A Rural Hospital-Based Study on Temporal Bone Pathologies by High Resolution Computed Tomography from Bangalore, Karnataka

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ABSTRACT

BACKGROUND

The tympanic cavity is susceptible to infection by viruses and bacteria through the Eustachian tube, thereby making ear pathologies and particularly middle ear inflammatory conditions a frequent reason to consult an otorhinolaryngologist. With the advent of High-Resolution Computed Tomography, diagnosis of the middle ear anatomy, pathology and its complications if any, could be made out with better precision by providing a direct visual window by providing minute structural details. The aim of the study was to assess temporal bone pathologies that could be evaluated by HRCT study of the temporal bone in a rural hospital based setup and correlate if possible with surgical/histopathological findings.

METHODS

The study was a retrospective study done in M.V.J Medical College and Research Hospital, Bangalore amongst 50 patients from February 2020 to January 2021 who underwent HRCT of the temporal bone and relevant statistics were drawn from these cases. After local examination, clinical evaluation and consent, CT scan was performed. Follow-up of patients was done for confirmation with operative and/or histopathological findings whenever possible. All the data obtained were recorded in a tabulated form and analysed on MS Excel.

RESULTS

Amongst 50 patients, infective aetiology was found to be the most common cause, of which chronic otomastoiditis was the most common, followed by chronic Cholesteatoma, otitis media, chronic mastoiditis, and otitis externa. Amongst the congenital aetiology, we had 1 case each of osteoma, facial nerve involvement, microtia and inner ear dysplasia. Amongst the traumatic cases, longitudinal type of fracture was the most common type, followed by transverse and mixed fractures with hemotympanum being the most common HRCT finding.

CONCLUSIONS

HRCT of the temporal bone helps in accurate assessment of infective, congenital, traumatic and neoplastic aetiologies and helps the otologist understand the disease's extent and aid in surgery.

KEYWORDS

High-Resolution Computed Tomography, HRCT, Temporal bone, Radiology

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DOI: 10.18410/jebmh/2021/542

How to Cite This Article:
Boney L, Pandith M. A rural hospital-based study on temporal bone pathologies by high resolution computed tomography from Bangalore, Karnataka. J Evid Based Med Healthc 2021;8(32):2968-2973. DOI: 10.18410/jebmh/2021/542

Submission 21-05-2021,
Peer Review 29-05-2021,
Acceptance 24-06-2021,
Published 09-08-2021.

BACKGROUND

The temporal bone is a highly complex structure located at the base of the cranium and lateral to the temporal lobes of the cerebrum.[1] The temporal bone consists of five parts: squamous, mastoid, petrous, tympanic, and styloid. The external ear includes the auricle and the External Auditory Canal (EAC) which extends medially up to the tympanic membrane. The tympanic membrane is attached to the tympanic annulus and measures approximately 10mm in diameter. The lateral third of the EAC is fibrocartilaginous and the medial two-thirds is bony surrounded by the tympanic part of the temporal bone. The middle ear is an air filled cavity which lies within the petrous part. It contains the ossicular chain and is bounded laterally by the tympanic membrane, medially by the inner ear structures, superiorly by the tegmen tympani and inferiorly by the jugular wall. The scutum is a sharp bony projection to which the tympanic membrane attaches.

The tegmen is a thin plate of bone which separates the dura of the middle cranial fossa from the middle ear and mastoid cavity. Another critical area in the middle ear is the Prussak's space (superior recess). This space is bounded laterally by the pars flaccida and scutum, superiorly by the lateral malleal ligament and medially by the neck of the malleus. The middle ear is further divided into epitympanum (attic) superior to the level of tympanic membrane, mesotympanum at the level of tympanic membrane, and hypotympanum inferior to the level of tympanic membrane. The inner ear within the petrous part contains the cochlea, vestibule and semicircular canals. The cochlea is a spiral shaped structure containing 2 1/2 to 2 3/4 turns and contains the end organ for hearing. The vestibule and the semicircular canals are responsible for balance and equilibrium.

