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Research Article

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Role of high resolution computed tomography in the evaluation of temporal bone lesions: our experience

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ABSTRACT

Background: High resolution computed tomography (HRCT) is a modification of routine computed tomography. It provides visual information of the minute structural details of the temporal bone. The present study aimed at studying the pathological processes of the temporal bone and their extent using HRCT.
Methods: This prospective study was done by taking HRCT of the temporal bone in 50 patients who presented to us with clinical features of temporal bone diseases. Both contrast and no enhanced images were obtained by taking 2mm sections using ultra high algorithm in both coronal and axial planes. The results were then analysed statistically.
Results: Amongst the 50 cases, infection was the most common pathology affecting the temporal bone. Neoplasms formed the second largest group of lesions with acoustic neuroma being the most common tumour.
Conclusions: HRCT is a revolutionary imaging tool in evaluating the various pathologies affecting the temporal bone. It identifies the hidden areas of the temporal bone. It also lays down an anatomical roadmap for the surgeon preoperatively.

Keywords: Computed tomography, Acoustic neuroma, Cholesteatoma, Middle ear, Temporal bone

INTRODUCTION

Computed tomography (CT) and magnetic resonance imaging (MRI) are the most widely used modalities for evaluation of the temporal bone pathologies.[1] CT scanning excels in the evaluation of bone and air space anatomy and disorders. Also, CT scans are more accurate in identifying many soft tissue abnormalities and are much less prone to artefacts.[2] Also, CT has the advantage of producing images with higher contrast and a better spatial resolution.[3] On the other hand, MRI can image many soft tissue entities not visible by other techniques.[4] High resolution computed tomography (HRCT) is a modification of routine CT. It provides a direct visual window into the temporal bone and provides minute structural details of both anatomy and pathology of temporal bone. HRCT has the advantage of excellent topographic visualization, devoid of artifacts from superimposition of structures. It helps in accurate assessment of pathology prior to surgical exploration regarding location, extent and complication of the disease.

The purpose of the study is primarily was to understand the capability of HRCT in diagnosis and detection of pathologies of the temporal bone.

METHODS

This is a prospective study done at department of otolaryngology at Navodaya Medical College, Raichur during the period of 1st June 2012 to 31st May 2014. Fifty patients who presented to our outpatient department for clinical features suggesting temporal bone pathologies

were subjected to HRCT of the temporal bone. The patients included were those having ear discharge, head trauma, facial palsy or those complaining of vertigo, tinnitus and hearing loss. Patients with history of previous surgery and those with electric devices at the skull base, such as cochlear implants were excluded from the study.

All the HRCT scans were performed at our institute on the computed tomography system which is modified third generation machine. Patients were scanned in the axial and coronal (supine or prone) axes. Scout films were taken routinely in all patients before starting the scan. Scanning commenced from the lower margin of the external auditory meatus and extended upward to the arcuate eminence of the superior semicircular canal as seen on lateral tomogram. Slight extension of the head was given to avoid gantry tilt and thereby protect the lens from radiation. Coronal images were obtained perpendicular to the axial plane from the cochlea to the posterior semicircular canal. Continuous 2mm thick slices were obtained at 3 mm interval using an ultra high algorithm with a scan time of 4 seconds at a 133 KV tube voltage. The mA selected was 70. At 133 KV, the noise level is low, bone penetration is better and there is minimal beam hardening. At 70 mA, the soft tissue differentiation is better. A long scan time of 4 seconds increases the image sharpness but there is a greater probability of motion artifacts. Intravenous contrast studies were done for vascular tumours like glomus tumours, cerebellopontine angle tumours and in intracranial or extracranial extension of middle ear diseases.

For axial imaging, sections are made in a plane rotated 300 superior to the anthropologic base line. Scan produced in this plane display the temporal bone structures to good advantage. This plane allows separation of individual component of the temporal bone so that they are better visualized in their entirety, with less of overlap and fewer partial volume imaging artifacts. Direct coronal images are usually obtained at an angle of approximately 1200 from arthropologic baseline, while reconstruction coronal images are usually oriented 900 from arthropologic baseline. The important patient factor influencing HRCT is motion. Therefore, patients were instructed to the motionless during the procedure. For contrast enhancement, a bolus injection of diatrizoatemeglumine and diatrizoatesodiuim were given in the dose of 300 mg lodine/kg of body weight trazograf or urograffin 60% was used in children and trazograf or urograffin 76% was used in adults. This was given just before the contrast enhancement CT was to be performed.

RESULTS

Our study group comprised of 27 males and 23 females. The age group of the subjects ranged from 7 years to 60 years. Of the 50 temporal bone HRCT studies done by us, 41 scans were having infections of the temporal bone (82%), 5 were having tumours (10%) and 4 were having traumatic injuries to the temporal bone (8%).

