A DISSERTATION ON

"THE USEFULNESS OF DIFFUSION-WEIGHTED IMAGING IN CHOLESTEATOMA DIAGNOSIS AND POSTOPERATIVE PATHOLOGIC CORRELATION "

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BONAFIDE CERTIFICATE

Certified that this dissertation is the bonafide work of **Dr.S. ARUN PRASAD** on **"THE USEFULNESS OF DIFFUSION WEIGHTED IMAGING IN CHOLESTEATOMA DIAGNOSIS AND POSTOPERATIVE PATHOLOGIC CORRELATION "** during his M.D.RADIODIAGNOSIS course from Feb 2015 to July 2015 at the Madras Medical College and Rajiv Gandhi Government General Hospital, Chennai – 600003.

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DECLARATION

I, certainly declare that this dissertation titled, **"THE USEFULNESS OF DIFFUSION-WEIGHTED IMAGING IN CHOLESTEATOMA DIAGNOSIS AND POSTOPERATIVE PATHOLOGIC CORRELATION "**, represent a genuine work of mine. The contribution of any supervisors to the research are consistent with normal supervisory practice, and are acknowledged.

I, also affirm that this bonafide work or part of this work was not submitted by me or any others for any award, degree or diploma to any other university board, neither in India or abroad. This is submitted to The Tamil Nadu Dr.MGR Medical University, Chennai in partial fulfilment of the rules and regulation for the award of Master of Radiodiagnosis Branch VIII.

Date :

Place: Chennai **Dr. S ARUN PRASAD**

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DR. S.ARUN PRASAD

TABLE OF CONTENTS

LIST OF ABBREVIATION

- EPI - Echoplanar imaging
- DWI - Diffusion weighted imaging
- CT - Computed Tomography
- HRCT - High Resolution Computed Tomography
- MRI - Magnetic Resonance Imaging
- ADC - Apparent Diffusion Coefficient
- HASTE - Half-Fourier acquisition single-shot turbo spin-echo
- BLADE - Proprietary name for periodically rotated overlapping parallel lines with enhanced reconstruction (PROPELLER) in MR systems from Siemens Healthcare
- STIR - Short Tau Inversion Recovery

- FLAIR - Fluid Attenuated Inversion Recovery
- TM - Tympanic membrane
- EAC - External auditory canal
- ENT - Ear ,nose and throat
- Gd - Gadolinium
- TSE - Turbo spin echo
- FASE - Fast advanced spin-echo
- PPV - Positive predictive value
- NPV - Negative predictive value
- MS-EPI - Multishot echoplanar imaging
- SS-EP I- Single shot echoplanar imaging
- CSF - Cerebrospinal fluid
- SI - Signal intensity
- HPE - Histopathology
- USG - Ultra sonogram
- No.- Number
- Eg - Example

THE USEFULNESS OF DIFFUSION- EVALUATION WEIGHTED IMAGING IN CHOLESTEATOMA DIAGNOSIS AND POSTOPERATIVE PATHOLOGIC CORRELATION

ABSTRACT

INTRODUCTION

- Middle ear cholesteatomas consist of ectopic keratinized epithelial tissue that grows inside the mucosa-lined middle ear cavity and desquamates, accumulating keratin and epithelial debris leads to bone erosion. Bony erosion can result in destruction of the ossicles, creating conductive hearing loss, labyrinthine fistulas with sensorineural hearing loss and vertigo, facial nerve canal erosion and facial paralysis, and rare intracranial complications, such as meningitis and abscess
- Diffusion-weighted imaging is a technique that measures the molecular diffusion of water (Brownian motion) within the tissues, which can be quantified using Apparent Diffusion co-efficient (ADC)

AIM

To evaluate the usefulness of DWI in diagnosing middle ear cholesteatomas and to differentiate post operative inflammatory changes from recurrent cholesteatoma with the aid of postoperative pathological correlation

OBJECTIVES

1. To determine the usefulness of diffusion restriction in differentiating middle ear focal lesions
2. To determine the usefulness of newer diffusion techniques to detect smaller lesions and in postoperative recurrent lesions

MATERIALS AND METHODS

Forty patients between 10-60 YEARS of either sex with suspected cholesteatoma both new and postoperative cases will be included in this study after approval of local ethical committee and obtaining informed consent.

Sequences used

Using 3 tesla MRI scanner following sequences are used

TI AXIAL AND CORONAL

FST2 AXIAL AND CORONAL

DWI AXIAL& CORONAL

STIR

RESULTS

From the study it is concluded that DW MRI has 100% sensitivity, 75 % specificity , 97.3% PPV and 100% NPV in detecting cholesteatoma. Hence the MRI is more accurate than HRCT in diagnosing cholesteatomas

CONCLUSION

Diffusion-weighted imaging is highly specific due to the high keratin content of cholesteatomas.Newer techniques allow detection of smaller lesions and may be sufficient to replace second-look surgery in patients with prior cholesteatoma resection .Thus early detection avoids unnecessary complications and can avoid second looking surgery. DWI is superior to conventional T2 sequence in detecting the cholesteatomas. HRCT and MRI are complementary to each other in diagnosing cholesteatomas. In preoperative cases HRCT has high diagnostic accuracy and MRI is usually used to confirm the diagnosis whereas in postoperative cases HRCT is highly non specific and MRI plays significant role in diagnosing cholesteatomas.

KEYWORDS : Diffusion restriction , Apparent diffusion coefficient, second look surgery

INTRODUCTION

A cystic collection of keratinised squamous epithelium laid on a fibrous matrix predominantly involving middle ear cavity rarely involving external auditory canal is called as cholesteatoma . Also called as “pearl tumor,” “margaritoma,” or “keratoma.”

DWI is the MRI technique which is based on the brownian movement of particles within the particular voxel.

DWI finds its utility in detecting cholesteatomas if middle ear is not clearly visualised by otoscopic examination and when HRCT temporal bone findings found to be inconclusive.

DWI is very useful in recurrent cholesteatoma followup especially in postoperative cases where middle ear cavity is filled with soft tissue and no bone /ossicular erosions detected on HRCT scan.

By using modern techniques (non echoplanar imaging) smaller lesions are accurately diagnosed and so second look surgery is avoided in previously operated patients.

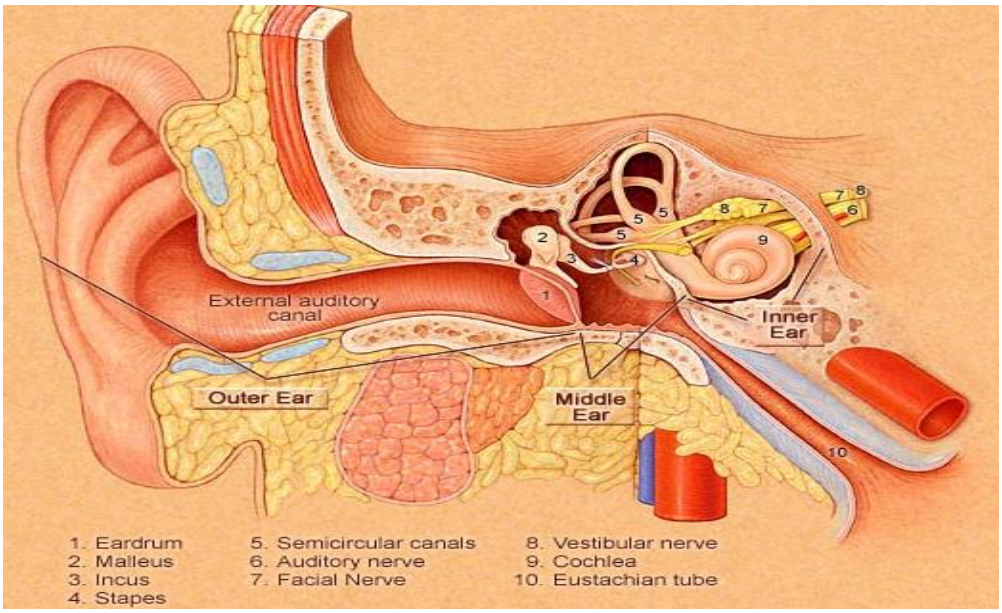
Newer techniques avoids skull base and ghost artifacts with high image resolution.

ANATOMY OF EAR [1]

EXTERNAL EAR

MIDDLE EAR

INTERNAL EAR



EXTERNAL EAR

Starts from the pinna to the tympanic membrane . Its length is 2.5 centimetres and diameter is 0.7 centimetres.

It has S shaped and it runs above downward and forward direction.

Ear canal is divided into two parts

- **OUTER 1/3 CARTILAGENOUS**

  Anterior and inferior wall - cartilaginous.

Superior and posterior wall - fibrous.

- **INNER 2/3 BONY**

The bony part is much shorter in children.

MIDDLE EAR [2]

Important Structures:

- Epitympanic recess
- Tympanic cavity
- Ossicles
- Aditus ad antrum
- Mastoid air cells

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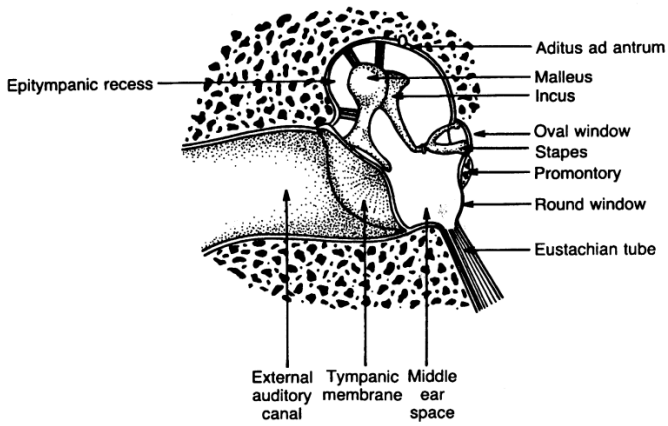
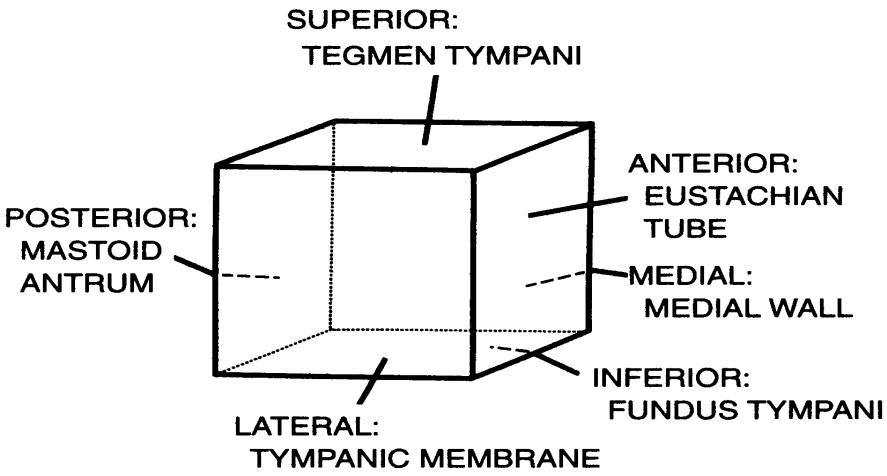


The boundaries of middle ear are

- **Roof (tegmental wall):** Tegmen tympani separates the tympanic cavity from middle cranial fossa.
- **Floor (jugular wall):** A bony plate separates tympanic cavity from superior bulb of the internal jugular vein .
- **Lateral wall (membranous wall) :** The tympanum .
- **Medial (labrinthine wall)**: Separates middle ear cavity from inner ear structures. This wall has important features, namely:
    - The promontory: Is formed by the first turn of the cochlea.
    - Tympanic plexus: Is formed by fibres of the facial, and glossopharyngeal nerve.
    - Two openings: Fenestra vestibuli and fenestra cochleae.
- **Posterior(mastoid wall):** Separates the cavity from the mastoid antrum air cells. It has the following openings:
    - Aditus to the mastoid antrum or aditus ad antrum- mastoid antrum or air cells.
    - Pyramidal opening: For tendon of stapedius
    - Posterior chorda tympani canaliculus: Transmits the chorda tympani nerve.

- **Anterior(carotid wall)** :Separates the cavity from the carotid canal, with its contained internal carotid artery. It has two openings:

    - Communicating with tensor tympani muscle
    - Auditory tube (pharyngo tympanic or Eustachian tube)

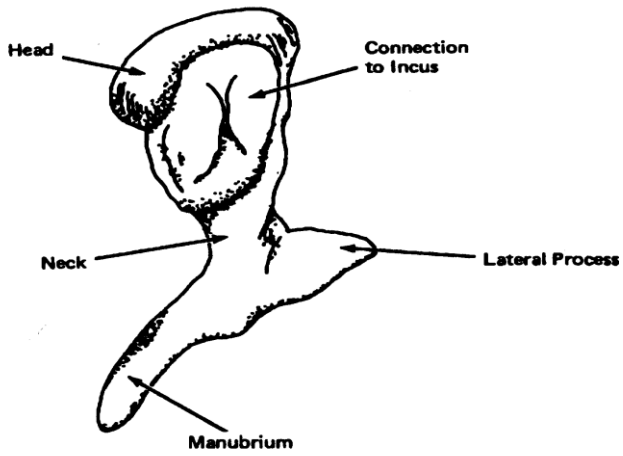


The ossicles

- Malleus (hammer)
- Incus (anvil)
- Stapes (stirrup)

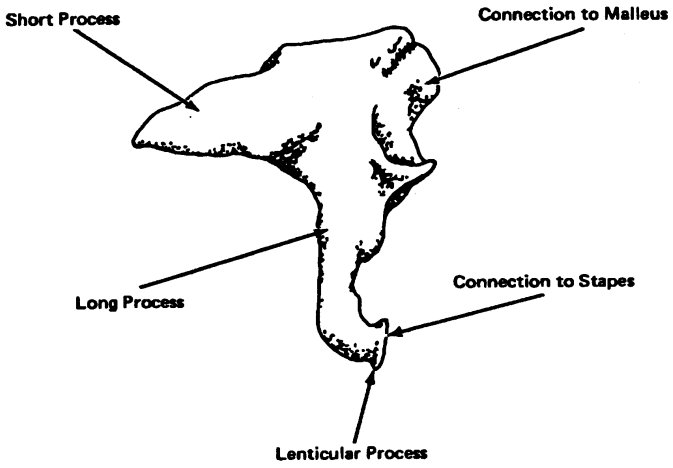
The malleus

- Manubrium
- Neck
- Head
- Lateral process



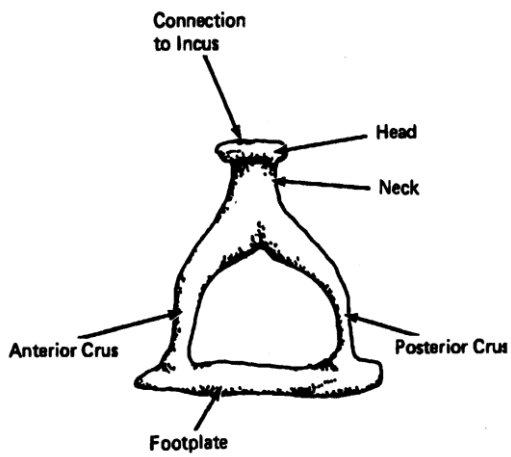
The incus

- Short process
- Long process
- Lenticular process
- Incudostapedial joint



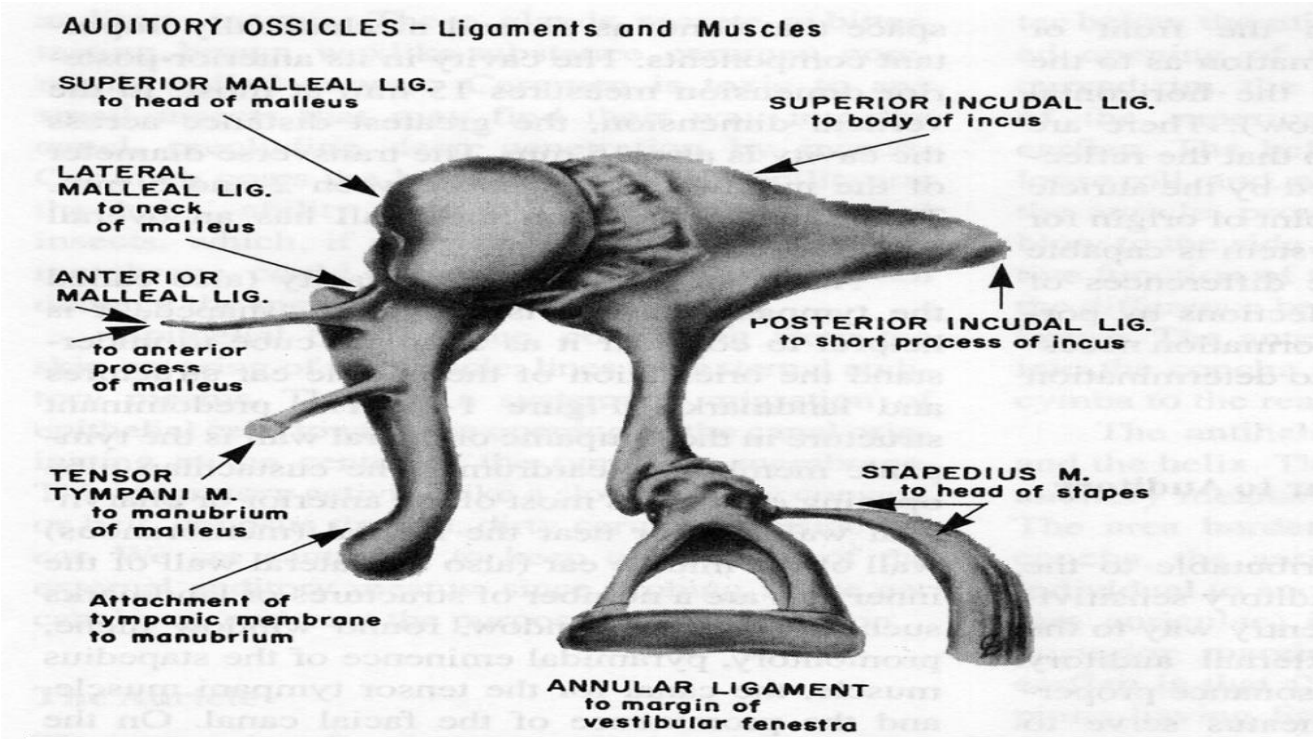
The stapes

- Head
- Neck
- Anterior crus
- Posterior crus
- Footplate



Ligaments of the ossicular chain

- Superior malleal ligament
- Anterior malleal ligament
- Lateral malleal ligament
- Posterior incudal ligament

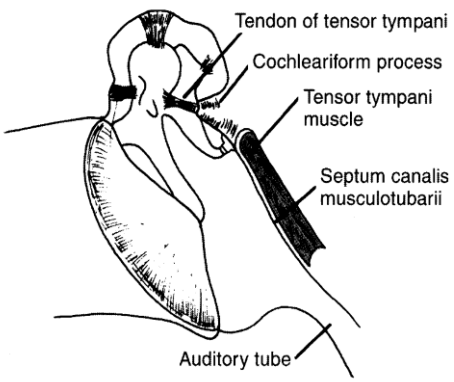


Purpose of the ossicuar chain

- Impedance matching
- Protection

The tensor tympani

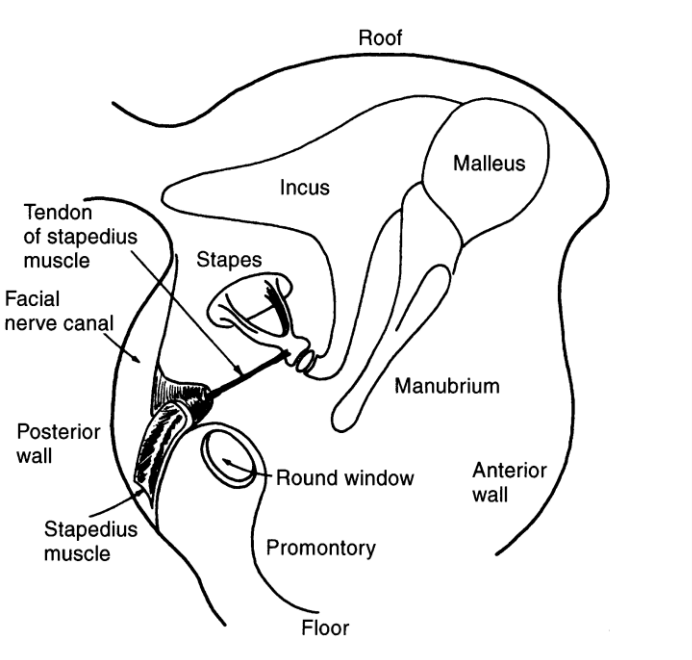
- Larger of the two tympanic muscles.
- Tendon leaves the bony wall via the cochleariform process.