The tympanic cavity is an air-containing space within the temporal bone, which communicates with the nasopharynx through the Eustachian tube and the mastoid air cells through the mastoid antrum. Being an extension of the upper airway tract, this space is susceptible to infection by viruses and bacteria through the Eustachian tube, thus making ear pathologies and particularly middle ear inflammatory conditions a frequent reason to consult an otorhinolaryngologist.

Majority of pathologic processes in the temporal bone are either inflammatory or neoplastic. Inflammatory conditions in the external auditory canal (EAC) include keratosis obturans, Cholesteatoma and malignant otitis externa. Expansion of the EAC without erosion indicates Keratosis obturans. Bone erosion is characteristic of Cholesteatoma and Malignant Otitis externa. The most common inflammatory condition in the middle ear includes acute and chronic otitis media, cholesterol granuloma and Cholesteatoma.

The most common tumours in the internal auditory canal/cerebellopontine angle cistern include vestibular schwannomas and meningioma. Common tumours in the middle ear includes glomus tumour and facial nerve tumours extending into the middle ear cavity.

Earlier, clinical diagnosis played a significant role in diagnosing these clinical conditions. But in complicated and recurrent conditions, clinical examination alone was not sufficient and had to be supplemented by imaging.[2] Due to the complex anatomy of the temporal bone, conventional radiological methods like X-ray mastoid have limited ability to delineate the anatomical details of the temporal bone and identify pathologies.[3] With the advent of advanced helical scanning techniques in the form of Computed Tomography, in particular, High Resolution Computed Tomography, diagnosis of middle ear anatomy, pathology and their complications, if any can be made out with better precision by providing a direct visual window by providing minute structural details.[2]

For HRCT study of the temporal bone, patient is asked to lie down in the supine position and positioned so that the eyes of the patient are away from the X ray beam. In order to provide high spatial resolution, collimation is essential. A collimator of 0.6mm is routinely used and most commercially available units can be collimated up to 1 mm. Helical mode is chosen for clearer coronal and oblique reformats and to decrease susceptibility to motion artifacts. Intravenous contrast if used, is of the low osmolar type which is administered by a power injector at the rate of 1 ml / lb to a maximum dose of 80 to 100 ml for adults. The raw data from each ear is separately obtained and reconstructed using bone algorithm into 0.6mm slice thickness axial images at a dual field of view of 100mm that magnifies the images obtained. Then these 0.6mm images for each ear are brought up on the CT scanner console, where the raw data are displayed in axial, coronal and sagittal planes. Multidetector CT provides shorter acquisition times, a decrease in tube current load and provides improved spatial resolution.

Objectives

1. To assess the temporal bone pathologies on HRCT study of temporal bone in a rural Hospital based setup.
2. To correlate HRCT findings with surgical/histopathological findings wherever possible.

METHODS

It was a retrospective study done in the Department of Radiodiagnosis and Imaging in M.V.J Medical College and Research Hospital, Bangalore amongst 50 patients referred to our department with a suspicion of temporal bone disorders. It was conducted in our department for one year from February 2020 to January 2021 amongst 50 patients who underwent HRCT temporal bone, and relevant statistics were drawn from these cases.

The subjects included patients of both sexes between the age groups of 1 and 60 years. Inclusion criteria included suspected unsafe chronic serous otitis media, known or suspected deformities of the inner, middle or external ear, suspected temporal bone fracture, suspected tumors of the temporal bone evaluation of congenitally deaf child and evaluation of tinnitus or vertigo. Patients aged < 1 and > 70 years of age, patients requiring contrast but were clinically unfit for contrast workup, pregnant women and patients who could not give valid consent were excluded from the study. Relevant clinical evaluation was carried out at the time of presentation. X-ray of the mastoid was also reviewed if taken. After relevant examination and informed consent, CT scan was performed as follows.

The study of the patients was done using GE Brivo 16 slice CT scanner and after eliminating all artifacts from the scanning area. It was done with 0.625mm thick sections at slice gap of 0.625 mm. 120 kV and 200 mAs as voltage and current, 2-second cycle duration in the axial plane. Scan plane was kept parallel to the infraorbitomeatal line to prevent radiation to lens. Scanning was done to include temporal bone anteroposteriorly on both sides. The entire petrous temporal bone was scanned anteroposteriorly in accordance with the topogram.

