Original Research Article

Role of high resolution computed tomography in evaluation of temporal bone diseases

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Abstract

Background: The imaging modalities for evaluation of temporal bone are plain radiographs, multidirectional tomography, angiography, CT and MRI. Plain X-ray is an inexpensive method to study temporal bone, but results in an inaccurate diagnosis. Multidirectional tomography provides excellent bony details; however, soft tissues can't be delineated. Also, there is increased radiation to the eye lens. Angiography is the gold standard for evaluation of vascular lesions but is invasive with the risk of complications. The aim of the present study was to evaluate Role of High Resolution Computed Tomography in Temporal Bone Diseases and correlate HRCT image based findings with the operative and pathological findings to determine the accuracy of HRCT findings wherever possible.

Materials and methods: This prospective study was done in Department of Radiodiagnosis & Imaging of Govt. Medical College Srinagar, J&K in collaboration with the Department of Otorhinolaryngology, in patients suspected of having temporal bone disease. All the patients who were, suspected of unsafe chronic serous otitis media (CSOM), evaluation of congenitally deaf child, having known or suspected deformities of inner, middle or external ear, tinnitus or vertigo, tumors of temporal bone and temporal bone fracture were included in the study. While exclusion criteria included, Patients of age <1 or >70 years.

Results: Various findings associated with temporal bone trauma on HRCT showed 10 cases of Hemotympanum, 6 with facial nerve involvement, 2 with Labyrinthine involvement and Intracranial involvement was seen in 6 cases. In the current study 9 patients had symptomatic congenital anomalies involving various structures of the ear and temporal bone.

Conclusion: With the advent of modern high-resolution CT scanners, detailed demonstration of temporal bone anatomy has become a practical reality. The improved contrast and soft tissue definition possible with HRCT has resulted in production of excellent images of soft tissue lesions in air spaces. However HRCT has its own limitations like in evaluation of labyrinthine soft tissue structures, evaluation of enhancement pattern and associated radiation hazards to the eye lens. Despite its limitations, HRCT of the temporal bone is a highly efficacious modality for accurate delineation of the anatomy and various pathologies of the temporal bone and it has revolutionalized the role of radiology in diagnosis and management of temporal bone diseases.

Key words

High Resolution Computed Tomography, Temporal bone disease, CT scan.

Introduction

The ear is an organ of special sense that has evolved from being an organ of balance to serving the complex and highly specialized function of hearing. The ear is unique in demonstrating the resourcefulness and richness of invention of biologic system. It has evolved from a fluid filled pocket beneath skin surface to a highly complicated inner ear structure deeply encased and concealed within the skull base. It has an extremely complicated anatomy with minute structural components. The middle and inner ear are housed in the petrous part of temporal bone, therefore, the temporal bone and it's diseases have profound impact on hearing and balance. Imaging in temporal bone was confined to plain radiography and multidirectional tomography. With the advent of Computed Tomography (CT) and Magnetic Resonance Imaging (MRI), temporal bone imaging has been revolutionized [1]. The imaging modalities for evaluation of temporal bone are plain radiographs, multidirectional tomography, angiography, CT and MRI. Plain X-ray is an inexpensive method to study temporal bone, but results in an inaccurate diagnosis [2]. Multidirectional tomography provides excellent bony details; however, soft tissues can't be delineated. Also, there is increased radiation to the eye lens. Angiography is the gold standard for evaluation of vascular lesions but is invasive with the risk of complications [2]. High Resolution Computed Tomography (HRCT), MRI and Digital Subtraction Angiography (DSA) have largely replaced the above-mentioned modalities. MRI has excellent soft tissue resolution, more sensitivity to effects of gadolinium as contrast agent, better spatial resolution and no exposure to radiation. However, MRI provides poor information about cortical bone and air spaces.

HRCT is better than multidirectional tomography as soft tissue abnormalities can be well delineated. It is less prone to artifact and there is less radiation to lens [3, 4]. HRCT excels in evaluation of disorders that primarily affect the air spaces or cortical bone [1]. However, soft tissue characterization is limited as compared to MRI [2]. Hence, in evaluation of air spaces and cortical bone, HRCT is better while for evaluation of soft tissues and vascular lesions, MRI is preferred. HRCT and MRI can be complimentary to each other in some cases [5]. In a developing country like ours, HRCT is the modality that is easily available and affordable to the patients. Therefore, a radiologist is likely to be exposed to greater number of HRCT studies and the knowledge of anatomy and pathology of temporal bone on HRCT will be extremely useful in reaching an accurate diagnosis.

The aim of the present study was to evaluate Role of High Resolution Computed Tomography in Temporal Bone Diseases and correlate HRCT image based findings with the operative and pathological findings to determine the accuracy of HRCT findings wherever possible.