The stapedius

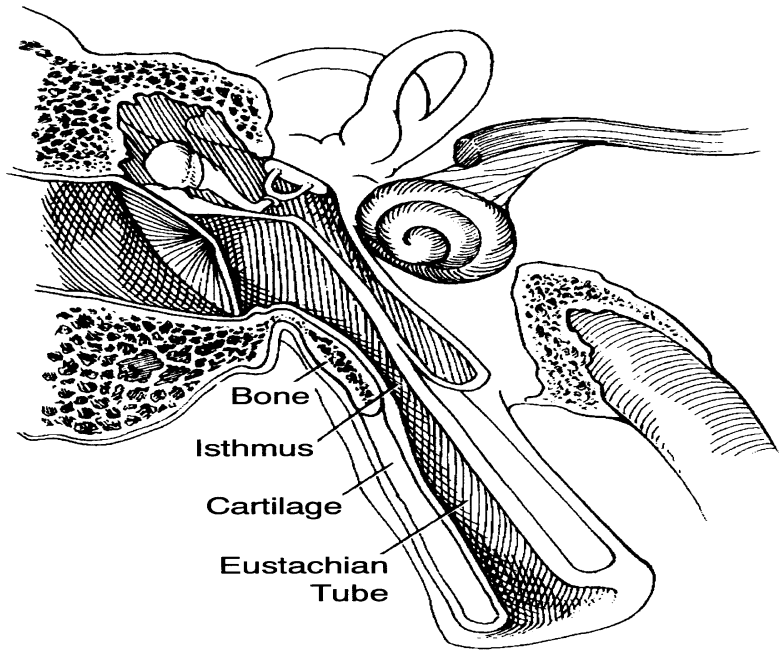
The smaller of the two tympanic muscles.

Tendon leaves the bony wall via the apex of the pyramidal eminence.



The eustachian tube

- 35-38 mm long.
- Oriented downward, forward, medially.
- Cartilaginous portion - outer 2/3.
- Osseous portion - inner 1/3.
- Isthmus.
- Tensor palatini muscle.

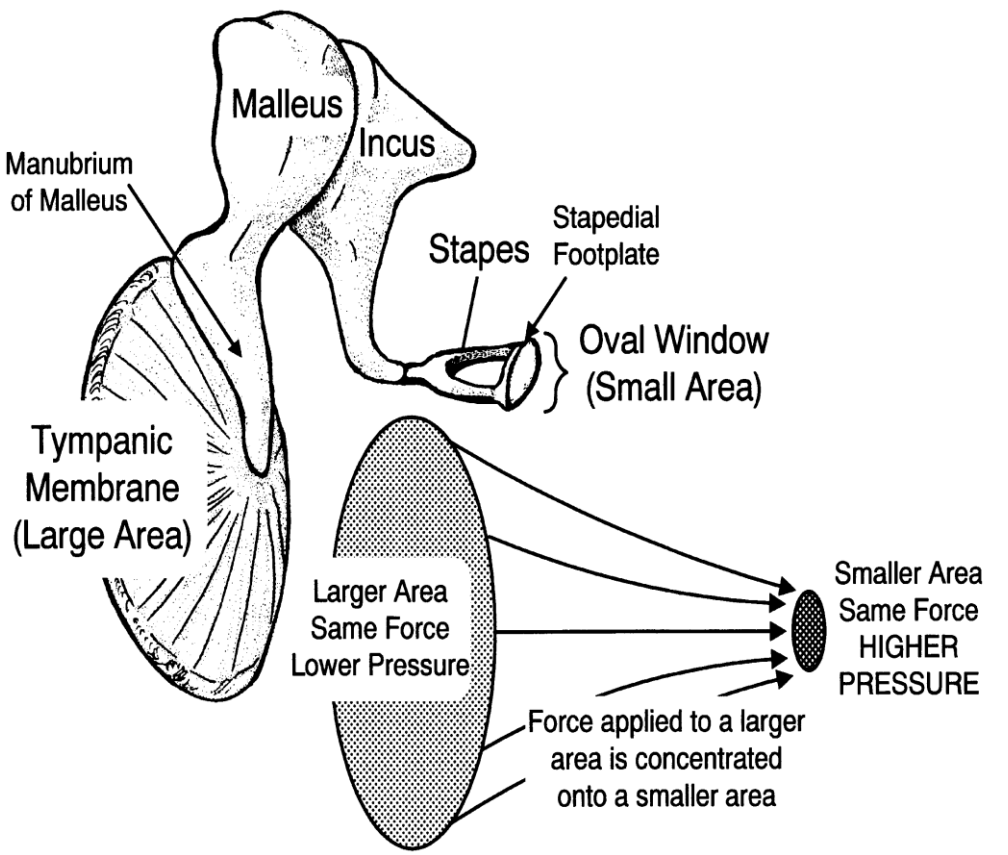


Impedance matching of the middle ear [3]

- Acoustic resistance of air - 41.5 ohms.
- Acoustic resistance of cochlear fluid - 161,000 ohms.
- This represents a ratio of 3880:1.
- Without the impedance matching capabilities of the middle ear, only 1/10 of 1% of the energy of an incoming sound wave would make it into the cochlea--99.9% of the energy would be reflected at the boundary.

Area advantage

- The area of the tympanic membrane is 17 times that of the oval window.
- As the area decreases, the pressure increases.



ACOUSTIC REFLEX

- Bilateral.
- Occurs in response to sound intensities delivered to either ear at 80-90 dB above threshold.

INNER EAR

- Bony labyrinth
- Membranous_labyrinth

Bony labyrinth

The bony labyrinth (or otic capsule) forms the outer wall of the inner ear. It consists of three parts:

- Cochlea
- Semicircular canals
- Vestibule

They contain perilymph, a clear fluid

The vestibule includes:

- Utricle
- Saccule

Receptors in the vestibule responsible for gravity and linear acceleration sensations.

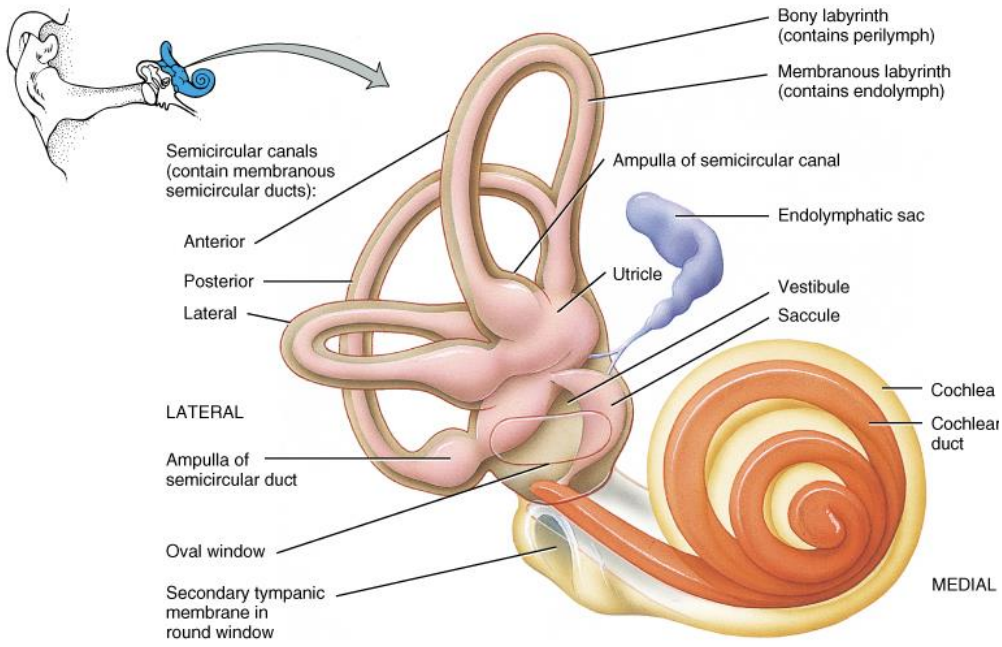
The semicircular canals has thin semicircular ducts within it which is responsible for angular acceleration. The semicircular canals are continous with perilymph filled regions within the vestibule .

The cochlea is a bony, snail like structure with two and half turns that contains the cochlear duct. The sense of hearing is provided by receptors within the cochlear duct.

Membranous_labyrinth

It contains endolymph. Its walls are lined with distributions of eighth cranial nerve.

It includes the utricle and the saccule.



CHOLESTEATOMA [4]

A sac of keratin collection lined by squamous epithelium that enlarges progressively is called as cholesteatoma.

Epidermoid cyst and Cholesteatoma are histologically similar.

Cholesteatomas are of 2 types:

- Congenital cholesteatoma : seen in 2% of cases.
- Acquired cholesteatoma: seen in 98% of cases.
    - Primary - no history of chronic middle ear infection.
    - Secondary -history of chronic middle ear infection.

Rarely external ear cholesteatomas are reported.

Acquired cholesteatomas are common in two sites

- Middle ear
- Mastoid

Congenital cholesteatomas are seen in

- Cerebellopontine angle
- Calvarium
- Suprasellar cistern

Congenital Cholesteatoma [5]

Three criteria for congenital cholesteatoma

- Pearly white mass medial to the tympanum.
- Normal tympanum.
- No previous history of ear surgery, ear perforation or otitis media.

Three important sites

- Middle ear cavity
- Cerebropontine angle
- Petrous bone apex

Commonly seen in the anterior middle ear cavity or around the eustachian tube.

Seen usually in age group of 6 months to 5 years.

Staging of congenital cholesteatoma [6] (Derlacki and Clemis):

Divided into 3 stages

1. Disease involving petrous pyramid.

2. Disease localised to the mastoid .

3. Disease localised to the middle ear.

Potsic staging [7]:

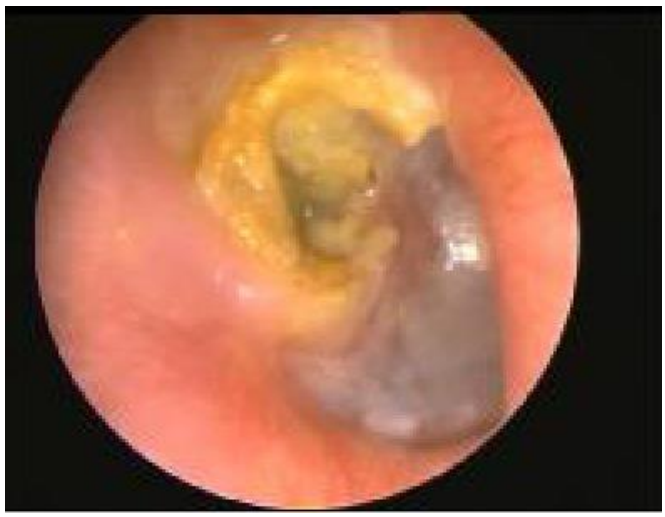
Stage 1 : Single quadrant involvement. Ear ossicles and mastoids are spared.

Stage 2 : Multiple quadrant involvement. Ear ossicles and mastoids are spared.

Stage 3 : Ear ossicles involved with sparing the mastoids.

Stage 4 : Mastoid involvement.

Pearly white mass behind the tympanic membrane



Acquired Cholesteatoma

Wittmaack theory :

Posterosuperior region of attic or pars tensa with invagination of tympanum leads to formation of retraction pockets which further leads cholesteatoma formation.

Toss classification of retraction pockets [8]:

1. Grade 1: Retracted pars flaccida of tympanum . malleus neck seen separately from the tympanic membrane.

2. Grade 2: Retracted pars flaccida of tympanum covering the neck of the malleus. No erosion of scutum.

3. Grade 3: Retracted pars flaccida of tympanum with malleus neck contact and with mild erosion of scutum.

4. Grade 4: Grade 3 with severe erosion of scutum or the outer attic wall .

Ruedi's theory :

Infection leads to proliferation of the basal cells of stratum germinatum and forms collections of stratified squamous epithelium.

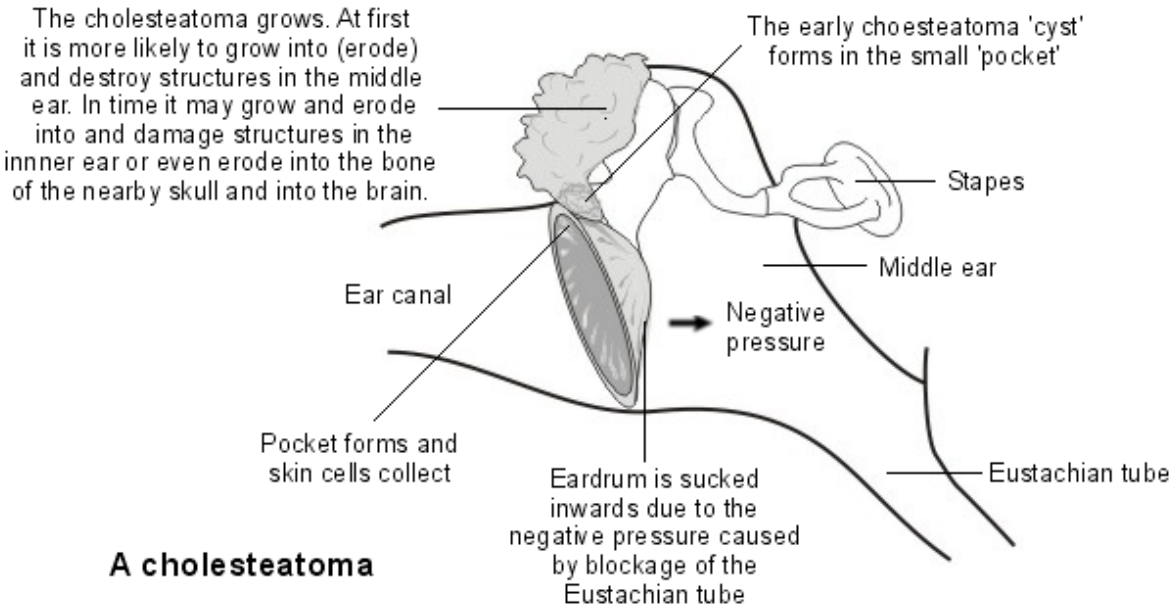
Habermann theory:

Through the perforation in the tympanic membrane , epithelium from external ear canal protrudes into the mesotympanum and proliferates to form cholesteatoma

Other theories [9]:

- Metaplastic change in the mucosa of the middle ear.

- Trauma leads to implantation of squamous epithelium into the mesotympanum



Primary acquired cholesteatoma [10]

Primary acquired cholesteatoma is due to tympanic membrane retraction.

Medial retraction of the pars flaccida progressively into the attic leads to cholesteatoma . Scutum is eroded gradually and a enlarging defect is formed in the epitympanum.The ear drum progressively retracts over the ear ossicles causing ossicular destruction. It enters posteriorly into the mastoids . It also erodes the lateral semicircular canal leading to vertigo and deafness.

Another type of primary acquired cholesteatoma forms if there is the retraction of posterior quadrant of the tympanum . The tympanic membrane attaches to the incus then retracts postero medially laying down squamous epithelium which surrounds the stapes and finally retracts into the sinus tympani.

This type exposes the facial nerve and stapes destruction . Surgical eradication of these lesions are very difficult so recurrence more common.

Secondary acquired cholesteatoma

Secondary acquired cholesteatomas is because of an injury to the tympanic membrane. Causes include

- Trauma.
- Surgical injury to the drum.
- A perforation (Posterior marginal perforation) caused by acute otitis media .

Even tympanostomy tube insertion could leads to cholesteatoma formation.

Classification based on Location in the Tympanic Cavity:

Middle ear cholesteatomas can be classified as the following:

● “Pars flaccida cholesteatomas ” localised to the Prussak space . Due to chronic infection ,keratin collects and sac forms .

Behind normal tympanum -primary acquired type.

Through a perforation of the tympanum - secondary acquired type.

● “Pars tensa cholesteatomas” are located in the lower portion of the TM Commonly seen in

- Facial recess .
- Sinus tympani of the tympanic cavity.
- Mastoid region.

Special Groups of Cholesteatomas

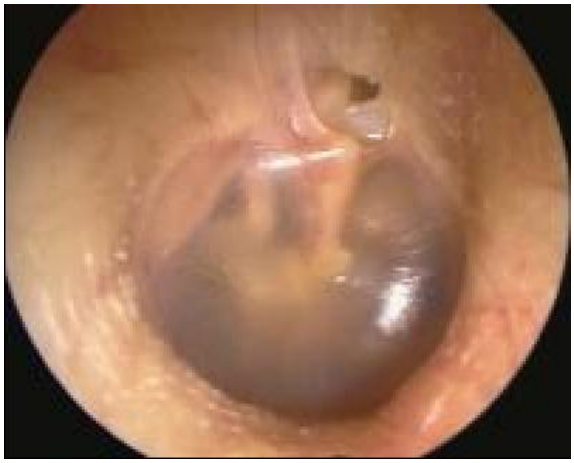
● “Mural cholesteatomas” - “automastoidectomy lesion " are extensively seen in the mesotympanum or mastoid antrum .They drain their contents into the external auditory meatus through tympanic perforation and leave the emptysac behind. The cavity expands because of the enzymatic activity and look like a mastoidectomy defect with no previous surgical history .

- "EAC cholesteatomas" [11], occurs in older population

They are subdivided into

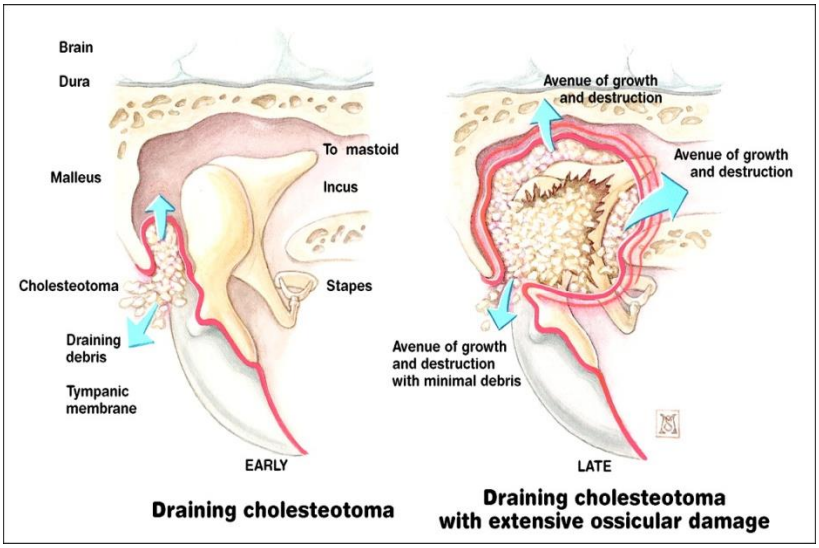
- Idiopathic - Floor of the EAC is the commonest site and it is usually bilateral .
- Secondary - Depending upon the inducing factor, its location can vary.

Epitympanic (attic) cholesteatoma



Cholesteatomas cause bony erosion by the following mechanisms:

- Pressure effects leads to remodeling of bone .
- Increased enzymatic activity leads to increased osteoclastic activity, which further leads to bone resorption aggressively . When it becomes infected this process lightens up causing severe bone erosions.



EPIDEMOLOGY

Peak incidence occurs in the second decade.

Cholesteatoma affects all age groups from infants upto extreme old age.

HISTORY AND ETYMOLOGY [12]

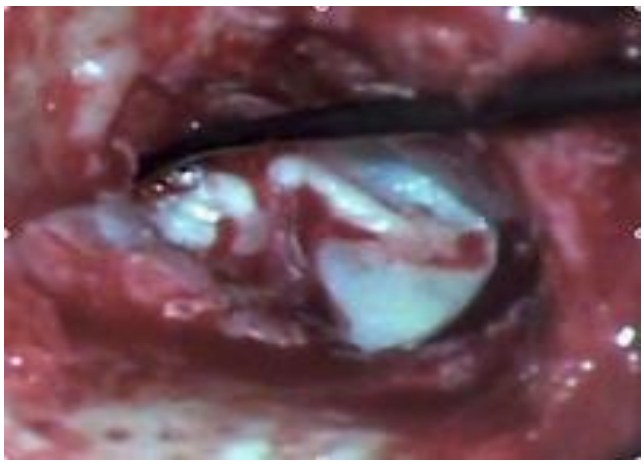
In 1683 Joseph Guichard Duverney described a middle ear soft tissue lesion most likely cholesteatoma.

In 1838, Johannes Muller, the German pathologist named it as “cholesteatoma” (Greek ; chole + stear =fat, oma =tumor) . This term is misnomer because it is not a tumoural lesion and the lesion does not contain fat.