Of the 41 scans having infection in the temporal bone, 2 scans revealed malignant otitis externa, 29 scans showed varying degrees of mastoiditis and 10 scans showed cholesteatoma which ranged from limited form to extensive type shown in Figure 1. The HRCT findings like extension of cholesteatoma, opacification of mastoid air cells, ossicular erosion and intra cranial extension were compared with the intraoperative findings and in all the cases, both were similar. In all the cases, nature of surgery was dependent on the nature and extent of the disease.

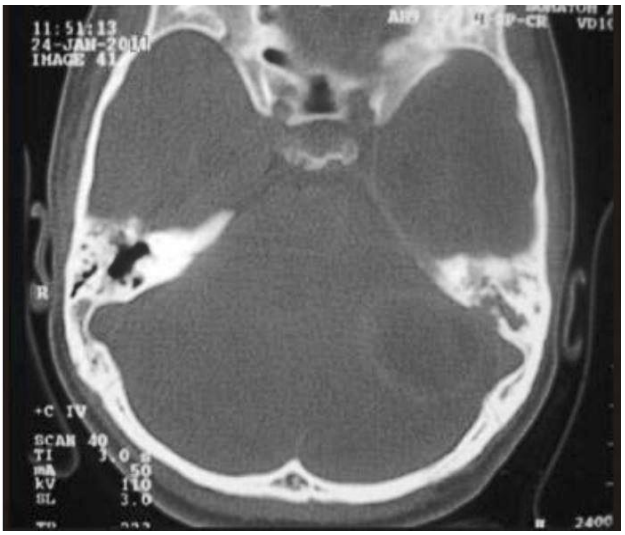

Figure 1: Cholesteatoma.

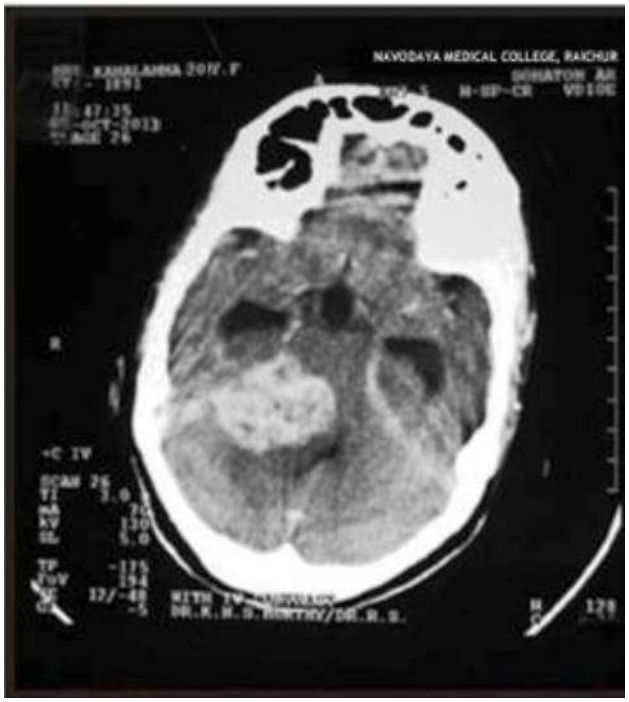

Figure 2: Acoustic neuroma.