Materials and methods

This prospective study was done in Department of Radiodiagnosis and Imaging in Govt. Medical College Srinagar, J&K in collaboration with the Department of Otorhinolaryngology in patients suspected of having temporal bone disease. It was carried out during the time period of 24 months from 01-09-2016 to 31-08-2018. The patients who were referred from OPD or IPD with complaints and clinical findings pertaining to temporal bone disease for evaluation by high resolution CT were included in the study. All the patients who were, suspected of unsafe chronic serous otitis media (CSOM), evaluation of congenitally deaf child, having known or suspected deformities of inner, middle or external ear, tinnitus or vertigo, tumors of temporal bone and temporal bone fracture were included in the study. While exclusion criteria included, Patients of age <1 or >70 years, Pregnant women, Patient requiring contrast study but is clinically unfit for contrast workup and Patients who cannot give a valid consent. At the start of the study relevant clinical evaluation was carried out, relevant history was taken and clinical findings were reviewed and X-ray mastoid, if available, was reviewed.

After relevant local examination findings and informed consent, CT scan was performed. The examination of patients was done using 16- Slice Somaton Emotion Scanner of Seimens, after removing all the external artefacts from the scanning field. HRCT was done using 0.625 mm thick sections at an interslice gap of 0.625 mm. The voltage of 140 kV and current of 300 mAs were used. The cycle time used was 2 seconds. Images were reconstructed in high frequency bone algorithm. Field of view was 180 mm and scanning was done in axial plane. Documentation was done on 14 x 17” Kodak films. Images of each temporal bone were magnified and documented on separate films to facilitate comparison. The findings were recorded in a tabulated manner and a differential diagnosis based on HRCT findings was made.

Data which was collected was entered in Microsoft excel sheet. All the data was analyzed using tables. Descriptive statistical analysis was carried and results were prepared in tables.

Results

The present study was conducted with an aim to evaluate Role of High Resolution Computed Tomography in Temporal Bone Diseases. The study was carried out on 100 patients including both male and females, in the age group of 1 year to 60 years, who underwent HRCT temporal bone and relevant statistics were drawn from these cases. The study comprised of 100 patients. **Table - 1** presents the age distribution of the subjects. **Table - 2** shows the distribution of patients according to the side of involvement. The distribution of cases according to the etiology was shown in **Table - 3**. Out of the total 100 cases seen total cases of infective etiology were 57, distribution of these cases was depicted in **Table - 4**. **Table - 5** shows the distribution of cases of cholesteatoma, Tabular distribution of various structures in cholesteatomas on HRCT was shown in **Table - 5**. A total of 34 cases were seen with cholesteatoma on HRCT. A total of 9 cases with cholesteatoma with associated Intracranial Complications were seen, **Table - 6** presents the distribution of these cases. A total of 20 patients with provisional diagnosis of traumatic etiology were seen which included 19 patients who had fractures of temporal bone with 68 % having longitudinal fracture (**Table - 7**).

Table - 1: Distribution of the subjects according to age (n=100).

Age (years)	No. of patients	%
1-20	36	36
20-40	39	39
40-60	22	22
60-70	3	3
Total	100	100

Various findings associated with temporal bone trauma on HRCT showed 10 cases of Hemotympanum, 6 with facial nerve involvement, 2 with Labyrinthine involvement and Intracranial involvement was seen in 6 cases. In the current study, 9 patients had symptomatic congenital anomalies involving various structures of the ear and temporal bone. The tabular distribution of congenital anomalies was presented in **Table - 8**. Total number of cases with neoplastic etiology who were diagnosed by HRCT were 5 the tabular distribution of neoplastic lesions was presented in **Table - 9**.

Table - 2: Distribution of subjects according to the side of involvement is as follows (n=100).

Side of pathology	No. of patients	%
Right	36	36
Left	37	37
Bilateral	18	18
No involvement (normal)	9	9
Total	100	100

Table - 3: Distribution of subjects according to the etiology (n=100).

Etiology	No. of cases	Percentage
Infective	57	57
Traumatic	19	19
Congenital	9	9
Neoplastic	5	5
Dysplasia	1	1
Normal	9	9
Total	100	100

Table - 4: Distribution of subjects with infective etiology (n=57).

