Sudan University of Science and Technology

College of Graduate Studies

Study of Temporal Bone Diseases Using High Resolution Computed Tomography (HRCT)

دراسة أمراض العظم الصدغي باستخدام الأشعه المقطعيه عالية التمييز

A thesis Submitted for Partial Fulfillment the Requirements of M.Sc. Degree in Diagnostic Radiologic Technology

By

Enaam Abuelgasim Hassan Elamin

Supervised by

Dr. Ikhlas Abdelaziz Hassan

2017

الآيـة

بسم الله الرحمن الرحيم

ٱلرَّحْمَـٰنُ (١) عَلَّمَ ٱلقُرْآنَ (٢) خَلَقَ ٱلإنسَانَ (٣) عَلَّمَهُ ٱلبَيَانَ (٤)

(صدق الله العظيم)

Dedication

To my parents

To my brothers

To my sisters

To my teachers, friends and colleagues

Acknowledgments

Praise and thanks are due to **Allah, the lord and creator.**

Special thanks to my supervisor, Dr. Ikhlas Abdelaziz, for her valuable and continuous help and guidance.

My thanks are extended to the staff of the CT department in Alzaytouna specialist hospital & Antalya medical center which helped me in collecting the information.

Abstract

This study was aimed to study the temporal bone diseases using HRCT. Data was obtained retrospectively from 52 patients of different ages and gender who are selected from ENT hospital and clinically suspected of having symptoms related to the temporal bone such as ear discharge, conductive hearing loss, vertigo and facial palsy. traumatic patients were excluded.

The study was done at Alzaytouna specialist hospital&Antalya medical center during 2016 year. HRCT images were obtained by taking 2mm sections using ultra high algorithm in both coronal and axial planes. Contrast media was used as and when required. The results were then analyzed statistically.

In this study temporal bone diseases were more common in female 60% than male population 40%. Majority of patient are in the age group of 21-40 years old. Infection was the most common pathology 82%, followed by neoplasm (benign and malignant) 10%, congenital malformation 2% and other pathological lesions 6%. The incidence of unilateral involvement 66% is more than bilateral involvement 34%.

HRCT has major role in the demonstration of detailed anatomy and identifying various findings related to the location, extent and complication of the disease.

HRCT can able to evaluate air space and bony structure and it can detect the presence of opacification and soft tissue density but cannot able to distinguish the type of tissues, the clinical correlation and biopsy was advised in this cases.

HRCT has a great importance in guiding the surgical approach that can prevent further serious complications.

المستخلص

هدفت الدراسه لدراسة امراض العظم الصدغي بواسطة الأشعه المقطعيه عالية التمييز. وقداشتملت الدراسه علي 52 مريض من مختلف الاعمار والاجناس تم اختيارهم من الحالات المحوله من مستشفي الانف والاذن والحنجره لديهم اعراض امراض العظم الصدغي مثل الصديد المزمن,الفقد الجزئي او الكلي للسمع ,الدوار و اعراض شلل العصب السابع واستبعدت الدراسه مرضي الاصابات.

اجريت هذه الدراسه خلال عام 2016 في مستشفي الزيتونه التخصصي ومركز انطاليا الطبي.

تم اجراء الأشعه المقطعيه عالية التمييز لجميع الحالات في الوضعين المحوري والتاجي عن طريق اخذ مقاطع متجاوره ,سمك المقطع 2 ملم مع استخدام مرشح عالي التمييز وقد استخدم وسيط التباين حسب الحوجه وتم تحليل النتائج احصائيا.

وجدت الدراسه ان امراض العظم الصدغي اكثر انتشارا بين الاناث 60% من الذكور40% واكثر فئه عمريه عرضه للأمراض هي 20-40 ومثلت الالتهابات اكثر الأمراض شيوعا 82% تليها الاورام (حميده و خبيثه) 10% وشكلت التشوهات الخلقيه 2% من الحالات وعدد من الامراض غير الشائعه 6%. و ان معدل الاصابه بجانب واحد66 % اكثر من الاصابه بالجانبين 34%.

اكدت الدراسه ان للأشعه المقطعيه عاليه التمييز دورا اساسيا في تحديد مكان الاصابه بدقه ومدي انتشارها والمضاعفات الناتجه عنها.كما يمكنها الكشف عن التغيرات الطارئه علي العظم وكمية الهواء, وتؤكد علي وجود ضبابيه وانسجه رخوه لكنها لا تستطيع تمييز نوع النسيج وينصح في هذه الحالات بالمقارنه مع الفحص السريري او اخذ عينه للفحص المعملي.

للأشعه المقطعيه عاليه التمييز مقدرة الكشف عن الاختلافات التشريحيه الطبيعيه التي تمثل اهميه قصوي لجراحي الانف والاذن والحنجره مما يفيد في اختيار الاسلوب المناسب للمريض وعدم تعرضه لمخاطر ومضاعفات.

List of tables

.

List of Figures

List of abbreviations

AN	Acostic neuroma
CPA	Cerepropontine angle
CSF	Cerepro spinal fluid
CSOM	Chronic suppurative otitis media
CT	Computed tomography
EAC	External auditory canal
EBCT	Electron beam computed tomography
ELSTs	Endolymphatic sac tumors
EMI	Electric and Musical Industries
H	Hour
HRCT	High resolution computed tomography
IAC	Internal auditory canal
KO	Keratosis obturanse
KV	Kilovoltage
KW	Kilowaats
MA	Mili Ampair
ME	Middle ear
MPR	Miltiplaner reconstrction
OE	Otitis externa
OM	Otitis media
SNHL	Sensorineuronal hearing loss
TM	Tympanic membrane

Table of contents

Chapter One

Introduction

Chapter one

1.1 Introduction

Many imaging modalities are available for the evaluation of the temporal bone including plain radiography, angiography, cerebrospinal fluid analysis, air and non-ionic 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. CT has the advantage of producing images with higher contrast and a better spatial resolution. High resolution CT (HRCT) images are obtained with thin sections (1-2 mm) and special bony algorithm for high details. (Chakeres, 2003)

HRCT, a modification of routine CT, provides a direct visual window into the temporal bone providing hitherto unavailable minute structural details. HRCT scanning excels in the evaluation of bone and air space anatomy and disorders of temporal bone. (Chandra, 1999)

Computed tomography is the method of choice for imaging of temporal bone fractures, middle ear disease, and conductive hearing loss, although magnetic imaging can add important information. (Casselman, 1996).

Indications for computed tomography (CT) of the temporal bone have been significantly expanded with the inclusion of soft-tissue abnormalities of the external ear and the auditory canal. (Chakers, 1985)

Newer high resolution multidetector spiral imaging system can generate nearly isotropic voxels for multiplanar reconstruction, making need for multiple series with direct imaging in several planes unnecessary. (Chakeres, 2003)

Wide array of pathology may affect the relatively small anatomical region of the temporal bone. Often there is overlap of clinical symptom in pathological entities arising from temporal bone. Thus, the combination of a good clinical history in conjunction with dedicated temporal bone CT facilitates evaluation for subtle or not-so subtle disease. There are four general categories of pathology affecting the temporal bone: congenital malformations, inflammatory conditions, trauma and tumor and tumor-like conditions. (Phillips, 2012)

The most important advantage of spiral CT in temporal bone imaging is it is perfect visualization of the contrast between bony structure and the air in the middle ear. In addition to detailed evaluation of the bony structure and also permits assessment of soft tissue component as well. (Maffee, 1983)

Computed tomography (CT) has revolutionized imaging of the temporal bone. Recent advances in 32, 64 and now 128-sliceCT scanners allow the acquisition, volumetric data that allows image reconstruction in any plane. (Phillips, 2012)

1.2 The problem of study:

Temporal bone is complex structure with tiny bony object which are less than 1mm in diameter, these are close to the limits of resolution by imaging.

1.3 Objectives of the study:

1.3.1 General objective:

To study the temporal bone pathologies using HRCT.

1.3.2 Specific objectives:

- To determine the most common disease affecting the temporal bone.
- To find the outcome of HRCT scans in diagnosing of temporal bone disease.
- To evaluate the bony structure and assess the soft tissue component.
- To assess temporal bone pneumatization

.

1.4 Significances of study:

This study will enhance evaluation of temporal bone disease by HRCT. Although there is other modalities like MRI and X-ray but cannot give high resolution and clear detail of temporal bone.

1.5 Overview of the study:

This study fall into five chapters: chapter one is an introduction what is CT temporal as well as statement of the problem, objectives and overview of the study. Chapter two theoretical backgrounds and literature review of the study. Chapter three which deal with material and method ,chapter four which presented the results of the study, chapter five which involves discussion, conclusion and recommendations. Finally the study ends with the references and appendixes.

Chapter two

Theoretical background and literature Review

Chapter two

Theoretical background and literature Review

2.1Anatomy of the temporal bone:

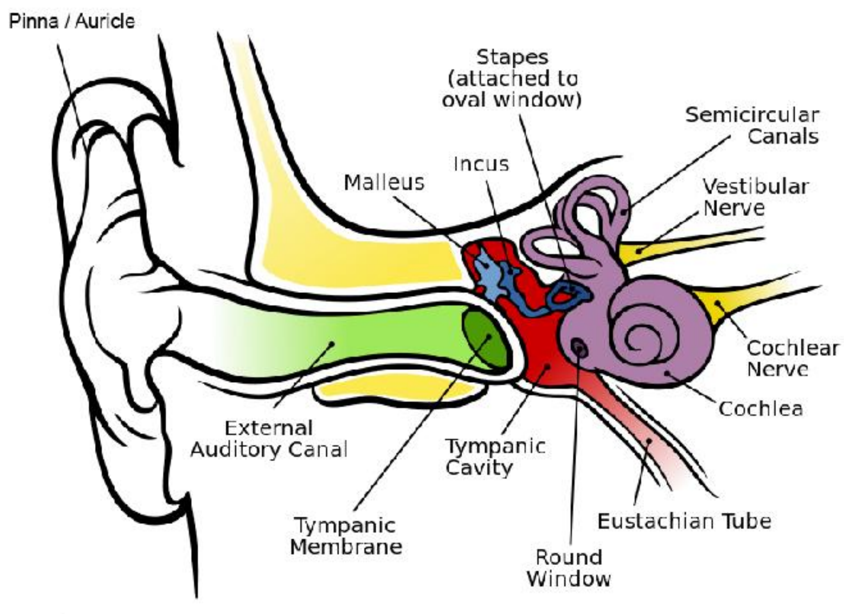
The two temporal bones contain many complex and important structures. They form part of the sides and base of the cranium and together with the sphenoid bone create the middle cranial fossa. The temporal bone can be divided into four portions: squamous, tympanic, mastoid, and petrous. (Lorrie, 2007)

The thin squamous portion projects upward to form part of the side walls of the cranium. Extending from the squamous portion is the zygomatic process, which project anteriorly to the zygoma of the face to form the zygomatic arch. At the base of the zygomatic process is a bony eminence termed the aritcular tubercle that forms the anterior boundary of the mandibular fossa. The mandibular fossa is the depression that articulates with condyloid process of the mandible, creating the tempromandibular joint. (Lorrie, 2007)

The tympanic portion lies below the squama and forms the majority of the external auditory meatus. Just posterior to the tympanic portion is the mastoid portion, which has a prominent conical region termed the mastoid process. The mastoid process encloses the mastoid air cells and mastoid antrum.(Lorrie, 2007)

The mastoid antrum is located on the antrosuperior portion of the mastoid process. It is an air-filled cavity that communicates with the middle ear (tympanic cavity). (Lorrie, 2007)

The petrous portion of the temporal bone is pyramidal in shape and situated at an angle between the surfaces of the petrous pyramid forms the anterior bony limit of the posterior fossa. Near the center of this surface is the opening to the internal auditory canal, which transmits the seventh and eighth cranial nerves. Other openings associated with the posterior surface of the petrous pyramid are the jugular foramen and the carotid canal, which provide passage for the internal jugular vein and the internal carotid artery. An enlargement of the jugular foramen is the jugular fossa. The carotid canal courses superiorly at its lower segment then changes direction and is seen coursing posterior to anterior. Superior to the carotid canal is an indentation on the petrous portion called Meckel cave, Also known as the *trigeminal cave*, which located between two layers of dura and encloses the trigeminal ganglion. Between the apex of the petrous pyramid, The body of the sphenoid bone and the basilar portion of the occipital bone is jagged slit termed the foramen lacerum, which contains cartilage and allows the internal carotid artery to enter the cranium, providing small arteries that supply the inner surface of the cranium .the inferior surface of the petrous pyramid gives rise to the long slender styloid process that is attached to several muscles of the tongue and ligament of the hyoid bone. The stylomastoid foramen is situated between the mastoid process and styloid process. This foramen constitutes the end of the facial nerve canal. The interior of the petrous pyramid houses the delicate middle and inner ear structure figure (2.1). (Lorrie, 2007)



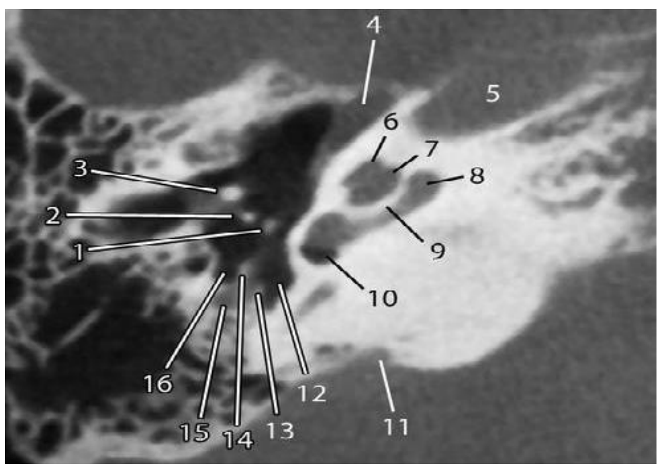
Figure(2.1): Overview diagram of the ear**.** This illustration represents the outer ear (pinna, external auditory canal, and outer portion of the tympanic cavity known as the ear drum), the middle ear (malleus, incus, stapes, and Eustachian tube) and the inner ear (cochlea, semicircular canals, and the vestibule). (Chittka and Brockmann, 2005).

