



HIGH RESOLUTION COMPUTED TOMOGRAPHY AS THE PRIMARY IMAGING MODALITY IN EVALUATION OF CHRONIC INFECTIOUS DISEASE OF THE MIDDLE EAR

Radiodiagnosis

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ABSTRACT

INTRODUCTION: HRCT, a modification of routine CT provides a direct visual window into the temporal bone providing hitherto unavailable minute structural details. The purpose of the study is primarily to understand the capability of HRCT in diagnosis and detection of pathologies of the temporal bone.

AIMS AND OBJECTIVES:

1. To study various imaging patterns on High Resolution Computed Tomography in chronic infectious middle ear diseases and inflammations.
2. To evaluate the extent and sites of involvement of the middle ear and the mastoid air cell system in 50 patients.
3. To study the effect of infections of the tympano-mastoid compartment on the adjacent, critical and important neurovascular structures.
4. To provide a road map to the surgeon prior to patient's management plan.

PATIENTS, MATERIALS AND METHODS: The study was conducted at GOVERNMENT GENERAL HOSPITAL, GUNTUR. We included patients clinically suspected to have infectious disease of the middle ear, who were referred for HRCT of the temporal bone in our hospital during a period of 19 months from January 2017 to August 2018. Un enhanced CT of the PNS was performed for 50 patients in the axial plane, complemented by coronal and sagittal reconstructions. The investigations were performed by using a GE BRIGHT SPEED 16 slice spiral CT machine.

OBSERVATIONS AND RESULTS: During the period of 19 months of the study, 50 patients who fulfilled the inclusion criteria were studied, out of which 52 percent were male and 48 percent were female. Most of the patients were in the 20-30 years age group comprising 55 percent of the study population. Patients with the clinical suspicion of middle ear infections were sent for evaluation with HRCT of the temporal bone. All 50 patients had positive findings indicating infectious disease of the middle ear.

KEYWORDS

INTRODUCTION:

Many imaging modalities are available for the evaluation of the temporal bone pathologies including plain radiographs, angiography, air and non-ionic contrast cisternography, computed tomography (CT), and magnetic resonance imaging (MRI). CT and MRI are currently the most widely used techniques and have largely replaced the other modalities.

Conventional radiography has been of value in screening the entire temporal bone. It produces a composite single plane image of a tridimensional temporal bone resulting in superimposition where larger and denser structures obscure smaller and less dense ones. CT scanning excels in the evaluation of bone and air space anatomy and disorders. CT also has the advantage of producing images with higher contrast and a better spatial resolution.¹

HRCT, a modification of routine CT provides a direct visual window into the temporal bone providing hitherto unavailable minute structural details. The purpose of the study is primarily to understand the capability of HRCT in diagnosis and detection of infectious pathologies of the temporal bone.

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 otoscopic findings.

Various anatomical variants encountered during middle ear imaging are as follows:

- Dehiscent facial nerve
- Aberrant internal carotid artery
- Jugular bulb variants
- Persistent stapedial artery
- Anterior and wider sigmoid sinus
- Size of mastoid antrum
- Presence of Koerner's septum
- Deep posterior wall recesses
- Low lying middle cranial fossa

HRCT appearance:

Dehiscent facial nerve: The mid tympanic segment is the most common site of involvement. The nerve is seen in cross section below the lateral semi circular canal on coronal images. This nerve is prone to infection and surgical trauma².

Aberrant internal carotid artery: It occurs when an enlarged inferior tympanic artery anastomoses with enlarged carotico-tympanic artery as a result of regression of cervical internal carotid artery. Aberrant internal carotid artery is seen entering the tympanic cavity through the enlarged tympanic canaliculus posterior to the normal internal carotid artery. It courses anteriorly across the promontory to join the horizontal internal carotid artery. It is seen as a soft tissue density and may mimic a vascular middle ear mass.

Jugular bulb variants: Asymmetric jugular bulbs. A high riding jugular bulb which extends above the tympanic spine. A dehiscent jugular bulb presents as a vascular mass in the retrotympanum. It is best seen on coronal CT as being directly continuous with the middle ear.