PATHOLOGY

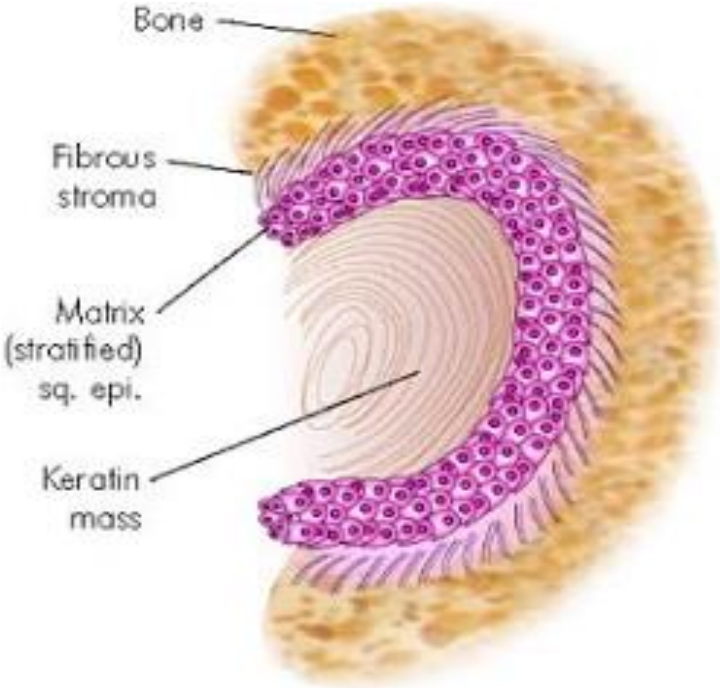
GROSS DESCRIPTION [13]

Pearly white masses of different sizes with creamy granular material embedded on it.



MICRO DESCRIPTION [14]

- Keratin debris.
- Layers of stratified squamous epithelium mixed with granulation tissue .
- Chronic inflammatory infiltrate admixed with foreign body giant cell granulomas, cholesterol clefts and hemosiderin.
- No evidence of metaplasia or dysplasia.



SYMPTOMS

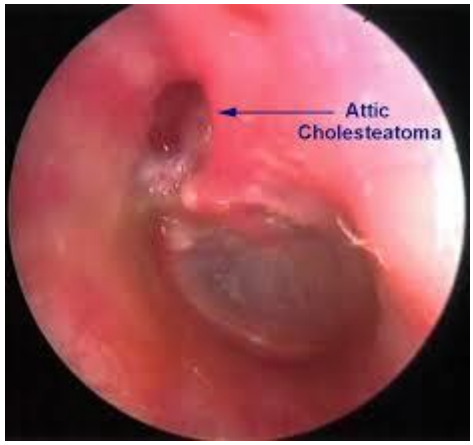
- Conductive hearing loss
    - Ear discharge
    - Ear pain
    - Facial weakness
    - Vertigo
- Dizziness: Relatively uncommon
- Headaches
- Bleeding from the ear

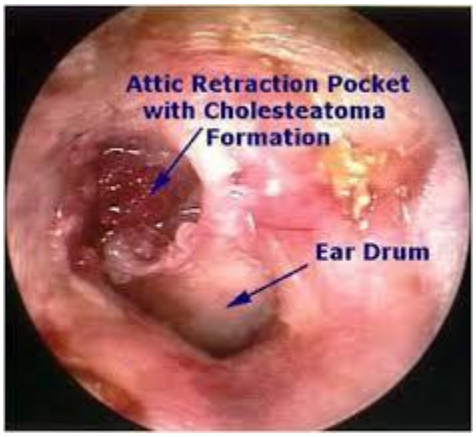
COMPLICATIONS

1. Labyrinthine fistula (perilymphatic fistula) [15]
2. Cochlear fistula: less common
3. Labyrinthitis
4. Facial nerve dysfunction
5. Extension into internal acoustic meatus leading to deafness
6. Meningitis
7. Cerebral abscess
8. Petrous apicitis
9. Sigmoid sinus thrombosis

SIGNS OF UNSAFE PERFORATION OF TYMPANIC MEMBRANE ON OTOSCOPY

- Tympanic membrane perforation usually posterior and superior.
- Annulus of the tympanic membrane perforation..
- Pearly white mass behind ear drum.
- Bone erosions.
- Associated granulation tissue.





DIAGNOSTIC IMAGING

HRCT [16]

Cholesteatomas appear as soft tissue attenuation mass with bony erosions

- **Pars flaccida**
  - Superior extension: most common. Involves prussak space and with erosion of scutum and ear ossicles .
  - Inferior extension: commonly seen in children

- **Pars tensa**
    - Posterosuperior : It displaces ear ossicles laterally

LOOK FOR

- EROSIONS OF THE
    - Scutum
    - Ossicles
    - Lateral semicircular canals
- DEHISCENSE OF THE
    - Facial nerve canal
    - Tegment tympani
- INTEGRITY OF THE
    - Epitympanum
    - Aditus ad antrum and mastoid antrum
    - Oval and round window

Preoperative imaging is necessary for

- Otoscopically hidden lesions especially sinus tympani region .
- Antrum and epitympanum involvement .
- To look for congenital anatomic variations .

HRCT is ideal only when the middle ear cavity is aerated and with bony erosions, but it lacks specificity when only soft tissue is present.

MAGNETIC RESONANCE IMAGING [17]

Diffusion-weighted imaging is superior to Conventional non-contrast MR imaging .

Recurrence or residual tumour are accurately diagnosed using DWI . If DWI not restricted "second look" surgery can be avoided .

MRI is to look for

- Dural invasion
- Epidural abscess
- Subdural abscess
- Meningitis
- Brain herniation into the mastoid
- Facial nerve involvement
- Thrombosis of venous sinuses especially sigmoid sinus

SIGNAL INTENSITIES IN VARIOUS MR SEQUENCES

- **Cholesteatoma**
  - **T1:** Hypointense
  - **T2:** Hyperintense
  - **DWI:** Restriction (due to keratin)
  - **T1 C+ (Gd):** No enhancement (avascular)
- **Cholesterol granuloma**
  - **T1:** Hyperintense (due to fat)
  - **T2:** Hyperintense
  - **DWI:** No restriction
  - **T1 C+ (Gd):** No enhancement
- **Granulation tissue**
  - **T1:** Heterointense
  - **T2:** Hyperintense
  - **DWI:** No restriction
  - **T1 C+ (Gd):** Delayed Enhancement (poorly vascular)
- **Scarring**
  - **T1:** Hypointense
  - **T2:** Hypointense (fibrous tissue)

- **DWI:** No restriction

Gadolinium enhanced T1-weighted MRI can reliably distinguish granulation tissue and residual cholesteatoma. Cholesteatomas are avascular so no enhancement .Granulation tissue is poorly vascularized so it enhances on delayed images.

DWI is a specialized technique in MRI that measures the molecular diffusion of water within the tissues, which can be quantified using Apparent Diffusion co-efficient (ADC)

B value indicates the degree of diffusion weighting applied.

Higher b values are used to detect slow moving particles.

ADC values are calculated using various b-values .

ADC values less than 1.0 to 1.1 x 10^{-3} mm^2/s are considered significant.

High keratin in cholesteatomas are responsible for diffusion restriction. High bone density of the inner ear structures and numerous air-bone interfaces leads to various artifacts hindering the diagnostic ability of DWI .

Newer techniques such as HASTE and BLADE allow detection of smaller lesions and may replace second-look surgery in patients with prior cholesteatoma resection. Thus early detection avoids unnecessary complications and can avoid second looking surgery.

DIFFERENTIAL DIAGNOSIS [18]

- Cholesterol granuloma
- Granulation tissue
- Scar
- Cerumen: seen in the external ear
- Middle ear abscess: can show diffusion restriction but different clinical scenario .

TREATMENT [19]

Eradication of cholesteatoma is mandatary but multiple surgeries may be required.

The surgical removal has two objectives

- Remove a progressive primary pathology .
- Preservation of normal hearing function.

Removal of involved ear ossicles is mandatary if there is high probability of residual disease.

Transcanal atticotomy approach with subsequent tympanoplasty can be used for smaller lesions within prussak space.

Very low rate of recurrence of cholesteatomas seen in Canal wall–down tympanomastoidectomy .

Patients have traditionally undergone two -stage operations

- First stage procedure for eradication of the primary pathology.
- Second stage procedure performed 6–18 months after the initial surgery to look for residual /recurrent disease.

Canal wall–down tympanomastoidectomy helps in removal of cholesteatoma in 3 ways :

1. Adherent surface of the cholesteatoma is removed.
2. Hidden cholesteatomas can be eliminated by removing the barrier.
3. It provides the path for the surgical instruments to enter into middle ear cavity .

Careful design and construction of the mastoid cavity,reconstruction of the ear canal wall,preservation of the auditory canal wall and reconstruction of the chain of ossicles are essential to prevent recurrent disease.

REVIEW OF LITERATURE

- Jean-Philippe Vercruysse et al [20] states that sensitivity, specificity, PPV and NPV for DWI is 81, 100, 100 and 40%, respectively for primary cholesteatomas and for recurrent post operative cases DWI has the sensitivity, specificity, PPV and NPV of 12.5, 100, 100 and 72%, respectively. So it concludes DWI is accurately able to detect large primary cholesteatoma but inable to detect small residual cholesteatoma <5mm.

- Bert De Foer et al [21] proves Single shot turbo spin echo DWI sequence has high sensitivity in detecting small cholesteatomas .Smallest size detected is 2 mm. In study of 21 patients DWI can identify 19 of cases accurately.

- Milan Profant et al [22] states pooled sensitivity of nonechoplanar diffusion weighted imaging for cholesteatoma detection is 96.15%, specificity was 71.43%. Positive predictive value was 92.59% and negative predictive

value was 83.33% . In 25 out of 33 patients (both primary and recurrent cases) DWI accurately detects the cholesteatoma.

- Anne Geoffray et al [23] states sensitivity to diagnose recurrent cholesteatoma was 87% for both DWI and delayed post-gadolinium sequences and the specificity was 71% and 83%, respectively . Adding both sequences, the sensitivity was 87%, the specificity increased to 100%. DWI is equally sensitive to contrast enhanced MRI in detecting recurrent cases . In 20 pediatric cases 18 are correctly diagnosed and it avoids the second looking surgery in recurrent cholesteatoma in children. Small recurrences less than 5 mm may be missed, so this study recommends prolonged follow-up for 5 years.

- Mark C.J. Aarts et al [24] states for the 8 EPI DWI studies, the pooled sensitivity was 68%, specificity was 87%, positive predictive value was 81%, and negative predictive value was 78 % For the 3 non-EPI DWI studies, the sensitivity was 97%, specificity was 97%, positive predictive value was 97%, and negative predictive value was 97 %. Non-EPI is superior to EPI in detecting cholesteatomas as it avoids susceptibility artifacts and even detects smaller lesions.

- In Stasolla, Alessandro et al [25] 18 postoperative cases suspected for having relapsing/residual cholesteatoma are subjected to DWI. In EPI-DWI, 5 out of 6 patients with cholesteatoma showed diffusion restriction Noncholesteatomatous lesions doesnot show diffusion restriction . The study has sensitivity of 86%, specificity of 100%, positive predictive value of 100%, and negative predictive value of 92% in diagnosing relapsing/residual cholesteatomas .

- S. Khemani et al [26] states non-echo planar DWI is highly sensitive and specific for detecting recurrent cholesteatoma .HRCT ,conventional MRI and delayed contrast T1 are used in detecting postoperative cholesteatoma. Delayed contrast T1 is comparatively good than HRCT and conventional MRI. Sensitivities and specificities of all other MR sequences and HRCT methods are low and non echo planar DWI is proved to be superior to all other techniques.

- In S. Thiriata et al [27] cohort of 15 postoperative patients were retrospectively studied. Diffusion-weighted images were obtained and the apparent diffusion coefficient values were calculated. Three specific ADC value ranges are obtained for three groups of lesions detected at surgery (pure cholesteatoma, cholesteatoma with infection, and abscess

or infection). Mean ADC values of abscess /infection is found to be significantly lower than the cholesteatoma.

- Amit Karandikar et al [28] states in a retrospective study of 15 patients clinically confirmed or suspected cholesteatomas who underwent PROPELLER DWI, 13 patients had cholesteatomas while two patients had mastoid abscesses. "Average ADC values of cholesteatoma was 0.868×10^{-3} mm^2/s and ADC values for abscess is 0.425×10^{-3} mm^2/s".

- Migirov et al [29] states DWI shows bright signal in 27 cases of primary and 23 cases of recurrent cholesteatoma with 98 % clinical and radiological concordance . DWI overestimates the diagosis of recurrence in one case and smallest lesion detected is 3 mm. Lesion less than 8mm confined to middle ear are removed by endoscopic transcanal technique whereas larger lesions are removed by retroauricular mastoidectomy.

- Corrales et al [30] states HRCT and DWI are complementary to each other in diagnosing cholesteatoma. It proved that Non EPI DWI is superior to EPI and delayed contrast gadolinium enhanced MR images.

- In Kodama et al [31] cholesteatoma was accurately diagnosed by showing diffusion restriction on EPI-DWI and FASE sequence with sensitivity of

73.3% and 90%, respectively. Image distortion noted in EPI-DWI compared to FASE-DWI mainly because of susceptibility artifacts in EPI.

- P D Yates et al [32] states the role of HRCT in diagnosing cholesteatoma and its extent and involvement of tegmen tympani, semicircular canals , ear ossicles and facial nerve canal involvement. However in absence of bony erosion diagnosis is difficult.

- In M.Wake et al [33] pre-operative HRCT was performed prior to revision surgery in 10 patients to check for cholesteatoma. Three independent radiologist reports were obtained on the HRCT scans and compared with the peroperative findings. It emphasise HRCT is not useful in the diagnosis of recurrent cholesteatoma. There was poor inter-observer agreement in interpretation of the HRCT temporal bone.

- In Dirk Vanden Abeele et al [34] 18 patients were examined with MRI prior to revision surgery. It states that only 61% radiosurgical correlation and at present MRI is not a very good alternative to revision surgery in recurrent cases . MRI not clearly delineates small cholesteatoma from scar tissue.

- Pisaneschi, Mark J., and Bradley Langer et al [35] explains the ability of MRI in differentiating congenital cholesteatoma and cholesterol granuloma of the temporal bone due to hyperintense signal of cholesterol granuloma in T1 images and cholesterol granuloma does not shows any diffusion restriction.

- Joselito L. Gaurano, Ismail A. Joharjy et al [36] states the role of HRCT in detection of early erosive changes suggestive of cholesteatoma in study of 64 patients. however MRI is needed to confirm the diagnosis if there is no bone erosion.

- K. Barath et al [37] states the role of conventional MR imaging (T1 ,T2 and postcontrast T1 images) in differentiating other soft tissues from cholesteatomas and proves post contrast T1 is superior to conventional T2 images in diagnosing cholesteatomas.

- In Venail et al [38] 45 patients incuded in the study and it compares DW-EPI with delayed Gadolinium enhanced T1 MR imaging in postoperative patients. It confirms DWI has high specificity but less sensitivity compared to delayed Gadolinium enhanced T1 MR imaging. Specificity was further increased by combining these two techniques only for larger

cholesteatomas more than 5 mm but for small cholesteatomas there is no improved specificity.

- In Pizzini et al [39] out of 30 patients HASTE DWI accurately detects all the cases with sensitivity ,specificity, PPV and NPV of 100 %.

- In Kasbekar et al [40] 19 patients are studied using PROPELLER DWIand it proves DWI has sensitivity of 57% , specificity of 75%, PPV 62% and NPV 75%. Kasbekar et al states if a low-resolution imaging matrix of 128 × 128 was used, smaller lesions can be missed . Higher signal noise ratio and less blurring are seen in PROPELLER comparison with HASTE DWI.

- In Lehman et al [41] 35 patients are studied using PROPELLER DWI with sensitivity of 96.5% , specificity of 100%, PPV 100%, NPV 96.3%.

- In Dubrulle et al [42] 24 patients are studied using multishot DWI with sensitivity of 100% , specificity of 91%, PPV 93% and NPV 100 %.

- Fernando Más-Estellés et al [43] states non EPI is superior to HRCT for accurately diagnosing cholesteatoma and detects small lesions of size 2mm and avoids posterior fossa susceptibility artifacts. Out of 52 patients studied using PROPELLER sequence with sensitivity 92.8% and specificity 92.3%.ADC values found to be 0.8–1.1 $\times 10^{-3}$mm2/sec ADC values found found in abscesses is 0.4–0.6 $\times$ 10^{-3}mm2/sec and very high values found in cholesterol granulomas 2–3 $\times$ 10^{-3}mm2/sec . The bright signal at DWI on b = 0 sec/mm2 images that persists or increases on high b value (1000 sec/mm2) is characteristic of cholesteatoma .

- In A. Turan Ilıca et al [44] 17 cases are included in study both primary and recurrent lesions. HASTE DWI accurately detects 11 primary and 5 postoperative cases . one small lesion 4mm is missed . This study has the sensitivity of 94% , specificity of 100%, PPV 100% and NPV 80%.

- In Dhepnorraret et al [45] 22 patients are studied using multishot DWI with sensitivity of 100% , specificity of 100%, PPV of 100% and NPV 100%. Smallest lesion detected is 3mm.

- In Kimitsuki et al [46] 19 patients were studied . It states that conventional MRI should not replace revision surgery for recurrent cholesteatoma due to poor radiosurgical correlation in 30% of their patients .However, in this study no diffusion MRI was used, and the Gadolinium enhanced images were also not delayed.

- "K.M. Schwartz J.I. Lane B.D. Bolster, Jr and B.A. Neff" [47] states modern non EPI sequences used in DWI though increases scanning time it avoids ghost artifacts , susceptibility artifacts, off resonance effects and geometrical distortion. However T2 blurring will be seen in DWI HASTE images and it also proves non EPI has high sensitivity and specificity in diagnosing cholesteatomas.

- In K. Yamashita et al [48] 30 clinically suspected patients were operated and cholesteatoma was histopathologically proved in all the cases. 30 cases of cholesteatomas, 20 primary and 10 recurrent patients were assessed by the observers. Excellent interobserver agreement was found for both MS-EPI (kappa values 0.856) and SS-EPI (kappa values 0.820). It proves MS-EPI has a higher sensitivity and accuracy than SS-EPI.

  4 cholesteatomas were not diagnosed on both SS-EPI and MS-EPI. Even on retrospective observation, these lesions were not able to

identified on conventional MR sequences .

- Schaefer et al [49] measured the ADC values of cholesteatoma which are identical to gray matter but lower than CSF. They showed combination of T2 shine through and restricted diffusion was responsible for the bright signal of cholesteatomas on DWI.

- Chen et al [50] reported a series of 8 patients with epidermoids and measured ADC values. They concluded that the hyperintensity of epidermoids on DWI is only by T2 shine-through effects not by restricted diffusion . Chen et al states the "mean ADC of epidermoids was found to be 1.197×10^{-3} mm^2/s". T1, Fast T2, proton density weighted dual-echo sequences, Fast-FLAIR sequences, and DW EPI totally five sequences used and are compared. Echo-planar DW imaging is better than Fast FLAIR and other conventional sequences in detecting epidermoids.

- Sharad Maheshwari and Suresh K. Mukherji [51] states the apparent diffusion coefficient values in the cholesteatoma were 0.58×10^{-3} mm^2/s.. The hyperintensity of cholesteatoma on DWI is likely a combination of T2 shine through and restriction effects .

- In Dalia Monir Fahmy and Sameh M. Ragab [52] case study 20 patients (7 female and 13 male patients) were subjected to MR examination before surgery DWI combined with conventional MR sequences depicted 8 cholesteatomas. Two lesions were missed that were <3 mm. One patient was misdiagnosed as cholesteatoma, biopsy revealed acute inflammation. It has sensitivity of 80%, specificity of 90%, positive predictive value of 89% and negative predictive value of 82%. Granulation tissue ADC ranged from 0.541 to 0.128 x 10^{-3} mm2/s (with a mean value of 0.33± 0.09),all showed moderate enhancement on post contrast study. All eight cases of residual cholesteatoma showed high SI on DWI, ADC value ranged from 0.984 to 0. 563 x 10^{-3}mm2/s (with a mean value of 0.77 ± 0.13). Three cases showed no significant enhancement, while remaining five showed marginal enhancement. No overlap was found between ADC values of residual cholesteatoma and granulation tissue with a cut off value of 0.55 x 10^{-3} mm2/s.

- Poornima Digge et al [53] states the limitation of HRCT in diagnosing cholesteatomas . In HRCT cholesteatomas appears as non-dependent soft tissue density and bony erosions, which is also seen in cholesterol granuloma, ectopic meningioma and middle ear effusion .HRCT scan correlated with the surgical finding and histopathologic reports with a

high degree of accuracy for middle ear ossicular erosion (96.8%),for the incus erosion (96.4%) and (100%) for the malleus erosion. however MRI is ideal in diagnosing recurrent cholesteatoma .

- Mosnier et al [54] operated on 50 patients with brain herniation and chronic otitis media: 14 of them (28%) were found to have an encephalocele that was the result of previous mastoid surgery. Their study findings confirmed that a CT scan is the procedure of choice for identifying tegmen erosion and when there is suspicion of an existing encephalocele, but that MRI is essential to differentiate between cholesteatoma, brain herniation and inflammatory tissue.