2.1.1 Structure of the External, Middle and Inner Ear:

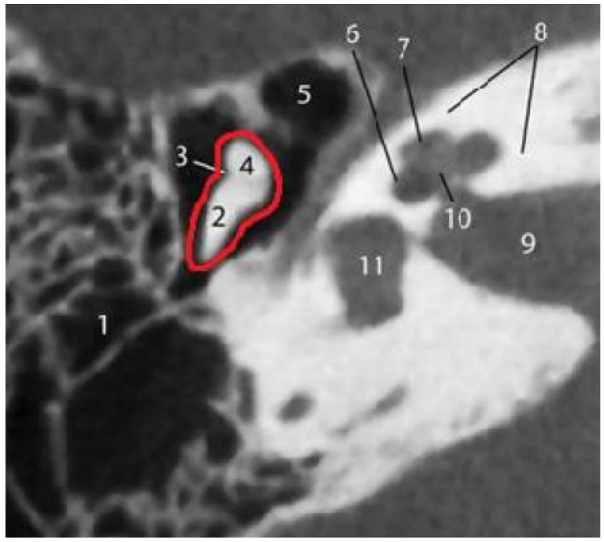
The structure of the ear can be divided into three main portions: external, middle, and inner.

The external ear consists of the auricle and the external auditory meatus. The external auditory meatus terminates at the tympanic membrane of the middle ear (TM).The air-containing middle ear, or tympanic cavity, communicates with both the mastoid antrum and the nasopharynx. Air is conveyed from nasopharynx to the tympanic cavity through the auditory tube (Eustachian tube). The external auditory canal (EAC) is an s-shaped tube terminated medially (centerally) by the TM. The walls of the EAC are lined with skin and the most external part of the canal is covered with small dust –filtering hairs and mucous glands producing cerumen (ear wax). The lateral (outer) one-third of the canal is surrounded by cartilage and the medial (inner) two-thirds of the canal pass through the temporal bone. The average length of the adult EAC is 25mm (1inch) (Wever & Lawrence, 1954; Yost&Nielsen, 1977).

The middle ear consist of the tympanic membrane and three auditory ossicles (malleus, incus,and stapes) as well as their supporting muscles (stapedius and tensor tympani) and ligament .The lining of the middle ear cavity covers the air cells of the mastoid bone figure (2.2&2.3). (Lorrie, 2007)

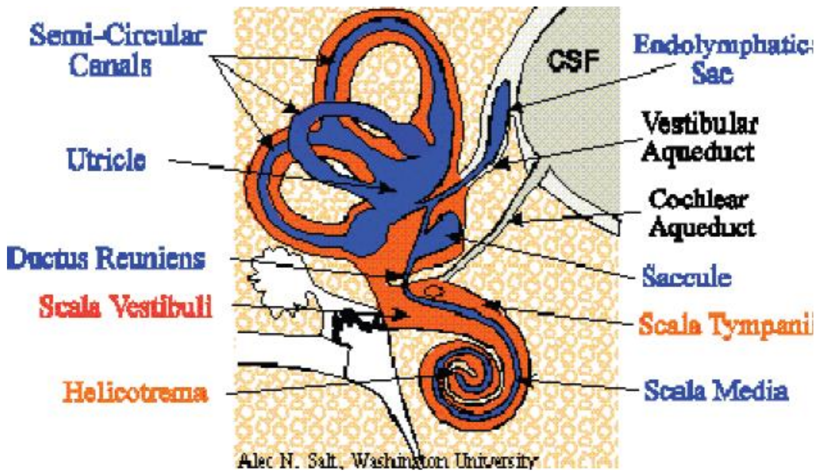


Figure(2.2): Axial CT scan of the middle ear. This axial CT scan illustrates the features of the middle and inner ear as well as surrounding structures. 1, stapes; 2, incus; 3, malleus; 4, tensor tympani; 5, carotid canal; 6, apical turn of the cochlea; 7, middle turn of the cochlea; 9, interscalar septum; 10, round window niche; 11, vestibular aqueduct; 12, sinus tympani; 13, stapedius; 14, pyramidal eminence; 15, mastoid portion of the facial nerve; 16, facial recess. (Juliano , 2013)



Figure(2.3): Axial CT of ossicular chain and surrounding structures .This figure shows an axial CT image of the middle ear and clearly demonstrates the ice-cream cone appearance of the ossicular chain (circled). 1, mastoid air cells; 2, incus; 3, incudomalleal joint; 4, malleus; 5, epitympanum; 6, basal turn of the cochlea; 7, middle turn of the cochlea; 8, oticcapscule; 9, IAC; 10, modiolus; 11, vestibule. (Juliano, 2013)

The inner ear or bony labyrinth contains the vestibule, semicircular canals, and the cochlea. The vestibule is small compartment located between the semicircular canals and the cochlea. Two openings of the vestibule are the oval window for the foot plate of the stapes and the vestibular aqueduct, which contains the endolymphatic duct .The semicircular canals are continuous with the vestibule and are easily identified because of their three separate passages (superior [anterior], posterior and lateral) that are at right angles to each other. The cochlear is a conical structure with a base that lies on the internal auditory canal. Located within the basilar turn of the cochlea is the round window. Within the bony labyrinth is a complicated system of ducts called the membranous labyrinth. The membranous labyrinth is filled with endolymph, a fluid that helps with the propagation of sound waves. Extending from the vestibule is a slender endolymphatic duct that terminates as the endolymphatic sac, which is located between two dural layers on the posterior wall of the petrous pyramid figure (2.4). (Lorrie, 2007)



Figure(2.4): The structures of the inner ear. (The darker [endolymph] and lighter [perilymph] spaces are filled with the inner ear fluids. The dashed line in the picture separates graphically the vestibular system [above] from the cochlea [below]. (Henry, 2007)

Temporal bone pneumatization is divided into five compartments: middle ear, squamo – mastoid (mastoid), perilabyrinthine, petrous apex and accessory. Accessory regions are;squamous, zygomatic, occipital and styloid cells.The squamomastoid region is subdivided into three compartments: mastoid antrum, central mastoid tract and the peripheral mastoid area .(Alberti, 1995)

The pneumatized cells are believed to appear on the 22-24thweeks of fetal life. The pneumatization of the mastoid cells begins at the 33rd weeks and continues up to 8-9 years of age. The antrum reaches to adult size on the 35th week. (Ahmet, 2004)

2.2 physiology:

2.2.1 The functions of temporal bone air cells are:

Reception of sound, Resonances, Insulation, Air reservoir action, Acostic dissipation and Protection from external violence and lightening of the weight of the skull. (Virapongse, 1985)

2.2.2 The function of auditory system:

The act of hearing is called audition. The sensory and perceptual system that facilitates hearing is called the hearing mechanism or the auditory system which consists of right and left ear connected through a network of ascending and descending neural fibers connected to the brain. The ear is organ for hearing and balance and it has three major parts: the outer ear (external ear), middle ear, and the inner ear. **(**Alberti, 1995)

2.2.2.1 Outer ear:

The outer ear is anatomical structure directing the sound waves to the middle ear and acting as a sound collector and acostic amplifier .It includes the pinna (auricle), which is the visible earflap, and the external auditory canal terminated by the tympanic membrane (TM). The TM separates the outer ear from middle ear. The acostic function of the outer ear is to collect and selectively amplify incoming acostic stimuli and to direct them toward the TM and associated structure of the middle ear. Additionally, both the pinna and the external auditory canal (EAC) protect the TM against injury, foreign bodies, and outside changes in temperature and humidity. (Alberti, 1995)

2.2.2.2Middle ear:

The stapedius and the tensor tympani muscles provide mechanical support for the ossicles but also contract when the ear is exposed to an intense sound .The contraction of stapedius muscles pulls the stapes and tilt its base in the oval window, thereby reducing the range of movement of the stapes. The tensor tympani muscle contraction pulls the handle of the malleus medially, tensing the TM, and reducing the amplitude of its oscillations. This contraction in response to a loud sound is known as the *acostic reflex* or (middle ear reflex) which is most effective at reducing the transmission of low frequency sound. (pickles, 1988)

2.2.2.3 Inner ear:

The vestibular system is organ of balance containing receptors sensitive to gravity, linear movement, and angular acceleration of the head. The cochlea contains the cochlear aqueduct that houses the neural receptors sensitive to vibrations and serves as the organ of hearing. **(**Alberti, 1995)

The vibration of the stapes in the oval window sets into motion the cochlear fluid (perilymph) in scala vestibuli. When the stapes is pushed medially, some of the incompressible fluid in the inner ear is pushed through the helicotrema to scala tympani, which causes an outward bulging of the round window. When the stapes pulled away, the round window membrane of scala tympani is displaced inward toward the cochlea. The presence of the round window eliminates potential reflections so that there are no interference effects inside the cochlear fluid during oval window motion. (Henry, 2007)

The motion of the oval and round window membranes are delayed against each other because of the time needed to move fluid through the helicotrema. These create pressure differentials between both channels which set into motion of basilar membrane. This movement set into motion of the organ of corti those results in creating a biochemical reaction in the nerve cells of the organ. The organ of corti is structure containing the vibration receptors of the inner ear that convert mechanical energy into electrical energy. This energy results in neural impulses that are transmitted to the brain. **(**Alberti, 1995)

2.2.3 Function of mastoid part:

Mastoid air cell system is an air reservoir and also an active cavity having gas exchange capability independent of Eustachian tube .Mastoid cavity buffers the effects of pressure change in the middle ear by supplying air to the middle ear. (Virapongse, 1985)

2.3 Pathology:

2.3.1 Normal variant:

2.3.1.1 Variant which simulate disease:

There are several normal variants which may simulate disease and it should be reported because they can be danger during surgical approach. (Vercruysse, 2006)

2.3.1.1.1 Cochlear cleft:

A cochlear cleft is a narrow curved lucency extending from the cochlea towards the promontory. It is often visible in infants and children but can also be seen in adults. It can be mistaken for fracture line or an otosclerotic focus. (Vercruysse, 2006)

2.3.1.1.2 Petromastoid canal:

The petromastoid canal or subarcuate canal connect the mastoid antrum with the cranial cavity and houses the subarcuate artery and vein .It diameter is around 0.5mm. It can be confused with a fracture line. (Vercruysse, 2006)

2.3.1.1.3 cochlear aqueduct:

The cochlear aqueduct is a narrow canal which runs toward the cochlea in almost the same direction as the as the direction as the inner auditory canal, but situated more caudally .It connects the perilymph with the subarachoid space and it point where infected cerebrospinal fluid. (Vercruysse, 2006)

2.3.1.2 Variant which may pose a danger during surgery:

2.3.1.2.1 Jugular bulb or jugular bulb diverticulum:

The jugular bulb often asymmetric, with the right jugular bulb usually being larger than the left .If it reaches above the posterior semicircular canal it is called a high jugular bulb. If bony separation between the jugular bulb and tympanic cavity is absent it termed a dehiscent jugular bulb. Rarely an out pouching is seen-this is known as jugular bulb diverticulm. (Vercruysse, 2006)

2.3.1.1.2 Bulging sigmoid sinus:

The sigmoid sinus can protrude into the posterior mastoid. It can be accidentally lacerated during a mastoidectomy and therefore should be mentioned in the radiological report when present. It can be mistaken for a fracture line. (Vercruysse, 2006)

2.3.2 External Auditory Canal:

2.3.2.1 Benign neoplasm:

The most common benign lesions of the external auditory canal include exostosis and osteomas. Exostoses are more common than osteomas. They tend to arise in the medial portion of the canal along the tympanomastoid and tympanosquamous suture lines. Exostoses are frequently bilateral. Where exostosis are often multiple with broad bases, osteomas are single with pedunculated shapes. They may also occur in the mastoid or IAC, but the EAC is by far more common. (Alan, 2004)

2.3.2.2 Malignant neoplasm:

Malignant neoplasm of the EAC is uncommon. Most involve the canal by local extension. Skin neoplasm such as squamous or basal cell more commonly occur on the auricle and then extend into the canal. Salivary gland neoplasm such as mucoepidermoid carcinoma or adenoid cystic carcinoma may also invade the EAC from the parotid. Squamous cell carcinoma of the EAC may mimic necrotizing external otitis due to the findings of pain, otorrhea, and bone destruction on CT. (Alan, 2004)

2.3.2.3Malignant Otitis Externa:

