"HEARING IMPROVEMENT IN INTERPOSITION OSSICULOPLASTY AND MYRINGOSTAPEDIOPEXY"

By

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In partial fulfilment of the requirements for the degree of

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IN
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Under the Guidance of

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I hereby declare that this dissertation entitled **"HEARING IMPROVEMENT IN INTERPOSITION OSSICULOPLASTY AND MYRINGOSTAPEDIOPEXY"** is a bonafide and genuine research work carried out by me under the guidance of **Dr.K.C. PRASAD,** Professor, Department of Otorhinolaryngology, Sri Devaraj Urs Medical College, Kolar, in partial fulfilment of University regulation for the award "**M.S. DEGREE IN OTORHINOLARYNGOLOGY**", the examination to be held in April, 2018 by SDUAHER. This has not been submitted by me previously for the award of any degree or diploma from the university or any other university.

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Dr. SHASHNAK CHAUDHARY

LIST OF ABBREVIATIONS

- AAO-HNS –AMERICAN ACADEMY OF OTORHINOLARYNGOLOGY AND HEAD AND NECK SURGERY
- A-K CLASSIFICATION – AUSTIN KARTUSH CLASSIFICATION
- AC – AIR CONDUCTION
- ABG- AIR BONE GAP
- BC – BONE CONDUCTION
- COM – CHRONIC OTITIS MEDIA
- dB- DECIBEL
- EAC-EXTERNAL AUDITORY CANAL
- ENT-EAR ,NOSE,THROAT
- FIG- FIGURE
- HRCT – HIGH RESOLUTION COMPUTED TOMOGRAPHY
- Hz- HERTZ
- KHz- KILOHERTZ
- I –INCUS
- IL- INTERLUKIN
- I.E- THAT IS
- LIG-LIGAMENT
- OPD- OUTPATIENT DEPARTMENT
- PRE-OP- PRE OPERATIVE
- POST-OP- POST OPERATIVE
- M- MALLEUS
- S- STAPES
- SD- STANDARD DEVIATION
- SRT- SPEECH RECEPTION THRESHOLD
- TNF-TUMOUR NECROSIS FACTOR

ABSTRACT

Background: Chronic otitis media (COM) may lead to partial or complete loss of tympanic membrane and erosion of the ossicles resulting in attenuation of sound transmission from tympanic membrane to the oval window. Depending on the type of ossicular defect autologous sculptured incus, tragal cartilage or cortical bone may be used to bridge the gap between the malleus and the stapes suprastructure – interposition ossiculoplasty or may be used to establish a link directly between the tympanic membrane and the stapes suprastructure– myringostapediopexy

Aims and Objectives: To determine the hearing outcome and the long-term stability of sculptured autologous incus, cartilage or bone in interposition ossiculoplasty and myringostapediopexy in intact canal wall tympanoplasty with or without cortical mastoidectomy

Methodology: A minimum of 64 patients diagnosed with chronic otitis media, 32 patients in each group undergoing interposition ossiculoplasty (Group A) and myringostapediopexy (Group B), satisfying the inclusion and exclusion criteria, presenting to the department of otorhinolaryngology and head and neck surgery of R.L Jalappa hospital, Tamaka, Kolar, from december 2015 to july 2017 were included in this study.

All the patients were followed up at the end of 3 months after surgery. The neo-tympanum was examined and patients were then subjected to tuning fork tests and pure tone audiogram to assess the improvement in hearing. The hearing results were compared

in terms of mean pre-op and post-op Air conduction thresholds, Air-Bone gap and hearing gain or ABG closure.

Type of study: Prospective observational study

Results: The average pre-op ABG for Group B (40.7 dB) was higher than the average pre-op ABG for Group A (31.8 dB). All patients showed significant hearing improvement following both procedures i.e Interposition ossiculoplasty and myringostapediopexy using autologous grafts. The mean post-op ABG in Group A was 16.5dB and the mean post-op ABG for Group B was 19.2 dB. The average hearing gain for Group B was higher than Group A. Incus was the most common autologous graft used for ossiculoplsty in both groups. Hearing gain with cortical bone graft was higher than hearing gains with incus or tragal cartilage in both the goups, but not statistically significant.

Conclusion: Ossicular reconstruction by interposition ossiculoplasty and myringostapediopexy using autologous grafts provide significant hearing improvement in patients with COM. Improvement in hearing is better in patients with higher preoperative hearing loss when compared to patients with lesser preoperative hearing loss. Myringostapediopexy provides marginally better hearing gain compared to interposition ossiculoplasty. Aulogous incus, and cortical bone graft are suitable autologous materials for ossicular reconstruction and provide similar hearing outcome.

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INTRODUCTION

Middle ear ossicles serve as acoustic transformers which compensate for loss of sound energy while passing through inner ear fluids by its impedance matching mechanism. Any destruction or discontinuity of the ossicular chain results in loss of acoustic transformer or impedance matching mechanism resulting in conductive hearing loss.

Chronic otitis media (COM) may lead to partial or complete loss of tympanic membrane and erosion of the ossicles resulting in attenuation of sound transmission from tympanic membrane to the oval window. Cholesteatoma is by far the most common cause, and chronic oto-mastoiditis without cholesteatoma can also cause erosion of ossicles. A conductive deficit in excess of 40 dB indicates ossicular discontinuity usually from erosion of the long process of incus or stapes suprastructure.[1]

With the development of newer technology in middle ear surgeries over the years, the aim of otology surgeons at present is eradication of disease and prevention of recurrence along with reconstruction of tympano-ossicular chain for improvement of hearing.

The term ossiculoplasty refers to the operation performed on the middle ear to restore the hearing mechanism by ossicular chain reconstruction.[2] Ossicular reconstruction is still a developing and evolving surgical discipline in otolaryngology. The goal of ossiculoplasty is to achieve a connection between the tympanic membrane and the stapes footplate which is stable and produce reliable long term hearing result.