- Elefante et al [55] recommends replacement of Single shot EPI with multishot turbospin echo in the MRI routine study of primary and recurrent middle ear cholesteatoma because of the increased diagnostic accuracy(0.97) and the lower NPV(1), with a substantial reduction of misdiagnosis. In the study of 32 patients, 16 patients were suspected of having primary cholesteatoma and 16 of having recurrent disease are subjected to MRI interpreted by two unexperienced radiologists and two experienced neuroradiologists. Inter reader agreement between the observers revealed the superiority of multishot turbospin echo compared to Single shot EPI. Inter rater agreement among all the four

observers was higher by using multishot turbospin echo compared to Single shot EPI.

- In P. Aikele et al [56] 22 post operative patients were subjected to MR imaging. DWI with conventional MR imaging diagnosed 10 of 13 cholesteatomas with sensitivity of 77%. 3 small lesions were missed . Specificity of MRI was 100%.The positive predictive value was 100%. and negative predictive value was 75%.

- In H. Sharifian et al [57] 35 clinically cholesteatoma suspected patients were subjected to 3 MRI sequences including delayed post-Gadolinium enhanced MRI, EPI and non-EPI-DW sequences and the MR findings were compared with postoperative findings. Two experienced radiologists analysed the images.. 26 cases of cholesteatoma detected at the surgery. Sensitivity and specificity of non EPI DWI is superior to EPI and delayed post-Gadolinium enhanced MRI. Specificity of EPI DWI is only slightly higher than delayed post contrast images.

Imaging	sensitivity		specificity		
	Radiologist 1	2	Radiologist 1	2	
Delayed post-Gadolinium enhanced MRI	73.1 %	84.6	77.8%	88.9	
EPI	61.5%	50	88.9%	88.9	
Non EPI	96.2%	92.3	100%	100	

- In Cimsit et al [58] 26 patients with both primary and recurrent lesions were analysed with HRCT and MRI. Loss of middle ear aeration on HRCT and signal changes on DWI were analysed .Histopathology was compared with image findings. Out of 26 patients 14 were diagnosed as non cholesteatomatous lesion. 12 patients were diagnosed as recurrent cholesteatoma of which 11 were histopathologically confirmed. This study has PPV of 91.7% and NPV of 100 % .

  Associated granulation tissue noted in 4 patients which shows soft tissue more than diffusion restricted areas noted within the middle ear. It confirms DWI can reliably distinguish cholesteatoma from other middle ear soft tissue lesions and can be used in place of second look surgery

AIM:

To evaluate the usefulness of DWI in diagnosing middle ear cholesteatomas and to differentiate post operative inflammatory changes from recurrent cholesteatoma with the aid of postoperative pathological correlation

OBJECTIVE:

1. To determine the usefulness of diffusion restriction in differentiating middle ear focal lesions
2. To determine the usefulness of newer diffusion techniques to detect smaller lesions and in postoperative recurrent lesions

MATERIALS AND METHODS

Forty patients between 10-60 years of either sex with suspected cholesteatoma both new and postoperative cases will be included in this study after approval of local ethical committee and obtaining informed consent.

Inclusion Criteria

- 10 – 60 years of either sex in whom middle ear focal lesion suspected on otoscopic examination
- In patients whom HRCT temporal bone found to be inconclusive
- Postoperative patients before second looking surgery

Exclusion Criteria

- Patients whom not given the consent.
- Pregnant patients
- Patients with cochlear implant
- Patient with MR incompatible pacemaker
- Other general contraindications for MRI

Sequences used

Using 3 tesla MRI scanner following sequences are used

TI AXIAL AND CORONAL

FST2 AXIAL AND CORONAL

DWI AXIAL& CORONAL

STIR

DWI

Patients suspected of having middle ear focal lesions by otoscopic examination,postoperative patients ,HRCT temporal bone inconclusive patients are subjected to different MRI sequences, DWI especially HASTE axial images with b-values of 0 and 1000 s/mm^2.

DW images obtained and ADC maps were derived automatically from the software on voxel-by-voxel basis.

The results are compared with the postoperative pathological findings and analysed using statistical package.

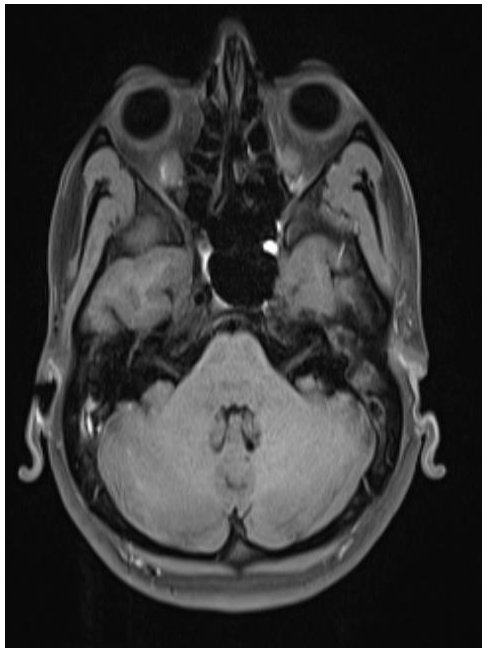
CASE 1

A 40 year male outpatient comes with left ear discharge and mild deafness for past 6 months.

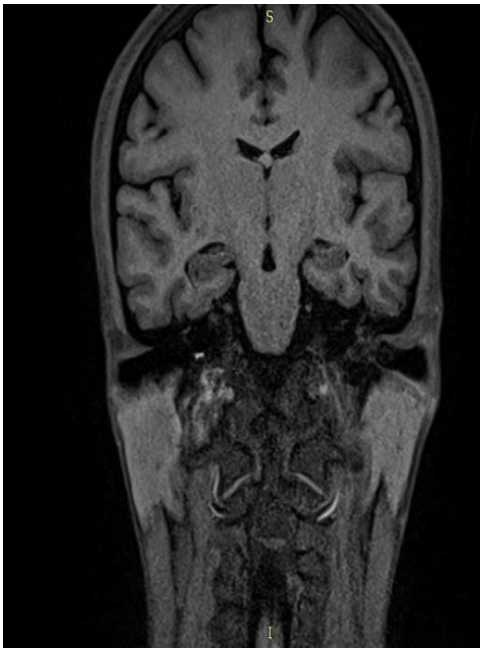
Headache on and off for 2 months duration.

History of left middle ear surgery 10 years back for the similar complaints cortical mastoidectomy done and cholesteatoma removal done.

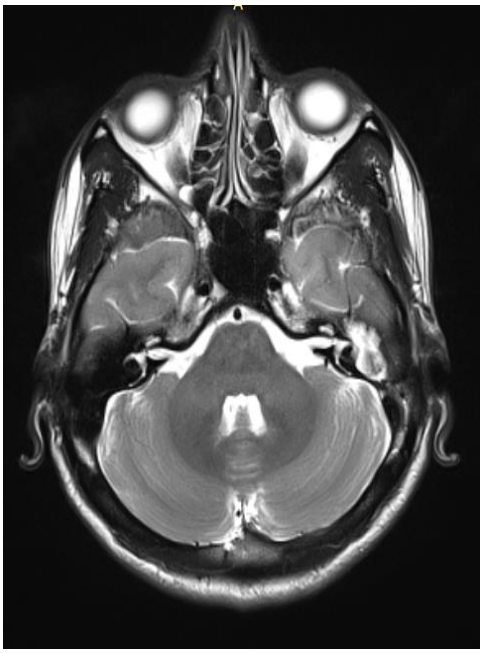
T1 AXIAL



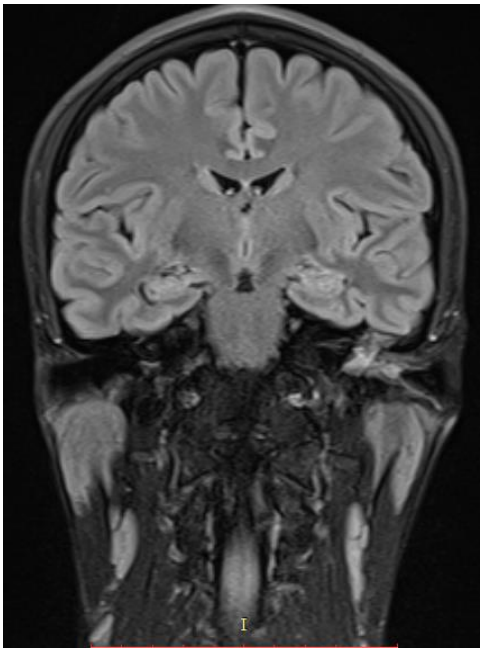
T1 CORONAL



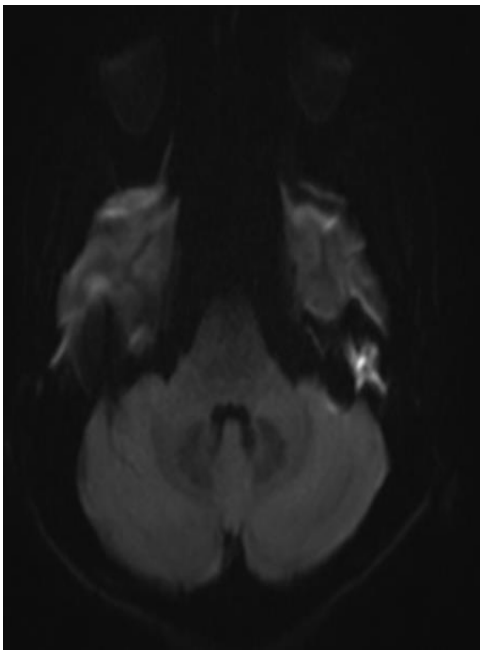
T2 AXIAL



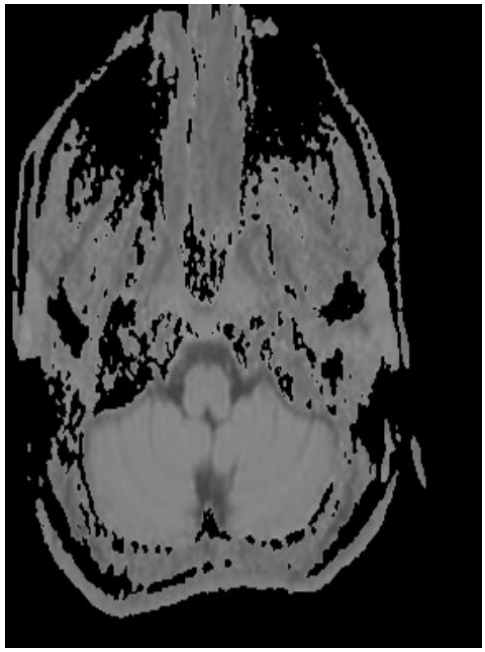
FLAIR CORONAL



DWI



ADC



DISCUSSION

Lesion noted in the left middle ear has low signal on T1 images, high signal on T2 and FLAIR images and showing diffusion restriction with corresponding low ADC values - 0.59 x 10^{-3} mm^2/s and the provisional diagnosis of cholesteatoma was made . Patient was taken for surgery and removal of middle ear mass done and specimen sent for histopathological analysis.HPE reveals and confirms the diagnosis of cholesteatoma.

CASE 2

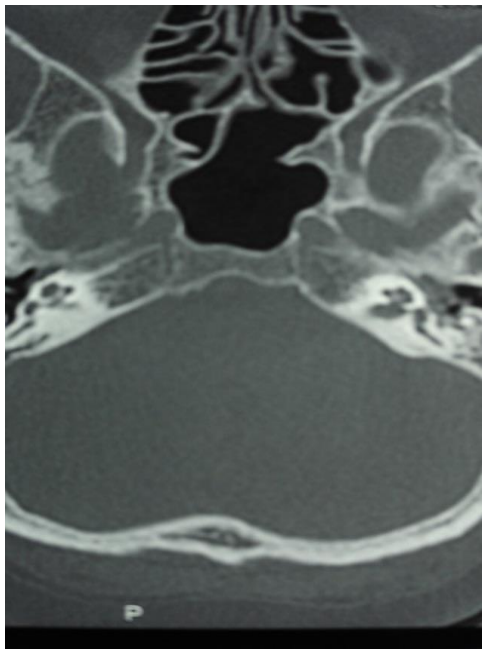
A 38 year old male comes with complaints of left middle ear hearing loss and ear discharge for past 4 months duration.

History of cholesteatoma surgery 7 years back.

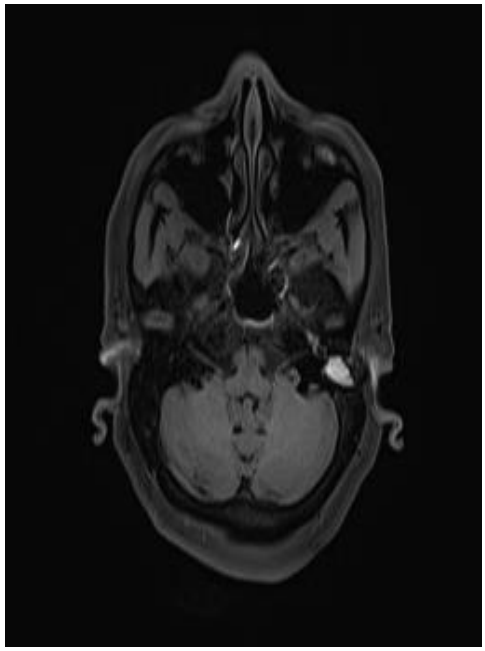
Otoscopy reveals the lesion in the middle ear.

CT shows soft tissue density lesion in left middle ear and patient is referred for MRI for suspicion of recurrent cholesteatoma .

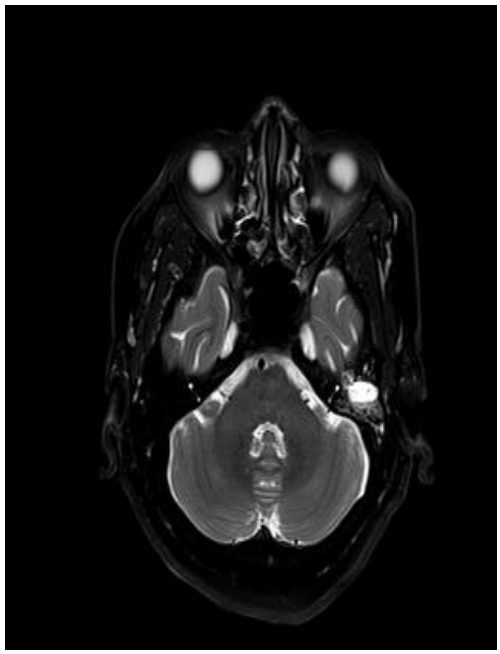
CT



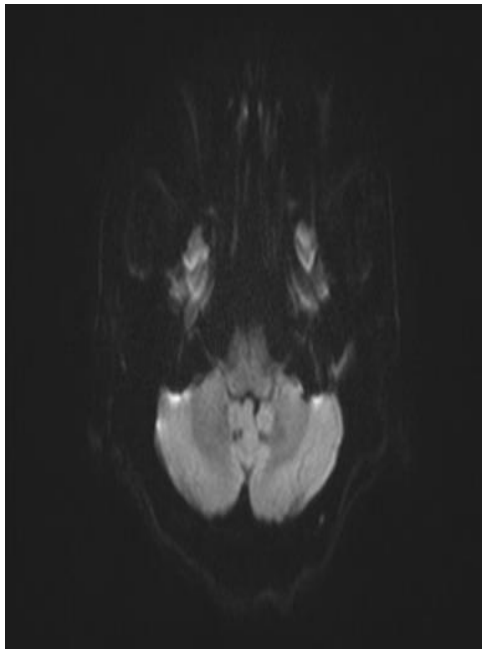
T1 AXIAL



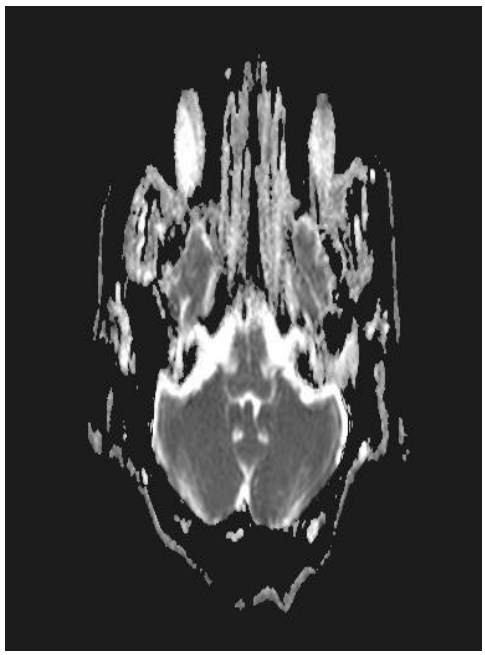
T2 AXIAL



DWI



ADC



DISCUSSION

Lesion appears hyperintense both in T1 and T2 sequences and doesnot shows diffusion restriction with ADC value - 0.45x 10^{-3} mm^2/s and diagnosis of granulation tissue was made which was subsequently confirmed by postoperative histopathological analysis.

CASE 3

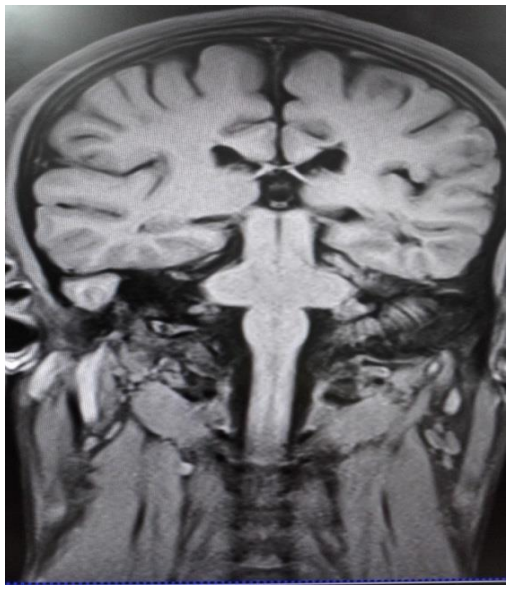
42 year old male patient who has been operated twice for cholesteatoma comes with compliants of ear pain with discharge for past 6 months .

First surgery in 2005 and second in 2009.

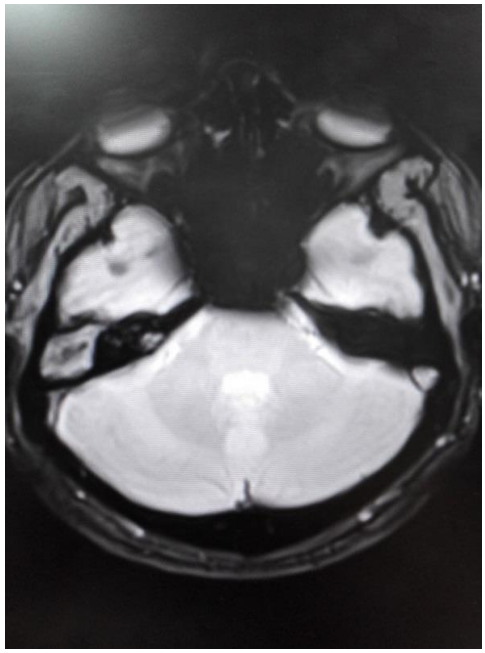
Otoscopy suspicious for recurrent lesion.

CT shows soft tissue opacity in the right middle ear .

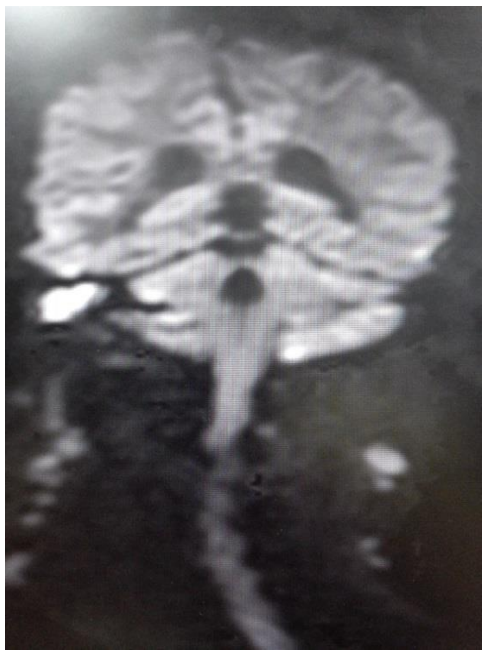
T1 CORNAL



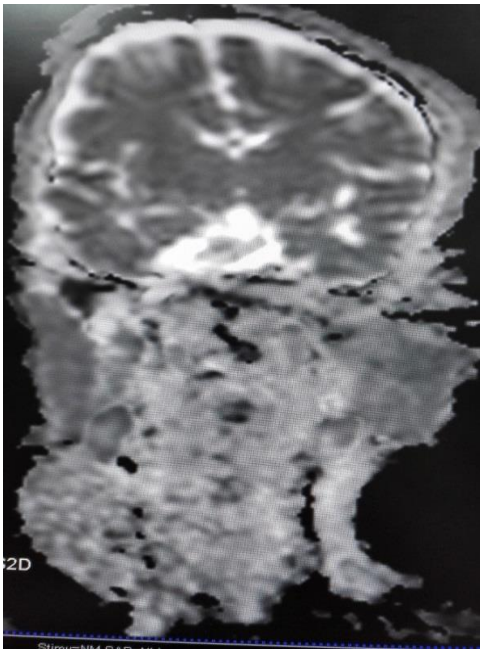
T2 CORONAL



DWI



ADC



DISCUSSION

Lesion appears heterointense in T1 and hypertintense on T2 and shows diffusion restriction significantly with low ADC values - $0.62x10^{-3}$ mm^2/s and the diagnosis of cholesteatoma was made .