The term malignant, when referring to OE, does not imply tumor, but rather the aggressive nature of the disease. Other terms for the disease include necrotizing external otitis and skull base osteomyelitis. As the infection progresses, it may extend through the fissures of Santorini and access the deep neck spaces and infratemporal fossa resulting in life-threatening infections and cranial nerve deficits. Radiologic workup most commonly consists of CT scan to delineate bony destruction. If intracranial complications or extension is suspected, then MRI is preferred. (Alan, 2004)

2.3.2.4 Cholesteatoma:

While very common in the middle ear and mastoid, cholesteatoma occurs only about 0.1 – 0.5% of otologic patients. These lesions tend to occur in the posterior aspect of the EAC, directly lateral to the annulus. Due to this position, CT is often recommended to evaluate for involvement of the facial nerve. These lesions are commonly focal, do not extend around the circumference of the EAC, and often present with persistent otorrhea and pain. On CT the lesions usually appear focal and show erosion of local bony cortex. (Alan, 2004)

2.3.2.5 Keratosis Obturans:

This condition usually occurs in patients with a history of sinusitis or bronchiectasis and not has persistent drainage. It occurs throughout the EAC, often causing total obstruction of the canal. Rather than destroying the bone, KO progressively widens the EAC in a broad, usually circumferential manner. The bony cortex should appear intact on CT figure (2.5). (Alan, 2004)

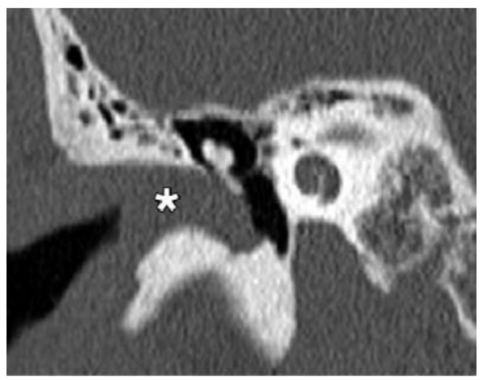


Figure (2.5): Coronal CT image of keratosis obturans demonstrates a soft-tissue plug in the external canal(*), with mild expansion of the canal but no bone erosion. (Juliano, 2013)

2.3.3 Middle Ear and Mastoid:

2.3.3.1 Otitis Media:

Clinically, OM is less aggressive than mastoiditis. It may cause local pain and drainage, but pain over the mastoid cortex and swelling over the mastoid cortex would be unusual for the diagnosis of OM. Radio graphically, fluid may partially or totally fill the middle ear space and mastoid cavity, which is the source of confusion in the differential. OM may have complete opacification of the mastoid and ME space, but will have no destruction of bony septae or mastoid cortex. (Alan, 2004)

2.3.3.2 Mastoiditis:

Where OM will have partial to complete ME and mastoid opacification, mastoiditis commonly will have complete mastoid opacification. The presence of bony septae destruction may allow for the application of the term “coalescent” mastoiditis which indicates the destructive nature of the disease. Lateral cortex disruption may result in a sub-periosteal abscess. Inferior cortical disruption (mastoid tip) may result in a Bezold’s abscess. Superior disruption of the tegmen may result in meningitis, venous sinus thrombosis, or several types of intracranial abscesses figure (2.6). (Alan, 2004)

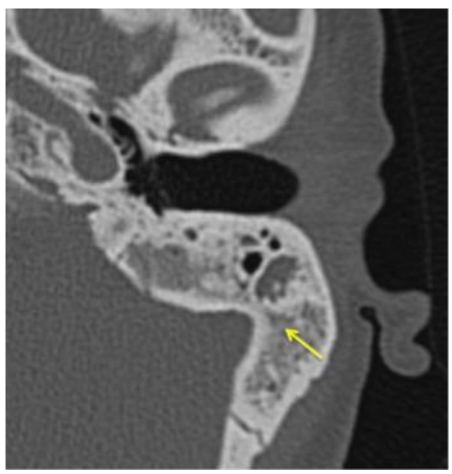


Figure (2. 6): Axial CT image of chronic mastoiditis. Shows cloudy Mastoid cells with fewer than normal, thickened trabeculae (Juliano , 2013)

2.3.3.3 Cholesteatoma:

Cholesteatoma may present as a primary or acquired lesion. Congenital lesions are by far less common, accounting for only 2% of cholesteatomas. They may occur anywhere within the temporal bone, and radiologic differentiation may not be possible. Acquired cholesteatomas are thought to arise from aberrant rests of epithelial cells which may be present due to trauma, prior surgery, or more commonly, eustacian tube dysfunction or recurrent otitis media. Both eustacian tube dysfunction and recurrent OM are thought to produce a prolonged negative pressure within the middle ear space. This allows for a slow retractive process to occur along the weak area of the TM at the pars flacida. The result is a pocket of epithelial cells which produce keratin but cannot clear this debris. The result is a cholesteatoma. As a result, most acquired cholesteatomas will present within Prussak's space which is just deep to the pars flacida. Early cholesteatomas of this region may begin to erode the scutum (superior EAC wall) or the ossicles.

As the mass grows, openings in Prussak's space allow the tumor to spread posteriorly where it then has access to the remainder of the middle ear space and mastoid. When it expands, it causes remodeling or erosion of surrounding bone, which may show as scutum, ossicle, or septae erosion. Large lesions may erode into vital structures, and care should be taken to evaluate the tegmen for possible dura exposure, fallopian canal for dehissences of the facial nerve, and the bony labyrinth for canal fistulas figure (2.7). (Alan, 2004)

Figure (2. 7: Axial CT of cholesteatoma shows a soft- tissue mass in Prussak space and extend medial to the ossicles. (Juliano, 2013).

2.3.3.4 Paragangliomas,also known as **glomus tumors** or **choddectomas:**

Are the second most common tumor to involve the temporal bone and the most common tumor of the middle ear. These tumors originate from paraganglia along the tympanic branch of the glossopharyngeal nerve and the auricular branch of the vagus nerve and within the interavagal paraganglia inferior to the foramen .Paragangliomas are highly vascular and can result in bone destruction as the tumor grows figure (2.8). (Alan, 2004)

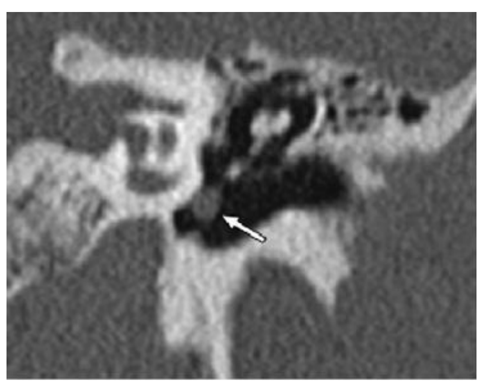


Figure (2.8): Coronal CT image of glomustympanicum demonstrates a Small, rounded nodule in the middle ear abutting the cochlear Promontory (arrow). (Juliano, 2013).

2.3.3.5 Chronic suppurative otitis media:

Chronic suppurative otitis media (CSOM) is chronic inflammation of the middle ear and mastoid cavity, which presents with recurrent ear discharges or otorrhoea through a tympanic perforation. (Acuin, 2004)

Safe CSOM is CSOM without cholestetoma .It can be sub divided into active or inactive depending on whether or not infection is present .Unsafe CSOM involves cholestetoma. Cholestetoma is a non malignant but distructive lesion of the skull base .The underlying pathology of CSOM is an ongoing cycle of inflammation, ulceration, infection and granulation. Acute infection of the middle ear causes irritation and inflammation of mucosa of the middle ear with oedema .Inflammation produces mucosal ulceration and break down of epithelial lining .Granuloma formation can develop into polyps in the middle ear. This process may continue, destroying surrounding structures and leading to various complications of CSOM. (Acuin, 2004)

2.3.4 Labyrinth:

2.3.4.1 Labyrinthitis:

This disease has multiple causes; bacterial, viral, autoimmune, or traumatic. Viral is the most common, and symptoms include vertigo, sensory hearing loss, tinnitus, and possibly nausea/vomiting. While radiographic confirmation of this disease is not necessary for diagnosis in most cases, common features may be noted on imaging. MRI is the study of choice. This usually demonstrates enhancement of the membranous labyrinth on T1 after contrast administration. Pre-contrast images should not enhance, and if present may represent labyrinthine hemorrhage due to trauma. (Alan, 2004)

2.3.4.2 Labyrinthitis ossificans:

This disease is the result of labyrinthine inflammation. CT may show a non-descript fibrous or bony opacification of the normally fluid filled membranous labyrinth. MRI may show a signal void on T2 images which would normally be bright due to the presence of perilymph. (Alan, 2004)

2.3.4.3 Otosclerosis:

This disease is due to resorption of the endochondral layer of the otic capsule with deposition of new spongy bone. CT scans are usually not necessary for diagnosis, but when performed may show a small focus of soft tissue density at the anterior aspect of the oval window. This may be small, or may obscure the oval window entirely. Care should be taken to evaluate the position of the facial nerve, since a facial nerve overlying the oval window may preclude surgical intervention. When the sclerosis is present beyond the area of the oval window, it may be referred to as retro-fenestral or cochlear otosclerosis figure (2.9). (Alan, 2004)

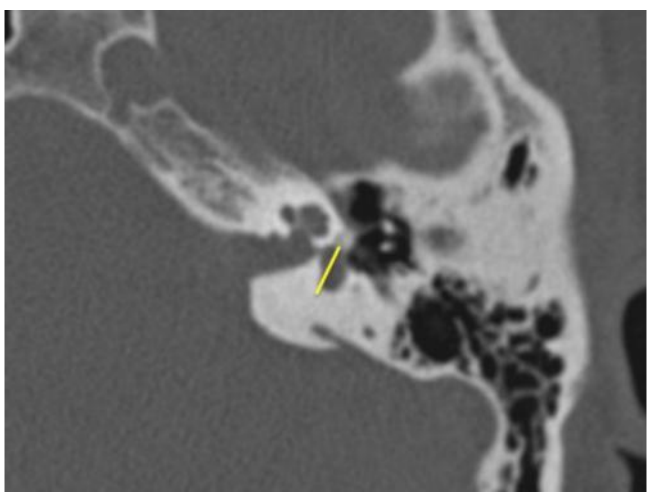


Figure (2. 9): Axial CT image of Fenestral otosclerosis .shows otosclerosis of Fissula antefenestram and oval window . (Juliano, 2013)

2.3.5 Internal Auditory Canal and Cerebellopontine Angle:

2.3.5.1 Acoustic Neuroma:

Acoustic neuroma or vestibular schwannoma is the most common mass of the cerebellopontine angle. They are benign masses. These lesions may also remain stable for multiple years with no signs of growth on long-term follow-up. CT scans of acoustic schwannomas tend to show the features of porus-centered mass, acute angles, IAC involvement. They also demonstrate the homogeneous nature of the mass. Calcifications and central necrosis are rare; however, central clearing has been noted in some larger lesions. The density of AN on CT is similar to that of nearby brainstem, and denser than surrounding CSF. If given IV contrast, the tumor will most likely show homogeneous uptake and turn very bright. A non-homogeneous uptake may be seen with previously treated lesions and large tumors. MRI is the study of choice if the diagnosis of AN is in question. On standard T1 images, the tumor should be relatively isointense to pons but more intense than CSF. On T2 images, the lesion should be mildly brighter than pons, but darker than CSF. After Gadolinium, the T1 sequence should show a very intense lesion, brighter than all other surrounding structures. (Alan, 2004)

2.3.5.2 Meningioma:

Meningioma is the second most common diagnosis of a primary CPA lesion. The meningioma is a vascular tumor, not homogeneous masses, and may show central clear. Calcifications can be present in up to 25% and the significant finding is a “dural tail. On CT scan, meningiomas may appear Isodense to surrounding structures and it may also show calcifications within the tumor, which are highly suggestive of the diagnosis. MRI is the study of choice. T1 images will show a lesion near the intensity of pons, however, it is may not be homogeneous, and may have a central hypointensity in larger lesions. On T2 images the lesion is between pons and CSF in intensity. After administration of gadolinium, the T1 image should show an intense lesion. (Alan, 2004)

2.3.6 Petrous Apex:

2.3.6.1 Cholesterol Granuloma:

This is the most common primary lesion of the petrous apex. Inflammation in the apical air cells leads to deposition of cholesterol debris which leads to a foreign body reaction. This reaction leads to friable vessels and repeat hemorrhage and cholesterol deposition, thus restarting the cycle. These lesions have a characteristic appearance on MRI, with intense signals on both T1 and T2 differentiating it from other lesions figure (2.10). (Alan, 2004)

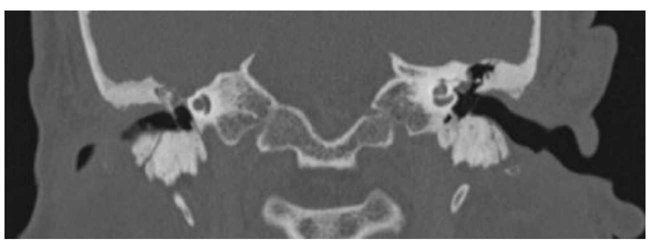


Figure (2. 10): Coronal CT image of wright cholesterol granuloma With ossicular destruction. (Juliano , 2013)

