"A COMPARATIVE STUDY OF INTERLAY AND UNDERLAY MYRINGOPLASTY IN CHRONIC OTITIS MEDIA"

By

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Under the Guidance of

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LIST OF ABBREVIATIONS

COM	⇨	Chronic Otitis Media
AOM	⇨	Acute Otitis Media
TM	⇨	Tympanic Membrane
PTA	⇨	Pure Tone Average
TM	⇨	Tympanic Membrane
EAC	⇨	External Auditory Canal
EP	⇨	Epithelium
LP	⇨	Lamina Propria
DNS	⇨	Deviated Nasal Septum
DNE	⇨	Diagnostic Nasal Endoscopy
PO	⇨	Post-Operative
A-B gap	⇨	Air-Bone gap

ABSTRACT

Background:

One of the common sequelae of chronic otitis media is tympanic membrane perforation which can cause hearing loss and otorrhoea, necessitating myringoplasty.[1]

There are mainly three goals to achieve in chronic otitis media surgery- an intact tympanic membrane, a middle ear cavity lined with normal mucosa and a long standing and effective sound conducting mechanism.[2]

The two traditional methods for repairing a perforation include underlay and overlay Myringoplasty. Each technique has its own advantages and disadvantages but repairing an anterior perforation remains a challenge because of remnant tympanic membrane perforation due to less support anteriorly and medialization of graft.

Objectives

1. To perform Interlay and underlay Myringoplasty in randomized patients diagnosed with mucosal type of chronic otitis media.
2. To compare the outcome of Interlay and Underlay Myringoplasty in terms of graft uptake, anterior blunting and improvement in hearing threshold.

Methods:

120 patients above 16 years of age diagnosed as COM in the department of Otorhinolaryngology and Head and Neck Surgery of R L Jalappa Hospital and Research Centre, Tamaka, Kolar from December 2015– March 2017 were included in the study. Patients diagnosed with mucosal type of chronic otitis media were taken up for the study

after taking informed consent. Patients fit for surgery were posted for Myringoplasty either under general or local anesthesia. The operative technique for each patient was determined using 6 block randomization technique. Based on this, patients were assigned into two groups A- interlay technique and B-underlay technique. Patients were assessed post-operatively after the 1st, 2nd and 3rd month. At each follow up Otoscopic examination was done to assess the graft take-up and anterior blunting, a pure tone audiometry was performed to assess the improvement in hearing.

Results

In the interlay group, the graft uptake was 93.3% and the mean postoperative Air-Bone gap at the 3rd month of follow up was 35.3 ± 3.6 dB. Whereas, in the underlay group the graft uptake was 88.3% and the mean postoperative Air-Bone gap at the 3rd month of follow up was 35.2 ± 4.6 dB. Anterior blunting was not seen in either technique

Conclusion:

Although there were statistically significant results in each technique, there wasn't a statistically significant difference between the results of each technique. Hence, both interlay and underlay grafting can be performed during surgery based on the convenience and skillset of the surgeon.

KEYWORDS:

Chronic Otitis Media, Tympanoplasty, Temporalis fascia graft, interlay, underlay.

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INTRODUCTION

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One of the common sequelae of chronic otitis media is tympanic membrane perforation which can cause hearing loss and otorrhoea, necessitating myringoplasty.[1]

There are mainly three goals to achieve in chronic otitis media surgery- an intact tympanic membrane, a middle ear cavity lined with normal mucosa and a long standing and effective sound conducting mechanism.[2]

The two traditional methods for repairing a perforation include underlay and overlay Myringoplasty. Each technique has its own advantages and disadvantages but repairing an anterior perforation remains a challenge because of remnant tympanic membrane perforation die to less support anteriorly and medialization of graft.

"Underlay" technique is the most commonly performed type of Myringoplasty. In this technique, there are chances of medialization of the graft, reduction of middle ear space, a longer healing time and is less suitable for large anterior perforations.[3] Whereas in "Overlay" technique, there are chances of anterior canal wall blunting, lateralization of the graft, excessive membrane thickness and also a longer duration of healing.[3] The interlay technique has certain added advantages over the other grafting techniques due to lesser chances of medialization compared with underlay technique and minimal blunting of the tympanomeatal angle thus reducing chances of anterior remnant perforation.[4]

A review of literature in otorhinolaryngology suggests that there is paucity in data comparing the interlay and underlay grafting technique and therefore the purpose of this study is to compare interlay with underlay grafting technique.

OBJECTIVES

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REVIEW OF LITERATURE

REVIEW OF LITERATURE

Chronic suppurative otitis media (CSOM) is quite common in India and presents in all age groups. Subtotal and large perforations of the tympanic membrane are found in a large number of cases.

The operative surgery for repair of a tympanic membrane perforation is a Myringoplasty.[4] Modern techniques can be traced to Zollner and Wullstein. Today, the three most popular types of grafting techniques for Myringoplasty are the underlay, overlay and interlay techniques which are classified based on the placement of the graft in relation to the remnant tympanic membrane:

a) Underlay technique- graft placed medial to the mucosal layer.[4]

b) Overlay technique- graft place lateral to the fibrous layer of tympanic membrane after the squamous epithelium is elevated.

c) Interlay technique- graft placed between fibrous and endothelial layer.

"Underlay" technique is widely used and is relatively simpler to perform as the graft is placed entirely medial to the remaining drum and malleus.[4] This technique is ideal to repair small and easily visualized perforations, blunting and lateralization of the graft is relatively less, the drum heals at the correct level relative to the annulus and the ossicles and is quick and easy to perform.[4]On the other hand, its disadvantages are that the middle ear space is reduced and adhesions may occur, exposure of the middle ear is relatively limited and it is not the ideal technique for perforations extending into the anterior annulus since placement of the graft is difficult.[5] In contrast, the overlay technique is

more challenging and typically reserved for total perforations, anterior perforations, or failed underlay surgery.[5]

In the "Overlay" technique, the graft is placed lateral to the annulus and any remaining fibrous middle layer has to be carefully removed .[5]In this technique there is excellent visualization of the anterior meatal recess, which is important in cases of perforations reaching the annulus.[5] In addition, the healing rate is high because the drum is essentially replaced intact .[5] The most serious disadvantages are, blunting of the anterior meatal recess, the lateralization of the graft and iatrogenic cholesteatoma.[5]The technique is more laborious and the healing time is longer.

In "interlay technique", the graft is placed in between the mucosal and fibrous layers of the remnant tympanic membrane.

The various advantages of this technique over "overlay" technique include:

a) Rapid epithelialization compared to other techniques.[5]

b) Minimal blunting compared to overlay as the anterior sulcus is lined by skin.[5]

c) Nil drum lateralization.[4]

d) Not associated with epithelial cyst formation.

e) Myringitis due to endothelial overgrowth on the graft is avoided.

The advantages over "underlay" technique include:

a) Less medialization thereby reducing chances of anterior remnant tympanic membrane perforation.[5]

b) Less reduction in middle ear space compared to other techniques.[4]

Interlay technique of grafting in type 1 Tympanoplasty for a large central perforation results in excellent graft uptake and post-operative improvement in hearing.[5] In interlay technique there was a successful graft uptake of 96%. Whereas only 85.7% in overlay, underlay or a combined technique. [5]

The post op air-bone gap was <10 dB in 76% of patients, 11-20 dB in 18% of cases, 21-30db in 4% and >30db in 2 %. [5] Whereas in underlay technique, the air-bone gap was <10 dB in only 63.2% of patients.[5] Complications took place in 6 out of 100 cases. Out of which, four cases had a residual perforation and 2 cases developed partial flap necrosis in the posterior part of tympanomeatal flap.[6]

It was also observed that the tympanosclerotic plaques present in the tympanic membrane can be easily excised without damaging the remnant epithelium once the interlay plane is achieved.[5]The graft healing time is better in interlay compared to other grafting techniques. In interlay technique the average period for complete epithelialization was 16.1 days after surgery.[6]Complete epithelialization took 6-8 months in 75% of patients with the overlay method and more than 30 days in 63% of patients with the underlay method.[6]

In conclusion, most previous studies have stated that interlay technique is superior to underlay and overlay techniques in respect to graft uptake, hearing improvement and healing period. But, most studies are retrospective without adequate follow up studies. Hence, our aim was to perform a prospective study with regular follow up and documentation.

SURGICAL ANATOMY:

External ear

The primary function of the external ear is transmission of sound from an external source to the middle ear. It consists of the pinna or auricle and the external acoustic meatus.

Development of external ear

Primordium of the external acoustic meatus is the dorsal end of the first external branchial cleft, in related medially to the mesoderm separating it from the tub tympanic recess. The primitive meatus present at the fourth week is replaced by a solid core of ectodermal (epithelial cells) which persists from the 8^{th} until the 28^{th} week, when it undergoes canalization by dissolution of cells from within outwards.

The development of pinna begins at 4 weeks as tissue condensations of the mandibular and hyoid arches appear at the distal portion of the first branchial groove. Within 2 weeks, six ridges known as hillocks of His, arise from the tissue condensations. The tragus and the anterior external auditory canal arise from the mandibular arch, while the rest of the pinna arises from hyoid arch. The Darwinian tubercle, corresponding to the tip of pinna in lower mammals, is seen roughly at 6 months. Adult configuration is achieved by the 5^{th} month, independent of developmental progress in the middle and inner ears.[7]

Auricle

A thin, convoluted, continuous sheet of yellow elastic cartilage forms the shape of the auricle that curves forward to enclose the floor and anterior wall of the external cartilaginous meatus but not the roof. Superiorly the cartilage of the meatus is deficient,

leaving a deep cleft, the incisura terminalis. This is utilized by the surgeon in making the extra cartilaginous endaural incision for surgical exposure of the temporal bone.[7]

The auricle is connected by two extrinsic ligaments to the temporal bone. The anterior ligament runs from tragus and from a cartilaginous spine on the anterior rim of the crus of the helix to the root of the zygomatic arch. Posterior ligament runs from the medial surface of the concha to the lateral surface of the mastoid prominence.[8]

The helix is the curved rim and on its postero- superior aspect is a small tubercle- Darwin's tubercle. Anterior and parallel to the helix is the antihelix. Superiorly this divides into two crus, between which is the triangular fossa; the scaphoid fossa that lies above the two crura. In front of the antihelix and partly encircling it is the concha. The anterior superior part of the concha is usually covered by the descending part of the anterior superior portion of the helix. This is called the cymba concha, which is in direct superior relation with the suprameatal triangle. Below the crus of helix and opposite to the concha, across the external auditory canal is tragus. The medial surface of auricle has elevation corresponding to the depressions on the lateral surface and possesses corresponding names. The cartilage depends on the perichondrium for nutritional supply.[9]

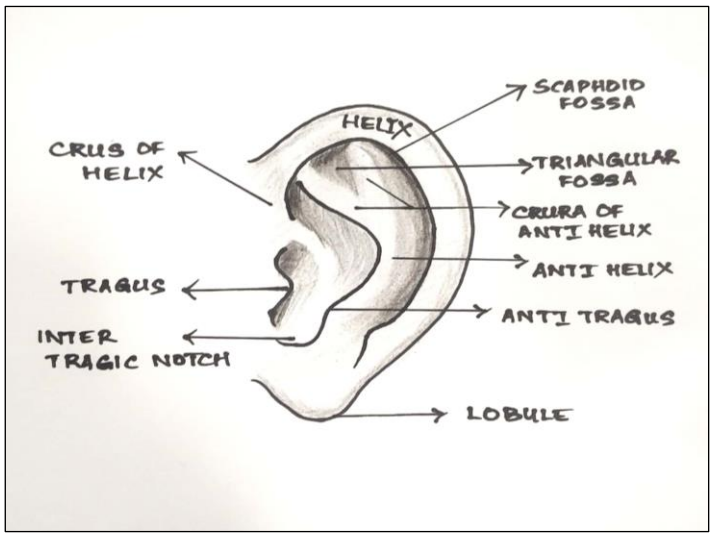


Figure 1: Left Pinna

Blood supply

It is derived from posterior auricular and superficial temporal arteries. The arteries form a network and communicate over the antihelix.[10]

Nerve supply

Lateral surface of the auricle is supplied by the auriculotemporal nerve (superior aspect) and greater auricular (inferior aspect), the medial surface by the lesser occipital (superiorly) and great auricular nerve (inferiorly) and the concha by the auricular branch of the vagus. [11]

Lymphatic drainage

The lymphatics drain into the preauricular, post auricular and superficial cervical lymph nodes.[12]

External auditory canal

It is a communicating passage between the pinna and tympanic membrane. In adults, the average length is 24 mm. It is composed of an outer cartilaginous portion which is around 8 mm in length and an inner bony portion which is around 16 mm long and it is slightly constricted in the middle by an isthmus. Since the tympanic membrane lies obliquely at the inner end of the meatus the anterior and inferior walls are longer than the posterior and superior walls.

The cartilaginous portion is oval in section with a backward convexity continuous with the cartilage of the auricle. The direction is medially upwards and backwards, while that of the bony meatus is medial slightly downwards and forwards.

At the junction of the inferior wall with the tympanic membrane there is a depression the inferior meatal recess. This recess can be difficult to visualize and can act as an unsuspected reservoir of debris in an infected ear. There are two constrictions in the canal, one at the junction of the cartilaginous and bony part and the other, in the osseous part 5 mm from the tympanic membrane, where a prominence of the anterior canal wall reduces the diameter.

In cartilaginous part, the fissure of Santorini provides a potential path of infection between the parotid gland and the superficial mastoid region. Foramen Huschke is the deficiency in the anteroinferior part of the bony part of the external auditory canal in adults.

The meatus may be partially straightened in the adult by pulling the auricle upwards, outwards and backwards. However, in neonates, there is virtually no bony external meatus as the temporal bone is not yet developed and the tympanic membrane is more horizontally placed. The auricle must hence be pulled downwards and backwards for a view of the tympanic membrane.[13]

The external auditory meatus is lined by skin continuous with the auricle and extends over the tympanic membrane. The cartilaginous part contains hair follicles, sebaceous and ceruminous glands, which are absent in the bony part. The skin in the bony portion is firmly attached to the periosteum and is very thin whereas in the cartilaginous portion the subcutaneous tissue attaches the skin firmly to the perichondrium, which accounts for the pain and tenderness of the furuncle in the cartilaginous portion.

Blood supply

The auricular branches of the superficial temporal artery supply the roof and anterior portion of the canal. The deep auricular branch of the first part of the maxillary artery arises in the parotid gland in the temporomandibular joint, pierces the cartilage or bone of the external meatus and supplies the anterior meatal wall skin.[10] The auricular branches of the posterior auricular artery pierce the cartilage of the auricle and supply the posterior portions of the canal.

Venous drainage

Veins drain into the external jugular vein, the maxillary vein and the pterygoid plexus.[10]

Lymphatic drainage

The lymphatics of the tragus and anterior external portion of the auricle drain into the superficial parotid lymph nodes, the posterior external and medial aspect of the auricle into the retroauricular lymph nodes and of the lobule and inferiorly of the external auditory canal drains into the superficial cervical group of nodes.[13]

Tympanic membrane

It is an elliptical disc stretched obliquely across the medial end of external auditory canal. It is broader above than below forming an angle of 55° with the floor of the external auditory canal. It forms the lateral wall of the mesotympanum and small part of the epitympanum, separating the tympanic cavity from the external auditory canal. It is convex towards the tympanic cavity. The diameter from posterosuperior to anteroinferior is 9-10 mm; perpendicular to this is 8-9 mm. The circumference is thickened to form a fibro cartilaginous ring, the tympanic annulus which is lodged in a groove in the temporal

bone, the tympanic sulcus. This sulcus does not extend to the roof of the canal, which is formed by the squamous portion of the temporal bone. Form the superior limits, the annulus becomes fibrous bands which run centrally as anterior and posterior malleolar folds to the lateral process of malleus. The malleolar folds divide the tympanic membrane into pars flaccida and pars tensa. Pars flaccida is a triangular region of tympanic membrane above the malleolar folds, while pars tensa forms rest of tympanic membrane. The handle of malleus lies within the layers of the tympanic membrane.[10,13]

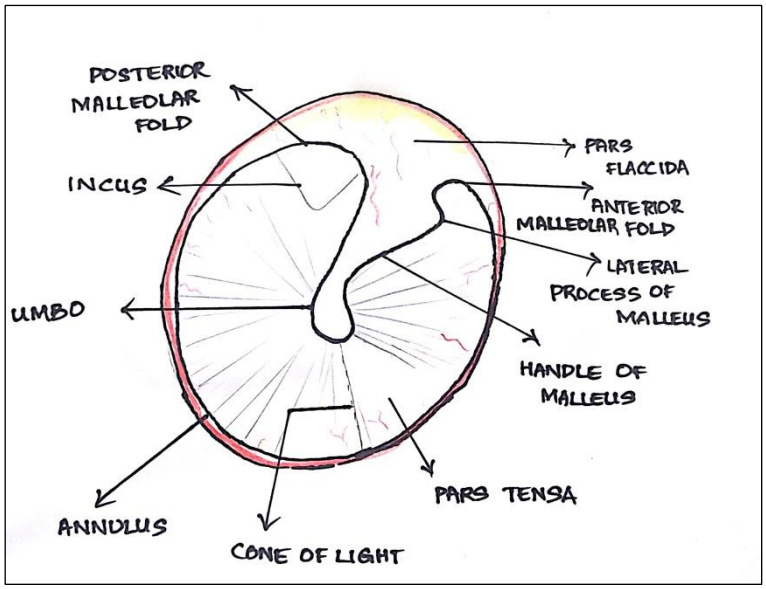


Figure 2: Right tympanic Membrane

Blood supply:

Vessels supplying the tympanic membrane lie in connective tissue layer of the lamina propria. This layer has peripheral rim of arteries connected by radial anastomosis. The arteries involved are:

Lateral surface: Deep auricular branch of maxillary artery.

Medial surface:

(a) Posteriorly – stylomastoid branch of the posterior auricular artery.

(b) Anteriorly: Tympanic branch of maxillary artery.

(c) Twigs from middle meningeal artery.

Nerve supply

Lateral surface:

(i) Anterior half by auriculotemporal branch of the fifth cranial nerve.

(ii) Posterior half by auricular branch of vagus nerve. Medial surface is supplied by tympanic branch of the glossopharyngeal nerve.

Venous drainage

Veins drain into external jugular vein, traverse sinus, dural sinus and venous plexus around the eustachian tube.

Histology of the tympanic membrane

Tympanic membrane consists of three layers:

(a) Outer epidermal layer

(b) Middle fibrous layer – lamina propria

(c) Inner mucosal layer

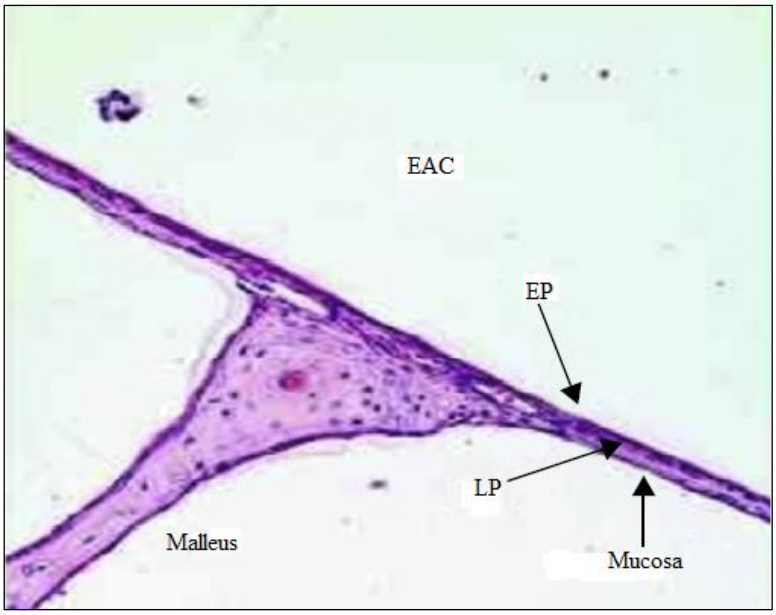


Figure 3: Histology of tympanic membrane

(a) **Outer epidermal layer**

This layer is continuous with the skin of the external auditory canal, it contains four layers.

Stratum corneum: Outermost layer contains 1-6 compressed layers of cellular structure.

Stratum granulosum: Contains 1-3 layers of cells with smooth borders and inter connecting desmosomes, keratohyaline granules, and lamellar granules and occasionally monofilaments are present.

Stratum spinosum: Contains 2-3 layers of cells. It has prominent interdigitations with neighboring cells. Cells contain fewer bundles of monofilaments with mitochondria and ribosomes.

Stratum basale: Contains single layer of cells separated by lamina propria, cells are polyhedral in shape or elongated parallel to the basement membrane.[14]

(b) **Lamina propria**

This is more marked in pars tensa. It contains sub epithelial connective tissue layer, outer radiate collagenous layer, inner circular collagenous layer and submucosal connective tissue layer. In pars tensa the lateral fibers are radially arranged, and deeper fibers are arranged in a circular, parabolic or transverse fashion. The arrangement in pars flaccida is more random.[14]

c) **Mucosal layer**

It is the innermost layer. The cells are simple squamous or cuboidal or columnar ciliated in pars tensa, whereas in pars flaccida taller ciliated cells are not found.[14]

Middle ear cleft

It consists of the eustachian tube, the tympanic cavity, the adieus and the mastoid air cell system. It is lined by a continuous layer of epithelium of respiratory type. Near the eustachian tube and anteroinferior part of the tympanic cavity it is columnar epithelium. Above and behind this level the epithelium is flattened.