Jugular diverticulum is a finger like projection from the jugular bulb which projects cephalad

Persistent stapedial artery: The foramen spinosum is absent and the proximal tympanic segment of the facial nerve canal is enlarged. This important anomaly is to be identified to prevent excess intraoperative bleeding.

A wide sigmoid sinus and mastoid antral size: It is present more anteriorly and the mastoid antral size is consequently compromised. The post auricular approach has to be guarded in these cases to prevent entry into the sigmoid sinus.

Koerner's septum: It is a bony demarcation between mastoid and temporal squamae. It presents as a thick bony plate during mastoid surgery and may mimic sigmoid wall.

Deep posterior wall recesses: These are the facial canal recess and sinus tympani. On occasion these may be abnormally deep and house occult infection.

Low lying middle cranial fossa: It occurs due to absence of tegmental

pneumatization. The tegmen plate is thin and prone to infection and surgical trauma.

AIMS AND OBJECTIVES OF THE STUDY:

1. To study various imaging patterns on High Resolution Computed Tomography in chronic infectious middle ear diseases and inflammations with emphasis on temporal bone high resolution imaging.
2. To evaluate the extent and sites of involvement of the middle ear and the mastoid air cell system in 50 patients.
3. To study the effect of infections of the tympano -mastoid compartment on the adjacent, critical and important neurovascular structures.
4. To provide a road map to the surgeon prior to patient's management plan.

PATIENTS, MATERIALS AND METHODS:

The study was conducted at GOVERNMENT GENERAL HOSPITAL, GUNTUR. We included patients clinically suspected to have infectious disease of the middle ear, who were referred for HRCT of the temporal bone in our hospital during a period of 19 months from January 2017 through August 2018. Unenhanced CT of the PNS was performed for 50 patients in the axial plane, complemented by coronal and sagittal reconstructions. Contrast enhanced study was done wherever intracranial extension was suspected. The investigations were performed by using a GE BRIGHTSPEED 16 slice spiral CT machine.

For axial studies, patients were put in supine position. Direct scans 0.6 mm in thickness were made. The exposure settings used were 140 kVp and 80 to 100 mAs.

INCLUSION CRITERIA:

1. Patients clinically suspected to have chronic otitis media due to attico- antral or tubo- tympanic pathology (unilateral or bilateral).
2. Age group of 5- 70 years, both men and women.

EXCLUSION CRITERIA:

1. History of trauma.
2. Patients with malignancies of the ear.
3. Congenital ear disease.
4. Patients unfit for surgery or anaesthesia.
5. Pregnant women.

In all cases, systematic studies of the Temporal bone were performed in axial, complemented by coronal and sagittal reconstructions. Analysis of anatomical variants was performed both using a soft tissue window and a bone density window.

All the cases were also evaluated for the presence of anatomical variants of the middle ear.

CT Machine:

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 topogram.

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.

Contiguous 2mm thick slices were obtained at 3mm interval using an ultra high algorithm with a scan time of 4 seconds at a 133KV tube voltage. The mA selected was 70.

At 140 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 medium was injected wherever there was clinical

suspicion of intra cranial extension of infection.

HRCT Technique:

CT excels in the evaluation of disorders that primarily affect air spaces or cortical bone.

The optimal technique for HRCT was described in detail by Shaffer and Turski³. Gantry angulations for axial and coronal scans have been suggested for evaluating specific intratemporal structures⁴.

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.

HRCT comprises the use of a thin collimation, a high spatial frequency algorithm, smallest practical FOV (15 to 20cm) and a large reconstruction matrix (512 x 512). With a 1cm collimation the volume averaging within the plane of scan reduces the ability of CT to resolve small structures significantly. Therefore, scanning with thin collimation is essential. A high spatial frequency algorithm reduces image smoothing and increases spatial resolution, making structures appear sharper. This also increases the noise present in the image, which is reduced by increasing the KVp and MAs setting.