2.3.6.2 Endolymphatic sac tumors (ELSTs):

Occur along the posterior petrous apex and typically involve the vestibular aqueduct. These tumors are locally invasive papillary cyst adenomatous tumors arising from the endolymphatic sac. It cause local bone destruction as they grow and have central calcification and posterior rim calcification figure (2.11). (Alan, 2004)

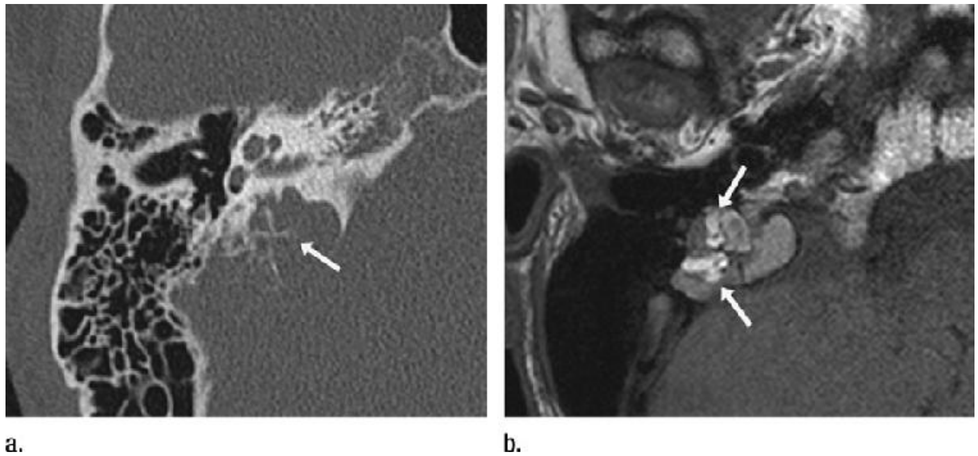


Figure (2.11): Axial Images of endolymphatic sac tumor (a) Axial CT image demonstrates an expansible lesion causing lytic bone destruction, centered around the vestibular aqueduct. Intratumoral spicules can be seen (arrow) (b) On non enhanced T1-weighted MR image, areas of intrinsic T1 shortening are quit characteristic of this tumor (arrows). The tumor was resecte By means of a translabyrinthine approach.(Juliano, 2013)

2.3.6.3 Cholesteatoma:

Cholesteatoma of the petrous apex may be congenital (also known as epidermoid), or may result from extension of mastoid disease. The presentation may be similar to a middle ear cholesteatoma, with recurrent otorrhea. Radiographic findings are similar with soft tissue densities, erosion of surrounding bone (Alan, 2004)

2.3.6.4 Petrositis:

Acute petrositis is an infection of the air cells of the petrous apex. This typically occurs from extension of a middle ear or mastoid infection through the peri-labrynthine air cells. CT findings resemble those of mastoiditis, including opacification of the petrous air cells with destruction of bony septae. Acute petrositis is severe diagnosis, and complications include brain and epidural abscesses, meningitis, and venous sinus thrombosis. (Alan ,2004)

2.3.7 Metastasis:

Metastasis to the temporal bone has been found with almost any type of tumor. The most frequent lesions include breast, lung, prostate, and melanoma being the most common. These lesions may arise at almost any location within the temporal bone. (Alan, 2004)

2.3.8 Trauma:

On the basis of the fracture plane, temporal bone fracture classified into two main categories longitudinal and transverse. Additional classification described fractures with respect to involvement of the otic capsule or petrous apex. (Phillips, 2012)

The longitudinal fracture run parallel to the long axis of the petrous bone it, is typically traverse the middle ear cavity with frequent disruption of the ossicles and resultant conductive hearing loss .The transverse fracture runs perpendicular to the long axis of the petrous bone. The fracture plane typically extends from the jugular foramen magnum to the middle cranial fossa, commonly passing through or near the vestibular aqueduct with variable involvement of the otic capsule .There are two subtypes of the transverse fractures: medial and lateral relative to the arcuate eminence. Both subtypes frequently result in SNHL. (Phillips, 2012)

Of the ossicles, the incus is the most vulnerable to injury, owing to the anatomy and the supportive ligamentous structure stabilizing the malleus and stapes. As a result, most common injuries are incudostapedial joint subluxation, malleoincudal subluxation, incus dislocation, and dislocation of the malleoincudal complex. Less common ossicular injuries include stapedial and mallear fractures. (Phillips, 2012)

2.4 CT machine:

Since its introduction by Godfrey Hounsfield and Allan Cormack, CT has continued to evolve. New techniques cover a wide variety of applications. However, with such technologic innovation comes complexity. (Lois, 2001)

The main advantages of CT over conventional radiography are in the elimination of superimposed structures, the ability to differentiate small differences in density of anatomic structures and abnormalities, and the superior quality of the images. (Lois, 2001)

2.4.1 Step-and-Shoot scanning:

The scanning systems of the 1980s operated exclusively in a “step-and-shoot” mode. In this method the x-ray tube rotated 360° around the patient to acquire data for a single slice, the motion of the x-ray tube was halted while the patient was advanced on the CT table to the location appropriate to collect data for the next slice, and steps one and two were repeated until the desired area was covered. (Lois, 2001)

2.4.2 Helical (Spiral) scanning:

Many technical developments of the 1990s allowed for the development of a continuous acquisition scanning mode most often called spiral or helical scanning. Key among the advances was the development of a system that eliminated the cables and thereby enabled continuous rotation of the gantry. This, in combination with other improvements, allowed for uninterrupted data acquisition that traces a helical path around the patient. (Lois, 2001)

2.4.3 Multidetector row CT scanning:

The first helical scanners emitted x-rays that were detected by a single row of detectors, yielding one slice per gantry rotation. This technology was expanded on in 1992 when scanners were introduced that contained two rows of detectors, capturing data for two slices per gantry rotation. Further improvements equipped scanners with multiple rows of detectors, allowing data for many slices to be acquired with each gantry rotation (Lois, 2001)

2.4.4 CT scanner:

CT scanners are complex, with many different components involved in the process of creating an image. Adding to the complexity, different CT manufacturers often modify the design of various components. From a broad perspective, all makes and models of CT scanners are similar in that they consist of a scanning gantry, x-ray generator, computer system, operator's console, and physician's viewing console. Although hard-copy filming has largely been replaced by workstation viewing and electronic archiving, most CT systems still include a laser printer for transferring CT images to film. (Lois, 2011)

Data are acquired when x-rays pass through a patient to strike a detector and are recorded. The major components that are involved in this phase of image creation are the gantry and the patient table. (Lois, 2011)

2.4.4.1 Gantry:

The gantry is the ring-shaped part of the CT scanner. It houses many of the components necessary to produce and detect x-rays. Gantries vary in total size as well as in the diameter of the opening, or aperture. The range of aperture size is typically 70 to 90 cm. The CT gantry can be tilted either forward or backward as needed to accommodate a variety of patients and examination protocols. The degree of tilt varies among systems, but ±15° to ±30° is usual.

The gantry also includes a laser light that is used to position the patient within the scanner. Control panels located on either side of the gantry opening allow the technologist to control the alignment lights, gantry tilt, and table movement. In most scanners, these functions may also be controlled via the operator’s console. A microphone is embedded in the gantry to allow communication between the patient and the technologist throughout the scan procedure figure (2.12). (Lois, 2011)

Figure (2.12): CT scanner **.**The gantry and patient table are Major components of a CT image system. . (Lois, 2011)

2.4.4.2 Slip ring:

Early CT scanners used recoiling system cables to rotate the gantry frame. This design limited the scan method to the step-and-shoot mode and considerably limited the gantry rotation times. Current systems use electromechanical devices called slip rings. Slip rings use a brush like apparatus to provide continuous electrical power and electronic communication across a rotating surface. They permit the gantry frame to rotate continuously, eliminating the need to straighten twisted system cables (Lois, 2011)

2.4.4.3 Generator:

High-frequency generators are currently used in CT. They are small enough so that they can be located within the gantry. Highly stable three-phase generators have also been used, but because these are stand-alone units located near the gantry and require cables, they have become obsolete.

Generators produce high voltage and transmit it to the x-ray tube. The power capacity of the generator is listed in kilowatts (kW). The power capacity of the generator determines the range of exposure techniques (i.e., kV and mA settings) available on a particular system. CT generators produce high kV (generally 120–140 kV) to increase the intensity of the beam, which will increase the penetrating ability of the x-ray beam and thereby reduce patient dose. In addition, a higher kV setting will help to reduce the heat load on the x-ray tube by allowing a lower mA setting. Reducing the heat load on the x-ray tube will extend the life of the tube. (Lois, 2011)

2.4.4.4 Cooling system:

Cooling mechanisms are included in the gantry. They can take different forms, such as blowers, filters, or devices that perform oil-to-air heat exchange. Cooling mechanisms are important because many imaging components can be affected by temperature fluctuation (Lois, 2011)

2.4.4.5 X-ray source:

X-ray tubes produce the x-ray photons that create the CT image. Their design is a modification of a standard rotating anode tube, such as the type used in angiography. Tungsten, with an atomic number of 74, is often used for the anode target material because it produces a higher-intensity x-ray beam. This is because the Compensating filters are used to shape the x-ray beam (Lois, 2011).

CT tubes often contain more than one size of focal spot; 0.5 and 1.0 mm are common sizes. Just as in standard x-ray tubes, because of reduced penumbra small focal spots in CT tubes produce sharper images (i.e., better spatial resolution), but because they concentrate heat onto a smaller portion of the anod they cannot tolerate as much heat. (Lois, 2011)

2.4.4.6 Filtration:

They reduce the radiation dose to the patient and help to minimize image artifact. As radiation emitted by CT x-ray tubes is polychromatic, Filtering the x-ray beam helps to reduce the range of x-ray energies that reach the patient by removing the long-wave length (or “soft”) x-rays. These long-wave length x-rays are readily absorbed by the patient, therefore they do not contribute to the CT image but do contribute to the radiation dose to the patient. In addition, creating more uniform beam intensity improves the CT image by reducing artifacts that result from beam hardening. (Lois, 2011)

2.4.4.7 Collimation:

Collimators restrict the x-ray beam to a specific area, thereby reducing scatter radiation. Scatter radiation reduces image quality and increases the radiation dose to the patient. Reducing the scatter improves contrast resolution and decreases patient dose. Collimators control the slice thickness by narrowing or widening the x-ray beam. (Lois, 2011)

The source collimator is located near the x-ray source and limits the amount of x-ray emerging to thin ribbons. It is referred to as prepatient collimation. The source collimator affects patient dose and determines how the dose is distributed across the slice thickness. The source collimator resembles small shutters with an opening that adjusts, dependent on the operator’s selection of slice thickness. In MDCT systems, slice thickness is also influenced by the detector element configuration. Some CT systems also use predetector collimation. This is located below the patient and above the detector array. Because this collimator shapes the beam after it has passed through the patient it is sometimes referred to as postpatient collimation. The primary functions of predetector collimators are to ensure the beam is the proper width as it enters the detector and to prevent scatter radiation from reaching the detector. (Lois, 2011)

2.4.4.8 Detector:

The term detector refers to a single element or a single type of detector used in a CT system. The term detector array is used to describe the entire collection of detectors included in a CT system. Specifically, the detector array comprises detector elements situated in an arc or a ring, each of which measures the intensity of transmitted x-ray radiation along a beam projected from the x-ray source to that particular detector element. Also included in the array are elements referred to as reference detectors that help to calibrate data and reduce artifacts. (Lois, 2011)

The optimal characteristics of a detector are as follows: high detector efficiency, defined as the ability of the detector to capture transmitted photons and change them to electronic signals; low, or no, afterglow, defined as a brief, persistent flash of scintillation that must be taken into account and subtracted before image reconstruction; high scatter suppression; and high stability, which allows a system to be used without the interruption of frequent calibration. (Lois, 2011)

The patient lies on the table (or couch) and is moved within the gantry for scanning. The process of moving the table by a specified measure is most commonly called incrementation, but is also referred to as feed, step, or index. Helical CT table incrementation is quantified in millimeters per second because the table continues to move throughout the scan. The degree to which a table can move horizontally is called the scannable range, and will determine the extent a patient can be scanned without repositioning. (Lois, 2011)

2.4.5 Scanner Generation:

The configuration of the x-ray tube to the detectors determines scanner generation. As new developments in scanning occurred, each new tube-detector design was referred to by a consecutive generation number.