Development

The tympanomastoid compartment appears at three weeks as an out pouching of the first pharyngeal pouch known as the tubotympanic recess. The endodermal tissue of the dorsal end of this pouch eventually becomes the Eustachian tube and tympanic cavity. By 7 weeks, concomitant growth of second branchial arch constricts the midportion of the

tubotympanic recess, the primary tympanic cavity lies lateral and primordial eustachian tube lies medial to this constriction. The terminal end of the first pharyngeal pouch buds into four sacci (anticus, posticus, superior and medius) which expand progressively to pneumatize the middle ear and the epitympanum. Expansion of the sacci envelops the ossicular chain and lines the tympanomastoid compartment, whereas the interface between two sacci gives rise to mesentery like mucosal folds, transmitting blood vessels.

By 21 weeks, pneumatization reaches the antrum. The tympanic cavity is essentially complete by 30 weeks. Mastoid pneumatization is evident as early as 33 weeks and proceeds by well-established tracts. [15]

By birth, the antrum approximates that of the adult. Mesenchymal resolution continues as late as one year post-natal. Similarly, mastoid continues to grow for up to 19 years after birth. The first evidence of ossicular development in the humans occurs at approximately 4 weeks. The first arch (Meckel's cartilage) through cartilaginous differentiation gives rise to primordial malleus and incus. Stapes is derived from 2nd arch (Reichert's cartilage) except for the medial surface of footplate and the annular ligament, which are of otic capsular origin.[15]

The tensor tympani and stapedius muscle develop from the mesenchyma of first and second branchial arches. The ossicles assume adult configuration by 20 weeks.

The ossicular chain has enchondral bone development. The anterior process of the malleus is unique in that it develops as membranous bone without a cartilaginous model. Development of stapes blasteoma involves progressive encirclement of the stapedial artery. The obturator foramen represents the complete ring left empty after the stapedial artery involutes.

By 15 weeks, the ossicles attain adult size and ossification soon begins, first in incus, then in the malleus and finally in the stapes. [15]

Eustachian tube

The tube is about 36 mm long in the average adult, it connects the tympanic cavity with the nasopharynx. It is directed downwards, forwards and medially from the middle ear. There are two parts, a lateral bony posterior part arising from the anterior wall of the tympanic cavity and a medial fibro cartilaginous part entering the nasopharynx. The tube is lined by respiratory mucosa. The bony portion is 12 mm long. Isthmus is the narrowest portion which is only 2 mm in diameter. The cartilaginous portion of tube is about 24 mm. the lower opening lies behind and on a level with the posterior end of the inferior turbinate. In infants the tube is more horizontal and relatively wider and shorter than in adults. The tensor palate muscle helps in opening the tubal end on swallowing and yawning. [10,13]

Blood supply

It is supplied by ascending pharyngeal and middle meningeal arteries.

Venous drainage

Veins drain into pterygoid venous plexus.

Lymphatic drainage

Lymphatics drain into retropharyngeal nodes.

Nerve supply

Pharyngeal branch of the sphenopalatine ganglion (Vb) for the ostium, the nervus spinosus (Vc) for the cartilaginous portion and from the tympanic plexus (IX) for the bony part.[10]

Middle ear cavity

It lies between the external ear and inner ear and measures about 15 mm above downwards and 13 mm from behind forwards. It is very narrow in its transverse diameter measuring 6 mm across in the upper part, 4 mm in its lower part and 2 mm at its center which is the narrowest part.

It has six walls; floor, roof, and medial, lateral anterior and posterior walls. It is divided into 3 compartments.

1. The epitympanum or attic lies above the level of the anterior and posterior malleolar folds.
2. Mesotympanum lies medial to the tympanic membrane.
3. Hypotympanum, lies below the level of the inferior part of the tympanic sulcus medially.

Roof

It is formed by Tegmen tympani which is formed partly by petrous part and partly by the squamous portion of the temporal bone. This wall separates the middle ear cavity, mastoid antrum and canal of tensor tympani from the middle cranial fossa. Incomplete ossification of the petrosquamous suture may allow passage of infection from the middle

ear cavity or mastoid antrum to the middle cranial fossa. Similarly, venous channels passing through this fissure may allow infection to reach the superior petrosal sinus.[16]

Floor

It is formed by a thin plate of bone which separates the middle ear cavity from the dome of jugular bulb. In some patients, the floor may be deficient and thus the jugular bulb can project into the tympanic cavity.[17] Anteromedial to the vein, the tympanic branch of the glossopharyngeal nerve pierces the floor on its way to ramify over the promontory in the formation of the tympanic plexus.

Anterior wall

The anterior wall which is vertical is angulated acutely with the floor forming a hypotympanic recess where secretions accumulate. The portion of the recess is indicated by the 'cone of light' on the membrane, whose base points towards it.

This wall has four openings. The eustachian tube opening is seen in the lower part of the anterior wall. A thin plate of bone separates the eustachian tube and the middle ear from the internal carotid artery, which is perforated by caroticotympanic nerves derived from the sympathetic plexus on the internal carotid artery sheath. The canal for tensor tympani muscle is above the opening for eustachian tube. Canal of Huguier is a small opening in the upper part which transmits chorda tympani nerve. Glasserian fissure is the 4^{th} opening, which transmits tympanic artery and anterior ligament of malleus.

Posterior wall

It is wider above than below and has in its upper part the opening (aditus) into the mastoid antrum. This is a large irregular hole that leads back from the posterior

epitympanum. Below the aditus is a small depression, the fossa incudis, which houses the short process of the incus and the ligament connecting the two. Inferior to the fossa incudis is the pyramid, a conical projection with its apex pointing anteriorly. It contains stapedius muscle, the tendon of which passes forward to be inserted into the neck and posterior crura of the stapes. Between the pyramid and the tympanic annulus is the facial recess. This is bounded medially by the facial nerve and laterally by the tympanic annulus, the chorda tympani runs between the facial nerve and tympanic annulus. This nerve always runs medial to tympanic membrane, which means that the angle between the facial nerve and the chorda allows access to the middle ear from the mastoid without disruption to the tympanic membrane.

Sinus tympani is the posterior extension of mesotympanum deep to the pyramid and the facial nerve. This extension of air cells into the posterior wall can be extensive when measured from tip of the pyramid, the sinus can extend as far as 9 mm into the mastoid bone.[18] The medial wall of the sinus tympani becomes continuous with the posterior portion of the medial wall of the tympanic cavity.

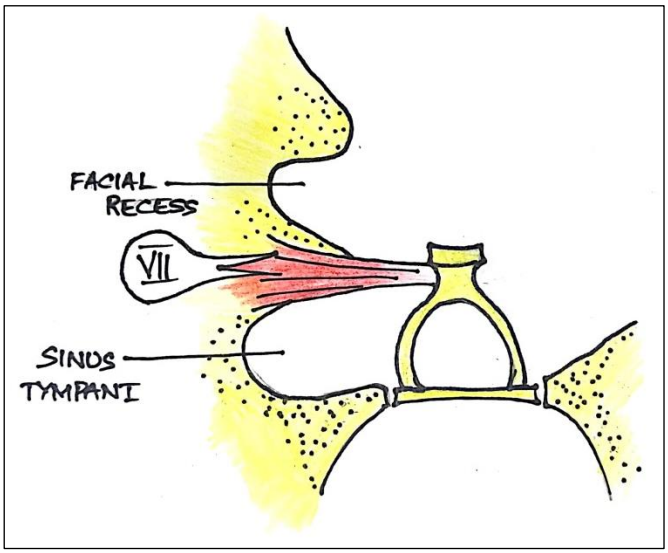


Figure 4: Sinus tympani

Medial wall of tympanic cavity

The medial wall separates the tympanic cavity from the inner ear. Its surface possesses several prominent features and two openings. The promontory is a rounded elevation occupying much of central portion of the medial wall, over whose surface is the nerves which form the tympanic plexus. The promontory covers part of the basal coil of cochlea and in front merges with the anterior wall of the tympanic cavity.

Behind and above the promontory is the fenestra vestibuli (oval window), a kidney shaped opening that connects the tympanic cavity with the vestibule, which in life is closed by the foot plate of the stapes and its surrounding annular ligament. The long axis of fenestra vestibuli is horizontal. The size is 3.25 mm long and 1.75 mm wide. Above the fenestra vestibuli is the facial nerve and below is the promontory.

The fenestra cochlea (round window) which is closed by the secondary tympanic membrane (round window membrane) lies below and a little behind the fenestra vestibuli from which it is separated by a posterior extension of the promontory called the subiculum. Occasionally a spicule of bone extends from promontory above the subiculum and runs to the pyramid on the posterior wall of the cavity. This spicule is called the ponticulus.

The round window niche is triangular in shape, with anterior, posterosuperior and posteroinferior walls. The latter two meets posteriorly and lead to the sinus tympani. The average lengths of the walls are: anterior – 1.5 mm, superior – 1.3 mm and posterior – 1.6 mm. The shape of the round window membrane varies from round through oval and kidney shaped the spatulate, with the average longest and shortest diameters of 2.30 mm and 1.87 mm respectively.

The round window membrane consists of three layers: outer mucosal, middle fibrous and inner mesothelial layer. The mucosal layer contains the capillaries and nerves.

The membrane of the fenestra cochlea forms part of its floor. The Scala tympani terminate posterior and medial to the membrane. The ampulla of the posterior semicircular canal is the closest vestibular structure to the membrane and its nerve (singular nerve) runs almost parallel to and 1 mm away from its medial attachment. The membrane is thus a surgical landmark for singular nerve.

The facial nerve canal runs above the promontory and fenestra vestibuli in an anteroposterior direction. It is marked anteriorly by processus cochleariformis, which is a curved projection of bone, concave anteriorly and houses the tendon of tensor tympani muscle as it turns laterally to the handle of malleus. Behind the fenestra vestibuli, the facial canal starts to turn inferiorly as it begins its descent in the posterior wall of the tympanic cavity. The dome of lateral semicircular canal extends lateral to facial canal and is the major feature of the posterior portion of the epitympanum.

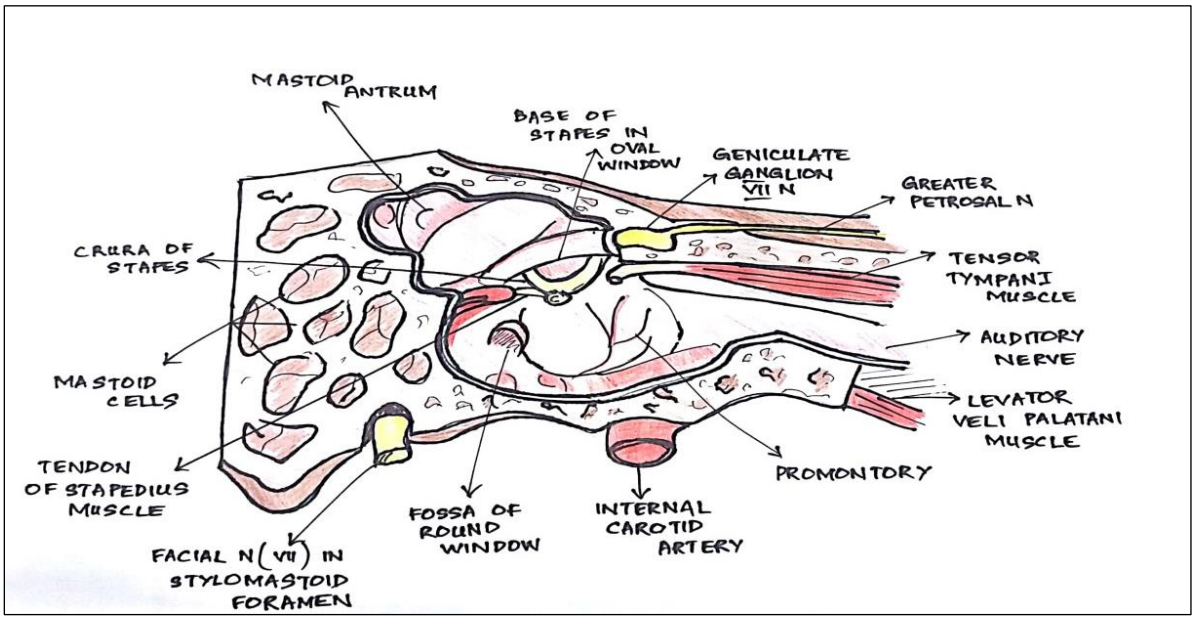


Figure 5: Medial wall of the middle ear

Lateral wall

It is mainly composed of the tympanic membrane. Scutum or (outer) attic wall is party wall between the epitympanic recess and the roof of the external auditory meatus. The fibro cartilaginous circumference of the pars tensa of the tympanic membrane is fixed into the tympanic sulcus. The upper limits of the sulcus are marked behind by the posterior canaliculus and in front by the anterior canaliculus of the chorda tympani nerve. The anterior canaliculus is placed at the medial end of petrotympanic fissure, which lodges the anterior ligament of the malleus and admits the anterior tympanic branch of the maxillary artery. The contents of middle ear cavity are: auditory ossicles, muscles, chorda tympani nerve and facial nerve.

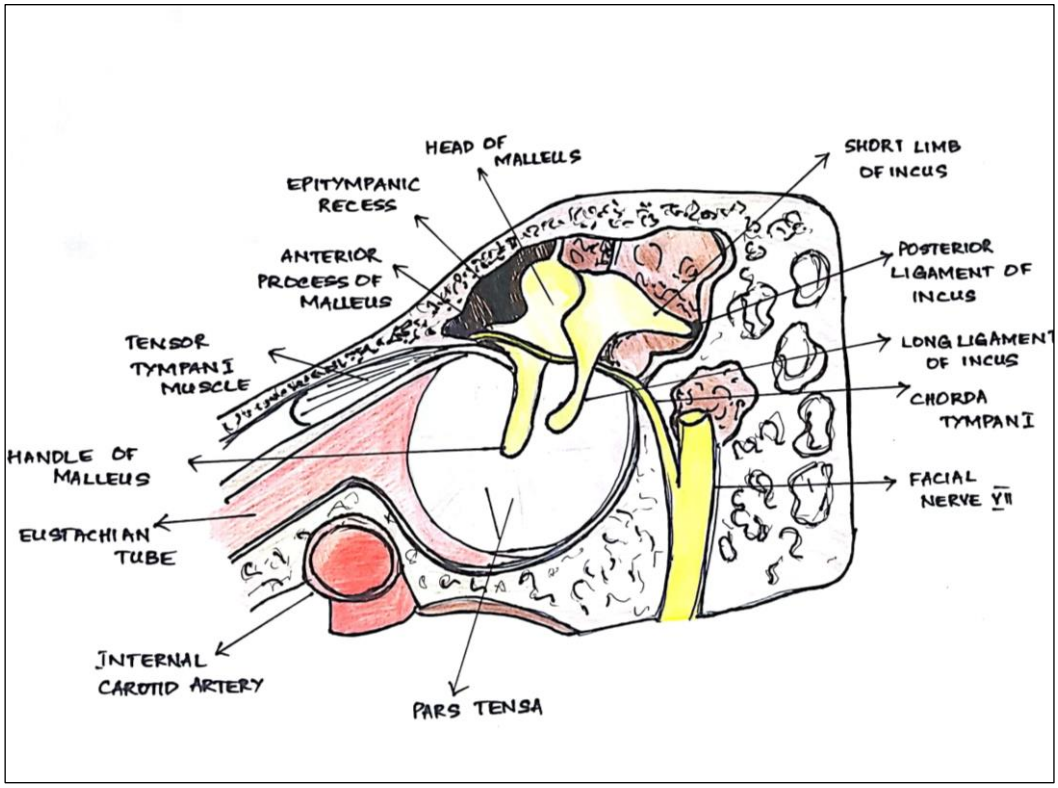


Figure 6: Lateral wall of the middle ear

Ossicles

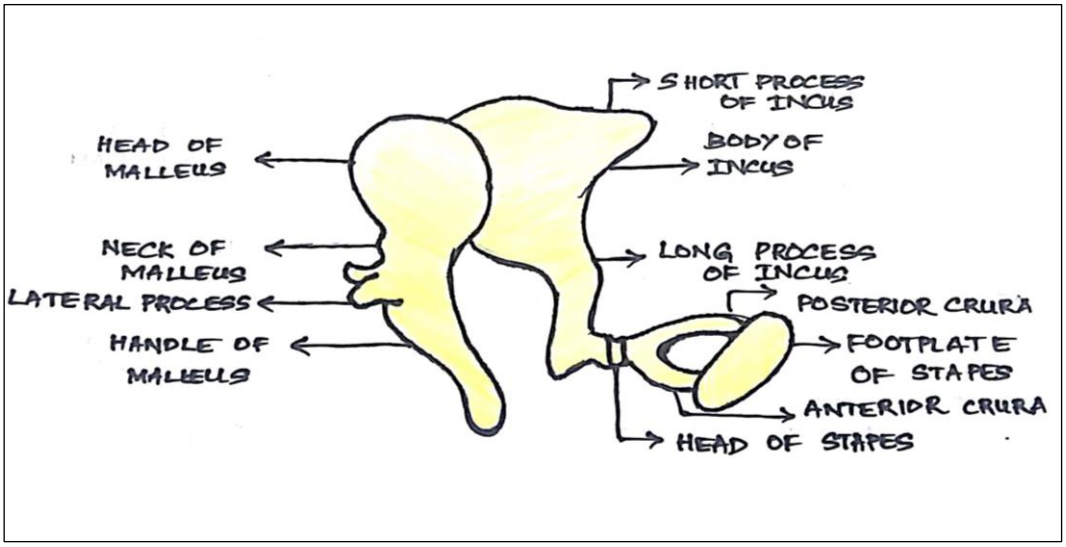


Figure 7: Assembly of the ossicles

1. Malleus

It is about 7.5 mm in length, has a head, neck, anterior and lateral (short) process and a handle. The head is in the attic or in the epitympanic recess of the middle ear. The handle or manubrium is crescentic, concave laterally. The lower horn of the crescent terminates flatly at the umbo. The upper horn projects into the lumen of the external meatus as the lateral process. The neck is set at about 135° to the medial aspect of the handle, where the upper quarter joins the lower three quarter.

The anterior surface of the neck is thickened and drawn forwards into a small spicule known as the anterior process, which is connected to the petrotympanic fissure by ligamentous fibers, occasionally augmented by muscle fibers (luxator tympani muscle).

2. The incus

It consists of a body and two processes. The processes are set on to the body at right angles to each other. The long process is slender, and descends posteromedial and parallel to the slightly longer handle of malleus. The lower end of the long process is bent inwards

and surmounted by a small tubercle covered with cartilage, the lentiform nodule, which articulates with the head of the stapes. The short process is thicker and shorter and passes horizontally backwards to obtain lodgment and ligamentous attachment to fossa incudis.

A shallow saddle shaped depression in the anterior face of the head of the incus accommodates the convex facet on the posterior aspect of the head of the malleus. This joint allows a rotatory gliding movement. The excessive motion of the malleus on its outward swing is countered by the disengagement mechanism, while excessive inward swing is believed to be opposed by the mutual action of tensor tympani and stapedius muscle.

3. The stapes

The stapes consists of the head, neck, two crura (limbs) and a footplate. The footplate of the stapes is around 3mm x 1.4mm wide and covers the fenestra vestibule where it attaches to the bony labyrinth by an annular ligament. To the footplate is attached the two crura. The head of the stapes articulates with the lenticular process of the incus. The stapedius muscle is inserted into the posterior part of the neck and the upper portion of the posterior crura.

Auditory muscles

The two auditory muscles tensor tympani and stapedius muscle exert a dampening effect on the amplitude of the vibratory waves, thus protecting the cochlea from excessive stimulation by loud noise.[19]

Tensor tympani

It arises from cartilaginous portion of auditory tube, the adjoining portion of greater wing of the sphenoid, as well as from bony canal, above the auditory tube. It passes backwards in a tendon, round the processes cochleariformis and is inserted into the medial aspect of the upper end of the handle of malleus. It has got definite frequency selectivity for its contractions at 0.5 to 1 kHz resulting in decreased conductivity.

Nerve supply

Supplied by mandibular division of Vth nerve, via a branch leaving the nerve to the medial pterygoid muscle

Stapedius

It is housed in a bony cavity. The tendon is seen issuing from the orifice of the pyramidal projection on the posterior wall at the posterior end of fenestra vestibuli. It is inserted into the posterior aspect of the neck of stapes.

Nerve supply

It is innervated by nerve to stapedius branch from facial nerve.

Vessels and nerves of the tympanic cavity

There are six arteries of the tympanic cavity:

1. Anterior tympanic branch of maxillary artery supplies the tympanic membrane.

2. Stylomastoid branch of posterior auricular artery supplies posterior part of the cavity and mastoid air cells.

3. Superficial petrosal branch of middle meningeal artery, which enters through the hiatus for the greater petrosal nerve.

4. Superior tympanic branch of middle meningeal artery enters via canal for tensor tympani.

5. Inferior tympanic branch from ascending pharyngeal artery accompanying the tympanic branch of the glossopharyngeal nerve.

6. Carotico tympanic branch of internal carotid artery passes directly into the cavity through the anterior wall.

Venous drainage

Veins drain into pterygoid plexus and superior petrosal sinus.

