INTRODUCTION

The eustachian tube is an organ consisting of lumen with its mucosa, cartilage, surrounding soft tissue, para tubal muscles and bony support.

Eustachian tube systems is contiguous organs including the nose, palate, nasopharynx, ET, middle ear, and mastoid air cells. The eustachian tube's patency and appropriate functioning are essential for normal middle ear function. Any eustachian tube malfunction causes negative pressure to build up in the tympanum, resulting in retraction, effusion, and other problems.

In terms of the middle ear, the Eustachian tube serves three purposes.

Ventilation or pressure regulation is the physiologic function of the eustachian tube to regulate atmospheric pressure and gas pressure between the nasopharynx and middle ear.

Protection is the physiologic function of the eustachian tube in which unwanted nasopharyngeal secretions and sound pressures are prevented from entering the middle ear by the unique structural and functional aspects of the tubal system.

Muco-ciliary is the physiologic function of the eustachian tube in which liquid is drained toward the nasopharynx by the muco-ciliary system of the tubal lumen and pumping action of the tube during passive closing.

Impedance audiometry is a tool to assess the ventilation function of the middle ear tube.

Dye test and saccharine tests are used to assess the muco-ciliary function of the eustachian tube.

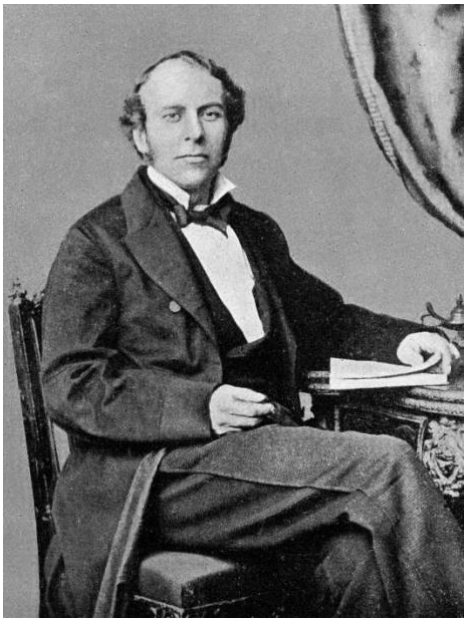
HISTORICAL PERSPECTIVE

Bartolomeus eustachius in 1562 in his work “Epistola de auditus organis” described the anatomy and physiology of eustachian tube

Antonio maria Valsalva described the cartilaginous, membranous and osseous parts of the tube. He described the views on acoustic functions of the Eustachian tube and supported the concept of drainage

of purulent material from the middle ear. Valsalva maneuver is based on his studies.

Joseph Toynbee explained about the muscles that open the eustachian tube and also described the Toynbee test.



Adam politzer is universally called as the Father of modern otology. He described politerization. His studies supported the view of role of eustachian tube in middle ear pathologies.

Arnold rice rich studied the physiologic experiments in which he assessed the function of muscles of the eustachian tube and surrounding structures

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Henry B Perlman made notable contributions to the understanding of the patulous eustachian tube .

REVIEW OF LITERATURE

The evaluation of Eustachian tube function is one of the prerequisites for successful middle ear surgeries and mastoidectomy.

The pathologies in the nose and nasopharynx are likely to affect the Eustachian tube function and thereby it hampers its normal function such as ventilation, mucociliary clearance and protective function, and ultimately the middle ear is directly affected by alteration in the Eustachian tube function.

There are various quantitative and qualitative methods have described in the literatures yet no single method is perfect in all respects.

Politzer more than 100 years ago Suggested that Abnormal function of the eustachian tube is the most important factor in the pathogenesis.

Bayramoglu et al stressed on the small mastoid cellular system allowing for less efficient gas exchange between the middle ear cleft and micro circulation of the mucosa of middle ear disease.

Rogers et al in 1962 evaluated the Eustachian tubal function by fluorescent dye studies. He concluded that tympanic injection of fluoresceine dye followed by ultra violet examination of the pharynx is a

safe, rapid and reliable method for determining patency or obstruction of the Eustachian tube.

Sade in 1966 did a study on middle ear mucosa. He concluded that ciliary tract has a role in muco-ciliary clearance.

Sade in 1967 studied on the function of the ciliary pathways in the human middle ear. He did this by photographing the movement of foreign materials over the mucus blanket in the middle ear. From their experiments it was observed that dry central perforartion with normal and healthy middle ear mucosa , can actively clear any foreign material towards and into the Eustachian tube.

Holmquist et al in 1970 in cases with chronic otitis media, was the first to study the relationship between Eustachian tube function, size of mastoid air cell systems and healing. The authors found a relationship between the size of the mastoid air cell system and Eustachian tube function. Poor Eustachian tube function and a small mastoid air cell system in poor long term results after myringoplasty

Sidentop et al in 1972 assessed the relationship of Eustachian tube function and size of mastoid air cell system (SMACS) in ears with chronic otitis media before tympanoplasty. They concluded that it is more reliable to base prediction of surgical success on preoperative tubal function than on size of mastoid air cell system; and further, that trying to predict surgical success from the combination of Eustachian

tube function and SMACS does not enhance the accuracy of the prediction.

Larsen et al in 1976 assessed the function of Eustachian tube function in 44 patients with dry perforations of the tympanic membrane by means of the saccharin test, the aspiration test and by the Valsalva maneuver.

In This study they came to a conclusion that there is no relationship between the results of above mentioned tests. However a correlation seems to exist between the hearing improvement obtained as determined by the postoperative air-bone gap, the positive or negative results of the saccharin test, and the saccharin perception time.

Bluestone et al in1979 studied the Eustachian tube function in relation to the results of tympanoplasty in 45 children. Pre operative assessment of Eustachian tube function using Modified Inflation Deflation test failed to redict the success of tympanoplasty.

Valles et al in 1981 tubal manometry and clearance time study in 78 patients. They found that in cases of normal equipressive function, clearance time was considerably better than in those tubes with manometric dysfunction or blocking, with no significant differences between these two cases.

Nuutinen et al in 1983 measured the muco-ciliary function of the Eustachian tube with a radio isotopic method using 0.01 ml of a serum albumin labeled with technetium 99m. They concluded that the mucociliary function was totally absent in chronic otitis media in untreated secretory otitis media, and in the ear with a moist perforation of the tympanic membrane. The muco-ciliary transport time returned to normal when the ear was clinically healed.

Manning et al in 1987 studied the prognostic value of the Eustachian tube function in pediatric tympanoplasty. They tested the tubal function in 63 ears undergoing tympanoplasty for central perforations. They found that Eustachian tube function according to inflation-deflation and forced response test results were predictive of the operations success not failure.

Takashi et al in 1989 studied Eustachian tube function in children with secretory otitis media. They concluded that the pathogenesis of long lasting secretory otitis media involves both a fundamental defect in negative pressure equalizing function and secondary impairment of the clearance function of the Eustachian tube.

Gimenez et al in 1993 studied the muco-ciliary Eustachian tube functions, using 5% sodium saccharine and tubal manometry in fifty eight ears with chronic disease undergoing tympanoplasty. The position of the perforation site determines the results, as the poorest results are

obtained from the posterior ones. Significant differences in transport times have been noted for the anterior and posterior perforations, being shorter for the anterior ones. When the surgical outcome is correlated with mucociliary transport , the normal transport time percentage is seem to be considerably higher in the success group (50%) than in the failure group (22%).

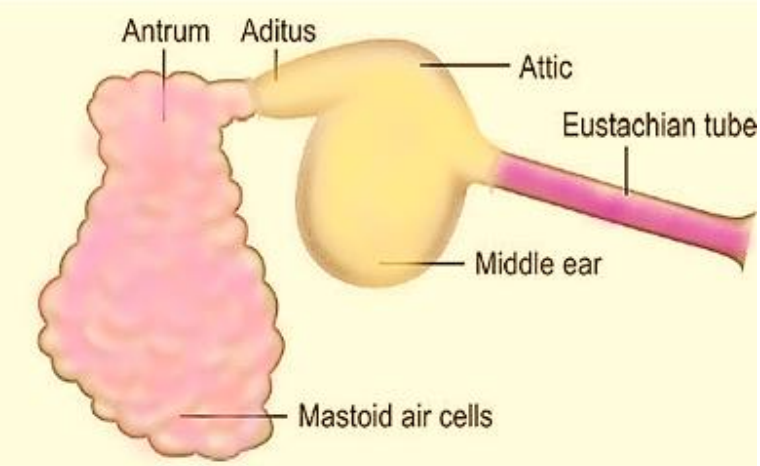
Brenner et al in 1997, in their study concluded that ventilation scintigraphy procedure was easy to perform and had a success rate of approximately 70%.

Tos M (1998) observed that the ETF is an important prognostic factor in predicting the outcomes of middle ear surgery.

ANATOMY OF MIDDLE EAR CLEFT DEVELOPMENT

Middle ear cleft is a mucous membrane lined, air filled space comprising of

1. Eustachian tube
2. Middle ear
3. Aditus ad antrum
4. Mastoid antrum
5. Mastoid air cells



RELATIONS:

ROOF: tegmen plate

FLOOR: jugular bulb

MEDIAL: labyrinth and facial nerve

LATERAL: temporal bone and tympanic bone

ANTERIOR: petrous part of carotid artery

POSTERIOR: sigmoid sinus

POSTERO-MEDIAL: cerebellum in posterior cranial fossa

EUSTACHIAN TUBE

Eustachian tube or auditory tube is a slender tube that connects the middle ear cavity with the nasopharynx and serves to equalize air pressure on either side of the eardrum.

It is a hollow structure of bone and cartilage lined with a respiratory mucosa and equipped with a muscular opening mechanism.

DEVELOPMENT

The eustachian tube derives from the first pharyngeal pouch , which extends laterally between the first and second pharyngeal arches to form the tubotympanic recess.

The distal part of the TTR becomes the primitive tympanic cavity, and the proximal part constricts to form the lumen of fibro-cartilaginous eustachian tube.

This process occurs between 4-6weeks of gestation.

The main growth of auditory tube in the fetal period is between 16-28weeks.

The ET lengthens rapidly during early childhood. In infants it is about 18mm and reaches Adult size by 7years of age.

ANATOMY OF EUSTACHIAN TUBE

It is a narrow osteo cartilaginous channel connecting the tympanic cavity to the nasopharynx.

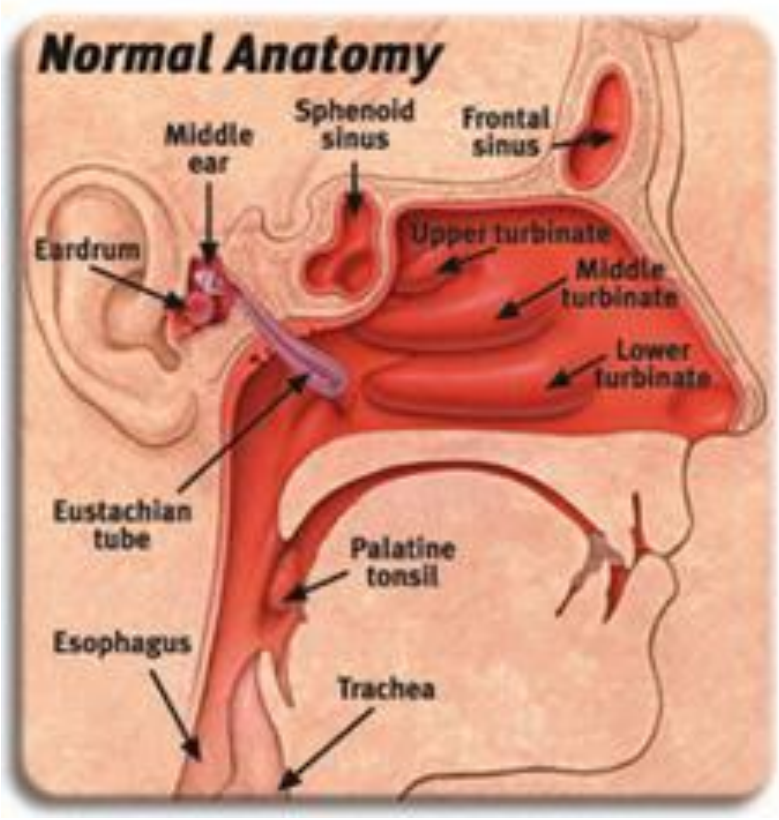
Its lumen allows the passage of two different substances – one is gaseous for middle ear ventilation and second is fluid from middle ear clearance. The eustachian tube begins at the tympanic orifice of the protympanum and ends at the pharyngeal orifice situated on the lateral wall of nasopharynx

The general shape of eustachian tube is hourglass made of two unequal cones. The posterior cone is small and fixed and represents the bony eustachian tube.

The anterior is elongated and mobile and represents the fibro-cartilaginous part. Both the parts are connected at junctional zone, the isthmus with an angle of 160.

In adults the tubal axis forms with the plane of the hard palate an average angle of 36 degree Length of ET is 31-38mm in adults.It is directed downwards, forwards, medially

In children the tube is shorter and more horizontal.



Adult vs INFANT

	ADULT	INFANT
Length	36 mm	18 mm
Angle with horizontal	45 ^{0}	10 ^{0}
Lumen	Narrower	Wider
Angulation at isthmus	Present	Absent
Cartilage	Rigid	Flaccid
Elastic recoil	Effective	Ineffective
Ostmann's fat	More	Less

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CARTILAGINOUS PART:

It is the proximal part and opens into nasopharynx. It is angled 30-40 degrees to transverse plane and 45 degrees to sagittal plane .It is closely attached to basal aspect of skull and is fitted into sulcus tubae (sphenoid sulcus) between the greater wing of the sphenoid bone and petrous portion of the temporal bone. The cartilaginous part of the tube is firmly attached at its posterior end to the osseous orifice by fibrous bands and extends 3mm into osseous portion of the tube.

It is inverted J shaped in cross section ; it is like a dome with two arms of different length called laminae described as short lateral laminae and elongated medial lamina with a hinge at junction of two laminae.

The medial lamina , much more voluminous than the lateral lamina , starts as a short structure of 9mm and increases rapidly to 13mm just posterior to attachment of the cartilage to the medial pterygoid plate. The medial lamina is much more mobile in its nasopharyngeal end and rotates medially during tubal dilation principally by action of levator veli palatini.

The lateral lamina has a constant height of 2mm overall its extension.

This part of ET forms a valve that protects the middle ear from pressure fluctuation in the pharynx and decreases transmission of a

person’s voice to middle ear cavity. The cartilage provides structural support to the eustachian tube while still allowing mobility.

The fibrous part forms the lateral and inferior part of fibrocartilaginous ET and – called as salpingopharyngeal fascia of von troltsch.

BONY PART:

It is also called pro-tympanic /aural/ bony /or middle ear portion of eustachian tube. It lies completely within the petrous portion of the temporal bone .

The lumen is roughly triangular in shape and measures 2-3mm vertically and 3-4mm horizontally. It is 12mm long and lies in petrous temporal bone near the tympanic plate . the medial end is narrower and lateral end is wider .

JUNCTIONAL PART: it is where the osseous and cartilaginous part increases proximal to distal end.

OSTMANN PAD OF FAT:

It is lympho adipose body , running the length of cartilaginous ET located in the inferolateral aspect of pharyngeal end of ET. Lateral ostmann pad of fat serves as a fulcrum for the deep layer of the TVP and hence the LOPF limits the ET opening .

PHARYNGEAL END:

The pharyngeal end of the ET above the superior constrictor muscle through the sinus of Morgagni. The pharyngeal orifice is triangular in shape with inferior base and it measures 8-10mm and 3-5mm in width. The pharyngeal orifice is closed at rest and becomes elliptical or triangular with a superior apex during opening. The anterolateral border is a vertical crease called the salpingopalatine crease of troeltsch. It corresponds to the lateral plate of the tubal cartilage and the TVP muscle.

The posteromedial border is prominent and corresponds to tubal cartilage pressing against the nasopharyngeal mucosa , called the torus tubaris. The inferior border of the pharyngeal orifice is bounded by the levator veli palatini.

Medial and behind the torus tubarius , there is recess called the fossa of rossenmuller – triangular recess of about 1.5cm deep. Apex is in close relationship with carotid canal and base is closely related to its skull base .

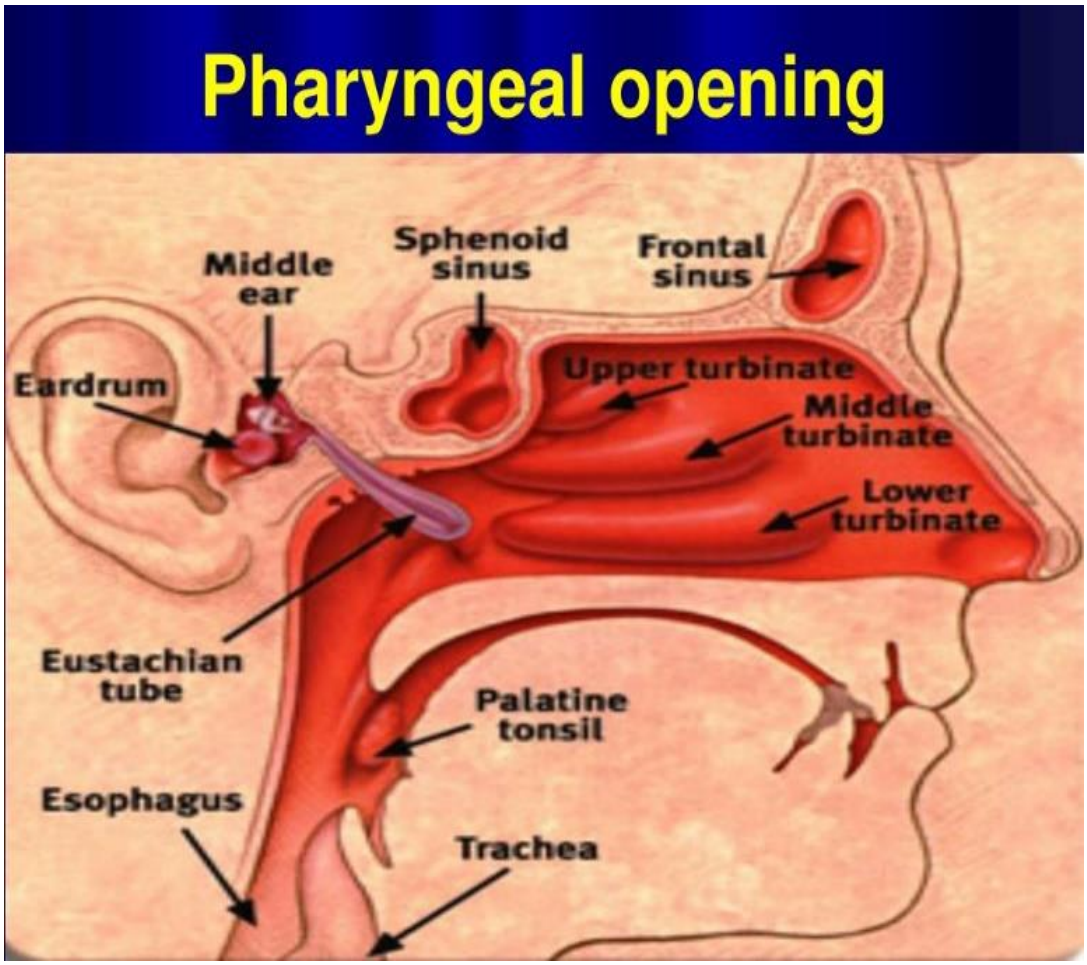
LUMEN:

The isthmus is located on the cartilaginous portion's distal end. The physiologic protective mechanism of the eustachian tube relies heavily on the lumen's smaller diameter. PSEUDOSTRATIFIED

CILIATED COLUMNAR EPITHELIUM lines the tubal lumen. The mucosal lining is continuous at its distal end with the lining of the tympanic cavity and at its proximal end with the lining of the nasopharynx. Ciliated columnar epithelium is related with goblet cells. ET's cartilaginous portion is known as MALT.

