INTRODUCTION

Cholesteatoma is a benign keratinizing epithelial lined cystic structure found in the middle ear and mastoid. Management of patients with cholesteatoma is done by canal wall up and canal wall down techniques of which canal wall down is the most preferred. Canal wall down /Modified radical mastoidectomy is a surgical procedure which involves eradication of the disease, exenteration of diseased and all the accessible mastoid air cells with exterioristion of the mastoid by making mastoid and middle ear as a single cavity. Conventionally it is done using a microscope. With the advent of endoscopes and the advantages it offers like providing a wider, clearer view of the working field, better visualization of inaccessible areas thereby leading to reduced disruption of normal anatomy and a more complete clearance makes it more acceptable. This study compares microscopic and endoscopic methods in different aspects in the treatment of patients with cholesteatoma.

AIMS AND OBJECTIVES

AIM :

To compare the outcomes of microscopic modified radical mastoidectomy and endoscopic mastoidectomy in patients with cholesteatoma.

OBJECTIVES :

To compare

-hearing improvement

-Preservation of anatomical structures like facial nerve

-postoperative pain

-healing time

-operating time

-complete clearance of disease process

between microscopic and endoscopic mastoidectomies in patients with cholesteatoma.

REVIEW OF LITERATURE

In a study conducted by **Muaaz Tarabichi et al**, seventy-three ears with limited attic cholesteatoma underwent endoscopic transcanal tympanotomy and extended atticotomy to access and completely remove the sac. Appropriate ossicular reconstruction was performed. The defect was reconstructed with a composite tragal graft. A transcanal endoscopic approach was adequate for removal of disease in all cases. There were no iatrogenic facial nerve injuries. Bone thresholds were stable. Five ears required revision for recurrent disease, and eight were revised for failed ossicular reconstruction or persistent perforation. The study concluded that the endoscopic technique allows transcanal, minimally invasive, eradication of limited attic cholesteatoma. Preservation of the ossicles coupled with complete removal of disease is more likely with the endoscope.[4]

In a study conducted by **Arindam Das et al**, the median middle ear structural visibility index (MESVI) for endoscopic group was better than that for microscopic group ($P < .0001$). The mean operating time in endoscopic approach was less than that in case of microscopic approach, with $P < .05$. The median postoperative pain score in the endoscopic group was less than that in microscopic group ($P < .05$). No significant difference was found between two groups in terms of vertigo experienced at the end of first week and air-bone gap closure. When long-term surgical outcomes were assessed at 1 year, in endoscopic group, one patient had disease recurrence, one cartilage displacement, one perforation, and two had retraction pocket formation . In the

microscopic group, two patients had recurrence, four cartilage displacement, one perforation, and five retraction pocket formation.

In a study conducted by **Giuseppe Magliulo et al,** eighty patients suffered from attic cholesteatoma. Forty patients surgically treated with endoscopic ear surgery and forty patients surgically treated with microscopic ear surgery. None of the patients in the survey developed postoperative iatrogenic facial palsy. Graft success rate was 100% in both groups. The overall operation time of endoscopic ear surgery presented a mean value of 87.8 min, while in the group of patients treated via microscopic ear surgery a lower mean value of 69.9 min was reported. The average healing time was 36.3 days for the endoscopic subgroup and 47.8 days for the microscopic subgroup. The surgical outcomes of endoscopic ear surgery were comparable to those of the conventional approach in terms postoperative air-conduction, graft success rate and taste sensation. The analysis of postoperative pain and healing times showed better results for endoscopic ear surgery.[14]

In a study conducted by **Bo Li et al,** thirteen studies were included in the quantitative meta-analysis. The pooled recurrence and residual rates of cholesteatoma were significantly lower in the endoscopic group than in the microscopic group .There were no significant differences in other parameters, such as graft uptake success rates, audiological performance, and operation times, between the 2 groups. The pooled results showed that endoscopic ear surgery reduced the residual lesion rate and postoperative recurrence risk in patients with middle ear cholesteatoma.

In a study conducted by **Lela Migirov et al,** thirty patients, aged 9 to 75 years, underwent the exclusive endoscopic transmeatal cholesteatoma eradication between July 2008 and May 2010. There were no incidents of iatrogenic injuries to the facial nerve or ossicles. Closure of the tympanic membrane and good hygienic status (water tolerance and absence of inflammation) were achieved in all operated ears. Two patients had significant postoperative worsening of their sensorineural hearing loss: the cholesteatoma of one of them involved all 3 ossicles and oval window and the other patient experienced postoperative labyrinthitis. There was no residual disease in 18 patients who were followed for more than 1 year, and the non echo-planar diffusion-weighted sequence magnetic resonance imaging was negative in 3 patients. The minimally invasive endoscopic ear surgery showed complete eradication of cholesteatoma from the middle ear and its extensions, with minimal morbidity and good functional results.[11]

In a study conducted by **Mi Rye Bae et al,** data was collected from patients with attic cholesteatoma who were treated using endoscopic (10 patients) and microscopic (10 patients) approaches by a single surgeon. The data were retrospectively reviewed for patient characteristics, intraoperative findings, hearing levels, and followed up.Ossiculoplasty was performed in four patients in the endoscopic group and two patients in the microscopic group. The mean operation time in the endoscopic group was 1.65 hours; this was a little less than the 1.79 hours in the microscopic group, but the difference was not significant (P=0.63). There were no significant differences between the two groups regarding hearing improvement. And, there were no recurrences during the follow-up period in both groups.[16]

In a study conducted by **Daniel E. Killeen et al**, fifty-nine patients treated for cholesteatoma via endoscopic techniques and 35 patients treated via microscopic postauricular approach were analyzed. The endoscopic group required significantly fewer mastoid procedures (28%versus 80%, p-value 0.001). Postoperative changes in median ABG (5dB versus 3.75dB, p 0.9519), median PTA (6.875dB versus 1.25dB, p 0.3864), and median word recognition score (0% versus 0%, p 0.3302) were not significantly different between the EES and microscopic surgery groups. Median operative times were not significantly different between the two groups (182min endoscopic versus 174min microscopic, p-value 0.66). The rate of residual disease (17% EES versus 17% microscopic, p¼0.959) or disease recurrence (18% endoscopic versus 20% microscopic, p 0.816) were not significantly different between the two groups.

In a study conducted by **Sheikh Shawkat Kamal et al**, 31 patients of age 9 to 54 years underwent transcanal endoscopic open cavity mastoidectomy for their mastoid cholesteatoma with or without cholesteatoma related complications.In all ears, mastoid antrum was explored after removal of posterior bony canal wall through transcanal route purely under endoscopic guidance. Total excision of cholesteatoma from mastoid antrum and peri-antral mastoid cells along with repair of the cholesteatoma related complications such as labyrinthine fistula and cranial fossa fistula were done. Most of the cavity became dry with good self cleaning attitude after first surgery. Residual perforation of the tympanic membrane was the main reason of recurrent postoperative wet cavity. Partial obliteration was done by bone grafts and produced smaller and self-

cleaning cavity. It was observed that with consistent rational modifications, the transcanal endoscopic open cavity mastoidectomy has emerged as the least invasive procedure for total removal of mastoid cholesteatoma with favorable outcomes.

In a study conducted by **Livio Presutti et al**, thirty-two ears with acquired cholesteatoma (primary) were resected. Twenty cases were resected using a canal wall up (CWU) technique and six cases using a canal wall down (CWD) technique, and in six cases, a transcanal tympanotomy-atticotomy was performed. All of the patients in the study group underwent explorative and operative endoscopic ear surgery complementary to use of the operating microscope to uncover and remove residual chotesteatoma. In the primary surgery after completion of microscopic cleaning, the overall incidence of intraoperative residual disease detected with the endoscope was 37.5%. Of the 20 CWU cases, 12 second-look endoscopies were performed.No significant complications were associated with the 32 endoscopy procedures.The study concluded that endoscope allowed a better understanding of cholesteatoma and improved eradication of residual disease from hidden areas such as the anterior epitympanic recess, retrotympanum, and hypotympanum not yet controllable by the operating microscope.[6]

EMBRYOLOGY:

Auricle : Formed by the fusion of six tubercles or Hillocks of His in the sixth week of embryonic life around the first branchial cleft .From the tubercle of the first branchial

arch arises the tragus and the remaining pinna from the rest of the five tubercles of second arch.

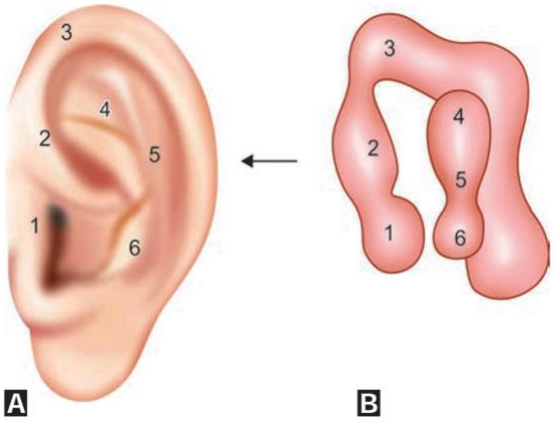


Fig. 1 Embryology of pinna

External auditory canal (EAC) develops from the first branchial cleft . Cells proliferate from the bottom of ectodermal cleft and form a meatal plug in the 16th week of embryonic life.External ear canal is fully formed by the 28th week .

Tympanic membrane: All three germinal layers contribute to the tympanic membrane. Outer epithelial layer is formed by the ectoderm, middle fibrous layer from the mesoderm and inner mucosal layer from the endoderm.

Middle ear cleft : The tympanic cavity, attic, antrum, mastoid air cells and the eustachian tube are derived from the endoderm of tubotympanic recess which arises from the first and partly from the second pharyngeal pouches. Malleus and incus develops from mesoderm of the first arch. The stapes superstructures develop from the second arch. Footplate of stapes and annular ligament are derived from the otic capsule.[1]

(1)1st branchial arch - Meckel's cartilage

(2)2nd branchial arch – Reichert's cartilage

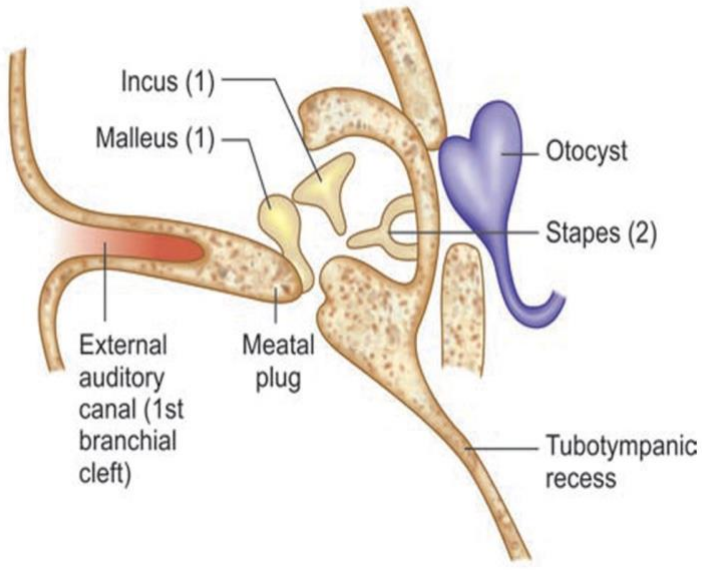


Fig. 2 Embryology of EAC and middle ear

Inner ear: Development begins in third week of fetal life and completed by 16th week. Auditory Vesicle is formed by the invagination of the auditory placode, which is the

thickened ectoderm of hind brain . The auditory vesicle later differentiates into endolymphatic duct and sac, utricle, semicircular ducts, saccule and cochlea. Development of pars superior (semicircular canals and utricle) takes place earlier than pars inferior (saccule and cochlea).

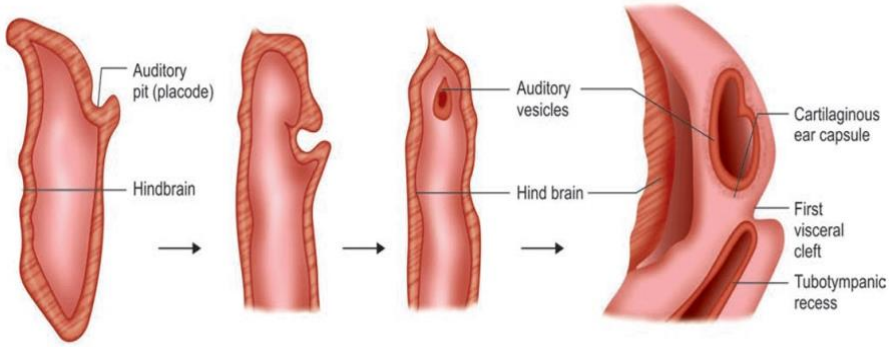


Fig. 3 Embryology of inner ear

RELEVANT ANATOMY

MIDDLE EAR CLEFT:

Consists of middle ear cavity, mastoid air cell system and the eustachian tube.

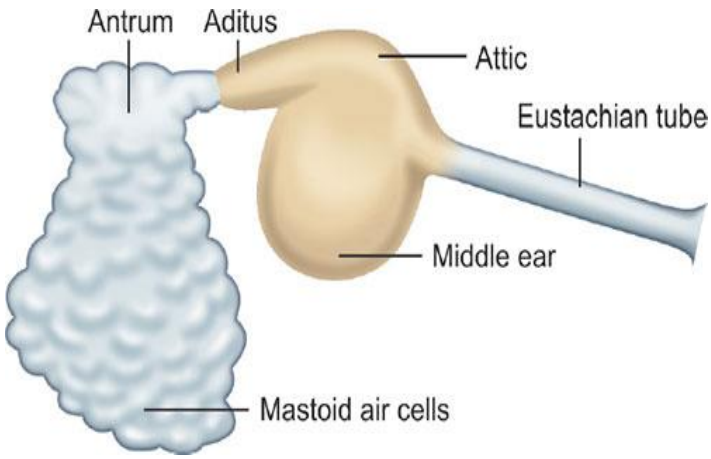


Fig. 4 Middle ear cleft

A.MIDDLE EAR CAVITY:

Irregular air filled space within the temporal bone. Has six walls.

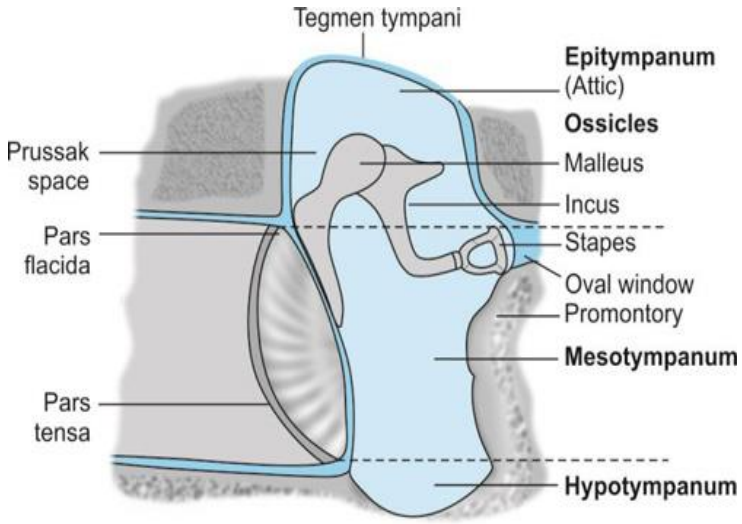


Fig. 5 Tympanic cavity

ROOF :

Formed by a thin bony plate called tegmen tympani which separates middle ear from middle cranial fossa . Formed by petrous & squamous parts of temporal bone. Petrosquamous suture line present can provide a route of infection into extradural space in children.Veins from middle ear pass through this line, drains into superior petrosal sinus. Bony crest from it known as COG divides the epitympanic space into large posterior epitympanic space & small anterior space.[1]

FLOOR:

It is narrower than the roof and consists of a convex plate of bone separating the cavity from the superior bulb of internal jugular vein. Sometimes the floor is deficient,jugular bulb covered only by mucous membrane and fibrous tissue and lie exposed in which case ,the surgeon has to be careful in raising inferior portion of tympanomeatal flap. Jacobson's nerve enters through the floor.

ANTERIOR WALL:

Upper third- supratubal recess.

Middle third- Eustachian tube orifice. Just above this is a canal for tensor tympani muscle.

Lower third- bony plate covering the carotid artery pierced by superior and inferior caroticotympanic nerves.

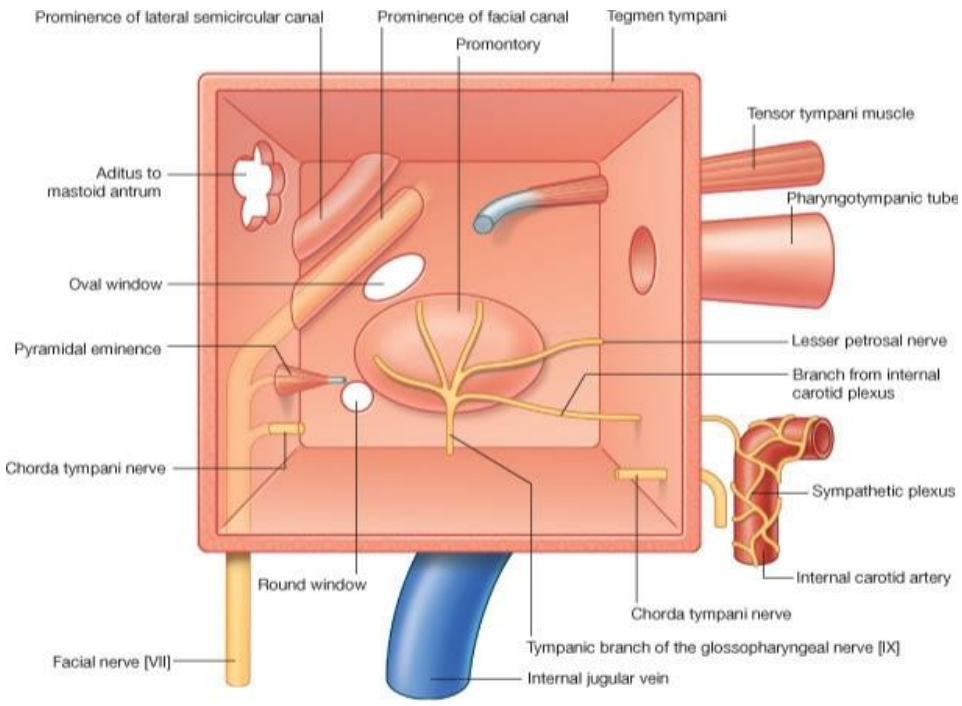


Fig.6 Walls of middle ear

POSTERIOR WALL:

Aditus ad antrum- Large irregular opening in the upper part connecting middle ear and mastoid antrum.

Fossa incudis- below aditus housing short process of incus and its suspensory ligament.

Pyramid –conical projection below the fossa incudis and medial to the chorda tympani nerve opening, which houses stapedius muscle and its tendon .

Facial recess: Lies between pyramid and facial nerve medially, tympanic annulus laterally with the chorda tympani nerve running obliquely.

Sinus tympani- Posterior extension of the mesotympanum into the posterior wall and it lies deep to the facial nerve, pyramid, stapedius.[1]

MEDIAL WALL:

Separates tympanic cavity from inner ear.

PROMONTORY : Rounded elevation in the central portion covering basal turn of the cochlea.

OVAL WINDOW: Behind & above the promotory . It is closed by foot plate of stapes and its annular ligament.

ROUND WINDOW : Below and little behind the oval window separated by a posterior extension of the promontory forming a bony ridge called the SUBICULUM. Ridge of bone from the promontory above the subiculum to the pyramid on the posterior wall of

the cavity is called PONTICULUS. Another bony ridge inferiorly between basal helix of cochlea & bone over the jugular bulb is called FINICULUS.