Lymphatics drainage

The lymph vessels of the epithelial lining of the tympanum and mastoid antrum pass to the parotid and upper deep cervical lymph nodes.

Nerve supply

The nerves are contributory to or derivative from a plexus which ramifies over the promontory.

Tympanic plexus

It is formed by:

1. Tympanic branch of glossopharyngeal nerve.

2. The superior and inferior caroticotympanic branches of the sympathetic plexus of internal carotid artery.

It supplies:

1. The lining membrane of the tympanic cavity, mastoid air cells and auditory tube.

2. A branch of greater superficial petrosal nerve.

3. Lesser superficial petrosal nerve. It is a continuation of the tympanic branch of the glossopharyngeal nerve which passes through the foramen ovale to the otic ganglion, from this post-ganglion secretomotor fibers are relayed via the auriculotemporal nerve to the parotid gland.

Mastoid air cell system[10,13]

In most of adult population, an extensive system of interconnecting air-filled cavities arises from the walls of the mastoid antrum and sometimes even from the walls of the epitympanum and mesotympanum. These air cells like the mastoid itself are lined with a flattened non-ciliated squamous epithelium. Pneumatization can be very extensive (cellular or well aerated).

Alternatively, the mastoid antrum may be the only air-filled space in the mastoid process when the name acellular or sclerotic is applied. This condition is noted in about 20% of adult temporal bones. In between these two forms are the so called diploeic or mixed types where air cells are present but are interspersed with marrow containing space that have persisted from the late fetal life.

Temporalis fascia

Temporalis muscle is covered by deep temporal fascia which in turn is covered by superficial temporal fascia.[20] It is a strong aponeurosis overlapped by auricularis anterior and superior, the epicranial aponeurosis and part of orbicularis oculi. The superficial temporal vessels and the auriculotemporal nerve ascend over it. Above it is a single layer, attached to whole of the superior temporal line, below it has two layers, one attached to the lateral and other to the medial margin of the upper border of the zygomatic arch between these layers are the zygomatic branch of superficial temporal artery, zygomatic temporal branch of the maxillary nerve and small quantity of fat.

The deep surface of the fascia offers attachment to the superficial fibers of temporalis. The size of this fascia alters with its hydration.[21]

Physiology of conduction of sound[22]

Hearing is the vital basis for acquisition in speech and language and these skills in turn are most important tools of constructive thought. The sound conducting mechanism comprising the ossicles which forms a link extending from the pinna to the organ of corti. Its functions include:

1. Collection and transmission of sound energy involving impedance matching at every stage and particularly matching between the external air and cochlear fluids.

2. Protection of the inner ear from the excess loud sounds, a function carried out by the tympanic muscle sacrificing the sensitivity of low intensity sound levels.

Middle ear sound conduction[23]

The sound waves in air cannot be transmitted efficiently to the fluid medium which fills the cochlea without the help of some device to overcome the impedance mismatch. The role of middle ear is to match these impedances by acting as an acoustic sound pressure transformer. It also has to provide for acoustic separation of the round window from oval window if movement of stapedial foot plate is to be transmitted to the perilymph in the cochlea. The round window membrane provides the elasticity needed for the transmission of the sound wave into the fluid medium. If an incident sound wave falls on the oval and round windows simultaneously, the perilymph column will be unmoved, because the pressure exerted by the footplate at the oval window would be exactly resisted by pressure, acting in the opposite direction on the round window membrane. This difficulty is overcome by protection of the air cushion within the tympanum and by the preferential channeling of the sound waves from the tympanic membrane through the ossicular chain to the oval window. By these means the round window is acoustically isolated from the oval window.

Ossicular movement[22,23]

The vibrations of the tympanic membrane are conveyed to the malleus through its handle. The malleus and incus move as one functional unit, except at very high intensity, rotating in and out through a tiny arc, about an axis which passes from the anterior process of the malleus backwards to the end of the short process of the incus. The oscillating movement of the stapes in the oval window, received from the long process of the incus, is in and out, like that of a piston, when amplitude is low. At higher amplitude the footplate executes a rocking motion about a vertical axis through its posterior edge. When the stapedius muscle contracts, in response to sound pressure levels 80 dB or more

above the threshold, the mode of stapes movement may change to one of longitudinal rotation about its long axis. This form of vibration attenuates sound levels reaching the cochlea, especially in the low frequencies.[19]

Sound pressure transformation

The problem of impedance matching, so that relatively light and inelastic air can impart its energy to relatively dense and highly elastic fluid, solved by two mechanisms – ossicular lever action and hydraulic action. The pressure of sound waves on the stapes footplate is almost twenty times greater than on the tympanic membrane as a result of the combined effect of these mechanisms.

Ossicular leverage

It is provided by the movement of the malleus – incus complex acting as a lever about its axis of rotation. The handle of the malleus is about 1.3 times longer than the long process of the incus, when each is measured from its tip to the fulcrum at the axis. This factor of 1.3 is the size of the mechanical gain provided by the lever action.

Hydraulic action

It depends on the relative surface areas of the tympanic membrane and the stapes footplate. Anatomically the surface area of the tympanic membrane is about 21 times that of the footplate. It is known that the central $2/3^{rd}$ of area of tympanic membrane moves as a unit and it is this central part which provides the area to relate to that of the footplate. The functional ratio of tympanic membrane surface area to footplate area is then $2/3^{rd}$ of 21:1 = 14:1, which is the mechanical advantage derived from the hydraulic

action. The combined benefits of lever action and the hydraulic action provide an increase of pressure at the oval window of 14 x 1.3 or just over 18 times.

Auditory tube function

Effective sound transmission through the middle ear and into the cochlea requires that the air in the middle ear is maintained at a pressure level identical to that of the ambient air in the external acoustic meatus. Deviations from this ambient level of pressure, the impedance of middle ear increases. The pressure of air in the middle ear must at all times be kept at the ambient external level as a prerequisite for efficient middle ear function and inner ear sound conduction. Auditory tube maintains this pressure. Auditory tube obstruction raises the threshold of hearing by 30-40 dB. In normal individuals, the limits of variation for compliance and resistance are much narrower for female subject, but the average values are similar to both sexes.[24]

Sensorineural function

Air conducted sound waves are admitted to the cochlear perilymph through the oval window, and the information they convey emerges at the other end of the cochlea as nerve impulses in the afferent fibres of the cochlear nerve. The cochlea is a tube filled with perilymph, coiled on itself 2¾ times. Along the length this tube is divided into two channels by a cochlear partition. The upper channel is the scala vestibuli, into which the oval window opens. The lower channel is the scala tympani, which is sealed at its end by the round window membrane. These two perilymphatic channels communicate with each other only at the cochlear apex, through the helicotrema, scala media containing the endolymph is separated from scala vestibuli by Reissner's membrane and from scala tympani by basilar membrane supporting the organ of corti and associated structure. The

basilar membrane is 35 mm long gradually increases in width from 0.08 mm at the base near the oval window to 0.5 mm at the apex. The progressive increase in mass and decrease in stiffness along the length of the membrane. An account of sensorineural function demands a description of movement of the cochlear partition by sound waves, of the conversion of the mechanical energy of movement to electrical energy (transduction) and of the electrical events induced in the fibres of cochlear nerve.

Movement of the cochlear partition[22]

1. Helmholtz in his 'place' theory suggested that, basilar membrane consist of a series of tuned resonators. In this theory, any segment of the basilar membrane is activated by a sound wave of the resonant frequency of that segment, with high frequency waves exciting segments in the basal turn and low frequencies exciting the more apical regions.

2. Rutherford's telephone theory: According to this the frequency of activating sound wave is signaled by the rate of discharge in the cochlear nerve fibres. The latent period of nervous action limits this theory to the perception only of frequencies below 1000 Hz, if the relationship between sound wave frequency and nerve impulse has a simple ratio of 1:1.

3. Wever's volley theory: Combines both place and telephone principles postulating that:

a. High frequencies are perceived as per place theory (in the basal turn).

b. Low frequency (below 1000 Hz) stimulate nerve action potentials at a rate equal to the stimulus frequency.

c. Intermediate frequencies are represented in the auditory nerve by asynchronous discharges in groups of neurons, whose combined activity represents the frequency of the stimulus.

4. Von Bekesy's Travelling wave theory: Each wave increases in amplitude until it reaches a maximum at a place, which is specific for its frequency and then rapidly dies away. Successive trains of waves produced by a sustained tonal stimulus have an envelope with a maximal displacement at a site determined by the stimulus frequency. High frequency waves activate only the basal turn, which appears to move as one. Lower frequency waves travel farther along the whole length of the partition to the apex before reaching their maximum. Sharpening of this frequency sensitivity takes place partly in the cochlea and farther by neural mechanisms in the brain. The traveling wave uniquely represents the frequency of excitation and many of its physical character may subsequently be used by brain for finer pitch assessment.

Cochlear transduction

Endolymph has a composition different from that of perilymph, which is an ultrafiltrate of plasma. Particularly the high potassium level of endolymph (150 mq/litre compared with 6 mEq/litre in perilymph) and the low endolymphatic sodium level (1.5 meq/litre compared with 150 meq/litre in the perilymph).

Electrically endolymph in the scala media has a positive potential of +80 mV relative to that of perilymph. This is endocochlear potential. The interior of hair cell has a potential negative relative to that of perilymph, of the order of -70 mV, so there is a potential difference of 150 mV between the endolymph and the interior of the hair cell.

Deformation of the cochlear partition by the traveling wave bends both the basilar membrane and the tectorial membrane, but since these pivot about different axes, the displacement 'wipes' the tectorial membrane with a shearing action, across the tops of hair cells. This changes the resistance of the surface of the hair cell in contact with the endolymph and so alters the amount of current flowing through the cell. In this way movements of the cochlear partition modulate the current flowing through the hair cell body. This causes the electrical excitation of the afferent nerve endings.

The stored electrical energy represented by the large potential differences, endows the cell with amplifier properties, so that tiny amounts of mechanical energy modulate the output of a greater electrical energy source. The endocochlear potential is changed by displacement of basilar membrane and resulting hair bending and the change is maintained as long as mechanical deformation persists. Movement upwards, which is the direction causing neural excitation, is associated with a reduction of the potential.

Cochlear nerve activity[22]

This nerves act on 'an all or none' basis, which implies that the nerve discharges only when its threshold of excitation is exceeded. A second action potential can follow only after a refractory period, during which the nerve regains its resting state. At rest all the cochlear nerve fibres are discharging. Each nerve fibre responds most readily to a stimulus of a particular frequency its characteristic frequency and less readily to stimuli of frequencies differing from that. The threshold for excitation increases the more the stimulus frequency differs from the characteristic frequency. Tuning curve of acoustic nerve fibres shows that frequency sensitivity is much finer or the tuning much sharper, than the mechanical response of the basilar membrane. The tuning curves overlap and

broaden at high intensities, high intensity sounds excite fibres whose characteristic frequencies are more and more distant from the stimulus frequency.

The tuning curves of low frequency fibres are symmetrical but those of fibres with high characteristic frequencies are asymmetrical with a sharp high frequency cutoff. This means, at high intensity, all fibres with characteristic frequency below the test tone will be activated. Thus the intensity of a sound is indicated by the rate of spike discharge and the number of active fibres. Frequency information is available from the site of maximum excitation and from the spatial pattern and responses of excited fibres. At very low frequencies, periodicity of discharge is informative, while at higher pitches phase locked information in groups of fibres extends the potential of volley theory information. The frequency and intensity determinants of nerve fibre impulse rates are finally separated centrally by the activity of 10^7 neurons in the brain with which the auditory fibres eventually connect.

Cochlear microphonics

These are alternating potentials, originating in the hair cells, which accurately follow the pattern of the sound stimulus, and the movements of the cochlear partition. They persist after nerve conduction ceases and appear as responses in opposite senses with upward and downward movement of the partition. Summating potentials show as steady baseline shifts in the recording. They reflect steady changes in endocochlear potential.

CHRONIC OTITIS MEDIA (COM)

Otitis media is defined as "an inflammation of the middle ear without reference to etiology or pathogenesis."[25] Otitis media also implies concomitant inflammation, to a greater or lesser extent, of the mastoid air cell system, owing to its anatomic linkage to the middle ear cleft. Accordingly, otitis media is more correctly conceived of as an inflammatory disorder of the entire tympanomastoid compartment.

COM is one of the most common causes of hearing impairment and this may have serious long-term effects on language, auditory, cognitive development and educational progress.

As per WHO, despite the shortage of accurate, standardized data, the prevalence of COM in Indian population is approximately 2% which is comparatively higher than that found in developed countries like that of USA and UK where the prevalence is <1%.[26] It is considered "Chronic" if the tympanic membrane defect is present for more than 3 months. Thus, a draining middle ear cavity that is associated with a perforation from acute otitis media would not qualify for this diagnosis if it responds to treatment within 3 months. Histologically, COM is defined as irreversible mucosal changes within the middle ear cleft.[27] COM is characterized by intermittent or persistent chronic purulent drainage through a perforated tympanic membrane and can be associated with cholesteatoma. On occasion, a permanent, central perforation of the tympanic membrane can remain dry, with only rare intermittent drainage, that is, inactive COM. More typically, chronic or recurrent mucoid otorrhoea, that is, active COM is provoked by exposure of the tympanic mucosa to bacteria of the external auditory canal as well as of the eustachian tube.

Clinical Classification

COM Classification	Otoscopic findings
Healed COM	Thinning and/or localized or generalized opacification of the pars tensa without perforation or retraction
Chronic Inactive mucosal	Permanent perforation of the pars tensa but the middle ear mucosa is not inflamed
Chronic inactive squamous	Retraction of pars flaccid or tensa which has the potential to become active with retained debris
Chronic active mucosal	Permanent defect of the pars tensa with an inflamed middle ear mucosa which produces mucopus that may discharge
Chronic active squamous	Retraction of the pars flaccid or tensa that has retained squamous epithelial debris and is associated with inflammation and production of pus from the adjacent mucosa

Table -1: Classification of Chronic Otitis Media[28]

Etiopathogenesis

A variety of underlying pathologies can cause COM including:

1. An acute episode of acute otitis media can result in a perforation of the ear drum and does not settle within two weeks;
2. Recurrent episodes of acute otitis media in an ear with a perforation from a previous episode of acute otitis media; or
3. An ear with a persistent perforation with active chronic otitis media with metaplastic changes to the mucosa of the middle ear and mastoid air cell system.[28]

In adults, most patients are likely to have COM with a perforation that will not spontaneously heal. This results in associated hearing impairment and ear discharge. Hearing impairment due to otorrhoea and a perforated eardrum will usually improve as the disease resolves.

However, untreated COM may result in permanent hearing loss due to damage to the ossicles which transmit sound vibrations from the eardrum to the cochlea. Since otitis media occurs mostly in children during pre-school years, the years in which the most dynamic phase of speech and language development occurs, there is concern that the associated hearing deficits may result in speech and language delays or permanent learning disabilities, as well as disturbances in behaviour.[29] Majority of the patients with otitis media do well with antimicrobial therapy but despite this there is a subset of the patients who develop serious complications from this otherwise self-limiting disease.

There are various intratemporal and intracranial complications likely in patients with COM and the mortality rate of these remains substantial ranging from 10 – 31%.[30] In addition to hearing impairment (with its associated consequences), complications of otitis media can result in death or severe disability, which is especially more common in developing countries, where immunity, housing conditions and access to medical services are often poorer than in high income settings.[31] The infection may extend and spread to the head and neck structures and to the brain. Intracranial infections include meningitis, abscesses, hydrocephalus, or thrombosis of the lateral venous sinus (from suppuration within the mastoid causing thrombus occluding the lumen of the vessel).[32] Alternatively complications may be extracranial, such as subperiosteal abscess (superficial accumulations of pus that eroded the bony mastoid cortex), facial paralysis, cholesteatoma (a destructive formation of layers of keratinizing epithelium, accumulating in the middle ear and mastoid, also described as 'active squamous/epithelial chronic otitis media), labyrinthitis (extension to the labyrinth through the round window), or acute mastoiditis (spread of the infection to the mastoid air cells) which may spread further due to necrosis of the bony wall of the cells resulting in further life-threatening complications.[32,33,34] In view of the above it is imperative to treat patients with COM and the mainstay of therapy remains surgical. In 1965, the American Academy of Ophthalmology and Otolaryngology Subcommittee on Conservation of Hearing set forth a standard classification for surgery of chronic ear infection and defined Tympanoplasty as "a procedure to eradicate disease in the middle ear and to reconstruct the hearing mechanism, with or without tympanic membrane grafting."[35]

The causes and risk factors associated with COM are unclear, and few studies have examined these for COM. Instead authors have extrapolated results of studies for AOM and otitis media with effusion to COM. However, these studies often have

conflicting findings, and there is no proven correlation between the various host and environmental factors associated with COM and the factors associated with AOM and otitis media with effusion. Despite this, some important factors that may be associated with COM include: environmental factors such as inadequate treatment (of COM and acute otitis media), poor access to medical care, poor socioeconomic conditions, season, exposure to tobacco smoke, overcrowding, attendance at day care center, lack of breastfeeding, or poor nutrition or hygiene; and host factors such as altered immunity and underlying diseases (e.g. HIV/AIDS, frequent upper respiratory tract infections), early onset of otitis media in the first months of life and family history of otitis media.[36,37]

Some populations are at increased risk of developing COM, and have high rates reported, including certain ethnic groups (such as Native American tribes of Apache and Navajo, Australian Aborigines, and Inuit of Canada, Greenland and Alaska), and individuals with anatomical defects (e.g. cleft palate or sub mucous cleft), altered physiological defenses(Eustachian tube dysfunction) or Down's syndrome.[38] In the ethnic groups found to be at high risk for developing COM, there is some evidence that this may be due to their eustachian tubes being semi patulous (of low resistance) or larger in diameter than in other ethnic groups which allows easier reflux of nasopharyngeal secretions into the middle ear. In addition, Australian aboriginal neonates have been shown to develop colonization of the nasopharynx earlier and more rapidly than Caucasian neonates.

Individuals with cleft palate or Down's syndrome more readily develop otitis media and they have on average shorter eustachian tubes than age-matched individuals without these disorders.

Treatment Modalities

The aims of treatment are to stop the discharge (and to eradicate infection), to heal the tympanic membrane, improve hearing, prevent the common problems of recurrent or new infections and to prevent potentially life-threatening complications.

Treatment options for uncomplicated COM include dry mopping, ear wicking, gentle syringing, or suctioning, to clean the ear discharge (aural toilet); systemic antibiotics (e.g. oral antibiotic preparations, or intravenous antibiotics); and topical treatment with either antiseptics or antibiotics, sometimes with steroids. If complications develop, surgery is usually required to remove the infected tissue from the middle ear and mastoid air cells, and possibly repair the damaged eardrum and ossicles. The treatments modalities available are as follows:

• Aural Toilet

• Systemic Antibiotic Treatment

• Topical Antiseptics

• Topical Antibiotics Without Steroids.[39]

• Systemic Versus Topical Treatments For Com

• Systemic Or Topical Steroids: Steroids, As Monotherapy Or Combination Therapy.

• Surgical Treatment

Surgery in otology dates back as far as the 17th century when Banzer (1640) described the first attempt at repair of a TM perforation with a pig's bladder. In that period, most of the

advances in otologic surgery were focused on the mastoid to treat life threatening infections. In 1853, Toynbee kept a rubber disk attached to a silver wire over a perforation. He found significant improvement in hearing with this method. Later Yearsley (1863) kept a cotton ball over a perforation and in 1877; Blake proposed the paper patch which is still used today for preoperative evaluation of potential hearing improvement. The treatment of TM perforations with chemical cautery was performed by Roosa (1876) and Okneuff (1895). The term myringoplasty was coined by Berthold in 1878. He placed a court plaster against the tympanic membrane for 3 days to remove the epithelium, and then applied a thick skin graft. Although success was reported in two cases, little more was heard of myringoplasty until Schulhof and Valdez mentioned it in 1944. Wullstein and Zollner are given credit for ushering in the modern era of tympanoplasty in the 1950s. They placed split thickness skin grafts over the de-epithelialized TM remnant. At first, good results were obtained; however, subsequent graft eczema, inflammation, and perforation were common. During this time, Wullstein (1956) described five types of tympanoplasty based on the relationship of the grafted TM to the middle ear structures. Storrs reported a series of patients in which temporalis fascia was used as an outer surface graft. Over the next three years, this technique became wide spread and resulted in over 90% graft take. House (1961),Glasscock, and Sheehy (1967) developed and refined techniques used for lateral graft tympanoplasty which are the same techniques used today. The first medial graft tympanoplasty was performed by Shea (1957). He was performing a stapedectomy and by chance, discovered that a medial vein graft was successful in repairing an accidental tear. Storrs later replaced the vein graft with temporalis fascia for use in medial grafting.

Over the past three decades temporal fascia has been the most commonly used grafting material in tympanoplasty operations, although tragal perichondrium, periosteum, loose

overlay tissue, fat, vein, alloderm, homograft TM, and homologous dura are also employed.

TYMPANOPLASTY

It is a procedure to eradicate the disease in the middle ear and reconstruct the hearing mechanism with or without tympanic membrane grafting as given by the American academy of ophthalmology and otolaryngology subcommittee on conservation of hearing in 1965.[35] This procedure can be combined with either an intact canal wall mastoidectomy or canal wall down mastoidectomy to eradicate the disease from the mastoid area.[40]

Principle of tympanoplasty[41,42]

1. To accomplish the sound protection for the round window by placement of a graft so that sound does not reach the oval window and round window at the same time and a phase difference is provided
2. To improve the sound pressure transformation by providing an increased surface after placement of the graft and reconstructing the hearing mechanism.

