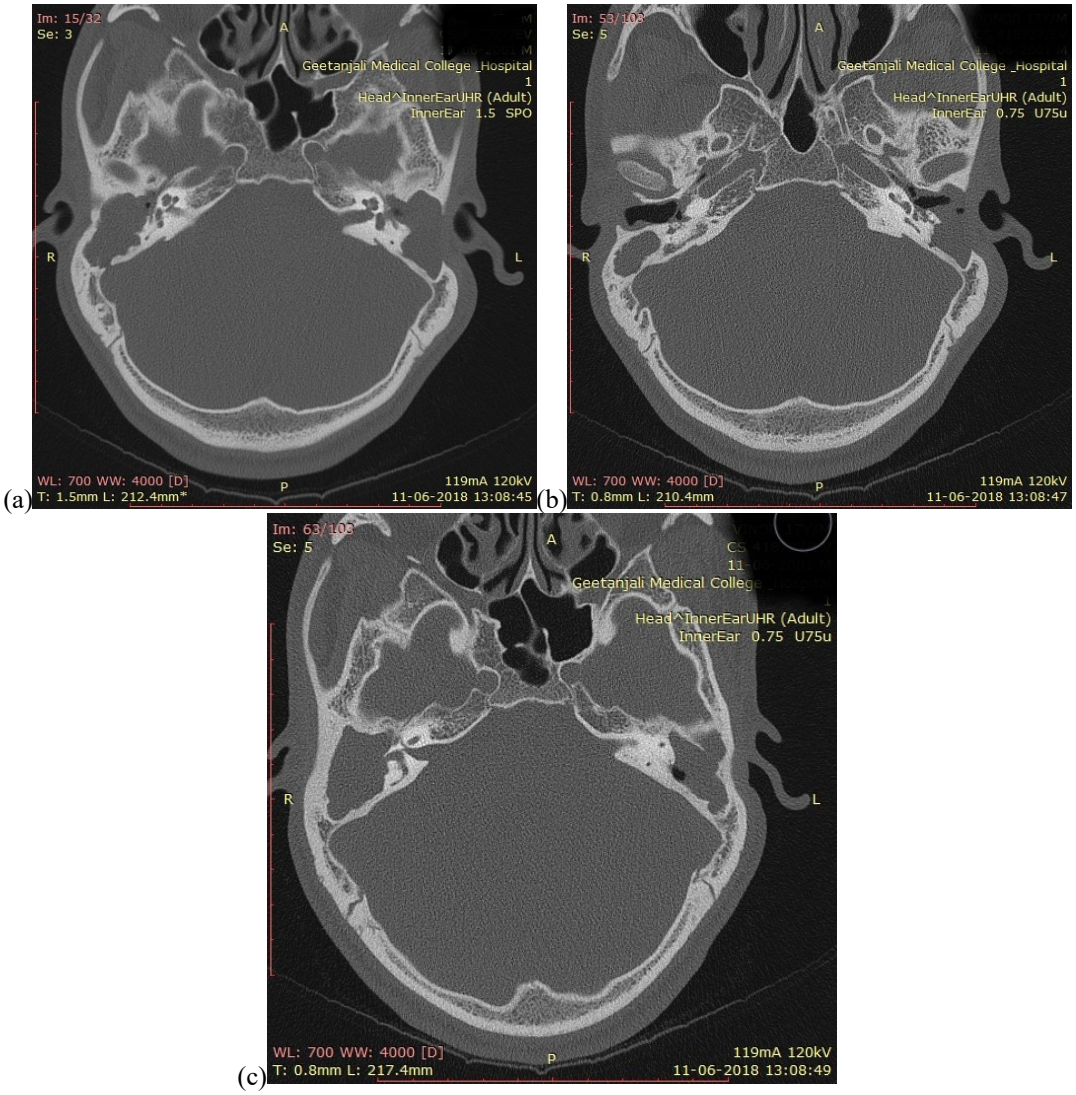
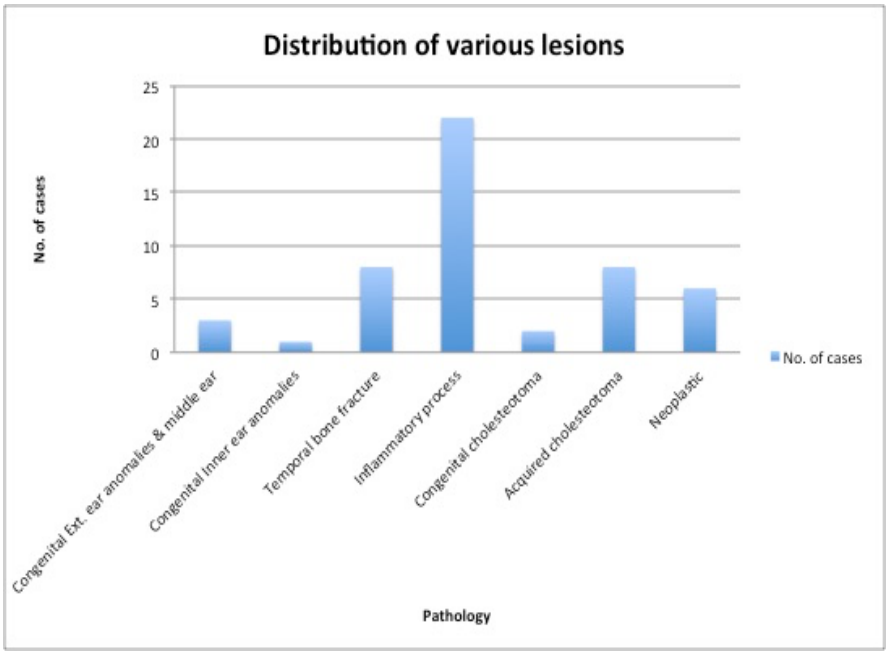