FALLOPIAN CANAL - Facial nerve canal runs above the promontory and oval window in an Anteroposterior direction. It is marked anteriorly by the processus cochleariformis, which houses tendon of tensor tympani.

LATERAL WALL:

Superior- bony lateral wall of epitympanum which is wedge shaped and its sharp inferior portion is known as outer attic wall or scutum.

Central - tympanic membrane.

Inferior- bony lateral wall of hypotympanum.

CONTENTS OF MIDDLE EAR:

- 3 ossicles : Malleus, incus, stapes
- 2 muscles : stapedius, tensor tympani
- Nerves: chorda tympani and tympanic plexus

  Nerve to stapedius, nerve to tensor tympani.

Malleus:

Has head, neck, handle/manubrium.

Head – lies in epitympanum, articulates through a facet in the posteromedial surface with body of incus by synovial joint.

Neck - broadens and gives rise to lateral process, anterior process, handle.

Lateral process - receives anterior & posterior malleolar folds from the tympanic annulus.

Anterior process - anterior ligament arises and gets attached to petrotympanic fissure.[2]

Incus:

Has a body, a short process and a long process. The body lies in the epitympanum wìth a facet for the incudomalleolar joint. The short process projecting backwards lies in fossa incudis. The tip of long process forms the lenticular process articulates via a ball and socket joint with the head of stapes.

Stapes:

Consists of head, neck, two crura and a foot plate. Insertion of the stapedius tendon is into the posterior part of neck and upper portion of the posterior crus. From the neck arises two crura which join the foot plate covering the oval window .Foot plate is attached to the bony margins by the annular ligament .

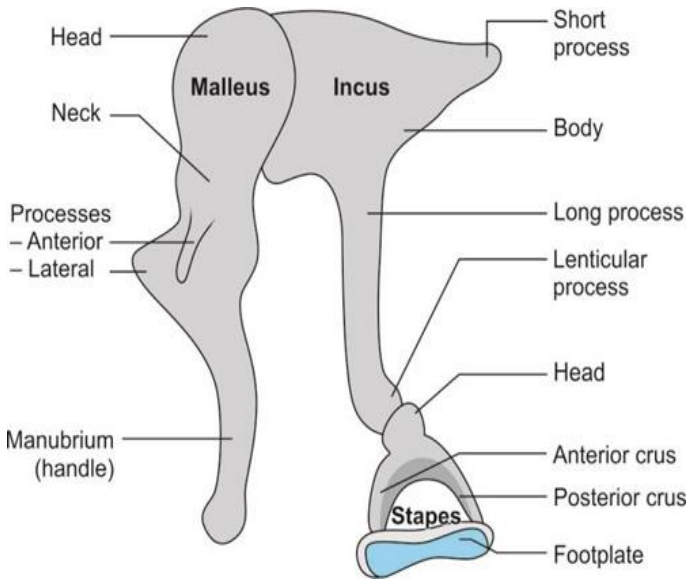


Fig. 7 Middle ear ossicles

MUSCLES:

Tensor tympani and the stapedius.

-**Tensor tympani**: runs above the eustachian tube with its tendon turning around the processus cochleariformis and passes laterally.

a. Origin: Bony canal above the eustachian tube, cartilaginous portion of eustachian tube and greater wing of sphenoid.
b. Insertion: upper end of handle of malleus.
c. Nerve supply: a branch of mandibular division of trigeminal nerve .

-**Stapedius**: It dampens the amplitude of loud noise by contraction thus protecting the inner ear.

a. Origin :Walls of pyramidal eminence
b. Insertion : Neck of stapes

c. Innervation : Nerve to stapedius (from facial nerve).[1]

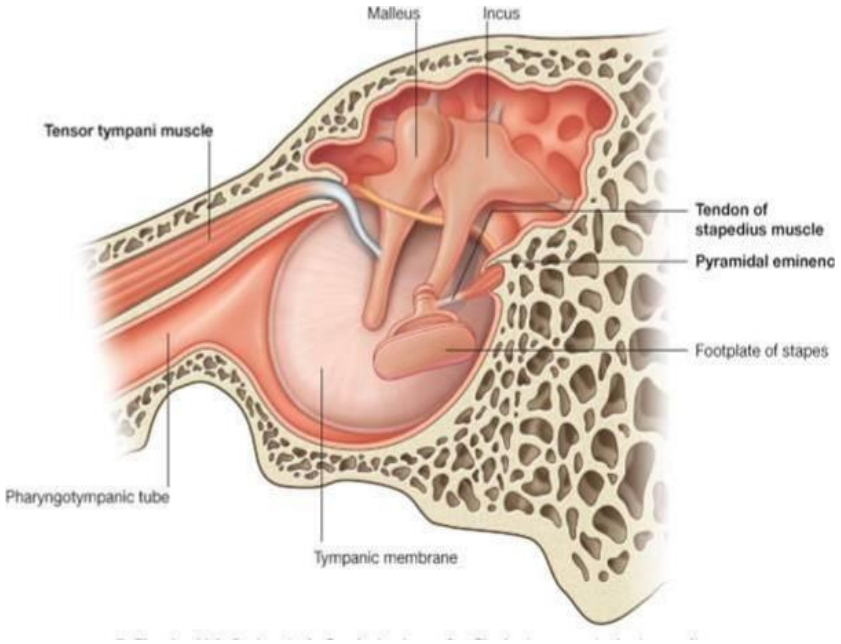


Fig. 8 Muscles of the middle ear

CHORDA TYMPANI NERVE :A branch of the facial nerve entering the middle ear through the posterior canaliculus, it is present on the medial surface of the tympanic membrane and lies medial to the upper portion of the handle of the malleus and lateral to long process of incus superior to insertion of tensor tympani. Anterior canaliculus is the exit point which joins the petrotympanic fissure. Responsible for sensory innervation from the anterior two-third of tongue and carries parasympathetic secretomotor fibers to the submaxillary and sublingual salivary glands.

TYMPANIC PLEXUS : Tympanic branch of the glossopharyngeal nerve (Jacobson's nerve) and caroticotympanic nerves arising from the sympathetic plexus around the internal carotid artery form the tympanic plexus on the promontory. Provides branches to the mucous membrane lining the tympanic cavity, Eustachian

tube and mastoid air cells, provides branches to join the greater superficial petrosal nerve and the lesser superficial petrosal nerve consisting of parasympathetic fibres of the glossopharyngeal nerve.

BLOOD SUPPLY:

Branch	Parent artery	Region supplied
Anterior tympanic	Maxillary artery	Tympanic membrane Malleus and incus Anterior part of tympanic cavity
Stylomastoid	Posterior auricular	Posterior part of tympanic cavity Stapedius muscle
Mastoid	Stylomastoid	Mastoid air cells
Petrosal	Middle meningeal	Roof of mastoid Roof of epitympanum
Superior tympanic	Middle meningeal	Malleus and incus Tensor tympani
Inferior tympanic	Ascending pharyngeal	Mesotympanum
Branch from artery	Artery of pterygoid canal	Meso- and hypotympanum
Tympanic arches	Internal carotid	Meso- and hypotympanum

VENOUS DRAINAGE:

- Pterygoid venous plexus
- Superior petrosal sinus
- Sigmoid sinus.

LYMPHATIC DRAINAGE:

Middle ear drains into retropharyngeal nodes and parotid nodes.[1]

ENDOSCOPIC ANATOMY OF MIDDLE EAR:

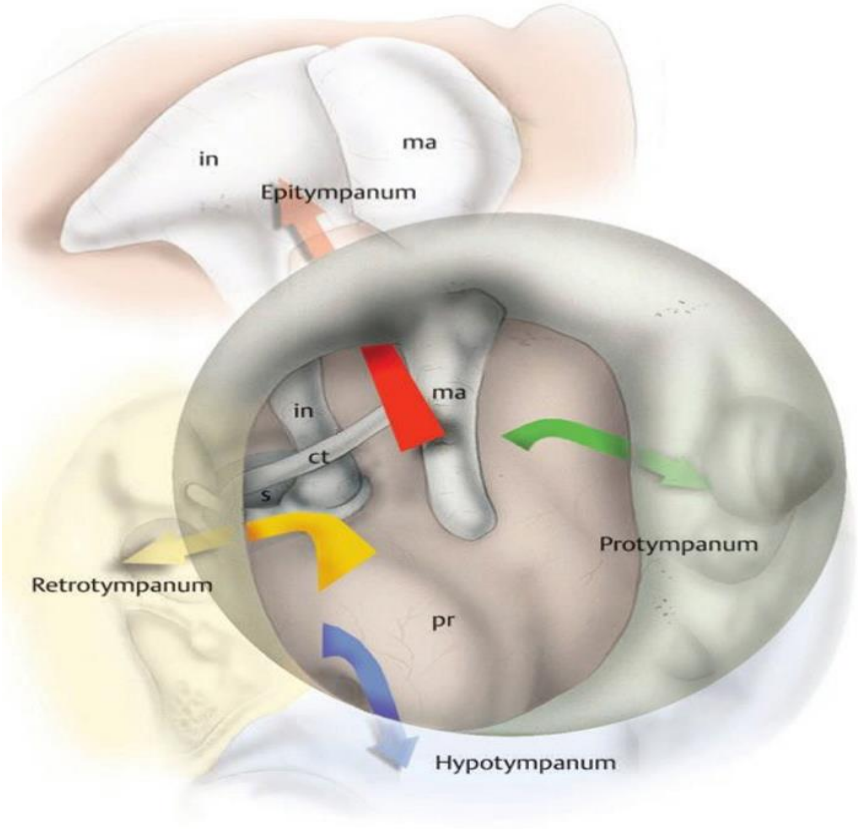


Fig. 9 Endoscopic anatomy of middle ear

- THE EPITYMPANUM:

  Lies above the level of malleolar folds.

  - Superior : tegmen tympani
  - Medial : prominence of lateral semicircular canal and horizontal portion of facial nerve.
  - Lateral : scutum
  - Posterior : fossa incudes
  - Contents : head of malleus , body and short process of incus, associated ligaments and mucosal folds .

Consists of 2 compartments divided by COG: small and anterior compartment (anterior epitympanic space); larger and posterior compartment (posterior epitympanic space) Cog is a transverse crest or a bony septum from the tegmen tympani vertically towards the cochleariform process. When complete, it is a consistent landmark for geniculate ganglion during endoscopic surgery.[8]

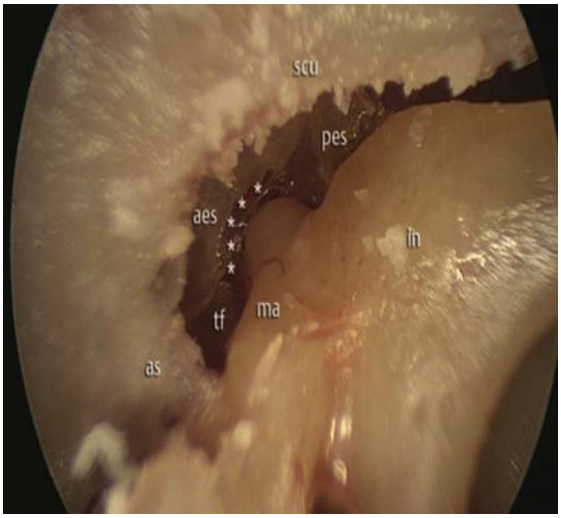


Fig. 10 Epitympanum

- THE MESOTYMPANUM:

  Mesotympanum is the part of the middle ear that lies between horizontal plates drawn at the top and bottom edges of parstensa. It is the part which we can see through the external ear canal with an

otoscope/microscope. It contains stapes, long processes of malleus and incus, oval and round windows. The mesotympanum acts like a channel, aiding in ventilation to the attic, and allowing air to go from the eustachian tube past the eminence of the tensor tympani through the tympanic isthmus.

- THE HYPOTYMPANUM:

It is that portion of middle ear that lies below the floor of bony ear canal/ below the level of tympanic membrane at the junction of tympanic and petrous parts of temporal bone. It is an irregular bony groove that is seldom involved by cholesteatoma. Inferior aspect of the hypotympanum separates the tympanic cavity from the jugular bulb. The bone covering the jugular bulb may be dehiscent in the hypotympanum. Spines, lamellae, trabeculae, pneumatised cells may be found in the hypotympanum.

- PROTYMPANUM:

Pneumatic portion of the middle ear anterior to the mesotympanum, inferior to the anterior epitympanic space and superior to the hypotympanum .Superiorly it is limited by the cochleariform process and the tensor fold with the tensor tympani canal and posteriorly limited by the promontory. Protympanum can be divided into two parts: superior-the supratubal recess , inferior- the eustachian tube orifice. Internal carotid artery runs superomedial to the eustachian tube orifice. As chronic disease of the middle ear seldom involves this recess, protympanic space is considered less important in middle ear surgery.[8]

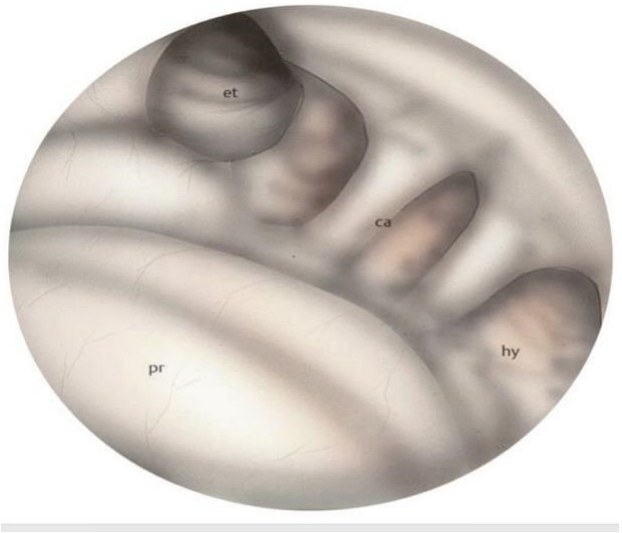


Fig. 11 Protympanum

- RETROTYMPANUM:

The retrotympanum is divided by a bony crest called subiculum (extends from styloid complex to posterior pillar of round window niche) into the superior retrotympanum and the inferior retrotympanum.

Superior retrotympanum :

Consists of Posterior tympanic sinus and sinus tympani separated by ponticulus (extends from pyramidal eminence to the promontary). SINUS TYMPANI is the space between ponticulus and subiculum.

Inferior retrotympanum:

Consists of sinus subtympanicus lying between the subiculum superiorly and finiculus inferiorly.

Overall,two bony structures arise from the pyramidal eminence :the chordal ridge outwards towards chordal eminence, separating the facial recess superiorly and the lateral tympanic sinus inferiorly; and the ponticulus extending inwards to the promontory dividing the posterior tympanic sinus superiorly and sinus tympani inferiorly .Thus 4 spaces in the superior epitympanum-2 medial and 2 lateral to the pyramidal eminence.[8]

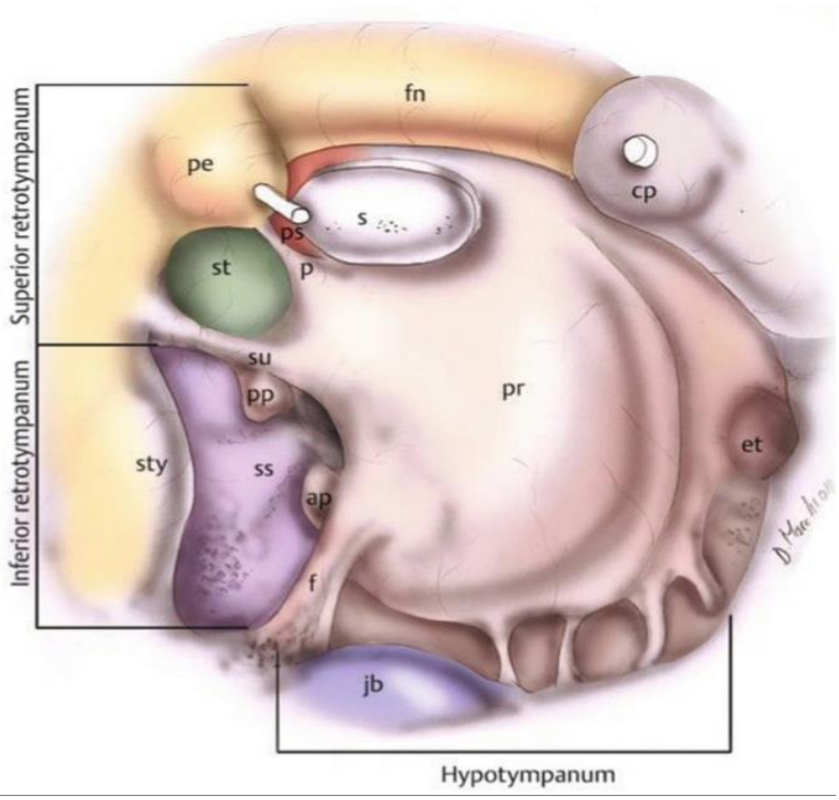


Fig. 12 Retrotympanum and hypotympanum

MUCOSAL FOLDS AND SPACES OF THE MIDDLE EAR :

The attic space is divided by the mucosal folds into various compartments.

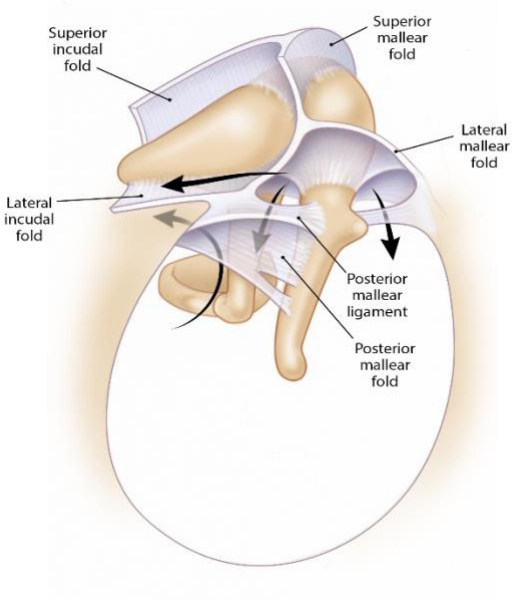


Fig. 13 Mucosal folds of middle ear

The superior malleolar fold lies between the superior surface of the malleus head and the superior attic wall. This fold is transversely placed and divides the attic into a small anterior malleolar space which lies above the tensor tympani fold that may prevent cholesteatoma from the attic reaching the anterior mesotympanum and a larger posterior compartment. The posterior compartment is further subdivided by the superior incudal fold into a superior incudal space (lateral to the fold) and a medial incudal space

The anterior malleolar fold (of von Troltsch, 1873) connects the anterior surface of the malleus head, the anterolateral wall of attic, and the anterior malleolar ligament

.

The lateral malleolar fold connects the neck of the malleus and the scutum . This forms the superior border of Prussak's space.

The superior incudal fold lies, like the superior incudal ligament, between the superior aspect of the incus body and the superior attic wall.

The medial incudal fold connects the long process of the incus and the tendon of the stapedius muscle.

The lateral incudal fold connects the lateral attic wall and the body of the incus extending back to the posterior incudal ligament.

The interossicular fold connects the malleus handle and the long process of the incus .

The anterior malleolar ligament lies between the long process of the malleus and the anterior attic wall.