Types of Tympanoplasty

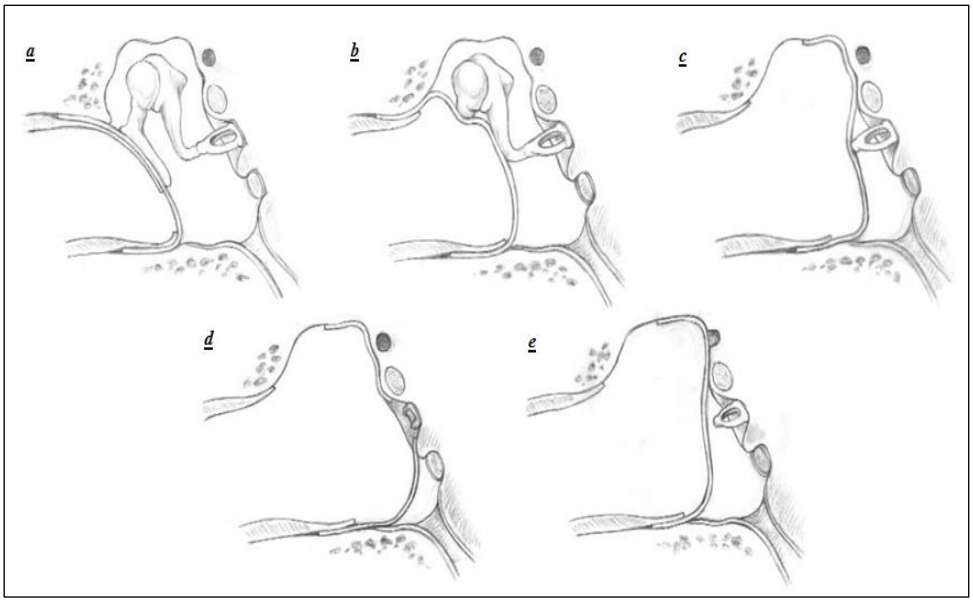


Figure 8: Types of Tympanoplasty based on Wullstein and Zolner classification.

Tympanoplasty type I [Figure 06 (a)]:

Type I Tympanoplasty is performed when all three ossicles are present and mobile and involves repair of a tympanic membrane perforation or retraction without ossicular chain reconstruction.

Tympanoplasty type II [Figure 06 (b)]:

Type II Tympanoplasty is utilized when the malleus is eroded and involves grafting the tympanic membrane to an intact incus and stapes or remnant of the malleus

Tympanoplasty type III [Figure 06 (c)]:

A type III Tympanoplasty is indicated when the lateral ossicles are eroded. The stapes must be intact and mobile. The tympanic membrane or graft or partial ossicular chain

reconstruction prosthesis is placed in contact with the stapes superstructure.

Tympanoplasty type IV [Figure 06 (d)]:

Type IV describes an absent or eroded suprastructure with the graft or tympanic membrane overlying a mobile stapes footplate. The resulting middle ear consists of the hypotympanum and the eustachian tube orifice only.

Tympanoplasty type V [Figure 06 (e)]:

Type V Tympanoplasty is used when the stapes footplate is fixed. Type Va involves grafting over a fenestration created in the horizontal semicircular canal. This technique has largely been abandoned in favor of the Type Vb which involves a stapedectomy.

Graft materials used in Tympanoplasty

1. Autologous / Autografts

Temporalis fascia, tragal perichondrium with or without cartilage, periosteum, fat, vein and fascia lata.

2. Homologous / Homograft

Duramater, tympanomeatal graft, cornea, amniotic membrane.

3. Heterologous / Heterograft

Bovine jugular vein, calf caecal serosa.

Advantages of Temporalis fascia graft:[43]

1. It has a thickness comparable to the tympanic membrane
2. It has a low basal metabolic rate
3. Can be harvested in the same incision as the postaural or endaural incision
4. Also, large amount of graft is available even if a revision Tympanoplasty is planned

TYPES OF GRAFT PLACEMENT

Overlay technique

This is a technique of placement of the graft where the connective tissue graft is placed lateral to the annulus tympanicus i.e. between the outer epithelial layer and the middle fibrous layer of the tympanic membrane. Overlay technique is best suited for a large central perforation

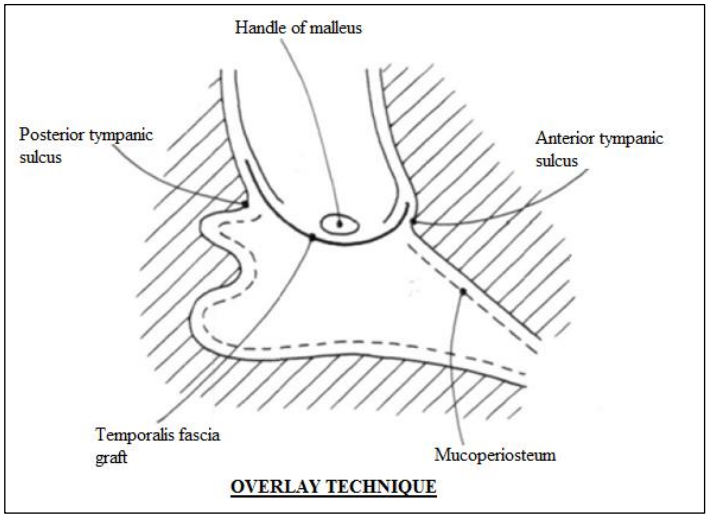


Figure 9: Overlay technique of grafting

Advantages of overlay technique:

1. Can be used in perforations of all sizes
2. Wide exposure

3. Anterior meatal recess can be visualized well

4. Higher success rate of graft take up

5. No reduction of middle ear space

Potential pitfalls of overlay Tympanoplasty:

1. Anterior angle blunting
2. Epithelial pearl formation
3. Lateralization of the graft
4. Prolonged healing as the canal skin is completely removed and replaced back as a free graft

Underlay technique

This is a technique where the connective tissue graft is placed medial to the remnant of the tympanic membrane i.e. the annulus tympanicus.

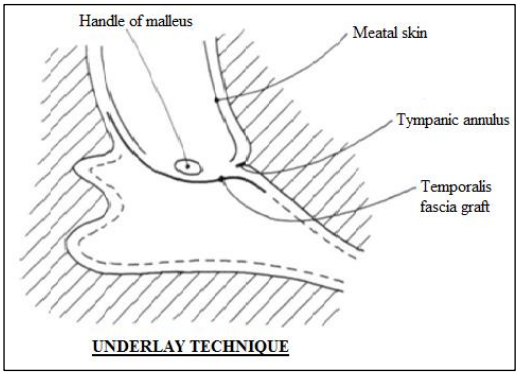


Figure 10: Underlay technique of grafting

Advantages of underlay technique:

1. Has a high take up rate

2. Ideal for small and easily visualized perforations

3. Technically less demanding compared to the overlay technique

4. Less time consuming

5. Graft lateralization, anterior blunting and epithelial pearl formation are not commonly encountered

Disadvantages of underlay technique:

1. Poor visibility of the anterior meatal recess

2. Reduction of the middle ear space

3. Not suited for large anterior perforations

4. Difficult in cases with small external auditory canal and may have to be combined with a canaloplasty to overcome the same

Interlay technique

The graft is placed in between the mucosal and fibrous layers of the remnant tympanic membrane.

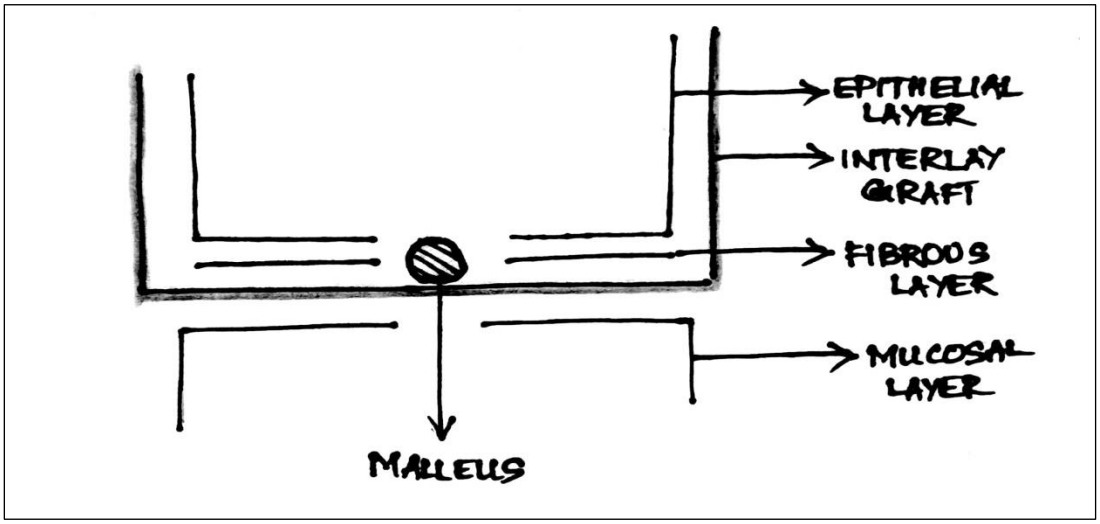


Figure 11 : Schematic diagram of Interlay grafting

The various advantages of this technique over "overlay" technique include:

1) Rapid epithelialization compared to other techniques[5]

2) Minimal blunting compared to overlay as the anterior sulcus is lined by skin [5]

3) Nil drum lateralization[4]

4) Not associated with epithelial cyst formation

5) Myringitis due to endothelial overgrowth on the graft is avoided

The advantages over "underlay" technique include:

1. Less medialization thereby reducing chances of anterior remnant tympanic membrane perforation[5]
2. Less reduction in middle ear space compared to other techniques[4]

Approaches for Tympanoplasty

1. **Transcanal approach:**

It consists of a U- shaped incision, starting just lateral to the annulus tympanicus from the 12 o' clock position superiorly and meeting the inferior incision starting at 6 o' clock position at the bony cartilaginous junction which is around 5 to 7 mm from the annulus along the posterior meatal wall.

Advantages of transcanal approach

a. Small posterior perforations and medium-size perforations when the ear canal anatomy is favorable, and the entire perforation and an anterior tympanic membrane rim can be seen
b. Post aural scar is avoided
c. Less discomfort and better healing

Disadvantages of transcanal approach

a. Poor exposure(especially of the anterior mesotympanum)
b. Tympanomeatal flap obscures the vision
c. Has a greater learning curve

2. Endaural approach

This technique was by Lempert in 1937. It consists of two parts-

Lempert 1- A curvilinear incision made from the 12 o'clock to 6 o'clock position around 5mm from the annulus along the posterior meatal wall

Lempert 2- starting from the first incision at 12 o'clock position a linear incision is made passing between the crus of the helix and the tragus. Hence, the incision does not cut through the cartilage.

Advantages of endaural approach

a. Both hands free for instrumentation
b. Fairly good exposure of the surgical field
c. Absence of a visible surgical scar

Disadvantages of endaural approach

a. Presence of postoperative discomfort
b. Has a greater learning curve

3. Postaural approach

The canal incision consists of a curvilinear incision starting 5mm lateral to the annulus from 12 o'clock position to the 6 o'clock position along the posterior meatal wall. Vertical incisions are then taken at 12 o'clock and 6 o'clock positions which extend till the bony cartilaginous junction.

This is followed by a post auricular incision which is taken around 5mm from the postauricular groove starting from the highest point of the helix to the tip of the mastoid.

Advantages of postaural approach

a. Both hands free for instrumentation

b. Excellent exposure of the surgical field

c. Can be combined with mastoidectomy in case it is planned along with Tympanoplasty

Disadvantages of post aural approach

a. Presence of Postoperative discomfort
b. Delayed healing of the post aural wound
c. Presence of a visible but hidden surgical scar

Indications for Tympanoplasty

1. Improve healing

2. To prevent further infection of the ear via the eustachian tube and external auditory canal.

3. To prevent tympanosclerosis.

4. To enable proper fitting of the hearing aid.

5. To enable recruitment in certain professionals.

6. Prevent caloric effect

Contraindications for Tympanoplasty

Absolute contraindications

1. Presence of cholesteatoma

2. Malignant neoplasm of the outer and middle ear.

3. Invasive life-threatening infections with pseudomonas of outer and middle ear.

4. Suspected intracranial complications of chronic otitis media.

Relative contraindications

1. Dead ear or ear without cochlear reserve

2. Acute exacerbation of chronic otitis media

3. Allergic type of chronic otitis media

4. Chronic otitis externa

5. Non-functioning eustachian tube

6. Only hearing ear

7. Child < 10 years

CORTICAL MASTOIDECTOMY

Cortical mastoidectomy is the transcortical opening of the mastoid air cells and the antrum. It is also called simple mastoidectomy or Schwartz mastoidectomy. It forms the basic operation for several conditions of the middle ear as well as the initial stage surgery for the transmastoid surgery of the middle ear, inner ear, facial nerve, endolymphatic sac, labyrinth, internal auditory canal and removal of certain skull base tumors. The extent of the surgery depends on the disease process and the access required for the approach. It is generally combined with a Tympanoplasty to clear the disease from the mastoid. However, it is not indicated in all patients.[44,45]

The aims of performing a cortical mastoidectomy are:

1. To exenterate all the mastoid air cells.
2. To widen the aditus and facilitate better ventilation of the mastoid antrum.
3. To clear the hypertrophied mucosa and infection from the middle ear.
4. Also as an approach to other surgeries like facial nerve decompression, endolymphatic sac decompression, excision of glomus tympanicus, etc.

Indications for cortical mastoidectomy

1. Chronic otitis media not responding to medical management.
2. Presence of a retroauricular subperiosteal abscess, zygomatic subperiosteal abscess, bezold's abscess.
3. Masked mastoiditis.
4. Sagging of the posterosuperior canal wall due to thickening of the periosteum near the antrum.
5. Associated intracranial complications like meningitis, encephalitis, extradural & subdural abscess with acute otitis media.
6. Persistence of ear discharge for more than four weeks in acute otitis media.
7. Recurrent acute otitis media.
8. Refractory secretory otitis media.
9. As an approach to facial nerve decompression, endolymphatic sac decompression, internal auditory canal surgeries, certain skull base tumors.

Surgical Procedure

1. Infiltration in the post aural region is done using 2% lignocaine with 1:80000 units of adrenaline.
2. William wilde's incision is taken which is a curvilinear incision 5mm behind the post auricular groove from the root of the helix to the tip of the mastoid.
3. The skin incision is gradually deepened, and the periosteum identified.
4. A horizontal cut is taken along the linea temporalis and the vertical cut is made along the external auditory canal over the periosteum covering the mastoid.
5. The periosteum is then stripped to reveal the landmarks over the mastoid.

6. Drilling is begun in the MacEven's triangle. The mastoid antrum lies 1.5cms medial to this triangle.
7. The mastoid antrum is entered by drilling through the cortex and slowly the cavity is widened.
8. Drilling is continued till the tegmen plate superiorly; sigmoid sinus posteriorly; thin out the posterior canal wall anteriorly; digastric ridge inferiorly; lateral semicircular canal medially.
9. The disease in the aditus and mastoid antrum is cleared, and patency is achieved.
10. The periosteum and the skin are closed in layers.

Complications of cortical mastoidectomy

1. Injury to the duramater, sigmoid sinus, facial nerve and lateral semicircular canal.
2. Subluxation of the incus or dislocation of the ossicular chain.
3. Sensorineural hearing loss caused due to the use of drill.
4. Meatal stenosis.
5. Fixation of the malleus and the incus.

MATERIALS & METHODS

MATERIALS AND METHODS

Source of data:

The study was conducted at the Department of Otorhinolaryngology and Head and Neck Surgery of R L Jalappa Hospital and Research Centre, Tamaka, Kolar. Adults diagnosed with mucosal type of CSOM and planned for surgical treatment were included in the study after taking consent.

Inclusion criteria

Patients above the age of 18 years with mucosal type of chronic otitis media associated with subtotal or anterior central perforations.

Exclusion criteria

1. Active stage of chronic otitis media
2. Congenital ear anomalies and cleft palate
3. Chronic otitis media with complications
4. Suspected cases of ossicular discontinuity (cases were also excluded when ossicular discontinuity was encountered intra-operatively)

Method of collection of data:

120 patients above 18 years of age, diagnosed as mucosal type of COM in our department from December 2015– March 2017 were included in the study.

a. A detailed clinical history was taken, and comprehensive ENT examination was performed.

b. Otomicroscopic examination was done

c. Pure tone audiometry was done preoperatively to establish the extent and type of hearing loss.

d. Blood investigations and X-ray of the mastoid and PNS were obtained.

Patients fit for surgery were posted for Myringoplasty either under general or local anesthesia. The operative technique for each patient was determined using 6 block randomization technique

Based on this, patients were assigned into two groups A and B i.e. interlay technique and underlay technique. Patients were assessed post-operatively after the 1st, 2nd and 3rd month. At each follow up otoscopic examination was done to assess the graft take-up and anterior blunting. A pure tone audiometry was performed to assess the improvement in hearing.

OPERATIVE TECHNIQUE:

Infiltration:

It was done 10 minutes prior to the incision. Infiltration solution was prepared using 10 ml of 2% lignocaine, 10 ml of normal saline and 10 drops of 1:1000 adrenaline.

About 0.5 cc each of the prepared solution was infiltrated into the bony cartilaginous junction of the external auditory canal at 2, 4, 8 and 10 O' clock positions, without creating blebs. Further infiltration by injection of 1 ml of solution at several points into the skin and periosteum of the incisura terminalis was performed. Also, injection of 1 ml of solution at several points behind the auricle over the mastoid process and injection of the periosteum of the anterior surface of the mastoid process was done.

SURGICAL PROCEDURE:

A posterior transverse canal incision was placed just medial to the bony cartilaginous junction from 12 O'clock to 6 O'clock position and korner's flap was elevated.

↓

William Wilde's post auricular incision was placed and connected to the canal incision after soft tissue dissection

↓

Temporalis fascia was harvested.

↓

Margins of the perforation were freshened

INTERLAY TECHNIQUE

Incisions were taken such that a superiorly based tympano-meatal flap was elevated upto the annulus.

↓

The annulus was then elevated and separated from the underlying mucosal layer

UNDERLAY TECHNIQUE

Incisions were taken from the 12 O'clock to 6 O'clock position to elevate an anteriorly based tympano-meatal flap up to the annulus.

↓

Posteriorly, tympanotomy was performed after cutting the mucosal layer and elevating the

↓

Skeletonisation of the handle of malleus was done gently using a sickle knife

↓

The ossicular status was assessed

↓

The middle ear was filled with gel foam

INTERLAY TECHNIQUE **UNDERLAY TECHNIQUE**

The graft was placed in between the fibrous and mucosal layers of the remnant tympanic membrane

The graft was placed under the mucosal layer of anterior remnant of the tympanic membrane.

↓ ↓

The tympanomeatal flap was replaced and the graft was secured.

↓

The postaural wound was closed and mastoid dressing was applied.

↓

At the end of one month the canal pack was removed

↓

At the 1st, 2nd and 3rd post-op month, graft uptake and anterior blunting were assessed, and a PTA was done.

↓

The results of each technique were compared with each other.

FOLLOW UP:

Patients were assessed post-operatively after the 1st, 2nd and 3rd month. History regarding ear discharge and subjective improvement in hearing was obtained. At each follow up Otoscopic and microscopic ear examination was done to assess the graft take-up and anterior blunting. A pure tone audiometry was performed to assess the improvement in hearing. The results were then documented and compared with each other.