Postoperative histopathological report confirms the MRI finding.

Heterogenicity of the lesion in T1 is commonly seen in recurrent cholesteatoma.

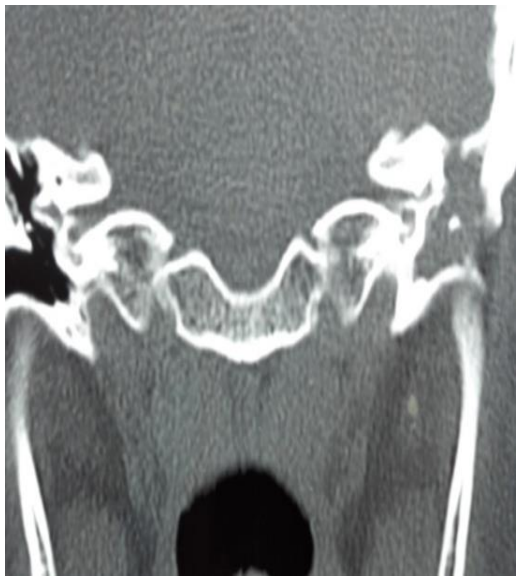
CASE 4

50 year old male patient comes with compliants of left ear pain and ear discharge for past 10months.

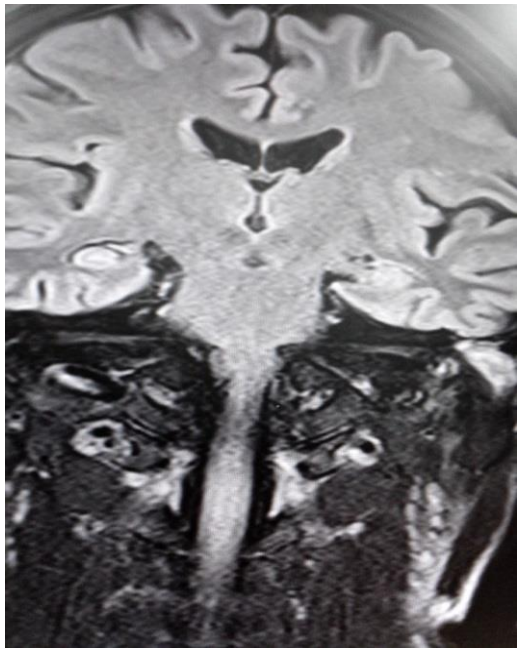
Otoscopy reveals pearly white mass behind the tympanum.

CT shows soft tissue opacity left middle ear with erosion of ear ossicles and tegmen tympani.

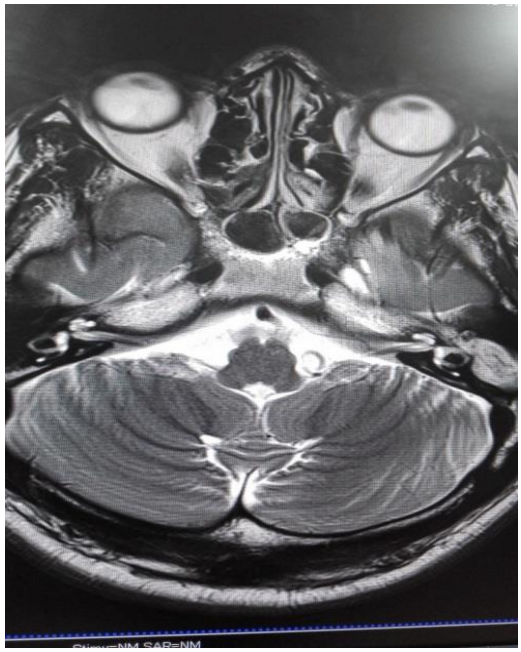
CT



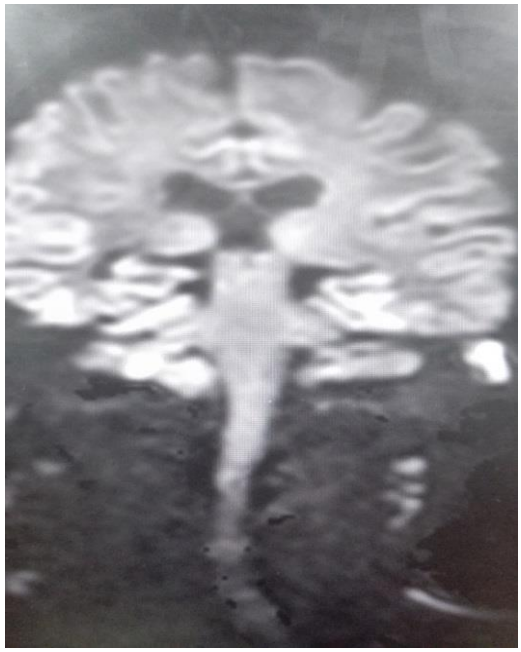
T1 CORONAL



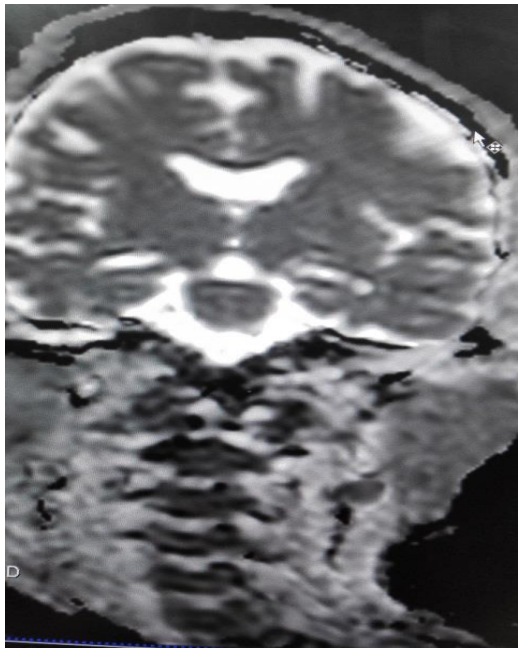
T2 AXIAL



DWI



ADC



DISCUSSION

Lesion appears heterointense in T1 and hyperintense in T2 and shows diffuse restriction with low ADC values - 0.59 x 10^{-3} mm^2/s and MRI findings consistent with cholesteatoma.

Postoperative follow up found to be cholesteatoma .

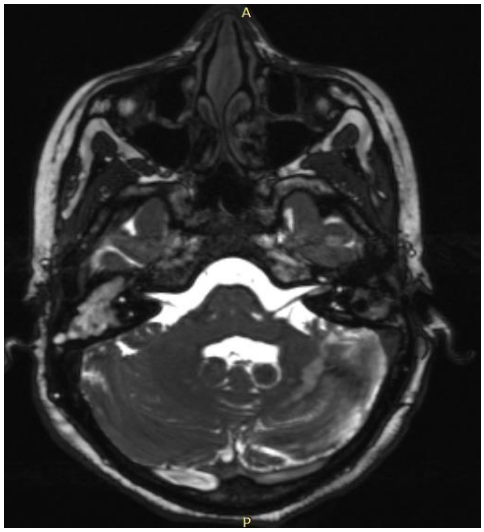
CASE 5

A 15 year old girl comes with complaints of left ear discharge with mild deafness past 4 months duration

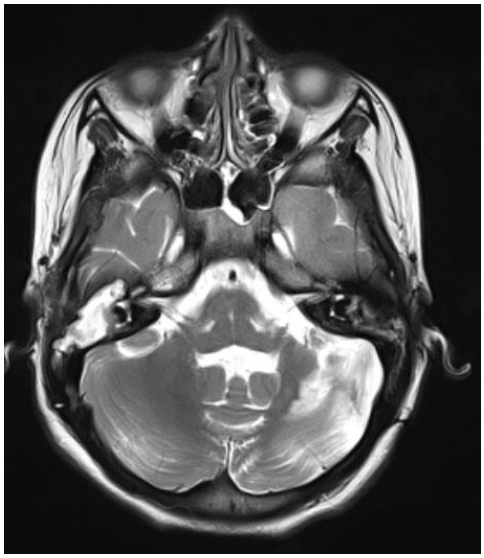
Patient was operated for cholesteatoma in left ear 1 year back

Otoscopy reveals middle ear lesion highly suspicious of recurrence and referred for MRI.

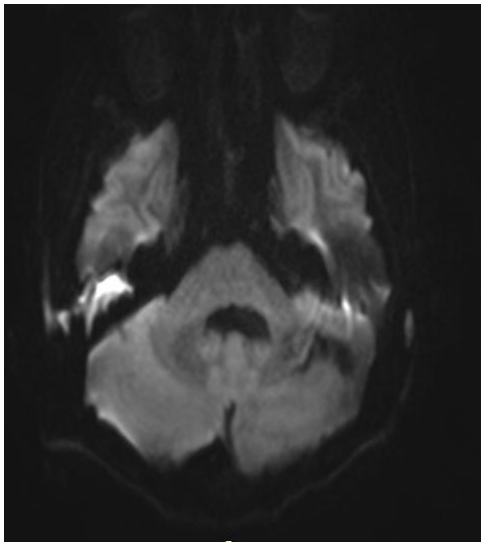
T1 AXIAL



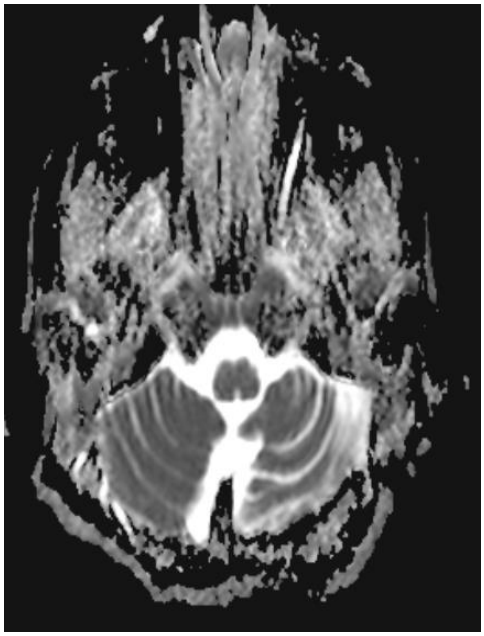
T2 AXIAL



DWI



ADC



DISCUSSION

Lesion is T1 and T2 hyperintense and appears bright on diffusion images but doesnot shows significant low ADC values.

Possibility of cholesteatoma based on high diffusion values and ADC values 0.41x 10^{-3} mm^2/s but Postoperative HPE reveals granulation tissue.

CASE 6

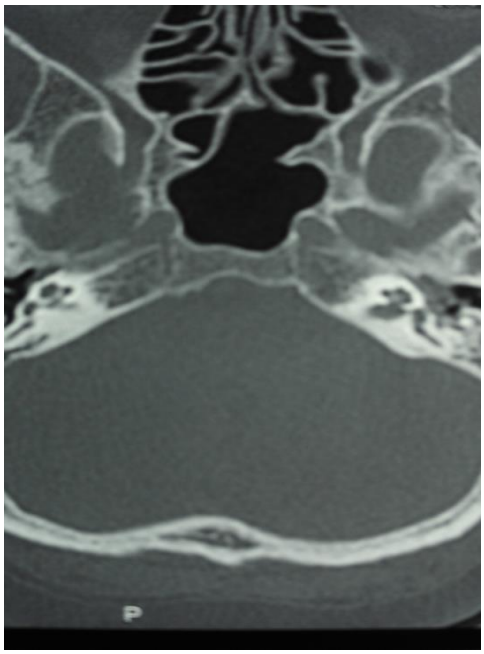
63 year old female patient comes with compliants of left ear discharge 7 months.

Mild hearing loss noted.

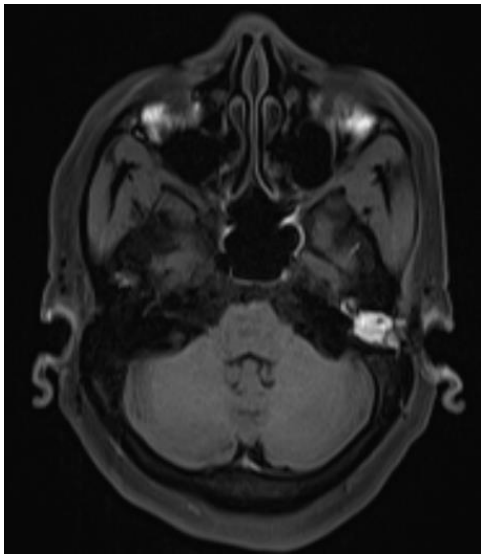
Otoscopy reveals nonspecific middle ear lesion.

HRCT reveals middle ear soft tissue lesion . no evidence of ossicular erosion.

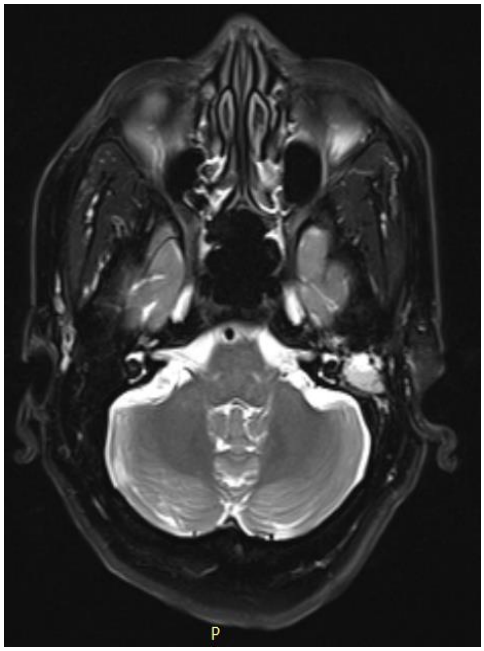
CT



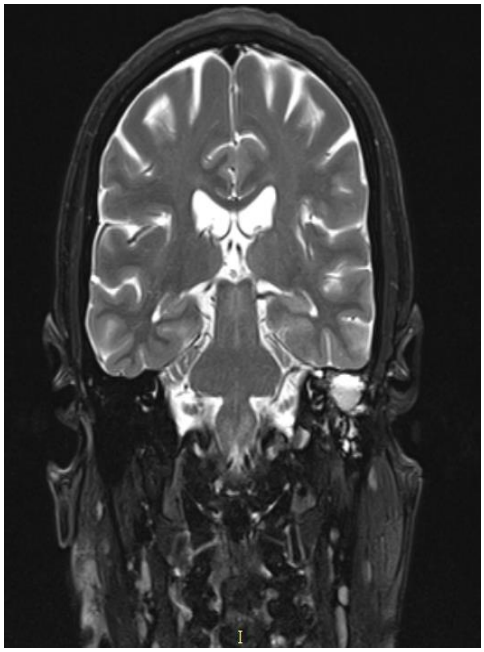
T1 AXIAL



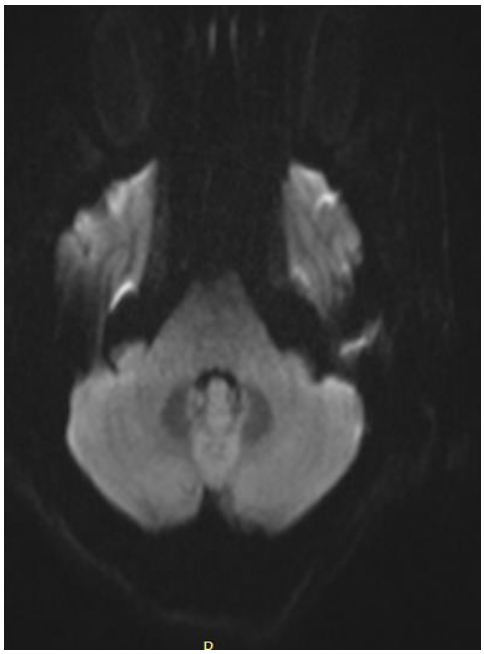
T2 AXIAL



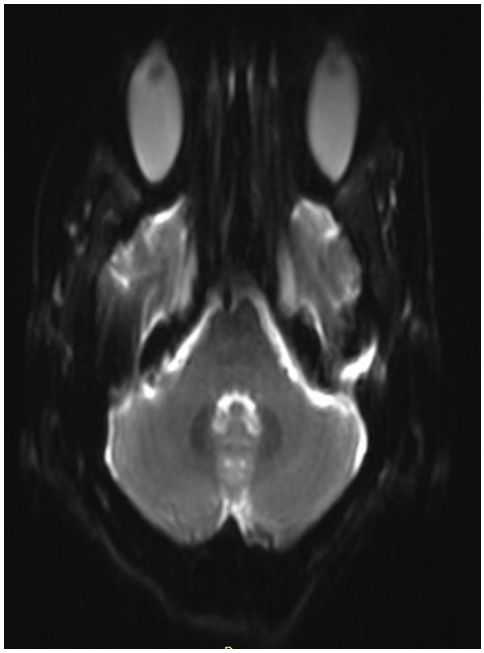
T2 CORONAL



DWI



ADC



DISCUSSION

Lesion appears hyperintense on T1 ,T2 and FLAIR sequences and hypointense in DWI and hyperintense in ADC sequences. ADC value is 1.9 x 10^{-3} mm^2/s .Since no history of previous surgeries diagnosis of cholesterol granuloma made out.

Postsurgical HPE analysis confirms the diagnosis.

CASE 7

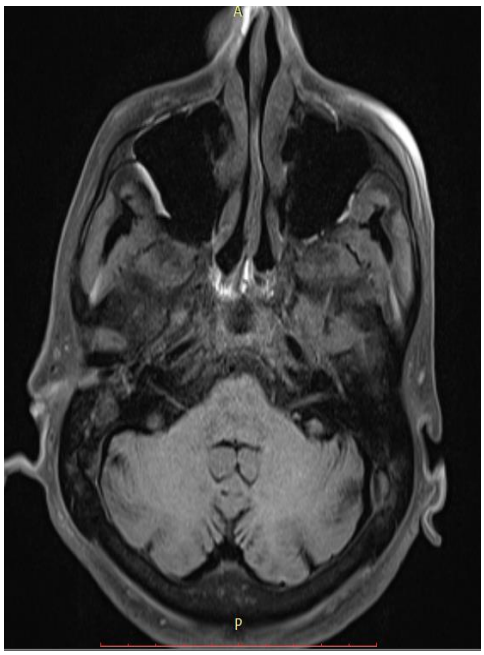
78 year old male comes with compliants of right ear discharge past 1 year.

Mild hearing loss 8 months duration.

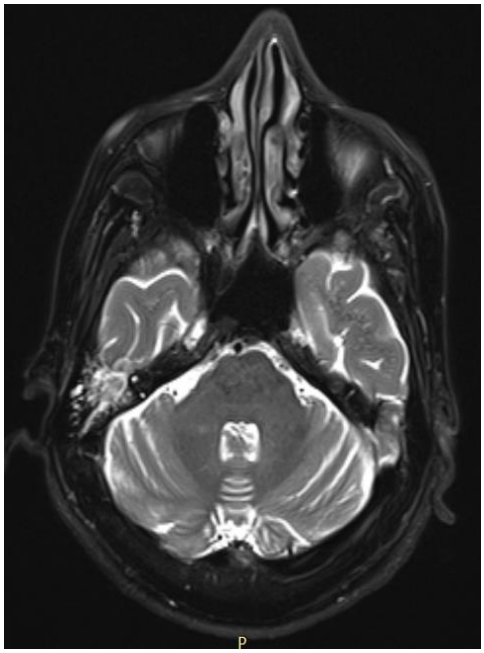
Otoscopy reveals lesion in right mesotympanum.

HRCT shows soft tissue mass in right middle ear with erosion of scutum.