In 1957, Hall and Rytzner performed the first ossicular chain reconstruction by repositioning the patient's own incus.[3] Since then various techniques have

been described to bridge the gap between the tympanic membrane and stapes footplate. Although these approaches to ossicular reconstruction have been shown to be successful, no single technique has received universal acceptance[4]. Among these techniques are interposition ossiculoplasty and myringostapediopexy.

Many materials including both biologic and alloplastic materials have been used for ossicular reconstruction. Biologic materials include autograft or homograft ossicles, cartilage or cortical bone. The use of autologous graft has several advantages such as biocompatibility, a very low extrusion rate, no risk of transmitting disease and being body's own tissue, it is cost effective.[5]

Depending on the type of ossicular defect autologous sculptured incus, tragal cartilage or cortical bone may be used to bridge the gap between the malleus and the stapes suprastructure – interposition ossiculoplasty or may be used to establish a link directly between the tympanic membrane and the stapes suprastructure– myringostapediopexy.

The two procedures differ regarding extent of the disease process, presence or absence of malleus and operative technique. The effectiveness of these two procedures in providing better hearing after tympanoplasty remains a question as very few studies are available in literature which document the hearing improvement following these two procedures.

AIMS & OBJECTIVES

OBJECTIVE OF THE STUDY

To determine the hearing outcome and the long-term stability of sculptured autologous incus, cartilage or cortical bone in interposition ossiculoplasty and myringostapediopexy in intact canal wall tympanoplasty with or without cortical mastoidectomy.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Ossicular chain erosion is a feature of chronic otitis media. A minor erosion of the lenticular process and a more pronounced resorption of the long process are among the most common ossicular defects encountered in tympanoplasty. Ossicular chain reconstruction has significantly improved hearing results after tympanoplasty and tympanomastoid surgery for chronic otitis media.

Ossicular reconstruction with autologous incus provides significantly better hearing improvement and graft take up rate when compared to titanium prosthesis. Postoperative air bone gap (ABG) was < 20 dB in 58 % patients and < 30 dB in 64% patients undergoing ossiculoplasty using autologous incus. The postoperative complications are also found to be less in patients of this group. Incus is well tolerated as it more physiological and biocompatible, thereby giving better hearing results and reducing graft extrusion rates. But this technique requires time and skill to ensure appropriate sculpting in order to minimize ankylosis of the fallopian canal, scutum and posterior canal wall.[1]

Sculptured autologous or homologous incus interposition provides hearing success comparable with current allograft prosthesis. Advantages of autograft prostheses include a very low extrusion rate, no risk of transmitting disease, biocompatibility, and remain stable over time. While some disadvantages might be displacement, complete absorption, and possibility of harbouring microscopic disease.[5]

Autologous ossicles and cartilage grafts show varying amount of conversion to viable bone and even after extended period of time, large amount of viable graft remains intact. Bone and cartilage graft maintain their size and shape. They show no tendency to resorb and incite prolific growth. Cartilage graft maintain their volumetric integrity but may loose their rigidity over a period of time.[6]

Apart from ossicular reconstruction in patients with Chronic otitis media incus interposition may also be done for patients with tympanosclerosis with malleus and incus fixation and for those requiring facial nerve decompression following trauma where it is necessary to remove the incus in order to completely expose the middle ear segment of facial nerve upto the geniculate ganglion. In a postoperative follow-up of two to five years incus interposition resulted in closure of ABG from 30 dB to 15 dB or less in 69.4% of 216 ears.[7]

Long term follow-up (10-15 years) of the same group revealed despite significant middle ear dysfunction hearing gains achieved from autologous or homologous incus interposition are sustained over a long period of time.[8]

In a study of 172 patients who had a mean preoperative air bone gap of 28db and out of which 109 patients underwent ossiculoplasty using autologous incus without mastoid surgery. 85% of these patients showed postoperative air bone gap of less than 20 db.[9]

Patients who underwent incus interposition had better drum closure and postoperative hearing improvement when compared to classical myringostapediopexy (tympanic

membrane to stapes assembly). Patients who underwent incus interposition ossiculoplasty achieved mean post-operative ABG of 29.6 dB that was 31% improvement over pre-operative mean ABG of 42.6dB. Whereas in patients with classical myringostapediopexy improvement was 14.4% with mean pre-op ABG as 42.4 dB, and mean post-op ABG as 36.3 dB.[10]

Long term follow up of ear reconstructed with cartilage allograft used as PORP or TORP was associated with good and stable postoperative hearing and a low incidence of failures. Patients in PORP group had a mean gain of 22.2 dB and patients in TORP group had a mean gain of 23dB at the end of 10 year follow-up.[11]

Modified radical mastoidectomy provides safe surgical access for removal of middle ear and mastoid disease and produces hearing results that are comparable to those of intact canal wall procedures. Incus interposition and myringostapediopexy using autologous grafts with removal of the posterior canal wall does not decrease the chances of hearing improvement.[7][12]There are no significant changes in the bone conduction despite prolonged disease and extensive surgery. Hearing results after modified radical mastoidectomy are better after primary surgery than after revision surgery in case of recurrence of disease and better in the presence of intact stapes.[12]

143 patients underwent ossicular reconstruction with canal wall down mastoidectomy. In 90% of patients aulogous incus or autologous cartilage (tragal or chonchal) was used and synthetic prosthesis was used in 10% of patients as PORP or TORP. Pre-operative audiometric testing revealed a mean air conduction pure tone average (PTA) of 50.97 dB