CT images are usually acquired or displayed in axial and coronal planes. For axial imaging, sections are made in a plane rotated 30 degrees 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 artefacts. Direct coronal images are usually obtained at an angle of approximately 120 degrees from arthropologic baseline, while reconstruction coronal images are usually oriented 90 degrees from arthropologic baseline.

Retrospective image targeting and reconstruction of the other side from stored raw data, significantly reduces image pixel size and increases spatial resolution. The important patient factor influencing HRCT is motion. Therefore, patients were instructed to the motionless during the procedure.

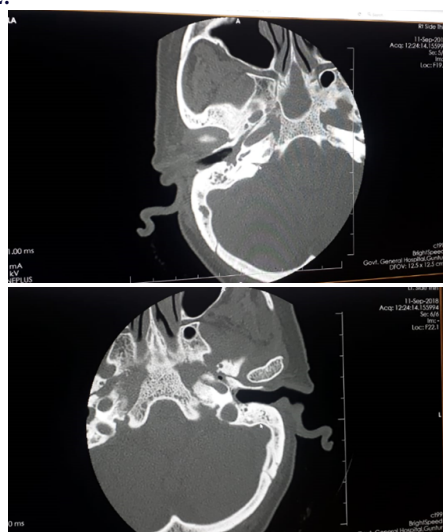
For contrast enhancement, a bolus injection of Diatrizoatemglumine and Diatrizoatesodium were given in the dose of 300mg Iodine/kg of body weight Trazograf or urografin 60% was used in children and trazograf or urografin 76% was used in adults. This was given just before the contrast enhancement CT was to be performed.

CASES:

CASE 1:



FIGURES 1 & 2: Case 1: Mucosal thickening in left middle ear cavity along with soft tissue density in the left mastoid air cells in a case suggesting Otitis with mastoiditis. The scutum and the semicircular canals were noted to be preserved.

CASE 2:

Figures 3 & 4: Case 2: A Case showing mucosal thickening with soft tissue density in bilateral mastoid air cells suggesting bilateral otitis media with mastoiditis. Scutum and ossicles were preserved bilaterally.

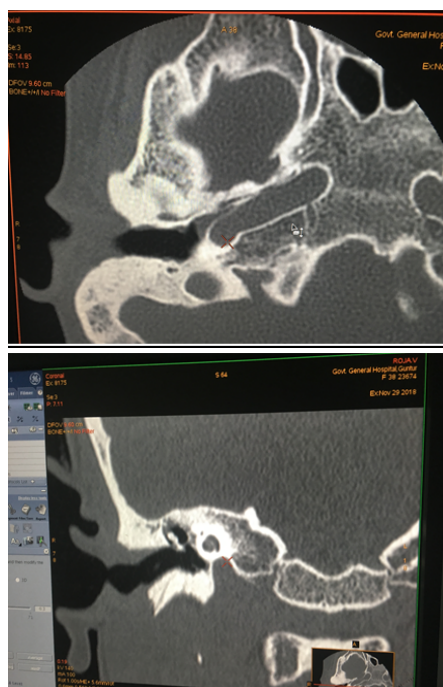
CASE 3:

Figure 5 & 6 : Case 3: Another case showing mucosal thickening the middle ear cavity indicating chronic otitis., Coronal reformat in a case where there was mucosal thickening but the ossicles and scutum were preserved as shown.



Figure 7: Case 4: A case showing asymmetry of jugular bulbs

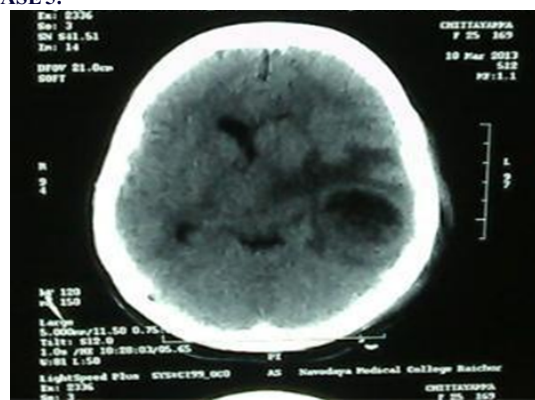
CASE 5:

Figure 8: Case 5: Mastoiditis with left temporoparieto occipital abscess.