The first system produced by the now defunct EMI medical division had a design that is referred to as first generation. A thin x-ray beam passed linearly over the patient, and a single detector followed on the opposite side of the patient. The tube and detector were then rotated slightly, and the process was repeated until a 180° arc was covered. Scan times were very long. This design is no longer in use .The second-generation design is one in which the x-ray beam also passed linearly across the patient before rotating. However, a fan-shaped x-ray beam was used, rather than the thin beam used with first-generation designs. Only part of the field of view could be covered with this fan beam. A detector array was also incorporated in the second-generation design. Although scan times were shorter than that of the original design, they were still very long. This type of design is also no longer used .The next advance in CT technology brought the third generation design. This design consists of a detector array and an x-ray tube that produces a fan-shaped beam that covered the entire field of view and a detector array. Reference detectors are typically located at either end of the detector array to measure the unattenuated x-ray beam . (Lois, 2011)

Fourth-generation scanners use a detector array that is fixed in a 360° circle within the gantry. The tube rotates within the fixed detector array and produces a fan-shaped beam. Although many more detector elements are included in this design, the number of detectors in use at any one time is controlled by the width of the beam. Fourth-generation scanners may also be called rotate-only systems. (Lois, 2011)

Many variations of these basic designs have been introduced and then abandoned. The only other design currently in use is called electron beam imaging, also referred to as EBCT or ultrafast CT. It differs from conventional CT in a number of ways. This system, which was originally produced by Imatron, uses a large electron gun as its x-ray beam source. A massive anode target is placed in a semicircular ring around the patient. Neither the x-ray beam source nor the detectors move, and the scan can be acquired in a short time. Invented in the 1980s, its superior speed compared with traditional CT scanners of the time made it particularly suited to cardiac imaging. However, shortfalls in spatial resolution kept EBCT from use in routine imaging, dramatically limiting the technology's clinical versatility. Additional drawbacks were high cost and difficulties obtaining insurance reimbursement. The future of EBCT is uncertain as the newer multidetector row technology applied to third-generation scanners has increased scanning speed so that they compare favorably with EBCT. (Lois, 2011)

2.5 Previous studies:

Jyothi AC et al (2016) studied the role of high resolution computed tomography in the evaluation of temporal bone lesions.

This prospective study done at department of otolaryngology at Navodaya Medical College, raichur during the period of 1st June2012 to 31st May 2014.fifty patient 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 implant were excluded from the study.

The study comprised of 27 males and 23 females. The age group of subjects ranged from 7 years to 60 years. Of the 50 temporal bone HRCT studies 41 scan were having infections of the temporal bone (82%), 5 were having tumors (10%) and 4 were having traumatic injuries to the temporal bone(8%).Of 41 scans having infection in the temporal bone,2 scan revealed malignant otitis externa, 29 scans showed varying degrees of mastoiditis and 10 scans showed cholesteatoma which ranged from limited form to extensive type. The HRCT findings like extension of cholesteatoma, opicification of mastoid air cells, ossicular erosion and intracranial extension were compared with the intraoprative 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. He conclude that the middle ear disease is a common clinical entity; imaging, especially HRCT, play 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 the 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; HRCT is ideal for the evaluation of temporal bone lesion.

Kumar R. et al (2016) Studied Role of High Resolution Computed Tomography in Evaluation of Pathologies of the Temporal Bone.

A total of 50 patients were studied. Age group varied from 3 to 70 years. Data for the study were collected from patients attended/referred to the Department of Radio-Diagnosis, PBM Hospital, Bikaner (RAJ.) Patients were selected on the basis of their symptoms and clinical findings suggestive of a lesion involving the temporal bone such as otalgia, otorrhoea and sensorineuronal deafness, pulsatile tinnitus, vertigo and giddiness. All the HRCT scans were performed at our institute using Phillips Brilliance MDCT scanner with Phillips windows workstation and software. The images are acquired in a single imaging plane using a multi-slice detector scanner. The patient is lying on his/her back and the gantry of the scanner is not tilted. After acquiring the raw dataset images are reconstructed in axial and coronal plane with a slice thickness of 1 mm and by using an ultra high resolution reconstruction mode. Intravenous contrast was used as and when required. The features evaluated were site, size, characterization, involvement of adjacent structures, vascular involvement.

Commonest age group: 11-30 years. No of males: 30 (60%) No of females: 20(40%). Among all the diseases, infection was the most common pathology seen (88%) followed by neoplastic pathologies (8%). Among the infectious group most common pathology was cholesteatoma (54.55%) followed by mastoiditis (43.18%). Erosion of scutum and Korner’s septum was found in 70.83% cases and 62.50% cases respectively.Complication were seen in 54.17% cases. Out of them extra cranial complication seen in 41.67% cases and intra cranial complication seen in 3 cases 12.50% cases.

He concludes that High Resolution Computed Tomography is the imaging modality of choice in evaluation of the temporal bone which is a relatively inaccessible area of the human anatomy. It also dictates proper and adequate medical treatment or timely surgery that can prevent further serious complications.

ArzuT et al (2011) studied the role of computed tomography scanning in chronic otitis media.

A series of 50 COM patients with preoperative CT scanning, operated on between April 2008 and January 2010, were included in the study. The mean age of the subjects was 29.20 ± 11.52 years, with a range of 12–66 years; 54% (n = 27) of the patients were females. Each patient underwent a surgical procedure for treatment of their COM. The patients included in this retrospective study suffered from chronic tympanic membrane perforation and intermittent or refractory otorrhoea. Thirty-four patients had mastoidectomy as a part of their surgery (canal wall down, canal wall up). The results of CT scanning and the intraoperative findings were compared. The evaluation of the CT scan was based on the preoperative reports. The parameters of comparison were the presence of cholesteatoma, granulation tissue, attic blockage, presence of malleus, incus necrosis, lateral semicircular canal erosion, facial canal dehiscence, erosion of tegmen, erosion of the scutum or external ear bony canal, and status (intact or not) of the bony chain of the middle ear. In some patients, details regarding these parameters were missing in the operative notes. In these patients, available data were used for the statistical comparison.

Cholesteatoma was noticed in 46% cases intraoperatively. In 62% of cases, the CT scan showed cholesteatoma. Surgical findings revealed cholesteatoma in61.3% of these cases. In four cases, although cholesteatoma was diagnosed during surgery, CT results in dictated granulation tissue. In the remaining non-cholesteatoma cases, granulation tissue was noticed in 22.5%. The presence of both abnormal soft tissue densities and the signs of bone erosion were found in 46% of patients on CT and proved to be cholesteatomain 60.8% cases intraoperatively. In 34% of cases, abnormal soft tissue density was observed in the absence of osseous erosion on CT. In 52.9% of these cases, cholesteatoma was observed intraoperatively. The remainder of the cases was related to granulation tissue or fluid. Cholesteatoma was detected in 66.6% of the cases where both soft tissue density and ossicular chain erosion were present together in the CT scan. In 20% of cases, the CT scan revealed no evidence of abnormal soft tissue collection. All of these ears were free of cholesteatoma. In 26% of cases, CT showed a soft tissue mass blocking the attic region, although the surgery revealed no blockage. This ratio was the highest rate of a false positive result by CT scan. Attic blockage was noticed in 25 cases during surgery. Surgical findings revealed that attic blockage resulted from cholesteatoma in 52% of the cases .Cholesteatoma was noticed intraoperatively in 83.3% of cases in which a bone eroding soft tissue mass was involved in the epitympanum on CT. Our detection rate for an external ear bony canal defect was 90%; this was one of the highest ratios reached. In 77.7% of these cases, cholesteatoma was present either in the mastoid or middle ear. The external ear bony canal defect could not be seen on CT in four patients. In one patient, although CT demonstrated the defect, the canal was noticed to be intact intraoperatively. Dehiscence of the facial nerve mostly was seen on the second part of facial nerve. Although our detection rate for facial nerves was 89.7%, four facial canal dehiscences were not detected. CT scanning could not detect the lateral canal fistulae present in three cases. Preoperative evaluation of these cases revealed that one had total hearing loss, and the other had severe sensorineural hearing loss. In two cases, although the CT scan was reported as semicircular canal erosion, the canal was noticed to be intact intraoperatively. Although we used both coronal and axial scans, we could detect tegmen erosion only in 2 out of 4 cases; there were three false positives the heads of the malleus and incus were consistently visualized on both the axial and coronal planes, although the axial was the preferable view. Intactness of the ossicular chain, the presence of malleus, and the presence of incus necrosis were correctly detected by CT at a rate of 85.71, 94, and 86.67%, respectively. On the other hand, ossicular chain intactness could not be detected in seven cases; similarly, the presence of malleus in three cases and incus necrosis in six cases could not be demonstrated. CT is helpful in determining the anatomy of the middle ear and mastoid and the extent of the disease.

They conclude that:

• CT is useful for follow-up of residual or recurrent cholesteatoma after ear surgery. It also is helpful in making decisions regarding revision surgery.

• CT cannot reliably distinguish cholesteatoma from mucosal disease and fluid.

• Coexistence of soft tissue density in the epitympanic region and bone erosion is suggestive of cholesteatoma.

• Coexistence of an external ear bony canal defect and soft tissue density may indicate cholesteatoma.

• The total absence of abnormal soft tissue on CT scan essentially excludes cholesteatoma.

• CT occasionally gives the erroneous impression of lateral semicircular canal fistulization, tegmen tympani erosion, and facial nerve involvement due to volume averaging of the thin bony covering of these structures with adjacent soft tissues.

• CT may affect the decision regarding the type of operation (mastoid pneumotisation, attic blockage/intact canal wall, canal wall down, atticoantrotomy) and can provide surgeons with a warning about possible difficulties due to anatomical variations (e.g., low-lying dura, anteriorly placed sigmoid sinus). This could help prevent surgical complications.

Although our study was retrospective in nature, we believe it has revealed some of the practical uses of CT scanning. We conclude that CT scanning has limitations, but that it is a useful adjunct for the surgical management of COM patients.

Viveck R et al (2014) studied the evaluation of HRCT temporal bone and pathologies. Patients were selected from outpatient clinics and wards of Department of Otolaryngology RMMCH Chidambaram. Patients were selected on the basis of their symptoms and clinical findings suggestive of a lesion involving the temporal bone such as otalgia, otorrhoea and sensorineuronal deafness, pulsatile tinnitus, vertigo and giddiness.

Our study included 50 patients in the age group of 5 to 75 with the mean age of 30-35 years with a male: female 1.7:1 with greater number of patients in age group of 20-40 years. Common symptoms included otorrhoea 58.33% followed by otalgia, features of raised intracranial tension and fever with percentage incidence of each being 43.43%, 40% and 38.33% respectively and deafness 36.66%. 34.68 % of cases had acute mastoiditis, 17.22% of cases had coalescent mastoiditis, 48.10% of cases had chronic mastoiditis.100% of cases of cholesteatoma were of acquired type of which attico-antral 30.78%, tubo-tympanic 15.38% and extensive 53.84%. Cochlear erosion was seen in 1.69%, lateral semicircular canal erosion in 1.69% and facial nerve canal erosion in 30.76% of cases. Longitudinal fractures were seen in 40%, atypical fractures in 40% and complex fractures in 20% of cases. They conclude that High Resolution Computed Tomography is the imaging modality of choice in evaluation of the temporal bone which is a relatively inaccessible area of the human anatomy. By using an orthogonal plane of 30° we are able to reduce the radiation to the eye with no compromise in the image quality. It also dictates proper and adequate medical treatment or timely surgery that can prevent further serious complications. High Resolution Computed Tomography has abled in planning more direct procedures like cochlear implantation, avoiding fatal surgical interventions on aberrant ICA etc, while preserving function of the essential structures of Temporal bone thereby making HRCT a valuable tool in diagnosis and treatment.

Sunita M et al 2015 studied the importance of pre-operative HRCT temporal bone in chronic suppurative otitis media.

Study done on 50 patients of chronic suppurative otitis media with pre-operative HRCT temporal bone and the results analyzed.

In this study 31 patients (62%) were in the age group 20-30 years old and the mean age group was 27 years old. The youngest was 11 years and the oldest was 59 years. On HRCT temporal bone, pneumatisation was seen in 38%, diploeic in 4%, sclerosed in 50% and cavity in 8% of the cases. Soft tissue density was seen in 6 cases in actively discharging tubotympanic type of CSOM and in all the19 cases of atticoantral type of CSOM. The extent of involvement of the disease in this tubotympanic type ofCSOM was more in the antrum followed by epitympanum, aditus, mastoid air cells and middle ear. The ossicular destruction was more common with incus, followed by stapes in actively discharging tubotympanic type of CSOM. In atticoantral type of CSOM, incus was most commonly eroded, followed by stapes and malleus. Scutum, tegmen, lateral semicircular canal, mastoid cortex and sinus plate erosion was seen inatticoantral type of CSOM, but not in tubotympanic type of CSOM. Facial canal dehiscence was seen in 1 case in Jan- June tubotympanic type and in 4 cases in atticoantral type of CSOM.

They conclude that HRCT temporal bone could detect bony erosion accurately and also the extent of soft tissue involvement with ossciular chain status. This was very much useful in planning the surgical approach not only in atticoantral but also in tubotympanic type of CSOM. We emphasize the need for HRCT temporal bone study pre-operatively not only in atticoantral but also in tubotympanic of CSOM with actively discharging ears.

Bagul (2016) study the HRCT study of temporal bone pathologies.

It was conducted at RKDF Medical College, Bhopal, Madhya Pradesh from December 2014 to March 2016. HRCT scan was performed in 120 patients who presented with history, symptoms, and signs of the temporal bone pathologies.

The most common age group involved was 11-20 years (38%) and least commonage group was 61 and above comprising (3%) of total cases The etiologic distribution of the lesions was inflammatory (50%) followed by traumatic (11.6%), benign (10%), congenital (6.6%), and malignant (5%) . Thus, the inflammatory disease was found to be the most frequently occurring pathology affecting the temporal bone. Inflammatory pathologies were common in younger age group (<30 years) and neoplastic pathologies were common in older age group (>50 years). Traumatic conditions equally distributed in all age group. Congenital disease frequently diagnosed in <10 years of age group.