The tensor tympani fold occupies the window between the tensor tympani tendon, the anterior bony plate of the attic wall, the tensor tympani eminence, and the anterior malleolar ligament .[8]

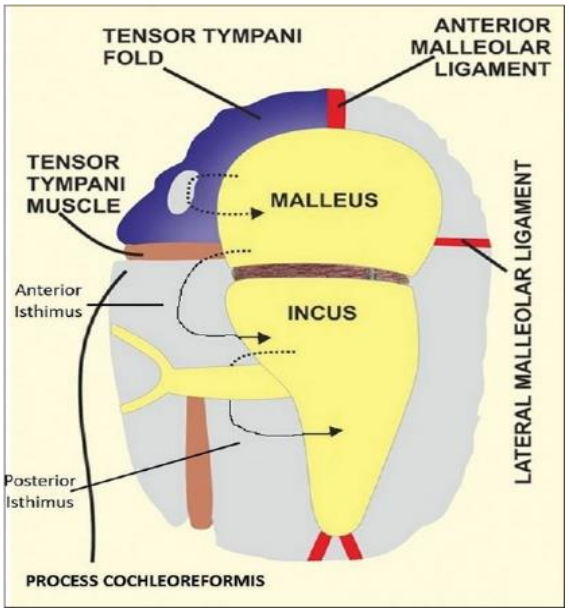


Fig. 14 Tensor tympani fold

POUCH OF VON TROLTSCH:

- The **anterior pouch of Von Troltsch** lies between the anterior malleolar fold and pars tensa of tympanic membrane/portion of TM anterior to the handle of malleus.

- The **posterior pouch of Von Troltsch** lies between the posterior malleolar fold and pars tensa of tympanic membrane/ portion of the tympanic membrane posterior to the handle of malleus.

ANTERIOR TYMPANIC ISTHMUS:

It is a narrow space between the tensor tympani muscle anteriorly and incudostapedial joint posteriorly. The diameter is about 1.0–3.0 mm. It is an

important route of aeration, and openly communicates with the anterior epitympanum (superior attic). It is always present.

POSTERIOR TYMPANIC ISTHMUS:

It is a narrow inconsistent space between the stapedius muscle and short process of incus. It communicates the epitympanum, the mesotympanum, and the airway through incudal fossa.[3]

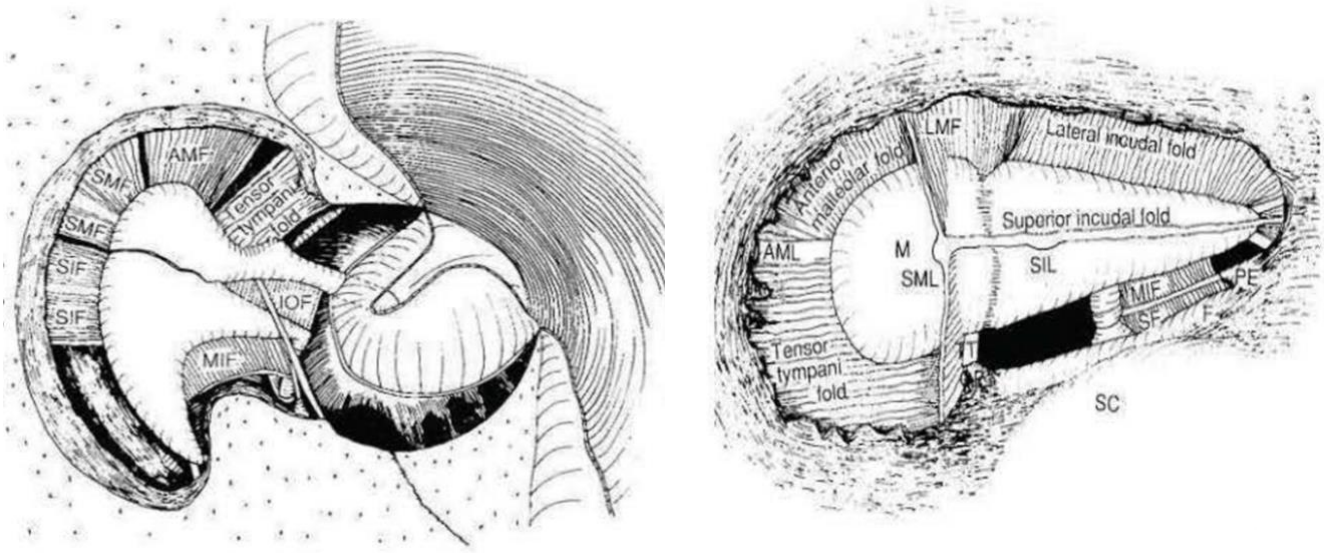
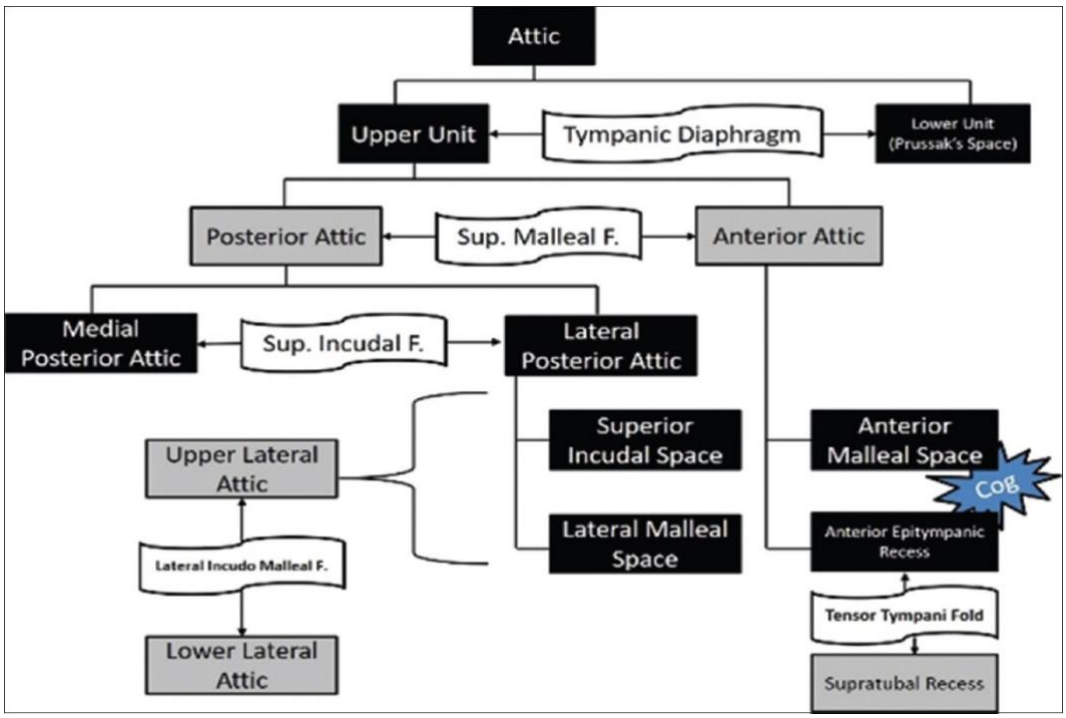


Fig.15 Mucosal folds of middle ear


Attic
Upper Unit
Tympanic Diaphragm
Lower Unit (Prussak's Space)
Posterior Attic
Sup. Malleal F.
Anterior Attic
Medial Posterior Attic
Sup. Incudal F.
Lateral Posterior Attic
Upper Lateral Attic
Superior Incudal Space
Anterior Malleal Space
COB
Lateral Malleal Space
Anterior Epitympanic Recess
Lateral Incudo Malleal F.
Tensor Tympani Fold
Lower Lateral Attic
Supratubal Recess

.

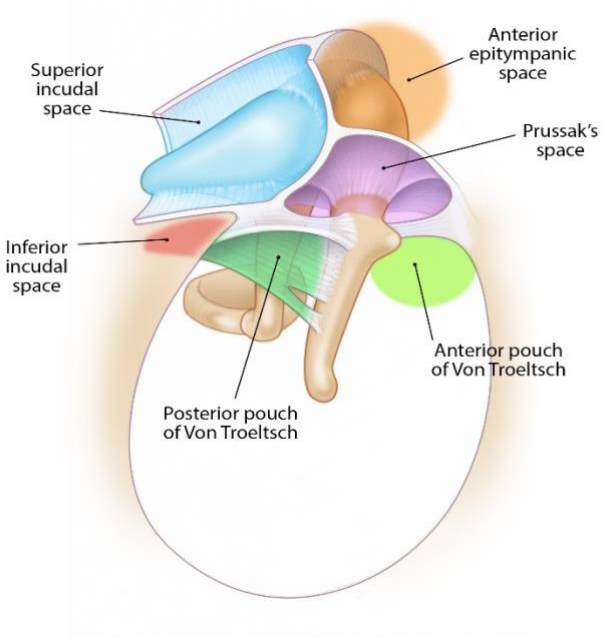


Fig. 16 Middle ear spaces

Prussack's space: It is small space bounded by the neck of malleus medially and the pars flaccida laterally ,lateral process of malleus inferiorly and fibres of lateral malleolar fold superiorly. Ventilation of Prussak's space is only possible posteriorly above the posterior malleolar fold and attaches to the posterior bony annulus.[3]

Cholesteatoma from the pars flaccida region may slip into Prussak's space and develop anterior to the malleus handle. It can remain hidden for a long time, and this gives Prussak’s space its clinical importance.

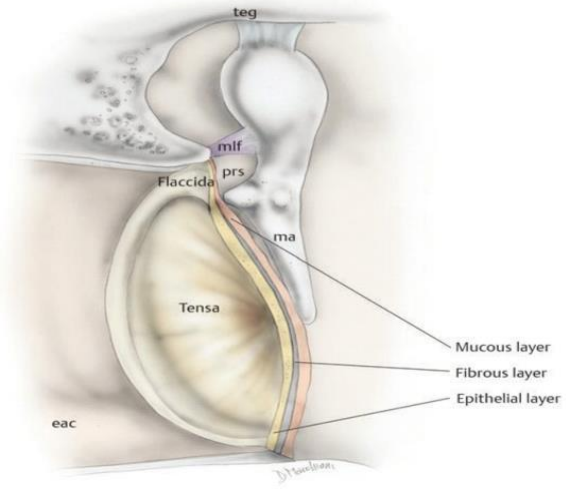


Fig. 17 Prussack's space

B) EUSTACHIAN TUBE:

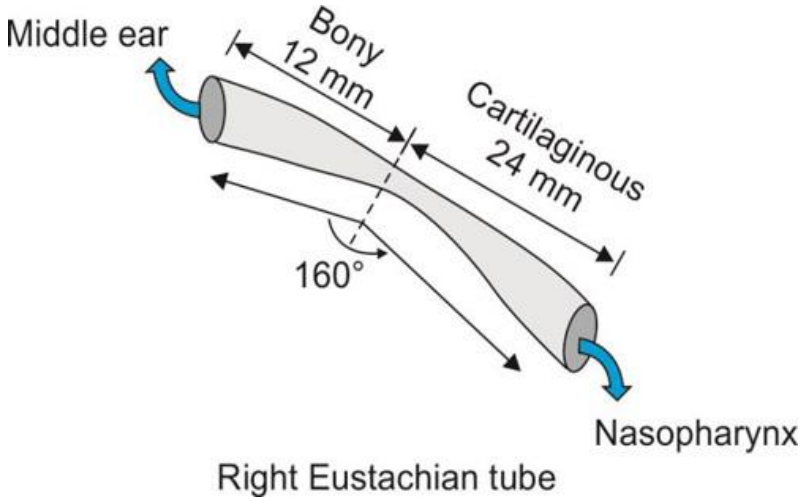
Connects middle ear and the nasopharynx. Measures 36 mm in length, runs downwards, forwards and medially from the middle ear. Has a lateral bony part (one third) arising from the anterior wall of the tympanic cavity and a medial cartilaginous part (two third) near the nasopharynx. It is lined by respiratory mucosa with goblet cells and mucous glands, and ciliated epithelium on its floor, separating the tube from the tensor tympani muscle above. Medially related to the carotid canal.

The peritubal muscles are attached to the cartilaginous part of the tube. The tube opens 1-1.25cms behind and a little below the posterior end of the inferior turbinate in the nasopharynx. The nasopharyngeal opening is triangular in shape and is surrounded

above and behind by the torus. The salpingopharyngeal fold extends from the lower part of the torus downwards to the wall of the pharynx.

The levator palati is seen as a small swelling immediately below the opening of the tube. Behind the torus is a recess known as pharyngeal recess or fossa of Rosenmuller. The tubal orifice and the fossa of Rosenmuller are surrounded by lymphoid tissue.[1]

Fig. 18 Eustachian tube



TUBAL MUSCLES : 4 muscles: Tensor palati , levator palati , salpingopharnygeus , tensor tympani.

- Tensor Palati:
  - Origin: bony wall of scaphoid, whole length of lateral cartilaginous portion of eustachian tube.
  - Insertion : converges to short tendon, runs medially around the pterygoid hamulus

- Innervation: mandibular nerve

- Salpingopharnygeus:

  Slender, attached to the inferior part of the cartilage of ET near its pharygeal end, it descends to blend with palatopharyngeus.

- Levator Palati:
  - Origin: Lower surface of cartilaginous as well as petrous bone, in front of carotid entry, also from fascia of carotid sheath.
  - Insertion : spread out into the soft palate after crossing the tube from inferior to medially.
  - Both the muscles are innervated by pharyngeal plexus.

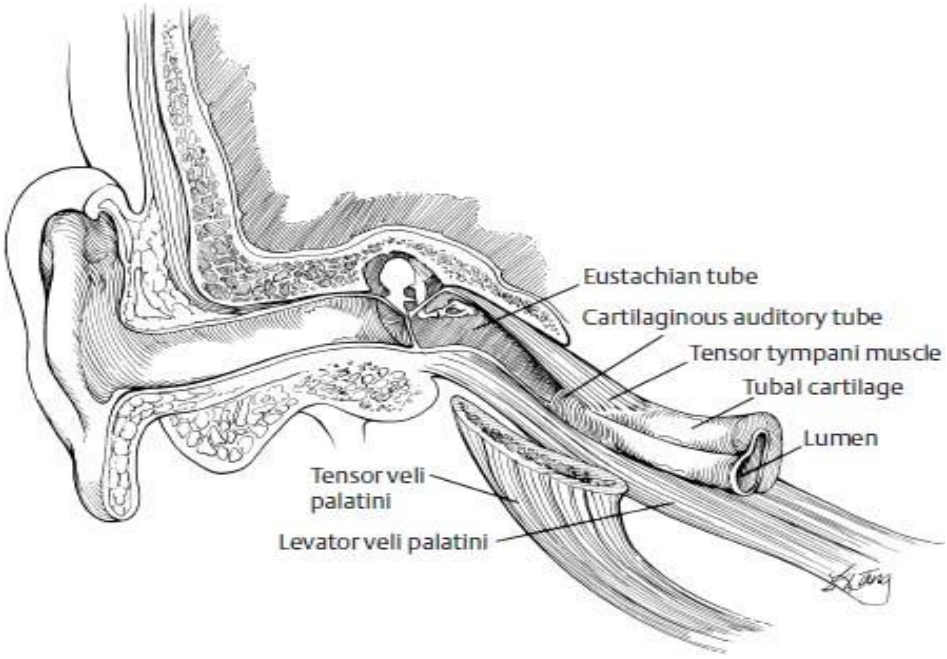


Fig. 19 Muscles of the eustachian tube

ANATOMY OF FACIAL NERVE:

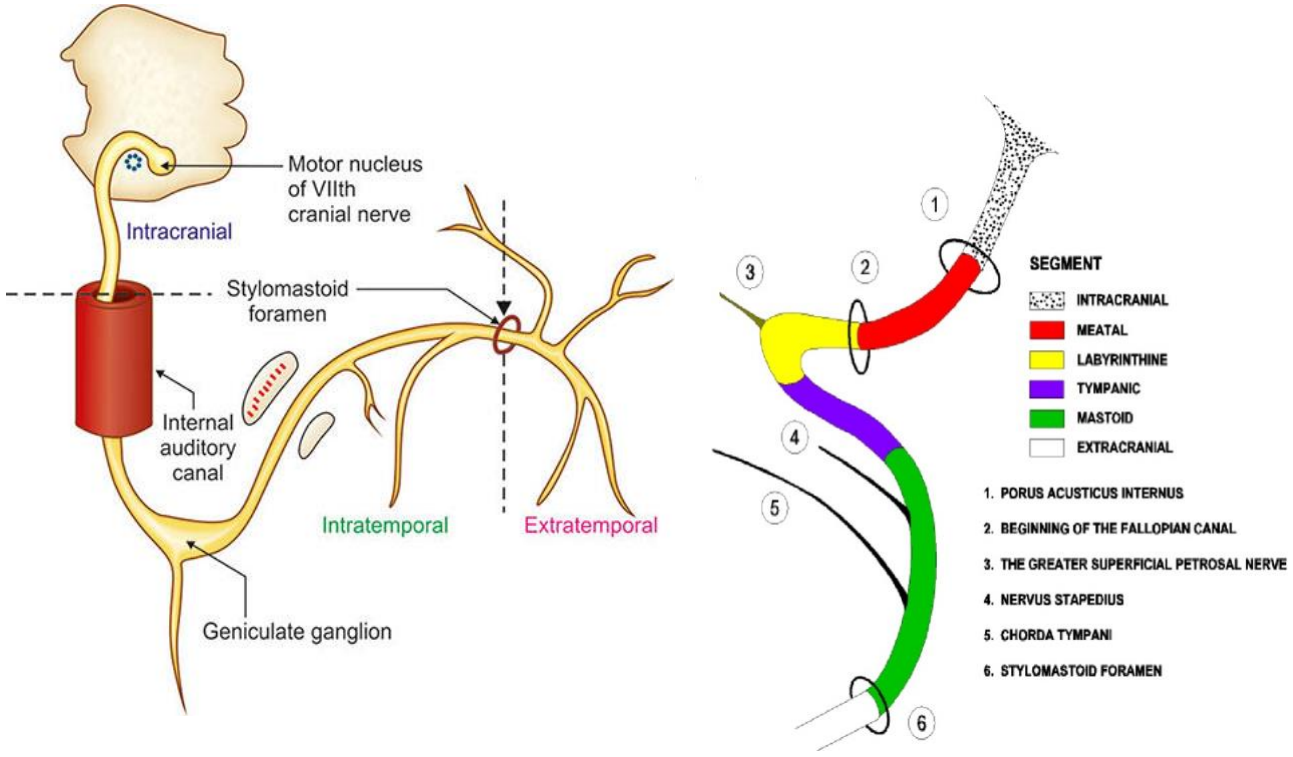
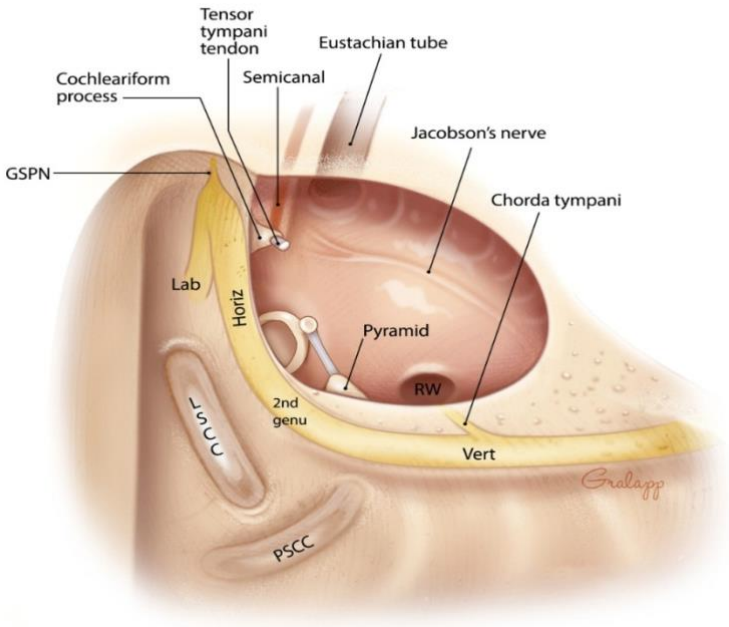


Fig.20 Course and parts of facial nerve

Portions of the facial nerve along its course are Intracranial / cisternal, intratemporal and extratemporal. Intratemporal portion is subdivided into 4 segments-meatal, labyrinthine, tympanic/horizontal and mastoid/vertical segments.