. The mean post-operative result for air conduction PTA was 37.62. The mean pre- and post-operative air–bone gaps (ABGs) were 28.83 and 13.94 dB, respectively, with a gain of 14.89 dB. Almost 62.67 per cent of patients closed their ABGs to within 20 dB. Mean ABG improvement of 15.27 dB was observed in patients undergoing ossicular chain reconstruction with autologous cartilage graft, and ABG improvement of 13.96 dB was observed in those with remodelled incus. No difference in postoperative ABG regarding the type used was noticed.[13]

Patient's perceived hearing improvement is best when the hearing level of the poorer hearing ear is raised to a level close to that of better hearing ear. Small improvements in hearing are more likely to be appreciated by patients with bilateral hearing loss. Austin stated that the two important ossicles for sound transmission were the malleus and the stapes suprastructure. The incus, therefore, could be safely removed and repositioned. Significant improvement of hearing was seen postoperatively in patients undergoing malleostapediopexy (interposition ossiculoplasty) and myringostapediopexy using sculptured autologous incus. The preoperative and 3 months' postoperative ABG values were 38.09 dB and 11.92 dB respectively. The improvement in the ABG was significantly more among malleostapediopexy in comparison to myringostapediopexy at 1 month and 3 months postoperative follow-up.[14]

SURGICAL ANATOMY OF MIDDLE EAR CLEFT

The middle ear cleft consists of the Eustachian tube, tympanic cavity and the mastoid air cell system. The tympanic cavity is a biconcave, air-filled space within the temporal bone. It is bounded by the osseous labyrinth medially and the tymapnic membrane laterally. It contains the ossicles and their tendons that attach them to the middle ear muscles. The tympanic segment of the facial nerve, run along its medial walls to pass through the cavity.[15]

THE TYMPANIC CAVITY

The tympanic cavity is shaped like a biconcave disc which measures around 15 mm in the antero-posterior and vertical dimensions. In its transverse dimension, it expands superiorly to 6mm and inferiorly to 4mm from a constriction of 2mm. It is divided into three compartments: the epitympanum, the mesotympanum and the hypotympanum.

The *epitympanum* or the *attic* is the portion of middle ear space above the level of malleolar folds. It contains the head of the malleus and the body/short process of the incus and communicates with the mastoid antrum via a narrow passage, the *aditus ad antrum*. The *mesotympanum* lies immediately deep to the pars tensa of tympanic membrane and contains the manubrium of the malleus, long and lenticular process of the incus, the stapes, tensor tympani, stapedial tendon and the chorda tympani nerve. The *hypotympanum* is the portion of the middle ear below the floor of the external auditory canal (EAC) and contains the opening of the Eustachian tube anteriorly.[16] The tympanic cavity can be linked to a six walled chamber consisting of the roof, floor, medial and lateral walls, anterior and posterior walls (fig 1).

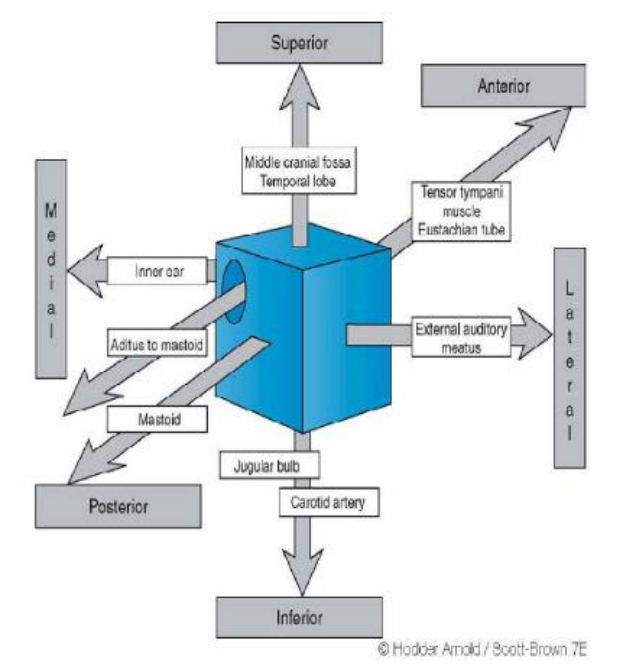


FIG 1: THE RELATIONSHIPS OF MIDDLE EAR[15]

THE SUPERIOR WALL (TEGMEN TYMPANI) OR ROOF

It is a thin plate of bone formed by both petrous and squamous part of the temporal bone. It separates the epitympanum and mastoid antrum from the middle cranial fossa. It extends posteriorly to form the roof of aditus ad antrum where it is known as tegmen antri.

THE FLOOR OF THE TYMPANIC CAVITY

It separates the hypotympanum from the dome of jugular bulb. The tympanic branch of the glossopharyngeal nerve from its origin at the skull base enters the middle ear through a small opening at the junction of the floor and the medial wall of tympanic cavity.

LATERAL WALL OF TYMPANIC CAVITY

The lateral wall of the tympanic cavity is formed by the bony outer attic wall (scutum) superiorly, the tympanic membrane centrally and the bony lateral wall of hypotympanum inferiorly.

There are three holes in the bone of the medial surface of the lateral wall of the tympanic cavity. The petrotympanic fissure is a slit (2 mm long), which opens anteriorly just above the tympanic membrane. It receives the anterior malleolar ligament and transmits the anterior tympanic branch of the maxillary artery to the middle ear cavity. The chorda tympani, which carries taste sensation from the anterior two-thirds of the tongue of the same side and secretomotor fibres to the submandibular gland, enters the medial surface of the fissure through a separate anterior canaliculus (canal of Huguier) which is sometimes merged with the fissure. Then it turns posteriorly and runs between the fibrous and the mucosal layer of the tympanic membrane. It crosses the handle of malleus and reaches the posterior bony canal wall just medial to the tympanic sulcus, enters the posterior canaliculus and then runs obliquely downwards and medially through the posterior wall of the middle ear cavity until it reaches the facial nerve.