Figure 2: Cholesteatoma

Fig.(a,b,c) axial HRCT, shows soft tissue density in bilateral external and middle ear cavity with destruction of ossicular chain and destruction of outer bony wall mastoid.

Table 6: Distribution of various lesions (49 out of 50)

Sl.no	Pathology		No. of cases
1	Congenital Malformations	External ear & middle ear anomalies	3
2		Inner ear anomalies	1
3	Temporal bone fracture		8
4	Inflammatory process		21
5	Cholesteatoma	Congenital	2
6		Acquired	8
7	Neoplastic		6



Among all the various lesions maximum prevalence of inflammatory process was seen, followed by acquired cholesteatoma, temporal bone fractures, neoplasms, congenital malformations of external and middle ear.

Table 7: Distribution of CT findings in temporal bone fractures

Sl no.	CT findings	No. of cases
1	Longitudinal fracture	5(62%)
2	Transverse fracture	3(37.5%)
3	Complex fracture	2(25%)
4	Hemotympanum	7(87.5%)
5	Ossicular disruption	4(50%)
6	Facial nerve canal injury	1(12.5%)

Among 8 positive cases of temporal bone fractures, most common CT finding was hemotympanum (87%) followed by Longitudinal fracture (62%), Ossicular disruption (50%) & Transverse fracture (37.5%). Facial nerve canal injury was also seen in 1 case.

Table 8: Distribution of neoplastic lesions

Sl.no	Neoplasm	No of cases	%
1	Acoustic Neuroma	2	33.33%
2	Glomus tumor	2	33.33%
3	Epidermoid	0	0%
4	1º Carcinoma (Ewing's Sarcoma)	1	16.66%
5	1º Carcinoma (Chondrosarcoma)	1	16.66%
	Total	6	100%

Among 6 positive cases of neoplasm, Acoustic Neuroma and Glomus tumor were seen in 2 cases each. 2 primary carcinomas were also noted 1 was Ewing's sarcoma and other was Chondrosarcoma.