- Labyrinthine segment is the shortest and narrowest part. At its distal end, the nerve takes a sharp turn at the geniculate ganglion forming the first genu from which the tympanic segment starts. Here, the superior semicircular canal is present posteriorly and the cochlea anteroinferiorly.
- There is a thin layer of bone covering the fossa containing geniculate ganglion which separates it from the middle cranial fossa. This bone may be dehiscent in some cases.

- Tympanic segment courses superiorly along the medial wall of the tympanic cavity,runs posteriorly and downwards till the pyramidal eminence where it forms the second genu . Proximally it is above the coclear iform process and tendon of tensor tympani,distally above the oval window,anterior and inferior to the lateral semicircular canal prominence. Tympanic segment can be distally approached via the facial recess during which chorda tympani nerve and fossa incudis are used to identify the nerve. Dehiscences are more common along the tympanic segment.
- Second genu lies inferolateral to the lateral semicircular canal, posterior is the



posterior semicircular canal. Greater superficial petrosal nerve is given off at the level of geniculate ganglion.

Fig. 21 Course of facial nerve in the middle ear

- Mastoid segment is the longest, running vertically downwards from the second genu ,distal to the pyramid to the stylomastoid foramen in the posterior wall of the tympanic cavity and anterior wall of mastoid. Runs posterolateral to the lateral semicircular canal. The digastric ridge marks the inferolateral aspect of the mastoid segment.[1]

Mastoid segment gives 3 branches-

- ✓ Nerve to stapedius- from behind the pyramidal eminence.
- ✓ Chorda tympani – from 5mm proximal to stylomastoid foramen

  Forms the lateral border of facial recess.

  In canal wall down procedure, chorda tympani is considered the medial limit while reducing the facial ridge.

- ✓ Sensory auricular branch

- Extracranial portion of facial nerve, after exiting stylomastoid foramen, gives posterior auricular nerve,muscular branches to supply posterior belly of digastric and stylohyoid muscles.
- 5 terminal branches of facial nerve given after leaving the substance of parotid are temporal, zygomatic, buccal, marginal mandibular and cervical.
- The facial recess is a triangular area inferior to the incudal fossa, lateral to the vertical segment of the facial nerve, and medial to the chorda tympani.

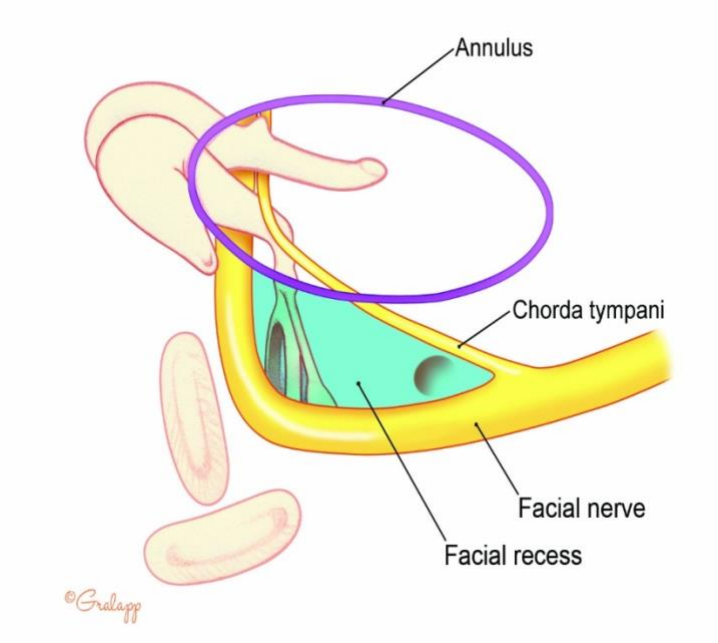


Fig. 22 Facial recess

C) THE MASTOID ANTRUM :

It is an air-filled sinus within the petrous part of the temporal bone. It communicates with the middle ear via aditus. It has a volume of about 2 mL in adult life.

Roof : forms the floor of the middle cranial fossa.

Medial wall : posterior semicircular canal. More deeply and inferiorly is the dura of the posterior cranial fossa and the endolymphatic sac.

Posterior : sigmoid sinus-curves downwards,turns upwards to pass medial to the facial nerve and then becomes the dome of the jugular bulb in the middle ear space.

Base :The posterior belly of the digastric muscle forms a groove here.The corresponding ridge inside the mastoid known as digasteic ridge lies lateral to the sigmoid sinus and to the facial nerve and is a useful landmark for finding the nerve during surgery.

Macewen's triangle is a direct lateral relation to the mastoid antrum and is formed by a posterior prolongation of the line of the zygomatic arch and a tangent to this that passes through the posterior border of the external auditory meatus.

In normal ears, the lining of the mastoid is a flattened, nonciliated epithelium without goblet cells or mucus glands.[1]

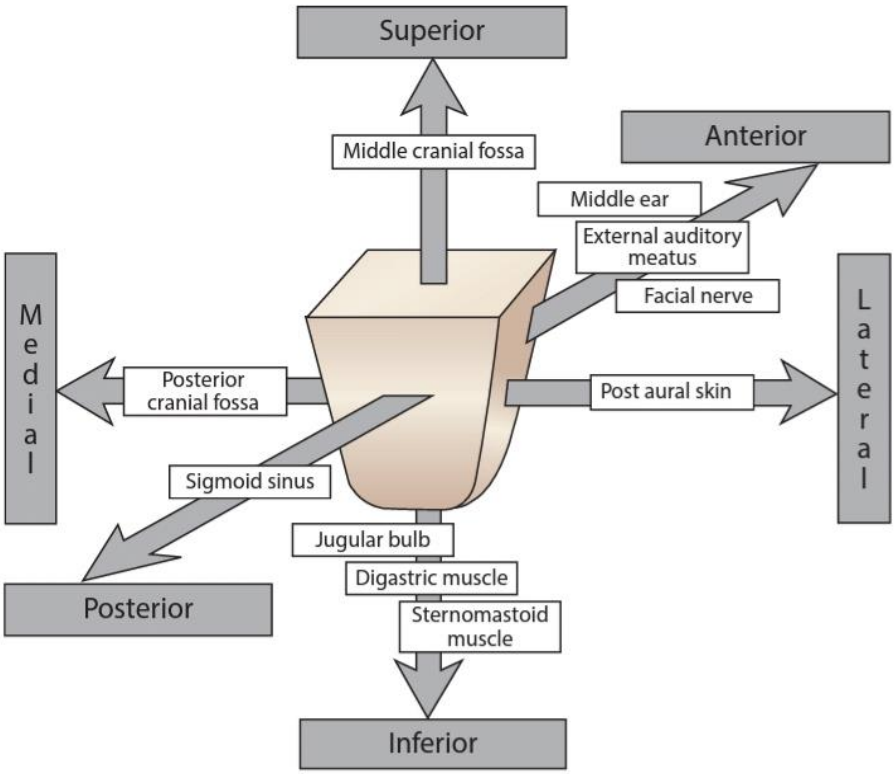


Fig. 23 Relationship of the mastoid antrum

Pneumatization :

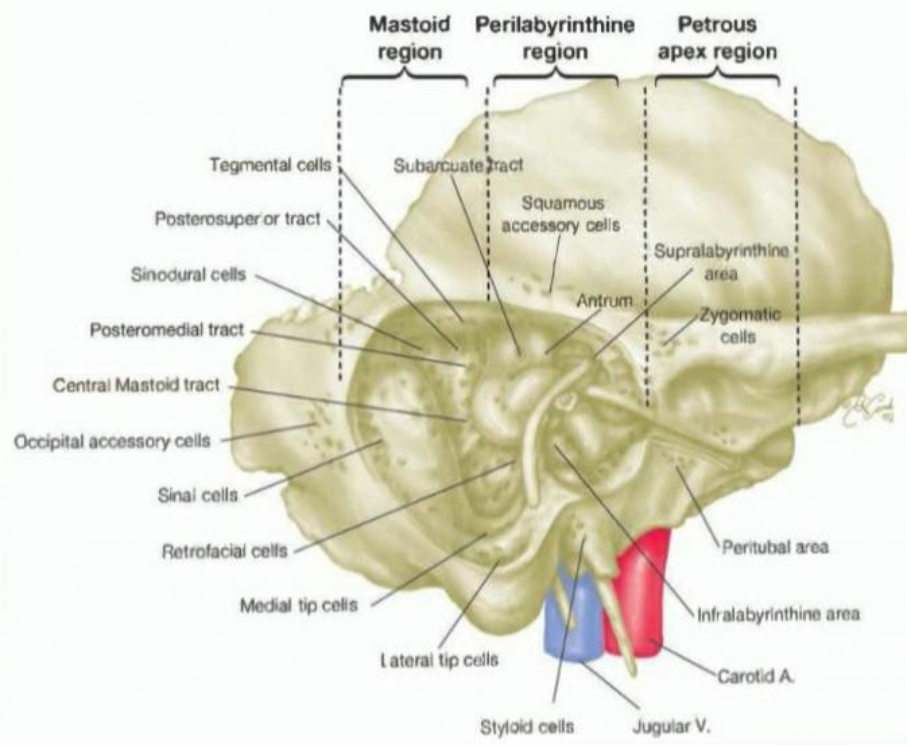


Fig. 24 Pneumatisation of the mastoid

The extent of temporal bone pneumatization depends on heredity, environment, nutrition, infection, and eustachian tube function. There are five recognized regions.

1. The middle ear region : divided into epitympanic , mesotympanic, hypotympanic, protympanic, and posterior tympanic areas.
2. The mastoid region : subdivided into the mastoid antrum, central mastoid, and peripheral mastoid.
3. The bony labyrinth divides the perilabyrinthine region into supralabyrinthine and infralabyrinthine areas.
4. The petrous apex region :The apical area and the peritubal area .
5. The accessory region : the zygomatic, squamous, occipital, and styloid areas.[2]

PHYSIOLOGY OF HEARING:

It includes

- Conduction of mechanical sound energy (external and middle ear conductive apparatus)
- Transduction of mechanical sound energy into electrical impulses (cochlear sensory system)
- Conduction of electrical impulses to brain (CN VIII, brainstem, thalamus and temporal lobe neural pathways).

CONDUCTION OF SOUND:

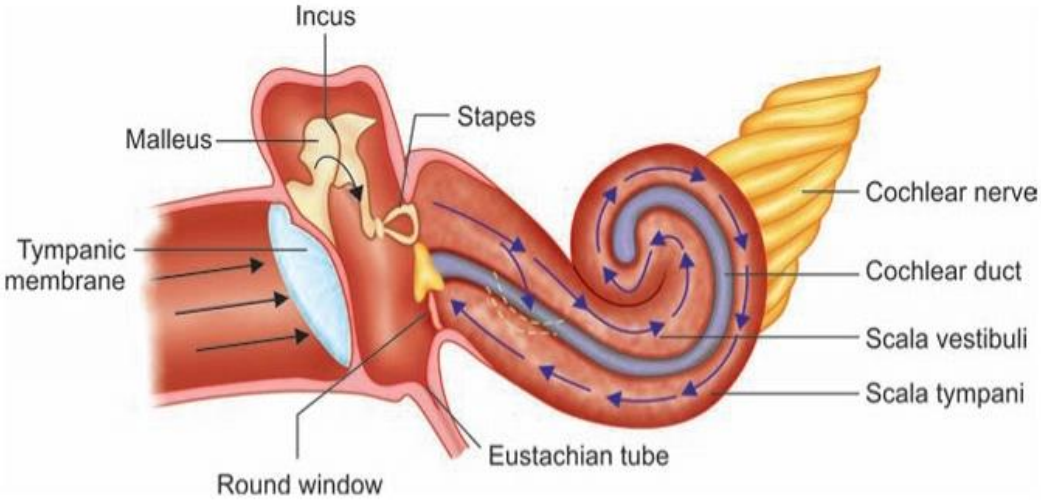


Fig.25 Conduction of sound

Pinna and External auditory canal:

Pinna collects sound by gathering sound waves from an arc of 135°, localizes the sound and concentrates the sound at the entrance of EAC. External auditory canal and the pinna can increase sound pressure by 15–22 dB at 4000 Hz at the tympanic membrane.

Middle ear:

OSSICULAR COUPLING:

Sound stimulus entering the external auditory canal causes the TM to vibrate. The TM motion causes malleus to vibrate as it is coupled to the TM making the entire ossicular chain to vibrate ,thereby resulting in sound transmission to the inner ear via the stapes footplate. This pathway of sound transmission is referred to as ossicular coupling. The ossicular chain vibrates along an axis through the head of the malleus and the body of the incus in an anteroposterior direction .

ACOUSTIC COUPLING:

The pathway of sound transmission to the inner ear in the absence of the ossicular system is known as acoustic coupling. If a sound stimulus strikes the fluid directly, most of the acoustic energy will be deflected because the impedance of fluid is much greater than that of air. It has been shown that the difference between ossicular coupling and acoustic coupling is about 60 dB, which is the maximal amount of hearing loss expected in patients with ossicular discontinuity.[1]

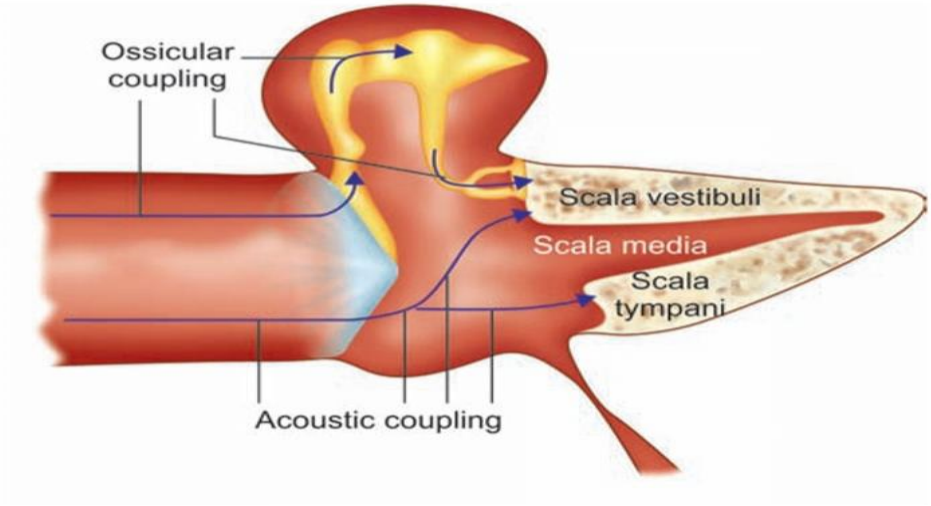


Fig. 26 Mechanism of sound conduction through middle ear

IMPEDANCE MATCHING / TRANSFORMER ACTION OF MIDDLE EAR:

When the sound reaches the cochlear fluids by air conduction, reflection of the sound energy takes place. Middle ear compensates for this loss by converting sound of greater amplitude, but lesser force, to that of lesser amplitude and greater force. This function is termed as impedance matching mechanism or the transformer action. This happens by 2 important mechanisms:

- Hydraulic Action of Tympanic Membrane/Areal ratio:

  The area of tympanic membrane is much larger compared to that of the stapes footplate. Hence, the tympanic membrane provides a larger hydraulic ratio . The effective areal ratio between tympanic membrane and stapes footplate is about 17:1.

- Lever ratio:

The manubrium of malleus is 1.3 times longer than the long process of the incus. This lever ratio of 1.3 provides a mechanical advantage.

Transformer ratio is the product of areal ratio and lever ratio of ossicles which is 22.1 (17 x 1.3). This offers a 25 dB increase in sound energy arriving at the cochlea.[1]

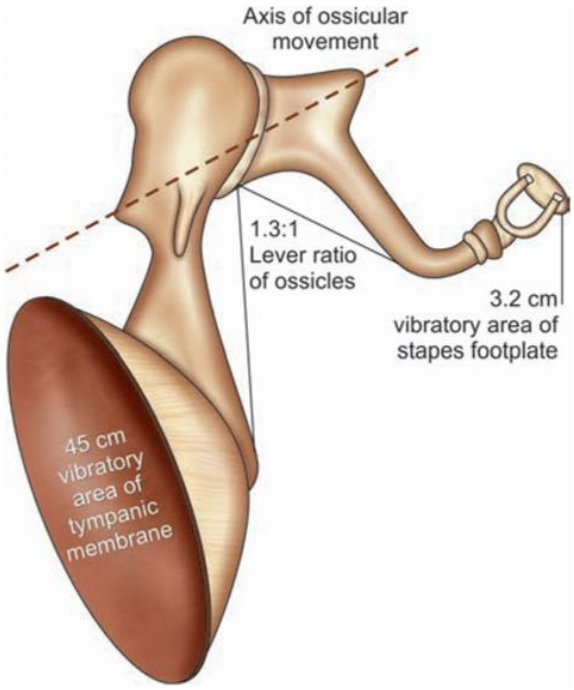


Fig. 27 Transformer action of middle ear

Phase Differential Between oval and Round window :

Sound waves do not strike the oval and round windows simultaneously. The preferential pathway to oval window receives sound vibrations first and round window acts as a relief window. When the oval window is receiving wave of compression, the round window is at the phase of rarefaction. If the sound waves strike both the windows

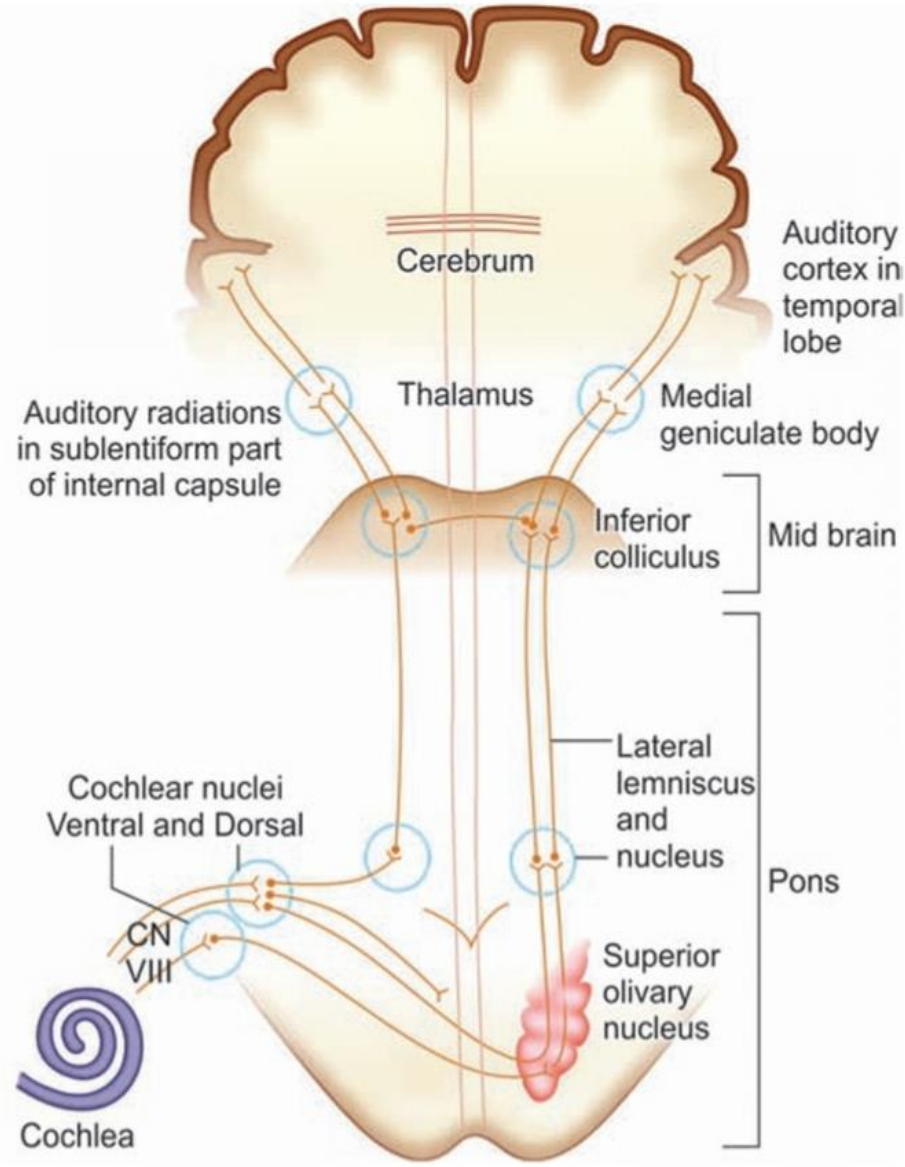
simultaneously, they would cancel each other's effect and there will not be any movement of the perilymph.

