Original research article

Role of HRCT In Evaluation of Temporal Bone Pathologies

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Abstract

Introduction: The imaging modalities available for temporal bone analysis include plain radiographs, multidirectional tomography, angiography, CT and MRI. HRCT is excellent for air spaces and cortical bones, whereas MRI is superior for soft tissue anatomy and vascular abnormalities.

Material and Methods: A prospective study of 100 cases was done. The study included all patients who had HRCT temporal bone and had clinical signs and symptoms of external, middle, and inner ear diseases, congenital abnormalities, or trauma.

Results: Infectious aetiology accounted for 60 of the total 100 cases, making it the most prevalent aetiology affecting the temporal bones. Out of 60 infective cases 25 cases were of cholesteatoma, 30 were of otomastoiditis /CSOM, and 5 were of otitis externa. A total of 20 traumatic aetiology patients with temporal bone fractures were observed. Out of these 20 patients 5 had longitudinal fracture ,9 had transverse fracture and 6 had mixed fractures. Four individuals in the current research exhibited symptomatic congenital abnormalities, including two cases of microtia with EAC atresia, one with an anomalous facial nerve, and one with fused ossicles.

Conclusion: HRCT is beneficial for diagnosing, planning surgery, managing temporal bone diseases as well as post surgical follow-up. HRCT is superior to radiographs in depicting detailed anatomy as well as diseases of temporal bone. It is better than MRI in providing bony details.

Keywords: HRCT, Cholesteatoma, CSOM, Otitis externa, Temporal.

Introduction

The invention of High resolution computed tomography (HRCT) in 1980 fundamentally changed temporal bone imaging. Of the currently available imaging modalities, it provides the best structural definition of minute structures. Previously, temporal bone pathologies were diagnosed largely based on clinical signs and symptoms. However, owing to a rise in the prevalence of ear infections, it was found that the existing setup towards preventing and treating the situation was inadequate. As a result, imaging plays a critical role, particularly in challenging and recurrent cases, because imaging findings may have a significant impact on treatment **[1]**.

HRCT is a variant of standard CT. It provides a clear and detailed insight into the temporal bone, allowing for the visualisation of minute anatomical detail about the temporal bone's anatomy and physiology. It has the capability of giving outstanding topographic observations independent of structure superimposition. It enables a complete evaluation of pathology prior to surgery, including the disease's location, severity, and complications. **[2]**.

The imaging modalities available for temporal bone analysis include plain radiographs, multidirectional tomography, angiography, CT and MRI. Plain X-ray is a less expensive way of evaluating the temporal bone, but it also leads to an incomplete or incorrect diagnosis **[3]**. Multidirectional tomography is excellent for bony specifics but not so good for delineating soft tissues. Furthermore, the risk of radiation damage to the eye lens increases. The gold standard for investigating vascular lesions is angiography, though it's invasive and has a higher risk of consequences **[3]**. HRCT is excellent for air spaces and cortical bones, whereas MRI is superior for soft tissue anatomy and vascular abnormalities. In certain cases, HRCT and MRI can be complementary to one another **[4]**.

The goal of this study was to determine the accuracy of HRCT findings by comparing HRCT image-based findings to clinical, surgical and pathological findings.

Material and Methods

A prospective study of 100 cases was done in the department of Radio diagnosis, Varun Arjun Medical College. The ethical committee clearance and patients' consent were taken for research purpose. A relevant clinical history and proper clinical examination of the patients were done prior to HRCT of temporal bone and whenever necessary CECT of brain was done.

Inclusion criteria

The study included all patients who had HRCT temporal bone and had clinical signs and symptoms of external, middle, and inner ear diseases, congenital abnormalities, or trauma.

Exclusion criteria

Patients under the age of one or above the age of 80, as well as those with cochlear implants, were excluded.

Image acquisition and patient preparation

Evaluation was done with Multi detector High Resolution Computed Tomography (G E health care ,optima CT 660 , 64 slices). 140 kV voltage and 300 mAs current were used. Thin sections (usually 0.625 mm) are acquired in axial plane and post processed into 0.312 mm slice thickness with sharp algorithm. Multiplanar images in coronal and saggital planes are reconstructed from the above post processed images.

In order to study the Hypervascular lesions like glomus tumours, Cerebellopontine angle masses and Intracranial or extra cranial extension of middle ear disease, intravenous contrast was administered. For contrast enhancement, a bolus injection of Iopamidol was given in the dose of 300mg lodine/ml(1.5-2ml/kg of body weight). Sedation was usually needed prior to the scan, particularly in infants and children under the age of six. Sedation was used to prevent motion artefact and ensure a diagnostic-quality CT scan. Tricloryl syrup, which was administered orally, was used as a sedative in our institution. Infants: 1/4 to 1/2 teaspoons, young children: 1 teaspoon, and older children: 2 teaspoons (Each 5ml – 1 teaspoon contains Triclofor sodium BP 500mg) provided 30 minutes before the analysis.