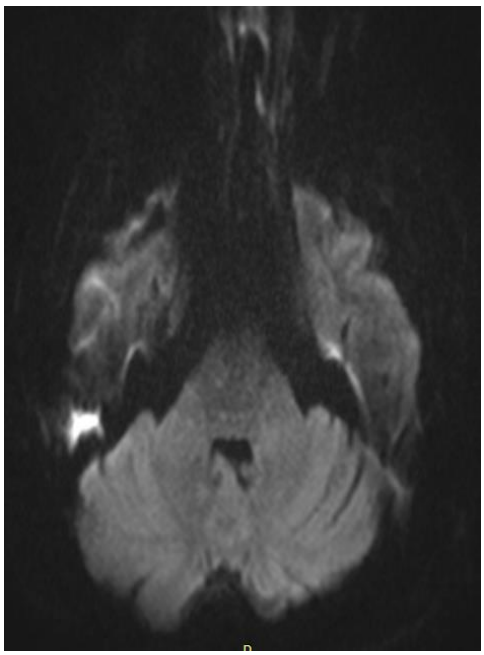
T1 AXIAL



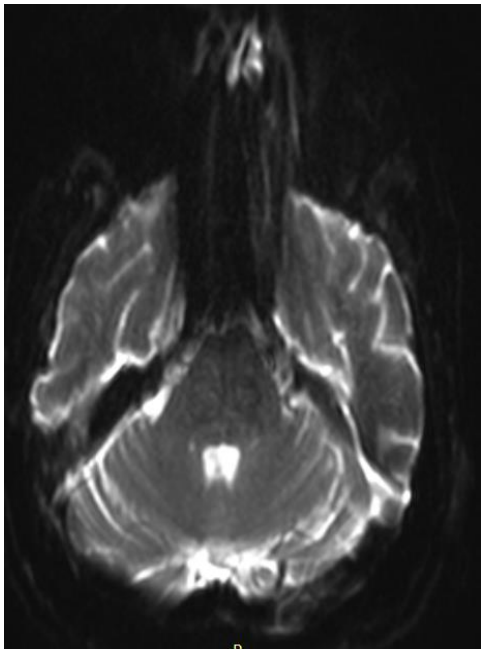
T2 AXIAL



DWI



ADC



DISCUSSION

Lesion noted in the left middle ear appearing hypointense on T1 images, hyperintense on T2 and FLAIR images and showing diffusion restriction with corresponding low ADC values - 0.75 x 10^{-3} mm^2/s and the provisional diagnosis of cholesteatoma was made . Patient was taken for surgery and removal of middle ear mass done and specimen sent for histopathological analysis.

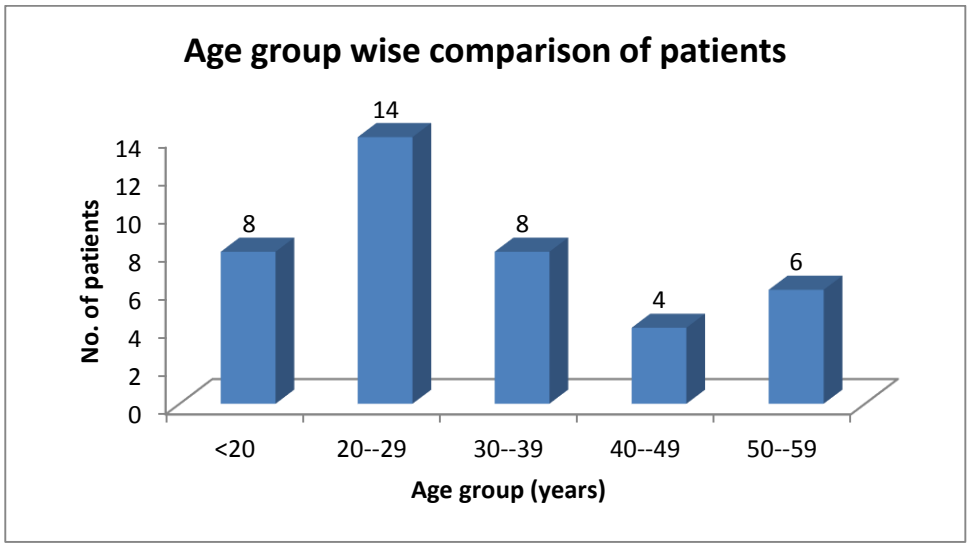
HPE reveals and confirms the diagnosis of cholesteatoma.

STASTICAL ANALYSIS

Table 1. Age group wise distribution of patients in the study

Age group (years)	N	Percentage
<20	8	20%
20--29	14	35%
30--39	8	20%
40--49	4	10%
50--59	6	15%
Total	40	100%

Fig. 1. Bar diagram shows age group wise comparison of patients in the study

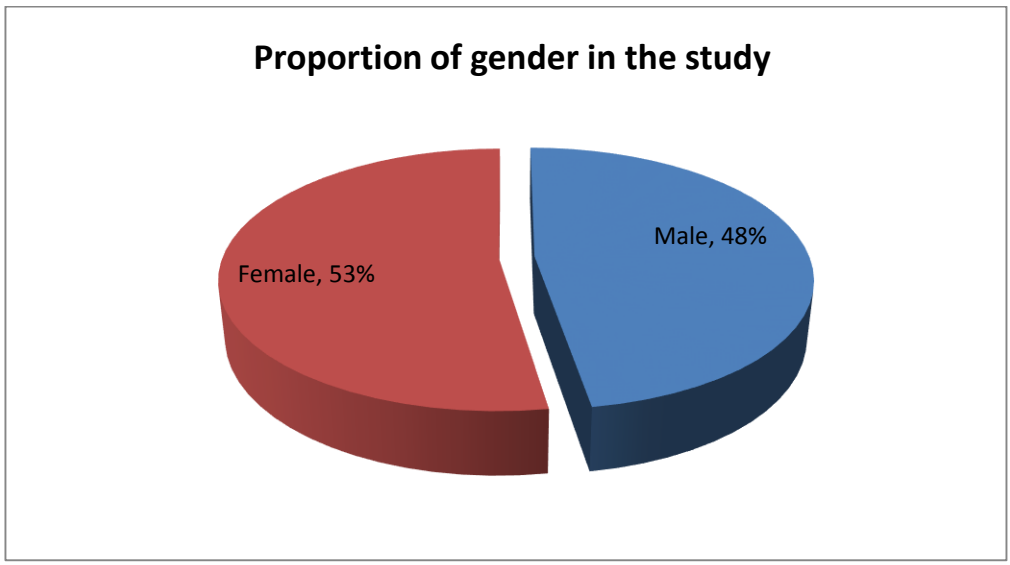


Cholesteatoma affects all age groups though it is common in middle age frequently.

Table 2. Proportion of gender in the study

Sex	N	Percentage
Male	19	48%
Female	21	53%
Total	40	100%

Fig. 2. Pie chart shows proportion of gender in the study

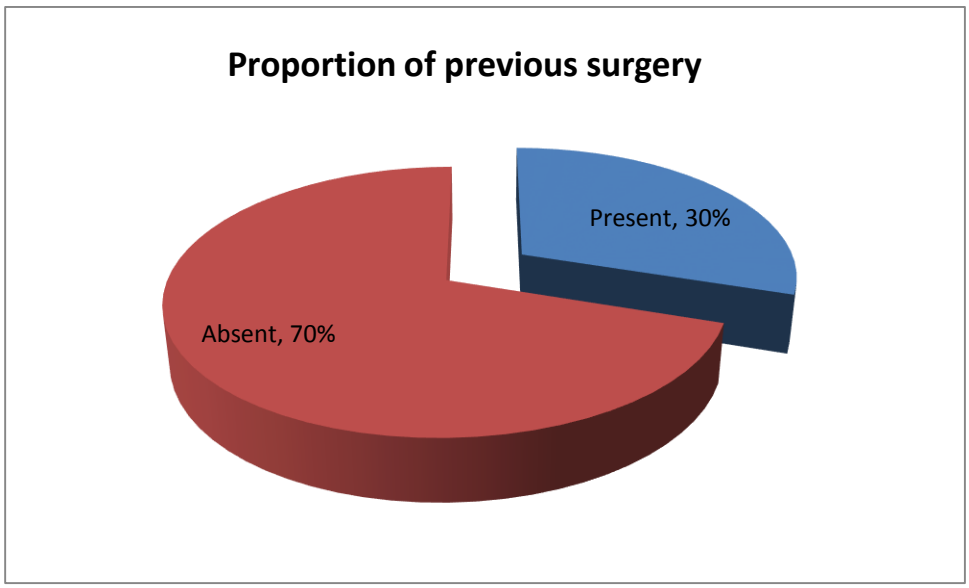


In cholesteatoma slight predominance seen in females than males

Table 3. Status of previous surgery of patients in the study

Previous surgery	N	Percentage
Present	12	30%
Absent	28	70%
Total	40	100%

Fig. 3. Pie chart shows proportion of previous surgery of patients in the study



In our study 28 preoperative and 12 postoperative cases are included to prove the effeciency of DWI in diagnosing cholesteatoma

Table 4.Report of HRCT scan of patients in the study

CT	N	Percentage
Bone erosions positive suggestive of cholesteatoma	29	72.5%
Bone erosions negative and suspicious of cholesteatoma	11	27.5%
Total	40	100%

Fig 4.Bar diagram shows Report of HRCT scan of patients in the study

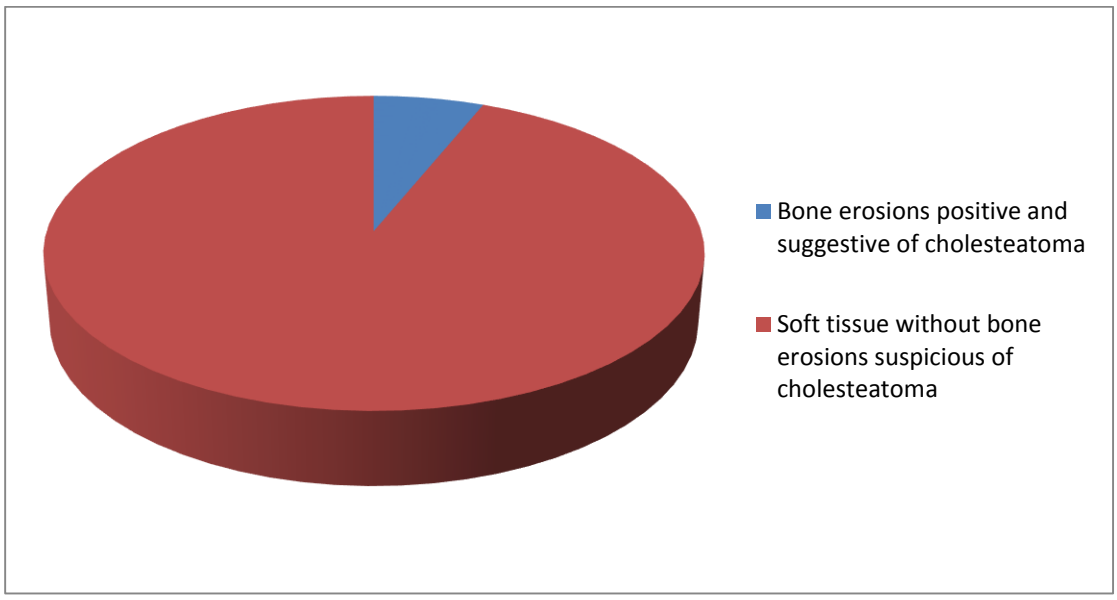


Table 5. Diagnostic evaluation of CT in pre and post operative cases with Histopathological report (HPE)

CT (Pre+post operative)	HPE Positive	HPE Negative	Total
CT with bone erosion	27	1	28
CT with out bone erosion	9	3	12
Total	36	4	40

CT: Computed Tomography

HPE +ve: Confirmed same as cholesteatoma

HPE -ve: Confirmed same as granulation tissue or cholesterol granuloma

HRCT can diagnose cholesteatoma confidently if accompanied by bone or soft tissue erosions and non specific if there is only soft tissue without accompanying bone erosions

Table 6.

Parameter CT (Pre+post operative)	**Estimate**	**Lower - Upper 95% CIs**
Sensitivity	75%	(58.93, 86.25)
Specificity	75%	(30.06, 95.44)
Positive Predictive Value	96.43%	(82.29, 99.37)
Negative Predictive Value	25%	(8.894, 53.23)
Diagnostic Accuracy	75%	(59.81, 85.81)
Method:Wilson Score		

Interpretation: In this study, Sensitivity was 75% with 95% confidence interval (58.93, 86.25) as well as Positive Predictive Value (PPV) showed an estimate 96.43% with 95% confidence interval (82.29, 99.37). It does mean that utility of CT in diagnosing middle ear cholesteatomas was 75% sensitive to get HPE and its estimate for future studies would vary between 58.93 to 86.25. Here, Diagnostic accuracy of CT was also 75%.

DWI

Table 7.DWI of patients in the study

DWI	N	Percentage
Restriction	37	93%
Not restricted	3	8%
Total	40	100%

Fig 5.Pie chart shows proportion of DWI of patients

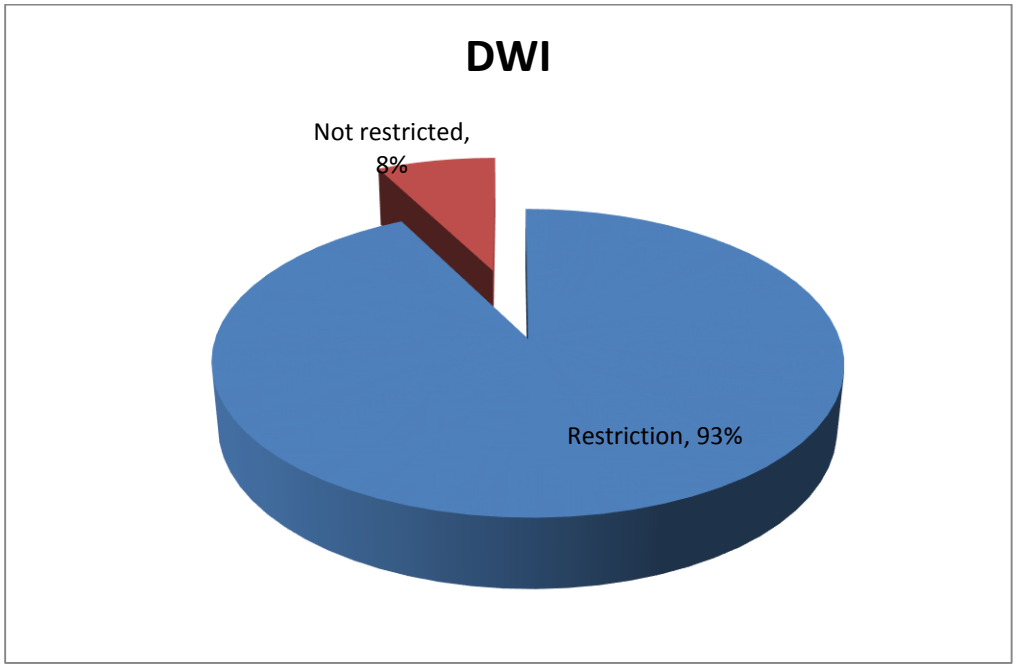


Table 8. Diagnostic evaluation of DWI with Histopathological report (HPE)

DWI	HPE Positive	HPE Negative	Total
Restricted	36	1	37
Not restricted	0	3	3
Total	36	4	40

DWI: Diffusion weighted image,

HPE +ve: Confirmed same as cholesteatoma

HPE -ve: Confirmed same as granulation tissue or cholesterol granuloma

Table 9.

Parameter DWI	**Estimate**	**Lower - Upper 95%** **CIs**
Sensitivity	100%	(90.36, 100)
Specificity	75%	(30.06, 95.44)
Positive Predictive Value	97.30%	(86.18, 99.52)
Negative Predictive Value	100%	(43.85, 100)
Diagnostic Accuracy	97.5%	(87.12, 99.56)
Method:Wilson Score		

Interpretation: In this study, Sensitivity was 100% with 95% confidence interval (90.36, 100). as well as Positive Predictive Value (PPV) showed an estimate 97.3% with 95% confidence interval (86.18, 99.52). It does mean that utility of DWI in diagnosing middle ear cholesteatomas was 100% sensitive to get HPE and its estimate for future studies would vary between 90.36 to 100. Here, Diagnostic accuracy of DWI was also higher (97.5%).

Table 10.

Diagnostic evaluation of DWI (preoperative cases) with Histopathological report (HPE)

DWI in preoperative cases	HPE Positive	HPE Negative	Total
Restricted	27	0	27
Not restricted	0	1	1
Total	27	1	28

DWI: Diffusion weighted image,

HPE +ve: Confirmed same as cholesteatoma

HPE -ve: Confirmed same as granulation tissue or cholesterol granuloma

Table 11

Parameter DWI in preoperative	**Estimate**	**Lower - Upper 95% CIs**
Sensitivity	100%	(87.54, 100)
Specificity	100%	(20.65, 100)
Positive Predictive Value	100%	(87.54, 100)
Negative Predictive Value	100%	(20.65, 100)
Diagnostic Accuracy	100%	(87.94, 100)
Method:Wilson Score		

Interpretation: In this study, DWI for preoperative cases, Sensitivity, Specificity, PPV and NPV were the same (100%) with various confidence intervals which show an estimate for future studies would vary between 95% CI respectively. Here, Diagnostic accuracy of DWI was also 100%.

Table 12. Diagnostic evaluation of DWI (postoperative cases)with Histopathological report (HPE)

DWI (postoperative cases)	HPE Positive	HPE Negative	Total
Restricted	9	1	10
Not restricted	0	2	2
Total	9	3	12

DWI: Diffusion weighted image,

HPE +ve: Confirmed same as cholesteatoma

HPE -ve: Confirmed same as granulation tissue or cholesterol granuloma

Table 13

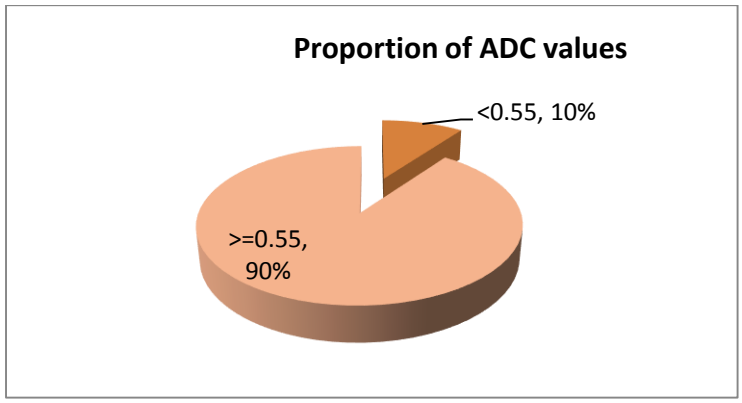
Parameter (postoperative cases)	**Estimate**	**Lower - Upper** **95% CIs**
Sensitivity	100%	(70.08, 100)
Specificity	66.67%	(20.77, 93.85)
Positive Predictive Value	90%	(59.58, 98.21)
Negative Predictive Value	100%	(34.24, 100)
Diagnostic Accuracy	91.67%	(64.61, 98.51)
Method:Wilson Score		

Interpretation: In this study, DWI for post operative cases, Sensitivity was 100% and PPV was 90% with confidence intervals which show an estimate for future studies would vary between 95% CI respectively. Here, Diagnostic accuracy of DWI was higher 91.67%.

Table 14 ADC values of patients in the study

ADC groups	N	Percentage
<0.55	4	10%
>=0.55	36	90%
Total	40	100%

Fig 6. Pie chart shows status of patients with ADC values



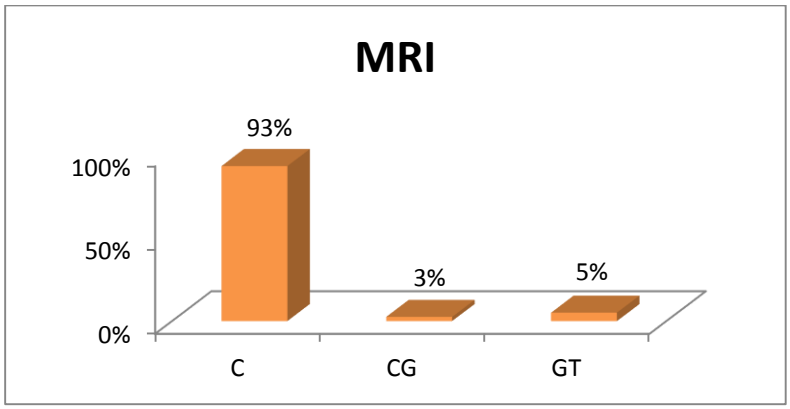
Granulation tissue shows significantly lower ADC values than cholesteatomas . most of cholesteatomas shows ADC values higher than 0.55 however infected cholesteatoma can show low ADC value.

Table 15 MRI report of patients in the study

MRI	N	Percentage
C	37	93%
CG	1	3%
GT	2	5%
Total	40	100%

C- Consistent with cholesteatoma, CG - Cholesterol granuloma, GT - Granulation Tissue

Fig 7 Bar diagram compares MRI report of patients in the study



C- Consistent with cholesteatoma, CG - Cholesterol granuloma, GT - Granulation Tissue

In MRI we diagnosed 37 cases as cholesteatoma and 1 case as cholesterol granuloma and 2 cases as granulation tissue.