Congenital malformation of the external and middle ear is more common than inner ear anomalies. Atresia or hypoplasia of the external auditory canal (EAC) is most common anomaly detected in our study. The degree of distortion range from web to small band of soft tissue covering EAC to complete absence.

He conclude that HRCT scan of temporal bone depicts complex bony details and associated soft tissue pathologies accurately. Due to various limitations of clinical examination and radiography, it is not possible to differentiate various pathologies affecting the temporal bone and study their extent. HRCT temporal bone overcome with all these limitations and its single most important imaging tool to evaluate various congenital, inflammatory, traumatic, and neoplastic pathologies of the temporal bone. Now HRCT temporal bone is standard imaging modality for pre-operative evaluation and management of various pathologies of the temporal bone.

Raga .M (2013) studied the charectrization of mastoid air cells pathologies using spiral CT.

The study was conducted in Alfaisal Specialized Hospital and Ibn Elhaitham Diagnosting center in the period from September 2012 to January 2013. 100 patients of different ages and different genders whom suspected of having mastoid air cells pathologies were included.

The gender distribution as follow (58% female&42% male). 28% of them diagnose on CT of having chronic mastoiditis& CSOM,8% as having CSOM, 2% as having cholesteatoma&CSOM.

The side of lesions in 49% of patients on bilateral side, 26% at the right side and 25% at the left side.

The pathological changes on the mastoid bone explain as the 13% with mastoid bone sclerosis, 6% with mastoid bone erosion and 81% with normal mastoid bones.

The middle ear cavity opacifcation noted in 78% of patients, 67% of them were diagnosed by CT as having chronic mastoiditis&CSOM while 11% of them diagnosed as having cholesteatoma.

Ossicular change were detected in 29% of patients, 14% of them with partial erosion, while 15% of them with total erosion .

She conclude that spiral CT is an effective imaging modality in study of mastoid air cells diseases and their complications.

The diseases of mastoiditis with CSOM had higher frequency and also their complications (ossicular erosion, scutum erosion, and loss of hearing).

There was correlation between mastoid air cells diseases and middle ear diseases, and with the help of spiral CT it is possible to acquire multiple slices and understand the complex relationships of anatomic structures.

Using 3D, multi-planar reformation techniques would be benefited to detect and diagnosed the complications of mastoid air cells diseases.

The advent of HRCT scanning has revolutionized diagnostic imaging of the temporal bone. spiral CT offers the greatest structural definition of any currently available imaging modality.

Chapter Three

Materials and Methods

Chapter Three

Materials and Methods

3.1 Materials

3.1.1 Machine used

GE 4 slice in Antalya medical center, Toshipa 64 slice in Alzaytouna specialist hospital.

3.1.2 Patients

52 patient (31 female, 21 male) their age (4 - 85) years old, whom suspected of temporal bone diseases were referred to CT department center.

3.2 Methods

3.2.1 Technique

The patient should wear comfortable, loose-fitting clothing during the procedure, metal object including jewelry, eye glasses, hairpins should be removed prior the exam. If contrast agent is request the patient must be fasted 4-6 h before the exam. CT scans were performed including protocol of axial images from the area of temporal bone with patient in supine position , head first .The images were made at 100 -120 kv and 80-225 mAs, with thin slice 1-2mm slice thickness and special bony algorithm. Topogram were taken routinely in all patients before starting the scan. Scanning commenced from the lower margin of the external auditory meatus including the inferior mastoid and extend upward to the arcuate eminence of the superior semicircular canal as seen on lateral topogram .Slight extention of the head was given to avoid gantry tilt and thereby protect the lense from radiation .

Helical acquisition in the axial plane was performed .Reformatted coronal images were obtained perpendicular to the axial plane from the cochlea to the posterior semicircular canal.

The contra lateral temporal bone was included for comparison .Intravenous contrast was used as and when required.

3.2.2 Image interpretation

All axial and coronal views were evaluated by technologist and diagnosed by radiologist.

3.2.3 Data analysis

The data were collected by using medical reports and were analyzed by using excel program.

Chapter four

The Results

Chapter four

The Results

The Results:

The study carried in 52 patients, age between (4-85) years old when underwent CT scan, the data collected by the following tables and graphs.

Table (4-1) demonstrates the study group**:**

Gender	Frequency	Percentage
Male	21	40%
Female	31	60%

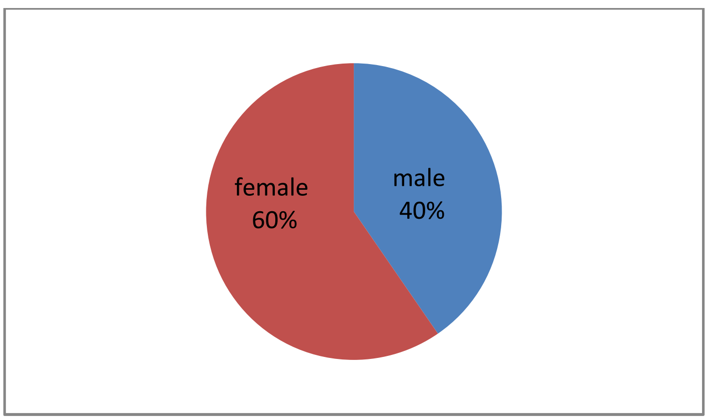


Figure (4-1-1) shows the study group

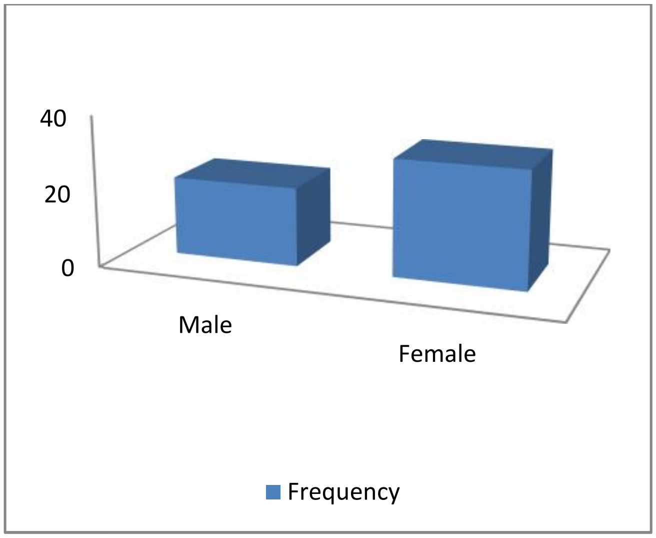


Figure (4-1-2) shows the study group

Table (4-2) Demonstrates age distribution of study group**:**

Age	Frequency	Percentage
01-20	8	15%
21-40	25	48%
41-60	15	29%
61-80	3	6%
81-100	1	2%

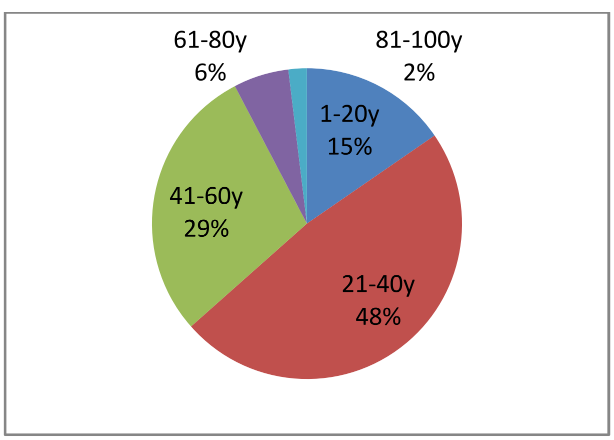


Figure (4-2-1) shows age distribution of study group

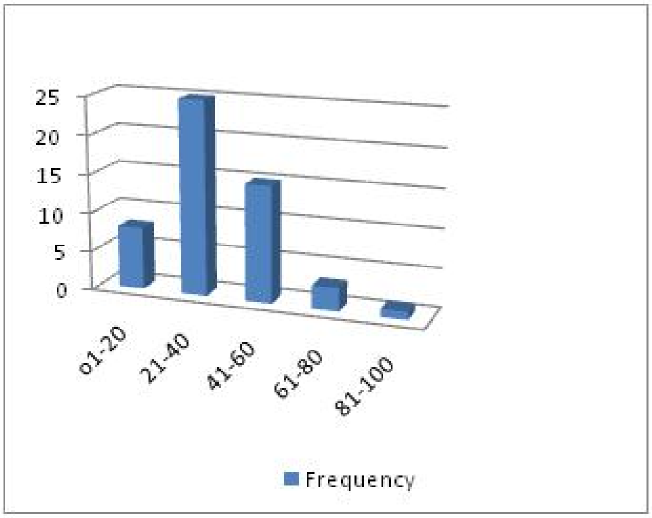


Figure (4-2-2) shows age distribution of study group

Table (4-3) Demonstrates the site of pathological lesion**:**

Site of lesion	Frequency	Percentage
External ear	8	7%
Middle ear	57	55%
Inner ear	0	0%
Mastoid	58	56%

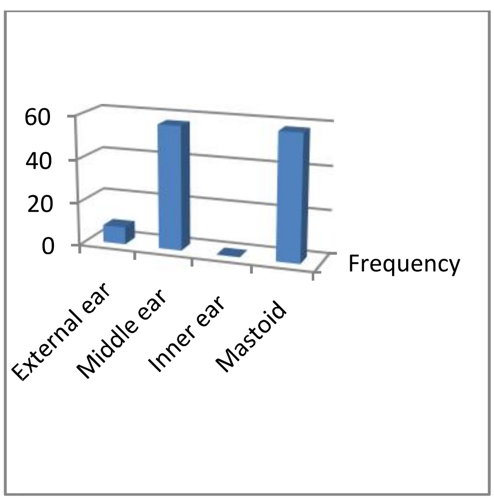


Figure (4-3) shows the site of pathological lesion

Table (4-4) Demonstrates etiopathological distribution**:**

Etiology	Frequency	Percentage
Inflammatory	43	82%
Congenital	1	2%
Benign	4	8%
Malignant	1	2%
Other	3	6%

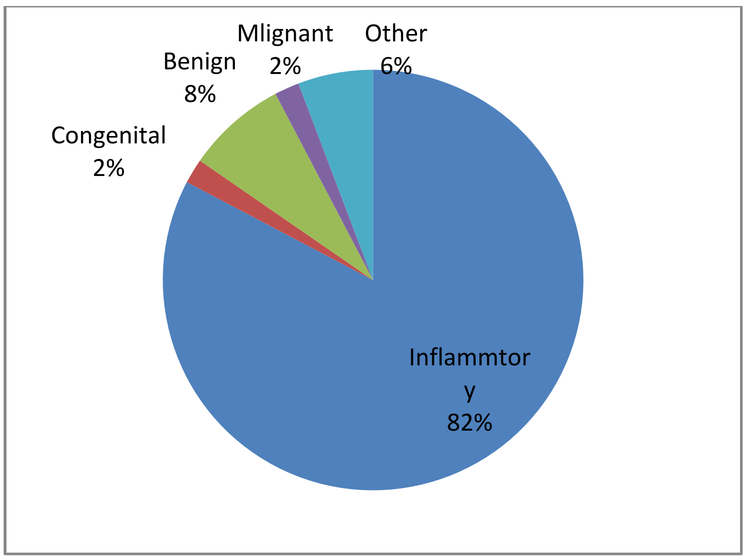


Figure (4-4) shows etiopathological distribution

Table (4-5) Demonstrates incidence of bilateral and unilateral Pathological lesion**:**

Pathological lesion	Frequency	Percentage
Unilateral	34	66%
Bilateral	18	34%

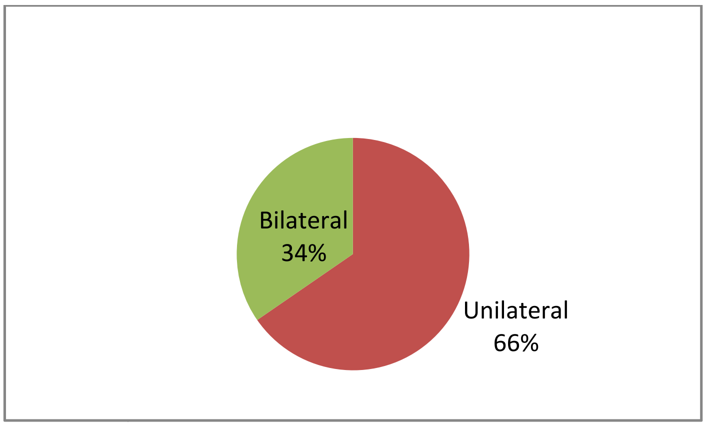


Figure (4-5-1) shows incidence of bilateral and unilateral Pathological lesion

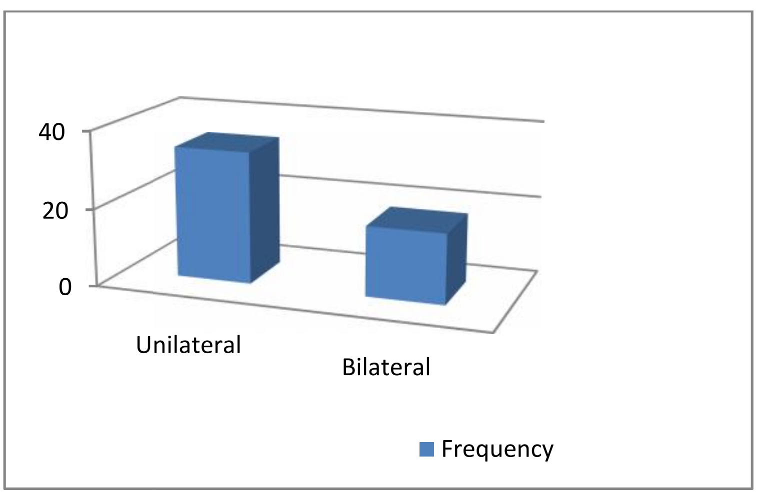


Figure (4-5-2) shows incidence of bilateral and unilateral Pathological lesion

Table (4-6) Demonstrates various type of infection**:**

Infection	Frequency	Percentage
Otitis externa	2	4%
Otitis media	5	12%
Mastoiditis	5	12%
CSOM	26	60%
CSOM&cholesteatoma	5	12%