Transduction :

It is the conversion of mechanical energy to electrical energy. Transmission of mechanical energy due to movement of the stapes footplate to the cochlear fluids causes movement of the basilar and tectorial membranes differentially which sets up shearing force causing bending of the stereocilia. Movement of stereocilia opens and closes ion channels producing receptor potential in the inner hair cells. This cochlear microphonics triggers the nerve impulse by releasing neurotransmitters onto afferent nerve fibers.

1. Traveling Wave Theory of von Bekesy: The movement of the basilar membrane in response to sinusoidal sound appears as traveling wave, which moves from the base to the apex. Depending on the frequency, a particular segment of the basilar membrane achieves maximum amplitude. Each wave is weak at the onset but becomes stronger as it reaches its natural resonant frequency.
2. Tonotopic Gradient in Cochlea: Tonotopic map of basilar membrane determines the site of largest peak of the wave. Higher frequencies are represented in the basal turn and the progressively lower tones towards the apex of the cochlea. High frequency waves travel a short distance and die. Low frequency waves travel a long distance and die.

Central neural pathways:



The electrical impulses from the nerve fibres are transmitted to the auditory cortex via central neural pathway.

Fig. 28 Auditory pathway

CHOLESTEATOMA

The term cholesteatoma was coined by Johannes Muller, a german physiologist.

It is a misnomer. Cholesteatoma is a beningn keratinising squamous epithelium lined cystic structure containing desquamated debri, mostly keratin with bone eroding qualities, with a fibrous stroma of varying thickness, cellularity and vascularity.[4]

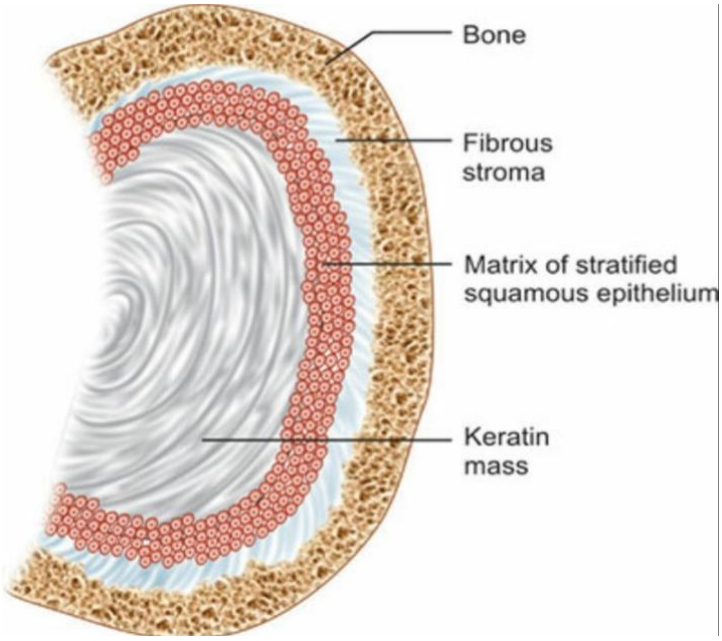


Fig. 29. Structure of cholesteatoma

TYPES OF CHOLESTEATOMA:

- congenital
- Acquired

- Congenital cholesteatoma: It is formed if the embryonic epidermal cell rests (keratinizing epithelium) becomes entrapped in the middle ear cleft or temporal bone . Common sites of congenital cholesteatoma are middle ear, petrous apex and the cerebellopontine angle. Presents with conductive hearing loss and on examination, a white mass is seen behind an intact TM with no prior history of otorrhea perforation or previous ear surgery.

- Acquired cholesteatoma: It is of two types: primary acquired and secondary acquired.
    - Primary acquired cholesteatoma: No history of previous otitis media, a pre-existing perforation, or otorrhoea

PATHOGENESIS:

INVAGINATION THEORY OF WITTMAACK:

- Primary mechanism for attic cholesteatoma.The negative middle ear pressure due to eustachian tube dysfunction causes retraction pockets which are formed by the invagination of tympanic membrane from the attic or posterosuperior part of pars tensa . The stratified squamous epithelium of the outer surface of tympanic membrane forms the matrix of cholesteatoma after invagination and keratin is laid down in the pocket.[6]
- The retraction pocket deepens due to the negative middle ear pressure and repeated inflammation, so that the desquamated keratin cannot be cleared from the recess and results in cholesteatoma.

- The most common sites for the primary acquired cholesteatoma are pars flaccida or attic and posterosuperior quadrant of pars tensa due to reduced resistance to displacement.

EPITHELIAL INVASION OR MIGRATION THEORY OF HABERMANN:

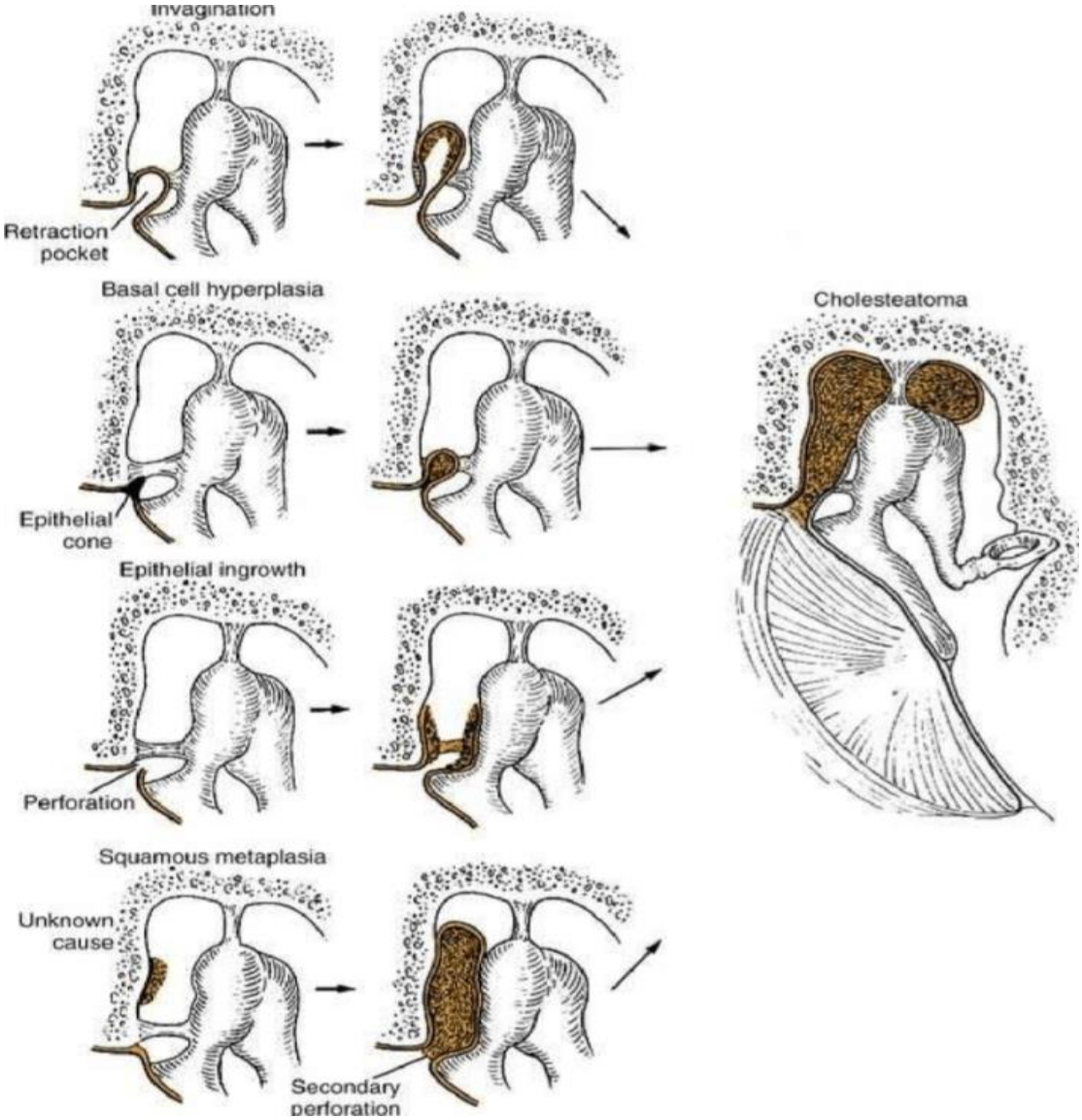
- Keratinising squamous epithelium of the tympanic membrane invades/migrates into the middle ear via the TM perforation (commonly marginal).
- This is produced by the damage caused by chronic inflammation of the inner mucosal lining of tympanic membrane allowing the migration of outer keratinizing squamous epithelium inwards .

BASAL CELL HYPERPLASIA THEORY (LANGE AND RUEDI):

- The basal cells of germinal layer of skin can proliferate and lay down keratinizing squamous epithelium, under the influence of infection. The Prickle epithelial cells of pars flaccida can invade the subepithelial tissue by of proliferating columns of epithelial cells.
- The basal lamina breaks causing invasion of epithelial cones into the sub epithelial connective tissue forming microcholesteatomas which may enlarge and perforate an intact tympanic membrane and present as primary acquired cholesteatoma.[6]

SQUAMOUS METAPLASIA THEORY OF WENDT AND SADE:

- The simple squamous or cuboidal epithelium of middle ear cleft can undergo a metaplasia and form keratinizing epithelium. Repeated infection and



inflammation causes cholesteatoma which results in perforation of the tympanic membrane and present as primary acquired cholesteatoma.

Fig. 30 Theories of cholesteatoma

Secondary acquired cholesteatoma: May develop due to the ingrowth of keratin epithelium associated with tympanic membrane perforation. Pre-existing

perforation usually involves posterosuperior marginal perforation or large central perforation**.**

SPREAD OF CHOLESTEATOMA:

- The mucosal folds and suspensory ligaments of the ossicles limits the growth of attic cholesteatoma.
- A cholesteatoma extends from attic to Prussack's space.
- From the Prussack's space cholesteatoma may spread in three directions.
    1) Posterior route. This is the commonest route.

       The cholesteatoma spreads from prussack's space into the superior incudal space lateral to the body of incus. From here it e nters the aditus and then to the mastoid antrum.
    2) Inferior route: Here the spread occurs from the prussack's space into the posterior mesotympanum via inferior incudal space or posterior pouch of Von Troltsch. From here ,it can spread to stapes, round window, sinus tympani and facial recess.
    3) Anterior route: It is less common. Here cholesteatoma involves the anterior epitympanum and supratubal recess by invading anterior to malleus. Extension into the anterior mesotympanum occurs through the anterior pouch of Von Troltsch.[7]
- The tympanic diaphragm resists the spread of epitympanic cholesteatoma to mesotympanum and vice versa.

- The patency of the aditus and antrum and tympanic isthmus is important for aeration of the mastoid.

CLINICAL FEATURES:

- Otorrhea: Scanty purulent foul smelling ear discharge, may be blood stained.
- Hearing impairment : Usually conductive hearing loss occurs due to ossicular disintegrity but the severity of hearing loss, varies.
- Hearing may be preserved until late stage of disease inspite of ossicular disruption as cholesteatoma sac bridges gap between the functioning ossicular chain and inner ear.
- Sometimes granulation and flesh polyp causes aural bleeding while probing.
- Facial palsy , fever, headache, Pain, vertigo, ataxia are the symptoms of complications of cholesteatoma

<u>Otoscopy/Microscopy/Endoscopy:</u>

- Perforation: commonest is the marginal perforation in the Attic and posterosuperior region
- Cholesteatoma: Postero superior retraction pocket along with pearly white flakes of cholesteatoma is usually present which may extend into other parts of middle ear cleft.

- Retraction pocket : May be shallow and self-cleansing or deep, non self cleansing pocket with accumulated keratin debris.
- Granulation tissue, aural polyps may be present .
- Ossicular necrosis: The long process of incus, stapes and handle of malleus or the entire ossicular chain may be involved in ossicular destruction by cholesteatoma. Involvement of incus is universal in cholesteatoma.[1]

Investigations:

- Tuning fork test and audiogram:

  To confirm the degree and type of hearing loss.

- Imaging:
  - To know the extent of disease and bone destruction, ossicular status,degree of mastoid pneumatization ,anatomical abnormalities like a low lying dura, high jugular bulb,dehiscent facial canal , anteriorly placed sigmoid sinus before taking up for surgery.
  - High-resolution computed tomography (HRCT) -standard method of imaging .

    Disadvantage :Inability to differentiate cholesteatoma from other soft tissues.

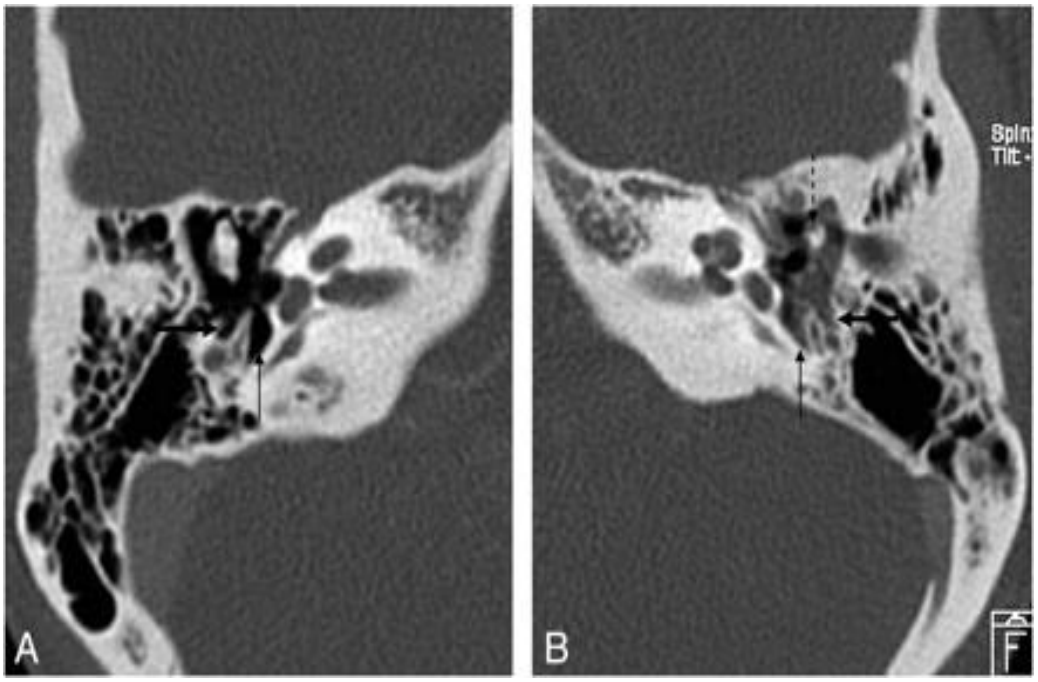


Fig. 31 HRCT Temporal bone showing cholesteatoma

- Non-echoplanar diffusion weighted MRI helps differentiating cholesteatoma from other soft tissues. Also in detecting residual cholesteatoma in revision cases.[1]

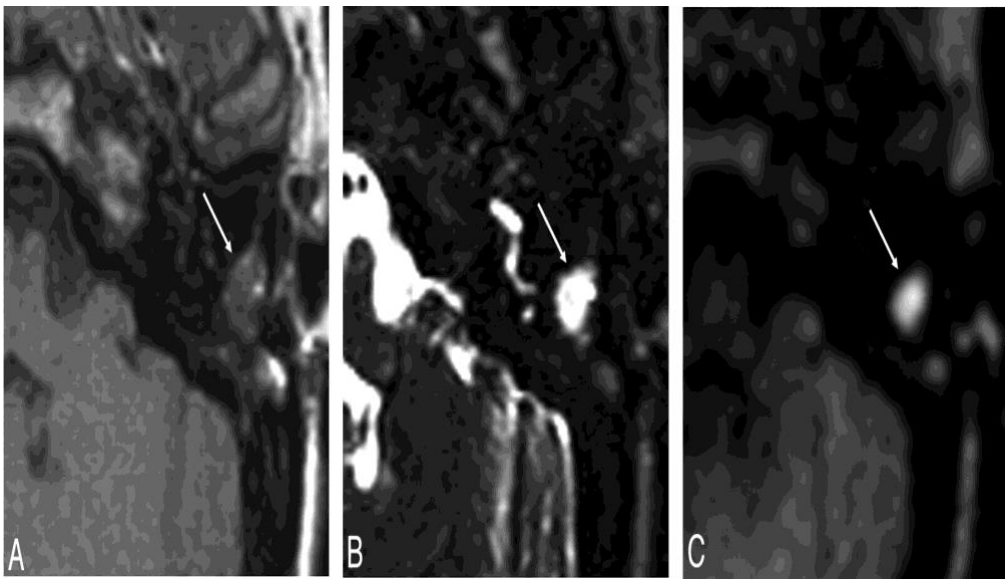


Fig.32 Diffusion weighted MRI showing cholesteatoma

-Culture and sensitivity for microorganisms for specific antibiotics.

EMERGENCY STATES OF CHRONIC OTITIS MEDIA WITH CHOLESTEATOMA AND COMPLICATIONS :

- Labyrinthine fistula involving horizontal semicircular canal.
- Hearing loss :conductive ,sensorineural ,mixed type
- Facial nerve paralysis
- Intracranial complications: Meningitis, epidural abscess, subdural abscess
- Encephalitis.

TREATMENT :

-Surgery is the mainstay in the treatment of cholesteatoma.

-various surgical approaches are:

- Atticotomy
- Simple mastoidectomy
- Canal wall up with or without facial recess approach
- Canal wall down procedure-radical/modified radical mastoidectomy

ADVANTAGES OF CANAL WALL DOWN APPROACH :

- Incidence of residual cholesteatoma is rare.
- Low recurrence rate.
- Recurrence, if present, can be diagnosed easily on follow up.
- Total exterioristion of facial recess is done.

DISADVANTAGES:

- Mastoid cavity problem
- Middle ear may become shallow making reconstruction difficult.

  -Modified radical mastoidectomy is the preferred method in the management of atticoantral cholesteatoma.