Figure 12: Photograph of PTA-Assessment of Air Conduction

Figure 13: Pre-operative photograph of the tympanic membrane showing a subtotal perforation

Figure 14: Pre-operative photograph of the tympanic membrane showing a medium size perforation in the anterior quadrant

Figure 15: Instruments Used in Ear Surgery

Figure16: Zeiss Operating Microscope

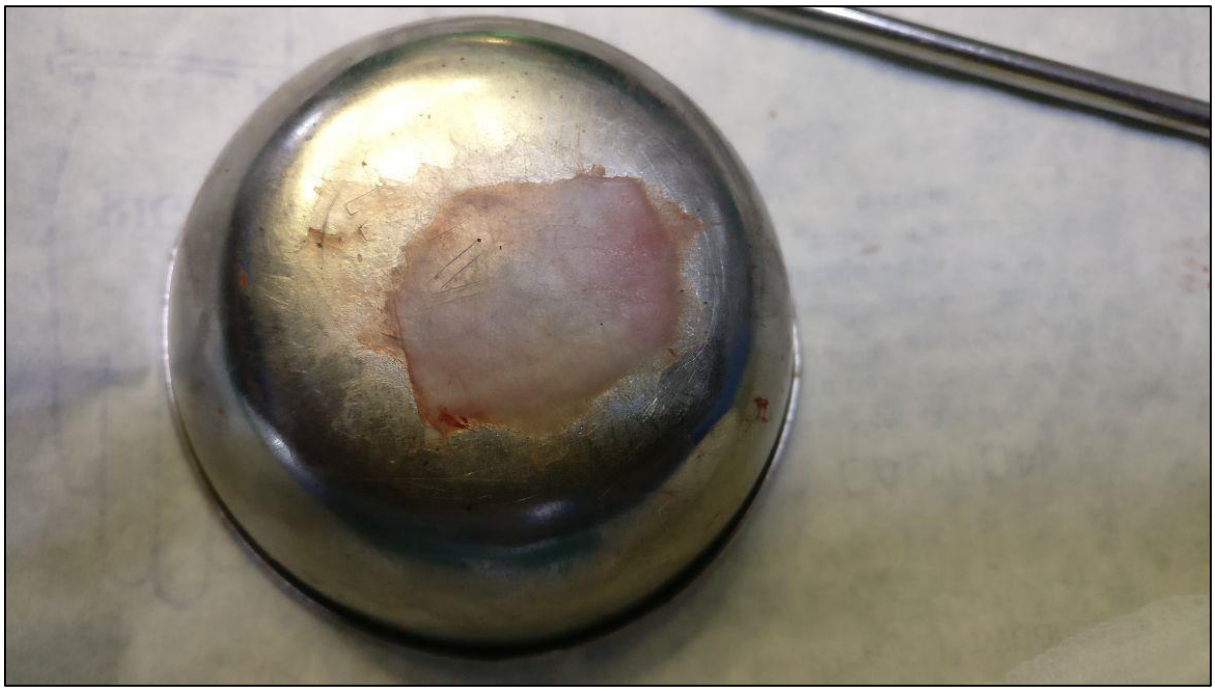


Figure17: Harvested Temporalis Fascia Graft

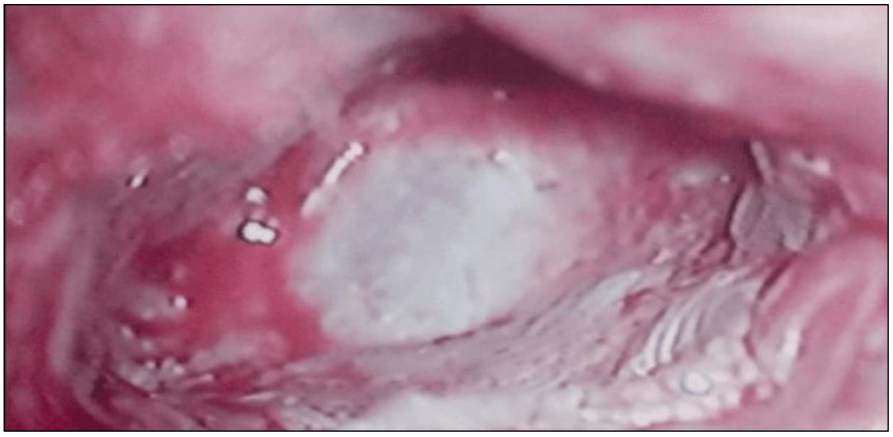


Figure 18: Graft Placement In Underlay Technique (left ear-surgical position)

Figure 19: Left ear- at third post-op month(underlay graft)

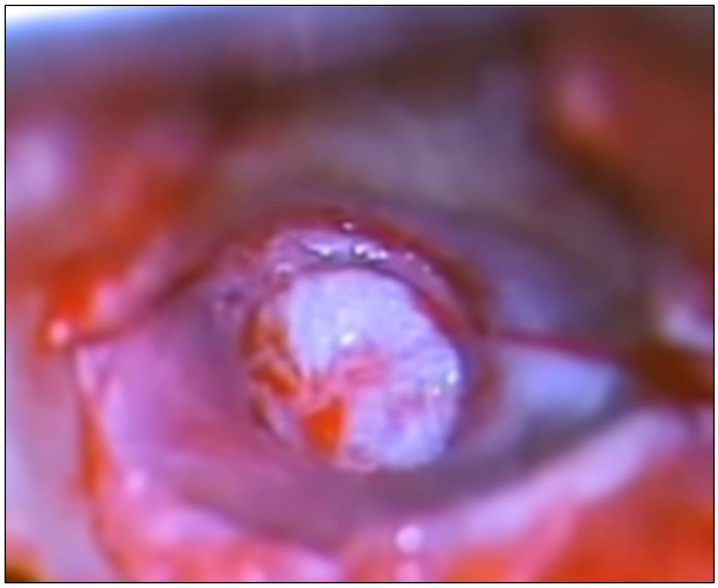


Figure 20: Graft Placement In Interlay Technique(right ear-surgical positiion)

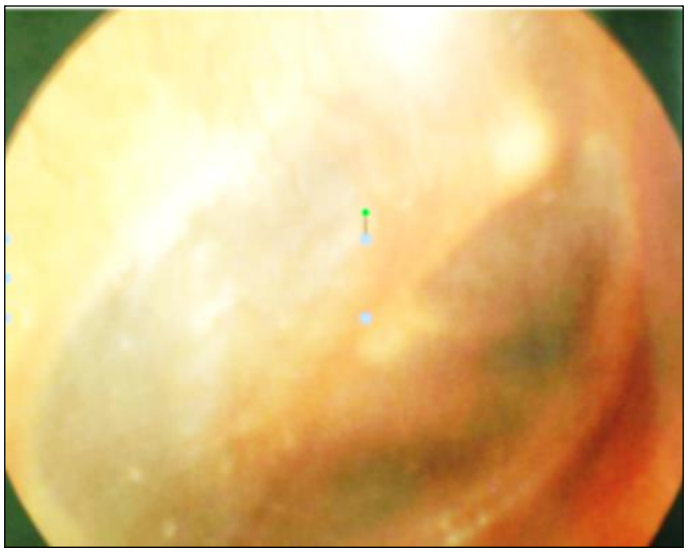


Figure 21 : Post-operative photograph of right tympanic membrane at 3rd post-operative month (interlay)

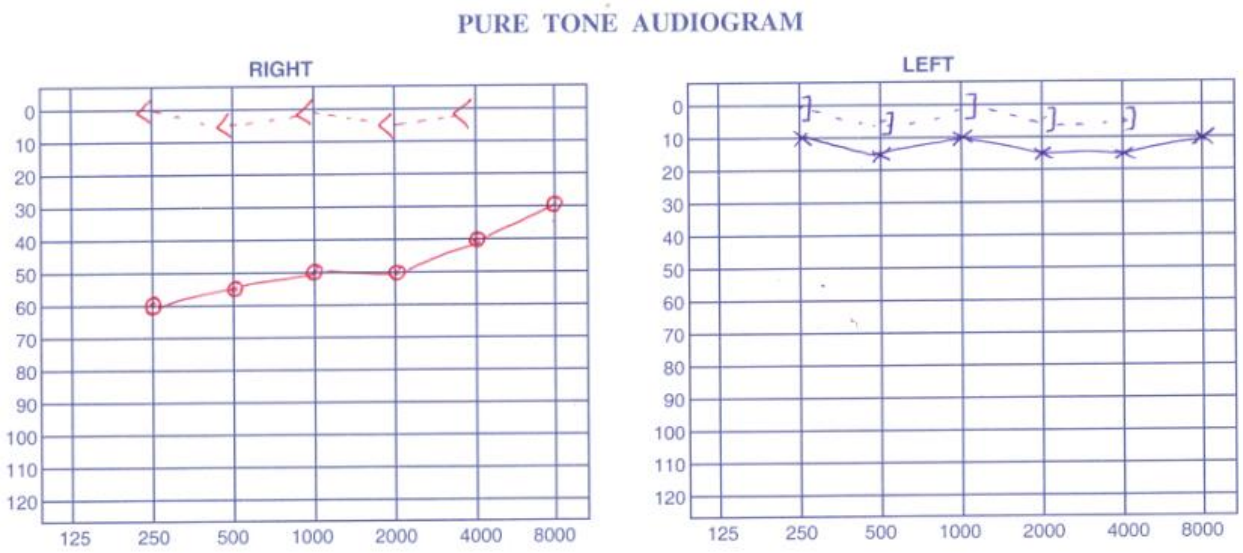


Figure 22: Pre-operative Pure tone audiogram showing PTA of 51.66dB on the right side and 13.33dB on the left side

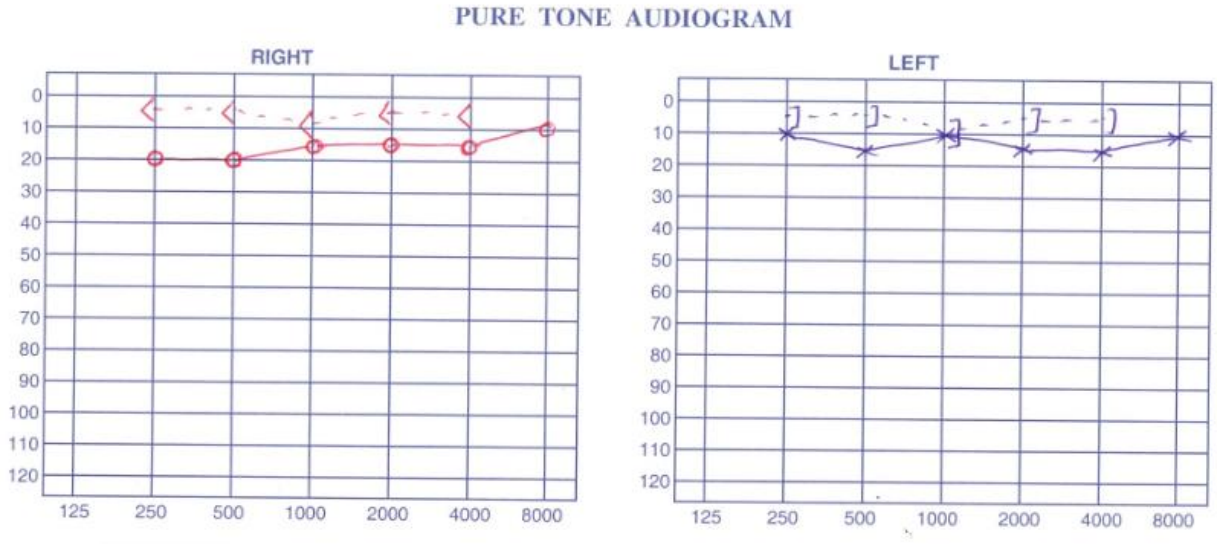


Figure 23 : Post-operative Pure tone audiogram of the same patient at 3 months follow up showing PTA of 16.66dB on the right side and 13.33dB on the left side

Statistical analysis:

Data was entered into Microsoft excel data sheet and was analyzed using SPSS 22 version software. Categorical data was represented in the form of Frequencies and proportions. **Chi-square test** was used as test of significance for qualitative data.

Continuous data was represented as mean and standard deviation. **Independent t test** was used as test of significance to identify the mean difference between two quantitative variables.

Graphical representation of data: MS Excel and MS word was used to obtain various types of graphs such as bar diagram.

p value (Probability that the result is true) of <0.05 was considered as statistically significant after assuming all the rules of statistical tests.

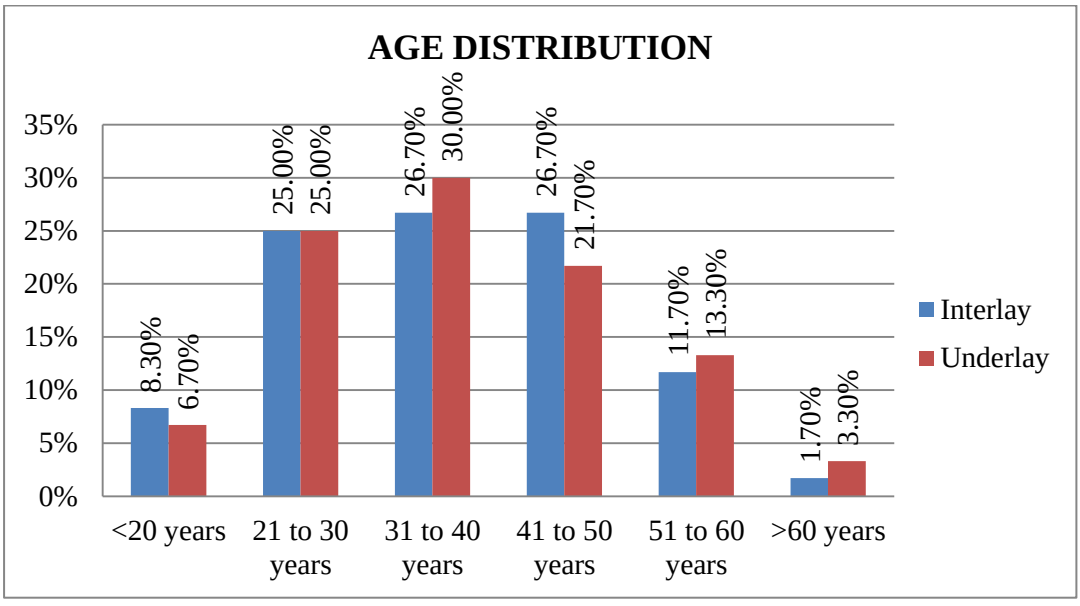
Statistical software: MS Excel**,** SPSS version 22 **(**IBM SPSS Statistics, Somers NY, USA) was used to analyze data

RESULTS

Table 2: Age distribution and mean age in Interlay and Underlay

Age	Group		
	Interlay	Underlay	
<20 years	5 (8.3%)	4(6.7%)	p = 0.967
21 to 30 years	15(25.0%)	15(25.0%)	
31 to 40 years	16(26.7%)	18(30.0%)	
41 to 50 years	16(26.7%)	13(21.7%	
51 to 60 years	7(11.7%)	8(13.3%)	
>60 years	1(1.7%)	2(3.3%)	

In the Interlay group, 26.7% of patients belonged to the age groups of 31 to 40 years and 41 to 50 years. In Underlay group, 30% of patients were in the age group of 31 to 40 years. There was no statistically significant difference between both groups. The mean age of patients in Interlay group was 36.2 ± 11.6 years and in that of Underlay group was 36.8 ± 11.8 years; with no statistically significant difference. (p= 0.767)

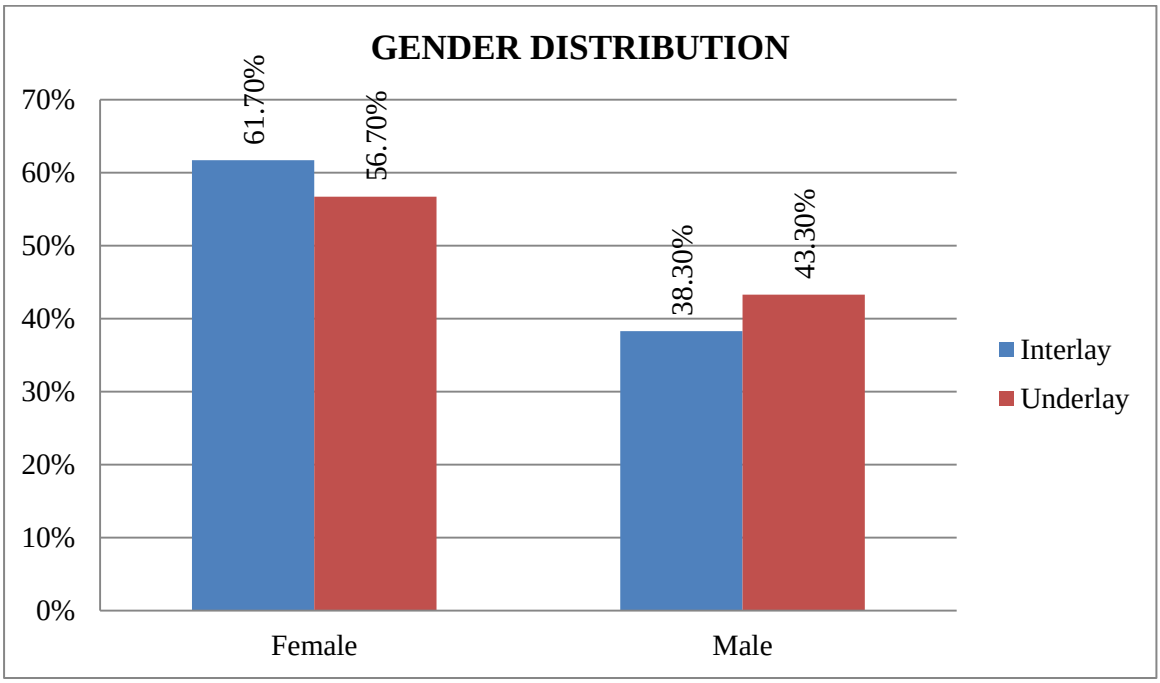


Graph 1: Bar diagram showing Comparison of age distribution between interlay and underlay

Table 3:Comparison of gender distribution between interlay and underlay technique

		Group			
		Interlay		Underlay	
		Number	%	Number	%
Gender	Female	37	61.7%	34	56.7%
	Male	23	38.3%	26	43.3%

In Interlay group, 61.7% were females and 39.3% were males and in the Underlay group, 56.7% were females and 43.3% were males. There was no significant difference in gender difference between two groups. (χ 2 = 0.310, df = 1, p = 0.577)

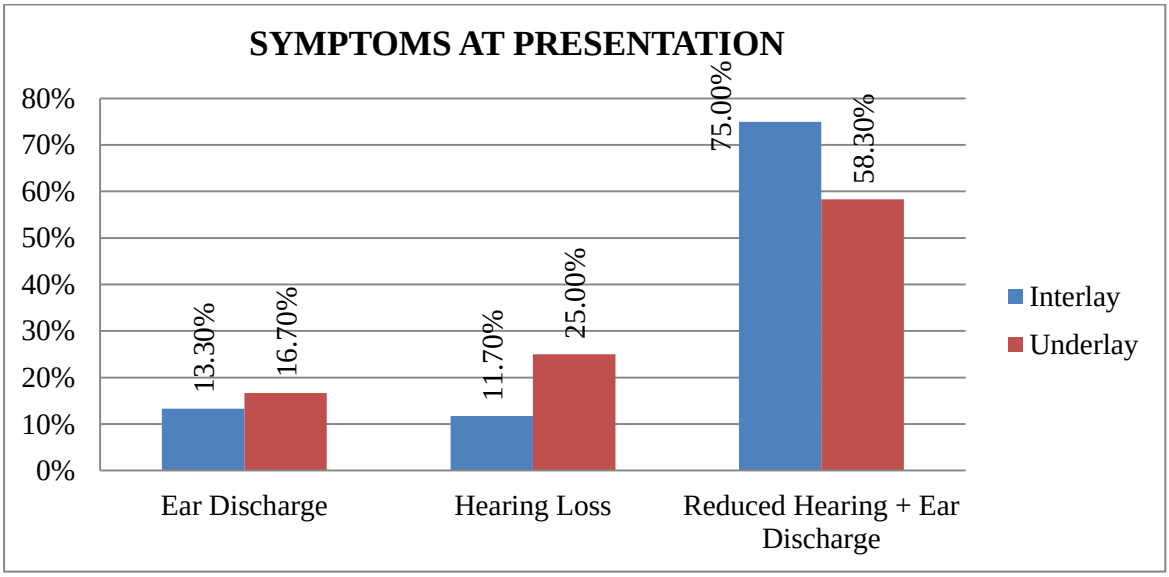


Graph 2: Bar diagram showing comparison of gender distribution between interlay and underlay technique

Table 4: Comparison of presenting symptoms in Interlay and Underlay technique

		Group			
		Interlay		Underlay	
		Number	%	Number	%
Symptoms	Ear Discharge only	8	13.3%	10	16.7%
	Hearing Loss only	7	11.7%	15	25.0%
	Reduced Hearing + Ear Discharge	45	75.0%	35	58.3%

At the time of surgery, all patients had inactive disease with no history of ear discharge. However, at presentation; 13.3% of patients had history of ear discharge and 11.7% of patients had history of hearing loss within the Interlay group. 75% had history of concomitant hearing loss and ear discharge. Whereas, in the underlay group, 16.7% of patients had history of ear discharge, 25% had history of hearing loss and 58.3% had history of both reduced hearing and ear Discharge. There was no statistically significant difference in symptoms between both groups ($\chi 2 = 4.381$, df = 2, p = 0.112).