THE MEDIAL WALL OF THE TYMPANIC CAVITY

The medial wall is also known as the surgical floor in middle ear surgery. It separates the tympanic cavity from the inner ear. Most of the central part of the medial wall is occupied by a rounded elevation called promontory. It

covers the basal coil of the cochlea and has grooves on its surface for nerves which form the tympanic plexus.

Behind and above the promontory is the *fenestra vestibuli* (oval window), it connects the middle ear with the inner ear and is covered by the footplate of stapes. The size of the fenestra vestibuli naturally varies with the size of the base of the stapes, but on average it is 3.25 mm long and 1.75 mm wide. Above the fenestra vestibuli is the facial nerve. Anterior to the oval window is a curved hook like projection called *processus cochleariformis,* which houses the tendon of tensor tympani..

The *fenestra cochleae* (round window) which is closed by the secondary tympanic membrane (round window membrane), lies below and a little behind the fenestra vestibuli. The round window is separated from oval window by a posterior extension of the promontory called the *subiculuin.* A spicule of bone extending from the promontory above the subiculum upto the pyramid on the posterior wall of the cavity is called the *ponticulus.* The round window lies completely under cover of the overhanging edge of the promontory in a deep niche which is most commonly triangular in shape. The shape of the secondary tympanic membrane varies from round to oval and kidney shaped, with average longest diameter of 2.30 mm and shortest diameter of 1.87 mm.[15] The ampulla of the posterior semicircular canal is the closest vestibular structure to the membrane and its nerve (the singular nerve) runs almost parallel to and 1 mm away from the medial attachment of the deep portion of the posterior part of the membrane. The membrane is therefore a surgical landmark for the singular nerve. The facial nerve canal runs above the promontory and fenestra vestibuli in an antero-posterior

direction. It has a smooth rounded lateral surface that is occasionally deficient, and is marked anteriorly by the processus cochleariformis.[16]

The medial wall of the epitympanum is formed by the region above the tympanic segment of the facial nerve canal. The dome of the lateral semicircular canal extends a little lateral to the facial canal and is a major feature of the posterior portion of epitympanum.[15]

Fig 2 shows the medial wall of the tympanic cavity depicting the promontory, oval window, round window, canal for facial nerve, processus cochleariformis, sinus tympani and the tympanic plexus.

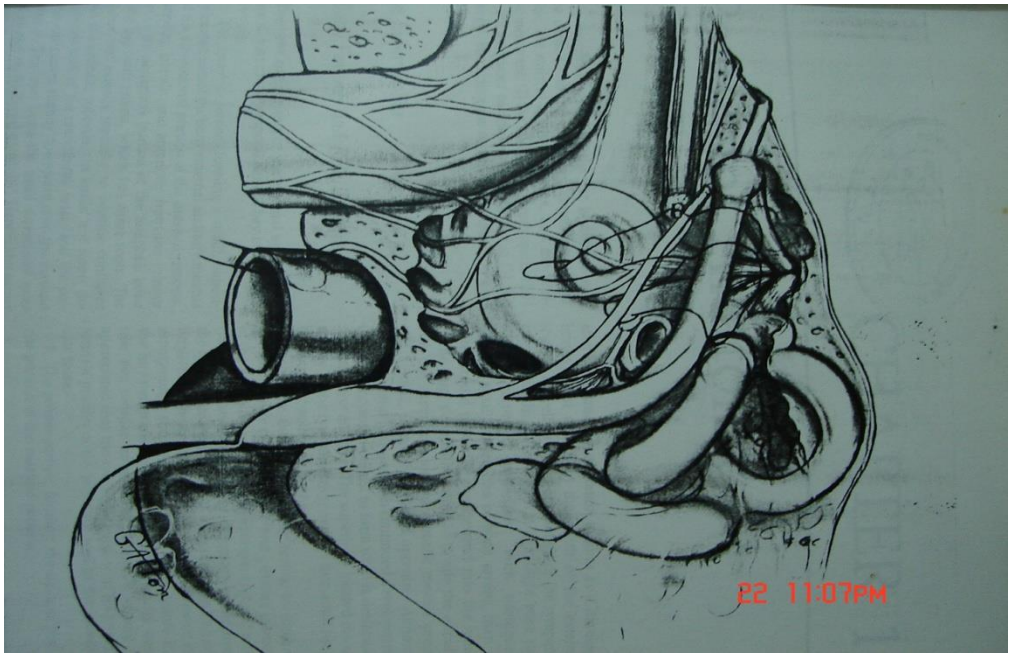


FIG 2: THE MEDIAL WALL OF TYMPANIC CAVITY

THE ANTERIOR WALL OF THE TYMPANIC CAVITY:

The lower portion of the anterior tympanic wall consist of a thin plate of bone covering the carotid artery as it enters the skull and before it turns anteriorly. This plate is perforated by the superior and inferior carotico-tympanic nerves carrying sympathetic fibres to the tympanic plexus, and by one or more tympanic branches of the internal carotid artery. The upper part of the anterior wall has two parallel tunnels placed one above the other. The lower opening is flared and leads into the bony portion of the Eustachian tube. Just above this is the canal for the tensor tympani muscle.[15][16]

THE POSTERIOR WALL OF TYMPANIC CAVITY:

The posterior wall 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, the pyramid is present that contains the stapedius muscle and the tendon which runs forward to insert into the neck of stapes. Between the aditus and the pyramid, is the fossa incudis which lodges the short process of incus and the suspensory ligament. Between the pyramid and the tympanic annulus is the facial recess. The *facial recess* is therefore, bounded laterally by the tympanic annulus and medially by the facial nerve, but running through the wall between the two, with a varying degree of obliquity, is the chorda tympani nerve.[15]

Deep to both the pyramid and the facial nerve is a posterior extension of the mesotympanum — the *sinus tympani* which is bounded by the subiculum

below and ponticulus above.[15] This extension of air cells into the posterior wall can be extensive and Anson and Donaldson (1981) reported that when measured from the tip of the pyramid, the sinus can extend as far as 9 mm into the mastoid bone.[15]

THE CONTENTS OF TYMPANIC CAVITY:

The tympanic cavity contains three ossicles, two muscles (tensor tympani and stapedius muscles), the chorda tympani nerve, the tympanic plexus, tympanic arteries, tympanic plexus of veins and air. The ossicles are the malleus, incus and stapes; the malleus is the most lateral and is attached to the tympanic membrane, whereas the stapes is attached to the oval window.