Patients were followed up and their operative and/ or histopathological findings were correlated wherever possible. All the data obtained during the research was documentated in a tabulated form and analysed.

Results

The study comprised 100 patients, both males and females, who had HRCT temporal bone imaging, and pertinent data were derived from these cases. Male preponderance was found in our study, with a male to female ratio of 2:1. The majority of the patients were in their third decade, followed by the second decade. Main clinical signs and symptoms were Hearing loss (30%), Ear discharge (75%), Ear pain (40 %), Head ache (50%) and Facial nerve weakness (8%) **(Table- 1)**.

Table 1: Showing distribution of clinical Features

Clinical features	No. of Patients	Percentage
Loss of hearing	30	30%
Discharge from ear	75	75%
Weakness of facial nerve	08	8%
Head ache	50	50%
Ear pain	40	40%
Tinnitus	15	15%
Cerebellar signs	10	10%
Diplopia	7	7%

The distribution of cases based on the aetiology has been shown in **Table-2**. Infectious aetiology accounted for 60 of the total 100 cases, making it the most prevalent aetiology affecting the temporal bones. Left side was predominantly affected in our study in infectious process. Out of 60 infective cases 25 cases were of cholesteatoma, 30 were of otomastoiditis /CSOM, and 5 were of otitis externa **(Table-2)**.

A total of 20 traumatic aetiology patients with temporal bone fractures were observed. Out of these 20 patients 5 had longitudinal fracture ,9 had transverse fracture and 6 had mixed fractures. Total 8 patients who were diagnosed having neoplastic etiology are shown in table 4. Four individuals in the current research exhibited symptomatic congenital abnormalities, including two cases of microtia with EAC atresia, one with an anomalous facial nerve, and one with fused ossicles **(Table-2)**.

Table 2: Distribution of cases according to etiology.

Etiology		No. of cases (100)	
Infective	Oto-mastoiditis/csom	30	60
	Cholesteatoma	25	
	Otitis externa	5	
Traumatic	Longitudinal	5	20
	Transverse	9	
	Mixed	6	
Neoplastic	Acoustic neuroma	4	8
	Metastasis	2	
	Glomus tympanicum	1	
	Meningioma	1	
Congenital	Ossicular abnormality	1	4
	Microtia with eac atresia	2	
	Anomalous facial nerve	1	
Anatomical variations	High riding jugular bulb	6	6
Normal (excluding anatomical variations)		2	2
Total		100	

Structures involved in cholesteatoma and trauma has been shown in **Table-3**. Out of 25 cases of cholesteatoma 13 patients were found with ossicular erosion, 8 with facial nerve involvement, 7 with tegmen tympani erosion and 5 with lateral SCC erosion. Similarly, structures involved in traumatic cases were also included in table 2. HRCT revealed 16 cases of hemotympanum, 3 cases of hemosinus, 7 cases of facial nerve involvement, 2 cases of intracranial involvement, 1 case of ossicular involvement, and 3 cases of tegmen tympani fracture associated with temporal bone damage. Involvement of facial nerve was predominantly seen in transverse fracture of temporal bone.

Table 3: Showing structures involved in cholesteatoma and trauma

Structures involved	Cholesteatoma (N=25)	Trauma (N=20)
Ossicles erosion	13	1
Facial nerve involvement	8	7
Semicircular canal involvement	5	-
Tegmen tympani involvement	7	3
Hemotympanum	-	16
Hemosinus	-	3

In our study 50 patients underwent surgery. Remaining 50 patients who didn’t required surgery were followed up and their improvement status was checked and we found that most of the patients of infective aetiologies were easily and successfully treated on the basis of HRCT findings. Management of traumatic cases were also followed up and we found excellent correlation with HRCT findings.

In patients who underwent surgical or histopathological diagnosis, the effectiveness of HRCT in evaluating temporal bone pathologies was determined by calculating sensitivity, specificity, PPV and NPV of cholesteatoma, mastoiditis/CSOM, otitis externa and various structures (facial nerve, LSSC, tegmen tympani, Scutum,ossicles, EAC etc.) involved during the disease process **(Table-4)**. With good sensitivity, specificity, PPV, and NPV of 87 percent, 98 percent,87 percent and 98 percent, respectively, out of total 8 cases of neoplasm, 7 cases were matched with surgical and/or histological results. With a sensitivity and specificity of 100 percent, HRCT properly identified four cases of EAC erosion, which were verified intraoperatively as well. With a sensitivity of 92 percent, a specificity of 100 percent, a PPV of 100 percent, and an NPV of 87 percent, HRCT properly predicted 92 percent of cholesteatoma cases. Accurate prediction of tegmen tympani degradation was established, with a sensitivity of 100 percent. Surgery and HRCT for Facial canal and lateral SCC erosion were shown to have a strong relationship. Only 57 percent of the time HRCT predicted facial canal deterioration. With a sensitivity of 100 percent and a specificity of 100 percent, HRCT predicted 100 percent of lateral SCC fistulas. Surgery and HRCT for scutum erosion were found to have a significant relationship. HRCT detected ossicular erosion with sensitivity and specificity of 80% and 97 percent, respectively.