MODIFIED RADICAL MASTOIDECTOMY

Modified radical mastoidectomy is a surgical procedure which involves eradication of the disease, exenteration of diseased and all possible mastoid air cells,exteriorisation of mastoid into EAC with removal of bridge, anterior buttress, posterior buttress, reduction of ridge with wide meatoplasty with or without ossiculoplasty.

AIMS OF THE PROCEDURE:

- Eradication of the disease
- Exenteration of mastoid air cells
- Exteriorisation of the mastoid cavity

Surgical technique:

- Infiltration given with 5 to 10 mL of local anesthetic with a vasoconstrictor in the concentration of 1% lignocaine with 1:100000 adrenaline in the post auricular region, incisura terminalis and 4 quadrants of external auditory canal.

REMOVAL OF THE DISEASE:

- In order to remove cholesteatoma into toto,it should be dissected in continuity.
- The status of incudostapedial joint should be found before proceeding with mastoidectomy.Cbolesteatoma or granulation tissue is dissected free from the ossicles, leaving the ossicular chain intact if possible. If preservation of the ossicular chain is not possible, separation of the incudostapedial joint is performed early to prevent injury to the stapes or inner ear.
- In case of intact ossicular status,incudostapedial joint should be dislocated.
- After opening the facial recess,incus is removed.

EXENTERATION AND EXTERIORISTION OF MASTOID:

- Modified william wilde incision made 5mm behind the post auricular groove.Superiorly incision is extended to harvest temporalis fascia graft. Inferiorly incision is made upto the level of anterior lateral surface of the mastoid tip.[2]

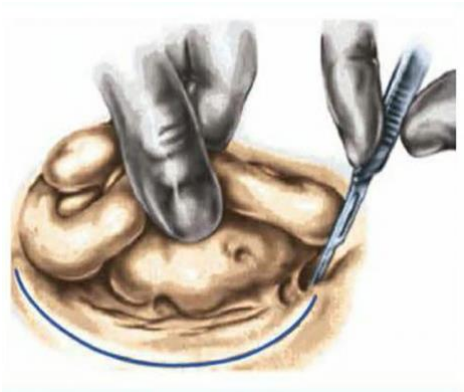
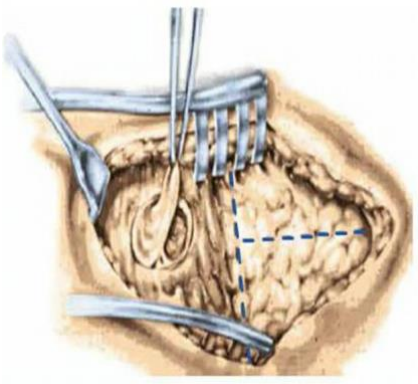


Fig. 33 Post aural incision

- Two periosteal incisions made along the temporal line and perpendicular to the 1st incision upto the mastoid tip and periosteal flaps elevated, retracted forwards with the auricle to expose the mastoid bone.A self retaining mastoid retractor is applied.



. Fig. 34 T shaped periosteal incision

- Mastoid cortex is drilled out to enter into the mastoid antrum which lies 12 to 15 mm deep to the suprameatal triangle (bounded by suprameatal crest, posterosuperior wall of external auditory canal and tangential line joining both).

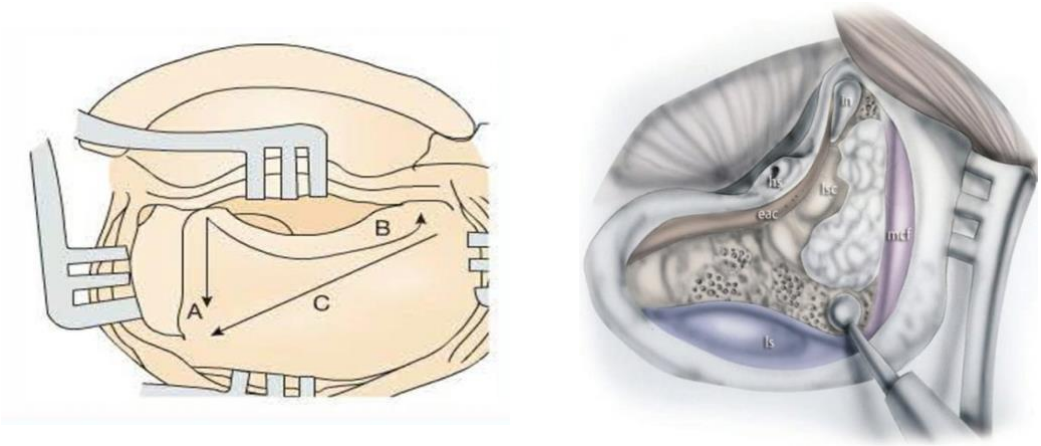


Fig. 35 Drilling in McEwan's triangle

- Appropriate irrigation is necessary to clear the bone dust and to prevent excessive heat transfer to critical structures like facial nerve and to maintain a clean cutting surface on the burr.[2]
- Key landmark in mastoid surgery is the identification of antrum,dome of horizontal semicircular canal along its floor.

- Key principles in dissection are saucerisation, identification of tegmen plate ,thinning of posterior canal wall, posteriorly identification of sigmoid sinus.

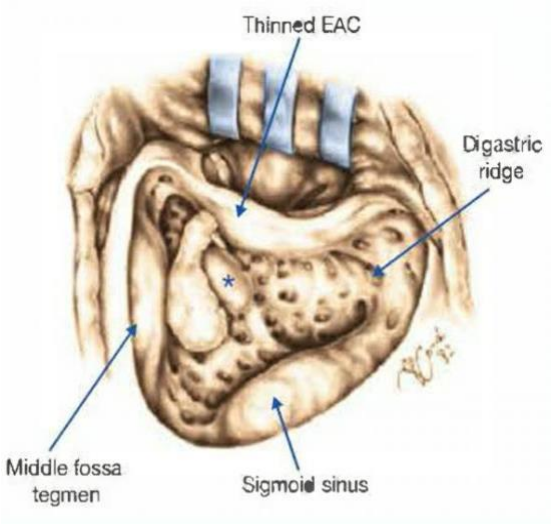


Fig. 36 Identification of sigmoid sinus and thinning of EAC

- Thin posterior canal wall aids in localisation of facial nerve with the tegmen, sigmoid sinus, and posterior canal wall identified, the antrum can now be dissected, following the tegmen anteriorly. Koerner's septum, the embryologic remnant of the fusion plane between the petrous and the squamous bones is often encountered next. After penetrating Koerner's septum , the antrum is uncovered and the surgeon can identify the lateral semicircular canal.
- After cortical mastoidectomy is complete, zygomatic root air cells are exenterated. Bridge is removed.
- Identification of the facial nerve helps in lowering the facial ridge appropriately in canal wall down procedures.[2]

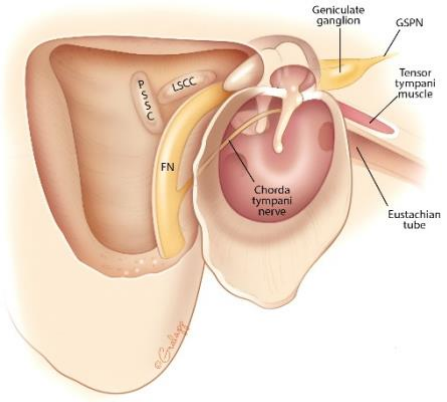
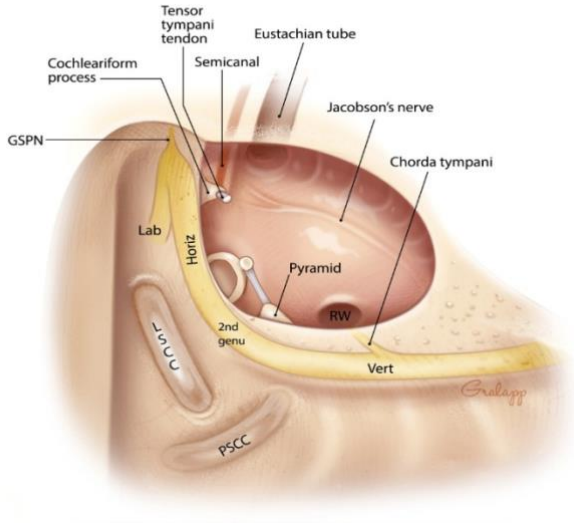


Fig. 37 Identification of facial nerve

- Most important landmarks for facial nerve are the horizontal semicircular canal, short process of incus and posterior bony wall of EAC. The genu and proximal portion of the mastoid segment lie anterior and medial to the dome of HSCC. The mastoid segment also lies medial to the plane of short process of incus at the base of posterior canal wall.



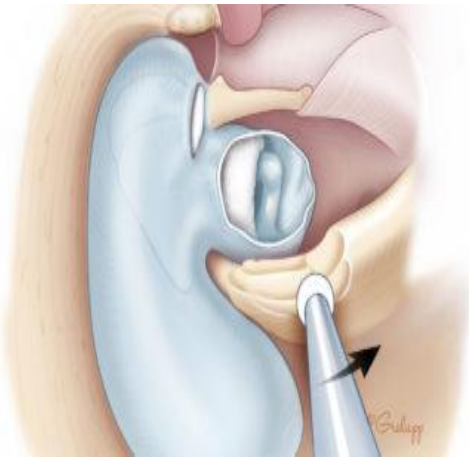


Fig. 38 Identification of vertical segment of facial nerve

Fig. 39 Removal of bridge

- The short process of incus is identified and bone over the area of the facial nerve in removed with continued thinning of posterior canal wall.

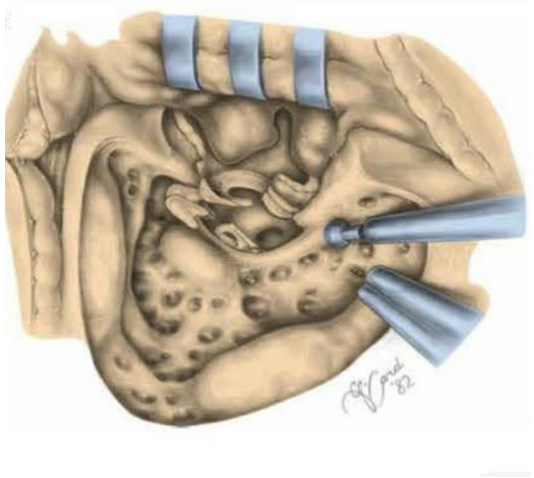


Fig. 40 Reduction of ridge

- Cholesteatoma dissection is continued along with bone dissection. The strategy for removal becomes a search for the adhesions, lysis of each

adhesion, and then resumption of elevation of the matrix until the next adhesion is encountered. Lysis of an adhesion or removal of cholesteatoma extending into recesses or air cells may sometimes require expanding the surgical exposure or drilling out the focal air cells involved.

CONVENTIONAL INSIDE OUT MASTOIDECTOMY :

- Inside out mastoidectomy is a procedure in which bone work is started at the bony annulus and proceeded posteriorly.
- With the help of microscope,cholesteatoma is followed in a posterior direction with atticotomy performed first followed by aditotomy and antrotomy with a view of preventing excess bone removal .[3]

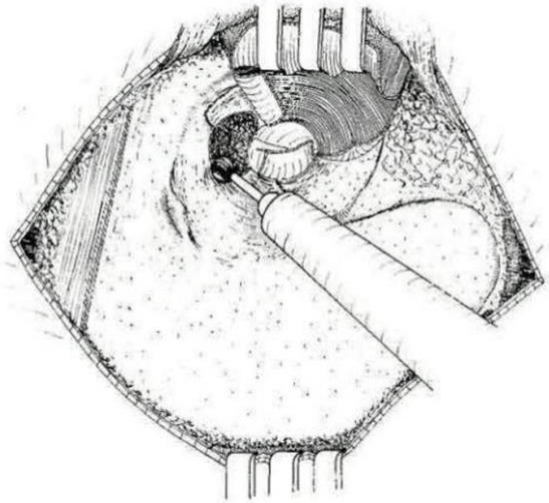


Fig.41 Retrograde mastoidectomy -atticotomy

- Usually drilling is started from the site of pathology where the cholesteatoma sac is visible.

- Anteriorly based subcuticular muscle periosteum flap is elevated in a retroauricular approach.
- Two radial incisions at 12 O' clock and 6 O'clock positions and a circumferential incision connecting both is made and tympanaomeatal flap elevated till fibrous annulus.
- Drilling is started from the posterosuperior meatal wall, moving posteriorly and removing the scutum to open the attic followed by opening the aditus and antrum with the aim of exposing complete cholesteatoma sac.[3]

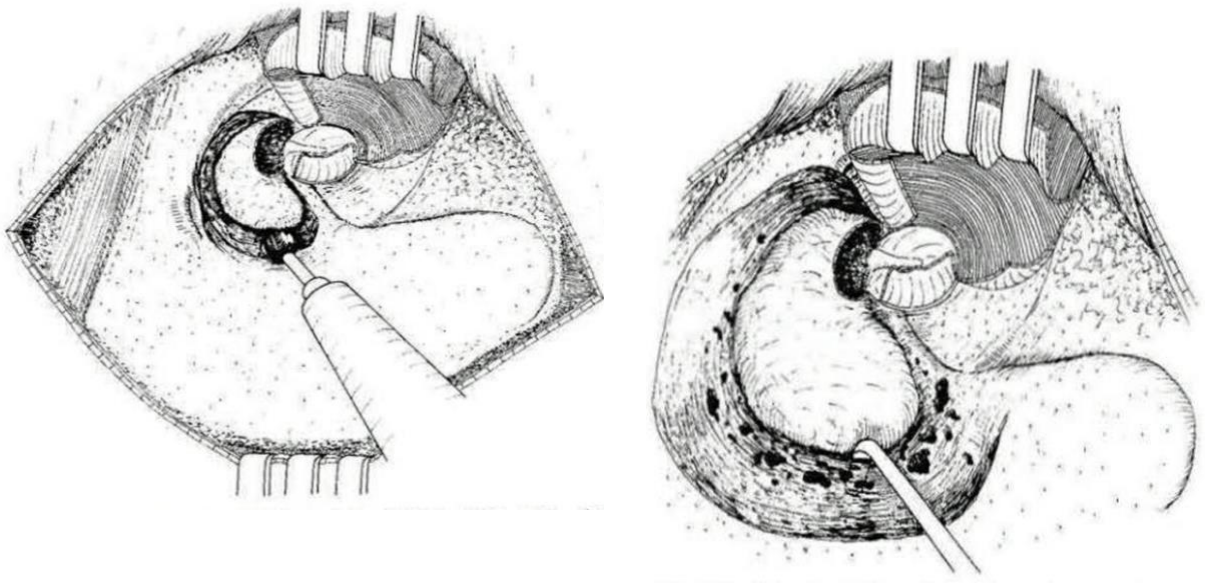


Fig.42 Further drilling of ear canal for exposing choleastaetoma sac

- Entire cholesteatoma sac is removed in toto with simultaneously exposing the entire mastoid tegmen, sinodural angle.
- Inside out mastoidectomy follows the pathology safely along the middle fossa dural plate with control of the position of the burr. Retrograde

mastridectomy with a retroauricular approach allows a large cavity as outside in method.

ENDOSCOPIC METHOD:

- Inside out mastoidectomy by endoscopic method is performed transmeatally without postaural incision.
- Using 0°hopkins rod nasal endoscope, ear canal visualised. TM flap incisions made and flap elevated. Bone drilling done from retraction pocket to the mastoid .
- Posterosuperior meatal wall is drilled and portion of the wall removed with kerrisons punch upto the fundus of the sac. Cholesteatoma sac is mobilised and removed.
- Scutum is removed. Ossicular status will be checked. If intact, incudostapedial joint will be dislocated.Anterior epitympanic recess visualised.Sac removed completely and checked for any residues.
- Tympanoplasty done. If needed, cartilage is harvested and used.Wound over the harvested site of temoralis fascia and cartilage were sutured using 3-0 ethilon.

Fig.43 Endoscopic images showing steps of inside out mastoidectomy

TYMPANOPLASTY :

- May or may not be combined with mastoidectomy.
- It is surgical procedure to eradicate disease in the middle ear and to reconstruct the hearing mechanism, with or without tympanic membrane grafting.
- Coined by Wullstein in 1953.[1]

ZOLLNER WULSTEIN CLASSIFICATION OF TYMPANOPLASTY :

-Type I

Perforated TM with normal ossicular chain.

Repair of perforated TM-Myringoplasty

-Type II

Sound transmission through a functioning but deformed chain.

Graft placed over the malleus remnant or incus.

- Type III

TM & ossicles destroyed except for intact & mobile stapes.

Graft kept over stapes head – Myringostapediopexy (columella type).

-Type IV (Baffle Effect)

Only a mobile footplate of stapes remains intact .

Round window protection with a small middle ear foot plate left exposed (cavum minor).

-Type V

Fixed foot plate.

Closed middle ear with round window protection; fenestra in the

horizontal semicircular canal covered by a skin graft.

MEATOPLASTY :

Meatoplasty is an important part of canal wall down mastoidectomy. It aids in proper ventilation, drainage, healing and facilitates a dry mastoid cavity. The meatoplasty size should be large enough according to the size of post operative mastoid cavity.

In Portmann's three flap technique, three flaps, a lateral, a superior, and an inferior flap are created without removal of any conchal cartilage. Done in small cavities.10mm lateral to the upper drum, a lateral circumferential incision is made between the 1-o'clock and 6-o'clock positions. An upper lateral radial incision is from the upper part of the circumferential incision toward the spine of the helix. The lower incision is from the inferior edge of the circumferential incision toward the concha. After canal wall-down mastoidectomy, a finger is placed through the ear canal to expose the lateral flap, which is cleaned and thinned out. The visible edge of the conchal cartilage and the laterally based flap is turned around the cartilage and fixed to its posterior aspect with sutures. This flap forms the lateral covering of the cavity. The ear canal skin is divided at 9-o'clock position down to the TM to create superior and an inferior flap. After tympanoplasty, fascia is placed on the medial wall of the cavity,the superior and inferior ear canal skin flaps are positioned,the auricle is replaced and sutured back into position. The laterally based flap is now in place, the inferior flap over the facial ridge, and the superior flap over the superior part of the cavity. The skin flaps are to be thin for them to remain in position after packing of the ear. [3]

MATERIALS AND METHODS

40 Patients attending OPD in the Department of ENT and head and neck surgery, Govt stanley medical college and hospital with CSOM (active squamosal disease-cholesteatoma) between november 2020 and october 2021 were selected based on inclusion and exclusion criteria. Thorough audiological evaluation was carried out preoperatively which included otoscopic examination, pure tone audiometry, HRCT temporal bone. All patients had dry ear. All of them underwent rt-PCR for covid-19. After getting consent for general anaesthesia and surgery, 20 patients were subjected to microscopic approach and 20 patients to endoscopic approach of mastoidectomy using 0°nasal endoscope and 30°endoscope. Preoperatively antibiotics were given along with T.Atenolol 25 mg, T.Alprazolam 0.5 mg. Post operatively antibiotics were given for 3 weeks with antihistamines. Post operatively the patients of both the groups were followed up at intervals of 1, 3 and 6months for otoscopic examination, endoscopic examination and pure tone audiometry.

INCLUSION CRITERIA :

- -Age >18 years.
- -Presence of chronic otitis media with cholesteatoma (active squamosal type).

EXCLUSION CRITERIA :

- -cases of revision mastoidectomies.
- -Patients not willing to give consent for the study.
- -Terminally ill patients.

METHODOLOGY :

PREOPERATIVE PREPARATION :

Parts prepared. Preoperative instructions given.Vitals checked. Intravenous antibiotics were given.