The narrowest part of the tube is the isthmus and is not at the junctional part.

The isthmus lies at the distal part of the cartilaginous portion. The reduced caliber of the lumen is a critical component of the physiologic protective mechanism of the eustachian tube. ie, the flask effect.



MUCOUS MEMBRANE OF THE TUBAL LUMEN:

The ET is lined with pseudostratified ciliated columnar epithelium which helps in transfer of material from middle ear and nasopharynx which works to sweep material from the middle ear to the nasopharynx.

Goblet cells represent about 20% to the cell population of the ET mucosa.

The goblet cells are prominent in the tympanic cavity end and contributing to the surfactant nature of the secretions- containing lecithin, lipid and mucopolysacchrides .

The density of the cilia increases as the tube runs dorsolaterally to open into nasopharynx, facilitating movement and drainage of mucus and other material.

1. Superior corridor – rudinger's safety canal: upper compartment of ET is for ventilation.

2. Inferior corridor: the floor, mainly surrounded by muscular or membranous wall of the eustachian tube and partly by medial lamina of the cartilage. It has several foldings which aims in muco-ciliary clearance and to the protective function of the eustachian tube.

In the cartilaginous portion of the tube

Superior part performs : ventilatory function

Inferior part performs: mucociliary (drainage function)

BLOOD SUPPLY :

- ✓ Ascending palatine artery
- ✓ The pharyngeal branch of Internal Maxillary artery
- ✓ The artery of Pterygoid canal
- ✓ The ascending pharyngeal artery
- ✓ Middle meningeal artery

Venous drainage is via the pterygoid venous plexus.

LYMPHATICS OF THE TUBE

Submucosa (tunica propria)of ET is rich in lymphatics , which drains to retropharyngeal nodes medially or deep cervical nodes laterally.

NERVE SUPPLY-

SENSORY – The pharyngeal orifice of the Eustachian tube receives innervation from Otic ganglion, sphenopalatine nerves and pharyngeal plexus. The remaining part of the tube receives innervation

from the tympanic and the pharyngeal plexus. The glossopharyngeal nerve is the predominant nerve in tubal innervation.

MOTOR – The tensor veli palatine and Tensor tympani are by Mandibular division of Trigeminal nerve.

The levator veli palatine muscle receives innervation from the Nucleus ambigus through the Vagus nerve.

AUTONOMIC- Sympathetic innervation of the tube is by the sphenopalatine ganglion, the Otic ganglion, paired Glossopharyngeal nerves, the petrosal nerves and the caroticotympanic nerve. The parasympathetic nerve supply is derived from the tympanic branch of glossopharyngeal nerve.

MUSCLES ASSOCIATED WITH ET:

a) Tensor Veli Palatini

b) Tensor tympani

c) Levator Veli Palatini

d) Salpingo pharyngeus

TENSOR VELI PALATINI MUSCLE: The tensor veli palatini muscle is composed of two distinct bundles of muscle fibers, (divided by a layer of fibro elastic tissue).

Tensor veli palatini

Dilator tubae.

Tensor veli palatini forms the more lateral bundle, forms a shape of inverted triangle. Its origin is from the scaphoid fossa and also from the greater wing of sphenoid. The force the muscle exerts on this origin creates the lateral osseous ridge of the sulcus tubarius. The muscle descends anteriorly; laterally and inferiorly to converge in a tendon that rounds the hamular process of the medial pterygoid lamina about an interposed bursa. These fibers group then inserts into the posterior border of the horizontal process of the palatine bone and into the palatine aponeurosis of the anterior portion of the velum.

Dilator tubae is the medial bundle of the tensor veli palatini muscle and lies immediately adjacent to the lateral membranous wall of the tube and this was first described by the Valsalva and subsequently confirmed by the anatomical dissections. Its superior origin is in the posterior half of the lateral membranous wall of the cartilaginous tube. These fibers descend sharply to enter and blend with the fibers of the lateral bundle of the tensor veli palatini. The inner bundle is responsible for the active dilatation of the tube. Thus this angular relationship between the tensor veli palatini muscle and the cartilage varies in the infants but it is relatively stable in adults. The dilator tubae of tensor veli palatini muscle inserts into the cartilaginous portion of the

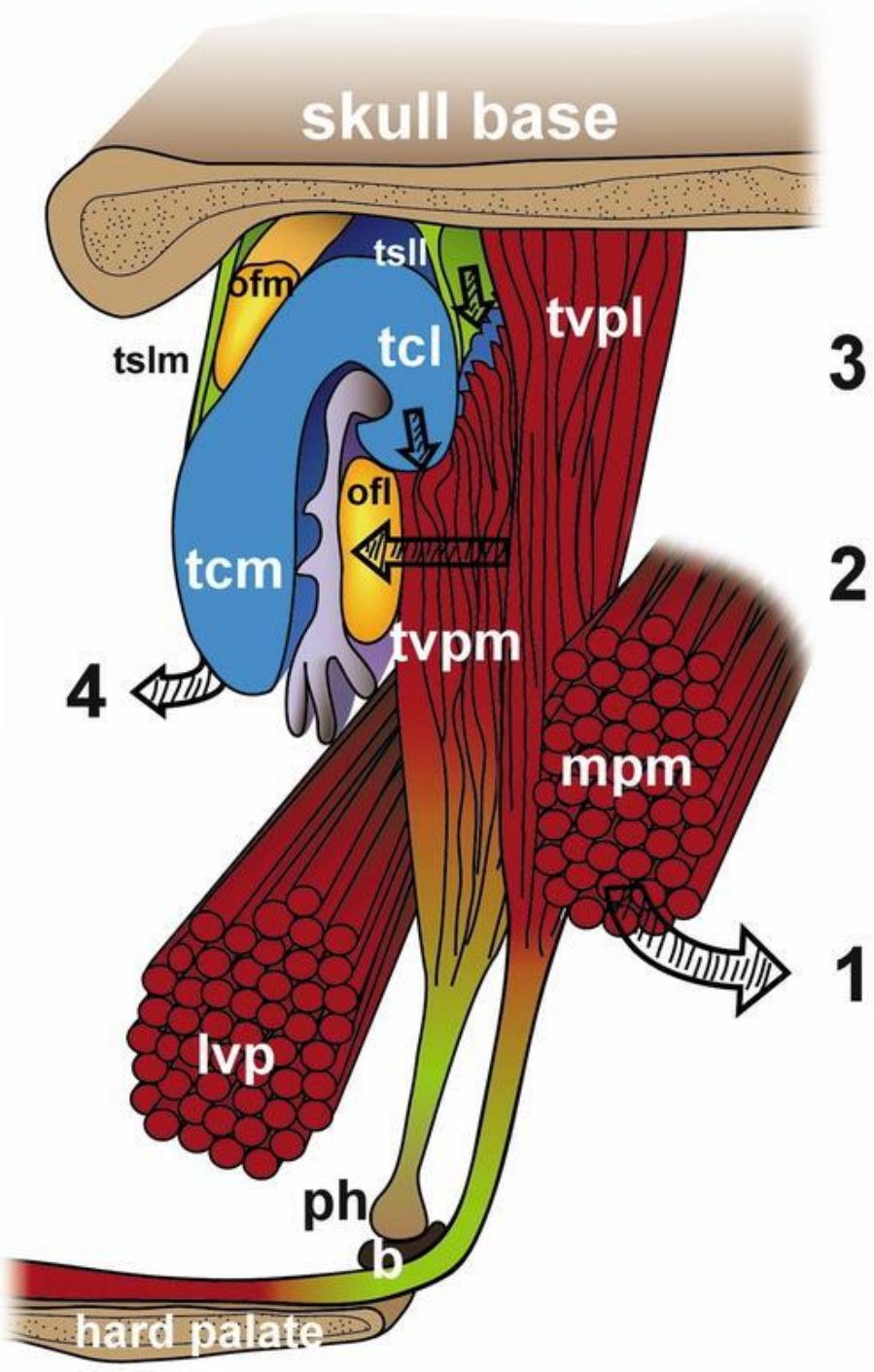
Eustachian tube which is responsible for the dilatation, to equilibrate the middle ear pressure during

LEVATOR VELI PALATNI: muscle arises from the inferior aspect of petrous apex of temporal bone. The fibresliesparallel and beneath the tubal cartilage. It is inserted by fanning out and blending with the dorsal surface of the soft palate. The levatorisnot the primary dilator but ends its support by elevating the medial arm of cartilage at the nasopharyngeal end.

TENSOR TYMPANI: The tensor tympani muscle arises from the Posterior fibers from the top of the cartilaginous part of the tube. From the adjacent portions of the greater wing of the sphenoid near the carotid canal. From the wall of the osseous canal through which the muscle passes It is about 2 cm in length. The rounded tendon of this bipennate muscle leaves the canal at the cochleariform process and extends in a direction almost at right angles to the belly of the muscle across the tympanic cavity and it is inserted on to the inner margin of the handle of malleus just below its short process

SALPHINGOPHARYNGEUS: The salphingopharyngeus muscle arises from the medial and inferior borders of the cartilage via muscular and tendinous fibers. This salphingopharyngeus muscle blends with the palatopharyngeus by coursing in Posteroinferior direction. This muscle helps to open the tube during the swallowing. The muscle is represented

by a ridge on the lateral wall of the nasopharynx in the resting stage but during contraction, this muscle fold stands out and narrows the nasopharynx [15]



ANATOMY OF NASOPHARNYX

Nasopharynx is the upper part of pharynx situated behind the nose and above the lower border of soft palate and Passavant's muscle.

It communicates

Anteriorly – with posterior nasal apertures

Inferiorly – with oropharynx at pharyngeal isthmus

Lateral wall from anterior to posteriorly

(i) Pharyngeal Opening of Eustachian tube

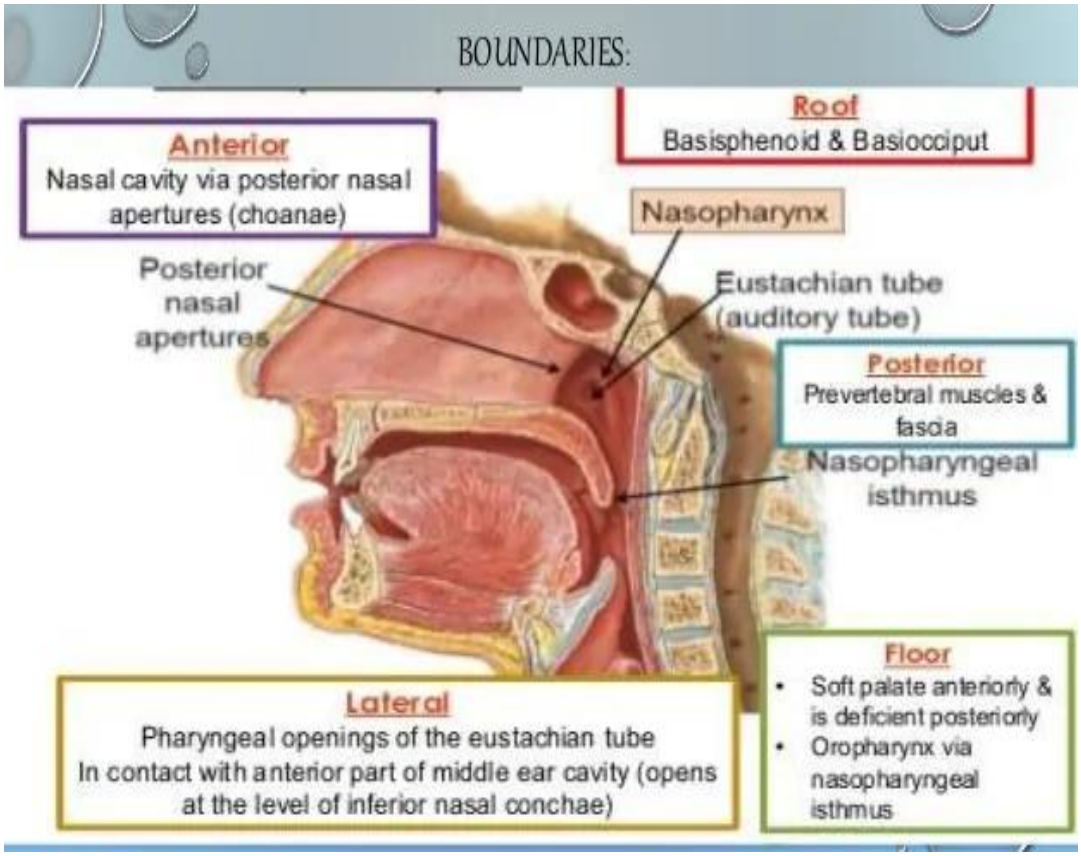
(ii) Tubal elevation bounds the tubal opening

(iii) Salpingo pharyngeal fold with salpingo pharynges muscle

(iv) Levator veli palatni Muscle

(v) Fossa of Rosenmuller / Lateral recess / Pharyngeal Recess Roof and posterior walls form a slope opposite the body of Sphenoid, basiocciput and anterior arch of atlas.

It presents (i) Pharyngeal tonsil/adenoids (ii) Tubal tonsil (iii) Pharyngeal burs



ANATOMY OF MIDDLE EAR

The middle ear is an irregularly laterally compressed , gas filled space situated in the petrous part of Temporal bone between the external and internal ear.

PARTS OF MIDDLE EAR:

Mesotympanum: medial to tympanic annulus

Epitympanum: or Attic- superior to annulus ,lying medial to shrapnell's membrane and bony attic wall

Hypotympanum: lying inferior to annulus and below the level of pars tensa

Pro Tympanum: anterior to annulus

Retro Tympanum: posterior to annulus

It communicates **anteriorly:** Nasopharynx through the Eustachian tube.

Posteriorly with mastoid air cell system through aditus ad antrum.

Shape – Biconcave – compressed from side to side

Vertical dimension- 15mm Anteroposterior dimension –

Transverse dimension –Eopitympanum-6mm ; mesotympanum-2mm; hypotympanum-4mm

CONTENTS OF MIDDLE EAR **Ossicles- Malleus, Incus and Stapes**

Ligaments of Ossicles

Muscles – Tensor tympani and Stapedius

Vessels supplying and draining the middle ear

Nerves – Chorda tympani and Tympanic plexus

AIR

The mucous membrane lining the middle ear cavity invests all the contents and forms several mucosal folds which project into the cavity

BOUNDARIES OF MIDDLE EAR

A) Roof (or) Tegmen- it separates middle ear from middle cranial fossa, formed by Tegmen tympani. The roof is prolonged forwards to cover semi canal of tensor tympani muscle and posteriorly to cover the mastoid antrum.

It transmits a vein from the middle ear to the superior petrosal sinus.

B) Floor (or) Jugular wall- separates middle ear from Superior bulb of Internal Jugular Vein. Formed by thin jugular fossa.

Transmits tympanic branch of Glossopharyngeal nerve passes through the tympanic canaliculus to the medial wall of middle ear cavity.

C) Carotid wall - from superior to inferiorly –

1. Opening of canal of tensor tympani,
2. Auditory tube opening and
3. Perforated by carotico-tympanic nerves and tympanic branch of internal carotid artery inferiorly.

The bony septum between the two semi canals for tensor tympani and auditory tube is continued posteriorly on the medial wall called processus cochleariformis.

Its posterior end forms a pully for the tendon of tensor tympani.

D) Posterior (or) Mastoid wall- from above downwards by Aditus ad antrum, Fossa incudis (lodges the short process of incus), Pyramid (or conical projection) with an opening at its apex for passage of stapedius muscle tendon and Posterior canaliculus for chorda tympani through which the nerve enters the middle ear cavity.

E) Lateral (or) membranous wall- formed by tympanic membrane along with tympanic ring and sulcus and partly by squamous temporal.

Near tympanic notch there are two apertures

(i) Petrotympanic fissure – transmitting the tympanic branch of maxillary artery

(ii) Anterior canaliculus for chorda tympani nerve

F) Medial (or) Labyrinthine wall- presents the following

(i) Promontory – bulge produced by basal turn of cochlea and grooved by tympanic plexus

(ii) Fenestra vestibule is an oval opening posterosuperior to promontory, closed by footplate of stapes

(iii) Prominence of facial canal running backwards just above the fenestra vestibuli towards the lower margin of aditus

(iv) Fenestra cochlea is a round opening at the bottom of a depression posteroinferior to promontory closed by secondary tympanic membrane

(v) Sinus tympani- is a depression behind promontory opposite to ampulla of posterior semi-circular canal.

ARTERIAL SUPPLY:

1. Anterior tympanic branch of maxillary artery through the Petro-tympanic fissure.
2. Posterior tympanic branch from stylomastoid branch of posterior auricular artery through the stylomastoid foramen
3. Superior tympanic branch from middle meningeal artery
4. Inferior tympanic branch from ascending pharyngeal artery
5. Tympanic branch from artery of the pterygoid canal
6. Caraticotympanic branch from ICA
7. Petrosal branch from middle meningeal artery.

VENOUS DRAINAGE:

Into the superior petrosal sinus and pterygoid plexus of veins

LYMPHATIC DRAINAGE: into the pre-auricular and retro-auricular lymph nodes

NERVE SUPPLY: by tympanic plexus over the promontory formed by tympanic branch of glossopharyngeal nerve and superior and inferior caratico-tympanic nerves (sympathetic plexus)

ANATOMY OF MASTOID

The mastoid process appears at the 29th week of gestation as a result of fusion of the petrous layers of the otic capsule and the tympanic process of squamous bone.

The mastoid process continues to grow till puberty and even beyond.

The size of antrum does not change after birth.

The adult mastoid process anatomy has a cone shaped and is slightly oblique forward and downward. Its anterior border is rounded and vertical. Its posterior border is inclined about 45 degrees downward and forwards.

The mastoid antrum is of 1cm*1cm*1cm in average.

It is situated within the posterior part of temporal bone – bounded

Superiorly: tegmen

Inferiorly: mastoid portion of temporal bone

Anteriorly: epitympanic recess

Posteriorly: by sigmoid sinus

Laterally: mac Ewan's triangle

Arterial Supply: posterior tympanic artery

Venous Drainage: emissary vein ; posterior auricular vein and sigmoid sinus

Lymphatic: post auricular and deep cervical lymph nodes

Nerve Supply: tympanic plexus and meningeal branch of mandibular nerve.

The Tracts of pneumatization

The mastoid air cells represent an extension of the air tracts into the mastoid process from the pharyngeal pouch. Pneumatization in the mastoid extends from middle ear cleft through aditus ad antrum to the central air tract from which further extension in several directions.