Table 4: Statistical analysis of HRCT diagnosis in relation to surgical/histopathological findings (n=50).

Etiology	Surgical/ HP correlation	Correctly Diagnosed by HRCT	Sensitivity	Specificity	PPV	NPV
Cholesteatoma	18	17	93 %	89 %	76 %	97 %
Mastoiditis/CSOM	16	15	94%	97%	94%	97%
Otitis externa	5	4	80 %	100 %	100 %	98 %
Otosclerosis	1	1	100%	100%	100%	100%
Tumours	8	7	87 %	98 %	87 %	98 %
Ossicular erosion	10	8	80%	97%	89%	95%
Scutum erosion	6	6	100 %	98 %	85 %	100 %
Tegmentympani erosion	3	3	100%	95%	75%	100%
Facial canal dehiscence	7	4	57 %	97 %	80 %	93 %
LSCC fistula	2	2	100%	100%	100%	100%
Meato-antral fistula	2	1	50 %	100 %	100 %	98 %
EAC erosion	4	4	100%	100%	100%	100%

Acoustic tumours are most common in people aged 20 to 59. Deafness, tinnitus, ear discharge, or 7th nerve palsy were the most common symptoms in these patients. A contrast enhanced CT scan was performed after the plain CT scan. Soft tissue enhancement was demonstrated using soft tissue windows.

Discussion

Radiographic examination of the temporal bone is challenging due to the complicated anatomical arrangement of the middle and inner ear. Because there are few imaging techniques for assessing the temporal bone, this study seeks to provide the role of HRCT in temporal bone imaging. Different parameters like amount of radiation to the lens, visualisation of small bony structures, technological considerations, patient orientation, image perception, and cost were all taken into account.

Radiographs play minimal role in the diagnosis of cholesteatoma. It is particularly difficult to detect minute changes including ossicular erosions, tegmen tympani erosion, facial canal involvement, and LSSC fistulas **[5].** HRCT accurately delineates minute changes and small structures of the temporal bone due to its high resolution, and has emerged as a significant improvement in identifying pathology prior to surgical exploration in patients with cholesteatoma **[6]**. Even if cholesteatoma in hidden areas is not visible clinically, radiological evaluation can reveal it. For assessing the extent of cholesteatoma prior to surgery, HRCT has been the imaging method of choice **[7].**

YuZ et al. discovered the early identification of bone and scutum erosions in cholesteatoma **[8].** HRCT helped us to correctly diagnose cholesteatoma in 94 percent of cases in our sample, with sensitivity and specificity of 94% and 96%, respectively. Out of total cases of cholesteatoma diagnosed on surgery/histopathology, HRCT mis-diagnosed one case as granulation tissue, probably due to the absence of erosion of surrounding bony structures. One case of mastoiditis was over-diagnosed as cholesteatoma. Chintan Shah et al. and Mafee et al. described aditus ad antrum enlargement with loss of its figure of 8 appearances, as well as mastoid antrum growth in cholesteatoma**[9].** According to Swartz et al., ossicular erosion was seen in only half of 54 cholesteatoma patients, both on imaging and intraoperatively **[10]**. This was also seen in this study, where we discovered 47 percent of cholesteatoma patients had ossicular erosions. In accordance with Amit Shankhwar et al. **[11]** and Rohit Vallabhaneni et al. **[12]**, Incus was the most degraded ossicle in our research. The least eroded was Stapes. According to Mehrdad Rocha et al. **[13]**, radio-surgical association in stapes erosion was weak, which was likely due to the bone's small size.

In the current study, 18 of the 25 patients of cholesteatoma were from low socioeconomic categories. This is backed by studies and is a well-known fact. Poor diet and cleanliness, along with illiteracy, may have a significant impact, since the majority of patients were found to be illiterate and unaware of ear illness. The majority of patients did not seek medical counsel until it was too late.

Otorrhhoea and otalgia were the most prevalent symptoms. The discharge was scanty, smelled terrible, and was purulent. The majority of the patients had persistent ear drainage. Cholesteatoma consequences included increased ear discharge, chronic ear pain, fever, post-auricular puffiness, and facial weakness. Vomiting, headache, sleepiness, and a changed sensorium suggested a more serious possibility of hidden cerebral problems. Bilateral cholesteatoma is an uncommon occurrence.