Intravenous contrast was used only in cases that needed assessment of vascular lesions, soft tissue changes and blood-brain barrier breakdown, suspected either clinically or on plain scan. The images were reconstructed and visualized in special bone algorithm. Multiplanar reconstructions were done whenever required in sagittal and coronal planes and documentation done on 14 x 17" films. Images were magnified and represented on separate sheets to enable comparison. Follow-up of patients was done for confirmation with operative and/or histopathological findings whenever possible.

Statistical Analysis

All the data obtained were recorded in a tabulated form and analysed on MS Excel.

RESULTS

The present study amongst 50 patients who came for evaluation by HRCT of temporal bone showed infective aetiology as the most common cause (Table 1). Amongst the infective causes, chronic otomastoiditis (n = 14) was the most common cause followed by chronic Cholesteatoma (n = 7), otitis media (n = 3), chronic mastoiditis and otitis externa (n = 2). Amongst the congenital aetiology, we had 1 case each of osteoma, facial nerve involvement, microtia and inner ear dysplasia. Amongst the traumatic cases, longitudinal fracture (n = 4) was most common followed by transverse (n = 2) and mixed (n = 1) fractures.

The study also revealed temporal bone pathologies to be more common in the age group between 21 to 30 years (Table 2) with no significant sex differences regarding the incidence of pathologies. In Table 3, we found that the ossicles (n = 5) were the most common structure to be involved in the 7 cases of Cholesteatoma followed by scutum and tegmen tympani (n = 4). The facial nerve and sinus plate were involved in 1 case of Cholesteatoma. Amongst the trauma cases (Table 4), we found that hemotympanum was the most common HRCT finding followed by ossicular involvement (n = 3) followed by facial nerve and intracranial involvement (n = 2).

Aetiology		No. of Cases	Total
Infective	Chronic otomastoiditis	14	28
	Chronic mastoiditis	2	
	Otitis media	3	
	Chronic cholesteatoma formation	7	
	Otitis Externa	2	
Congenital	Ossicular abnormalities (osteochondroma/osteoma)	1	4
	Facial nerve involvement	1	
	Microtia	1	
	Inner ear dysplasia	1	
Traumatic (fracture cases)	Transverse	2	7
	Longitudinal	4	
	Mixed	1	
Vascular	Capillary haemangioma	1	2
	Transverse sinus/sigmoid sinus stenosis	1	
Dysplasia		1	**1**
Neoplastic		1	**1**
Normal		7	**7**
Total		**50**	**50**

Table 1. Distribution of Cases Based on Aetiology

Age Group (years)	Male	Female	Total
1-10	1	1	**2**
11-20	2	3	**5**
21-30	7	6	**13**
31-40	6	7	**13**
41-50	8	5	**13**
51-60	1	1	**2**
61-70	1	1	**2**
Total	**26**	**24**	**50**

Table 2. Distribution of Cases Based on Age and Sex

Structures Involved	No. of Cases of Cholesteatoma (n = 7)
Facial nerve	1
Scutum	4
Ossicles	5
Tegmen tympani	4
Sinus plate	1
Intracranial structures	0
Inner ear	0

Table 3. Distribution of Cases According to Structures Involved Due to Cholesteatoma

HRCT Finding	No. of Cases of Trauma (n=7)
Hemotympanum	5
Facial nerve involvement	2
Labyrinthine involvement	0
Ossicular involvement	3
Intracranial involvement	2