1. The Anterolateral tract: which pneumatizes the squamous part of temporal bone,

2. The posteromedial tract: which pneumatizes the petrous portion of the temporal bone.

    - Posterosuperior cell tract
    - Posteromedial cell tract

- Sub arcuate cell tract
- Perilabryinthine cell tract
- Peritubal tract

Middle Ear Mucosa- modified respiratory mucosa

The middle ear cavity is covered with a thin mucosal membrane that covers all of the structures, including all of the ossicles, and links to the mastoid antrum's mucous membrane. The eustachian tube and the nasopharynx are two structures that connect the eustachian tube and the nasopharynx. Squamous epithelium dominates the mucosal epithelium in the epitympanic area, with islands of ciliated columnar cells.

From the mastoid antrum in the epitympanum, via the mesotympanum, and into the eustachian tube, these islands constitute a functioning muco-ciliary route.

Similarly, the mesotympanum's squamous epithelium has two routes of ciliated columnar cells, one continuing the journey from the mastoid antrum and the other linking the TM to the ET through the hypotympanum.

The mucosal surface of the mesotympanum of a healthy middle ear is made up equally of squamous and ciliated columnar cells.

The number of ciliated columnar epithelial cells in the mucosal lining rises as it approaches the eustachian tube, eventually accounting for around 80% of the cells near to the tube's opening .The function of an orderly muco-ciliary transposition system from the epitympanum and hypotympanum to the eustachian tube is facilitated by the changing cellular architecture of the middle ear canal.Although mainly squamous, the epithelium of the epitympanum is extensively vascularized and plays a gas exchange role with the mastoid and middle ear cavities to assist muco-ciliary clearance of the middle ear.

Gas pressurisation increases clearance of secretions from the middle ear by opening the eustachian tube intermittently during eating and yawning in combination with the mastoid antrum.

MIDDLE EAR AND EUSTACHIAN TUBE:

Good aeration of middle ear space is a necessity for a well-functioning middle ear with regard to both infections and audiological function.

Middle ear aeration is a result of a complex system involving two major contributors- middle ear mucosa and the eustachian tube.

MIDDLE EAR VENTILATION PATHWAYS:

The eustachian tube ventilates the pro-tympanum and the mesotympanum.

The tympanic diaphragm separates the mesotympanum from the epitympanum.

Marchioni illustrated the endoscopic anatomy of the aeration pathways and discussed the selective dysventilation phenomena as a principal factor in influencing middle ear pressure haemostasis.

Two main ventilatory routes to upper unit of attic are described- anterior route and posterior route of ventilation.

The middle ear mucosa is lined by cuboidal to columnar mucosal epithelium with scattered goblet cells. The eustachian tube is lined by pseudostratified, ciliated columnar epithelium. The goblet cells are more prominent proximal to the eustachian tube contributing to the surfactant nature of the secretions containing lecithin, lipids and mucopolysaccharides that decrease the surface tension and keep the tube patent. the density of cilia increases the as the tube runs dorsolateral to open into nasopharynx behind the soft palate , facilitating movement of drainage of mucus and other materials.

The middle ear mucosa is a modified respiratory mucosa; non ciliated cells are principally secretory cells – having characteristic of goblet cells.

The muco-ciliary cell system functions principally in the hypotympanum , protympanum and the eustachian tube.

This mucous floats on an aqueous layer that is critical for ciliary function ; if this aqueous layer is too thick, the cilia will not reach the mucous , if it is too thin , the ciliary movement is impeded by mucous viscosity.

GAS EXCHANGE:

The direction of gas exchange is determined by the differences in partial pressure of gases in the middle ear cleft and blood.

Gas in nasopharynx that regulates pressure in nasopharynx is 79.2% nitrogen , 14.7 oxygen , 1% argon and 25% co2 . Fluctuations in ambient pressure are bidirectional and these fluctuations reflect the rise and fall in barometric pressure.

ME and mastoid gas cell system is a rigid non collapsible gas pocket served by mucous membrane in which gases exchanged between ME space and mucosa

The middle ear cleft is affected by eustachian tube obstruction.

Also obstruction of the tympanic isthmus induces dysventilation and affects airflow within the pneumatized temporal bone. The tympanic diaphragm divides the middle ear cleft into two separate compartments – anteroinferior compartment for muco-ciliary function and posterosuperior for gas exchange function.

THE ANTERO-INFERIOR COMPARTMENT : Of the middle ear cleft , situated below the diaphragm , includes the pro-tympanum, mesotympanum, and hypotympanum and is covered by secretory ciliated cells that enables muco-ciliary clearance .

It communicates with the posterosuperior compartment by both anterior and posterior tympanic isthmi.

An inflammatory process involving the mucosa of the anteroinferior middle ear cleft compartment (ET dysfunction with secondary global dysventilation) leads to dysregulation of the mucociliary clearance with mucous accumulation and effusion.

THE POSTERO-SUPERIOR COMPARTMENT: situated above the diaphragm , includes the epitympanum and retrotympanum , aditus ad antrum , antrum and mastoid gas cell system . it is richly vascularized cuboidal epithelium that is devoted primarily to gas exchange which is compensated by intermittent ET openings and ventilation . inflammation of the mucosa of the postero-superior middle ear cleft compartment impairs the gas exchange and leads to the development of an “excessive gas deficit status”.

COMBINED MUCOSAL AND ET PRESSURE REGULATION:

According to Magnuson , the ME pressure regulation system depends on three components

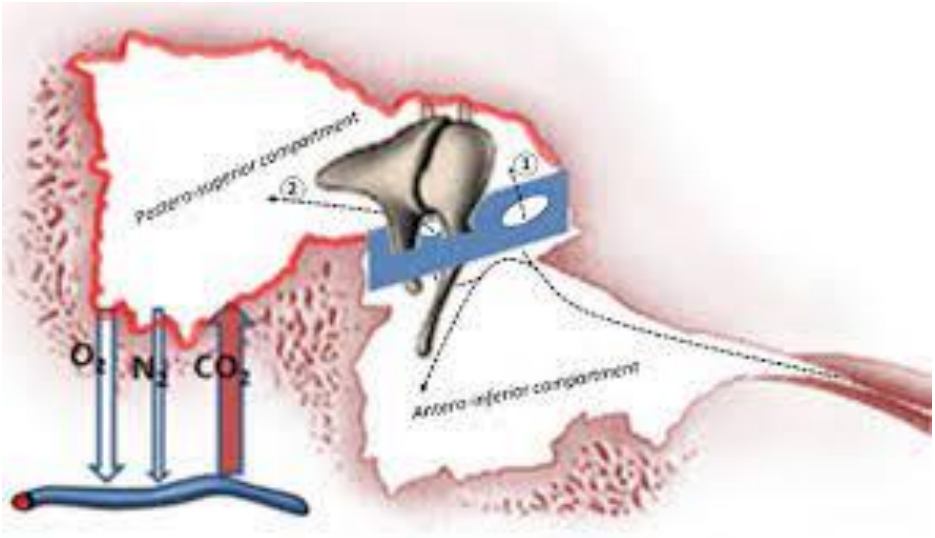
1. Intermittent bidirectional gas passage by the ET.

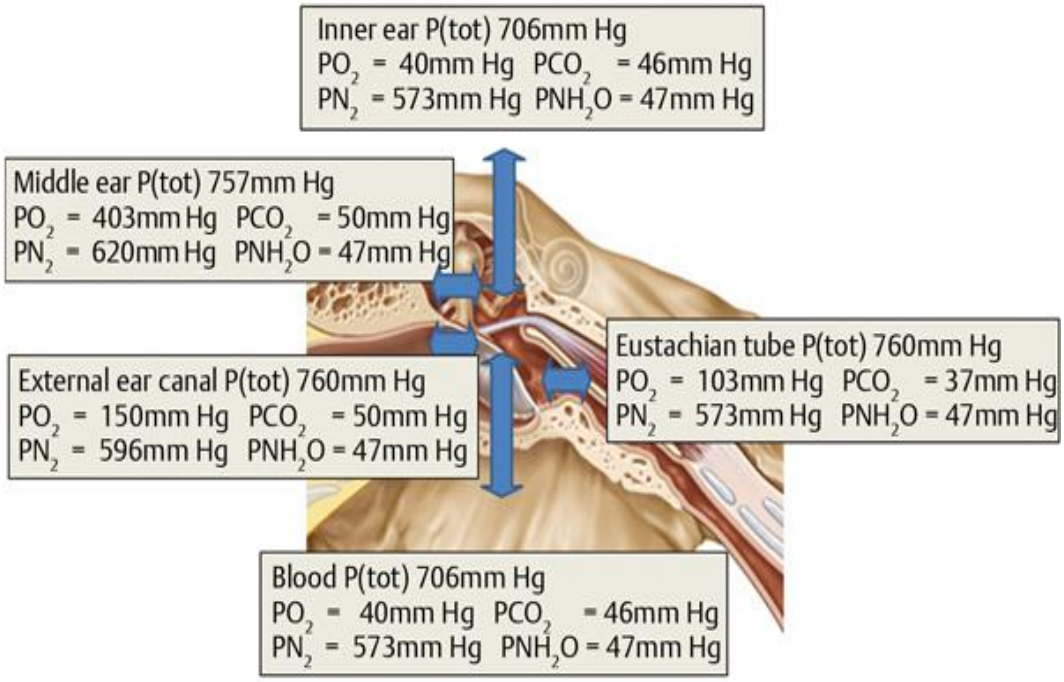
2. Bidirectional continuous diffusion of gas through the mucosal cells

3. The tensor veli palatini , with its dilator fibres moves air to the ME, by the pumping movement of the TM , maintaining air pressure at the level of ambient atmospheric pressure.

The ME air is in fact not air but relatively – hypercapnic, hypoxic, hyper nitrous, gaseous mixture (co2+, oxygen-, nitrogen +) fully saturated with water vapour . it is result of a bidirectional diffusion between the mucosal blood vessels of the ME cleft (partial pressure of gases in the middle ear cleft and blood) together with periodic pressure regulation via the ET during deglutition and yawning .

The human mastoid and the eustachian tube were capable of active counter regulation of the middle ear pressure (mastoid and ET function) . the mastoid provides continuous regulation of smaller pressures , whereas the ET is involved in intermittent regulation of higher pressures.





PHYSIOLOGY OF EUSTACHIAN TUBE

The Eustachian tube has three main functions:

1) Pressure regulation (ventilation) of the middle ear, which equilibrates gas pressure in the middle ear with atmospheric pressure;

2) Middle ear protection from nasopharyngeal sound pressure and secretions

3) Mucociliary clerance

VENTILATION- The management of middle ear pressure (ventilation) is the most crucial of the Eustachian tube's three functions.

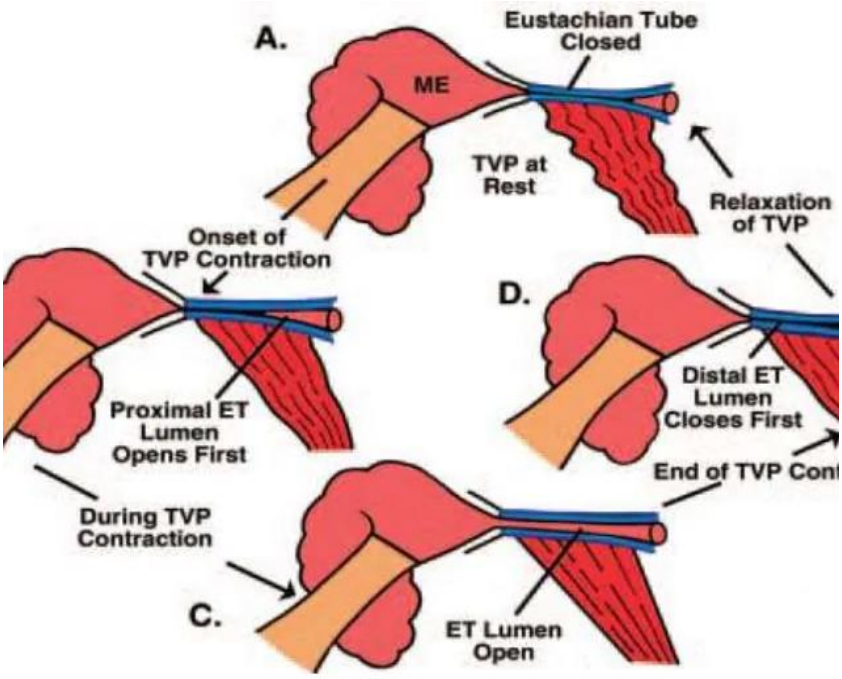
Hearing is best when the middle ear pressure is equal to the pressure in the External Auditory Canal. The Eustachian tube opens and closes intermittently when swallowing due to the contraction of the Tensor veli palate muscle. This keeps the middle ear pressure constant. The pressures in the middle ear of a healthy adult at rest ranges from 50to -50 mm H2O PROTECTION The Eustachian tube protects the middle ear and mastoid air cell system in two ways: 1) by its overall function, and 2) through immune and mucociliary defence mechanisms.

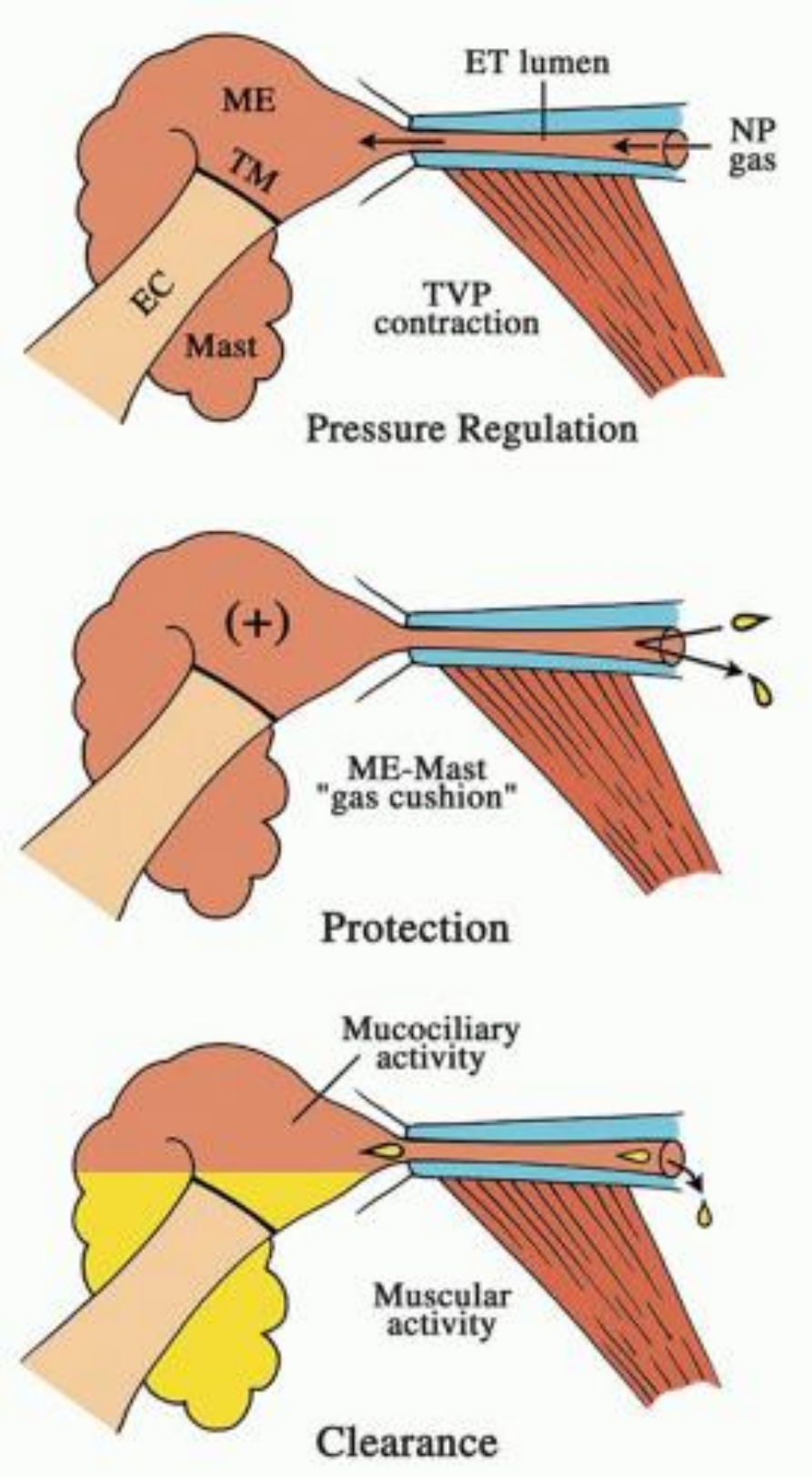
The normal anatomical form and function of the Eustachian tube protects the middle ear from abnormal nasopharyngeal secretions and sound pressure.

A gas cushion is also maintained by the middle ear and mastoid air cell system. The respiratory epithelium lines the middle ear and mastoid air cell system, providing local immunological defence and mucociliary clearance; during rest, the Eustachian tube and tubal lumen are compressed. This inhibits sound pressure and nasopharyngeal

secretion from entering the nasopharyngeal end. When the proximal end (cartilaginous section) of the Eustachian tube opens after swallowing, fluids can enter up to the neck.

CLEARANCE FUNCTION: The mucociliary clearance and muscle clearance helps in removing secretions from the middle ear into the nasopharynx. Respiratory epithelium lines the middle ear and Eustachian tube lumens. The mucociliary lining of the Eustachian tube clears the middle ear secretion, which is facilitated by the Eustachian tube's pumping activity when it closes. Ciliated cells in the middle ear become increasingly active as they get further away from the tube's entrance. The Eustachian tube's passive closure begins in the middle ear and proceeds to the nasopharyngeal end, with the middle ear secretion being pumped out through the Eustachian tube.




ET lumen
ME
TM
NP
gas
EC
Mast
TVP
contraction
Pressure Regulation
(+)
ME-Mast
"gas cushion"
Protection
Mucociliary
activity
Muscular
activity
Clearance

PATHOPHYSIOLOGY OF EUSTACHIAN TUBE

Classified into

1) Impairment of pressure regulation

2) Loss of protective function

3) Impairment of mucociliary clearance

IMPAIRMENT OF PRESSURE REGULATION Impairment of middle ear pressure regulation may be due to anatomical obstruction of Eustachian tube (to closed) or functional obstruction (failure to open) of the Eustachian tube.

ANATOMICAL OBSTRUCTION The anatomical obstruction may be at osseous portion or cartilaginous portion of the tube. The middle ear mucosal inflammation and cholesteatoma, polyps of middle ear can lead to obstruction at distal end of the tube. Adenoid, foreign body (pack),tumours of Nasopharynx may lead to obstruction at proximal end.

FUNCTIONAL OBSTRUCTION This is due to failure of opening of cartilaginous portion of Eustachian tube during swallowing. This may be caused by 1) due to increased compliance of the tube leading to persistent collapse of the tube 2) ineffective opening mechanism 3) combined effect The persistent collapse is attributed to less cartilage portion seen in infantile and an inefficient tensor veli palatine muscle.

LOSS OF PROTECTIVE MECHANISM The reasons for loss of protective mechanism are 1) the lumen of the Eustachian tube is abnormally patent 2) the length of the eusatachian tube is too short 3) development of abnormal air pressure at either ends of tube 4) non intact middle ear e.g:perforation of Typmanic membrane or tympanostomy can lead to loss of middle ear gas cushion effect.