THE OSSICLES

The malleus, incus and stapes articulate with each other to form a mobile semi-rigid bony chain known as the ossicular chain (Fig:2) which helps in coupling sound from external ear to the inner ear fluids.

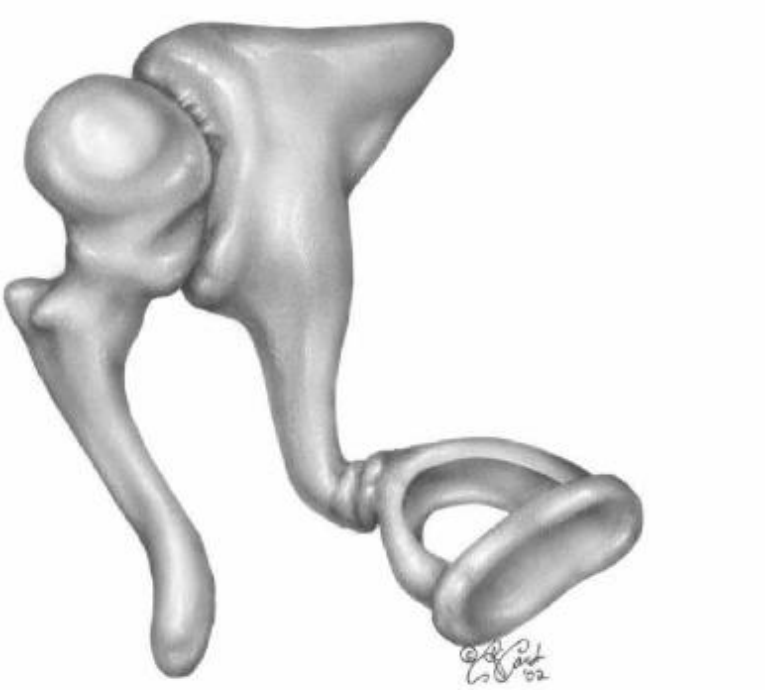


FIG 3: THE OSSICULAR CHAIN SHOWING THE MALLEUS, INCUS AND STAPES (LEFT TO RIGHT)[16]

DEVELOPMENT OF OSSICULAR CHAIN:

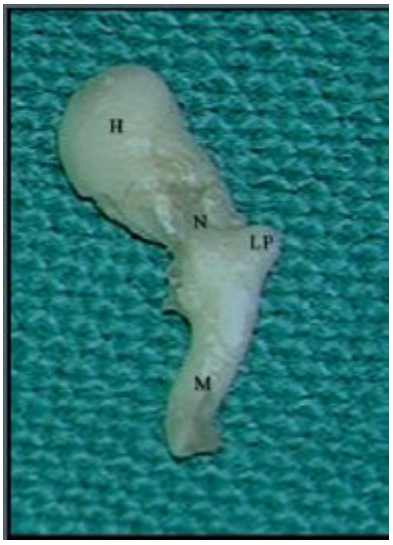
In 1959, Anson described the detailed developmental anatomy of ossicles. The ossicular chain starts developing by around 4 weeks in the human embryo. An interbranchial bridge appears, connecting the upper end of the first branchial arch referred to as the mandibular visceral bar and the central region of the hyoid (second branchial arch) visceral bar. It is this condensed mesenchymal bridge, consisting of both first and second branchial arch elements, that through cartilaginous differentiation gives rise to the primordial malleus and incus. All of the stapes blastema derives from the hyoid bar except

for the medial surface of the footplate and its annular ligament, which develop from the otic capsule (lamina stapedialis).[16]

Over the following 11 weeks, the future ossicular chain continues growth and development as a cartilaginous model; such formation of bone from a cartilage model is termed enchondral bone development. The first arch cartilage (Meckel's cartilage) forms the head of malleus and body of incus. The second arch forms handle of malleus, long process of incus and stapes crurae. The footplate of stapes develops from 3 sources i.e. outer periosteal layer of otic capsule, middle enchondral layer from otic capsule and inner endosteal layer from periotic mesoderm.

By *15 weeks,* the ossicles have attained *adult size,* and ossification soon begins, first in the incus, then in the malleus, and finally in the stapes. As the footplate attains adult size, tissue at the oval window rim develops into the fibrous tissue of the annular ligament. During the same time frame, the tensor tympani and stapedius muscles develop from the mesenchyme of the first and second branchial arches, respectively. The ossicles attain their adult configuration by 20 weeks, megalithic stapes of the fetus continues to lose bulk well into the thirty-second week. Otherwise, the endochondral bone of the ossicles, similar to that of the otic capsule, undergoes little change over the lifetime of the individual and demonstrates poor reparative capacity in response to trauma.[16]