T. Atenolol 25mg and T. Alprax 0.5mg were given the night before surgery.

CONVENTIONAL METHOD:

Patient in supine position, orotracheally intubated. Parts painted and draped. LA given in 4quadrants of EAC.Modified William Wilde incision made 5mm posterior to postaural groove. Subcutaneous tissue dissected. Auricularis posterior muscle released. T shaped incision made and periosteal flap elevated using Parabeuf's periosteal elevator. Posterior meatotomy made.Using microscope EAC visualised.Two radial incisions made at 12 o'clock and 6 o'clock positions and a circumferential incision between them made and tympanomeatal flap elevated upto the fibrous annulus, tympanotomy made to expose middle ear cavity. Bone work started by drilling posterosuperior meatal wall. A portion of it was removed with 1mm Kerrisons punch upto the fundus of cholesteatoma sac. Scutum drilled and attic opened. Head of malleus, body of incus removed and anterior epitympanic recess visualised. Stapes was foound to be intact and mobile. Cholesteatoma involving epitympanum, sinus tympani, aditus, antrum was dissected and removed intoto.Graft was placed over the head of stapes and gelfoam kept in the middle ear. TM flap repositioned. Meatoplasty done by Portmann's 3 flap technique. Gelfoam kept in the incision site. Mupirocin ointment instilled in EAC. Graft site and postauricular wound sutured using 3-o ethilon.

ENDOSCOPIC METHOD :

Patient in supine position, orotracheally intubated. Parts painted and draped. Local anaesthesia given in four quadrants of EAC. Using 0°hopkins rod nasal endoscope, ear canal visualised. TM flap elevated transmeatally with 0°nasal endoscope in a 240°fashion.Using a Fisch handpiece, canaloplasty done. Handpiece drill with irrigation and endoscope are handled by the surgeon and small suction by the assisting surgeon.Bone removal done progressively from retraction pocket towards mastoid antrum till the fundus of the sac is seen.Bone removal from posterosuperior meatal wall done with a Kerrison's punch. Once the fundus of the cholesteatoma sac is visualised, ossicular status was checked, if intact, dislocation of incudostapedial joint was done. Sac was removed with severance of tensor tympani tendon and nigging of head of malleus. Once sac was removed completely, close inspection of air cells done with angled nasal endoscopes to check for cholesteatoma residues. Using saline wash, residual bone dust particles removed. Temporalis fascia graft harvested and used for type III tympanoplasty.

Using a semicircular incision from 12'o clock to 6'o clock position in cavum concha, cartilage and excess fibrofatty tissue from cartilaginous part of EAC removed till the operated cavity visualised in a better manner from external auditory meatus. Wound was closed. Gelfoam was kept over the tympanoplasty site. Mupirocin ointment applied in the cavity and external auditory canal with meatus plugged with ointment soaked cotton.

FOLLOW UP:

Patients were discharged at post operative day 7

Post discharge :

- At 1st week-T. Amoxyclav 625mg BD.

T.levocetrizine HS, T.Montelukast HS were given.

- At 2nd week-T.Cefpodoxime bd with T. Levocetrizine and t. Montelukast were given.
- At 3rd week-T.Levofloxacin bd was given.

Advice given at discharge :

- No head bath.
- No administration of ear drops.
- Avoid upper respiratory tract infections.
- No probing,cleaning.
- Head bath after 1month.

-Otoscope was introduced only after 2 weeks.

RESULTS AND OBSERVATIONS

The collected data were analysed with IBM SPSS Statistics for Windows, Version 23.0.(Armonk, NY: IBM Corp).To describe about the data descriptive statistics frequency analysis, percentage analysis were used for categorical variables and the mean & S.D were used for continuous variables. To find the significant difference between the bivariate samples in Paired groups the Paired sample t-test was used & for Independent groups the Unpaired sample t-test and the Mann-Whitney U test was used. To find the significance in categorical data Chi-Square test was used. In all the above statistical tools the probability value .05 is considered as significant level.

Table 1: Age distribution

Age distribution		
	Frequency	Percent
21 - 30 years	11	27.5
31 - 40 years	18	45.0
41 - 50 years	10	25.0
51 - 60 years	1	2.5
Total	40	100.0
Mean ± SD = 53 ± 8 years		

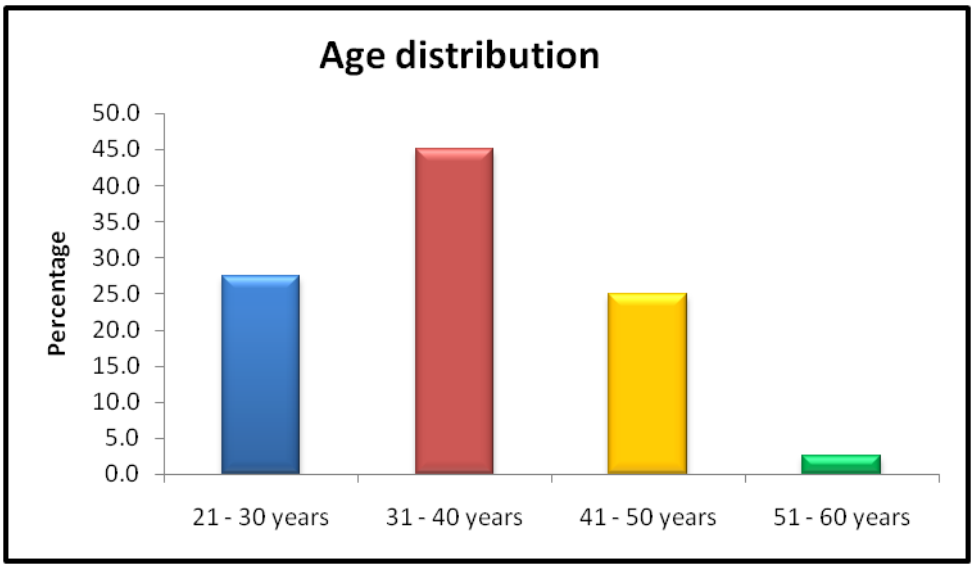


Figure 1

The above table shows Age distribution were 21-30 years is 27.5%, 31-40 years is 45.0%, 41-50 years is 25.0%, 51-60 years is 2.5%. The average age distribution is 53 ± 8 years.

Table 2: Gender distribution

Gender distribution		
	Frequency	Percent
Female	15	37.5
Male	25	62.5
Total	40	100.0

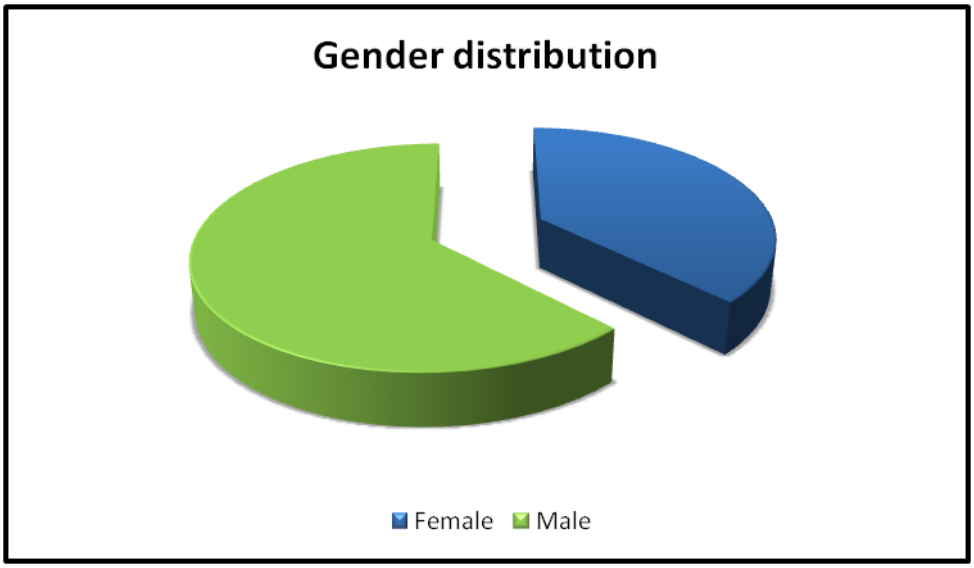


Figure 2

The above table shows Gender distribution were 37.5% are Female, 62.5% are Male.

Table 3: Complications distribution

Complications	Endoscopy	Microscopy
Burns	20.0%	0.0%
Cavity problem	0.0%	10.0%
Ear disharge	20.0%	15.0%
Granulation tissue	0.0%	10.0%
Perichondritis	0.0%	10.0%
Nil	60.0%	55.0%

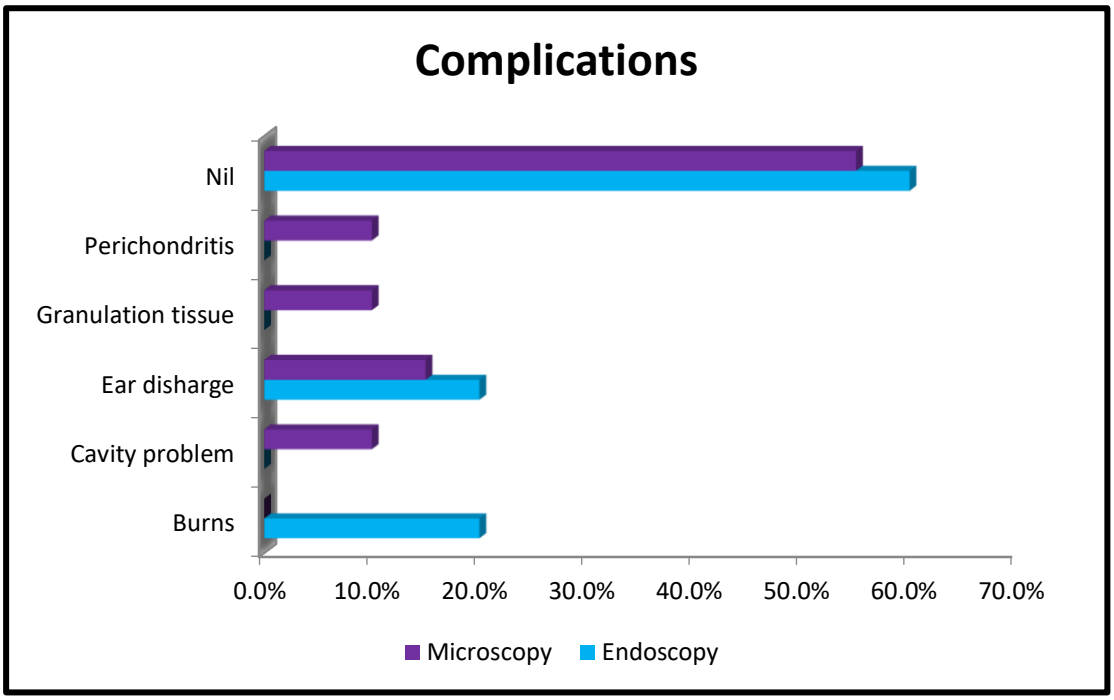


Figure 3

The above table shows Complications distribution. In Endoscopy method distribution were 20.0% is Burr burns, 20.0% is Ear discharge, 60.0% is Nil. In Microscopy method distribution were 10.0% is Cavity problem, 15.0% is Ear discharge, 10.0% is Granulation tissue, 10.0% is Perichondritis and 55.0% is Nil.

Table 4: Comparison between Age distribution with Method

			Method		Total	χ 2 - value	p-value
			Endoscopy	Microscopy			
Age	21 - 30 years	Count	5	6	11	1.091	0.779 #
		%	25.0%	30.0%	27.5%		
	31 - 40 years	Count	9	9	18		
		%	45.0%	45.0%	45.0%		
	41 - 50 years	Count	5	5	10		
		%	25.0%	25.0%	25.0%		
	51 - 60 years	Count	1	0	1		
		%	5.0%	0.0%	2.5%		
Total		Count	20	20	40		
		%	100.0%	100.0%	100.0%		
# No Statistical Significance at p > 0.05 level							

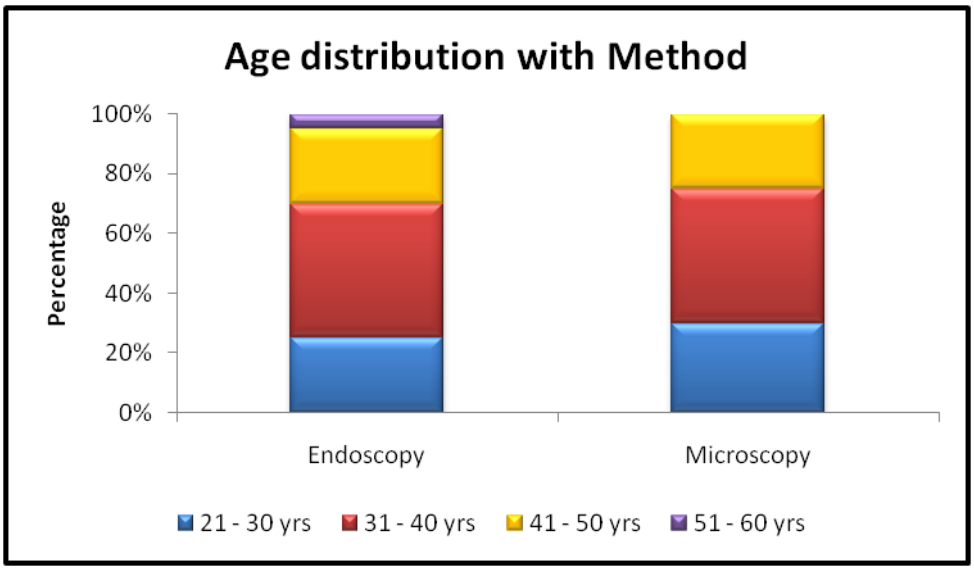


Figure 4

The above table shows comparison between Age distribution with Method by Pearson's chi-squared test were χ^2=1.091, p=0.779>0.05 which shows no statistical significant association between Age distribution and Method.

Table 5: Comparison between Gender distributions with Method

			Method		Total	χ 2 - value	p-value
			Endoscopy	Microscopy			
Gender	Female	Count	7	8	15	0.107	0.744 #
		%	35.0%	40.0%	37.5%		
	Male	Count	13	12	25		
		%	65.0%	60.0%	62.5%		
Total		Count	20	20	40		
		%	100.0%	100.0%	100.0%		
# No Statistical Significance at p > 0.05 level							

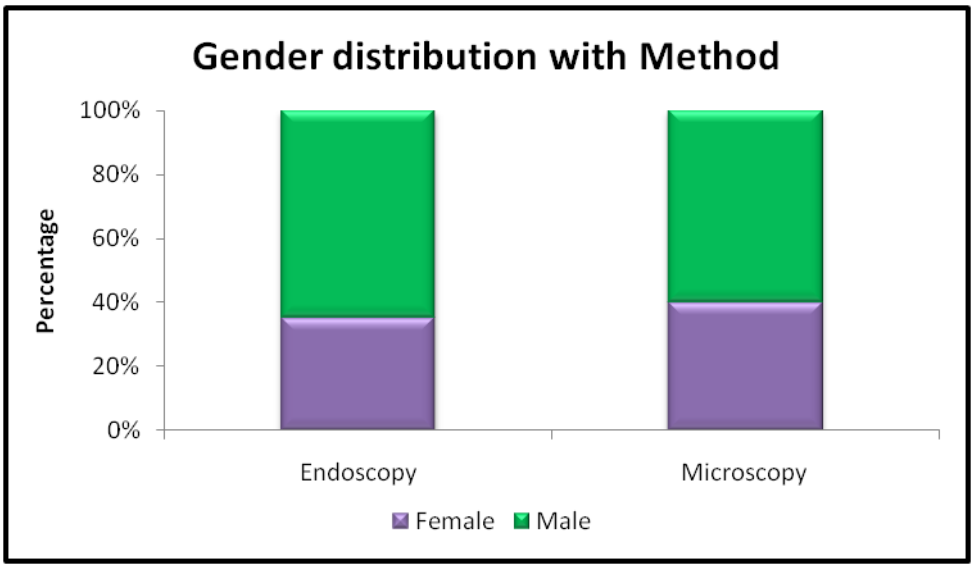


Figure 5

The above table shows comparison between Gender distribution with Method by Pearson's chi-squared test were χ^2=0.107, p=0.744>0.05 which shows no statistical significant association between Gender distribution and Method.

Table 6: Comparison between Complications with Method

			Method		Total	χ^2 - value	p-value
			Endoscopy	Microscopy			
Complications	Absent	Count	12	11	23	0.102	0.749 #
		%	60.0%	55.0%	57.5%		
	Present	Count	8	9	17		
		%	40.0%	45.0%	42.5%		
Total		Count	20	20	40		
		%	100.0%	100.0%	100.0%		
# No Statistical Significance at p > 0.05 level							

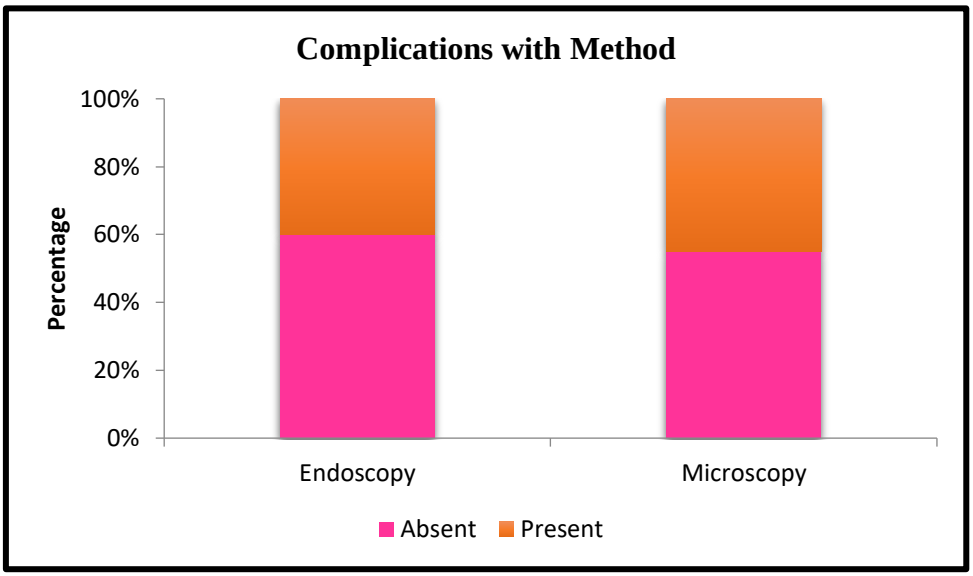


Figure 6

The above table shows comparison between Complications with Method by Pearson's chi-squared test were χ^2=0.102, p=0.749>0.05 which shows no statistical significant association between Complications and Method.