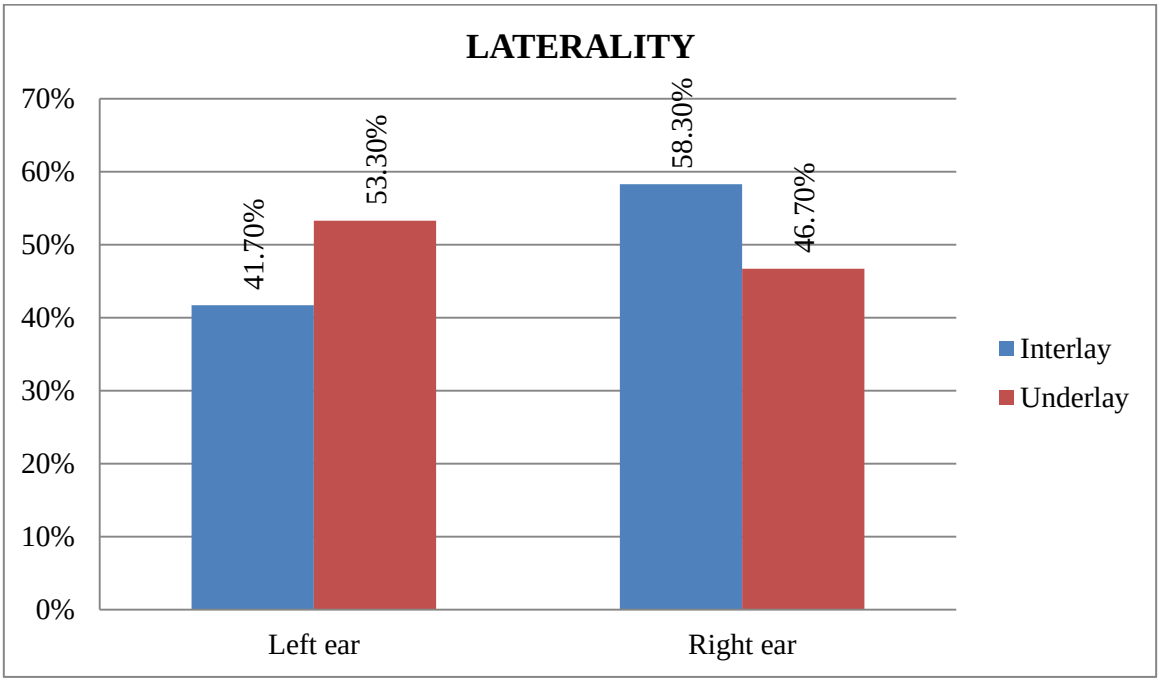


Graph 3: Bar diagram showing presenting symptoms in interlay and underlay technique

Table 5:Comparison of laterality between Interlay and Underlay technique

		Group			
		Interlay		Underlay	
		Number	%	Number	%
Diagnosis	Left COM	25	41.7%	32	53.3%
	Right COM	35	58.3%	28	46.7%

In Interlay group, 41.7% had COM in the left ear and 58.3% in the right ear. In Underlay group, 53.3% had COM in the left ear and 46.7% in the right ear. There was no statistically significant difference in diagnosis between both groups (χ 2 = 1.637, df = 1, p = 0.201).

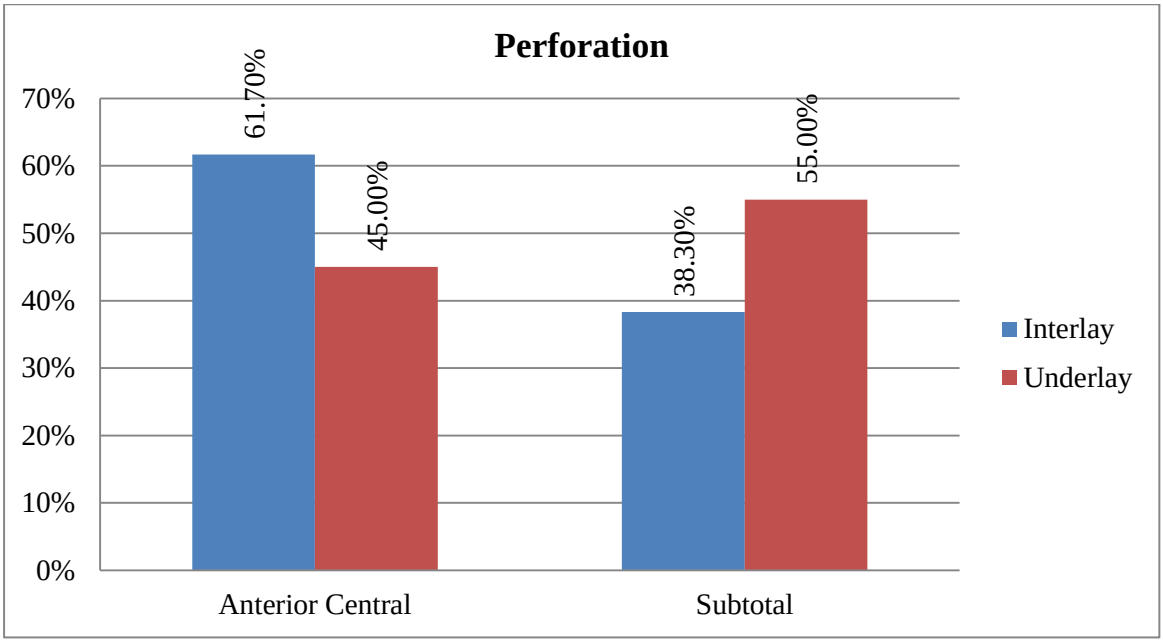


Graph 4: Bar diagram showing comparison of laterality of affected ear in both groups

Table 6: Comparison of the type of perforation between Interlay and Underlay technique

		Group			
		Interlay		Underlay	
		Number	%	Number	%
Perforation	Anterior Central	37	61.7%	27	45.0%
	Subtotal	23	38.3%	33	55.0%

In Interlay group, 61.7% had a medium central perforation involving the anterior quadrant and 38.3% had a subtotal perforation. In underlay group, 45% had a medium central perforation involving the anterior quadrant and 55% had subtotal perforation. There was no statistically significant difference in the type of perforation between both groups ($\chi 2 = 3.348$, df = 1, p = 0.067)



Graph 5: Bar diagram showing comparison of the type of perforation between interlay and underlay technique

Table 7: A-B gap in Interlay group at different periods of follow up

A-B GAP	Group		
	INTERLAY		
	Mean	SD	p value
PRE-OP	35.3 dB	3.6	-
1st Month	16.0 dB	2.7	<0.001*
2nd Month	15.5 dB	4.1	<0.001*
3rd Month	12.9 dB	4.8	<0.001*

In the Interlay group, the mean A-B gap in the pre-operative period was 35.3 ± 3.6 dB. The mean post-operative A-B gap was 16 ± 2.7 dB, 15.5 ± 4.1 dB and 12.9 ± 4.8 dB after the 1st, 2nd and 3rd month of follow up respectively. There was a statistically significant decrease in the mean A-B gap at all three intervals of follow-up (p=<0.001).

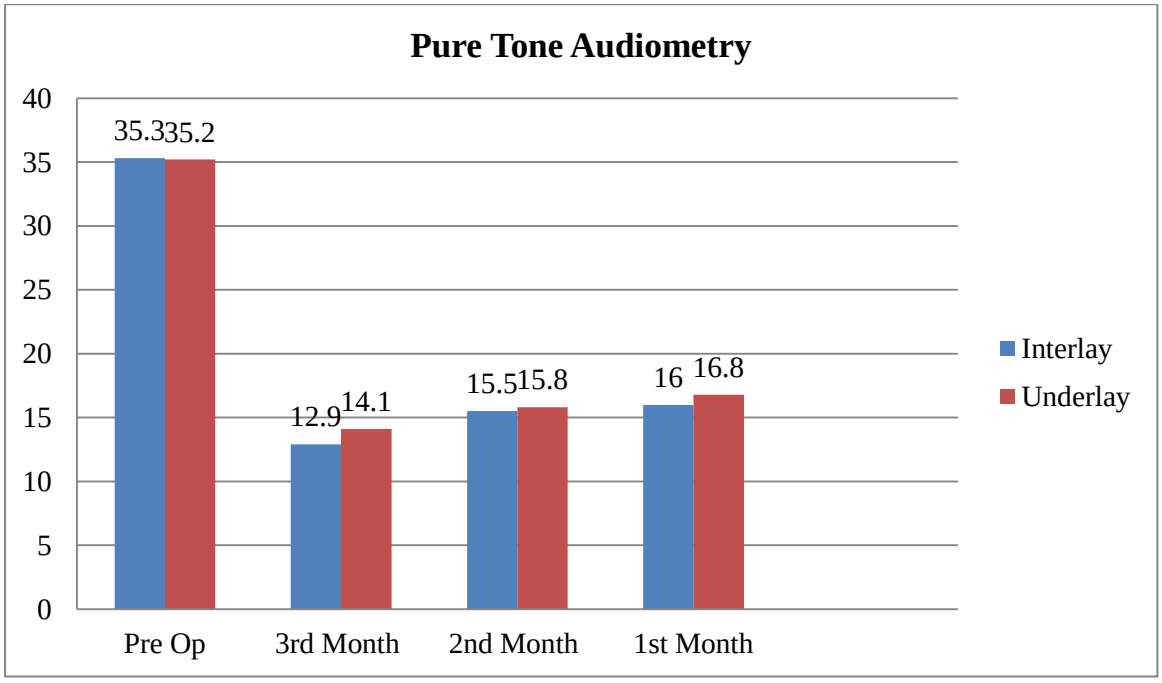
Table 8: A-B gap in Underlay group at different periods of follow up

A-B GAP	Group		
	UNDERLAY		
	Mean	SD	p value
PRE-OP	35.2 dB	4.6	-
1st Month	16.8 dB	3.4	<0.001*
2nd Month	15.8 dB	4.6	<0.001*
3rd Month	14.1 dB	5.6	<0.001*

On the other hand, in the Underlay group, the mean A-B gap in the pre-operative period was 35.2 ± 4.6dB. The mean post-operative A-B gap was 16.8 ± 3.4 dB, 15.8 ± 4.6 dB and 14.1 ± 5.6 dB after the 1st, 2nd and 3rd month of follow up respectively. There was a statistically significant decrease in the mean A-B gap at all three intervals of follow-up (p=<0.001).

The mean pre-operative A-B gap obtained in both groups were comparable, with no statistical significance (p =0.88).

We found that, there was no statistically significant difference between both methods, on comparison of the improvement in A-B gap at all three intervals of follow up(p=0.169, p=0.702, p=0.202).



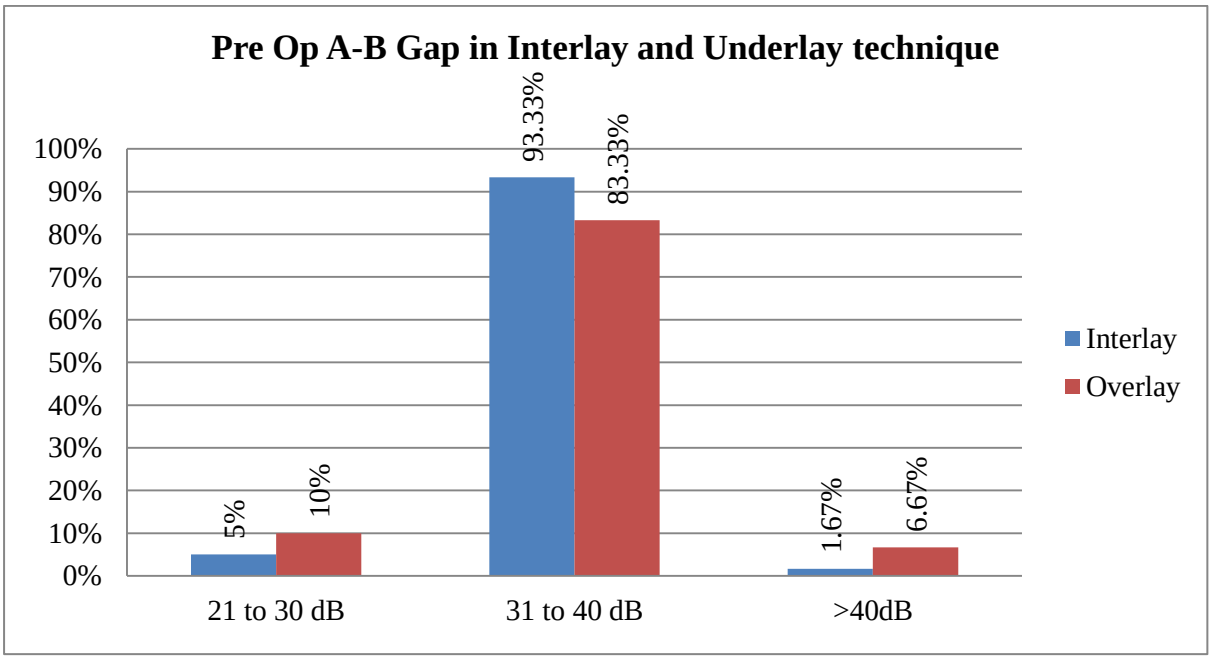
Graph 6: Bar diagram showing Comparison of A-B gap between interlay and underlay at different periods of follow up

Table:9 Pre-Op A-B Gap in Interlay and Underlay technique

	INTERLAY		UNDERLAY	
	No of Cases	%	No of Cases	%
21 to 30 dB	3	5	6	10
31 to 40 dB	56	93.33	50	83.33
>40 dB	1	1.67	4	6.67
Total	60	100	60	100

Pre-operatively in Interlay group, 5% had A-B gap of 21 to 30 dB, 93.33% had 31 to 40 dB and 1.67% had >40 dB.

In underlay group, 10% had A-B gap of 21 to 30 dB, 83.33% had 31 to 40 dB and 6.67% had >40 dB. There was no significant difference in Pre-Op Air bone Gap between both groups ($\chi 2 = 3.14$, df = 2, p = 0.2081).

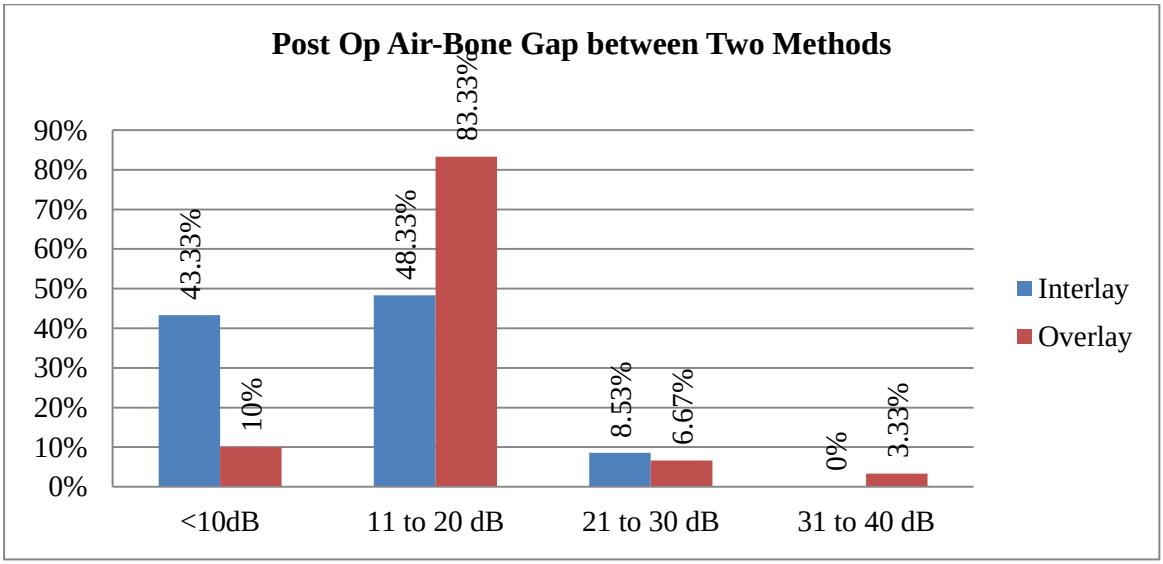


Graph 7: Bar diagram showing Comparison of Pre-Op Air-Bone Gap between Two Methods

Table:10:Comparison of Post Op A-B Gap between Interlay and Underlay technique

	INTERLAY		UNDERLAY	
	No of Cases	%	No of Cases	%
<10dB	26	43.33%	21	10%
11 to 20 dB	29	48.33%	32	83.33%
21 to 30 dB	5	8.53%	5	6.67%
31 to 40 dB	0	0%	2	3.33%
Total	60	100%	60	100%

Post operatively in Interlay group, 43.33% had an A-B gap of <10 dB, 48.33% had an A-B gap of 11 to 20 dB and 8.53% had an A-B gap of 21 to 30 dB . Whereas, in the underlay group, 10% had an A-B gap of of <10 dB, 83.33% had an A-B gap of 11 to 20 dB, 6.67% had an A-B gap of 21 to 30 dB and 3.33% had an A-B gap of gap 31 to 40 dB. This difference between both methods was not found to be statistically significant ($\chi 2 = 2.67$, df = 3, p = 0.443).



Graph 8: Bar diagram showing Comparison of Post Op Air-Bone between Interlay and underlay technique

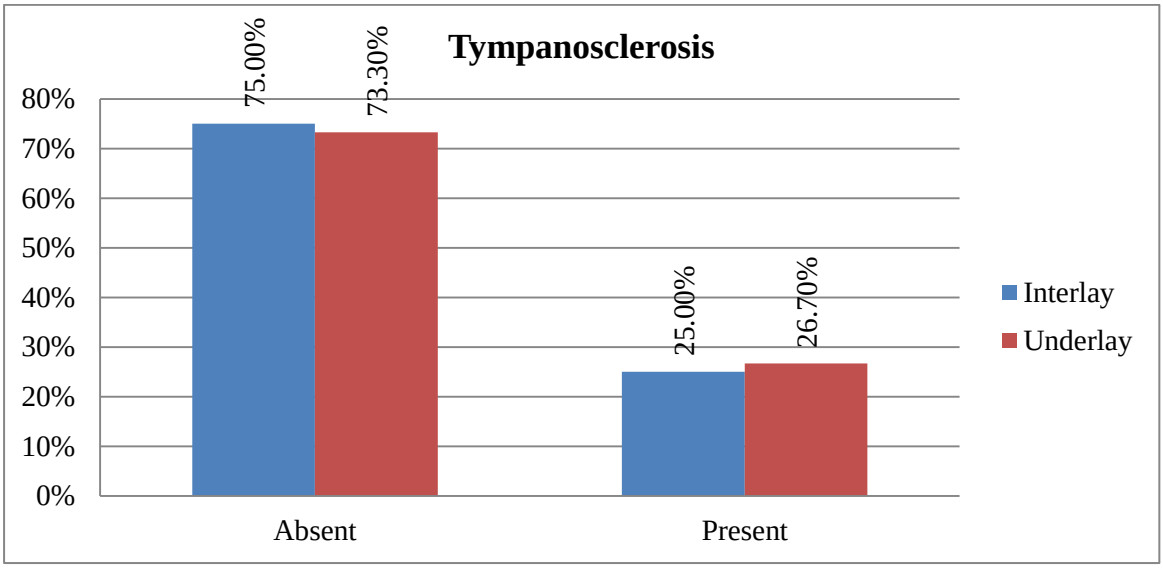
INCIDENCE OF ANTERIOR BLUNTING:

Anterior blunting was not encountered at any point of time during the 1st, 2nd and 3rd month of follow up in any patient operated either by the interlay or underlay technique.

Table :11 Incidence of tympanosclerosis in Interlay and Underlay group.

		Group			
		INTERLAY		**UNDERLAY**	
		Number	%	Number	%
Tympanosclerosis	Absent	45	75.0%	44	73.3%
	Present	15	25.0%	16	26.7%

In Interlay group, 25% of cases had tympanosclerosis and in underlay group 26.7% of cases had tympanosclerosis; the difference of which was found to be statistically insignificant ($\chi 2 = 0.043$, df = 1, p = 0.835).

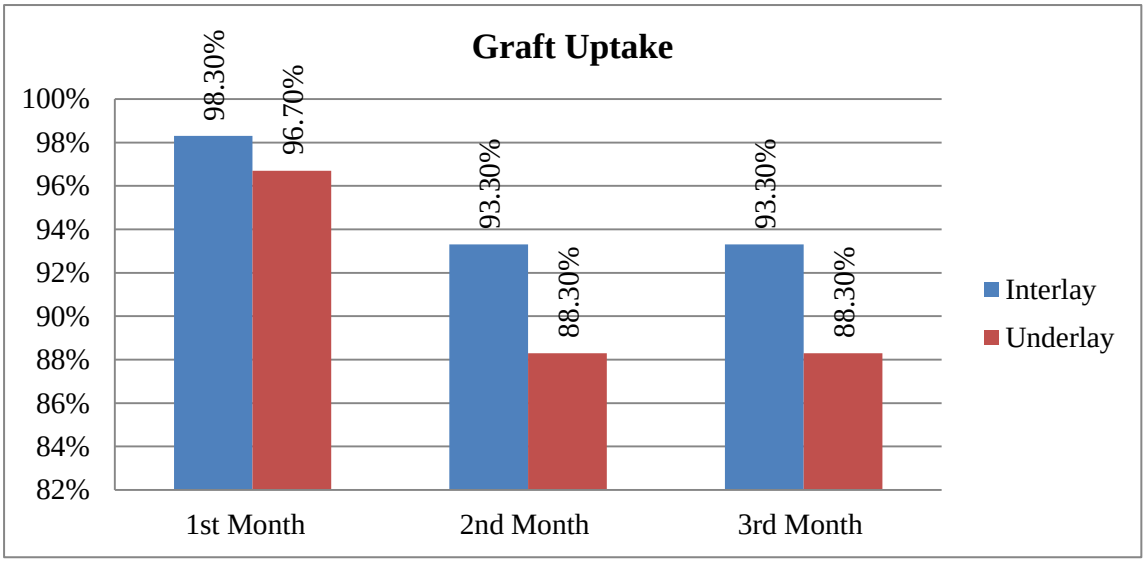


Graph 9: Bar diagram showing comparison of tymopanosclerosis between Interlay and underlay group.

Table 12:Comparison of graft uptake between Interlay and Underlay technique

GRAFT UPTAKE		Group				P value
		INTERLAY		UNDERLAY		
		Number	%	Number	%	
1st Month	Successful	59	98.3	58	96.7	0.559
	Failed	1	1.7	2	3.3	
2nd Month	Successful	56	93.3	53	88.3	0.343
	Failed	4	6.7	7	11.7	
3rd Month	Successful	56	93.3	53	88.3	0.343
	Failed	4	6.7	7	11.7	

In Interlay group, Graft uptake was successful in 98.3% at the 1st month of follow up and at both the 2nd and 3rd month of follow up the graft uptake was successful in 93.3%. on the other hand, in the Underlay group, Graft uptake was successful in 96.7% at 1st month of follow up and at both the 2nd and 3rd month of follow up, 88.3% had successful graft uptake. There was no statistically significant difference in graft uptake between both groups at all the intervals of follow up.