Table 4. HRCT Findings in Cases of Trauma

DISCUSSION

HRCT study of the temporal bone is the imaging modality of choice for most of the pathologic conditions of the temporal bone, especially the middle ear. In this study amongst 50 patients, we found that the infective cause was the most common aetiology. Most patients (56 %) came for HRCT evaluation of temporal bone, with chronic otomastoiditis being the most common amongst them. This was followed by traumatic aetiology (12 %) and congenital aetiology (8 %). This finding is in accordance with a study by Sasmita Parida et al., which showed 50% of cases to be of infective aetiology, 20 % to be of traumatic aetiology, and 10 % to be of neoplastic aetiology.[4] Similar results were also noted in another study by Manjit Bagul with inflammatory cause being the most common aetiology (50 %) followed by traumatic (11.6 %) and congenital causes (6.6 %).[5] Chronic inflammation of the middle ear is known as chronic otitis media or chronic otomastoiditis if there is mastoid involvement. Common mechanisms for development of infection include any underlying eustachian tube dysfunction and tympanic membrane perforation. Some important complications of chronic otitis media which may be appreciated on imaging includes middle ear effusion, granulation tissue, cholesterol granuloma and Cholesteatoma. Granulation tissue is a sequelae of inflammation of the middle ear and mastoid. It encases the middle ear structures, however it does not destroy or displace them.

Imaging of temporal bone has been revolutionised by High resolution Computed Tomography, which is a modification of routine CT.[4] It provides information about bony outline and soft tissue changes, making it possible to demonstrate the location and extent of disease and its complications. It clearly depicts the boundaries between external, middle and inner ear clearly, thereby localising the disease precisely.[5] Our study showed maximum cases to be amongst young and middle age groups with slight male preponderance. The studies by Sasmita Parida et al and Manjit Bagul also had similar results. However there was no significant sex differences within the most common age groups in our study in contrast to other studies. The role of X-rays in the evaluation of Cholesteatoma is limited although many views such as the Schuller's, Stenver's, Towne's, Owen's and Law's views have been described. Subtle changes like ossicular erosion, facial canal and LSSC erosion, involvement of hidden areas cannot be assessed on X-rays, but can be evaluated on HRCT scans due to increased spatial resolution.[6]

Cholesteatoma is a common condition in the developing world usually detected by a surgeon. It may be congenital or acquired. Congenital Cholesteatoma is formed due to lack of involution of distinct squamous cell rest. The middle ear including mastoid, petrous and squamous parts of temporal bone are common sites of congenital Cholesteatoma. The acquired type is further divided into (a) EAC cholesteatoma which is uncommon and occurs as a soft tissue mass in the canal part, particularly along the floor and (b) middle ear cholesteatoma, more commonly pars flaccida variety which is seen in the Prussak's space. Middle ear cholesteatomas are associated with erosion of bony scutum eventually extending into the aditus and antrum posteriorly, widening of the aditus and formation of a common cavity. Hidden areas like the anterior epitympanic recess and sinus tympani may be missed clinically and hence requires HRCT evaluation. The hallmark of Cholesteatoma is bony destruction with coexistent soft tissue density in the middle ear.[7] In our study, we had 7 cases of Cholesteatoma, out of which 6 cases were surgically proven (85 %). Chunni Lal Thukral et al[2] showed a high level of agreement (89.29 %) between surgical and radiological findings. There were 5 cases with ossicular erosion. All were surgically proven, 4 cases with scutum and tegmen tympani involvement and 1 case with facial canal involvement, which was surgically proven, all of which were in agreement with the study by Chunni Lal Thukral et al. Bone erosion may occur in both chronic otomastoiditis with or without Cholesteatoma, but more commonly occurs in the cholesteatomatous type. There are multiple theories explaining the process. According to the Pressure theory, osteoclastic bone resorption could occur at sites where adequate pressure was induced directly or transmitted by the tympanic cavity with or without the presence of Cholesteatoma. One popular theory since 1950's includes the chemical activity of Cholesteatoma where they found that the pH of keratin debris was acidic and lower than the antrum mucosa. This promoted bone erosion by decalcification of the adjacent bone structures. Another theory which showed positive correlation between bacterial biofilms and presence of Cholesteatoma suggested that the biofilms mediated host reaction in the form of chronic inflammation, proliferation and bone resorption. Certain inflammatory mediators like RANK-RANKL-OPG system, neurotransmitters like neuropeptides and vasoactive amines and Nitrous oxide also help initiate chronic inflammation and recruit osteoclasts inducing bone resorption.