IMPAIRMENT OF MUCOCILIARY CLEARANCE FUNCTION Drainage of secretion from the middle ear and Eustachian tube can be affected by bacteria, their toxin and mediation which can impair ciliary function

Allergy does not impair mucociliary function but can alter the mucous blanket in the Eustachian tube.

Eustachian tube dysfunction (ETD) leads to symptoms,

1. Aural fullness,
2. Impaired pressure equilibration,
3. Altered middle ear aeration,
4. Hearing loss,
5. Autophony.

The most common cause of obstructive dysfunction is mucosal inflammation within the cartilaginous Eustachian tube, history of

inflammatory processes, such as allergic rhinitis, chronic rhinosinusitis, laryngopharyngeal reflux (LPR), and smoke exposure.

Pediatric ETD may be caused by adenoids and mucosa swelling due to acute or chronic upper respiratory tract infections.

Cleft palate, granulomatous disease, cystic fibrosis, Sampter's triad, or Kartagener's syndrome are facilitating factors.

Eustachian tube dysfunction may be a contributing factor to vertigo.

OTHER CAUSES OF ET DYSFUNCTION

- Eustachian tube dysfunction associated with.
- Deviated nasal septum.
- Trauma caused by Nasogastric and Eustachian tube .
- Trauma to palate.
- Pterygoid bone and tensor velipalati muscle.
- injury to mandibular branch of Cranial nerve V.
- Trauma associated with surgical procedure like maxillary resection of tumor .
- Benign or malignant disease invading palate.

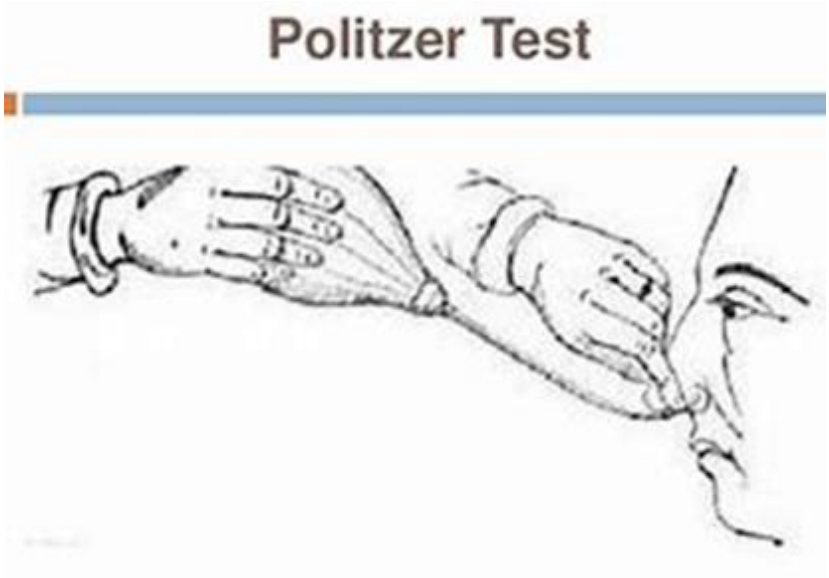
ASSESSMENT OF EUSTACHIAN TUBE FUNCTIONS:

1. Valsalva`s test,
2. Toynbee`s test and
3. politzer test
4. nasopharyngeal tube catheterization etc.

Valsalva test: This test qualitatively evaluates the effect of high positive nasopharyngeal pressure upon the Eustachian tube. It is positive when the auditory tube and tympanic cavity can be inflated by a forced expiration against the closed glottis and both the nostrils closed.

Toynbee test: It is performed by instructing the subject to deglutinate with the nostrils and closed lips or compressed. This process generally produces a positive pressure within the nasopharynx followed by a phase of negative pressure. This negative pressure within the

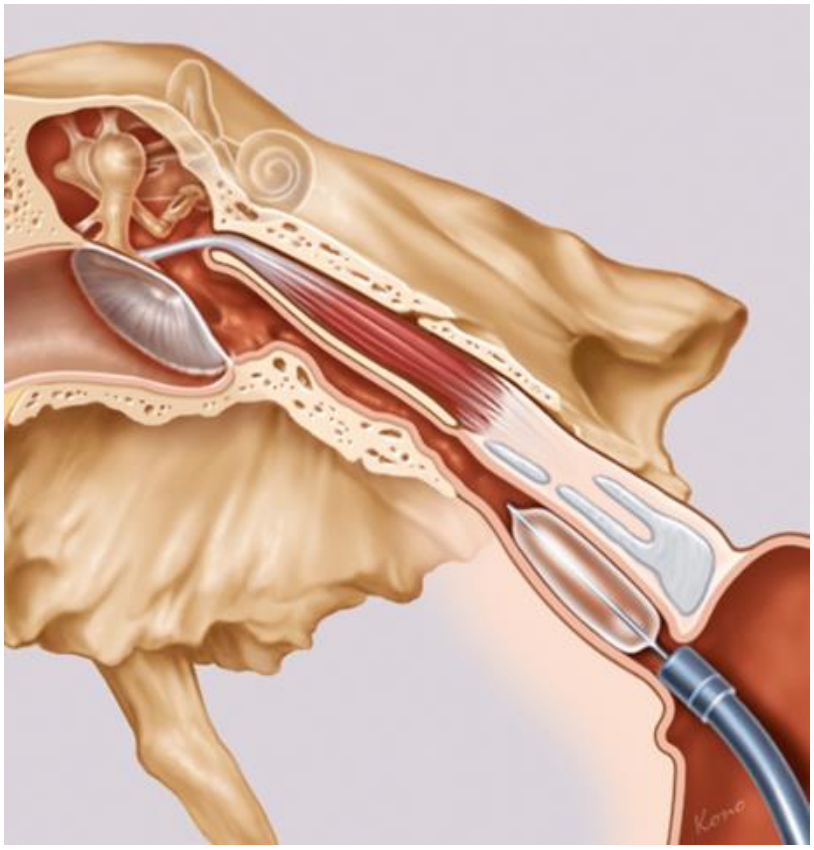
tympanic cavity after the Toynbee test or only transient negative tympanic cavity pressure followed by ambient pressure usually indicates good tubal function.



Politzer test: This test was performed by pressing one nostril into which the end of a rubber catheter is attached to an air bag had been inserted while the other nostril was compressed with pressure from the fingers. The patient was asked to repeat the alphabet “k” or the patient was asked to swallow in order 60 to close the velopharyngeal opening. The assessment of the tympanic cavity pressure and its importance of the results are similar to the test described previously.

Eustachian tube catheterization: This test was done by using the metal cannula which was introduced into the nasopharyngeal end of the Eustachian tube and a positive pressure was applied, successful transfer

of applied positive into the tympanic cavity clinches the functioning auditory tube.



TESTS OF VENTILATORY FUNCTION: Assessed by

1. Manometry,

2. Sonotubometry and

3. Tympanometry

Manometry:

This technique involves the placement of external auditory canal catheter with an airtight connection between a pressure monitoring

device and the tympanic cavity. The middle ear pressure can be measured Directly in the perforated tympanic membrane (i.e) the intratympanic manometry. Indirectly by measuring the changes in the ear canal pressure in intact tympanic membrane the change in the ear canal pressure called as the extratympanic manometry

I. Non intact tympanic membrane:

The systematically conducted inflation and deflation test was the first quantitative tubal function performed by the intratympanic manometry. The addition of flowmeter to the manometric system to involve pressure flow relationships during the pharyngotympanictube tube function testing was the next improvement in the technique. In the previous years only the active function of the nasopharyngeal tube was done. Later, bluestone and co-workers introduced the modified inflation-deflation test by which the passive function could also be described by the variables such as forced opening pressure and closing pressure of the tube. In later days the forced response test were developed to differentiate between the normal and abnormal nasopharyngeal tube function. This test eliminates the overlap encountered in the inflation and deflation test. With this forced response test, it has been possible to distinguish between the tubal dysfunction which arises as a result of inefficient opening and structural properties of the tube.

II. Intact tympanic membrane:

For the individuals with the intact tympanic membrane, the tubal function can be determined by using the two techniques such as

I. Pressure flow technique

II. Microflow technique The second method is more reliable than the first one. This method was done by the continuous recording of the volume deviation of the tympanic membrane arising due to changes in the ambient pressure and changes in pressure within the tympanic cavity. Since this method needs a pressure chamber and advanced Instrument, which is possible, only at the upgraded institutes.

Sonotubometry: It is a non-invasive technique and it provides the information about the active opening of eustachian tube. In this technique a tone of frequency greater than 5 kHz was presented to the nose and its recording taken from the ear through a microphone. The tone was heard louder when the tube was patent.

Tympanometry: In tympanometry there are five methods for the evaluation of the auditory tube.

Of these nine steps inflation and deflation test was more routinely used. Each of these methods was based on the indirect determination of the middle ear pressure under various conditions. However only the,

relative qualitative information can be obtained by the above methods. Hence there was no true satisfactory clinical test for detecting the tubal function with the intact tympanic membrane.

NINE STEP INFLATION-DEFLATION TYMPANOMETRIC TEST:

Bluestone developed a nine step test to study the Eustachian tube function if Tympanic membrane is intact.

MODIFIED INFLATION-DEFLATION TEST (NON-INTACT TM):

When the Tympanic membrane is not intact, the pump manometer system of impedance audiometer is used to do Modified Inflation–Deflation test.

To perform this test the middle ear should be free of any drainage.

A positive pressure is given to the middle ear and the Eustachian tube passively opened.

The pressure at which the Eustachian tube opens is the opening pressure and the pressure at which the Eustachian tube closes passively is the closing pressure.

Then the patient is asked to swallow to equilibrate the residual middle ear pressure.

If the Eustachian tube is not opened with this Electroacoustic impedance audiometer then another manometric system is used which increases pressure more than 400mmH2O.

The mean opening pressure for normal subjects with traumatic perforation is 330mm H2O (+70). If the tube does not open to 1000mmH2O there is total mechanical obstruction.

9-STEP TYMPANOMETRIC
INFLATION-DEFLATION
EUSTACHIAN TUBE FUNCTION TEST

STEP	ACTIVITY	MODEL	TYMPANOGRAM
1.	RESTING PRESSURE	TVP ME (0) ET TM EC	0
2.	INFLATION AND SWALLOW (x 3)	(+) (+)	
3.	PRESSURE AFTER EQUILIBRATION	(−)	− 0
4.	SWALLOW (x 3)	(−)	
5.	PRESSURE AFTER EQUILIBRATION	(0)	0
6.	DEFLATION AND SWALLOW (x 3)	(−) (−)	
7.	PRESSURE AFTER EQUILIBRATION	(+)	+ 0
8.	SWALLOW (x 3)	(+)	
9.	PRESSURE AFTER EQUILIBRATION	(0)	0

TESTS OF MUCOCILIARY FUNCTION: The ciliary function is an active function; hence the muco-ciliary action of the mucous membrane was responsible for the transport of materials from the tympanic cavity into the auditory tube. The muco-ciliary function of the Eustachian tube can be evaluated by the radiological contrast media, fluoresceine, methylene blue etc. the time taken for the particles 64 which was placed in the middle ear to its destination was calculated and hence the pathological state of the mucous membrane was estimated. **PHONOTUBOMETRY**: This method uses the fiberscope to observe the tubal orifice and to detect the Eustachian tube orifice by a photoelectric device. This test was done by placing a light source in the pharyngeal end of the auditory tube and a highly sensitive photodiode was placed in the external auditory canal which detects the tubal opening by the increased luminosity in the tympanic cavity. The disadvantage of this method was that the light conduction inside the opened tube was blocked by several factors such as middle ear effusion, fluid retention within the tube and anatomical deviation of the tube. Xe133GAS: The Kirchner in 1974 obtained the first scintigram of the air containing spaces of the ear and the paranasal sinuses with the 133Xe. This test was done by using a bolus of 133Xe gas insufflated into the nasopharyngeal space through a tube combined with the Valsalva manoeuvres. A significant difference between the sides of dysfunction and the normal tubal function has been noted

AIMS AND OBJECTIVES

PRIMARY OBJECTIVE:

1. To relate the outcome of surgery for CSOM-MUCOSAL DISEASE (INACTIVE AND ACTIVE.)

SECONDARY OBJECTIVE:

1. To study the patency of Eustachian tube in chronic suppurative otitis media (mucosal type).

2. To study the muco-ciliary function of Eustachian tube.

3. To study if there is any relation between site of perforation and graft uptake.

MATERIALS AND METHODOLOGY

Study Place: Rajiv Gandhi Government General Hospital, Chennai-600003.

Department: Upgraded institute of Oto-rhino-laryngology

Study Design: Prospective

Period of the study: June 2020- September 2021

Ethical clearance: Obtained

INCLUSION CRITERIA:

1. Patients suffering from chronic suppurative otitis media (mucosal disease – active and inactive) > 12 years of age.
2. Male and female patients
3. Patients with both unilateral and bilateral disease.
4. Patients who are able to understand and give consent for the study.

EXCLUSION CRITERIA:

1. Patients with CSOM- mucosal disease with non-intact tympanic membrane.
2. Patients with attico-antral disease.

3. Age less than 12 years.

4. Patients suffering from congenital anomaly/ cleft palate /tumor or mass in the nasopharynx.

5. Those who are not willing/ loss to follow up.

INVESTIGATIONS:

1. Plain Xray both Mastoids.

2. Pure tone audiometry

3. Impedance audiometry

4. Oto-endoscopy

5. Diagnostic nasal endoscopy

6. Methylene blue Dye test

DATA COLLECTIONS : Clinical

BENEFIT TO THE COMMUNITY:

1. A properly functioning Eustachian tube is an integral part of normally functioning middle ear and existence of good muco-ciliary drainage constitutes a favorable prognostic factor for reconstructive surgery of the middle ear.

2. Preoperative and Intraoperative corrective measures can be taken in patients with partial and absent tubal function to improve the success rate.

Conflict Of Interest: NIL

Financial Support: NIL

Principal Investigator: Dr.J.Janani, MS ENT, Post-Graduate

METHODOLOGY:

The study was conducted in Rajiv Gandhi Government General Hospital (Madras Medical College) at Upgraded Institute of Oto-Rhino-Laryngology.

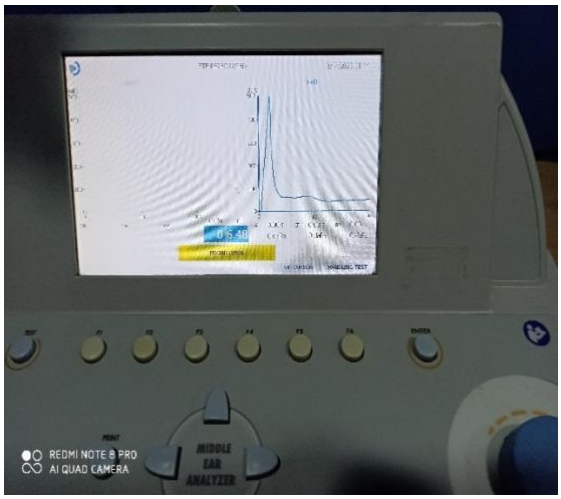
The study group comprised of patients who were diagnosed to have CSOM- The study group comprised of patients who were diagnosed to have CSOM mucosal type. Detailed history and clinical examination as per the proforma were performed. The patients were subjected to a complete otolaryngological examination to rule out any associated pathologies and foci of sepsis, which could influence the result of tympanoplasty.

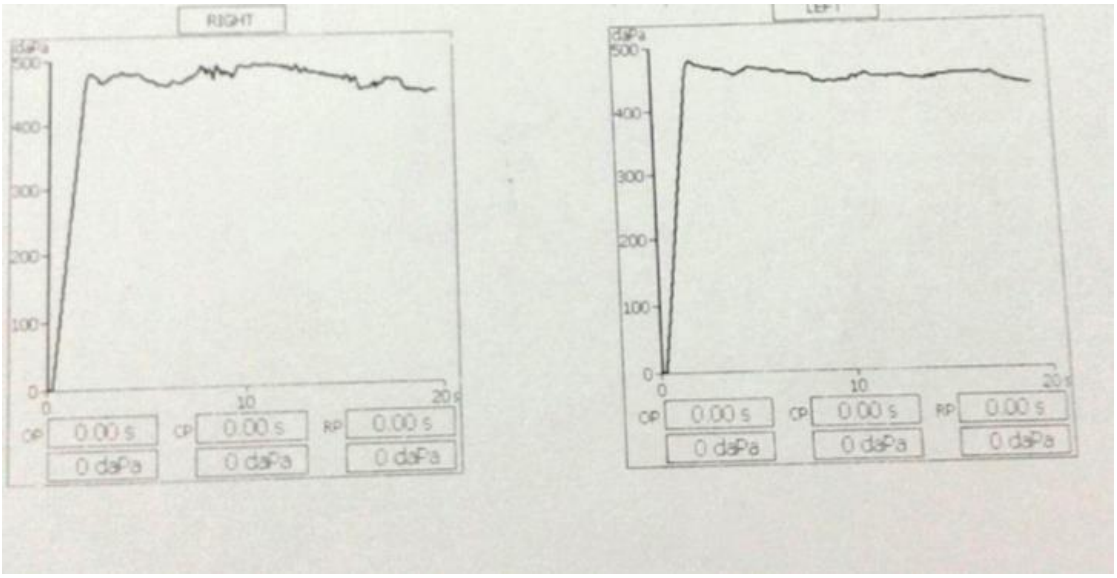
Each patient was subjected to blood investigation, pus culture and sensitivity, plain X-ray both mastoids. Pure tone audiometry, impedance audiometry and Diagnostic nasal endoscopy and dye instillation test.

IMPEDANCE AUDIOMETRY:

FORCED INFLATION TEST

In CSOM patients with non-intact Tympanic membrane the forced inflation test is done to assess Eustachian tube function. The probe of manometer is fitted to test ear and middle ear pressure is raised to 500dPa. This opens the Eustachian tube and pressure drops. This passive opening of Eustachian tube is called opening pressure. After the pressure is equilibrated the Eustachian tube closes and this is called as closing pressure. If there is no passive opening of Eustachian tube, then the patient asked to swallow 3-5 times. This will open the Eustachian tube and then the pressure drop occurs. This is active opening of the Eustachian tube. This is considered as a positive test. If the Eustachian tube doesn't open even after swallowing, then it is negative. Positive test suggests normal functioning of Eustachian tube and Negative test suggests grossly impaired Eustachian tube function.