CT diagnosis	No. of patients	%
Chronic otomastoiditis with cholesteatomas Formation	34	59.7
Chronic otomastoiditis	14	24.5
Chronic mastoiditis	5	8.8
Otitis externa	4	7.0
Total	57	100

Discussion

The current study included 100 patients with suspected pathologies of ear and temporal bone. HRCT was done using 0.625 mm thin sections in axial plane as recommended by Chakeres, et al. [2]. In axial plane CT gantry was positioned parallel to infra-orbitomeatal line. This is in accordance with recommendations by Swartz et al. [6]. In all the cases, coronal images were reconstructed from axially acquired data. It was found that these reformatted coronal images were of good diagnostic quality and this alleviated problems encountered with patient positioning during direct coronal scanning. These findings were consistent with Venema, et al. [7] who studied MPR images in 24 patients and concluded that there was no significant difference in quality of images from direct coronal scans and reconstructed coronal images. The present study included 34 cases of cholesteatomas and correlation with operative findings was obtained in 28 cases (specificity 89%). In remaining 6 cases only chronic otitis media was found with no cholesteatoma. These results were consistent with those of Johnson, et al. [8]. They studied 44 cases of cholesteatomas and found high degree of correlation between HRCT image based findings and operative findings.

Table - 5: Distribution of subjects according to involvement of various structures in cholesteatomas on HRCT (n=34).

<table>
<tr><th colspan="2">Structures Involved</th><th>No. of cases</th><th>%</th></tr>
<tr><td colspan="2">Facial nerve canal</td><td>28</td><td>82.3</td></tr>
<tr><td colspan="2">Ossicles</td><td>21</td><td>61.8</td></tr>
<tr><td rowspan="2">Inner ear</td><td>SCC</td><td>8</td><td rowspan="2">29.5</td></tr>
<tr><td>Labyrinth</td><td>2</td></tr>
<tr><td colspan="2">Tegmen tympani</td><td>20</td><td>58.8</td></tr>
<tr><td colspan="2">Sinus plate</td><td>18</td><td>52.9</td></tr>
<tr><td colspan="2">Intracranial structures</td><td>9</td><td>26.5</td></tr>
</table>

Table - 6: Tabular distribution of intracranial complications of cholesteatoma (n=9).

Intracranial Complication	No. of cases	%
Venous sinus thrombosis	5	55.6
Meningitis	2	22.2
Subdural empyema	1	11.1
Brain abscess	1	11.1
Total	9	100

Table - 7: Distribution subjects as per types of fracture of temporal bone of traumatic etiology (n=19).

Type of fracture	No. of cases	Percentage
Longitudinal	13	68.4
Transverse	3	15.8
Mixed	3	15.8
Total	19	100

Table - 8: Tabular distribution subjects in regard to symptomatic congenital anomalies.

Anomalies		No. of patients	%
Auricular dysplasia	Aplasia	2	66.7
	Hypoplasia	4	
Ossicular abnormalities	Fusion	2	33.3
	Absent	1	
Facial nerve involvement	Displaced	1	22.2
	Absent	1	
Congenital cholesteatoma		1	11.1
Inner ear dysplasia	SCC	1	22.2
	Cochlea	1	
Dehiscent jugular bulb		1	11.1

Table - 9: Tabular distribution of total number of cases with neoplastic etiology (n=5).

Type of neoplasm	No. of cases	%
Glomus tumor	2	40.0
Squamous cell carcinoma	1	20.0
Meningioma	1	20.0
Acoustic neuroma	1	20.0
Total	5	100

Typical complications of cholesteatoma such as destruction of ossicles, bony labyrinth, facial nerve canal, lateral wall of attic and superior and inferior wall of tympanic cavity were clearly demonstrated. The results of our study are consistent with the study by Koster, et al. [9]. They studied 30 cases of cholesteatoma and found that the extent of the soft tissue disease process is clearly demonstrated; however, the differentiation from accompanying inflammatory changes is not possible.

Out of 28 patients with facial canal dehiscence that were included in current study, 20 were confirmed by surgery (71%) and findings of inner ear fistula were confirmed in 9 out of 10 patients (90%). Thus the findings of the current study are in agreement with the study by Fuse et al, who studied 61 patients for pre-operative evaluation by HRCT and found that in 75% patients HRCT image based assessment of facial nerve canal dehiscence coincided with surgical findings [10]. In their study, in 97% patients HRCT findings of semicircular canal fistula coincided with surgical findings. Our study included 20 cases of head injury with suspected temporal bone trauma. Out of these, 19 cases had fractures of the temporal bone. We found that HRCT findings correlated with clinical signs and symptoms (hearing loss, facial nerve dysfunction, etc). In 2 patients who had facial nerve paralysis; finding of hematoma in relation to facial nerve was confirmed on surgery. This is in agreement with findings of Johnson, et al. [11]. They studied 12 cases of temporal bone trauma and found that HRCT findings correlated well with clinical and operative findings.