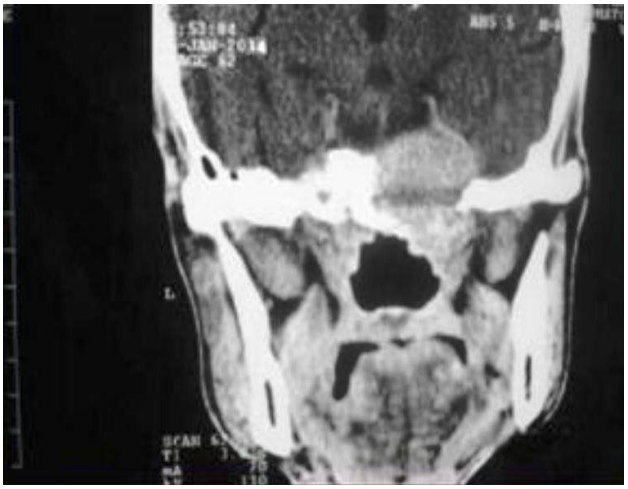

Figure 3: Metastasis to petrous apex

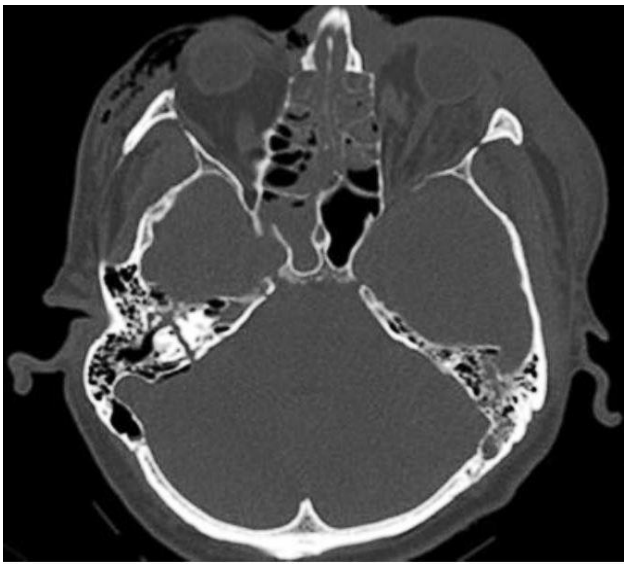

Figure 4: Transverse fracture

Of the 5 HRCT temporal bone scans having tumours, 3 were of acoustic neuroma and 2 scans showed metastatic secondaries in the temporal bone. In all these scans, soft tissue windows were used to show soft tissue enhancement. The acoustic neuroma was seen in HRCT as hypodense to slightly hyperdense cerebellopontine angle mass showing contrast enhancement with erosion of porous acousticus (Figure 2).

The extensions of the masses were confirmed by the intraoperative findings. In the 2 cases with temporal bone metastasis, the lesions appeared as destructive lesions at apex of petrous bone in both the cases (Figure 3).

Of the 4 scans with traumatic injuries to the temporal bone, 3 scans were having longitudinal fracture of the right petrous bone and 1 scan was showing transverse fracture of the right petrous bone (Figure 4). Facial nerve palsy was clinically seen in the patient having transverse fracture of the petrous bone.

DISCUSSION

Medical imaging has experienced significant changes in both the technologic and clinical arenas since the discovery of X-ray in 1895 by Wilhelm Conrad Roentgen, a German Physicist. In 1967, Hounsfield applied the reconstruction techniques to produce the world's first clinically useful CT scanner for imaging the brain. In 1979, Hounsfield and Cormack shared the Nobel Prize in medicine and physiology, for their contributions to the development of CT.

According to Lloyd study, high-resolution axial and coronal CT scans were compared with coronal and sagital complex motion tomograms in patients with suspected middle ear cholesteatomas. Information on CT scans equalled or exceeded that on conventional complex motion tomograms in 16 of 17 patients, and in 11 it provided additional information. Soft-tissue resolution was superior with CT. In 14 patients who underwent surgery, CT provided information that was valuable to the surgeon. On the basis of this study, high-resolution CT is recommended as the preferred method for evaluating most patients with cholesteatomas of the temporal bone.[5]

According to Fritz who took sixty-two patients with different temporal bone lesions were prospectively examined by high-resolution CT and conventional plain radiography, including pluri-directional tomography. High resolution CT enabled a clear diagnosis in 80% of cases, conventional radiology in 63%; 1.6 times more bone information was recorded by high-resolution CT which is clearly superior for imaging cholesteatomas, metastases and inflammatory processes and for evaluating osseous destruction. With regard to pathological soft tissue or effusions filling the tympanic cavities, conventional radiology shows poor sensitivity (0.61). High-resolution CT is the most sensitive method for the imaging and classification of temporal bone fractures, including labyrinthine damage and ossicular chain injuries. Only in cases of atypical fractures with an unfavourable relationship to the CT planes, can carefully directed tomography be more effective. In most cases high-resolution CT replaces conventional radiology and should be the method of choice for comprehensive radiological examination of the temporal bone. The HRCT temporal bone gives valuable information for evaluation of congenital anomalies, inflammatory diseases, otosclerosis, tumors and cerebellopontine angle lesions, post-operative mastoid cavities, anatomical variants as well as temporal bone trauma.[6]

In otitis media and mastoiditis, HRCT shows non-specific debris within middle ear and mastoid, possibly with several fluid levels. In coalescent mastoiditis, CT will show erosion of the mastoid septations with associated development of intramastoid empyema. In dural sinus thrombosis, a clot may be seen as a filling defect within the dural sinus (empty delta sign) on CECT.