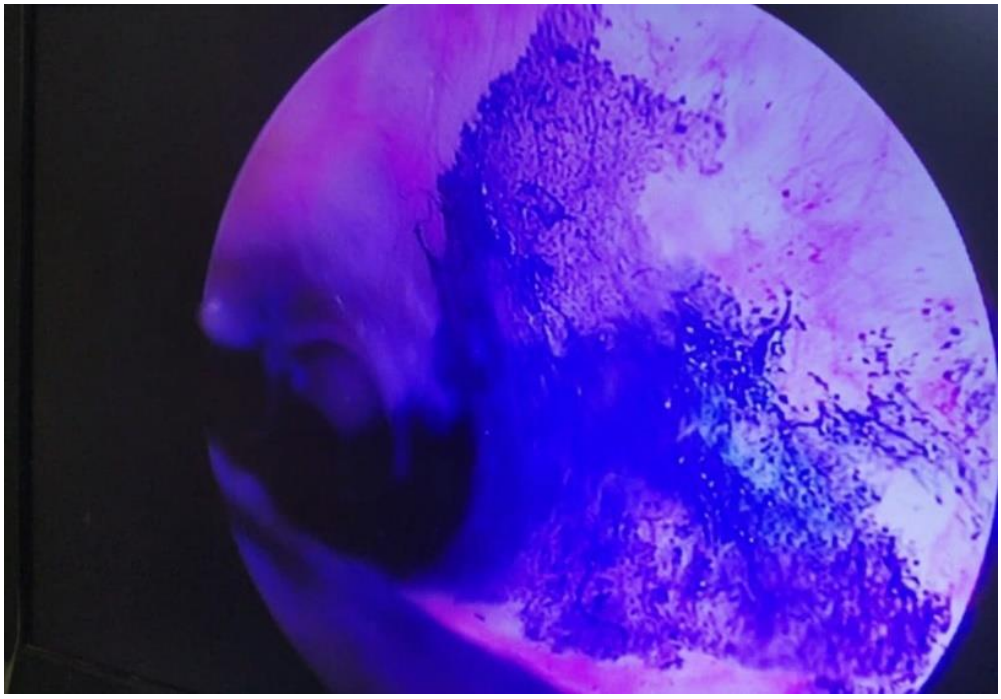


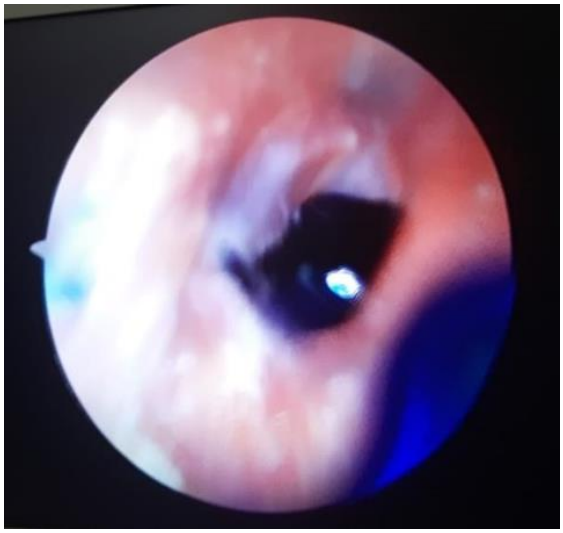
DYE INSTILLATION TEST The muco-ciliary mechanism of Eustachian tube assessed by dye test. The patients were then subjected to dye instillation test. 0.5 mL of Methylene blue dye is instilled into the test ear and the test ear was kept upwards for 5-10 minutes. Then by nasal endoscopy the nasopharyngeal end of Eustachian tube was visualized after spraying 4% xylocaine. The nasopharyngeal end was watched for appearance of dye.

Normal: less than 10minutes

Partial Dysfunction: 10-20 minutes

Gross Dysfunction: > 20minutes






SURGICAL PROCEDURE:

Patients with normal Eustachian tube function were taken up for underlay myringoplasty.

Patients with partially impaired eustachian tube function , with dry middle ear mucosa were taken up for tympanoplasty and those with wet middle ear taken up for cortical mastoidectomy with tympanoplasty. Patients with totally impaired ETF had wet middle ear mucosal status were taken up for cortical mastoidectomy.

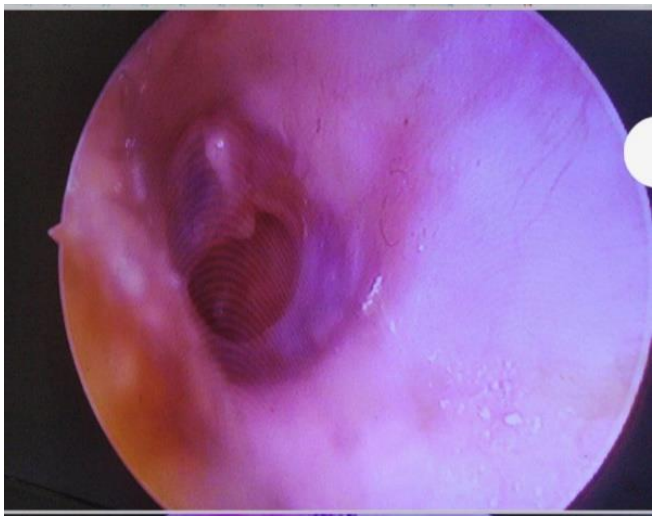
\POST OPERATIVE FOLLOW UP:

Post-op graft status was assessed

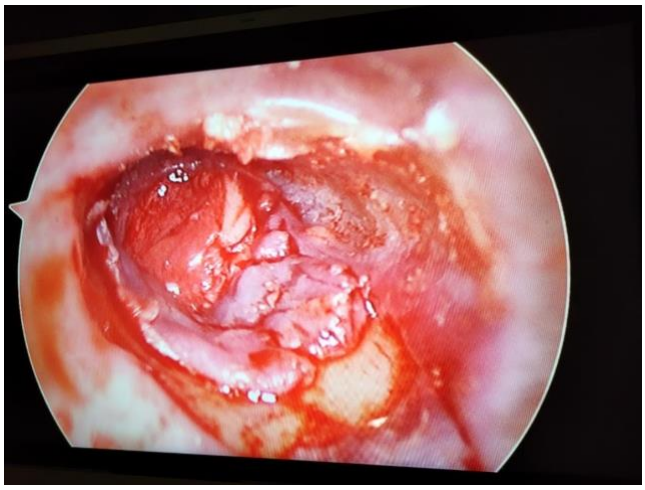
1. Periodically by otoscopy examination

2. Pure tone audiogram taken after 3 months following surgery.

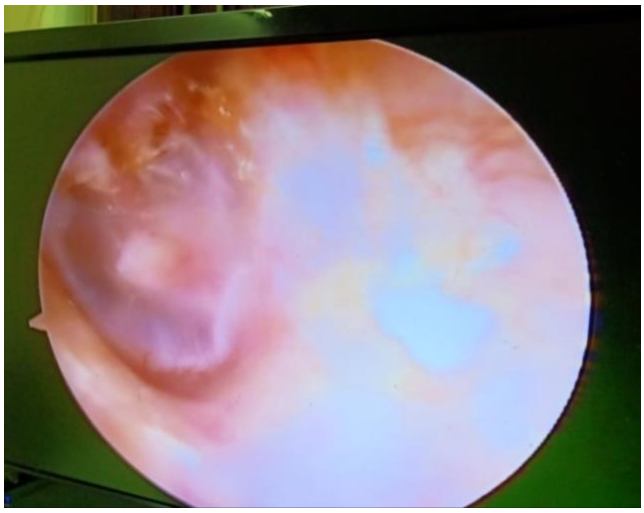
A statistical analysis is made. Graft uptake and improvement in air-bone conduction gap was taken as success of the study.



INTRA OPERATIVE GRAFT PLACEMENT



POST OPERATIVE GRAFT UPTAKE



STATISTICAL ANALYSIS

Data are presented as percentages and number of cases. Categorical data were analysed with Pearson chi-square tests and Fischer exact tests.

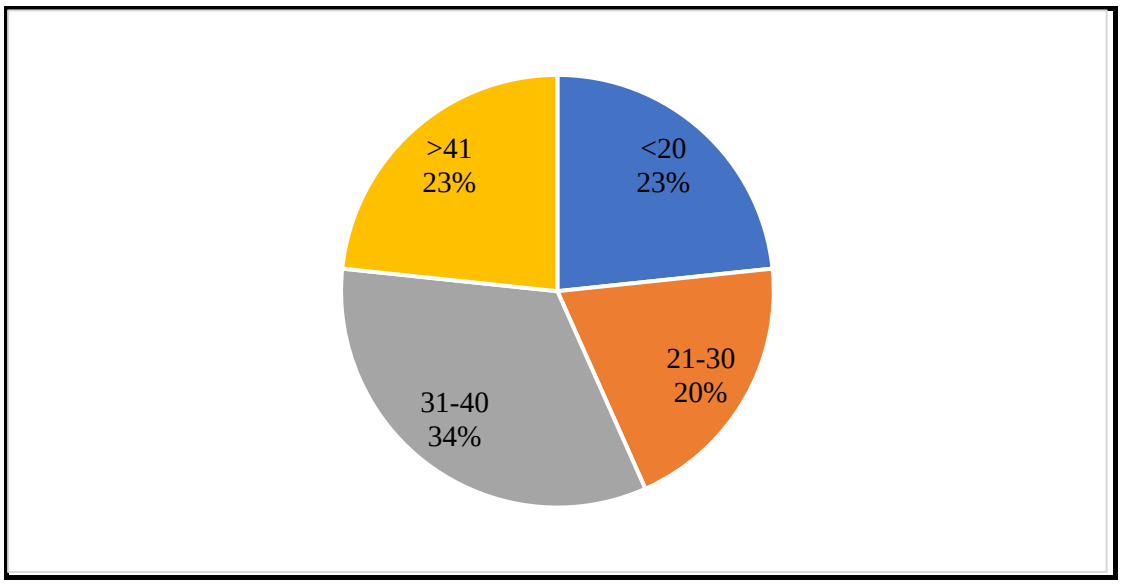
Significance was defined by P values . P values less than 0.05 was taken as significance using a two tailed test. Data analysis was performed using IBM-SPSS version 21.0

(IBM-SPSS Science Inc . Chicago, IL)

RESULTS AND OBSERVATIONS

This study has been done in Dept. of ENT, UIORL, Madras Medical College (Rajiv Gandhi Government General Hospital) for a period of One Year from June 2020-September 2021. The study group Consists of 30 patients of chronic suppurative otitis media -MUCOSAL TYPE.

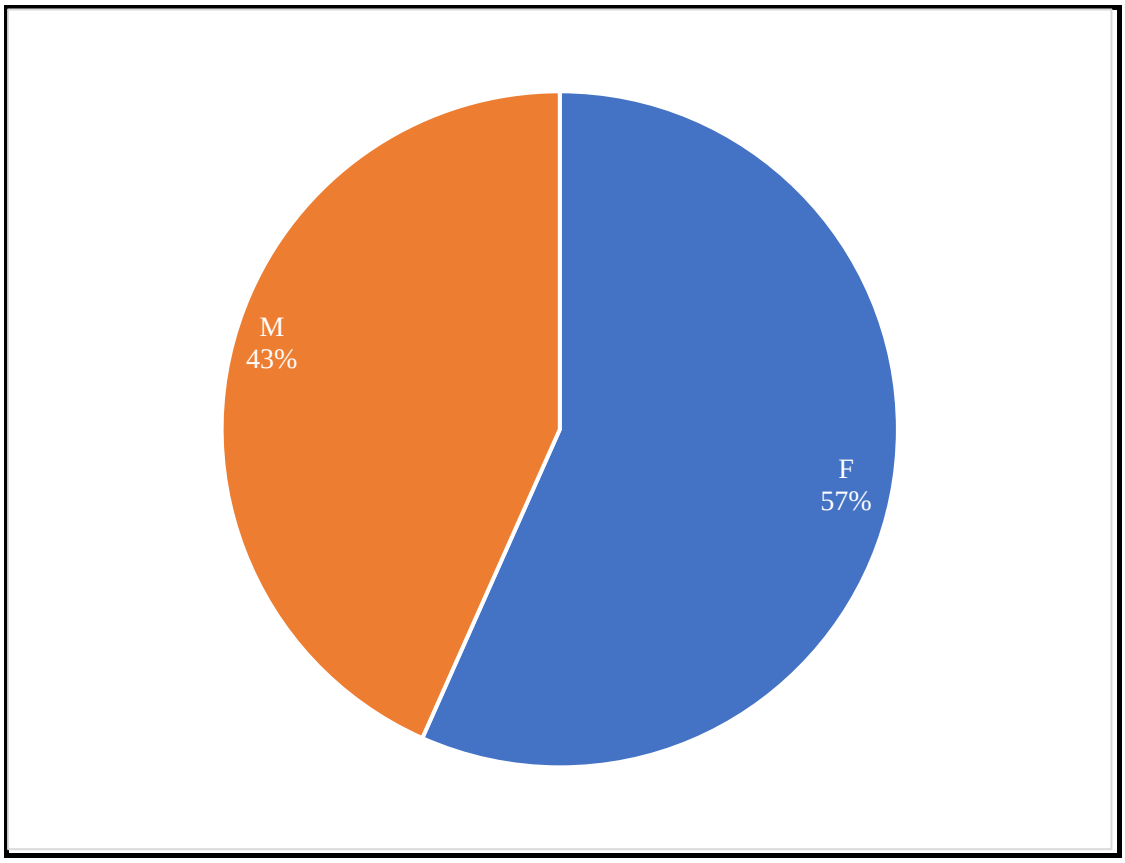
AGE GROUP	Frequency	Percent
<20	7	23.3
21-30	6	20.0
31-40	10	33.3
>41	7	23.3
Total	30	100.0



In this study, 30 patients with CSOM in the age group > 12 was included were included.

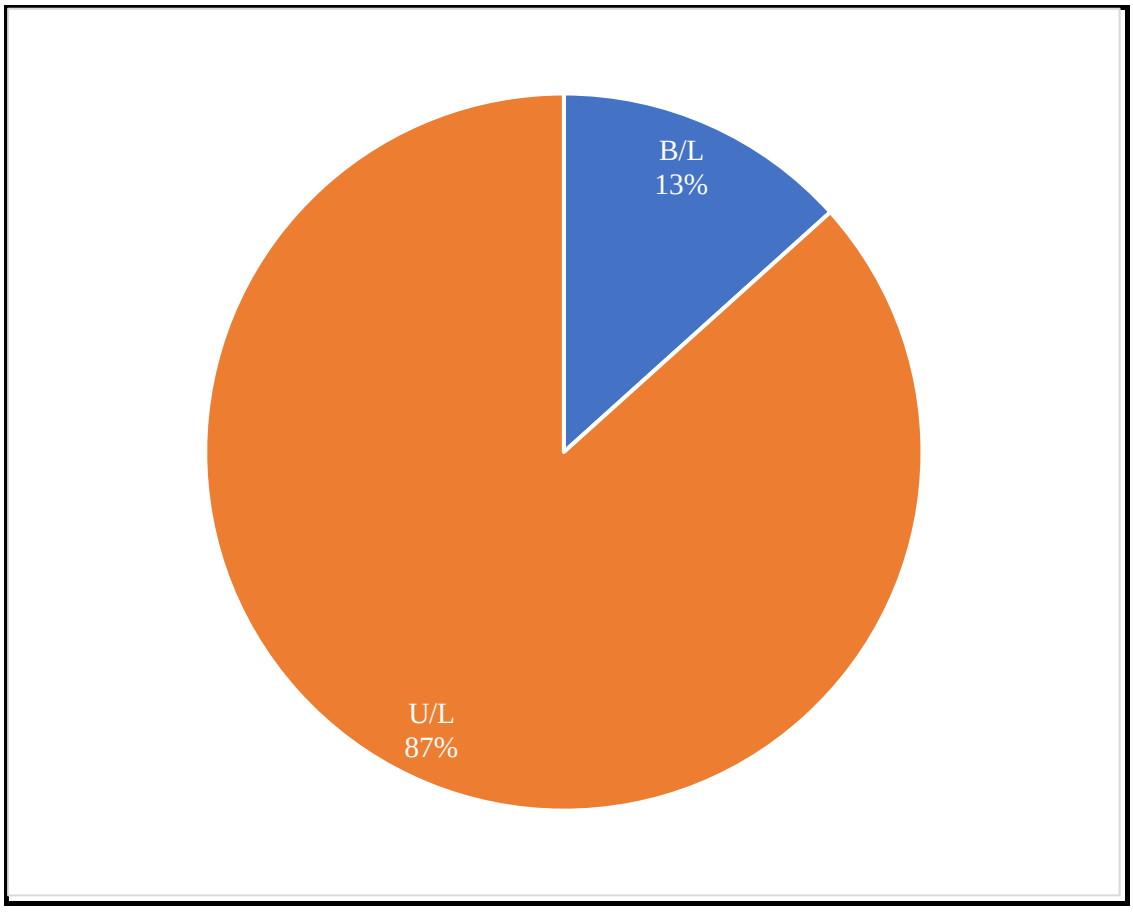
In our study the maximum number of patients were in the age group 31 to 40 years, followed by less than 20 years (23.3%) and more than 41 years (23.3%).

SEX	Frequency	Percent
F	17	56.7
M	13	43.3
Total	30	100.0



In our study CSOM- females had 56.7%, and males had 43.3%.

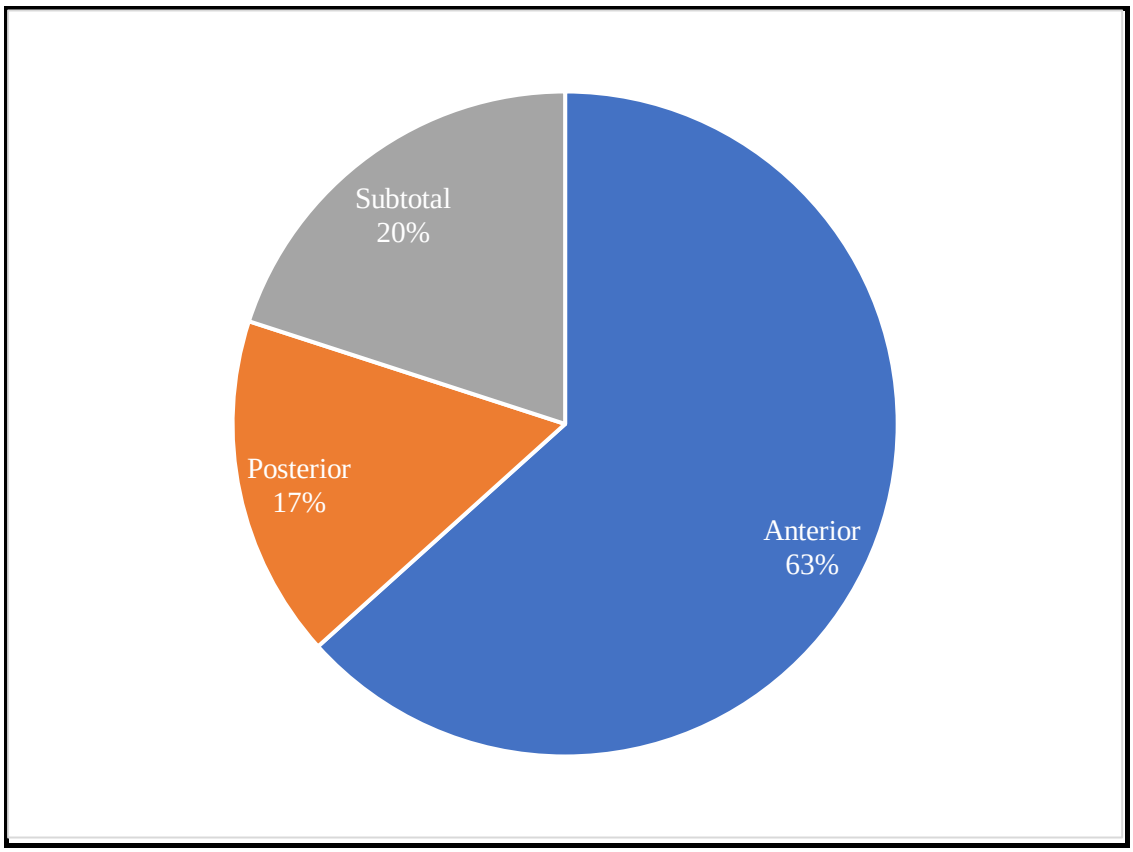
DIAGNOSIS	Frequency	Percent
B/L	4	13.3
U/L	26	86.7
Total	30	100.0



Unilateral CSOM is maximum in the study patients (86.7%), and bilateral CSOM in 13.3%.