ANATOMY OF OSSICULAR CHAIN



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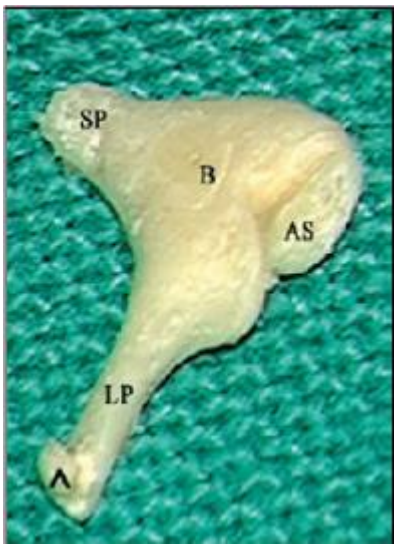

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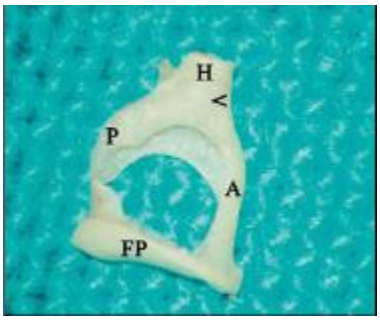

3c

FIG 4: 4(a) Malleus (left- lat surface) with Head(H), neck(N), lateral process(LP), Manubrium (M)

4(b) Incus (med surface) with Body (B), long process (LP), short process (SP), lenticular process (^)

4(c) Stapes with Head (H), neck (<), anterior & posterior crurae (A & P), Footplate (FP)

THE MALLEUS

The malleus (Hammer bone) is the largest of the three ossicles, measuring 7.5 to 9 mm in length. It comprises a head, neck and three processes arising below the neck. (Fig 4a). The head lies in the epitympanum and is suspended by the superior ligament, which runs upward to the tegmen tympani. The head of the malleus has a saddle-shaped cartilage covered facet on its posteromedial surface to articulate with the body of the incus by way of a synovial joint. Below the neck of the malleus, the bone broadens and gives rise to the lateral process, the anterior process and the handle. The lateral process is a prominent landmark on the tympanic membrane and receives the anterior and posterior malleolar folds from the tympanic annulus. The chorda tympani crosses the upper part of the malleus handle on its medial surface above the insertion of the tendon of tensor tympani, but below the neck of the malleus itself. A slender anterior ligament arises from the anterior process to insert into the petrotympanic fissure.[15] The handle runs downwards, medially and slightly backwards between the mucosal and fibrous layers of the tympanic membrane. While it is very closely attached to the membrane at its lower end, there is a fine web of mucosa separating the membrane from the handle in the upper portion before it becomes adherent again at the lateral process. This can be opened surgically to create a slit without perforating the membrane to allow prosthesis to be crimped around the malleus handle in certain types of ossicular reconstruction. On the medial surface of the handle, near its upper end, is a small projection into which the tendon of tensor tympani muscle is inserted.[15]

THE INCUS

The incus articulates with the malleus and has a body and two processes (Fig 4b). The body lies in the epitympanum and has a cartilage-covered facet for the articulation with malleus. The body of the incus is suspended by the superior incudal ligament that is attached to the tegmen tympani. The short process projects backwards from the body to lie in the fossa incudis to which it is attached by a short suspensory ligament. The long process descends into the mesotympanum behind and medial to the handle of malleus, and at its tip is a small medially directed lenticular process. This has sometimes been called the fourth ossicle because of its incomplete fusion with the tip of the long process. The lenticular process articulates with the head of stapes. The blood supply to the ossicular chain is most tentative at the lenticular process hence, this is the first portion of the ossicular chain to be resorbed in patients with chronic otitis media, producing ossicular discontinuity.[15]

THE STAPES

The stapes is shaped like a stirrup and consists of a head, neck, the anterior and posterior crura and a footplate (Fig 4c). The head points laterally and has a small cartilage-covered depression for a synovial articulation with the lenticular process of the incus. The stapedius tendon inserts into the posterior part of the neck and upper portion of the posterior crus.[15] The two crura arise from the broader lower part of the neck and the anterior crus is thinner and less curved than the posterior one. Both are hollowed out on their concave surfaces, which gives an optimum combination of strength and lightness.

The two crurae join the footplate which usually has a convex superior margin, an almost straight inferior margin and curved anterior and posterior ends. The average dimensions of the footplate are 3 mm long and 1.4 mm wide, and it lies in the oval window where it is attached to the bony margins by the annular ligament.[16] The long axis of the footplate is almost horizontal, with the posterior end being slightly lower than the anterior. There is great variation in the shape of the crura.[15]

ARTICULATIONS OF AUDITORY OSSICLES

A) THE INCUDOMALLEOLAR JOINT [17]