In our study, traumatic aetiology was the second most common aetiology detected on HRCT amongst which longitudinal fractures were the most common. Longitudinal fracture line runs parallel to the long axis of the petrous ridge along with the petrotympanic fissure and are associated with a lateral impact to the skull, whereas transverse fractures run perpendicular to the petrous ridge and usually occur with occipital and frontal sites of impact. Longitudinal fractures are associated commonly with ossicular injury, tympanic membrane rupture and hemotympanum with conductive hearing loss. Facial nerve is less commonly involved. Transverse fractures are more commonly associated with sensorineural hearing loss secondary to injury to the labyrinthine structures, cochlear nerve transection or stapes footplate injury with facial paralysis being more common in this type of fracture. Mixed fractures have both longitudinal and transverse components with more common involvement of the otic capsule and associated sensorineural hearing loss.[8] Our study results were in agreement with the studies by Sasmita Parida et al and Sankhla et al which showed similar statistics. We had 5 cases of hemotympanum, 3 cases with ossicular disruption and 2 cases each of facial nerve involvement and intracranial involvement which can be explained by the more common occurrence of longitudinal temporal bone fractures. When a fracture affects the walls of the tympanic cavity, haemorrhage occurs in the tympanic space and mastoid air cells. This haemorrhage is identified as fluid collection on imaging. Ossicular injury includes ossicular dislocation and ossicular fracture, however ossicular dislocation is more frequently seen with longitudinal fractures. The most common dislocation is the incudostapaedial joint dislocation with loss of the normal so-called "ice cream cone" sign on CT where head of malleus is the ice cream and body of incus being the cone. In cases of incudostapaedial joint dislocation, there is mal-alignment of the malleal head and incudal body giving a ice cream with a fallen off the "cone" appearance. The most common ossicle to be fractured is the incus especially at the long process, owing to its fragility and lack of support followed by the crura of stapes and least commonly involved is the malleus. Facial canal fractures occurs more commonly with transverse fractures and the most commonly injured locations include the distal labyrinthine portion, geniculate portion of facial canal and in the Internal Auditory Canal. The injury results in complete transection with permanent paralysis of the facial nerve. However, in longitudinal fractures, the facial nerve is involved in 10 - 20 % cases. The injury occurs at the geniculate ganglion or proximal tympanic segment and the paralysis is usually delayed and incomplete.

In our study we also had 4 cases with congenital abnormalities; 1 case each of osteoma, microtia, facial nerve involvement and inner ear dysplasia. The findings were in agreement with the study by Sankla[9] et al amongst 100 cases. Extracanalicular osteomas are rare, slow growing benign neoplasms. They may occur anywhere in the temporal bone, but most commonly seen in the mastoid area. Usually treatment is unnecessary when symptoms are negligible. Surgery is indicated when growth of the osteoma causes distressing symptoms. Microtia, also called congenial aural atresia comprises of anomalies of variable severity involving the pinna, external acoustic canal, middle ear structures and occasionally inner ear resulting in hearing impairment of varying degrees. HRCT study helps in preoperative assessment of external and middle ear anomalies, other anomalies like atretic plate pneumatization and aberrant facial and carotid canal in patients with microtia, thus helping in appropriate management. Inner ear malformations represent approximately 20% of congenital hearing loss cases based on radiology. Most of the patients have bilateral severe to profound hearing loss making them candidates for cochlear implantation. The latest (2017) Sennaroglu's classification of Inner ear malformations is divided into 8 subtypes from least to most differentiated inner ear structures which are as follows: complete labyrinthine aplasia(Michel deformity), rudimentary otocyst, cochlear aplasia, common cavity, cochlear hypoplasia, incomplete partition of cochlea, enlarged vestibular aqueduct and cochlear aperture abnormalities.

HRCT has the advantage of excellent topographic visualization, devoid of any artifacts due to superimposition of overlying structures, thereby helping in accurate localization of pathology and acting as an aid to surgical exploration regarding the location, extent and associated complication.[5] A study by Jeslean Jose et al. amongst 58 patients had concluded high specificity and sensitivity of HRCT in delineating disease at most of the sites in the temporal bone with highest correlative accuracy in the region of incus, labyrinth, scutum, sinus plate, inner ear and jugular bulb.[10] A study by Jytindu Debnath et al. amongst 145 patients also had concluded that due to the advantage of thinner collimations of HRCT allowing image reconstructions in planes of anatomical interest, HRCT is an excellent tool in the assessment of congenital and acquired conditions of the temporal bone.[11]

Neoplasms, however could not be studied in detail in this study due to limited number of cases as a result of small sample size. We recommend a larger sample size for better evaluation of all temporal bone pathologies on HRCT.