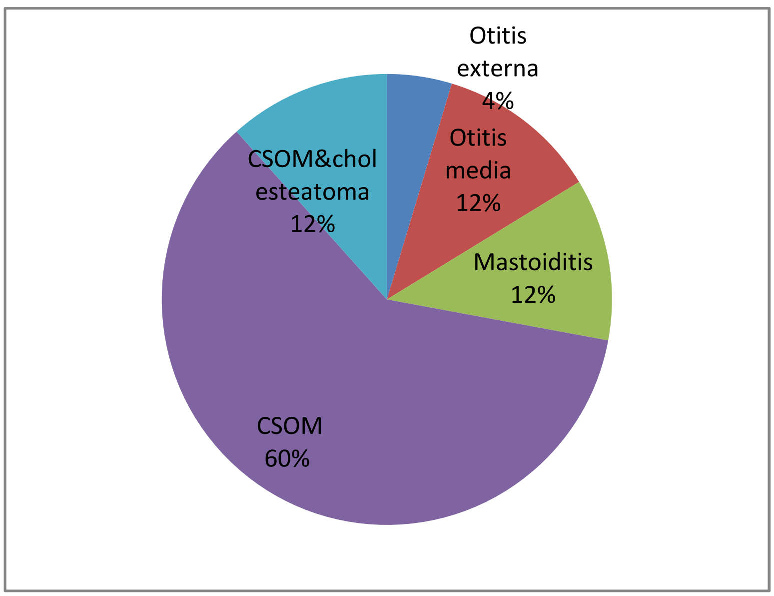


Figure (4-6) shows various type of infection

Table (4-7) Demonstrates CT findings of infection**:**

CT findings	Frequency	Percentage
Opacified mastoid	46	53%
Opacified middle ear	43	50%
Sclerosis of mastoid	18	21%
Bony septa destruction	6	7%
Mucosal change	3	4%
Erosion of ossicles	9	11%
Erosion of scutum	4	5%
Cholesteatoma	5	6%
Intracranial complication	1	2%
Soft tissue density	5	6%

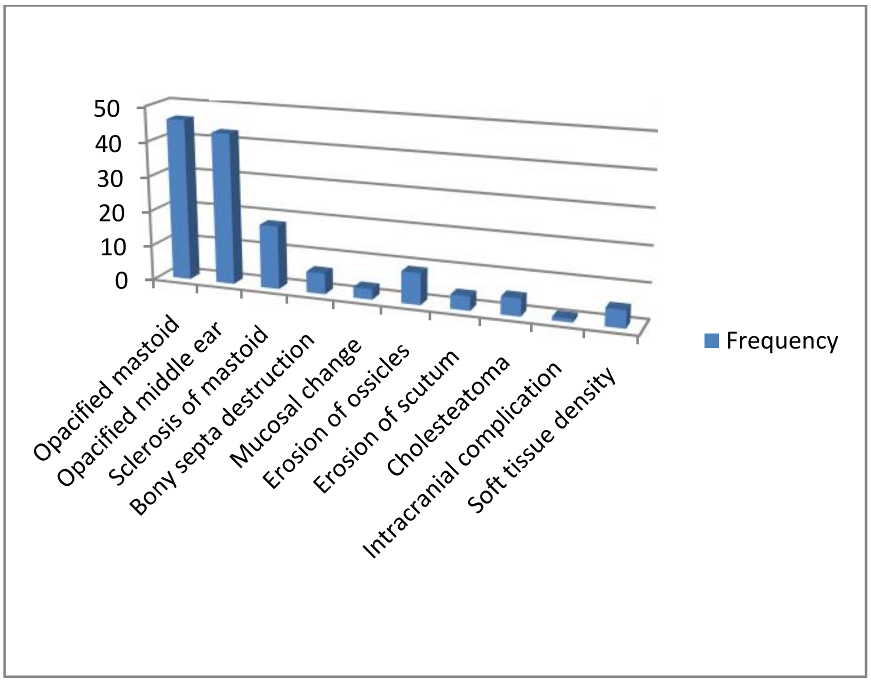


Figure (4-7) Shows CT findings of infection

Table (4.8) Demonstrates degree of opacification **&** sclerosis**:**

Site	Opacification		Sclerosis		Sclerosis& Opacification
	Total	partial	Total	Partial	
Middle ear	36	7	2	0	0
Mastoid	28	9	7	2	9

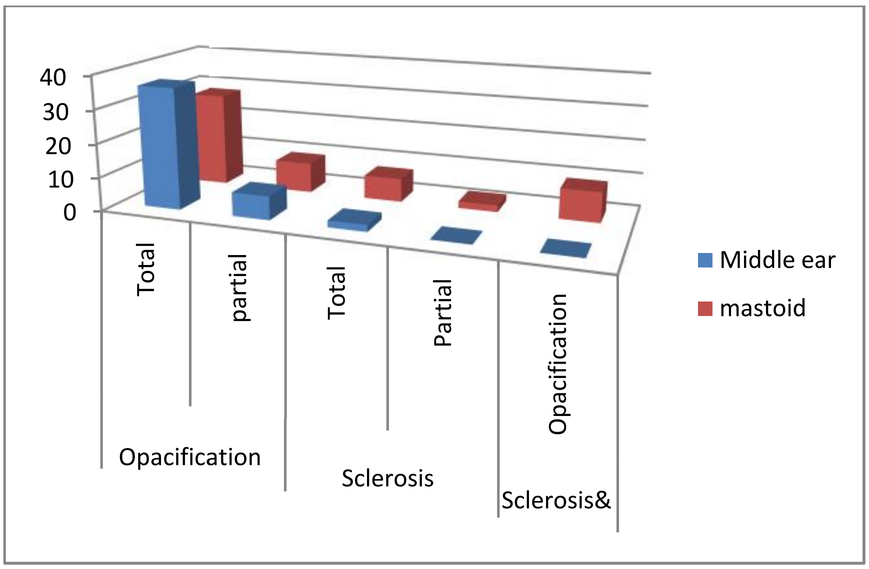


Figure (4-8) shows degree of opacification **&** sclerosis

Table (4-9) Demonstrates degree of ossiclular erosion**:**

CT findings	Frequency	Percentage
Partial erosion	2	3%
Complete erosion	4	5%
Ill defined	1	1%
Destruction	2	3%

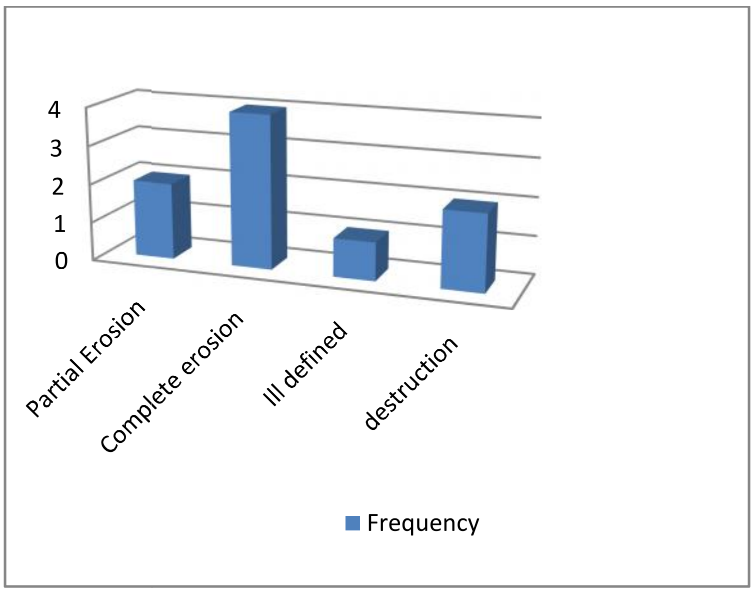


Figure (4.9) shows degree of ossiclular erosion

Table(4-10) Demonstrates CT findings of cholesteatoma**:**

CT findings	Frequency	Percentage
Opacification	2	40%
Soft tissue mass	3	60%
Inhancing soft tissue mass	0	0%
Erosion of ossicles	5	100%
Erosion of scutum	5	100%
Destruction mastoid septa	2	40%

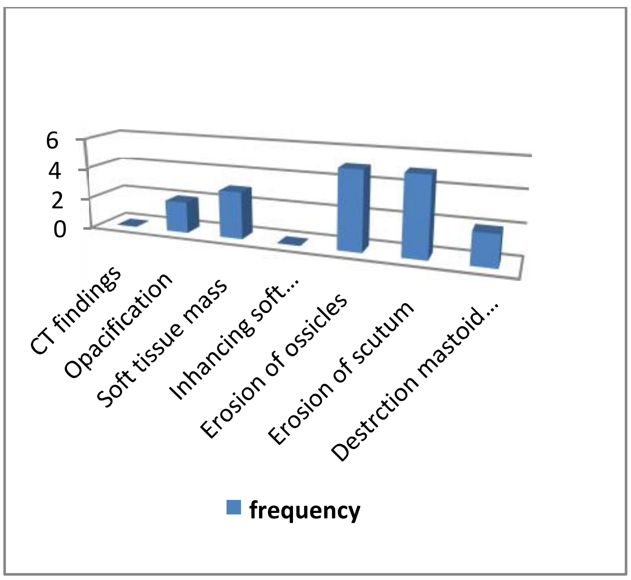


Figure (4-10) shows CT findings of cholesteatoma

Table (4-11) Demonstrates CT findings of neoplasm**:**

CT finding	Frequency	Percentage
Soft tissue density	2	40%
Enhancing soft tissue density	2	40%
Cystic density	1	20%
Bony destruction	2	40%
Intracranial complication	2	40%
Facial canal involvement	1	20%

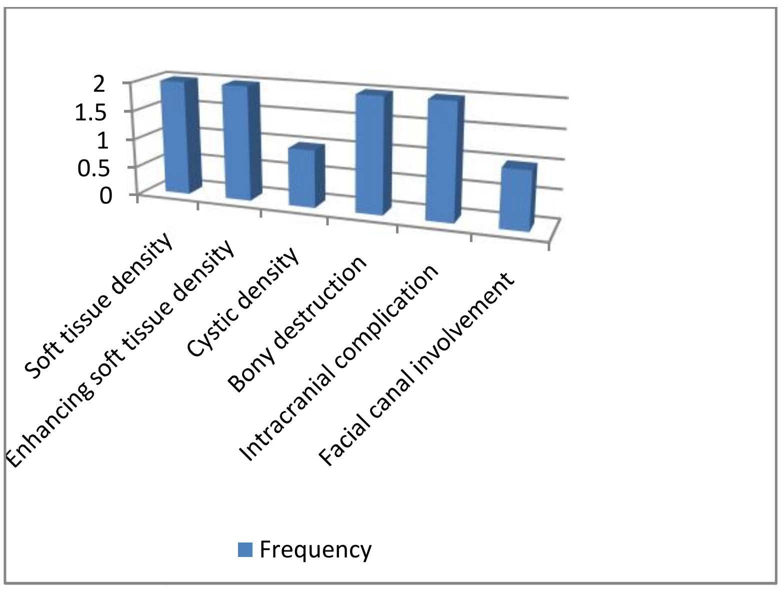


Figure (4-11) Shows CT findings of neoplasm

Chapter five

Discussion, Conclusion& Recommendations

Chapter five

Discussion, Conclusion and Recommendations

5.1 Discussion:

In this study 52 patients were evaluated for their various symptoms of temporal bone diseases.

The gender distribution show the female (60%) is more than male (40%) (Table 4-1). This result is reversed to study of (Kumar R et al 2016) and (Jyothi AC et al 2016), and similar to (Vivek et al 2014) , (Arzu et al 2011) and (Raga M 2013) .

The age distribution on table (4-2) shows the commonest age group of (21-40) which it similar result of (Vivek et al 2014).