OBSERVATIONS AND RESULTS:

During the period of 19 months of the study, 50 patients who fulfilled the inclusion criteria were studied, out of which 52 percent were male and 48 percent were female. Most of the patients were in the 20-30 years age group comprising 55 percent of the study population .The most common symptoms being otorrhea and otalgia.

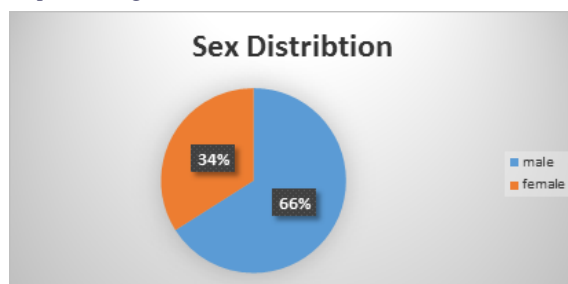
Anatomical variants like a dehiscence jugular bulb was seen in one patient, and asymmetry of jugular bulbs was seen in 2 patients. No other anatomical variants were encountered. Patients with the clinical suspicion of middle ear infections were sent for evaluation with HRCT of the temporal bone. All 50 patients had positive findings indicating infectious disease of the middle ear.

29 patients (58%) were noted to have chronic otitis media with mastoiditis while 21 patients (42%) had cholesteatomas in their middle ear .The left ear was involved in 23 patients while the right ear was involved in 21 patients. Bilateral involvement was rare in our study and was seen in 6 patients.

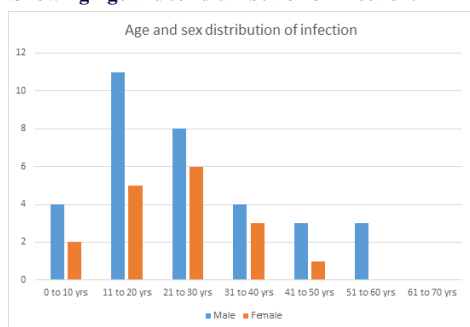
Intra operative correlation was done whenever possible with the HRCT findings and we found that there was excellent correlation between the findings demonstrated by HRCT and intraoperative demonstration of pathology.

Total number of patients = 50**Table Showing Sex Distribution**

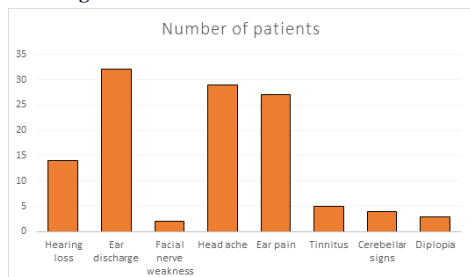
Sex	No. of Patients	Percentage
Male	33	66
Female	17	34

Graph Showing Sex distribution**Table Showing Age and sex distribution of infection.**

Age in years	Male	Female
0-10	4	2
11-20	11	5
21-30	8	6
31-40	4	3
41-50	3	1
51-60	3	0
61-70	0	0

Graph Showing Age and sex distribution of infection.**Table Showing Age Distribution**

Age (in years)	No. of Patients	Percentage
0-10	6	12
11-20	16	32
21-30	14	28
31-40	7	14
41-50	4	8
51-60	3	6
61-70	0	0

Graph Showing Clinical Features**Table Showing Distribution of Infection**

Distribution of Infection	No. of Patients	Percentage
Cholesteatoma	21	42
Otitis media with Mastoiditis	29	58

Table showing Ear affected

Unilateral/Bilateral	No. of Patients
Left	23
Right	21
Bilateral	6

Table Comparison between CT and operative finding in infections

CT appearance of studied patients	No. of patients	No. of patients with similar operative findings
Opacification of external ear	3	3
Cholesteatoma	15	12
Opacification of mastoid air cells	16	15
Ossicular erosion	14	14
Intra cranial extension	6	6

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. Innovations have become common in the Radiology Department, and today the introduction of new ideas and methods and refinements in existing techniques are apparent. One such development that is a revolutionary tool of medicine is computed tomography (CT).