1. It is a saddle shaped diarthrosis.

2. It is surrounded by an articular capsule.

3. The joint cavity is incompletely divided into two by a wedge-shaped articular disc or meniscus.

B) THE INCUDOSTAPEDIAL JOINT

1. It is a ball and socket type enarthrosis.

2. It is surrounded by an articular capsule.

3. Some observers have described an articular disc or meniscus in this joint; others regard the joint as syndesmosis[17]

LIGAMENTS OF OSSICLES

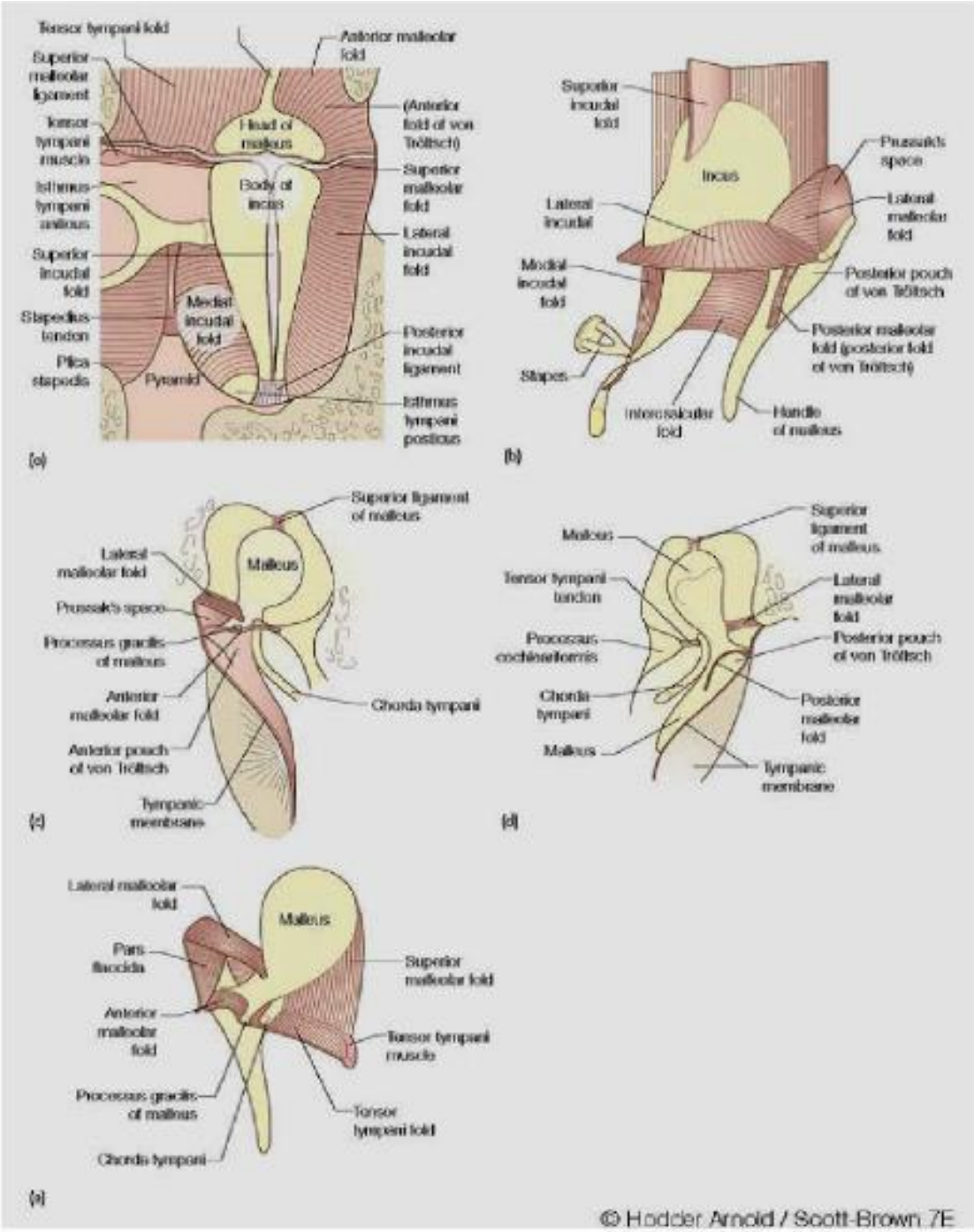

FIG 5: LIGAMENTS AND MUSCLES ATTACHED TO OSSICLES[15]

The ossicles are connected with the walls of the tympanic cavity by ligaments: three for the malleus and one each for incus and stapes [Fig.5].

1. THE ANTERIOR LIGAMENT OF THE MALLEUS (lig. Mallei anterius)

It is attached by one end to the neck of the malleus, just above the anterior process and by the other to the anterior wall of the tympanic cavity, close to the petrotympanic fissure, some of its fibers being prolonged through the fissure to reach the spina angularis of the sphenoid.[17]

2. THE SUPERIOR LIGAMENT OF THE MALLEUS (lig. mallei superius)

It is a delicate, round bundle, which descends from the roof of the epitympanic recess to the head of the malleus.

3. THE LATERAL LIGAMENT OF THE MALLEUS (lig. mallei laterale; external ligament of the malleus)

It is a triangular band passing from the posterior part of the notch of Rivinus to the head of the malleus.

4. THE POSTERIOR LIGAMENT OF THE INCUS (lig. incudis posterius)

It is a short, thick band connecting the end of the short crus of the incus to the fossa incudis. The anterior ligament of the malleus with the posterior incudal ligament creates the axis of ossicular rotation.[17]

5. THE SUPERIOR LIGAMENT OF THE INCUS (lig. incudis superius)

It has been described but it is little more than a fold of mucous membrane.

6. THE ANNULAR LIGAMENT OF THE BASE OF THE STAPES (lig. annul are baseos stapedis)

The vestibular surface and the circumference of the base of the stapes are covered with hyaline cartilage; that encircling the base is attached to the margin of the fenestra vestibuli by a fibrous ring, the annular ligament of the base of the stapes.[15]

THE STAPEDIUS MUSCLE [Fig 5a]

The stapedius muscle arises from the walls of the conical cavity within the pyramid and from the downward curved continuation of this canal in front of the descending portion of the facial nerve. A slender tendon emerges from the apex of the pyramid and inserts into the neck of stapes. The muscle is supplied by a small branch of facial nerve.[15]

THE TENSOR TYMPANI MUSCLE [Fig 5d]

This is a long slender muscle arising from the walls of the bony canal lying above the eustachian tube. Parts of the muscle also arise from the cartilaginous portion of the eustacian tube and the greater wing of the sphenoid. From its origin, the muscle passes backwards into the tympanic cavity where it lies on the medial wall, just below the level of the facial nerve. The bony covering of the canal is often deficient in its tympanic segment where the muscle is replaced by a slender tendon. This enters the spoon shaped processus cochleariformis where it is held down by a transverse tendon as it turns through right angle to pass laterally, and gets

inserted into the medial aspect of the upper end of the malleus handle. The muscle is supplied from the mandibular branch of trigeminal nerve by way of a branch from the medial pterygoid nerve, which passes through the otic ganglion without synapse.[16][17]