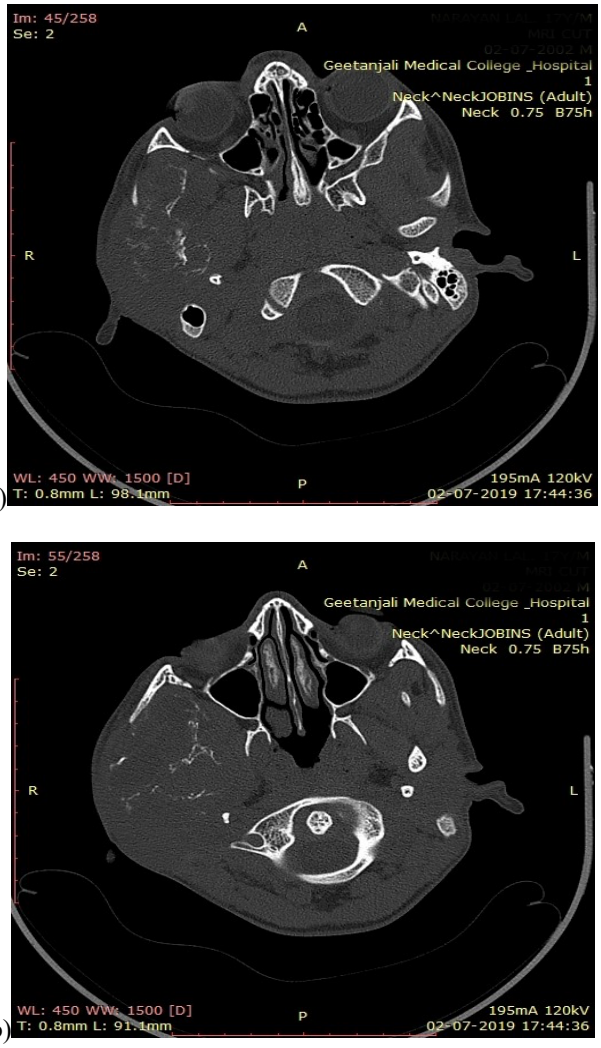


Figure 3: Ewing's Sarcoma

Fig.(a,b)axial noncontrast HRCT , shows extensive bone destruction of petrous and zygomatic part of temporal bone and maxilla with aggressive periosteal reaction in a 4year old .

Table 9: Relationship between HRCT and Intra-operative/follow-up findings of inflammatory disease.

Sl. no.	HRCT findings	No. of cases in HRCT	Intra-operative/ Follow up	False positive	False negative
1	Scutum erosion	15	14	1	0
2	Ossicular erosion	21	19	2	1
3	Erosion of Tegmen tympani	9	7	2	0
4	Erosion of facial nerve canal	6	4	2	2
5	Erosion of SCC canal	3	2	1	0
6	Intracranial extension	4	4	0	0
7	Mastoid involvement	29	29	0	0
8	Mesotympanum involvement	32	32	0	0
9	Epitympanum involvement	21	21	0	0
10	Hypotympanum involvement0	17	17	0	0
11	External ear involvement	5	5	0	1
12	Inner ear involvement	3	3	0	0

Sl. no.	HRCT findings	Sensitivity	Specificity	+ve predictive value	-ve predictive value	P value
1	Scutum erosion	100.00%	97.22%	93.33%	100.00%	<0.001
2	Ossicular erosion	95.00%	93.33%	90.48%	96.55%	<0.001
3	Erosion of Tegmen tympani	100.00%	95.35%	77.78%	100.00%	<0.001
4	Erosion of facial nerve canal	66.67%	95.45%	66.67%	95.45%	<0.001
5	Erosion of SCC canal	100.00%	97.92%	66.67%	100.00%	<0.001
6	Intracranial extension	100.00%	100.00%	100.00%	100.00%	<0.001
7	Mastoid involvement	100.00%	100.00%	100.00%	100.00%	<0.001
8	Mesotympanum involvement	100.00%	100.00%	100.00%	100.00%	<0.001
9	Epitympanum involvement	100.00%	100.00%	100.00%	100.00%	<0.001
10	Hypotympanum involvement	100.00%	100.00%	100.00%	100.00%	<0.001
11	External ear involvement	100.00%	100.00%	100.00%	100.00%	<0.001
12	Inner ear involvement	75.00%	100.00%	100.00%	97.87%	<0.001