Table 16. HPE of patients in the study

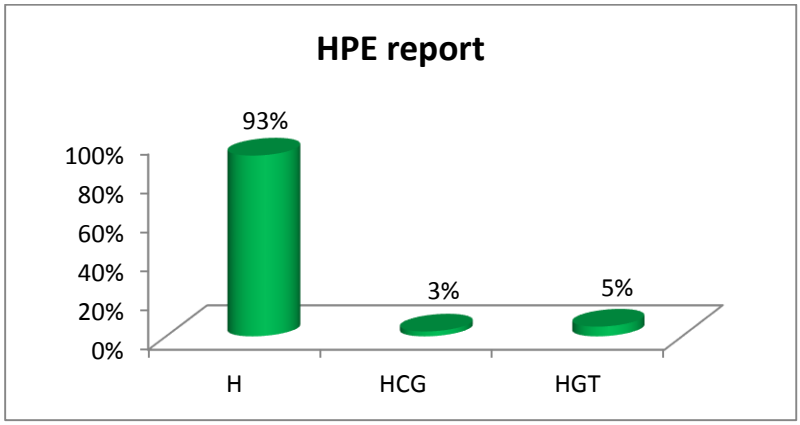
HPE	N	Percentage
H	36	93%
HCG	1	3%
HGT	3	5%
Total	40	100%

H-HPE Confirmed same as cholesteatoma,

HGT - Histopathology confirmed as granulation tissue,

HCG - Histopathology confirmed as cholesterol granuloma

Fig 17 .HPE report of patients in the study



In our study histopathology is used as gold standard against which our MRI findings are compared and analysed .

In one case granulation tissue was misdiagnosed as cholesteatoma

OBSERVATION AND DISCUSSION

NEWLY DIAGNOSED CHOLESTEATOMA

In Otoscopy- pearly white mass and retracted tympanic membrane are usually seen.

HRCT is most useful to identify middle ear soft tissue and ossicular chain erosion and also erosions involving scutum and tegmen tympani.

HRCT also useful to identify extent of disease.

MRI is useful to confirm the cholesteatoma .

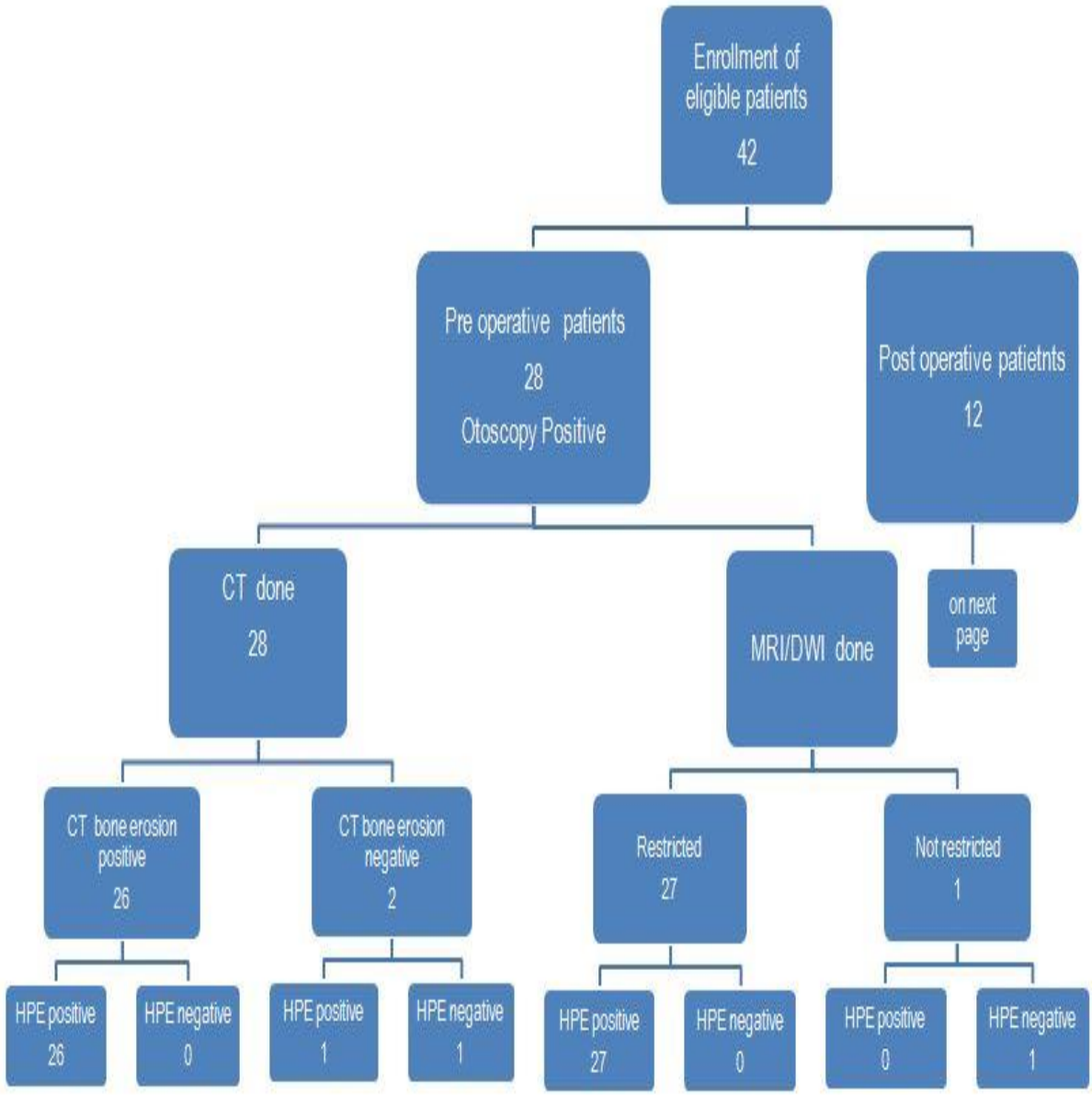
MRI is valuable in facial nerve and semicircular canal involvement.

DWI has high sensitivity and specificity in the diagnosis of cholesteatoma.

Diffusion restriction due to a combination T2 shine through effect and diffusion effects.

In our study out of 40 patients 28 cases are newly diagnosed cases of which MRI detects 27 cases accurately which confirmed post operatively. In one case it was found to be cholesterol granuloma which MRI detects accurately. In one case 12 year old male child CT reveals minimal soft tissue density in middle ear and MRI doesnot reveal any abnormality so surgery is avoided and patient was diagnosed as otitis media and put on antibiotics and followup and child

clinically improved and repeat CT after 1 month was normal. So this case is excluded from our study.



POSTOPERATIVE EAR:

Recurrent cholesteatoma needs revision surgery for eradication of underlying pathology . In case of granulation tissue usually supportive measures are needed and doesnot warrants revision surgery.

Diffuse mucosal thickening of the middle ear with bony irregularities are difficult to evaluate with HRCT or MRI in postoperative cases . So revision surgery is usually done by surgeons to know the cause of the soft tissue thickening.

Otoscopy not very useful if there is opaque tympanic membrane and after cartilagenous reconstruction.

CT can identify soft tissue mass but not able to differentiate between granulation tissue and cholesteatoma.

CT is not useful if there is no bone/ossicular erosion.

Cholesteatoma shows diffusion restriction with low ADC values whereas granulation tissue not shows diffusion restriction.

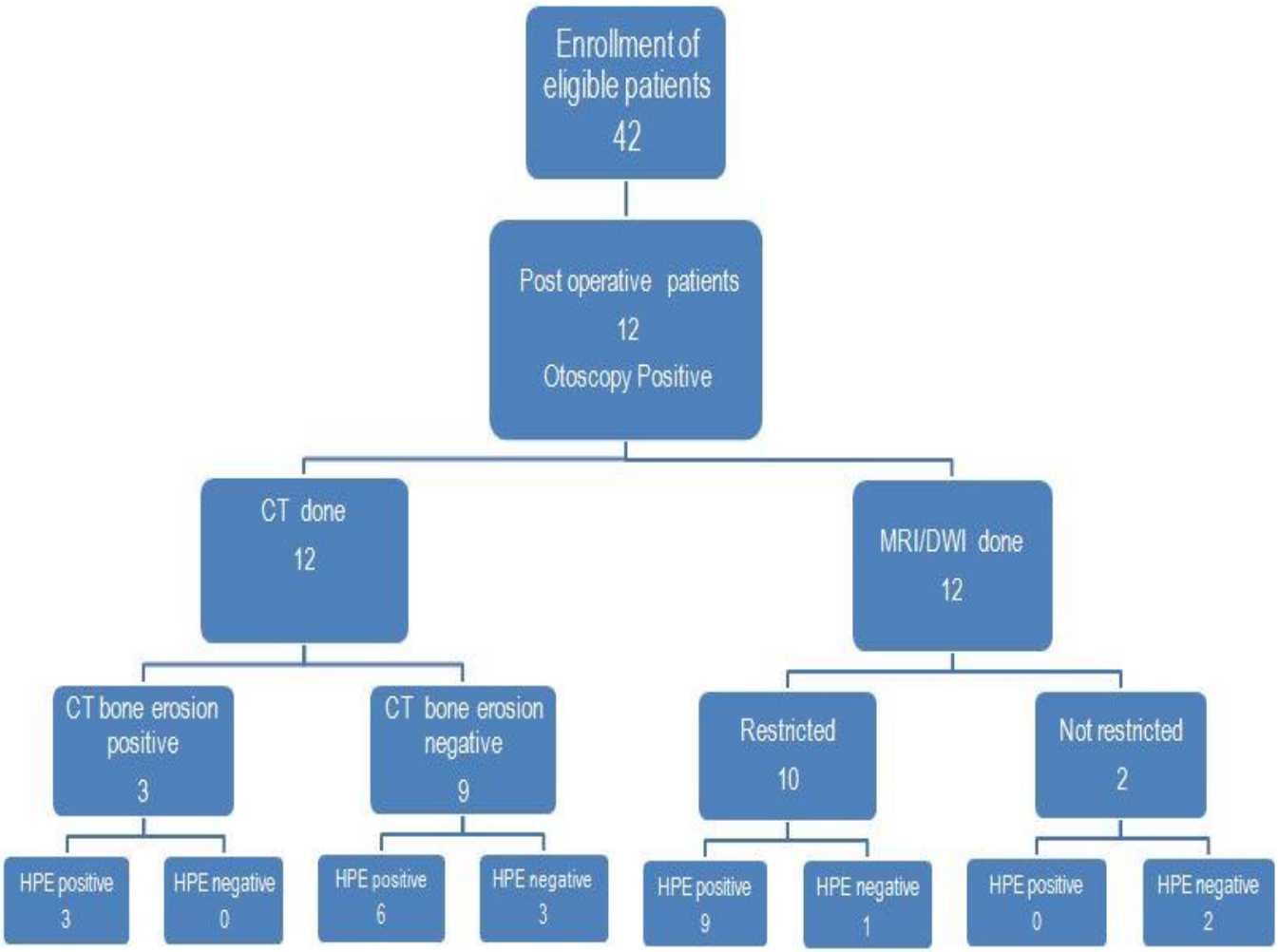
Second look surgery can be avoided if there is no cholesteatoma.

Our study confirms DWI has high sensitivity and specificity in diagnosing cholesteatoma and is confirmed with postoperative histopathological reports

In our study out of 40 patients 12 are post operative cases 9 cases are diagnosed as cholesteatoma accurately and confirmed by postsurigical HPE analysis, three cases were diagnosed as granulation tissue . Out of three granulation tissue two are picked up in the MRI accurately and one lesion is misdiagnosed as cholesteatoma which shows diffusion restriction but with low ADC values compared to other cholesteatomas.

MRI with DWI accurately diagnose all the cases of cholesteatoma in postoperative cases and has high sensitivity and specificity.

Smallest lesion detected in our study is 4 mm.



RESULTS

From the study it is concluded that DW MRI has 100% sensitivity, 75 % specificity , 97.3% PPV and 100% NPV in detecting cholesteatoma. Hence the MRI is more accurate than HRCT in diagnosing cholesteatomas.

CONCLUSION

ANNEXURES

CONCLUSION

DWI is very useful in middle ear soft tissue evaluation.It can reliably detects all cases of primary cholesteatomas with sensitivity and specificity of 100% in our study. It can accurately distinguish granulation tissue, scar and cholesteatoma in postoperative patients particularly when HRCT temporal bone found to be equivocal. Modern non echoplanar diffusion techniques with thinner sections helps in the detection of tiny lesions. These techniques has less incidence of susceptibility and ghost artifacts . DWI is primary used following cartilaginous reconstruction or after canal wall up mastoidectomy when clinical examination is difficult . The DWI technique can replace the secondlook surgery, avoiding another surgical morbidity. It is as efficient as post gadolinium enhanced scan and it has the advantage of non invasiveness and can be used in renal failure patients safely . DWI is superior to conventional T2 sequence in detecting the cholesteatomas. HRCT and MRI are complementary to each other in diagnosing cholesteatomas. In preoperative cases HRCT has high diagnostic accuracy and MRI is usually used to confirm the diagnosis whereas in postoperative cases HRCT is highly non specific and MRI plays significant role in diagnosing cholesteatomas.

BIBLIOGRAPHY

1. Standring, S. (2008). Gray\'s Anatomy: The Anatomical Basis of Clinical Practice
2. Zemlin, Willard R. "Speech and Hearing Science, Anatomy and Physiology." (1968).
3. Klinke, R. (1986). Physiology of Hearing. In Fundamentals of Sensory Physiology (pp. 199-223). Springer Berlin Heidelberg.
4. Saleh, H. A., and R. P. Mills. "Classification and staging of cholesteatoma."Clinical Otolaryngology & Allied Sciences 24.4 (1999): 355-359.
5. Nelson, M., Roger, G., Koltai, P. J., Garabedian, E. N., Triglia, J. M., Roman, S., ... & Hammel, J. P. (2002). Congenital cholesteatoma: classification, management, and outcome. Archives of Otolaryngology–Head & Neck Surgery,128(7), 810-814.
6. Schuring, Arnold G., et al. "Staging for cholesteatoma in the child, adolescent, and adult." Annals of Otology, Rhinology & Laryngology 99.4 (1990): 256-260.

7. Potsic, W. P., Samadi, D. S., Marsh, R. R., & Wetmore, R. F. (2002). A staging system for congenital cholesteatoma. Archives of Otolaryngology–Head & Neck Surgery, 128(9), 1009-1012.

8. Sudhoff, Holger, and Mirko Tos. "Pathogenesis of attic cholesteatoma: clinical and immunohistochemical support for combination of retraction theory and proliferation theory." Otology & Neurotology 21.6 (2000): 786-792.

9. Persaud, R., et al. "Evidence-based review of aetiopathogenic theories of congenital and acquired cholesteatoma." The Journal of Laryngology & Otology121.11 (2007): 1013-1019.

10. Cohen, David. "Locations of primary cholesteatoma." Otology & Neurotology8.1 (1987): 61-65.

11. Heilbrun, Marta E., et al. "External auditory canal cholesteatoma: clinical and imaging spectrum." American journal of neuroradiology 24.4 (2003): 751-756.

12. Soldati, D., & Mudry, A. (2001). Knowledge about cholesteatoma, from the first description to the modern histopathology. Otology & neurotology, 22(6), 723-730.

13. Olszewska, E., Wagner, M., Bernal-Sprekelsen, M., Ebmeyer, J., Dazert, S., Hildmann, H., & Sudhoff, H. (2004). Etiopathogenesis of cholesteatoma.European Archives of Oto-Rhino-Laryngology and Head & Neck, 261(1), 6-24.

14. Schechter, Gary. "A review of cholesteatoma pathology." The Laryngoscope79.11 (1969): 1907-1920.

15. Magliulo, Giuseppe, et al. "Labyrinthine fistula as a complication of cholesteatoma." Otology & Neurotology 18.6 (1997): 697-701.

16. Voorhees, R. L., et al. "High resolution CT scanning for detection of cholesteatoma and complications in the postoperative ear." The Laryngoscope93.5 (1983): 589-595.

17. Phelps, P. D., and A. Wright. "Imaging cholesteatoma." Clinical radiology 41.3 (1990): 156-162.

18. Robles, H. A. (2009). Imaging of the Temporal Bone. American Journal of Roentgenology, 193(2), W153-W153.

19. Martin, Chr, et al. "Cartilage and tympanoplasty." Acta oto-rhino-laryngologica Belgica 58.4 (2003): 143-149.

20. Vercruysse, J. P., De Foer, B., Pouillon, M., Somers, T., Casselman, J., & Offeciers, E. (2006). The value of diffusion-weighted MR imaging in the diagnosis of primary acquired and residual cholesteatoma: a surgical verified study of 100 patients. European radiology, 16(7), 1461-1467.

21. De Foer, B., Vercruysse, J. P., Bernaerts, A., Maes, J., Deckers, F., Michiels, J., ... & Casselman, J. W. (2007). The value of single-shot turbo spin-echo diffusion-weighted MR imaging in the detection of middle ear cholesteatoma.Neuroradiology, 49(10), 841-848.

22. Profant M., Slávikova, K., Kabátová, Z., Slezák, P., & Waczulíková, I. (2012). Predictive validity of MRI in detecting and following cholesteatoma. European Archives of Oto-Rhino-Laryngology, 269(3), 757-765.

23. Geoffray, A., Guesmi, M., Nebbia, J. F., Leloutre, B., Bailleux, S., & Maschi, C. (2013). MRI for the diagnosis of recurrent middle ear cholesteatoma in children—can we optimize the technique? Preliminary study. Pediatric radiology, 43(4), 464-473.

24. Aarts, M. C., Rovers, M. M., van der Veen, E. L., Schilder, A. G., van der Heijden, G. J., & Grolman, W. (2010). The diagnostic value of diffusion-weighted magnetic resonance imaging in detecting a residual cholesteatoma.Otolaryngology--Head and Neck Surgery, 143(1), 12-16.

25. Stasolla, A., Magliulo, G., Parrotto, D., Luppi, G., & Marini, M. (2004). Detection of postoperative relapsing/residual cholesteatomas with diffusion-weighted echo-planar magnetic resonance imaging. Otology & Neurotology,25(6), 879-884.

26. Khemani, S., Singh, A., Lingam, R. K., & Kalan, A. (2011). Imaging of postoperative middle ear cholesteatoma. Clinical radiology, 66(8), 760-767.

27. Thiriat, S., Riehm, S., Kremer, S., Martin, E., & Veillon, F. (2009). Apparent diffusion coefficient values of middle ear cholesteatoma differ from abscess and cholesteatoma admixed infection. American Journal of Neuroradiology,30(6), 1123-1126

28. Karandikar, A., Loke, S. C., Goh, J., Yeo, S. B., & Tan, T. Y. (2014). Evaluation of cholesteatoma: our experience with DW Propeller imaging. Acta Radiologica, 0284185114549568.

29. Migirov, L., Wolf, M., Greenberg, G., & Eyal, A. (2014). Non-EPI DW MRI in planning the surgical approach to primary and recurrent cholesteatoma. Otology & Neurotology, 35(1), 121-125.

30. Corrales, C. E., & Blevins, N. H. (2013). Imaging for evaluation of cholesteatoma: current concepts and future directions. Current opinion in otolaryngology & head and neck surgery, 21(5), 461-467.

31. Kodama, T., Yano, T., Tamura, S., Tono, T., & Machida, Y. (2007). Single-shot echo-planar diffusion-weighted MR imaging in the detection of a cholesteatoma.

32. Yates, P. D., Flood, L. M., Banerjee, A., & Clifford, K. (2002). CT scanning of middle ear cholesteatoma: what does the surgeon want to know?. The British journal of radiology, 75(898), 847-852.

33. Wake, M., Robinson, J. M., Witcombe, J. B., Bazerbachi, S., Stansbie, J. M., & Phelps, P. D. (1992). Detection of recurrent cholesteatoma by computerized tomography after 'closed cavity'mastoid surgery. The Journal of Laryngology & Otology, 106(05), 393-395.

34. Abeele, D. V., Coen, E., Parizel, P. M., & Van de Heyning, P. (1999). Can MRI replace a second look operation in cholesteatoma surgery?. Acta oto-laryngologica, 119(5), 555-561.

35. Pisaneschi, Mark J., and Bradley Langer. "Congenital cholesteatoma and cholesterol granuloma of the temporal bone: role of magnetic resonance imaging." Topics in magnetic resonance imaging 11.2 (2000): 87-97.#

36. Gaurano, J. L., & Joharjy, I. A. (2004). Middle ear cholesteatoma: characteristic CT findings in 64 patients. Ann Saudi Med, 24(6), 442-7.

37. Baráth, K., Huber, A. M., Stämpfli, P., Varga, Z., & Kollias, S. (2011). Neuroradiology of cholesteatomas. American Journal of Neuroradiology, 32(2), 221-229.

38. Venail, F., Bonafé, A., Poirrier, V., Mondain, M., & Uziel, A. (2008). Comparison of echo-planar diffusion-weighted imaging and delayed postcontrast T1-weighted MR imaging for the detection of residual cholesteatoma. American Journal of Neuroradiology, 29(7), 1363-1368.

39. Pizzini, F. B., Barbieri, F., Beltramello, A., Alessandrini, F., & Fiorino, F. (2010). HASTE diffusion-weighted 3-Tesla magnetic resonance imaging in the diagnosis of primary and relapsing cholesteatoma. Otology & Neurotology,31(4), 596-602.