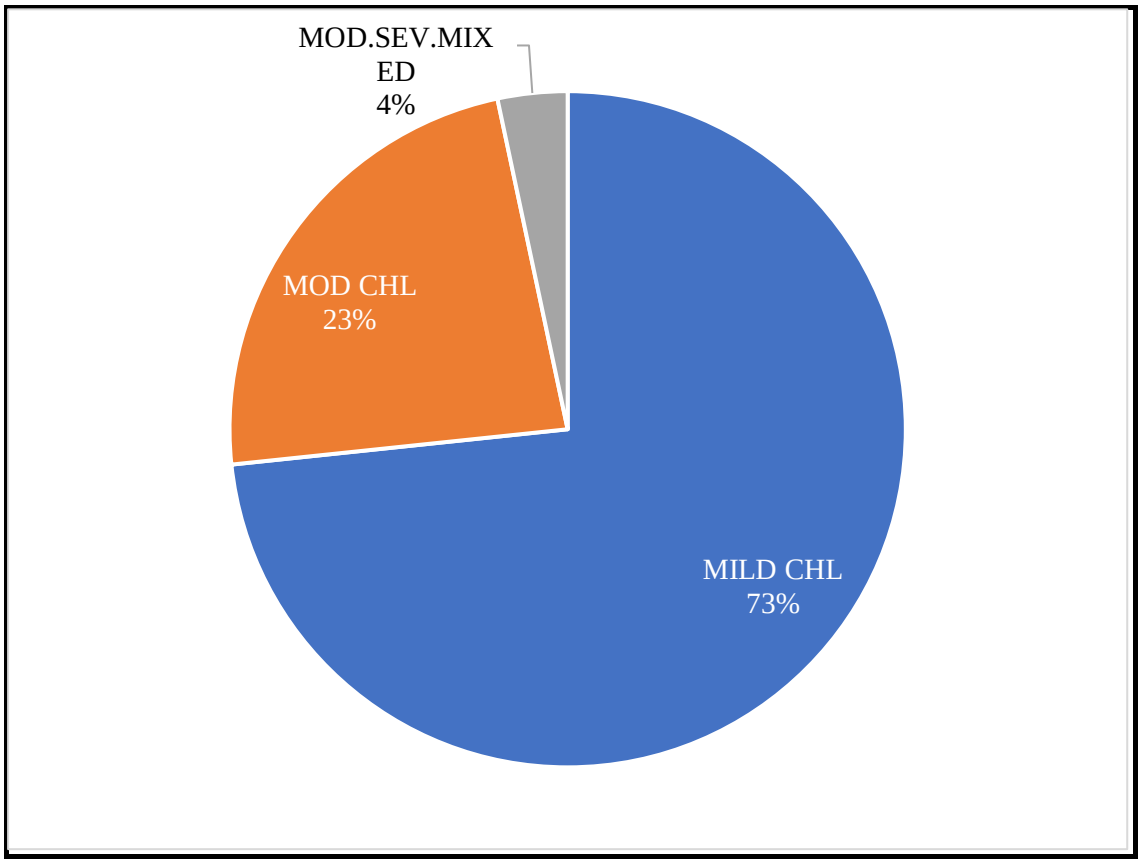
SITE OF PERFORATION	Frequency	Percent
Anterior	19	63.3
Posterior	5	16.7
Subtotal	6	20.0
Total	30	100.0

Site of tympanic membrane perforation was high on anterior (63.3%), followed by posterior 16.7% and subtotal (20%).



PTA	Frequency	Percent
MILD CHL	22	73.3
MOD CHL	7	23.3
MOD.SEV.MIXED	1	3.3
Total	30	100.0

Pure Tone Audiometry, mild conductive hearing loss was found in 73.3% of patients, moderate conductive hearing loss in 23.3% and moderately severe mixed 3.3% of patients



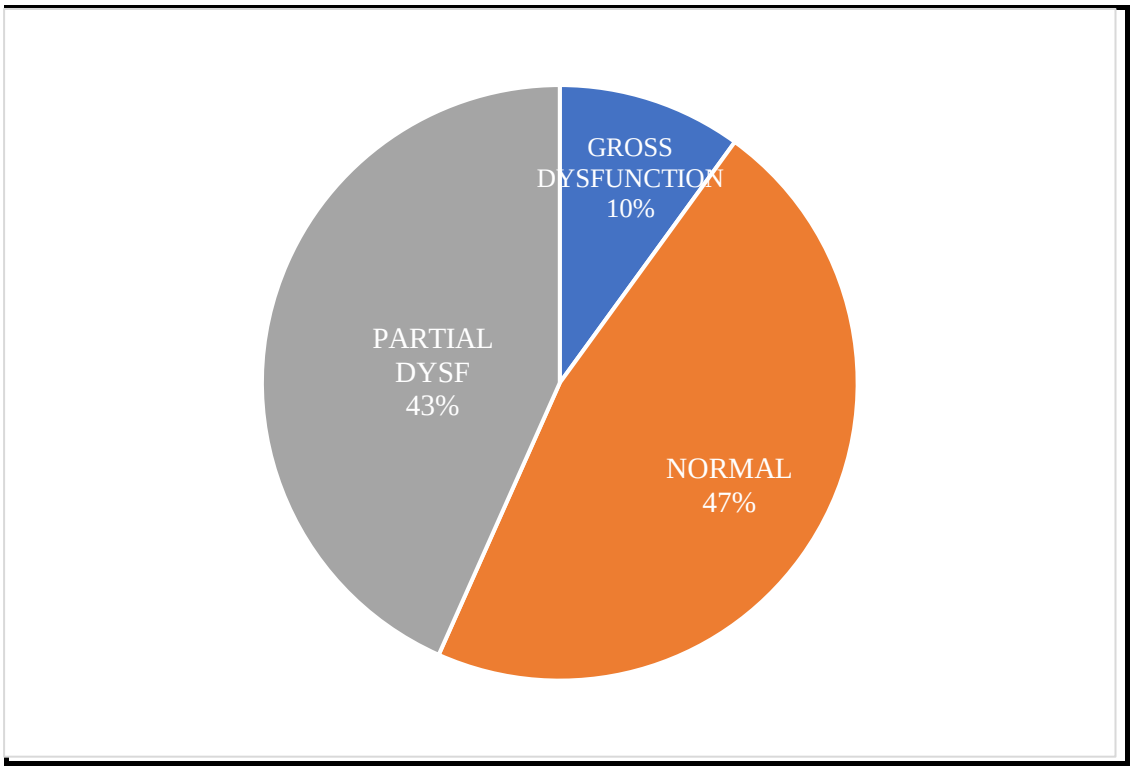
DYE TEST	Frequency	Percent
GROSS DYSFUNCTION	3	10.0
NORMAL	14	46.7
PARTIAL DYSF	13	43.3
Total	30	100.0

Dye instillation test was done to assess the muco-ciliary function of eustachian tube.

14 patients (46.7 %) normal

13 patients (43.3 %) had partial dysfunction

While 3 patients (10%) had gross dysfunction.



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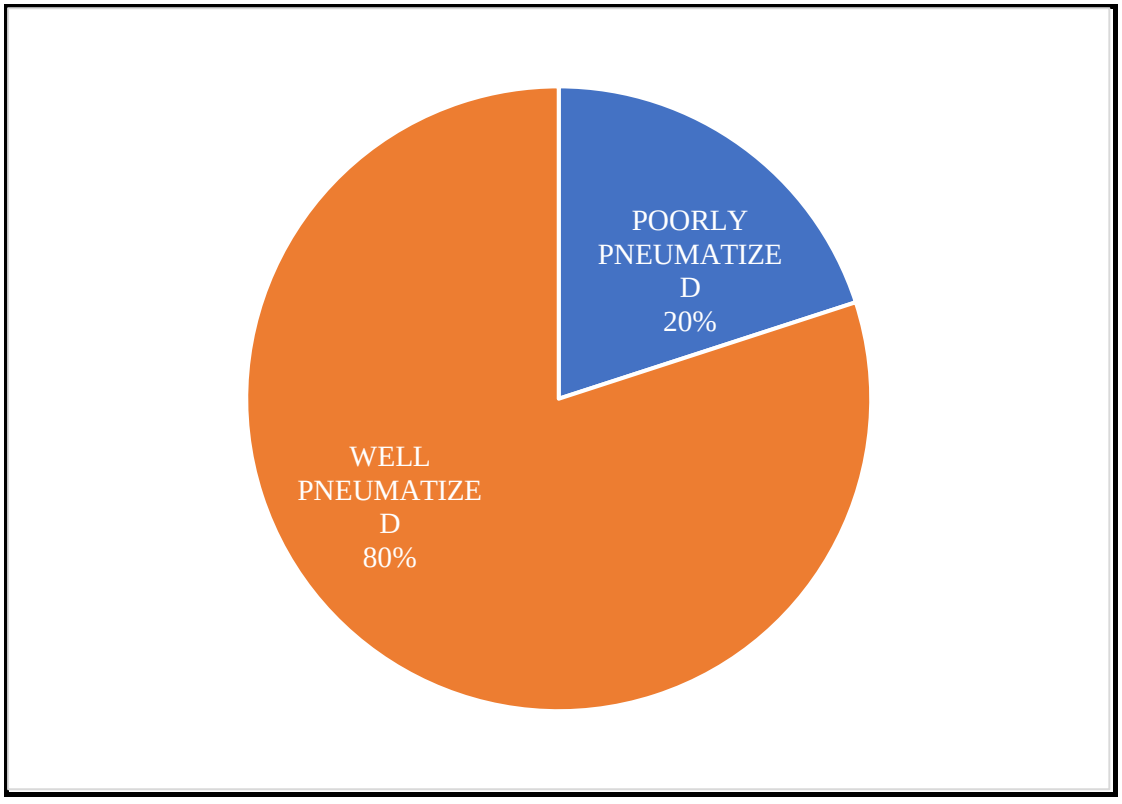
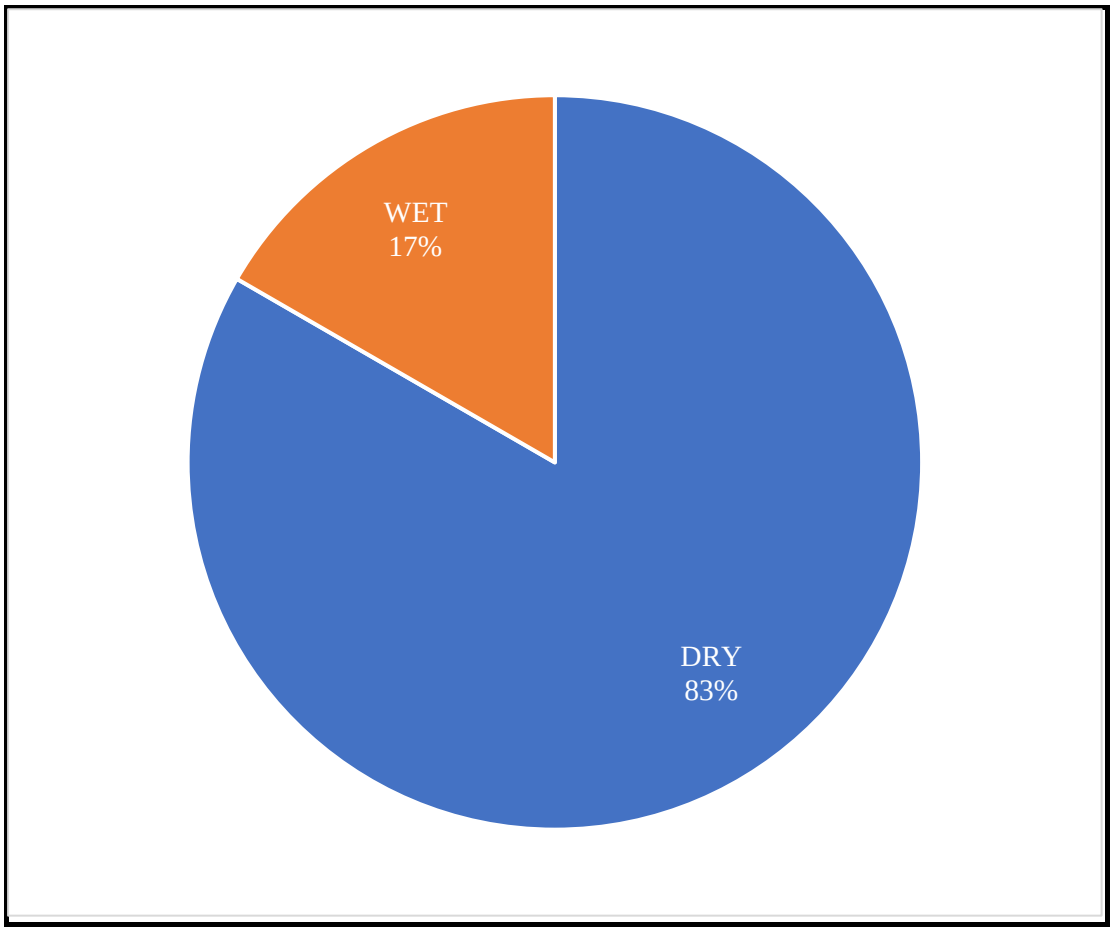
X RAY – MASTOID	Frequency	Percent
POORLY PNEUMATIZED	6	20.0
WELL PNEUMATIZED	24	80.0
Total	30	100.0

In our study, bilateral X Ray mastoids were taken – LAW's view was taken to see the pneumatization pattern. 80% has well pneumatized mastoid and 20% had poorly pneumatized mastoid.



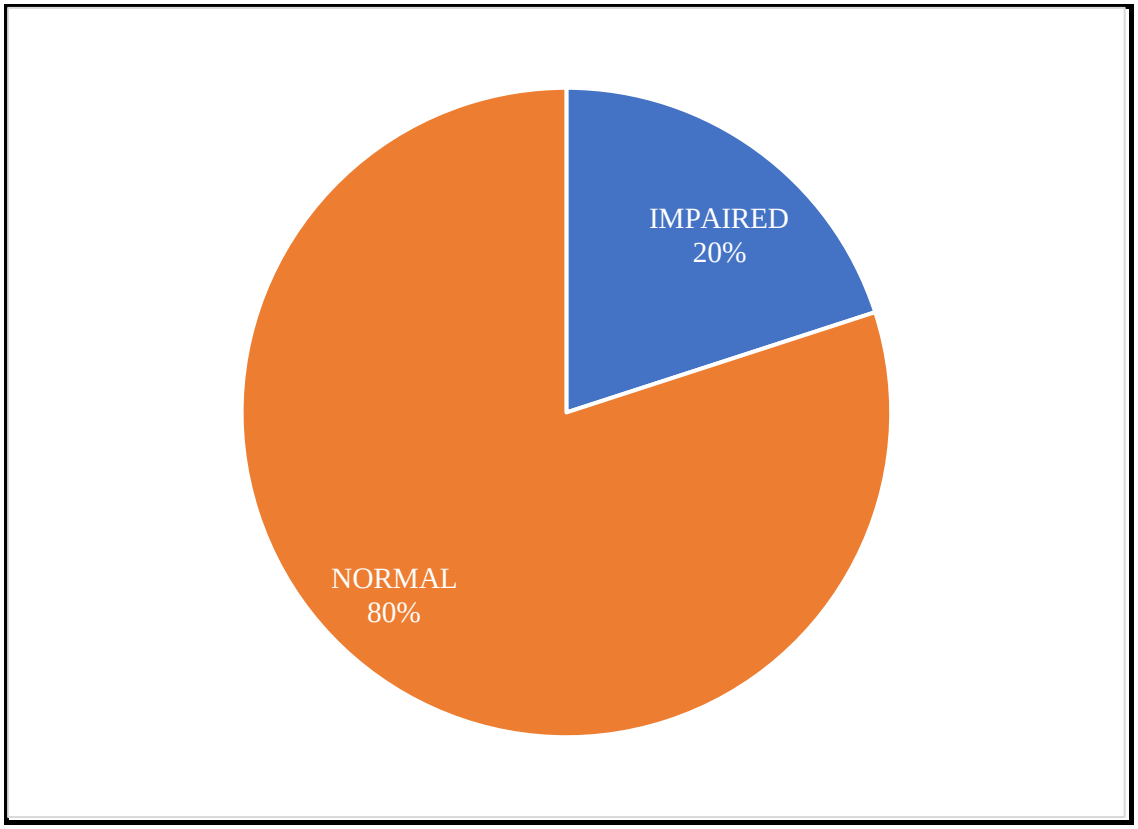
MIDDLE EAR STATUS	Frequency	Percent
DRY	25	83.3
WET	5	16.7
Total	30	100.0

Middle ear status was assessed in our study , 83.3% patients had dry ear , while 16.7 % had a wet ear with active discharge.



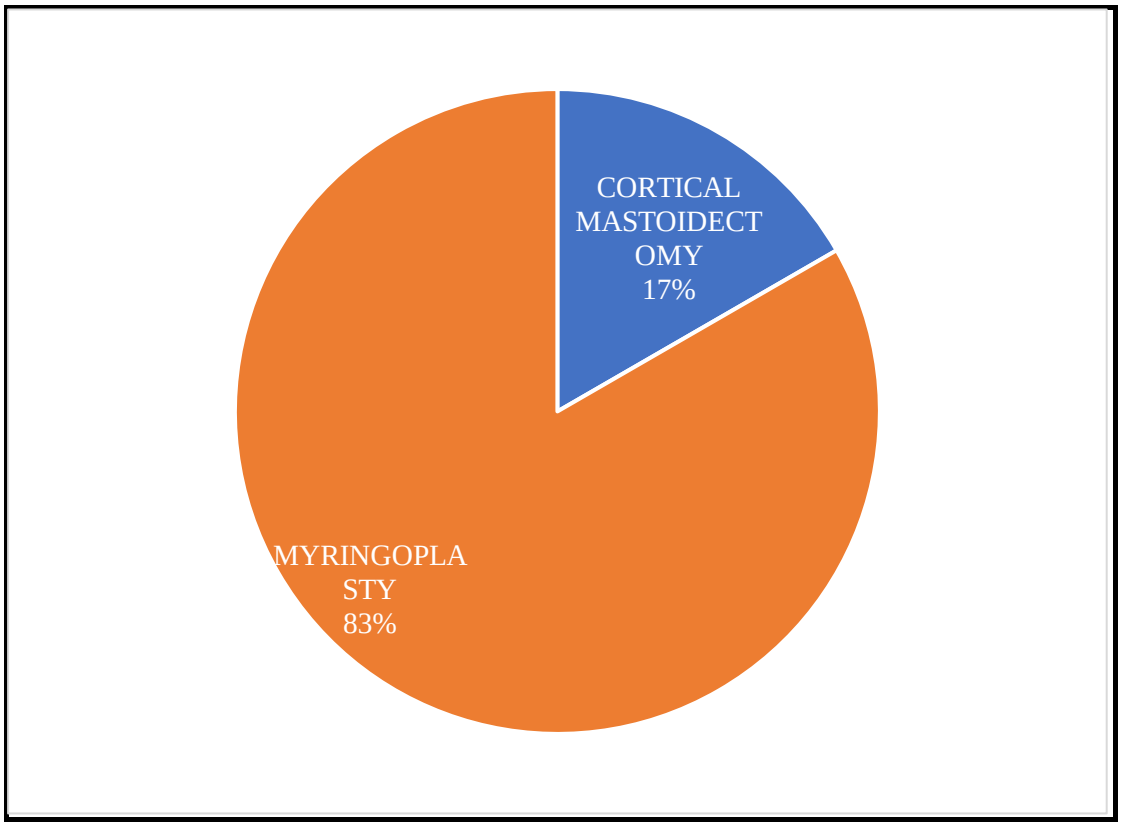
IMPEDANCE	Frequency	Percent
IMPAIRED	6	20.0
NORMAL	24	80.0
Total	30	100.0

In our study impedance was done to assess the eustachian tube function which revealed 20% of patients had impaired impedance, and 80% had normal impedance.