Table 10: Study Results

Sl.no	Type of lesion	HRCT diagnosis	Intra-op/ Follow up
1	CSOM	21	18
2	Cholesteatoma	10	10
3	Fracture	8	8
4	Acoustic Neuroma	2	2
5	Glomus Tympanicum	2	2
6	Ewing's Sarcoma	1	1
7	Chondrosarcoma	1	1
8	Atretic EAC	2	2
9	Common cavity malformation	1	1
10	Hypoplastic petrous ICA canal	1	1
11	Normal findings	1	1

CSOM and Cholesteatoma were the most common diseases found by HRCT and Intra-op/Follow-up scan followed by Fractures, acoustic neuroma, Glomus tympanicum and Atretic EAC.

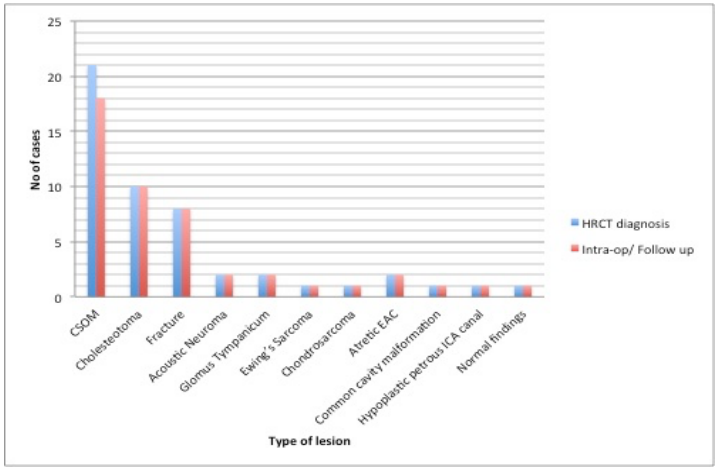


Table 11: Results for the diagnostic accuracy of HRCT temporal bone and confirmed by intra-op/follow-up.

	Intra-op/follow up		
HRCT	Positive	Negative	Total
Positive	46	0	46
Negative	3	1	4
Total	49	1	50

Almost all the lesions were correctly detected by HRCT when confirmed with Intra-op/follow up findings. Only 3 cases were wrongly diagnosed as positive cases by HRCT and with diagnostic accuracy of 94%, p value of <0.001, Sensitivity of 93.88% & Specificity of 100%, positive predictive value 100%, negative predictive value 25%, accuracy 94%.

Discussion:

Maximum prevalence of temporal bone pathologies was found in 21-30 yrs and 31-40 yrs age group (26%) each in our study. Temporal bone disease prevalence predominated in males (60%). Maximum prevalence of temporal bone pathologies was found in right ear (46%), followed by left ear (40%). Maximum patients presented with Hearing loss, Otalgia, Otorrhoea and Headache.