Tumors make up 8% of our study, which differs from the findings of GAS Lloyd et al (1980), who reported that neoplasms were the most frequent lesions **[14].** Males were more commonly affected by tumours than females in our sample, with a ratio of 2:1, which was consistent with the findings of GAS Lloyd et al, who found that temporal bone neoplasms were more frequent in males **[14].**

Acoustic neuromas were found in four of the eight tumours that were examined. In our research, we found right CP angle preponderance. All were hypodense to isodense in comparison to the surrounding brain, and post contrast intense enhancement and IAC enlargement. Other neoplasms include two cases of metastasis, one case of glomus tympanicum, and one case of Schwannoma. Except for one case of schwannoma that was misdiagnosed as meningioma on HRCT, all of these cases were proven on histopatholgical specimen obtained surgically . HRCT was shown to be very accurate in establishing the existence, extent, and spread of tumours, with a sensitivity, specificity, PPV, and NPV of 87 percent, 98 percent, 87 percent and 98 percent, respectively. Bird et al. **[15]**, who reported 10 cases of primary malignant tumours of the temporal bone, had also similar findings

HRCT findings were shown to be related to the patients' clinical signs and symptoms (hearing loss, facial nerve dysfunction, etc.) in two patients who had a clinical diagnostic of facial nerve palsy; HRCT findings of hematoma in relation to the facial nerve were confirmed on surgery. This is similar to the findings by Johnson et al **[16]**.

There were four examples of congenital malformations in this study. There are two cases of microtia with EAC atresia. In one patient, osseous fusion was discovered. One patient showed anterior facial nerve displacement. Meyer et al. had also similar observation**[17]**.

In six patients, a high-riding jugular bulb was discovered by chance. This is consistent with the findings of Overton et al., who reported a 6% incidence of high riding jugular bulb. By recognising a high-riding jugular bulb before surgery, surgeons may be able to plan the procedure to avoid life-threatening complications. Scutum erosion was accurately predicted with a sensitivity and accuracy of 100% and 98 percent, respectively, which was consistent with Gaurano et al. **[18]** and Rocher et al. **[19]** findings.

According to Mardassi Ali, lateral SCC is the most often eroded SCC in cholesteatoma due to its anatomical closeness to the medial wall of the attic **[20]**. In our study, HRCT correctly predicted lateral SCC fistula with a sensitivity of 100 percent. This is similar to Chuni Lal Thukral et al., who reported sensitivity and specificity of 100 and 97.73 percent, respectively. HRCT was found to be 100 percent sensitive for lateral SCC by Alzoubi et al. **[21]**, Chee and Tan et al. **[22]**, and Mafee et al. **[23]**.

In this study, HRCT properly predicted tegmen tympani erosion in 100% of patients. This is similar in observation by Sonika Kanotra et al. who found a sensitivity of 100% for identifying tegmen tympani erosion **[24]**.

Otosclerosis is another significant reason of conductive deafness. In our research, a single patient with clinically indicated otosclerosis was detected by HRCT and confirmed by surgery, with a 100% sensitivity.

Among the 5 cases, who were diagnosed as malignant otitis externa on bacteriological studies, HRCT correctly picked up 4 cases with a sensitivity of 80%. All these patients showed Pseudomonas on bacterial culture. One case which was misdiagnosed was found to be granulation tissue. Excruciating ear ache was the most common presenting symptom in these patients followed by persistent ear discharge.

There is a significant radio-surgical correlation in identifying and differentiating cholesteatoma from granulation tissue, as well as recognising malleus erosion, incus erosion, tegmen tympani erosion, scutum erosion, EAC erosion, high riding jugular bulb, LSSC fistula, neoplasms, and otitis externa. There was a moderate to poor radio-surgical correlation in detecting stapes erosion and facial canal erosion. This discrepancy in identifying stapes deterioration might be owing to the bone's tiny size and the thick soft tissue that surrounds it, making it harder to see.

Following are the limitations : Abnormal soft tissue densities in the middle ear or mastoid were discovered on CT images of persistently draining ears. HRCT was unable to predict cholesteatoma when soft tissue mass was not accompanied by bone erosion. The soft tissue lesions were occasionally found to be granulation tissue or mucosal hypertrophy. Thickening and perforations of the tympanic membrane were difficult to detect on HRCT and were better observed with otoscopy.

Conclusion

This research work revealed good agreement of HRCT with surgical and clinical findings. HRCT is a useful tool for determining the anatomy, congenital variations and pathological aspects of the temporal bone. Hence, we may infer that HRCT is beneficial for diagnosing, planning surgery, managing temporal bone diseases as well as post surgical follow-up. HRCT is superior to radiographs in depicting detailed anatomy as well as diseases of temporal bone. It is better than MRI in providing bony details. However, cochlea, the vestibulo-cochlear nerve and facial nerve are difficult to evaluate on HRCT, which needs MR evaluation.

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