Table 7: Comparison between Scutum erosion with Method

	Method		Total	χ^2 - value	p-value
	Endoscopy	Microscopy			

Scutum erosion	Absent	Count	10	12	22	0.404	0.525 #
		%	50.0%	60.0%	55.0%		
	Present	Count	10	8	18		
		%	50.0%	40.0%	45.0%		
Total		Count	20	20	40		
		%	100.0%	100.0%	100.0%		
# No Statistical Significance at p > 0.05 level							

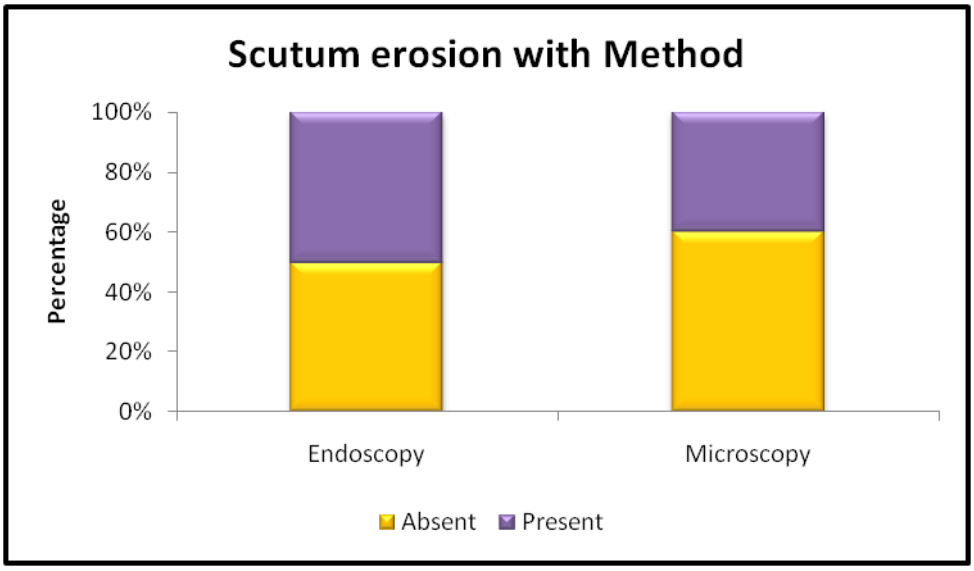


Figure 7

The above table shows comparison between Scutum erosion with Method by Pearson's chi-squared test were χ^2=0.404, p=0.525>0.05 which shows no statistical significant association between Scutum erosion and Method.

Table 8: Comparison of PTA with Method by Paired sample t-test

PTA	Method	N	Mean	SD	t-value	p-value
Pre Operative	Endoscopy	20	36.6	4.7	0.446	0.658 #
	Microscopy	20	37.2	3.4		
Post Operative	Endoscopy	20	14.3	4.3	0.434	0.667 #
	Microscopy	20	14.8	3.1		
# No Statistical Significance at p > 0.05 level						

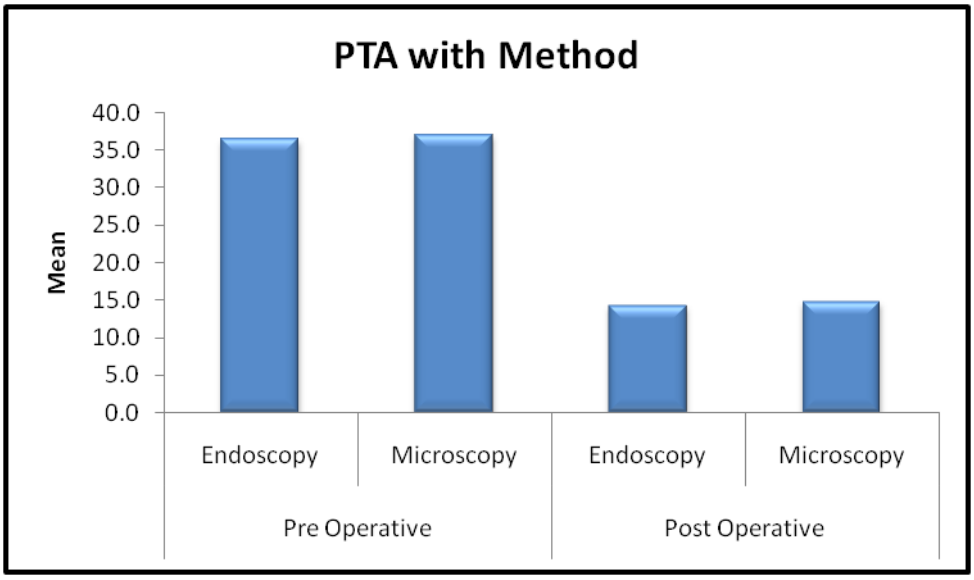


Figure 8

The above table shows comparison of PTA with Method by Paired sample t-test. In comparison of Pre Operative with Method were t-value=0.446, p-value=0.658>0.05 which shows no statistical significant difference at p > 0.05 level. Similarly in comparison of Post Operative with Method were t-value=0.434, p-value=0.667>0.05 which shows no statistical significant difference at p > 0.05 level.

Table 9: Comparison of Air bone gap gain(dB) with Method by Unpaired t-test

Variable	Method	N	Mean	SD	t-value	p-value
Air bone gap gain(dB)	Endoscopy	20	23.2	3.5	0.720	0.476 #
	Microscopy	20	22.5	2.0		
# No Statistical Significance at p > 0.05 level						

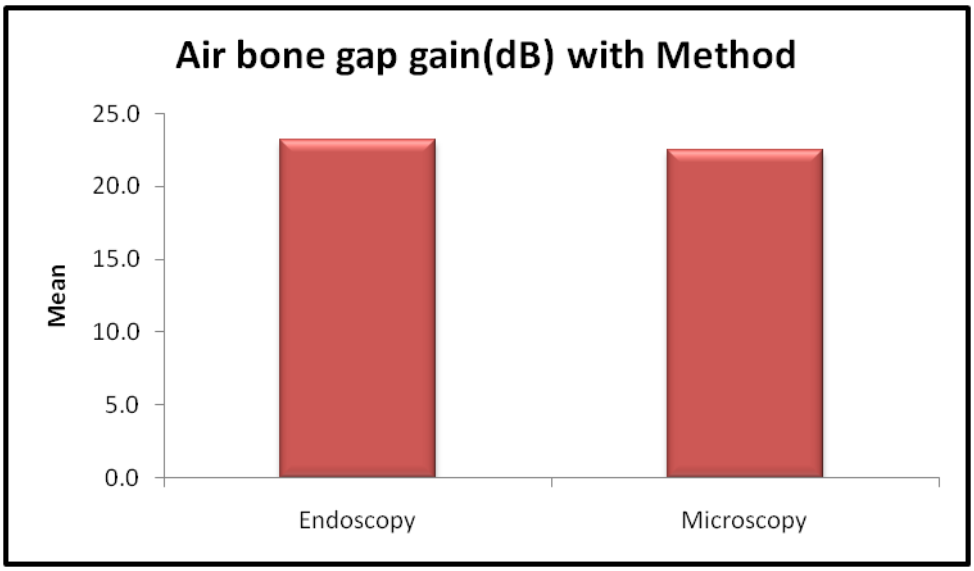


Figure 9

The above table shows comparison of Air bone gap gain(dB) with Method by Unpaired t-test were t-value=0.720, p-value=0.476>0.05 which shows no statistical significant difference at p > 0.05 level.

Table 10: Comparison of Healing time with Method by Mann-Whitney U test

Variable	Method	N	Mean	SD	Z-value	p-value
Healing time	Endoscopy	20	3.30	0.47	3.392	0.0005 **
	Microscopy	20	4.45	1.10		
** Highly Statistical Significance at p < 0.01 level						

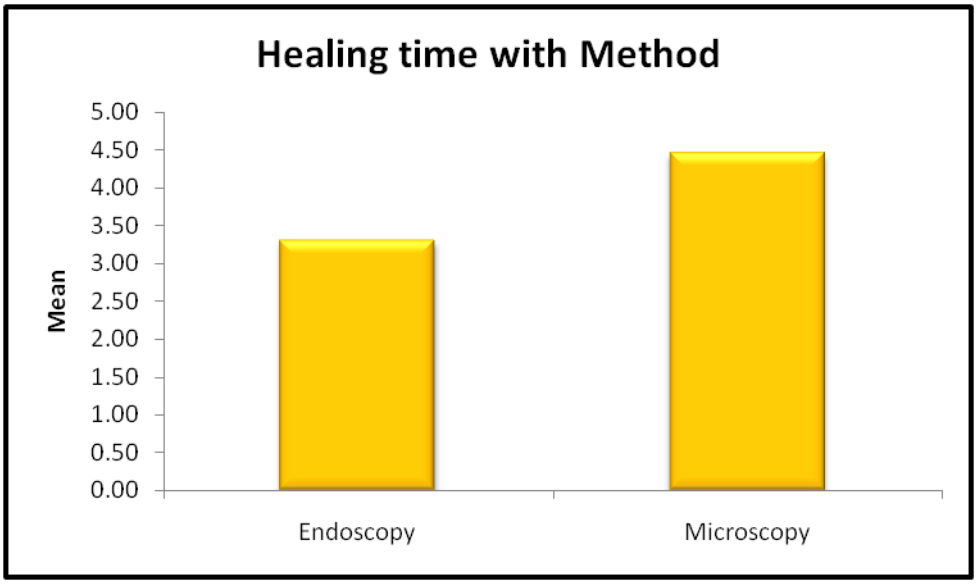


Figure 10

The above table shows comparison of Healing time with Method by Mann-Whitney U test were Z-value=3.392, p-value=0.0005<0.01 which shows highly statistical significant difference at p < 0.01 level.

Table 11: Comparison of Operating time {hrs} with Method by Mann-Whitney U test

Variable	Method	N	Mean	SD	Z-value	p-value
Operating time {hrs}	Endoscopy	20	2.6	0.3	2.741	0.007 **
	Microscopy	20	2.4	0.2		
** Highly Statistical Significance at p < 0.01 level						

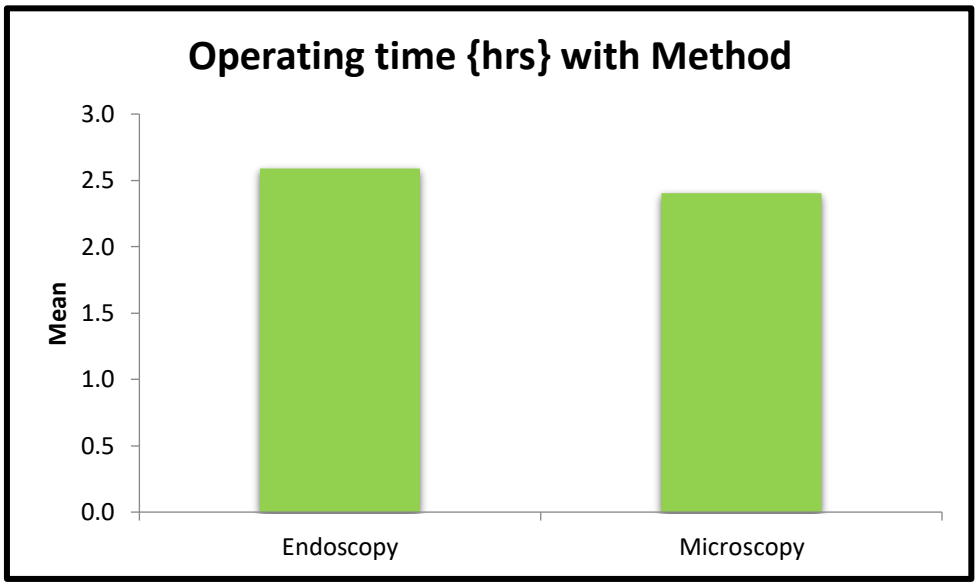


Figure 11

The above table shows comparison of Operating time {hrs} with Method by Mann-Whitney U test were Z-value=2.741, p-value=0.007<0.01 which shows highly statistical significant difference at p < 0.01 level.

Table 12: Comparison of Method with PTA by Unpaired t-test

Method	PTA	Mean	N	SD	t-value	p-value

Endoscopy	Pre OP	36.6	20	4.7	33.358	0.0005 **
	Post OP	14.3	20	4.3		
Microscopy	Pre OP	37.2	20	3.4	51.666	0.0005 **
	Post OP	14.8	20	3.1		
** Highly Statistical Significance at p < 0.01 level						

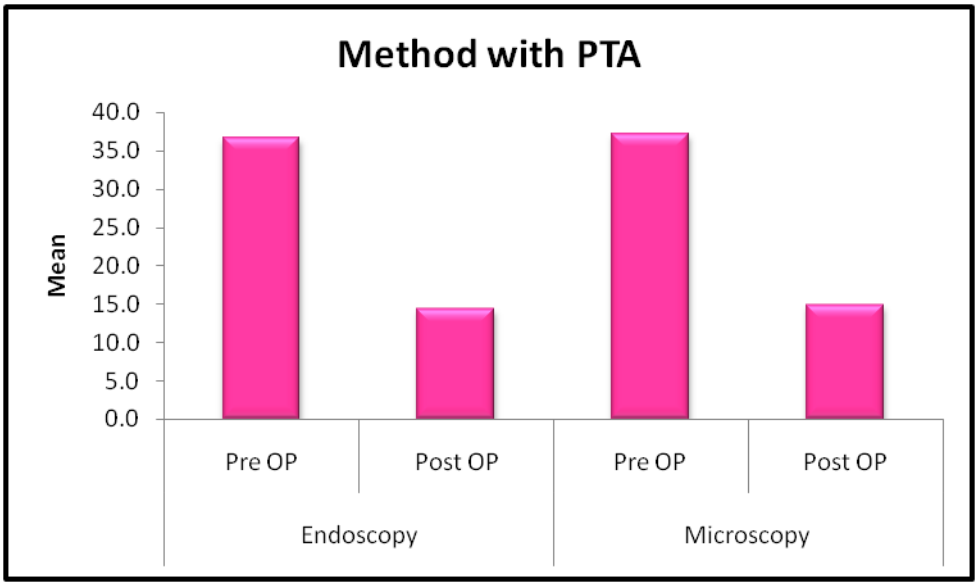


Figure 12

The above table shows comparison of Method with PTA by Unpaired t-test. In comparison of Endoscopy with PTA were t-value=33.358, p-value=0.0005<0.01 which shows highly statistical significant difference at p < 0.01 level. Similarly in comparison of Microscopy with PTA were t-value=51.666, p-value=0.0005<0.01 which shows highly statistical significant difference at p < 0.01 level.

SUMMARY

- Age distribution were 21-30 years is 27.5%, 31-40 years is 45.0%, 41-50 years is 25.0%, 51-60 years is 2.5%. The average age distribution is 53 ± 8 years.
- Gender distribution were 37.5% are Female, 62.5% are Male.
- Complications distribution. In Endoscopy method distribution were 20.0% is Burr burns, 20.0% is Ear discharge, 60.0% is Nil. In Microscopy method distribution were 10.0% is Cavity problem, 15.0% is Ear discharge, 10.0% is Granulation tissue, 10.0% is Perichondritis and 55.0% is Nil.
- Age distribution with Method by Pearson's chi-squared test were $\chi 2=1.091$, $p=0.779>0.05$ which shows no statistical significant association between Age distribution and Method.
- Gender distribution with Method by Pearson's chi-squared test were $\chi 2=0.107$, $p=0.744>0.05$ which shows no statistical significant association between Gender distribution and Method.
- Complications with Method by Pearson's chi-squared test were $\chi^2=0.102$, $p=0.749>0.05$ which shows no statistical significant association between Complications and Method.
- Scutum erosion with Method by Pearson's chi-squared test were $\chi 2=0.404$, $p=0.525>0.05$ which shows no statistical significant association between Scutum erosion and Method.
- PTA with Method by Paired sample t-test. In comparison of Pre Operative with Method were t-value=0.446, p-value=0.658>0.05 which shows no statistical significant difference at $p > 0.05$ level. Similarly in comparison of Post Operative

with Method were t-value=0.434, p-value=0.667>0.05 which shows no statistical significant difference at p > 0.05 level.

- Air bone gap gain(dB) with Method by Unpaired t-test were t-value=0.720, p-value=0.476>0.05 which shows no statistical significant difference at p > 0.05 level.
- Healing time with Method by Mann-Whitney U test were Z-value=3.392, p-value=0.0005<0.01 which shows highly statistical significant difference at p < 0.01 level.
- Operating time {hrs} with Method by Mann-Whitney U test were Z-value=2.741, p-value=0.007<0.01 which shows highly statistical significant difference at p < 0.01 level.
- Method with PTA by Unpaired t-test. In comparison of Endoscopy with PTA were t-value=33.358, p-value=0.0005<0.01 which shows highly statistical significant difference at p < 0.01 level. Similarly in comparison of Microscopy with PTA were t-value=51.666, p-value=0.0005<0.01 which shows highly statistical significant difference at p < 0.01 level.

DISCUSSION

- ✓ The purpose of using nasal endoscopes for otological procedures is both diagnostic and operative one.
- ✓ Endoscopes and camera can be easily shifted from place to place without any damage and it is an easier teaching aid tool.
- ✓ More over the illumination and view provided by endoscopes are end on and its easier to visualise the narrow spaces by means of angled nasal endoscopes easily and it provides constant magnification.
- ✓ Instruments used are the same as in microear surgeries with added on from nasal surgery instruments such as kerrison's punch.
- ✓ The only disadvantage is one hand constantly engaged in holding camera and endoscope, the other hand for doing surgical procedures.
- ✓ Anaesthetic techniques are the same used in microear surgery.
- ✓ With 0°nasal endoscope, TM flap elevation is made easier along with hypotensive anaesthetic techniques. Once TM elevation is completed, bony external auditory canal widened with microdrill and 3.0mm cutting burr to make adequate space for endoscope and instruments.

Intermittent irrigation and suctioning done to remove bone dust from auditory canal. After identifying the sac and cholesteatoma, the same was removed completely.

- ✓ Endoscopic mastoidectomy techniques can be done for disease extension upto mastoid antrum. If extension is below that we need more angled endoscopic instruments.
- ✓ Identification of recesses and removal of diseased ossicles is easier after microscope.
- ✓ Since it is similar to inside out mastoidectomy techniques used in microear surgery, its bone removal is just adequate and hence the cavity is also of correct size.
- ✓ Once the disease removal is completed, type III tympanoplasty is done.

  Meatoplasty done by placing semi circumferential incision in cavum conchae, dividing into upper and lower flaps with removal of underlying cartilage and fibrofatty tissue. Then the external auditory meatus is widened and visualisation of mastoid antrum made easy. Then the incision is sutured after achieving complete hemostasis.

  Part of cavity and external auditory canal are filled with mupirocin ointment.

  Usually the cavity takes 4-6weeks to heal.
- ✓ The operating time is bit more than microear surgery because of one handedness and both endoscope and instruments should be passed through small meatus and canal.

Other than that the surgical technique is same as that of micro ear surgery.

- ✓ The postoperative success rate is impressive with proper postop care and good follow up for atleast 6 months with hearing improvement similar to microear surgery.

- In this study, out of 40 patients selected, 20 underwent conventional method and 20 endoscopic method. All were adults with no co-morbidities. All patients had dry ear.
- Scutum was founded to be eroded in 10 cases.
- Operating time in endoscopic approach was slightly higher than by microscopic method.
- Patients were followed up for 1 month.
- In patients who underwent endoscopic surgery, postoperative pain was considerably reduced as no postaural incisions were made, so there was reduction in the administration of analgesics or NSAIDs thereby reducing the risk of drug induced toxicity.
- None of the patients developed perichondritis in endoscopic method whereas two patients developed perichondritis in microscopic group.
- Usually the healing time was 3 weeks.
- 2 cases developed cavity problems and 2 developed granulation in microscopic group which delayed healing time while no cases developed granulation in endoscopic group.
- 3 cases had ear discharge in microscopic method while 4 cases in endoscopic method which settled after 2nd week.
- In endoscopic group, 4 patients developed dark patches in EAC due to heat transmitted by the handpiece over EAC delaying the healing by one week.
- Overall healing time was reduced in endoscopic group compared to microscopic group.

CONCLUSION

Canal wall down mastoidectomy by endoscopy facilitates better visualisation of anatomical structures preventing undue injury to critical structure like facial nerve, semicircular canal etc.It shows wide view of the hidden areas like sinus tympani, facial recess thereby aiding in complete removal of the disease and preventing residual or recurrent cholesteatoma. Endoscopic method reduces the morbidity of the patient post operatively by reducing the pain, complications thereby the healing time. Though it has limitations like single handedness, increased learning curve, limited freedom of instruments in the operating field, it has more benefits than limitations by reduced morbidity postoperatively.

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