Among 50 patients, maximum patients presented with inflammatory disease (64%), followed by Traumatic (16%), Neoplastic (12%) and Congenital diseases (8%). Most common HRCT findings of Cholesteatoma included Soft tissue thickening, Ossicular and Scutum erosion, Opacified mastoid. Other findings were erosion of Tegmen tympani, Erosion of facial nerve canal and Erosion of Semicircular canal. 7 cases out of 10 Cholesteatoma patients were associated with complication like brain abscess being the most common (3 cases), post auricular abscess, Dural sinus thrombosis and Meningitis. Among all the various lesions maximum prevalence of inflammatory process was seen, followed by acquired cholesteatoma, temporal bone fractures, neoplasms, congenital malformations of external and middle ear. Among 8 positive cases of temporal bone fractures, most common CT finding was hemotympanum (87%) followed by Longitudinal fracture (62%), Ossicular disruption (50%) & Transverse fracture (37.5%). Facial nerve canal injury was also seen in 1 case.

Among 6 positive cases of neoplasm, Acoustic Neuroma and Glomus tumor were seen in 2 cases each. 2 primary carcinomas were also noted 1 was Ewing's sarcoma and other was Chondrosarcoma. Most common HRCT and Intra-op/Follow-up scan findings of inflammatory diseases in decreasing order were mesotympanum involvement, Mastoid involvement, Epitympanum involvement, Ossicular erosion, Hypotympanum involvement, Scutum erosion and Erosion of Tegmen tympani. CSOM and Cholesteatoma was the most common diseases found by HRCT and Intra-op/Follow-up scan followed by Fractures, acoustic neuroma, Glomus tympanicum and Atretic EAC.

Almost all the lesions were correctly detected by HRCT when confirmed with Intra-op/follow up findings. Only 3 cases were wrongly diagnosed as positive cases by HRCT and with diagnostic accuracy of 94%, Sensitivity of 93.88% & Specificity of 100%.

Fava C et al. [6] (1996) correlated HRCT findings with surgical findings of temporal bone in assessing the round window shape and patency, degree of temporal bone pneumatization and the surrounding vascular structures. They said that HRCT findings highly correlated with surgical findings. However HRCT failed in assessing the patency of the cochlear canal due to fibrosis.

Robert H. R. Betteman et al.[8] (2002) reported in their study that the preoperative CT measurements such as facial recess width and the angle between facial recess and basal turn of the cochlea were not useful in predicting the problems encountered during surgery and also said that the advances in CT such as Multislice CT, could improve diagnostic accuracy.

Chaturvedi A. et al. [11] (2006) evaluated the role of imaging modalities in pre and post operative evaluation in cochlear implant candidates. They evaluated HRCT scans of 30 patients and MRI scans of 15 patients. They said that HRCT was useful for pre-implant analysis of the temporal bone morphology due to its reliability and easy availability.

Luiz Rodlpho pena Lima Junior et al. [9] (2008) investigated the accuracy of imaging studies as predictors of possible complications of surgery on 104 patients who have undergone cochlear implantation surgery. Their study showed that preoperative radiological examination was effective in identifying anatomic abnormalities allowing surgeons to avoid, or at least be ware of possible complications. Their study also demonstrated that CT and MRI were superior to CT alone.

Antonio de Castro Rodrigues et al. [10] (2012) measured the distances between the stapedius muscle tendon, incus long crus and the cochleostomy on twenty seven fresh cadaveric temporal bones. They stated that the measurements of distances between different anatomical structures are vital for safe surgical planning during cochlear implantation.

Zou T et al. (2012) measured the distance between the various anatomical landmarks useful for cochlear implantation on twenty human temporal bones under surgical microscope. These values can be used a reference values for inserting electrode into the cochlea and opening the facial recess without causing damage to the facial nerve.

Dong-Hee Lee et al. [12] (2012) radiologically evaluated the anatomic factors that determine the view field or the accessibility of the posterior tympanotomy. They retrospectively reviewed 100 HRCT tomograms of the temporal bones. Thirty cases each of both pneumatic mastoids and unilateral sclerotic mastoids. The distance between Chorda tympani and Facial nerve, and angle between cortex of EAC and FN are the major factors that determine the view field or accessibility of the posterior tympanotomy. Their study also showed that pneumatic mastoids have a more complex relationship and lesser visibility of posterior tympanotomy than sclerotic mastoids.

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