The present study included 6 cases of microtia. Out of the 6 patients, 2 (33%) had aplasia of external auditory canal while 4 (66%) patient had hypoplasia of external auditory canal. Ossicular fusion was found in 1 patient, while 2 patients had absent ossicles. Anterior displacement of facial nerve was found in 1 patient and short facial nerve canal was found in 1 patient. These findings are in agreement with the findings of Meyer, et al. [12]. It was also found that the extent of the auricular anomalies corresponded to the severity of changes in the external auditory canal, excessive inclination of the external and internal auditory canals, dysplasias of the middle ear cavity and ossicles. This is also in accordance with the study by Meyer et al who examined HRCT of 184 cases of congenital auricular dysplasia and had similar findings [12].

The current study also included a case of absent lateral semicircular canal and a case of cochlear hypoplasia, comprising 50% of cases with congenital anomaly without microtia. This is in accordance with Meyer et al who found that in cases of inner ear malformation without microtia incidence of lateral semicircular canal dysplasia was highest (40%) [12]. A case of dehiscent jugular bulb causing pulsatile tinnitus was also included. Incidental finding of high riding jugular bulb was noted in 5 patients. This is in accordance with study by Overton et al who found that incidence of high riding jugular bulb to be 6%. The current study included 5 patients with neoplasms of ear and temporal bone [13]. These included 1 case of squamous cell of external auditory meatus, 2 cases of glomus tumor, a case of acoustic neuroma of VIII nerve and a case of meningioma involving internal auditory meatus. Four of these cases were operated and HRCT findings were confirmed. HRCT was found to be highly accurate in establishing the presence, extent and spread of tumor. This is in accordance with study by Bird et al who studied 10 cases of primary malignant tumors of ear and temporal bone [14]. Our results were also in accordance with a study of squamous cell carcinomas of the temporal bone by Oslen, et al. who found that the CT findings characteristic of squamous cell carcinoma of the EAC include presence of a large, destructive, soft-tissue mass; obliteration of adjacent normal-tissue fat planes and invasion of the adjacent structures [15].

We studied one case each of glomus jugulare and one case of glomus tympanicum tumor. HRCT in case of glomus jugulare revealed soft tissue mass in jugular foramen with destruction of bone, extension into middle ear cavity, mastoid, external auditory canal and lateral semicircular canal and involvement of facial nerve. This was in accordance with Chakeres DW and Lamasters DL who studied 15 cases of paragangliomas and found that the most characteristic HRCT signs of paragangliomas included jugular fossa expansion, soft tissue mass in hypotympanum and sinus tympani, permeation of infrachochlear surface and dural ballooning adjacent to jugular fossa [16]. Our study also included one case of acoustic schwannoma. HRCT revealed bilaterally widened internal auditory canals. On contrast administration adjacent enhancing cerebellopontine angle mass lesions were noted. These findings were in accordance with those of Curtin HD [17]. Twemlow S studied 205 cases of HRCT temporal bone and found that HRCT can accurately diagnose middle ear disease. He also inferred that it provides efficient use of resources at low risk to the patients [18]. The results in current study are consistent with the above mentioned study.

Conclusion

With the advent of modern high-resolution CT scanners, detailed demonstration of temporal bone anatomy has become a practical reality. The improved contrast and soft tissue definition possible with HRCT has resulted in production of excellent images of soft tissue lesions in air spaces. In patients with temporal bone trauma, HRCT accurately evaluates the fracture lines, ossicular disruptions and facial nerve canal injury. In patients with congenital malformations of ear and neoplastic lesions, HRCT characterizes the lesion, delineate the extent and shows structural alterations in temporal bone thus aiding substantially in preoperative planning. However HRCT has its own limitations like in evaluation of labranthine soft tissue structures, evaluation of enhancement pattern and associated radiation hazards to the eye lens. Despite its limitations, HRCT of the temporal bone is a highly efficacious modality for accurate delineation of the anatomy and various pathologies of the temporal bone and it has revolutionalized the role of radiology in diagnosis and management of temporal bone diseases.

Recommendations

HRCT temporal bone should be done in following categories of patients:

- Patients who present with signs of ear infection as it well delineates extent, nature of the inflammatory lesion and any underlying complications.
- For evaluation of suspected congenital anomalies of temporal bone as it is

highly accurate in establishing the diagnosis and demonstrating the extent of inner and middle ear anomalies which can aid in reconstructive surgeries.

- Whenever traumatic injury to the temporal bone is suspected as it accurately evaluates the fracture lines and associated ossicular disruptions and facial nerve canal injury.
- For evaluation of suspected neoplastic lesion involving the temporal bone region, since HRCT characterizes the lesion, delineate the extent and shows structural alterations in temporal bone thus aiding substantially in preoperative planning.

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