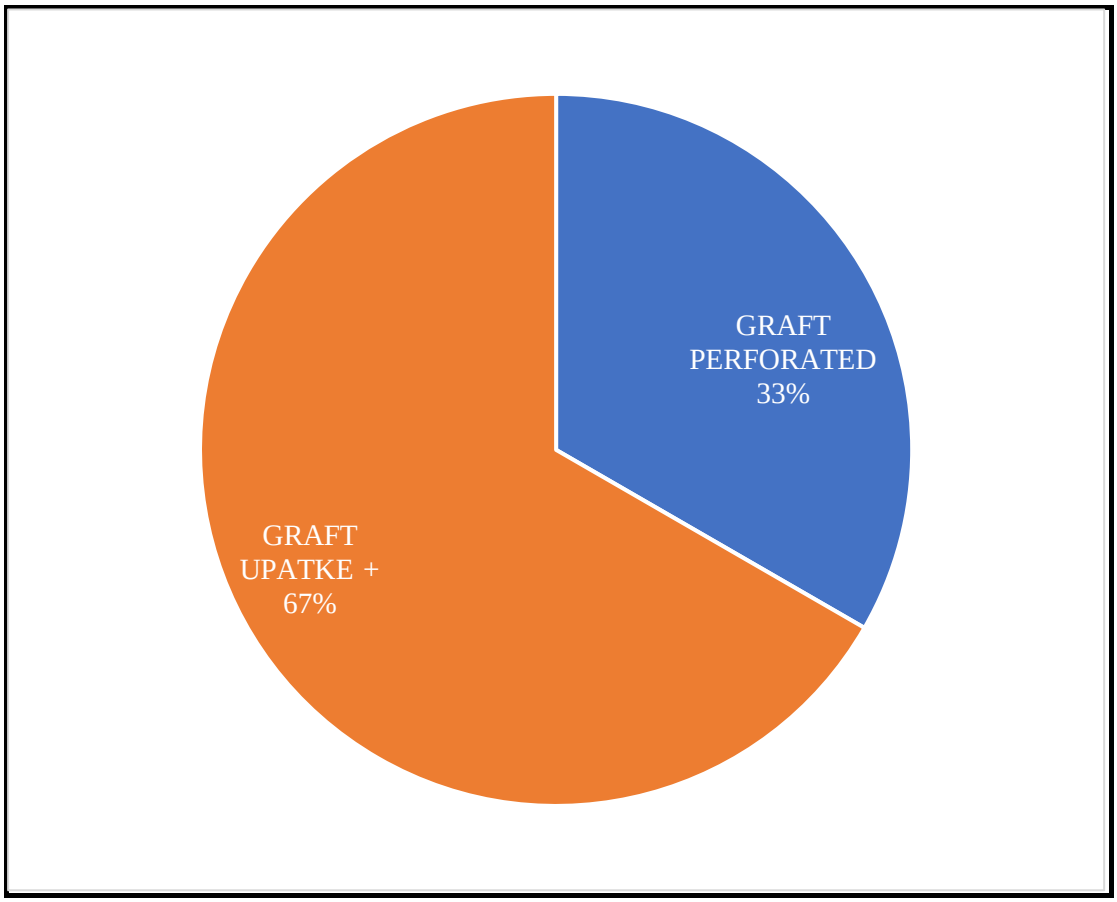
SURGERY	Frequency	Percent
CORTICAL MASTOIDECTOMY	5	16.7
MYRINGOPLASTY	25	83.3
Total	30	100.0

In this study, 84% of patients underwent myringoplasty, and 16% of patients underwent mastoidectomy.



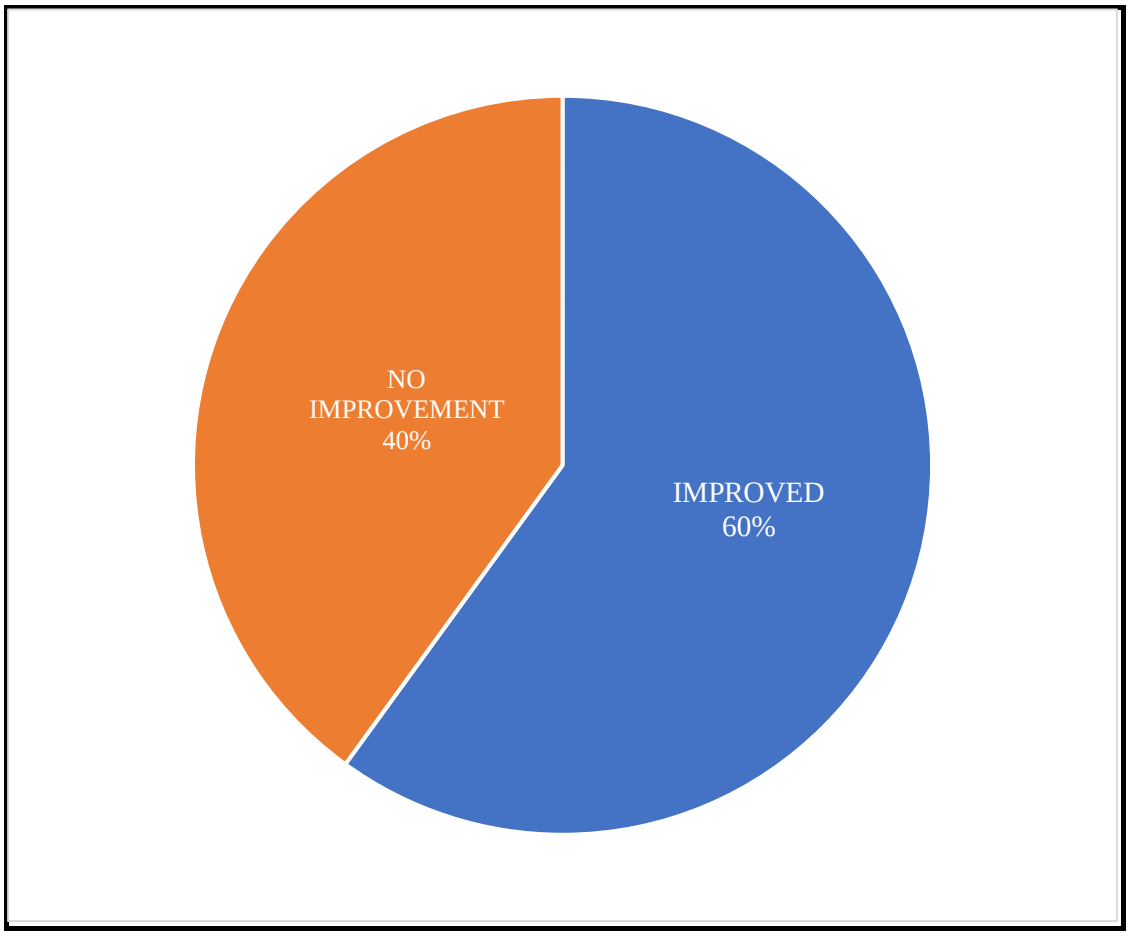
POST OP GRAFT	Frequency	Percent
GRAFT PERFORATED	10	33.3
GRAFT UPATKE +	20	66.7
Total	30	100.0

In this study, post graft uptake in 67% and graft perforated in 33% of patients.



POST OP PTA	Frequency	Percent
IMPROVED	18	60.0
NO IMPROVEMENT	12	40.0
Total	30	100.0

Pure tone audiometry had shown improvement in 60% of patients and no improvement seen in 40% of patients.



			Surgery		Total	P value
			Cortical mastoid dectomy	Myringo plasty		
Dye Test	Gross dys function	Count	3	0	3	<0.0001
		% within Dye Test	100.0%	0.0%	100.0%	
	Normal	Count	0	14	14	
		% within Dye Test	0.0%	100.0%	100.0%	
	Partial DYSF	Count	2	11	13	
		% within Dye Test	15.4%	84.6%	100.0%	
Total		Count	5	25	30	
		% within Dye Test	16.7%	83.3%	100.0%	

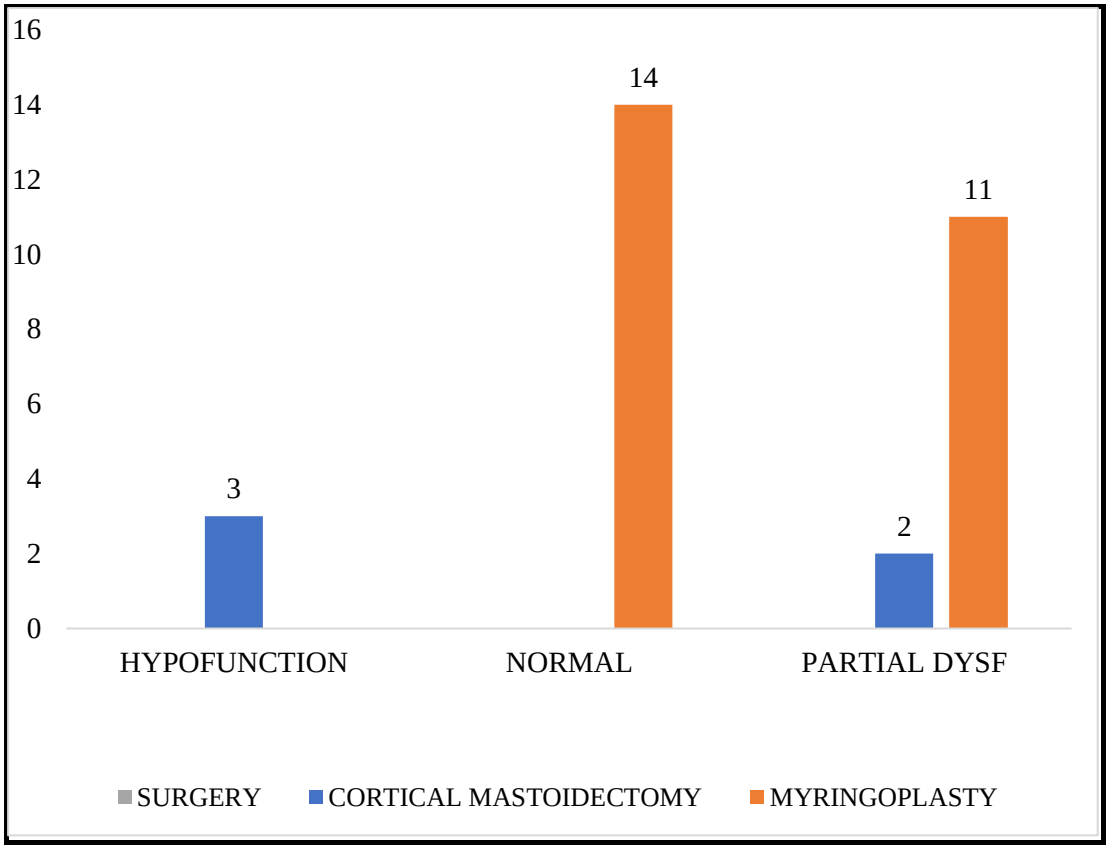
There is a statistically significant difference in dye test findings and surgery performed p<0.0001.

14 patients with normal dye test and dry ear underwent underlay-myringoplasty.

11(84.6%) patients with partial dysfunction in dye test underwent underlay- myringoplasty.

2(15.4%) patients with partial dysfunction in dye test with wet ear underwent cortical mastoidectomy.

3 patients with gross dysfunction in dye test underwent cortical mastoidectomy.



Dye test and graft uptake

S no	Dye test	Perforation	Uptake	P value
1	Normal(14)	2(14.3)	12(85.7)	0.038
2	Dysfunction(16) Partial- 13 Gross-3	8(50) 6(46.2%) 2(66.7%)	8(50) 7(53.8%) 1(33.3%)	

14 patients in the study had normal dye test, of which 12 patients (85.7%) had graft uptake and is statistically significant.

16 patients in the study had muco-ciliary dysfunction in dye test- in that 50 % had graft uptake.

13 had partial dysfunction and 3 had gross dysfunction. Out of 13 patients with partial dysfunction – 7(53.8) had graft uptake with and 3(33.3%) patients with gross dysfunction – one patient had graft uptake .

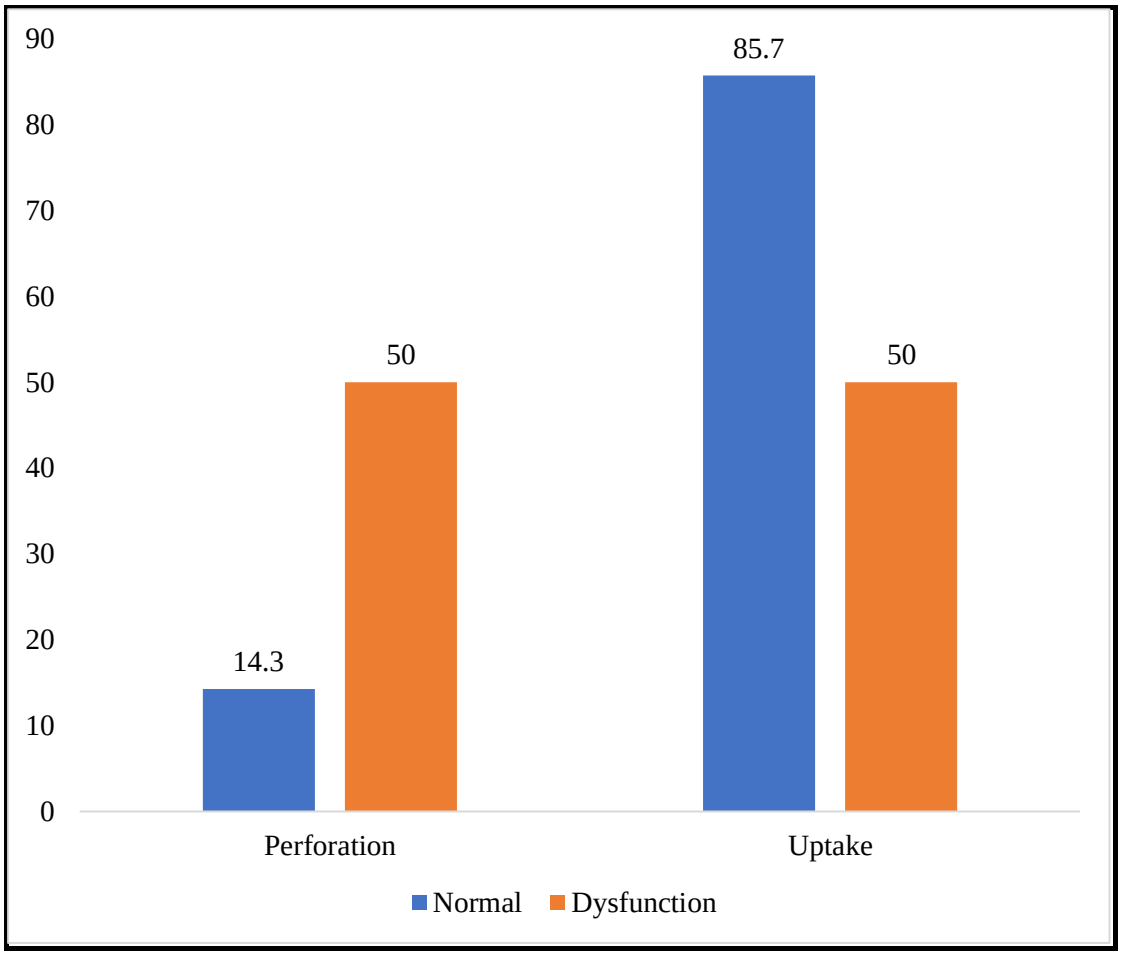
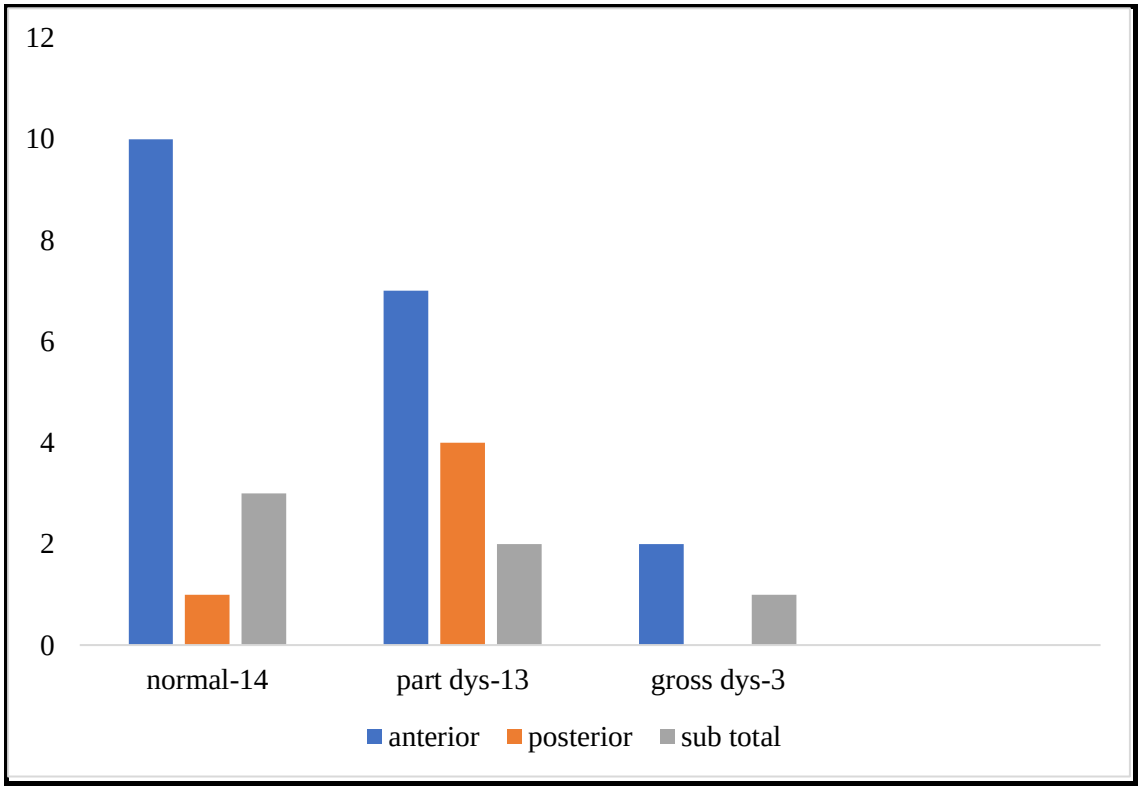