The word tomography was first used by Grossman in 1935 (from Greek tomos, meaning "section"). A conventional tomogram is an image of a section of the patients that is oriented parallel to the film. In 1937, Watson introduce tomographic technique in which the sections were transverse sections and this technique was referred to as transverse axial tomography. However these images lacked enough detail and clarity to be useful in diagnostic radiology.

CT overcomes the limitations of tomography by using image reconstruction from projections to produce sharp and clear images. The mathematical achievements of Radon in 1917 prompted a variety

of techniques of reconstruction by many authors referred to an inverse radon transformation.⁵

According to Lloyd et al study, High-resolution axial and coronal computed tomographic (CT) scans were compared with coronal and sagittal complex motion tomograms in patients with suspected middle ear cholesteatomas. Information on CT scans equaled 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.⁶

According to Fritz P et al who took Sixty-two patients with different temporal bone lesions were prospectively examined by high-resolution computed tomography (CT) and conventional plain radiography, including pluridirectional 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).

According to Howard JD, Elster AD, May JS study of Three-dimensional (3D) surface renderings were obtained from routine axial computed tomographic (CT) images in 15 patients with a variety of complex temporal bone abnormalities. The 3D CT reformations served as an adjunct to conventional sectional CT examination. While no diagnosis was substantially changed because of the 3D CT images, they did provide a more global perspective in cases of large tumors, bony destruction and fractures and at the postmastoidectomy site. Three-dimensional CT surface reformations are now practical and may be potentially useful for visualizing temporal bone lesions characterized by complex destructive change. (Howard JD, Elster AD, May JS. Temporal bone)⁷

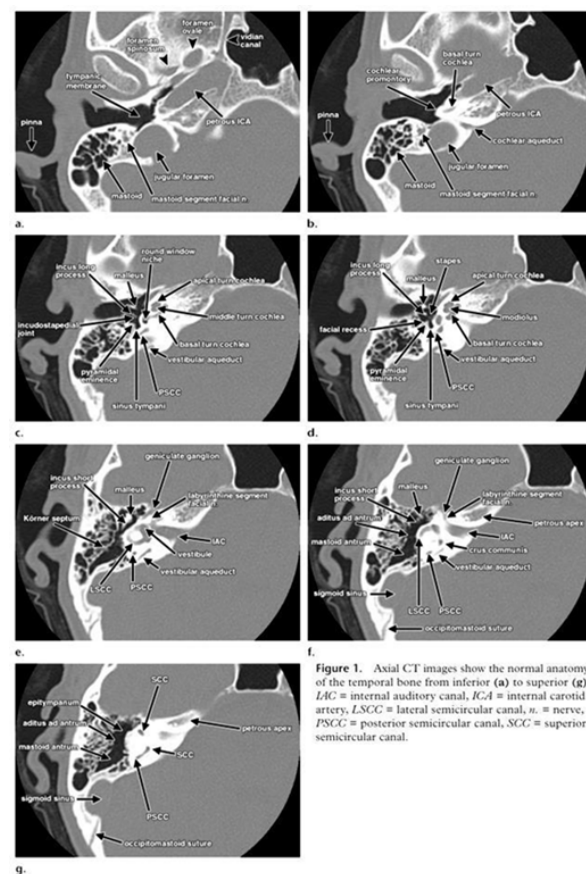
NORMAL HRCT ANATOMY OF TEMPORAL BONE

Figure 1. Axial CT images show the normal anatomy of the temporal bone from inferior (a) to superior (g). IAC = internal auditory canal, ICA = internal carotid artery, LSCC = lateral semicircular canal, n. = nerve, PSCC = posterior semicircular canal, SCC = superior semicircular canal.