CONCLUSIONS

Infective aetiology is the most common cause of temporal bone pathology. HRCT of the temporal bone due to its high spatial resolution helps in accurate assessment of infective, congenital, traumatic and neoplastic etiologies. It helps in excellent delineation of soft -tissue abnormalities against a background of air (in middle ear cavity, EAC, mastoid air cells). It also helps the otologist to understand the extent of the disease and aid in surgery.

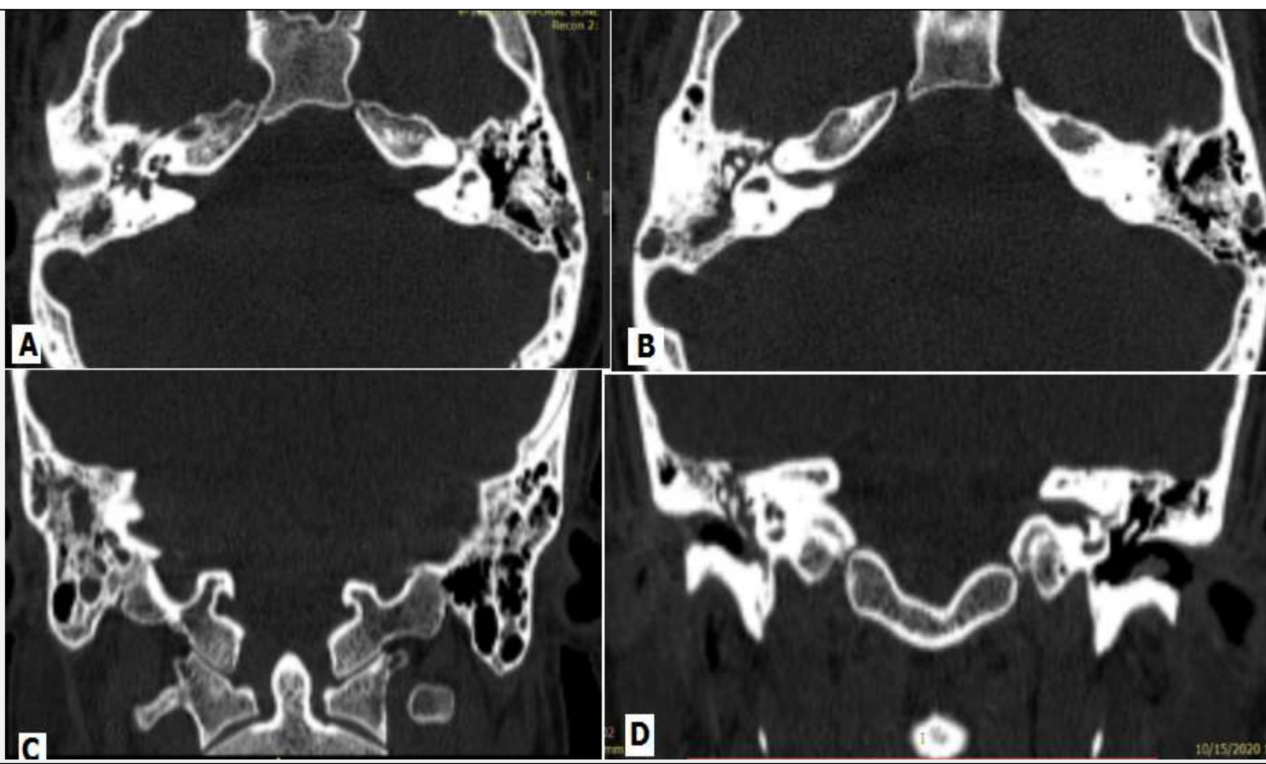

Figure 1. (a) and (b) Shows Axial Images, (c) and (d) Coronal Reformatted Sections and of HRCT Temporal Bone of a 25 Year Old Male Who Had Presented Following a Road Traffic Accident with Longitudinal Fracture of Petrous Part of Right Temporal Bone with Associated Right Sided Hemotympanum, Hemomastoid and Dislocation of the Right Incudomalleolar Joint