In thrombophlebitis of sigmoid and transverse regions, the thrombus may propagate retrograde into superior sagital sinus, causing venous outflow obstruction and venous hypertension can lead to cerebral oedema, infarction and haemorrhage. In middle ear effusions, HRCT shows presence of radio density in an incompletely opaque middle ear.[7] The CT appearance of cholesteatoma is a non-dependent, homogenous, soft tissue mass in an appropriate location. Acquired cholesteatomas are either present in pars tensa or pars flaccida. The Pars flaccida cholesteatomas begin in prussack's space with medial displacement of ossicles. They extend posteriorly into the attic and inferiorly into the posterior tympanic recesses. In pars tensa cholesteatomas, the disease begins in the posterior tympanic recesses. They are called sinus cholesteatomas. The ossicular chain is displaced laterally. Sometimes the HRCT may show erosion of bony structures like scutum, ossicles, facial nerve canal, tegmen and lateral semicircular canal.[8-10]

The tumours of the temporal bone present in HRCT as lesions iso to slightly hypodense to adjacent brain. Besides this, the HRCT of the acoustic neuroma may present with secondary changes such as widening of ipsilateral cerebellopontine angle and quadrigeminal cistern, narrowing of contralateral cisterna and displacement and compression of 4th ventricle. In addition bony changes such as, difference in canal height of more than 2mm, shortening of posterior wall of canal of more than 3mm, and presence of focal erosion are usually present.[11]

The meningiomas appear in HRCT as sharply circumscribed mass that abuts the dural surface and forms an obtuse angle. Majority of them are hyperdense to brain parenchyma and show strong and uniform enhancement calcification is seen in 20 to 25% cases with few tumours showing cystic areas. An epidermoid in cerebellopontine angle appears in HRCT as Well defined lucent appearing lobulated masses with attenuation similar to cerebrospinal fluid. Calcification uncommon, occasionally hyperdense due to haemorrhage, high protein content or iron containing pigment.[12] HRCT is a very significant diagnostic tool to diagnose and stage glomus tumours of the temporal bone.[13,14] The facial nerve schwannoma appears in HRCT as a radiolucent area eroding the bone.[15]

In HRCT in otosclerosis, fenestral foci are seen as dense bony plaques of variable size seen commonly in the anterior oval window. The other sites are posterior end of oval window. In active otosclerosis, the oval window margins become indistinct, merging with otospongiotic focus of adjacent cochlea which result in "wide window" appearance. In late stages there is thickening of stapes foot plate. The retro-fenestral disease is seen as an area of demineralization within otic capsule. In the remineralized state this may not be seen.[16-18]

Anatomical variations like dehiscent facial nerve, aberrant internal carotid artery, jugular bulb variants, persistent stapedial artery, anterior and wider sigmoid sinus, size of mastoid antrum, presence of korner's septum, deep posterior wall recesses and low lying middle cranial fossa are well appreciated in HRCT of the temporal bone. Aberrant internal carotid artery is seen entering the tympanic cavity through the enlarged tympanic canaliculus posterior to the normal internal carotid artery.[19] A dehiscent facial nerve is seen in cross section below the lateral semicircular canal on coronal images.[20] A dehiscent jugular bulb presents as a vascular mass in the retro-tympanum. It is best seen on coronal CT as being directly continuous with the middle ear.[21]

Of the 50 temporal bone HRCT studies done by us, 41 scans were having infections of the temporal bone (82%), 5 were having tumours (10%) and 4 were having traumatic injuries to the temporal bone (8%). The study of GAS Lloyd et al. claimed neoplasms to be the most frequent lesions. The same study showed infection as the 3rd most common cause of temporal bone lesions.[5]

HRCT outweighs the conventional modalities of investigations and provides higher spatial resolution and better soft tissue contrast. HRCT is far advantageous in assessing the complications of infection, lays down an anatomical roadmap for the surgeon preoperatively, predicts certain normal variants of surgical significance preoperatively and also identifies the hidden areas of the middle-ear, namely the posterior recesses.

A neoplastic disease of the middle ear is best staged with HRCT. By precisely defining intratympanic, mastoid, jugular wall, infra-labyrinthine and petrous apical involvement as well as posterior, middle and infra-temporal fossa extension. HRCT provides essential information for planning the surgical approach.

At the same time, there are some limitations of the use of CT in evaluation of chronic middle ear disease. CT scans of chronically draining ears demonstrated abnormal soft tissue densities in the middle ear or mastoid. However, if this soft tissue mass was not associated with bone erosion, it was not possible to discern whether or not cholesteatoma was present. Infrequently the soft tissue masses were proved to be granulation tissue or mucosal hypertrophy. Of greater predictive value in the diagnosis of cholesteatoma was the presence of abnormal soft tissue densities with bony erosion. Tympanic membrane thickening and perforations were difficult to assess on HRCT and better seen on otoscopy.

CONCLUSION

Middle ear disease is a common clinical entity; imaging, especially HRCT, plays a crucial role in diagnosis and assessing the disease extent, helping to decide appropriate management. Temporal bone imaging is challenging and involves thorough understanding of the anatomy,

especially in relation to HRCT imaging. Most of the middle ear pathologies appear as "soft tissue" on imaging. Careful analysis of the soft tissue on the HRCT is crucial in achieving the right diagnosis; clinical information is essential and the imaging findings need correlation with clinical presentation and oto-endoscopic findings. HRCT is ideal for the evaluation of temporal bone lesions.

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