This study is undertaken to develop a systemic method for evaluation of temporal bone as there are a variety of other imaging modalities. The lowest radiation dose to the lens, visualization of small bony structures, technical factors, ease of patient positioning, interpretation of the images and economic factors were all considered.

HRCT of the temporal bone helps in the accurate assessment of pathology prior to surgical exploration regarding location, extent and complication of the disease. It also helps in the proper preoperative assessment of the neurovascular structures and in the intracranial extension of the pathology. Administration of a contrast medium can further help the cause by enhancing the soft tissue resolution and is especially useful in cases suspected to have intra cranial extension.

Patients with clinical suspicion of middle ear infection were studied. The age range was from 0 months to 70 years, the youngest one was 2 years old, oldest one was 55 years. 50 cases, who were suspected clinically to have infectious disease of the middle ear were studied and out of which, all the patients had positive findings. Patients with otitis media and mastoiditis were 29 in number and patients with cholesteatomas were 21 in number.

Study by GAS Lloyd et al(1980)⁸ in 30 patients with CT showed infection as the 3rd most common cause of pathology among all the temporal bone lesions. The variations in certain statistical values between our study and the above mentioned study by GAS Lloyd could be due to the increasing number of complications associated with the infections among the patients in our study because of the late presentation of the disease in our study, which could be attributed to the low socio economic strata and illiteracy of the patients.

Table Showing Age Distribution comparison

Age in years	Gupta et al (%)(1998) ⁵⁰	Present Study (%)2018
0-10	11.46	12
11-20	30.57	32
21-30	33.12	28
31-40	16.56	14
41-50	8.28	8

In the current study, maximum age distribution of cases is seen in the 2nd decade of life. 32 % of the cases in this were in the age group of 11-20 years. Mean age of presentation in our study is 19.92 years which is in accordance with the study conducted by Gupta et al (1998)⁵⁰.

The male to female sex ratio in the present study is 2 : 1 which correlates well with the male to female ratio in the study conducted by Paparella and Kim (1977)⁹.

Limitations of the use of CT in evaluation of chronic middle ear disease:

- 1) CT scans of chronically draining ears demonstrated abnormal soft tissue densities in the middle ear cavities or the mastoid air cells. However, if this soft tissue mass was not associated with adjacent bone erosion, it was not practically possible to discern whether or not cholesteatoma was present. Infrequently, the soft tissue masses that were found proved to be granulation tissue or mucosal hypertrophy. Therefore, it can be concluded that, of greater positive predictive value in the diagnosis of cholesteatoma is the presence of abnormal soft tissue densities with adjacent bony erosion.
- 2) Tympanic membrane thickening and perforations were difficult to assess on HRCT and are better seen on otoscopy.

CONCLUSION:

HRCT outweighs the conventional modalities of investigations and provides higher spatial resolution and better soft tissue contrast.

For the assessment of middle-ear infections, a close clinical correlation is essential to evaluate the nature of middle-ear soft tissue masses as cholesteatoma is mimicked by many other middle-ear pathologies. In these cases, HRCT-

1. Is far advantageous in assessing the complications of infection.
2. Lays down an anatomical roadmap for the surgeon preoperatively.
3. Predicts certain normal variants of surgical significance preoperatively.
4. Identifies the hidden areas of the middle-ear, namely the posterior recesses.

A previously operated ear has an altered anatomy. The disease of such a ear has a different morphological pattern of involvement.

CT scan plays an important role-

1. To comment regarding the extent of surgery, and the general overall condition of the postoperative temporal bone including the internal auditory canal.
2. The residual/recurrent disease can be assessed.
3. Status of the inner ear can be established.
4. The facial nerve anatomy can be clearly depicted. The relationship of the facial nerve to any surgical change or cholesteatoma tissue can be studied.
5. The status of the ear ossicles or prosthesis employed by the surgeon can be seen.
6. The radiologist must pay close attention to anatomical variants in the preoperative evaluation and provide a road map to the surgeon and help avoid possible complications and improve success of management strategies.

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