Fig: Dye test and graft uptake

Correlation of dye test with site of perforation

Dye test	Total	Anterior perforation	Posterior perforation	Subtotal perforation
Normal	14	10	1	3
Partial dysfunction	13	7	4	2
Gross dysfunction	3	2	-	1
Total	30	19	5	6



			Dye Test			Total	P value
			Gross dys functio n	Partia l dysf	Norma l		
Site Of Perforation	Anterior	Count	2	7	10	19	0.468
		% within Site Of Perforatio n	10.5%	36.8%	52.6%	100.0 %	
	Posterior	Count	0	4	1	5	
		% within Site Of Perforatio n	0.0%	80.0%	20.0%	100.0 %	
	Subtotal	Count	1	2	3	6	
		% within Site Of Perforatio n	16.7%	33.3%	50.0%	100.0 %	
Total		Count	3	13	14	30	
		% within Site Of Perforatio n	10.0%	43.3%	46.7%	100.0 %	

S no	Anterior perforation with dye test	Perforation	Uptake
1	Normal	2(20)	8(80)
2	Dysfunction	5(55.6)	4(44.4)

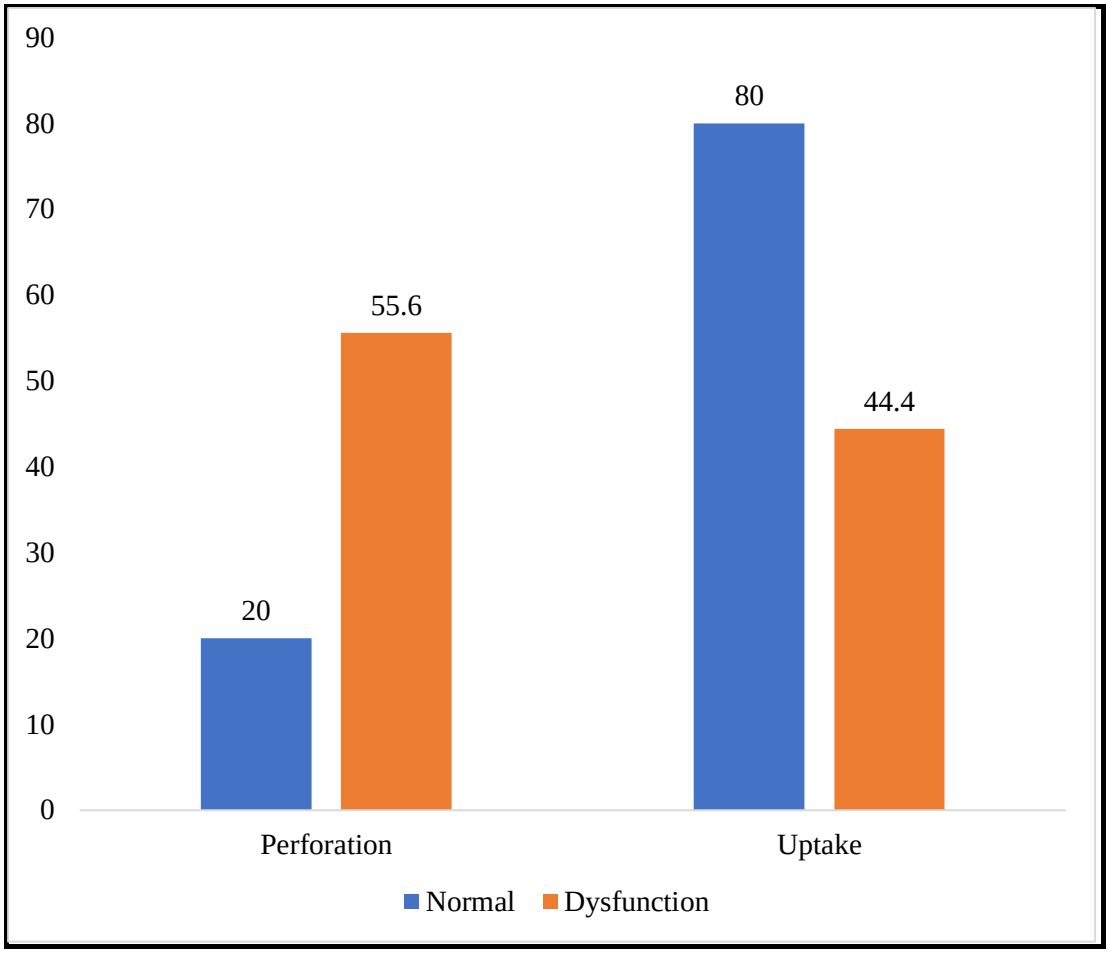
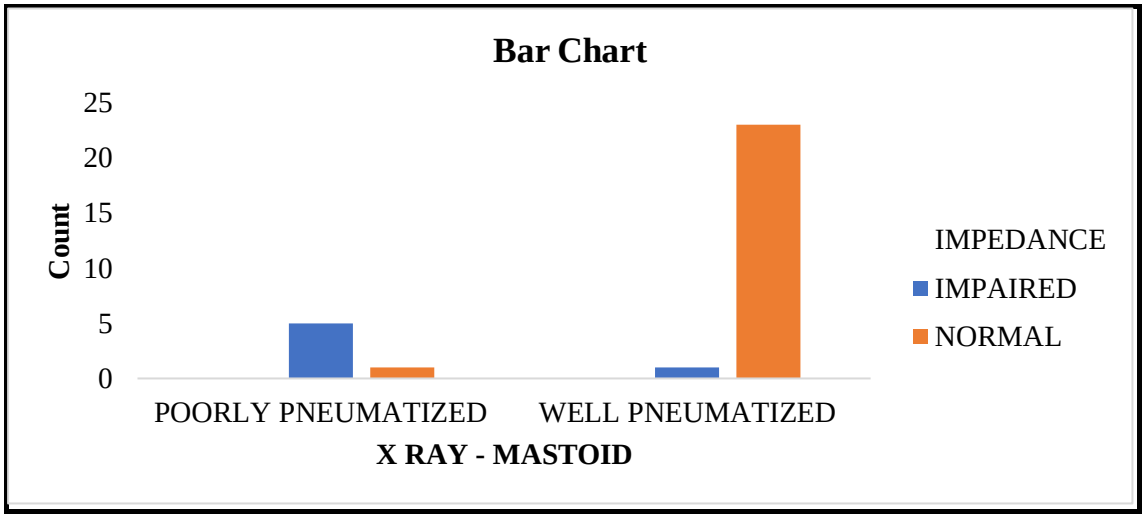


Fig: Graft status among the anterior perforation and dye test

X RAY - MASTOID * IMPEDANCE crosstabulation

			Impedance		Total	P value
			Impaired	Normal		
X Ray - Mastoid	Poorly pneumatized	Count	5	1	6	<0.0001
		% within X Ray – Mastoid	83.3%	16.7%	100.0%	
	Well pneumatized	Count	1	23	24	
		% within X Ray – Mastoid	4.2%	95.8%	100.0%	
Total		Count	6	24	30	
		% within X Ray – Mastoid	20.0%	80.0%	100.0%	

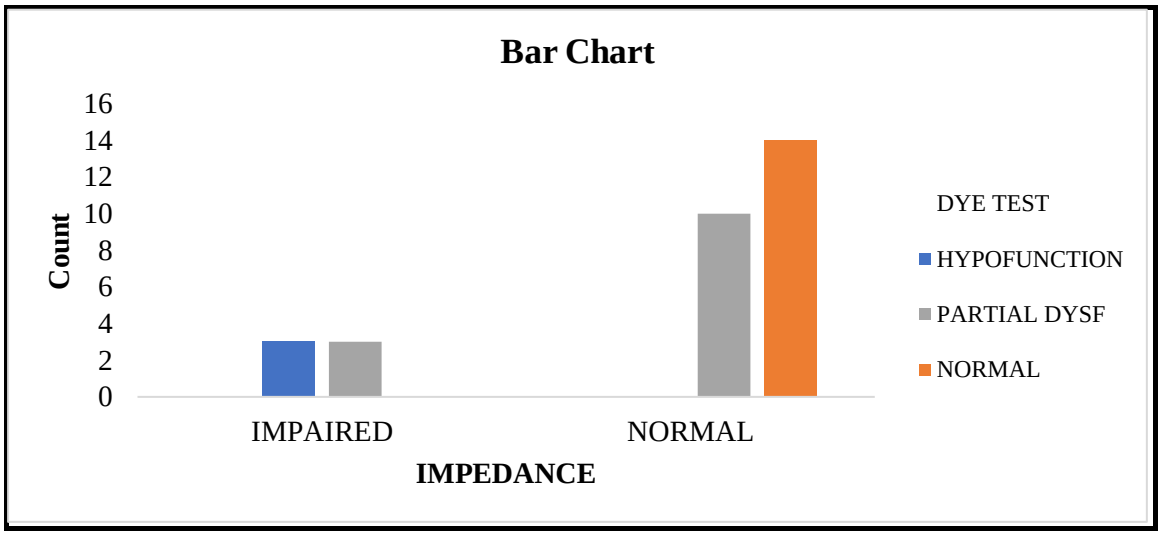


There is statistically significant difference in impedance between mastoid p<0.0001.

Patients with poorly pneumatized having impaired impedance.

IMPEDANCE * DYE TEST Crosstabulation

			Dye Test			Total	P value
			Gross dys function	Partial dysf	Normal		
Impedance	Impaired	Count	3	3	0	6	<0.0001
		% within Impedance	50.0%	50.0%	0.0%	100.0%	
	Normal	Count	0	10	14	24	
		% within Impedance	0.0%	41.7%	58.3%	100.0%	
Total		Count	3	13	14	30	
		% within Impedance	10.0%	43.3%	46.7%	100.0%	



Out of the 24 patients with normal impedance, 14 had normal functioning in dye test and 10 had partial dysfunction in dye test.

Out of the 6 patients with impaired impedance – 3 had partial dysfunction and 3 had gross dysfunction in dye test.

There is statistically significant difference between impedance and dye test with p value <0.0001.

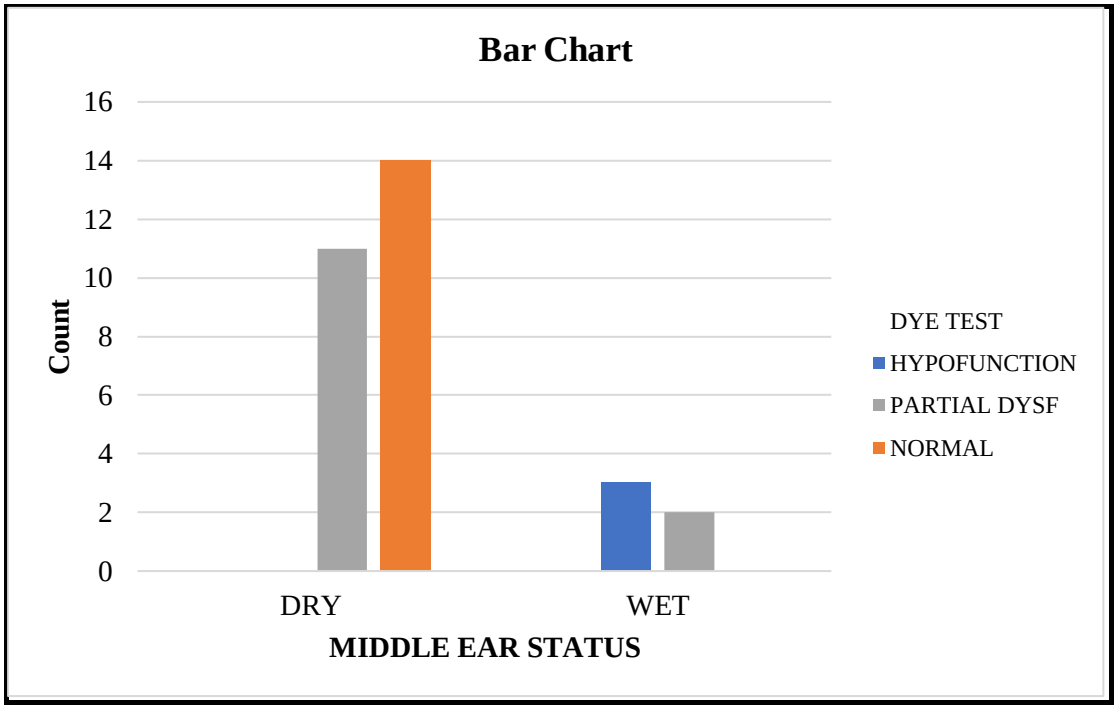
			Impedance		Total	P value
			Impaired	Normal		
Middle Ear Status	Dry	Count	1	24	25	<0.0001
		% with in Middle Ear Status	4.0%	96.0%	100.0%	
	Wet	Count	5	0	5	
		% with in Middle Ear Status	100.0%	0.0%	100.0%	
Total		Count	6	24	30	
		% with in Middle Ear Status	20.0%	80.0%	100.0%	

There is statistically significant difference in impedance between middle ear status performed $p<0.0001$.

Out of 25 patients with dry ear , 24 had normal impedance ,1 had impaired impedance .

Out of 5 patients with wet ear, 5 had impaired impedance.

			Dye test			Total	P value
			Gross dysfunction	Partial dysf	Normal		
Middle Ear Status	Dry	Count	0	11	14	25	<0.0001
		% within Middle Ear Status	0.0%	44.0%	56.0%	100.0%	
	Wet	Count	3	2	0	5	
		% within Middle Ear Status	60.0%	40.0%	0.0%	100.0%	
Total		Count	3	13	14	30	
		% within Middle Ear Status	10.0%	43.3%	46.7%	100.0%	



There is statistically significant in dye test between middle ear status $p<0.0001$. in our study out of 25 patients had dry ear- 14 (56%) had normal dye test while 11 patients (44%) had partial dysfunction in dye test.

Out of the 5 patients who had wet ear , 3 (60%) had a gross dysfunction of ET in dye test while 2(40%) , had partial dysfunction in the dye test.

DISCUSSION

Thirty patients both males and females , aged more than 12 years of different socioeconomic status were included in the study.

Patients were made to undergo routine investigations, pus culture and sensitivity, X Ray -mastoid , and pure tone audiogram.

Eustachian tube function was assessed with impedance audiometry and dye instillation test.

1. Impedance audiometry

24 (80%) patients had normal impedance while 6(20%) patients had impaired impedance.

2. Dye instillation test

14 (46.7%) patients had normal muco ciliary function

13 (43.3%) patients had partial muco ciliary dysfunction

And 3 (10%) patients had gross dysfunction.

3. 26 patients had unilateral CSOM while 4 of them had bilateral disease.

4. Middle ear was examined by oto endoscopy

25 (83.3%) Patients had dry ear

5 patients (16.7%) patients had wet ear.

5. Pneumatization was mastoid was assessed by X-ray mastoid

Which revealed 24 patients had well pneumatized mastoid, 6 patients had poorly pneumatized mastoid.

6. Patients with dry ear and normal dye test were taken for myringoplasty

Dry ear and partial dysfunction in middle ear were also taken for underlay myringoplasty and patients with wet ear and gross dysfunction in dye test were taken up for cortical mastoidectomy.

25 patients (83.3%) underwent myringoplasty

And 5 patients (16.7%) underwent cortical mastoidectomy.

7. Out of 19 patients who had anterior perforation, 10 of them had normal dye test; 7 had partial dysfunction and 2 had gross dysfunction.

Out of 5 patients with posterior perforation, 1 had normal dye test and rest 4 of them had partial dysfunction in dye test.

And out of remaining 6 patients in the study – 3(50%) had normal dye test and 2 had partial dysfunction and 1 had gross dysfunction.

8. The graft status was assessed by the oto endoscopy periodically

and , at the end of the 3rd month the graft was assessed again with the oto endoscopy, and pure tone Audiometry done after 3 months.

9. The outcome of the surgery was measured in the postoperative period which was divided into as follows,

   a) Successful (graft uptake) - the healed graft with proper middle ear aeration.

   b) Graft perforation as failure.

10. 14 patients in the study had normal dye test, of which 12 patients (85.7%) had graft uptake and is statistically significant.16 patients in the study had dysfunction in dye test. Out of which 8 patients had a graft uptake and is statistically significant.11 out of 13 patients with partial dysfunction and 1 out of 3 with gross dysfunction has graft uptake in our study.

11. Patients with normal dye test and anterior perforation had a better graft uptake following myringoplasty when compared to patients with mucociliary dysfunction.

12. Patients with normal impedance had well pneumatized mastoid.

13. Patients with normal muco-ciliary function in dye test had healthy and dry middle ear mucosa while patients with muco-ciliary dysfunction had wet middle ear mucosa.

Dr Kc Prasad et al shows that there is not a much a difference in disease prevalence among males and females. Our study comprised more females when compared to males.

In this study they used methylene blue and saccharine test to assess the muco-ciliary activity of eustachian tube.

Suresh palukuri et al reveals that most patients were in the age group of <35 yrs. However in our study maximum patients were in 31-40% of patients.

Sen et al in 1998 assessed ETF with impedance audiometry and results were 80% graft uptake in patients with normal ETF, 80% graft uptake in partially impaired ETF and 66% graft uptake in totally impaired ETF.

Abhinav Srivastava et al studied ventilatory function of eustachian tube and stated that there was a good graft uptake in patients with normal tubal function.

Bhatta .R et al used genitan violet as testing material to assess the muco-ciliary function.

Application of tragal pressures was not done as it forcefully pushes the testing agent in phayngotympanic tube.

Anirban biswas study on eustachian tube function test : a new dimension in management of chronic suppurative otitis media and

concluded that impaired tubal function is the major cause of persistent /recurrent otorrhea and important contributing factor for failure of tympanoplasty.

Jong woo chung et al studied that eustachian tube function measured by a modified pressure equilibration test using inflation-deflation manometric method was a good indicator of middle ear aeration and was predictive of better post op hearing.

Sato et al stated the percentage of unsuccessful outcomes increased with grade of tubal dysfunction and suggested that preoperative tubal function tests including positive pressure test and clearance are useful for predicting the outcomes of surgery.

Priya et al in 2012 assessed ETF using impedance audiometry. Those with normal ETF had 100% graft uptake and 76% graft uptake in impaired ETF

Kurein in 2009 found that diseased and edematous mucosa had a good graft uptake of 50% and dry ear had a better graft uptake of 69.5%.

J.Friedrick grimmer et al reveals that no single useful study for assessing the eustachian tube function completely.

In our study used dye test and impedance for assessing the tubal function.

CONCLUSION

- A functioning ET is an integral part of a normal middle ear & is an essential requirement for Optimum results after surgery for CSOM.
- Preoperative evaluation of Eustachian Tube Function thus becomes mandatory to decide the type of surgery for chronic suppurative otitis media patients.
- Impedance audiometry (Forced inflation test/passive test) & Methylene blue dye test are important tools to assess the functions of eustachian tube and mastoid pneumatization.
- We used methylene blue Dye test to assess the muco-ciliary function of eustachian tube and it was significant with post operative graft uptake (p value- 0.038).
- Dye test assesses the drainage pattern of ET and establishes the anatomical presence or absence of tube patency.
- Anterior perforation with normal muco-ciliary function group of patients has better graft uptake when compared to group of patients with muco-ciliary dysfunction.
- Mastoid pneumatization correlates with impedance audiometry
- Regular post operative follow up measures and care has to be taken to improve the outcomes of surgery for chronic suppurative otitis media.