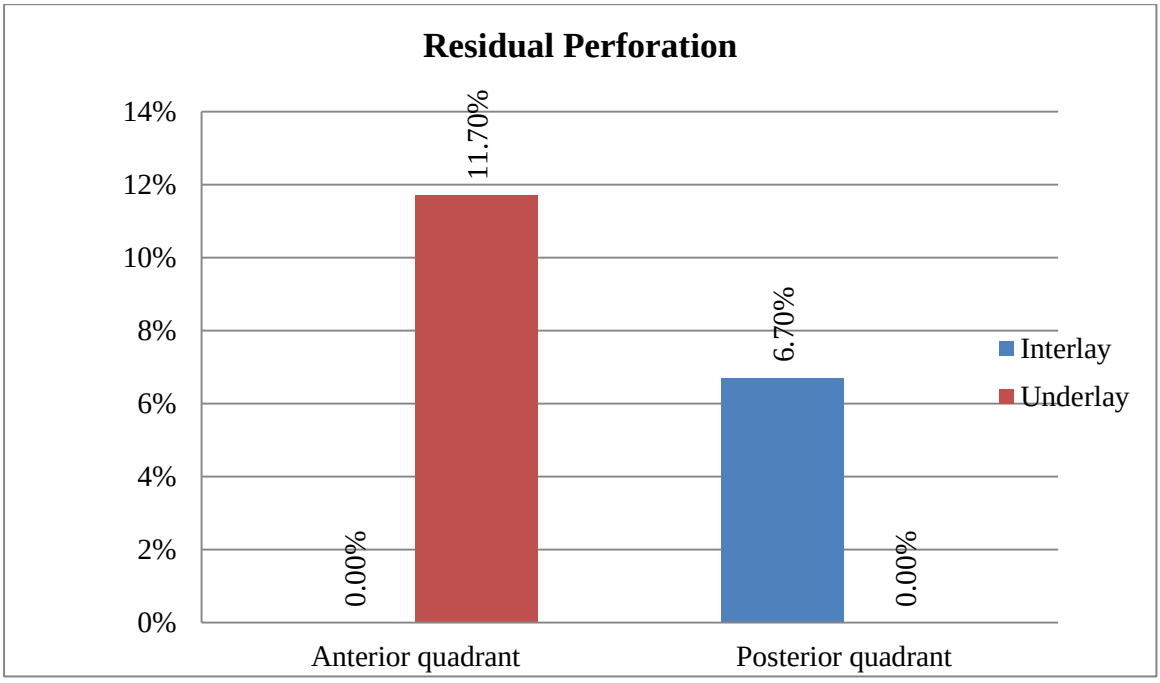


Graph 10: Bar diagram showing comparison of graft uptake between Interlay and underlay technique

Table 13:Residual perforation in Interlay and Underlay group.

		Group			
		INTERLAY		**UNDERLAY**	
		Number	%	Number	%
RESIDUAL PERFORATION	Anterior Quadrant	0	0	7	11.7
	Posterior Quadrant	4	6.7	0	0
	Absent	56	93.3	53	88.3

In interlay group, 6.7% had residual perforation involving the posterior quadrant and within the underlay group, 11.7% had residual Perforation involving the anterior quadrant. There was a statistically significant difference in the type of residual perforation between both groups. ($\chi 2 = 11.08$, df = 2, **p = 0.003***)



Graph 11: Bar diagram showing comparison of the residual perforation between interlay and underlay

DISCUSSION

DISCUSSION

Chronic otitis media (COM) is defined as chronic inflammation of the mucoperiosteum of the middle ear cleft causing permanent abnormality in the tympanic membrane.[25]It is one of the most common causes of preventable hearing loss in India.[46]Various modalities of treatment have been described in literature for the treatment of COM but surgery has remained the mainstay of treatment when other modalities fail.

Myringoplasty has evolved as the principal surgical treatment for a patient suffering from COM with permanent perforation. Over the past few years, Interlay technique has become quite popular, due to promising results and lower incidence of complications.

Our study included 120 patients treated between December 2015 and May 2017. These patients were randomized into two groups, namely an Interlay and an Underlay group.

The mean age of patients in the Interlay group was 36.2 +/- 11.6 yrs. and that in the Underlay group was 36.8+/- 11.8 yrs. with a slight female preponderance in both groups. In a study conducted by Glasscock in 1982, he found no association between the uptake rate of the graft and the age of the patient.[47]

In our study, majority of patients in both Interlay and Underlay group gave history of concomitant hearing loss and ear discharge at presentation. This is in accordance with the study conducted by Sengupta et al.[48]

Both anterior central and subtotal perforations, which were included in our study, are difficult to repair as there is only minimal support for the graft anteriorly. Also, due to Eustachian tube dysfunction there are higher chances of development of a residual perforation, particularly in the antero-superior quadrant.[49]

We also observed that around 25% of cases in both groups had a tympanosclerotic plaque preoperatively, all of which were limited to the antero-superior quadrant. This may have attributed to the relatively higher mean pre-operative A-B gap in both groups. As mentioned in the study performed by Patil et al, we noticed that tympanosclerotic plaques could be excised without difficulty with interlay technique, preserving the outer epithelial layer.[4]

Graft uptake in Interlay technique

In the Interlay technique, we found a successful graft uptake of 98.3% at the end of the first month and 93.3% at the end of both the second and third month of follow up.

In the study conducted by Patil et al, a successful graft uptake of 96% was noted.[4] Similarly in the study by Jain et al a graft uptake of 96.6 % was reported.[50] A successful graft uptake of more than 90% has been obtained in most studies related to the Interlay technique.[51,52,53]

Author	No. of cases	Graft Uptake
Jain et al	500	96.6%
Patil et al	100	96.0%
Kumar et al	90	93.3%
Guo et al	59	96.2%
Komune et al	69	94.2%
Our study	60	93.3%

Table14: Table depicting the success rate for Interlay technique in literature.

Graft uptake in Underlay technique

On the other hand, in the Underlay technique, the graft uptake was successful in 96.7% in the first month of follow up and 88.3% both in the second and third month of follow

In a study conducted by Michael E Glasscock in 1982, temporalis fascia was grafted by Underlay technique and showed that the take up rate of the graft was 93%.[54] In a study conducted in Italy, a successful uptake was obtained in 86% of the cases.[55]Similar results were obtained in various studies related to Underlay technique in current literature.[52,56,57,58] Hence; our results are in keeping with the observations of existing literature regarding Underlay grafting.

Author	Graft Uptake
Glasscock et al	93%
Albera et al	86.0%
Kawatra et al	93.3%
Guo et al	85.7%
Doyle et al	86%
Gibb et al	87.5%
Our study	88.3%

Table15: Table depicting the success rate for Underlay technique in literature.

Anterior blunting

In our study, we did not observe anterior blunting in any patient who was operated with either Interlay or Underlay grafting technique.

The absence of anterior blunting in Interlay in our study is consistent with the study done by Patil et al.[4] A study conducted in Jaipur, commented that the support that occurs from the medial aspect of the graft by the mucosal layer and the support laterally by the fibrosquamosal layer causes the fibrous annulus to be placed firmly in the sulcus. This prevents blunting, lateralization, medialization and epithelial cyst formation.[50] Also, there are minimal chances of anterior canal wall blunting as the fibrous annulus is replaced in the bony annulus and secured all around. Komune et al also had similar findings with no anterior blunting or obliteration of the anterior tympanomeatal angle.[5]Hence; anterior blunting was not encountered in our study or in the present literature.[59,60]

Improvement in A-B gap in Interlay technique

The preoperative A-B gap in majority of patients was between 31-40 dB (93.33%) i.e. mild conductive hearing loss according to Goodman and Clarke classification, with a mean preoperative A-B gap of 35.3 ± 3.6 dB.

In the study performed by Jain et al, most cases had a preoperative A-B gap within a range of 21–30 dB, with a mean A-B gap of 26.08 ± 8.32 dB.[50]Similar studies conducted in various parts of India such as Maharashtra and Karnataka, recorded a mean pre-operative A-B gap of 27.50 dB and 36.42 ± 12.01 dB respectively.[4,56] Majority of our cases had a preoperative A-B gap of >30dB probably due to the inclusion of only anterior central and subtotal perforations with a 25% incidence of tympanosclerosis.

Hearing improved in 91.66% of patients (postoperative A-B gap of <20dB). At the 3rd month of follow up, 48.33% had an A-B gap between 11-20dB with a mean postoperative A-B gap of 12.9 ± 4.8dB.

Jain et al achieved 95.4% improvement in hearing (477/500 patients) with the mean postoperative A-B gap reducing to 10.12 ± 5.84 dB.[50] In the study done by Patil et al 76% had an A-B gap within 10 dB with a mean postoperative A-B gap of 9.7 ± 6.71 dB at the end of the 3rd month.

Improvement in A-B gap in Underlay technique

The preoperative A-B gap was between 31-40dB (mild conductive hearing loss) in 83.33% with a mean preoperative A-B gap of 35.2 ± 4.6 dB.

Hearing improved in 88.3% of patients (postoperative A-B gap of <20dB). At the 3rd month of follow up, 53.33% had an A-B gap between 11-20dB with a mean postoperative A-B gap of 14.1 ± 5.6 dB. Likewise, related studies demonstrated similar improvement in A-B gap in Underlay myringoplasty.56,60

There was a significant improvement in the mean A-B gap at all intervals of follow up for both Interlay and Underlay myringoplasty (p=<0.01). However, on comparing both techniques, the difference in hearing improvement between both methods was not statistically significant (p = 0.443).

Residual perforation

In our study we found that all grafts that had failed in Interlay technique had a residual perforation limited to the posterior quadrant of the neotympanum. While in the Underlay

technique, all residual perforations were seen in the anterior quadrant. Repairing a perforation involving the anterior quadrant has always been quite a challenge. [49] Hence this observation is quite significant as it implies that the chance of residual perforation in the anterior quadrant after Interlay grafting is minimal when compared to Underlay grafting ($p = 0.03$).

As we embarked upon this study we found that there were numerous studies that had deliberated the results of each technique individually. However, there was a lacuna in literature comparing the results of both these popular techniques.

In our comparative study, results of both interlay and neck underlay were favorable, with only a marginal difference in terms of graft uptake and improvement in hearing.

CONCLUSION

CONCLUSIONS

1. Interlay Myringoplasty displayed favorable results with successful graft uptake and significant improvement in post-operative Air-Bone gap. Residual perforation was observed only in the posterior quadrant of the neotympanum.
2. Likewise, in underlay Myringoplasty, which is the standard grafting technique used, similar results were obtained. There was successful graft uptake and improvement in Air-Bone gap in majority of patients.
3. On comparing both methods, we observed that the results obtained by the interlay technique were marginally better than that obtained by the underlay grafting technique. However, this difference was not found to be statistically significant.
4. Anterior blunting was not encountered as a complication of the grafting technique in either method.

Thus, both grafting techniques are highly effective and suitable for the repair of both anterior central and subtotal perforations of the tympanic membrane in patients diagnosed with mucosal type of COM.

SUMMARY

SUMMARY

A total of 120 patients diagnosed to have mucosal type of COM and meeting the inclusion criteria were included in the study.

The diagnosis of mucosal type of COM was made based on history and routine ENT examination. The patients were subjected to microscopic ear examination, pure tone audiometry, mastoid radiography and haematological investigations.

These patients were then randomised (based on 6 block randomization) into interlay and underlay groups. In each group, patients were taken up for the repair of the tympanic membrane perforation with either interlay or underlay grafting with temporalis fascia.

The patients were then followed up monthly for 3 months post-operatively, where the graft uptake, anterior blunting and PTA were assessed, and the results compared groups.

The mean age of patients in the Interlay group was 36.2 +/- 11.6 yrs. and that in Underlay group was 36.8+/- 11.8 yrs. with a slight female preponderance in both groups.

Majority of patients in both Interlay and Underlay group gave history of concomitant hearing loss and ear discharge at presentation with either an anterior central or subtotal perforation on examination.

We also observed that around 25% of cases in both groups had a tympanosclerotic plaque, all of which were limited to the antero-superior quadrant. This may have attributed to the relatively higher mean pre-operative A-B gap in both groups.

In the Interlay technique, we found a successful graft uptake of 98.3% at the end of the first month and 93.3% at the end of both the second and third month of follow up. On the

other hand, in the Underlay technique, the graft uptake was successful in 96.7% in the first month of follow up and 88.3% both in the second and third month of follow up.

In our study, we did not observe anterior blunting in any patient who was operated with either Interlay or Underlay grafting technique.

The preoperative A-B gap within interlay technique in majority of patients was between 31-40dB (93.33%)- mild conductive hearing loss according to Goodman and Clarke classification-with a mean preoperative A-B gap of 35.3 ± 3.6 dB. Majority of our cases had a preoperative A-B gap of >30dB. Hearing improved in 91.66% of patients (postoperative A-B gap of <20dB). At the 3rd month of follow up, 48.33% had an A-B gap between 11-20dB with a mean postoperative A-B gap of 12.9 ± 4.8dB.

The preoperative A-B gap within underlay group was between 31-40dB (mild conductive hearing loss) in 83.33% with a mean preoperative A-B gap of 35.2 ± 4.6 dB. Hearing improved in 88.3% of patients (postoperative A-B gap of <20dB). At the 3rd month of follow up, 53.33% had an A-B gap between 11-20dB with a mean postoperative A-B gap of 14.1 ± 5.6 dB.

There was a significant improvement in the mean A-B gap at all intervals of follow up for both Interlay and Underlay myringoplasty (p=<0.01). However, on comparing both techniques, the difference in hearing improvement between both methods was not statistically significant (p = 0.443).

We found that the grafts that had failed in Interlay technique had a residual perforation limited to the posterior quadrant. Whereas, in the Underlay technique, all residual perforations involved the anterior quadrant.

In our comparative study, results of both techniques are favorable, with only a marginal difference in terms of graft uptake and improvement in hearing. Hence both interlay and underlay grafting can be performed during surgery based on the convenience and skillset of the surgeon.

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ANNEXURES

PROFORMA

COMPARISON OF INTERLAY WITH UNDERLAY MYRINGOPLASTY

PERSONAL DETAILS:

NAME: AGE: M F

SEX:

HOSPITAL NUMBER:

DATE: __/__/__

ADDRESS:

TELEPHONE NUMBER:

CHIEF COMPLAINTS:

Discharge from the ear (right/left/both): for the last-

Difficulty in hearing (right/left/both): for the last-

Sensation of imbalance/ rotation of self/surroundings: for the last-

Pain in the ear/ around the ear/headache/neck (right/left/both): for the last:

Fever -for the last

Previous ear surgery: yes/no

Head injury/trauma/use of Ototoxic drugs: yes/no

Systemic disease

Family h/o deafness

ENT EXAMINATION:

EXAMINATION OF EAR:	**RIGHT**	**LEFT**
PREAURICULAR AREA		
POSTAURICULAR AREA		
PINNA		
EXTERNAL AUDITORY CANAL		
TYMPANIC MEMBRANE		
MIDDLE EAR MUCOSA		

TUNING FORK TESTS	**RIGHT**	**LEFT**
RINNES TEST:		
128 HZ		
512 HZ		
1028 HZ		
WEBERS TEST		
ABC TEST		

NOSE AND PARANASAL SINUSES

ORAL CAVITY AND OROPHARYNX:

SYSTEMIC EXAMINATION:

INVESTIGATIONS:

X RAY MASTOID:

PRE-OPERATIVE PTA FINDINGS

AIR CONDUCTION THRESHOLD

BONE CONDUCTION THRESHOLD

DIAGNOSIS:

OPERATIVE PROCEDURE:

MYRINGOPLASTY WITH INTERLAY/ UNDERLAY GRAFTING TECHNIQUE

INTRAOPERATIVE FINDINGS:

POST OPERATIVE FOLLOW UP

PARAMETER	1ST MONTH	2ND MONTH	3RD MONTH
GRAFT TAKE-UP			
ANTERIOR BLUNTING			
PTA			

CONSENT FORM

STUDY TITLE: COMPARISON OF INTERLAY AND UNDERLAY MYRINGOPLASTY IN CHRONIC OTITIS MEDIA

PG GUIDE: DR.CHANDRAKALA.S

PRINCIPAL INVESTIGATOR: DR. MANNA JOSE PAPPANACHERRY

Name of the subject:

Age :

Address :

a. I have been informed in my own vernacular language the purpose of the study, the necessity of relevant investigations to be carried out and the risks and benefits of the operative procedure to be carried out
b. I understand that the medical information produced by this study will become part of institutional record and will be kept confidential by the said institute.
c. I understand that my participation is voluntary and that I may refuse to participate or may withdraw my consent and discontinue participation at any time without prejudice to my present or future care at this institution.
d. I agree not to restrict the use of any data or results that arise from this study provided such a use is only for scientific purpose(s).
e. I confirm that _____ (chief researcher/ name of PG guide) has explained to me the purpose of research and the study procedure that I will undergo and the possible risks and discomforts that I may experience, in my own language. I hereby agree to give valid consent to participate as a subject in this research project.

Participant’s signature

Signature of the witness: Date:

I have explained to _____ (subject) the purpose of the research, the possible risk and benefits to the best of my ability.

Chief Researcher/ Guide signature Date:

KEY TO MASTER CHART

AB GAP : AIR - BONE GAP

ANT : ANTERIOR

AVG : AVERAGE

CSOM : CHRONIC SUPPURATIVE OTITIS MEDIA

F : FEMALE

IMPVT : IMPROVEMENT

L: LEFT

M: MALE

MNT : MONTH

NA: NOT APPLICABLE

OP: OPERATIVE

PTA: PURE TONE AUDIOMETRY

R: RIGHT

INTERLAY

SEX	AGE	SYMPTOMS	DIGNOSIS	PERFORATION	PREOP PTA	3RD MNT PTA	2ND MNT PTA	1ST MNT PTA	PREOP PTA	AVG POST OP PTA	IMPVT IN AB GAP	OSSICLE STATUS	TYMPANOSCLEROSIS	1ST MNT ANT BLUNTING	2ND MNT ANT BLUNTING	3RD MNT ANT BLUNTING	1ST MNT GRAFT UPTAKE	2ND MNT GRAFT UPTAKE	3RD MNT GRAFT UPTAKE	RESIDUAL PERFORATION
F	32	REDUCED HEARING + EAR DISCHARGE	R CSOM	SUBTOTAL	36.7	13.66	13.06	12.8	36.7	13.173	23.527	INTACT	PRESENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
M	29	REDUCED HEARING + EAR DISCHARGE	R CSOM	ANTERIOR CENTRAL	38.3	10.32	17.66	21.21	38.3	16.397	21.903	INTACT	PRESENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
M	19	REDUCED HEARING + EAR DISCHARGE	R CSOM	ANTERIOR CENTRAL	32.66	12.01	14.32	18.49	32.66	14.94	17.72	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
M	23	REDUCED HEARING + EAR DISCHARGE	R CSOM	ANTERIOR CENTRAL	38.33	9.41	14.21	16.96	38.33	13.527	24.803	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
F	31	REDUCED HEARING + EAR DISCHARGE	R CSOM	ANTERIOR CENTRAL	31.22	10.07	14.08	14.43	31.22	12.86	18.36	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
F	37	HEARING LOSS	R CSOM	ANTERIOR CENTRAL	37.66	12.98	18.66	18.98	37.66	16.873	20.787	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
M	20	EAR DISCHARGE	L CSOM	SUBTOTAL	30.33	12.2	13.4	13.6	30.33	13.067	17.263	INTACT	PRESENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
M	23	REDUCED HEARING + EAR DISCHARGE	L CSOM	SUBTOTAL	32.33	9.48	11.65	17.32	32.33	12.817	19.513	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
F	52	EAR DISCHARGE	R CSOM	ANTERIOR CENTRAL	30.66	9.06	12.97	14.63	30.66	12.22	18.44	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
M	22	REDUCED HEARING + EAR DISCHARGE	L CSOM	ANTERIOR CENTRAL	38	13.3	16.4	17.23	38	15.643	22.357	INTACT	PRESENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
F	42	REDUCED HEARING + EAR DISCHARGE	R CSOM	ANTERIOR CENTRAL	36.26	27.32	26.3	18.37	36.26	23.99666667	12.263	INTACT	ABSENT	NIL	NIL	NIL	GOOD	POOR	POOR	ANTEROINFERIOR QUADRANT
F	34	HEARING LOSS	R CSOM	SUBTOTAL	37.23	12.71	16.66	18.21	37.23	15.86	21.37	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
F	26	REDUCED HEARING + EAR DISCHARGE	R CSOM	SUBTOTAL	33.33	10.32	14.32	15.23	33.33	13.29	20.04	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
F	41	EAR DISCHARGE	L CSOM	SUBTOTAL	26.2	13.33	18.8	18.9	26.2	17.01	9.19	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
F	34	REDUCED HEARING + EAR DISCHARGE	R CSOM	ANTERIOR CENTRAL	39.86	9.46	12.32	13.6	39.86	11.793	28.067	INTACT	PRESENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
F	42	REDUCED HEARING + EAR DISCHARGE	R CSOM	ANTERIOR CENTRAL	32.66	20.32	23.54	24.16	32.66	22.673	9.9867	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
F	44	REDUCED HEARING + EAR DISCHARGE	R CSOM	SUBTOTAL	38.62	10.77	14.87	17.01	38.62	14.217	24.403	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
M	28	HEARING LOSS	L CSOM	ANTERIOR CENTRAL	43.52	17.32	18.6	19.53	43.52	18.483	25.037	INTACT	PRESENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
M	34	REDUCED HEARING + EAR DISCHARGE	L CSOM	ANTERIOR CENTRAL	34.7	15.22	19.9	18.32	34.7	17.813	16.887	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
F	29	REDUCED HEARING + EAR DISCHARGE	R CSOM	ANTERIOR CENTRAL	38.62	8.45	10.32	10.76	38.62	9.8433	28.777	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
M	42	REDUCED HEARING + EAR DISCHARGE	L CSOM	SUBTOTAL	36.32	10.09	13.78	15.34	36.32	13.07	23.25	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
F	27	HEARING LOSS	R CSOM	ANTERIOR CENTRAL	39.08	11.43	17.54	18.65	39.08	15.873	23.207	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
F	33	REDUCED HEARING + EAR DISCHARGE	R CSOM	ANTERIOR CENTRAL	36.66	8.56	10.32	10.66	36.66	9.8467	26.813	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
M	21	REDUCED HEARING + EAR DISCHARGE	L CSOM	ANTERIOR CENTRAL	38.33	11.61	16.8	16.98	38.33	15.13	23.2	INTACT	PRESENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
M	42	REDUCED HEARING + EAR DISCHARGE	R CSOM	ANTERIOR CENTRAL	31.22	9.43	13.55	13.72	31.22	12.233	18.987	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
F	43	REDUCED HEARING + EAR DISCHARGE	L CSOM	SUBTOTAL	37.66	17.32	15.32	16.98	37.66	16.54	21.12	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
M	50	EAR DISCHARGE	R CSOM	ANTERIOR CENTRAL	30.33	10.99	15.31	17.5	30.33	14.6	15.73	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
M	49	REDUCED HEARING + EAR DISCHARGE	R CSOM	SUBTOTAL	32.33	10.74	11.86	13.12	32.33	11.907	20.423	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
F	34	HEARING LOSS	L CSOM	ANTERIOR CENTRAL	39.66	15.32	16.84	19.09	39.66	17.083	22.577	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
F	51	HEARING LOSS	R CSOM	ANTERIOR CENTRAL	37	9.7	11.99	12.06	37	11.25	25.75	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
F	48	REDUCED HEARING + EAR DISCHARGE	R CSOM	SUBTOTAL	34.56	11.87	16.21	18.9	34.56	15.66	18.9	INTACT	PRESENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
F	44	REDUCED HEARING + EAR DISCHARGE	L CSOM	ANTERIOR CENTRAL	38.3	11.87	15.87	16.45	38.3	14.73	23.57	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
M	38	REDUCED HEARING + EAR DISCHARGE	R CSOM	ANTERIOR CENTRAL	36.66	10.32	12.54	13.99	36.66	12.283	24.377	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
F	32	REDUCED HEARING + EAR DISCHARGE	R CSOM	SUBTOTAL	38.33	12.69	16.8	18.6	38.33	16.03	22.3	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
M	24	REDUCED HEARING + EAR DISCHARGE	R CSOM	ANTERIOR CENTRAL	31.22	11.89	13.01	17.05	31.22	13.983	17.237	INTACT	PRESENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
F	49	REDUCED HEARING + EAR DISCHARGE	L CSOM	SUBTOTAL	37.66	8.4	11.06	12.67	37.66	10.71	26.95	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
F	32	REDUCED HEARING + EAR DISCHARGE	R CSOM	SUBTOTAL	30.33	10.45	13.89	13.66	30.33	12.667	17.663	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
F	42	REDUCED HEARING + EAR DISCHARGE	L CSOM	ANTERIOR CENTRAL	35.76	28.76	28.66	17.66	35.76	25.027	10.733	INTACT	ABSENT	NIL	NIL	NIL	GOOD	POOR	POOR	ANTEROINFERIOR QUADRANT
F	48	REDUCED HEARING + EAR DISCHARGE	R CSOM	SUBTOTAL	37.06	12.21	15.43	16.66	37.06	14.767	22.293	INTACT	PRESENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
M	37	REDUCED HEARING + EAR DISCHARGE	R CSOM	ANTERIOR CENTRAL	38	9.51	13.67	13.98	38	12.386	25.614	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
F	21	REDUCED HEARING + EAR DISCHARGE	L CSOM	SUBTOTAL	36.66	13.12	14.87	15.37	36.66	14.453	22.207	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
M	34	REDUCED HEARING + EAR DISCHARGE	R CSOM	ANTERIOR CENTRAL	38.3	12.56	12.78	15.04	38.3	13.46	24.84	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
M	27	HEARING LOSS	L CSOM	ANTERIOR CENTRAL	36.66	10.79	14.32	15.87	36.66	13.66	23	INTACT	PRESENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
F	21	REDUCED HEARING + EAR DISCHARGE	R CSOM	ANTERIOR CENTRAL	38.33	12.04	16.8	17.21	38.33	15.35	22.98	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
F	54	REDUCED HEARING + EAR DISCHARGE	L CSOM	SUBTOTAL	31.22	18.34	15.56	16.01	31.22	16.637	14.583	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
M	30	REDUCED HEARING + EAR DISCHARGE	R CSOM	SUBTOTAL	37.66	10.59	12.74	13.67	37.66	12.333	25.327	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
F	19	REDUCED HEARING + EAR DISCHARGE	L CSOM	ANTERIOR CENTRAL	32.55	10.43	11.09	11.48	32.55	11	21.55	INTACT	PRESENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
F	35	REDUCED HEARING + EAR DISCHARGE	R CSOM	SUBTOTAL	32.33	7.99	11.38	13.11	32.33	10.827	21.503	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
F	45	EAR DISCHARGE	L CSOM	ANTERIOR CENTRAL	36.87	28.98	30.55	18.99	36.87	26.173	10.697	INTACT	ABSENT	NIL	NIL	NIL	GOOD	POOR	POOR	ANTEROINFERIOR QUADRANT
F	60	REDUCED HEARING + EAR DISCHARGE	L CSOM	SUBTOTAL	38	10.69	13.12	14.51	38	12.773	25.227	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
F	58	REDUCED HEARING + EAR DISCHARGE	L CSOM	ANTERIOR CENTRAL	32.54	11.71	13.05	14.76	32.54	13.173	19.367	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
F	36	EAR DISCHARGE	L CSOM	ANTERIOR CENTRAL	28.3	9.32	13.76	13.56	28.3	12.213	16.087	INTACT	PRESENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
F	19	EAR DISCHARGE	L CSOM	ANTERIOR CENTRAL	26.66	8.99	10.92	11.55	26.66	10.487	16.173	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	

F	21	REDUCED HEARING + EAR DISCHARGE	L CSOM	SUBTOTAL	38.33	11.9	12.39	15.2	38.33	13.163	25.167	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
F	33	REDUCED HEARING + EAR DISCHARGE	R CSOM	SUBTOTAL	38.3	12.96	15.19	17.21	38.3	15.12	23.18	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
M	53	REDUCED HEARING + EAR DISCHARGE	L CSOM	ANTERIOR CENTRAL	36.66	17.99	19.34	16.73	36.66	18.02	18.64	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
F	61	REDUCED HEARING + EAR DISCHARGE	L CSOM	ANTERIOR CENTRAL	38.33	12.46	16.8	18.6	38.33	15.953	22.377	INTACT	PRESENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
M	43	REDUCED HEARING + EAR DISCHARGE	R CSOM	ANTERIOR CENTRAL	31.22	11.73	15.55	17.21	31.22	14.83	16.39	INTACT	PRESENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
M	52	REDUCED HEARING + EAR DISCHARGE	R CSOM	SUBTOTAL	37.66	12.16	14.67	13.55	37.66	13.46	24.2	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	
M	19	EAR DISCHARGE	R CSOM	ANTERIOR CENTRAL	30.33	26.59	23.4	18.21	30.33	22.733	7.5967	INTACT	ABSENT	NIL	NIL	NIL	POOR	POOR	POOR	ANTEROINFERIOR QUADRANT
				MEAN PRE OP	35.34283333			MEAN POST O	14.801539											

UNDERLAY																		
SEX	AGE	SYMPTOMS	DIGNOSIS	PERFORATION	PREOP PTA	3RD MNT PTA	2ND MNT PTA	1ST MNT PTA	PREOP PTA	AVG POST OP PTA	IMPOVEMENT IN AB GAP	OSSICLE STATUS	TYMPANOSCLEROSIS	1ST MNT ANTERIOR BLUNTING	2ND MNT ANT BLUNTING	3RD MNT ANT BLUNTING	1ST MNT GRAFT UPTAKE	2ND MNT GRAFT UPTAKE	3RD MNT GRAFT UPTAKE	RESIDUAL PERFORATION
F	61	HEARING LOSS	L CSOM	SUBTOTAL	**36.66**	**13.66**	**13.06**	**12.8**	**36.66**	13.17333	23.486667	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
M	35	HEARING LOSS	R CSOM	ANTERIOR CENTRAL	48.3	18.32	17.66	17.76	48.3	17.91333	30.386667	INTACT	PRESENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
M	50	REDUCED HEARING + EAR DISCHARGE	R CSOM	ANTERIOR CENTRAL	32.66	16.2	17.31	17.9	32.66	17.13667	15.523333	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
F	43	REDUCED HEARING + EAR DISCHARGE	R CSOM	SUBTOTAL	38.33	12.05	12.54	15.6	38.33	13.39667	24.933333	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
M	31	REDUCED HEARING + EAR DISCHARGE	R CSOM	ANTERIOR CENTRAL	35.21	28.8	27.5	28.2	35.21	28.16667	7.0433333	INTACT	PRESENT	NIL	NIL	NIL	POOR	POOR	POOR	ANTEROINFERIOR AND POSTEROINFERIOR QUADRANT
F	37	HEARING LOSS	R CSOM	ANTERIOR CENTRAL	37.66	10.43	12.09	12.37	37.66	11.63	26.03	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
M	20	EAR DISCHARGE	L CSOM	SUBTOTAL	30.33	12.2	13.4	13.6	30.33	13.06	17.27	INTACT	PRESENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
F	23	REDUCED HEARING + EAR DISCHARGE	L CSOM	SUBTOTAL	32.33	11.41	13.56	15.98	32.33	13.65	18.68	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
M	52	EAR DISCHARGE	R CSOM	ANTERIOR CENTRAL	30.66	9.45	13.51	14.32	30.66	12.42667	18.233333	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
F	22	HEARING LOSS	L CSOM	ANTERIOR CENTRAL	48	13.3	16.4	17.23	48	15.64333	32.356667	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
M	42	REDUCED HEARING + EAR DISCHARGE	R CSOM	ANTERIOR CENTRAL	**26.26**	**22.32**	**21.2**	**18.66**	**26.26**	20.72667	5.5333333	INTACT	ABSENT	NIL	NIL	NIL	**POOR**	**POOR**	**POOR**	ANTEROINFERIOR
M	34	HEARING LOSS	R CSOM	SUBTOTAL	37.23	11.73	13.39	18.54	37.23	14.55333	22.676667	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
F	26	EAR DISCHARGE	R CSOM	SUBTOTAL	33.33	10.3	12.85	13.87	33.33	12.34	20.99	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
M	41	EAR DISCHARGE	L CSOM	SUBTOTAL	26.2	10.67	11.32	12.59	26.2	11.52667	14.673333	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
F	34	REDUCED HEARING + EAR DISCHARGE	R CSOM	ANTERIOR CENTRAL	39.86	17.56	16.37	15.81	39.86	16.58	23.28	INTACT	PRESENT	+	+	+	GOOD	GOOD	GOOD	NA
F	33	REDUCED HEARING + EAR DISCHARGE	R CSOM	ANTERIOR CENTRAL	32.66	12.32	15.89	16.08	32.66	14.76333	17.896667	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
F	29	REDUCED HEARING + EAR DISCHARGE	L CSOM	SUBTOTAL	28.62	10.67	10.32	12.69	28.62	11.22667	17.393333	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
M	28	HEARING LOSS	L CSOM	ANTERIOR CENTRAL	43.52	13.87	18.6	17	43.52	16.49	27.03	INTACT	PRESENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
M	23	REDUCED HEARING + EAR DISCHARGE	R CSOM	SUBTOTAL	34.7	9.85	11.19	12.42	34.7	11.15333	23.546667	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
F	29	REDUCED HEARING + EAR DISCHARGE	L CSOM	ANTERIOR CENTRAL	38.62	31.04	29.59	18.76	38.62	26.46333	12.156667	INTACT	PRESENT	NIL	NIL	NIL	GOOD	POOR	POOR	ANTEROINFERIOR AND POSTEROINFERIOR QUADRANT
F	42	REDUCED HEARING + EAR DISCHARGE	L CSOM	SUBTOTAL	**36.32**	**11.31**	**13.42**	**17.99**	**36.32**	14.24	22.08	INTACT	ABSENT	**NIL**	**NIL**	**NIL**	**GOOD**	**GOOD**	**GOOD**	NA
M	27	HEARING LOSS	R CSOM	ANTERIOR CENTRAL	29.08	27.21	22.2	18.48	29.08	22.63	6.45	INTACT	ABSENT	NIL	NIL	NIL	GOOD	POOR	POOR	ANTEROINFERIOR AND POSTEROINFERIOR QUADRANT
F	33	REDUCED HEARING + EAR DISCHARGE	L CSOM	ANTERIOR CENTRAL	36.66	11.86	12.28	15.54	36.66	13.22667	23.433333	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
F	19	REDUCED HEARING + EAR DISCHARGE	L CSOM	SUBTOTAL	38.33	12.11	16.8	18.6	38.33	15.83667	22.493333	INTACT	PRESENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
M	42	HEARING LOSS	R CSOM	ANTERIOR CENTRAL	31.22	10.88	10.98	13.33	31.22	11.73	19.49	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
M	43	REDUCED HEARING + EAR DISCHARGE	L CSOM	SUBTOTAL	37.66	27.56	26.42	28.32	37.66	27.43333	10.226667	INTACT	ABSENT	NIL	NIL	NIL	GOOD	POOR	POOR	NFERIOR QU

M	50	EAR DISCHARGE	L CSOM	ANTERIOR CENTRAL	30.33	12.21	14.78	15.89	30.33	14.29333	16.036667	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
M	35	REDUCED HEARING + EAR DISCHARGE	R CSOM	SUBTOTAL	32.33	10.79	15.81	17.23	32.33	14.61	17.72	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
M	34	HEARING LOSS	L CSOM	ANTERIOR CENTRAL	39.66	10.99	13.4	14.9	39.66	13.09667	26.563333	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
F	51	HEARING LOSS	L CSOM	ANTERIOR CENTRAL	37	10.21	12.67	13	37	11.96	25.04	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
M	19	REDUCED HEARING + EAR DISCHARGE	R CSOM	SUBTOTAL	**35.76**	**11.23**	**14.9**	**15.11**	**35.76**	13.74667	22.013333	INTACT	PRESENT	**NIL**	**NIL**	**NIL**	**GOOD**	**GOOD**	**GOOD**	NA
F	44	REDUCED HEARING + EAR DISCHARGE	R CSOM	ANTERIOR CENTRAL	38.3	10.3	12.2	13.98	38.3	12.16	26.14	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
M	38	HEARING LOSS	L CSOM	SUBTOTAL	36.66	10.99	14.08	20.32	36.66	15.13	21.53	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
F	23	REDUCED HEARING + EAR DISCHARGE	R CSOM	SUBTOTAL	38.33	11.99	16.8	18.6	38.33	15.79667	22.533333	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
F	24	REDUCED HEARING + EAR DISCHARGE	R CSOM	ANTERIOR CENTRAL	31.22	9.76	11.68	17.33	31.22	12.92333	18.296667	INTACT	PRESENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
M	49	HEARING LOSS	R CSOM	SUBTOTAL	37.66	11.09	12.41	13.86	37.66	12.45333	25.206667	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
F	32	REDUCED HEARING + EAR DISCHARGE	L CSOM	SUBTOTAL	30.33	12.55	14.32	15	30.33	13.95667	16.373333	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
F	42	REDUCED HEARING + EAR DISCHARGE	L CSOM	SUBTOTAL	32.33	11.39	14.21	15.78	32.33	13.79333	18.536667	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
M	54	REDUCED HEARING + EAR DISCHARGE	R CSOM	SUBTOTAL	37.06	10.61	11.38	13.55	37.06	11.84667	25.213333	INTACT	PRESENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
F	37	REDUCED HEARING + EAR DISCHARGE	R CSOM	ANTERIOR CENTRAL	38	13.21	19.4	20.2	38	17.60333	20.396667	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
F	21	REDUCED HEARING + EAR DISCHARGE	L CSOM	SUBTOTAL	**36.32**	**12.99**	**16.12**	**17.9**	**36.32**	15.67	20.65	INTACT	ABSENT	**NIL**	**NIL**	**NIL**	**GOOD**	**GOOD**	**GOOD**	NA
M	34	HEARING LOSS	R CSOM	SUBTOTAL	38.3	10.32	11.21	12.86	38.3	11.46333	26.836667	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
F	27	HEARING LOSS	L CSOM	ANTERIOR CENTRAL	36.66	12.28	14.9	16.32	36.66	14.5	22.16	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
F	36	REDUCED HEARING + EAR DISCHARGE	L CSOM	ANTERIOR CENTRAL	38.33	10.89	14.21	18.6	38.33	14.56667	23.763333	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
F	54	REDUCED HEARING + EAR DISCHARGE	L CSOM	SUBTOTAL	31.22	10.98	11.6	14.69	31.22	12.42333	18.796667	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
M	30	REDUCED HEARING + EAR DISCHARGE	R CSOM	SUBTOTAL	37.66	18.99	19.99	15.81	37.66	18.26333	19.396667	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
M	21	REDUCED HEARING + EAR DISCHARGE	R CSOM	ANTERIOR CENTRAL	30.33	10.78	11.39	15.99	30.33	12.72	17.61	INTACT	PRESENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
M	35	REDUCED HEARING + EAR DISCHARGE	L CSOM	SUBTOTAL	32.33	28.97	24.2	18.2	32.33	23.79	8.54	INTACT	ABSENT	NIL	NIL	NIL	GOOD	POOR	POOR	ANTEROINFERIOR AND POSTEROINFERIOR QUADRANT
M	45	HEARING LOSS	L CSOM	SUBTOTAL	30.66	10.87	11.32	12.09	30.66	11.42667	19.233333	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
F	60	REDUCED HEARING + EAR DISCHARGE	L CSOM	SUBTOTAL	28.98	13.79	16.66	18.96	28.98	16.47	12.51	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
F	54	EAR DISCHARGE	L CSOM	ANTERIOR CENTRAL	**32.54**	**11.98**	**15.21**	**19.8**	**32.54**	15.66333	16.876667	INTACT	PRESENT	**NIL**	**NIL**	**NIL**	**GOOD**	**GOOD**	**GOOD**	NA
F	36	EAR DISCHARGE	R CSOM	SUBTOTAL	38.3	10.3	13.79	13.99	38.3	12.69333	25.606667	INTACT	PRESENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
M	19	EAR DISCHARGE	L CSOM	ANTERIOR CENTRAL	36.66	30.11	29.99	26.01	36.66	28.70333	7.9566667	INTACT	ABSENT	NIL	NIL	NIL	GOOD	POOR	POOR	NFERIOR QU
F	21	REDUCED HEARING + EAR DISCHARGE	L CSOM	SUBTOTAL	38.33	13.11	16.8	18.6	38.33	16.17	22.16	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
F	33	REDUCED HEARING + EAR DISCHARGE	L CSOM	SUBTOTAL	37.66	15.12	18.78	19.21	37.66	17.70333	19.956667	INTACT	ABSENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
F	53	REDUCED HEARING + EAR DISCHARGE	R CSOM	ANTERIOR CENTRAL	30.33	18.89	20.11	18.21	30.33	19.07	11.26	INTACT	ABSENT	NIL	NIL	NIL	**GOOD**	**GOOD**	**GOOD**	NA
F	65	REDUCED HEARING + EAR DISCHARGE	L CSOM	SUBTOTAL	42.33	15.21	17.88	19.33	42.33	17.47333	24.856667	INTACT	PRESENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
F	43	EAR DISCHARGE	L CSOM	ANTERIOR CENTRAL	38.3	14.23	18.43	18.99	38.3	17.21667	21.083333	INTACT	PRESENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
F	37	REDUCED HEARING + EAR DISCHARGE	R CSOM	SUBTOTAL	28.32	11.2	16.32	17.99	28.32	15.17	13.15	INTACT	ABSENT	**NIL**	**NIL**	**NIL**	GOOD	GOOD	GOOD	NA
F	52	EAR DISCHARGE	L CSOM	SUBTOTAL	35.21	10.11	12.22	14.96	35.21	12.43	22.78	INTACT	PRESENT	NIL	NIL	NIL	GOOD	GOOD	GOOD	NA
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