40. Kasbekar, A. V., Scoffings, D. J., Kenway, B., Cross, J., Donnelly, N., Lloyd, S. W. K., ... & Axon, P. R. (2011). Non echo planar, diffusion-weighted magnetic resonance imaging (periodically rotated overlapping parallel lines with enhanced reconstruction sequence) compared with echo planar imaging for the detection of middle-ear cholesteatoma. The Journal of Laryngology & Otology,125(04), 376-380.

41. Lehmann, P., Saliou, G., Brochart, C., Page, C., Deschepper, B., Vallée, J. N., & Deramond, H. (2009). 3T MR imaging of postoperative recurrent middle ear cholesteatomas: value of periodically rotated overlapping parallel lines with enhanced reconstruction diffusion-weighted MR imaging. American Journal of Neuroradiology, 30(2), 423-427.

42. Dubrulle, F., Souillard, R., Chechin, D., Vaneecloo, F. M., Desaulty, A., & Vincent, C. (2006). Diffusion-weighted MR Imaging Sequence in the Detection of Postoperative Recurrent Cholesteatoma 1. Radiology, 238(2), 604-610.

43. Más-Estellés, F., Mateos-Fernández, M., Carrascosa-Bisquert, B., Facal de Castro, F., Puchades-Román, I., & Morera-Pérez, C. (2012). Contemporary non–echo-planar diffusion-weighted imaging of middle ear cholesteatomas.Radiographics, 32(4), 1197-1213.

44. Ilıca, A. T., Hıdır, Y., Bulakbaşı, N., Satar, B., Güvenç, I., Arslan, H. H., & İmre, N. (2012). HASTE diffusion-weighted MRI for the reliable detection of cholesteatoma. Diagn Interv Radiol, 18(2), 153-158.

45. Dhepnorrarat, R. C., Wood, B., & Rajan, G. P. (2009). Postoperative non-echo-planar diffusion-weighted magnetic resonance imaging changes after cholesteatoma surgery: implications for cholesteatoma screening. Otology & Neurotology, 30(1), 54-58.

46. Kimitsuki, T., Suda, Y., Kawano, H., Tono, T., & Komune, S. (2001). Correlation between MRI findings and second-look operation in cholesteatoma surgery. ORL, 63(5), 291-293.

47. Schwartz, K. M., Lane, J. I., Bolster, B. D., & Neff, B. A. (2011). The utility of diffusion-weighted imaging for cholesteatoma evaluation. American Journal of Neuroradiology, 32(3), 430-436.

48. Yamashita, K., Yoshiura, T., Hiwatashi, A., Kamano, H., Dashjamts, T., Shibata, S., ... & Honda, H. (2011). Detection of middle ear cholesteatoma by diffusion-weighted MR imaging: multishot echo-planar imaging compared with single-shot echo-planar imaging. American Journal of Neuroradiology, 32(10), 1915-1918

49. Schaefer, P. W., Grant, P. E., & Gonzalez, R. G. (2000). Diffusion-weighted MR imaging of the brain 1. Radiology, 217(2), 331-345.

50. Chen, S., Ikawa, F., Kurisu, K., Arita, K., Takaba, J., & Kanou, Y. (2001). Quantitative MR evaluation of intracranial epidermoid tumors by fast fluid-attenuated inversion recovery imaging and echo-planar diffusion-weighted imaging. American journal of neuroradiology, 22(6), 1089-1096.

51. Maheshwari, S., & Mukherji, S. K. (2002). Diffusion-weighted imaging for differentiating recurrent cholesteatoma from granulation tissue after mastoidectomy: case report. American journal of neuroradiology, 23(5), 847-849.

52. Fahmy, D. M., & Ragab, S. M. (2012). Detection of post operative residual cholesteatoma using PROPELLER DWI combined with conventional MRI. The Egyptian Journal of Radiology and Nuclear Medicine, 43(4), 543-548.

53. Digge, P. (1970). High-field MRI versus high-resolution CT of temporal bone in inner ear pathologies of children with bilateral profound sensorineural hearing loss: A pictorial essay. European Congress of Radiology 2015.

54. Mosnier, L. O., Zlokovic, B. V., & Griffin, J. H. (2007). The cytoprotective protein C pathway. Blood, 109(8), 3161-3172

55. Elefante, A., Cavaliere, M., Russo, C., Caliendo, G., Marseglia, M., Cicala, D., ... & Brunetti, A. (2015). Diffusion Weighted MR Imaging of

Primary and Recurrent Middle Ear Cholesteatoma: An Assessment by Readers with Different Expertise. BioMed research international, 2015.

56. Aikele, P., Kittner, T., Offergeld, C., Kaftan, H., Hüttenbrink, K. B., & Laniado, M. (2003). Diffusion-weighted MR imaging of cholesteatoma in pediatric and adult patients who have undergone middle ear surgery. American Journal of Roentgenology, 181(1), 261-265.

57. Sharifian, H., Taheri, E., Borghei, P., Shakiba, M., Jalali, A. H., Roshanfekr, M., & Firouznia, K. (2012). Diagnostic accuracy of non-echo-planar diffusion-weighted MRI versus other MRI sequences in cholesteatoma. Journal of medical imaging and radiation oncology, 56(4), 398-408.

58. Cimsit, N. C., Cimsit, C., Baysal, B., Ruhi, I. C., Ozbilgen, S., & Aksoy, E. A. (2010). Diffusion-weighted MR imaging in postoperative follow-up: reliability for detection of recurrent cholesteatoma. European journal of radiology, 74(1), 121-123.

INFORMED CONSENT FORM PROFORMA

ETHICAL COMMITTEE

PATIENT CONSENT FORM

Study title :

The Usefulness of Diffusion-Weighted Imaging in Cholesteatoma Diagnosis And Postoperative Pathologic Correlation.

Study centre :

Barnard Institute of Radiology & Oncology,

Rajiv Gandhi Government General Hospital,

Madras Medical College,

Chennai- 600 003

Participant

Name : Age:

Sex:

I confirm that I have understood the purpose of procedure for the above study . I have the opportunity to ask the question and all my questions and doubts have been answered to my satisfaction.

I have been explained about the pitfall in the procedure. I have been explained about the safety, advantage and disadvantage of the technique. I understand that my participation in the study is voluntary and that I am free to withdraw at anytime without giving any reason.

I understand that investigator , regulatory authorities and the ethics committee will not need my permission to look at my health records both in respect to current study and any further research that may be conducted in relation to it, even if I withdraw from the study . I understand that my identity will not be revealed in any information released to third parties or published , unless as required under the law . I agree not to restrict the use of any data or results that arise from the study .

I have been explained that the MRI DWI technique is a standard and approved technique. This may help in future research in the field of radiology. I consent to undergo this procedure

Insurance No:

Date:

Signature / thumb impression of patient

PROFORMA

Name of the patient: Date:

Age: Sex: Male/Female

OP/IP Number:

Clinical history :

Otoscopic findings	
CT findings	
MRI findings	
Postoperative pathology report	

SIGNATURE OF INVESTIGATOR SIGNATURE OF THE PARTICIPANT

WITNESS:

ETHICAL COMMITTEE APPROVAL LETTER

INSTITUTIONAL ETHICS COMMITTEE
MADRAS MEDICAL COLLEGE, CHENNAI-3

EC Reg No.ECR/270/Inst./TN/2013
Telephone No. 044 25305301
Fax : 044 25363970

CERTIFICATE OF APPROVAL

To
Dr.S.Arunprasad
Postgraduate M.D.(Radiology)
Madras Medical College
Chennai 600 003

Dear Dr.S.Arunprasad,

The Institutional Ethics Committee has considered your request and approved your study titled **"The usefulness of diffusion weighted imaging in cholesteatoma diagnosis and post operative pathologic correlation" No.13022015.**

The following members of Ethics Committee were present in the meeting held on 03.02.2015 conducted at Madras Medical College, Chennai-3.

1. Dr.C.Rajendran, M.D.,	: Chairperson
2. Dr.R.Vimala, M.D., Dean, MMC, Ch-3	: Deputy Chairperson
3. Dr.B.Kalaiselvi, M.D., Vice-Principal, MMC, Ch-3	: Member Secretary
4. Dr.R.Nandini, M.D., Inst.of Pharmacology, MMC	: Member
5. Dr.P.Ragumani, M.S., Professor, Inst.of Surgery, MMC	: Member
6. Dr.Md.Ali, M.D., D.M., Prof. & HOD of Medl.G.E., MMC	: Member
7. Dr.K.Ramadevi, Director, Inst.of Biochemistry, MMC	: Member
8. Dr.Saraswathy, M.D., Director, Pathology, MMC, Ch-3	: Member
9. Dr.S.G.Sivachidambaram, M.D.,Director i/c Institute of Internal Medicine, MMC, Ch-3	: Member
10.Thiru S.Rameshkumar	: Lay Person
11.Thiru S.Govindasamy, B.A., B.L.,	: Lawyer
12.Tmt.Arnold Saulina, M.A., MSW.,	: Social Scientist

We approve the proposal to be conducted in its presented form.

The Institutional Ethics Committee expects to be informed about the progress of the study and SAE occurring in the course of the study, any changes in the protocol and patients information/informed consent and asks to be provided a copy of the final report.

16/2/15

MEMBER SECRETARY
INSTITUTIONAL ETHICS COMMITTEE
MADRAS MEDICAL COLLEGE
CHENNAI-600 003

Member Secretary, Ethics Committee

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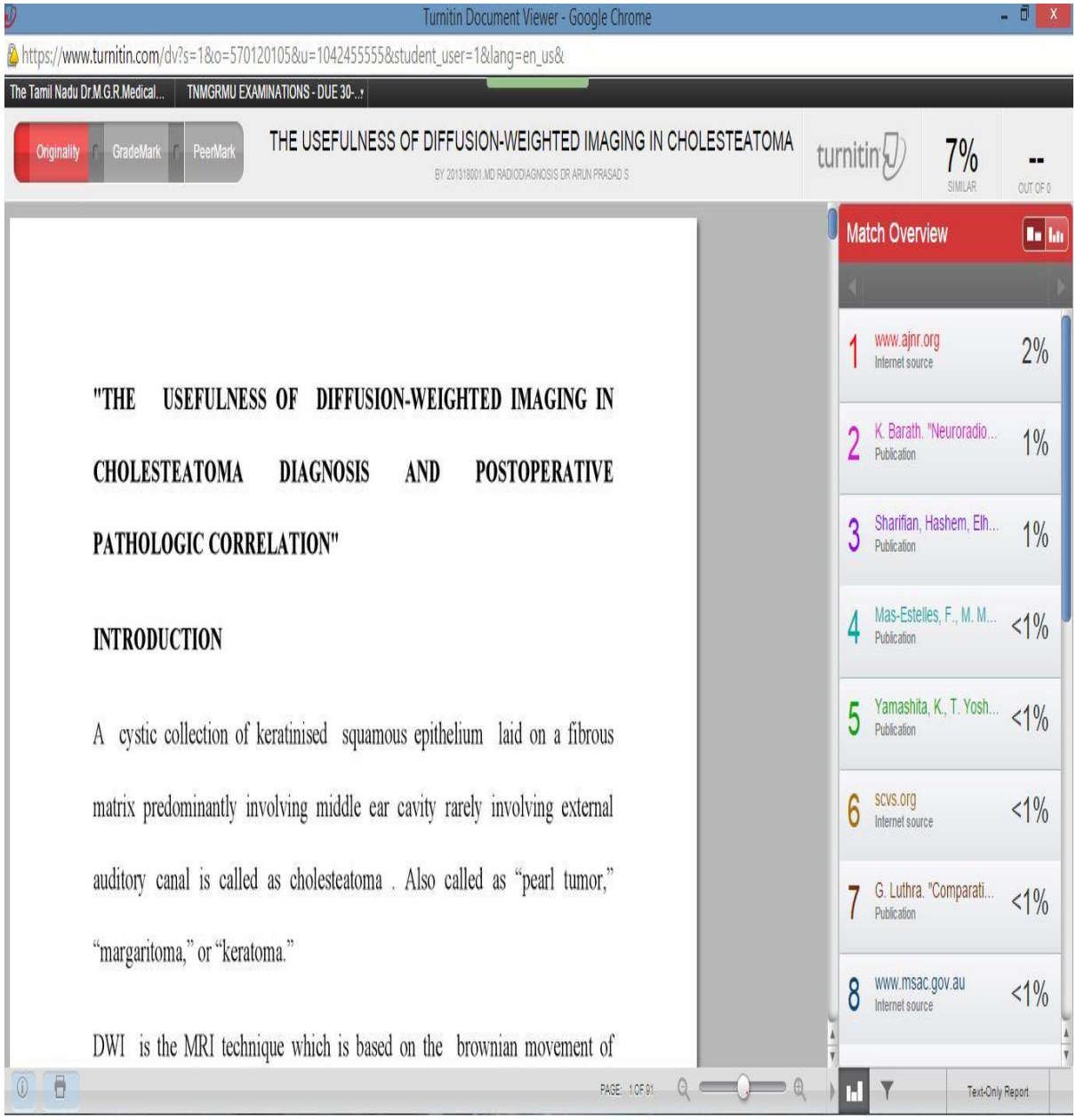
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"THE USEFULNESS OF DIFFUSION-WEIGHTED IMAGING IN CHOLESTEATOMA DIAGNOSIS AND POSTOPERATIVE PATHOLOGIC CORRELATION"
INTRODUCTION
A cystic collection of keratinised squamous epithelium laid on a fibrous matrix predominantly involving middle ear cavity rarely involving external auditory canal is called as cholesteatoma . Also called as "pearl tumor," "margaritoma," or "keratoma."
DWI is the MRI technique which is based on the brownian movement of
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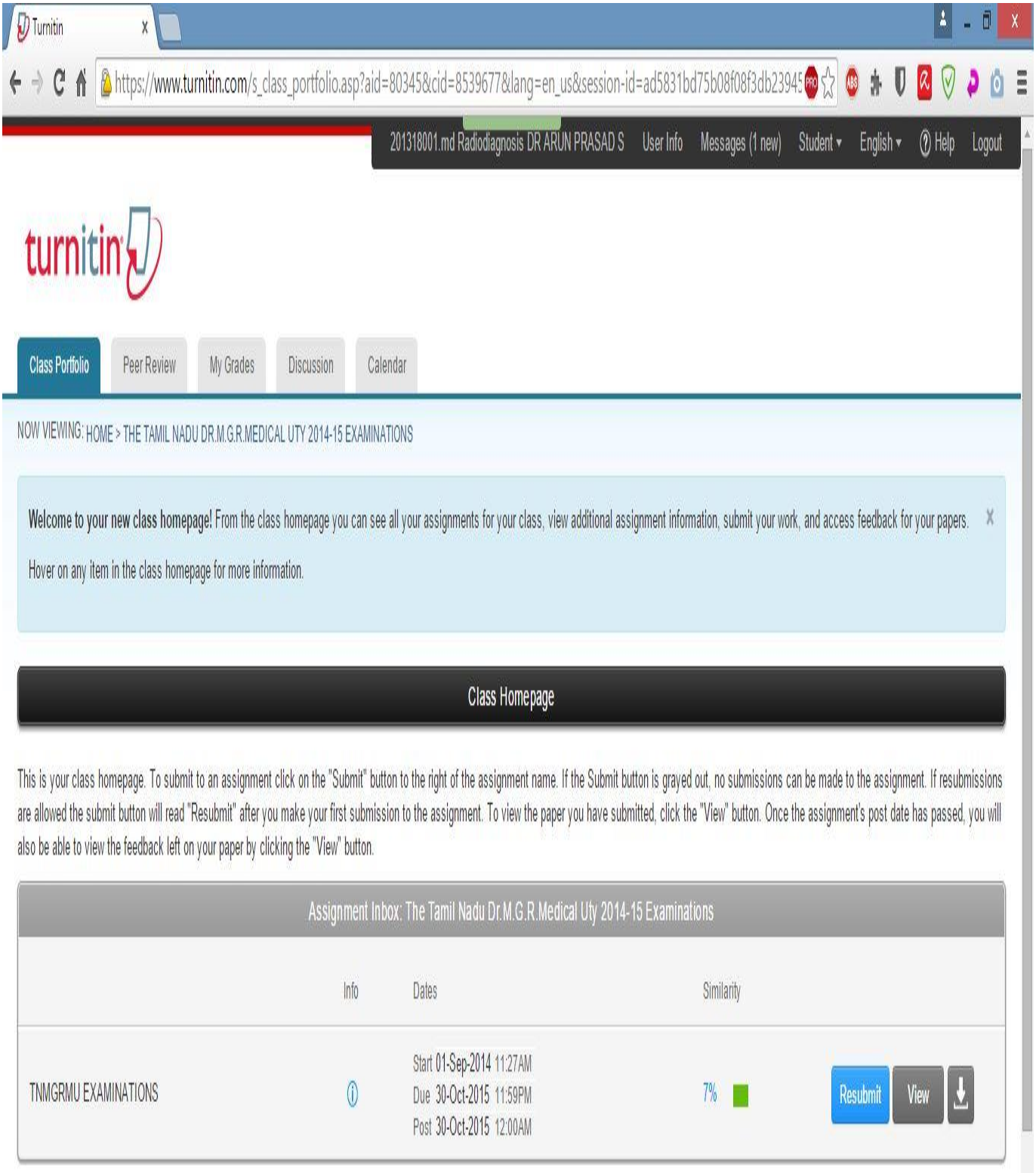
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"THE USEFULNESS OF DIFFUSION-WEIGHTED IMAGING IN CHOLESTEATOMA DIAGNOSIS AND POSTOPERATIVE PATHOLOGIC CORRELATION"

INTRODUCTION

MASTER CHART

S. No	Name	Age	Sex	OTOSCOPY FINDINGS	PREVIOUS SURGERY	HRCT	DWI	ADC $x10^{-3}$ m^2/s	MRI	HPE
1	Shanthi	52	F	PT	P	N	NR	0.45	GT	HGT
2	Dhanalakshmi	56	F	PT	P	N	R	0.59	C	H
3	Vasunthara	15	F	PT	A	PT	R	0.74	C	H
4	Mumtaz	30	F	PT	A	PT	R	0.57	C	H
5	Kalavathy	39	F	PT	P	N	R	0.53	C	H
6	Perumal	48	M	PT	P	N	NR	0.41	GT	H
7	Shankar	50	M	PT	P	N	R	0.57	C	H
8	Arunkumar	17	M	PT	A	PT	R	0.55	C	H
9	Vijayan	42	M	PT	A	PT	NR	1.9	CG	HCG
10	Karunakaran	59	M	PT	P	N	R	0.62	C	H
11	Sujatha	38	F	PT	A	PT	R	0.73	C	H
12	Rajeswari	32	F	PT	P	N	R	0.55	C	H
13	Nandhini	23	F	PT	A	PT	R	0.59	C	H
14	Kumar	40	M	PT	P	N	R	0.68	C	H
15	Thevaraj	27	M	PT	A	PT	R	0.56	C	H
16	Padma	22	F	PT	A	PT	R	0.59	C	H
17	Gayathri	25	F	PT	A	PT	R	0.57	C	H
18	Abraham	55	M	PT	P	PT	R	0.42	C	HGT

19	Raja	15	M	PT	A	PT	R	0.75	C	H
20	Gajendran	21	M	PT	A	PT	R	0.73	C	H
21	Anjali	32	F	PT	A	N	R	0.67	C	H
22	Vijaya	21	F	PT	A	PT	R	0.57	C	H
23	Lalitha	37	F	PT	P	PT	R	0.58	C	H
24	Mahesh	29	M	PT	A	PT	R	0.71	C	H
25	Dheenadayalan	27	M	PT	A	PT	R	0.64	C	H
26	Govindhammal	17	F	PT	A	PT	R	0.64	C	H
27	Sharmila	19	F	PT	A	PT	R	0.57	C	H
28	Suseela	41	F	PT	P	PT	R	0.75	C	H
29	Saroja	23	F	PT	A	PT	R	0.57	C	H
30	Fousiya	17	F	PT	A	PT	R	0.59	C	H
31	Siva	24	M	PT	A	PT	R	0.58	C	H
32	Sunil	21	M	PT	A	PT	R	0.76	C	H
33	Babu	15	M	PT	A	PT	R	0.73	C	H
34	Chinnappan	52	M	PT	P	N	R	0.76	C	H
35	Alexzander	23	M	PT	A	PT	R	0.77	C	H
36	Saranya	34	F	PT	A	PT	R	0.57	C	H
37	Nagaraj	25	M	PT	A	PT	R	0.59	C	H
38	Arthi	25	F	PT	A	PT	R	0.65	C	H
39	Venkatammal	35	F	PT	A	N	R	0.64	C	H
40	Mathialagan	18	M	PT	A	PT	R	0.57	C	H

P - Present

A- Absent

PT - cholesteatoma with bone erosion

N-soft tissue with no bone erosion

C- Consistent with cholesteatoma

CG - Cholesterol granuloma

GT - Granulation Tissue

H -HPE Confirmed same as cholesteatoma

HGT - Histopatholgy confirmed as granulation tissue

HCG - Hispathology confirmed as cholesterol granuloma

R - Restriction

NR - Not restricted