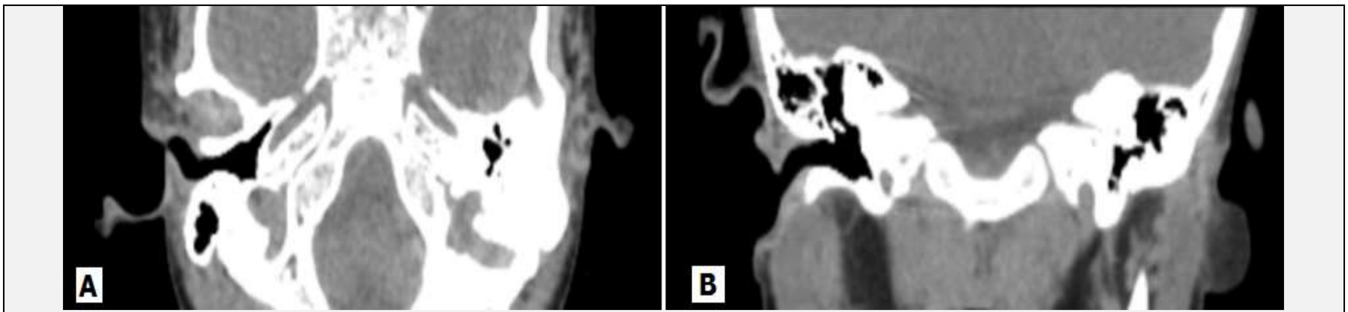

Figure 2. (a) Axial and (b) Coronal Reformatted Images of HRCT Temporal Bone of a 5 Year Old Girl Who Presented with Microtia of Left Ear Showing Absence of Cartilaginous and Bony Parts of Left External Auditory Canal with Hypoplastic/Deformed Pinna

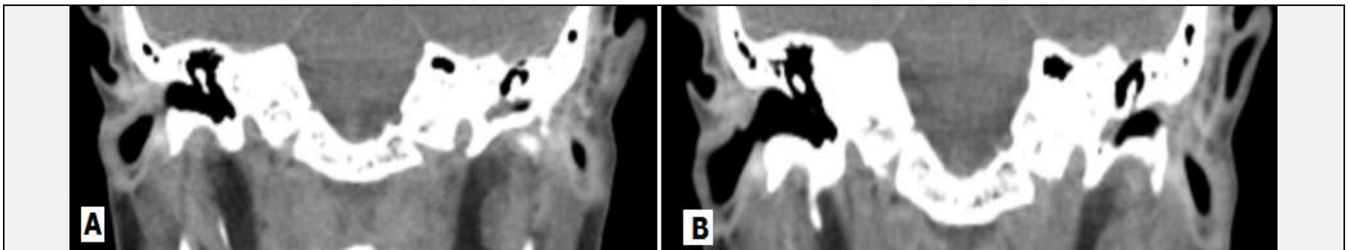

Figure 3. (a) and (b) Coronal Reformatted Images of HRCT Temporal Bone Shows Presence of Soft Tissue in the Left Middle Ear, Mastoid and Prussak's Space Suggestive of Cholesteatoma with Erosion of Left Middle Ear Ossicles and Tegmen Tympani

Data sharing statement provided by the authors is available with the full text of this article at jebmh.com.
Financial or other competing interests: None.
Disclosure forms provided by the authors are available with the full text of this article at jebmh.com.
I sincerely thank, Dr. Puneet Shirbur and Dr. Manasa Pandith Assistant Professors, Department of Radiodiagnosis, M.V.J. Medical College and Research Hospital, Bangalore for their continuous encouragement and help in doing this study. I also thank the CT technicians for their invaluable help in performing the HRCT studies on patients. I also thank the patients for their cooperation.

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