Inflammatory disease was the most common pathology seen (82%), which is similar result to (Kumar R et al 2016) and (Bagul 2016), followed by neoplastic pathologies (10%) also is the similar to (Jyothi AC et al 2016), The congenital malformations of temporal bone fall in to rare disease categories (2%), and we have one case of EAC atresia .In (Bugal 2016) study the congenital malformations representing (6.6%) of cases with EAC atresia most common anomaly detected. Other lesion includes one case of osteopetrosis, foreign body and EACs obstruction. Bilateral involvement (34%) is less common than unilateral pathological lesion (66%), table (4-5). In this study Mastoid and middle ear were affected more than the inner and external ear structures, (table 4-3) this result is agreement with (Raga M 2013). According to location (table 4-3) and degree of involvement table (4-8) & (4-9), HRCT can able to classify various type of infections with the CSOM most common, table (4-6), Also, CT scan can able to demonstrate any anatomical abnormality and assessing complications of infection table (4-4), it shows non specific deprise (opacification) (89%), this means it cannot able to detect the type of deprise. This is agreement with the result study of (Arzu et al 2011), also show mucosal change (3%). Sclerosis (18%) and erosion of surrounding bony tissue (such as the ossicle (11%), scutum(5%), mastoid septation (7%)), can be demonstrated in CT imaging as well table (4-7). CT appearance of cholesteatoma is a non-inhancment, homogenous, soft tissue mass associated with erosion of ossicles and scutum which is similar to result of (Jyothi AC et al 2016) and (Arzu T et al 2011). Two cases of cholesteatoma cannot differentiated from surrounding opacification but the presence of bone erosion aid in the diagnosis table (4-10). Neoplasm present in HRCT as lesions iso to slightly hypodense to adjacent brain (soft tissue density 40%), some tumor enhancing when contrast media is used (40%). HRCT is used to evaluate the bony invasion by the tumor, the aspect of bone invasion can provide information about the type and the exact extension of the tumor and the invasion of vascular structure, nerve cannels and intracranial extension table (4-11). In this study one case of benign lesion, CT cannot able to differentiate the type of soft tissue and clinical correlation is advised, (Appendixes), (Arzu T et al 2015) has the same result.

In osteopetrosis HRCT show most of the bony tissue was expanded by dense lamellar bone and replacement of mastoid and pertrous air cells. The ossicles were normal.

In EAC obstruction HRCT cannot able to differentiating the type of soft tissue and biopsy is advised.

Foreign body appears as partial opacification and clinical correlation was needed.

5.2 Conclusion

HRCT scan was helpful in determining the anatomy of the temporal bone and it would be benefited to detect and predicted the extent of the disease process, especially in patients who have or suspected of having complications. Also it lay down anatomical roadmap for the surgeon preoperatively, and it can able to evaluate both bony and air space structure accurately and detect the presence and extension of soft tissue, but could not be relied on to differentiate the type of tissue.

5.3 Recommendations

The study recommended that the study should be done on large number of patients as well as at multiple centers.

Obtaining of direct coronal scan may aid in differentiating of some pathologies and increase the diagnostic value.

Using of virtual endoscopy reconstruction soft ware, which it is non invasive Imaging method and permit the investigator to navigate through the anatomy non destructively.

MRI is essential for soft tissue and inner ear evaluation.

References

AcuinJ , Philippines .chronic suppurative otitis media. 1st edition, Geneva: World Health Organization, Switzerland, 2004.

Ahmet K, Osman K ,Turgay K. mastoid air cell system. Ato scop,2004;4:144-145.

Akan. HMN Medical-Nobel,. (2008); 2:104.

Alan. The essential guide to image processing. Academic press.pp,(2004). 743-9.

AlbertiP.W. The anatomy and physiology of the ear and hearing, Canada, university of Toronto press, 1995.

Arzu Tatlipinar, ArzuTuncel, Evren Ayöğredik, TanjuGökçeer, CelilUslu.The role of computed tomography scanning in choronic otitis media: Eur Arch Otorhinolaryngol 2012; 269:33-38.

CasselmanJW. Temporal bone imaging. Neuroimaging Clin N Am 1996 May; 6(2):265-289.

ChakeresD, KapilaA, Lamasters D. soft tissue abnormalities of external auditory canal: subject review of CT findings Radiology1985;156:105-109.

ChakersD , AugustynMA.Temporalbone:In:Haaga JR,Lanzieri CF, GilkesonRC .CT and MR Imaging of the whole body .4th ed.Ohio,Mosby, 2003.

Chandra S,Goyal M, Gandhi D, Gera S, Berry M, Anatomy of facial nerve in the temporal bone:HRCT.IndianJRadiol Imaging 1999;9:5-8.

ChittkaL,Brockman,A.(042005),e137,URLhttp://www.plobiology.org,articleinfo :doi 110-1371/Journal.pbio:0030-137.

Cowan A ,Matthew w ,Francis B,QuinnJ,Temporal bone lesions, Grand Round presentation,UT MB, Dept.of otolaryngology, 2004.

Henry.p, Letowskir. Boneconduction : anatomy, physiology and communication. 2007 ; 1:21005-5425.

Jam .Computed tomography of the petrous bone in otosclerosis and Meniere's disease.(2011) ;8(1):24-30.

Juliano,A,Ginat,D.,&MoonisG,Imaging review of the temporal bone:part 1.Anatomy and inflammotary and neoplasticprocesses.Radiology,2013;1:17-33.

JyothiA ,ShrikrishnaB,Role of high resolution computed tomography in the evaluation of temporal bone lesion :our experience.int J otorhinolaryngol head neck surg 2016;2:135-9.

Lois E R,computed tomography for technologists.1st edition ,china:wolters kluwer,2011.

Lorrie L K, Connie M P ,Sectional anatomy for imaging professionals.2ed edition .united state:Mosby,2007.

Mafee,M.F.,A.Kumar,D.A.Yannias,etal.Computed Tomography of the middle ear in the evaluation of choleesteatomas and other soft tissue masses:comparison with pluridirectionaltomography.Radiology (1983) ;148:465-472.

ManjitBagul M .High resolution computed tomography study of temporal bone pathologies .Int J sci stud 2016;4(4):60-63.

Phillips S,LogerfoE,RichardsomL,AnziY.Interactive web-based learing module on CT of temporal bone:Radiographics 2012;E85-E105.

Pickles,J.An introduction to the physiology of hearing ;Newyork (NY):Academic press,1988.

Raga M,Study of mastoid air cells diseases using spiral CT; Khartoum:university of sudan,2013.

Virapongse C ,SarwarM,BhimaniS,SasakiC,RobertS.Computed Tomography of temporal bone pneumatization 2.petrosquamosal suture and septum.American Rontgen Ray society,AJR 1985;6:561-568.

Vivek, P. Gunasekaran, S. Sethurajan, M. Adaikappan. “Evaluation of HRCT Temporal Bone and Pathologies”. Journal of Evolution of Medical and Dental Sciences 2014; Vol. 3, Issue 52, October 13; Page: 12118-12126

WeverE,LawrenceM.Physiologicalacostics. Princeton(NJ): Princeton university press,1954.

Yost W,Nielsen D ,fundamental of hearing :An introduction.New York (N Y):Holt,Rinehart and Winston,1977.

Appendixes

Appendixes

Appendix (A)

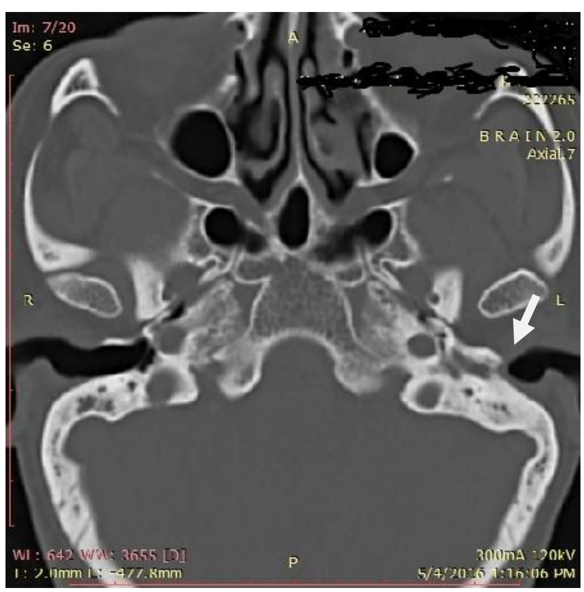
Data sheet

No	**Age**	**Gender**	**masoid**		**Middle ear**		**Inner ear**		**Ossicles**		**Scutum**		**IAC**		**EAC**		**Intra cranial extention**	**Diagnosis**
			R	L	R	L	R	L	R	L	R	L	R	L	R	L		

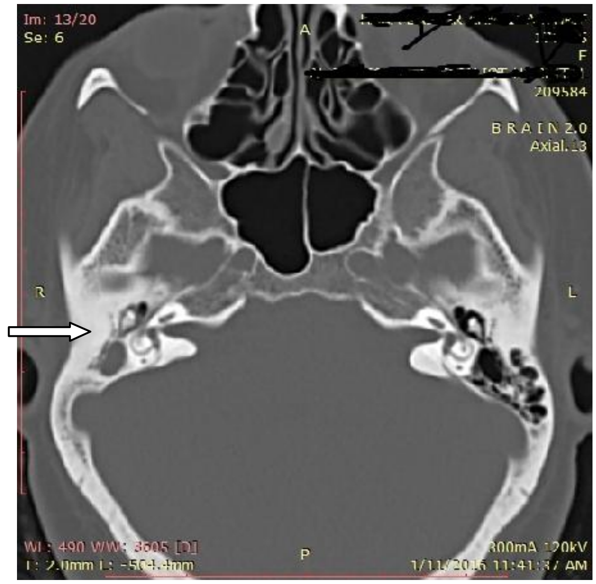
Appendix(B)

Image of the study

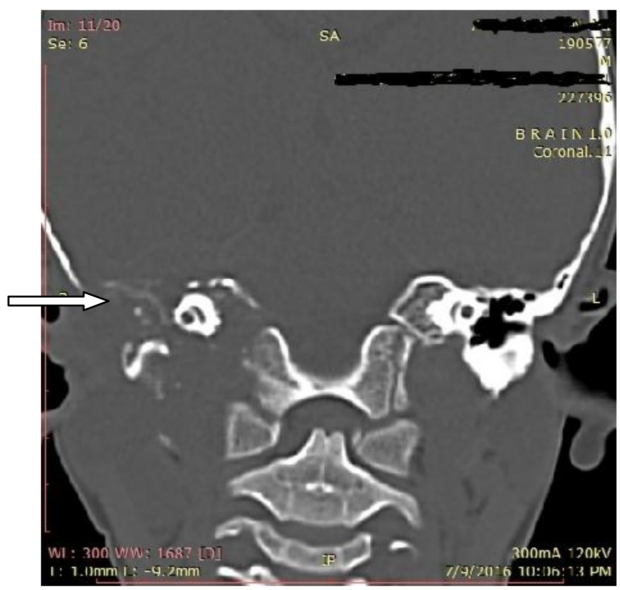
A female patient 14 years old with soft tissue density Seen in the left external auditory canal……?wax……? polyp, for clinical Correlation.



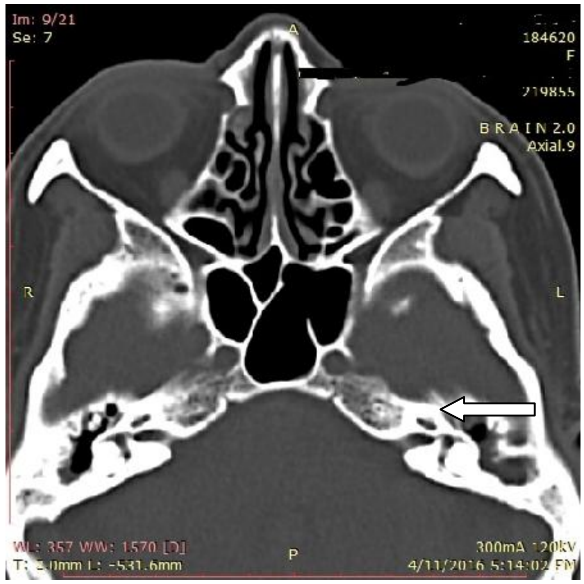
A female 22years old with left metal atresia.



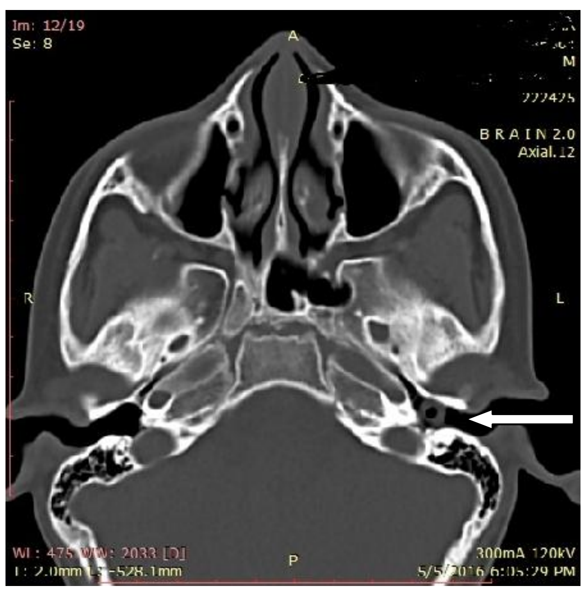
Afemale 26 years old with right oto-mastoiditis



A male patient 4 years old with right side benign tumor .



A female 52 years old with bilateral oto-mastoiditis and left Cholesteatoma.



A male patient 10 years old with foreign body in the distal part of the Left external auditory Canal and adjacent part of middle ear.