ACOUSTIC MECHANISMS IN MIDDLE EAR SOUND TRANSFER

PHYSICS OF SOUND

Sound energy is vibratory, consisting of alternating condensation and rarefaction of the molecules of the propagating medium. This energy travels from a source, expanding globally, and losing energy proportionate to the square of the distance from the source. The speed of the sound wave depends on the nature of the medium and is proportional to its density. Sound thus travels fastest through solids, less fast through liquid and slowest through gases.[18] In air at 200 C at sea level, sound travels at 344 meters (1120 ft) per second, in water, sound travels four times faster, at 1437 meters (4714 feet) per second, and in bone at approximately 3013 meters (9886 ft) per second. The resistance to the passage of sound through a medium is its acoustic resistance or impedance. Impedance is related to both the density and elasticity of the medium. The impedance of a complex system such as the middle ear is made up of a mass reactance or inertial component and a stiffness reactance, both of which are frequency dependent, and a frictional component that is not dependant on frequency.[18]

THE ACOUSTIC TRANSFORMER

The main contributors to the human acoustic transformer are the pinna, the external auditory canal and the middle ear sound conduction system.

PINNA

The pinna, serves an important role of gathering sound arriving from an arc of 135 degrees relative to the direction of the head. This pattern rejects sound arriving from the rear of the head and serves to determine the origin of the sound. The horn-shaped concha then acts like a megaphone to concentrate the sound at the entrance of the auditory canal.[18] This action increases sound pressure as much as 6dB (2 times).

EXTERNAL AUDITORY CANAL

A closed cylinder 3.5 cm in length, the external auditory canal resonates sound vibrations best at frequencies which the human ears hear most sharply. This resonance, acting in concert with the effect of the pinna, can increase sound pressure at the tympanic membrane by 15 to 22 dB at 3000 Hz. These effects, however, can vary greatly among individuals because of differences in size and shape of the canal and the angle of incidence of the arriving sound wave.[19]

MIDDLE EAR TRANSFORMER MECHANISM

The transformer system of the middle ear, although working as a complex whole, may be divided into three stages: that provided by the eardrum *(catenary lever),* that provided by ossicles *(ossicular lever)* and that provided by the difference in area between the tympanic membrane and the stapes footplate *(hydraulic lever).*[18]

A. CATENARY LEVER

In 1863, Helmholtz was first to propose the concept of catenary lever to action of the tympanic membrane (TM). A familiar example of this type of lever is tennis net. The tighter a tennis net is stretched, the greater the force exerted on the posts holding it. Because the bony annulus surrounding the tympanic membrane is immobile, sound energy applied to the tympanic membrane is directed away from the edges of the drum and amplified at its central attachment, the malleus. Experiments attempting to verify this concept were carried out by Bekesy and Weyer and Lawrence.[19] Neither investigation was able to confirm the existence of a catenary lever in action of the tympanic membrane and because of the pre-eminence of these investigators, this mechanism was forgotten.[18] Studies by Tonndorf and Khanna[17][20] using the sensitive method of time averaged holography were able to determine that the vibratory patterns of the tympanic membrane were similar to that hypothesized by Helmholtz rather than the stiff, plate-like motion described by Bekesy. It is estimated that even though

the curvature of the tympanic membrane is variable, the catenary lever provides at least two times (2X) gain in sound pressure at the malleus.[18]

B. OSSICULAR LEVER

Helmholtz described a lever system of the second class, the arm extending between the short process of the incus and the umbo with the incudal ligament serving as fulcrum. Later it was found that the malleus and incus acts as a unit, rotating around an axis running between the anterior malleal ligament and the incudal ligament. This concept generally accepted today and measures the lever arms from the rotational axis to the tip of the malleus and to the tip of the long process of the incus. The handle of malleus is 1.3 times longer than long process of incus, providing a mechanical advantage of 1.3. Hence, the lever ratio averages 1.3:1.[18]

The catenary lever is tightly coupled to the ossicular lever, because the tympanic membrane is extensively adherent to the malleus handle. Corrected calculations reveal a combined catenary-ossicular lever ratio of 1:2.3.[16][21]

C. HYDRAULIC LEVER

Helmholtz's third concept of impedance matching involved what is today commonly reffered as the areal ratio. Briefly stated, sound pressure collected over the larger area of the tympanic membrane and transmitted to the smaller footplate area results in an increase in force proportional to the ratio of the areas (Avg. ratio 21:1).[17] The mode of tympanic membrane motion

inferred by Bekesy allowed only the central portion to vibrate; therefore, he used two thirds of the drumhead area as effective vibratory area, thereby reducing the effective aerial ratio to 14:1.

According to Weaver and Lawrence[19], out of total of 90mm^2 area of human tympanic membrane, only 55mm^2 is functional and given the area of stapes footplate (3.2 mm^2), the areal ratio is 17:1.

Taking the three levers together, the middle ear offers a theoretical gain of approximately 34 dB.[21]

SOUND PRESSURE TRANSFORMATION

Following table1 summarizes the values for sound transformer action by human external ear and middle ear.

Table 1: Sound-Pressure Transformation[18]

Catenary lever: Force acting on TM / Force acting on malleus	2
Ossicular lever: Force acting on Malleus / Force acting on stapes	1.15
Areal ratio: Area of tympanic membrane / area of footplate	21.0
Total lever advantage	34dB
External ear contribution	15dB
Total system gain	49dB

PHASE PROTECTION

The electrical analogue of a pure tone sound is the sine wave. Points on this wave vary from 0 to 360 degrees. The fluids of the inner ear are incompressible;

thus, sounds arriving at the oval and round windows at the same phase exert a push-push effect and will not enter the labyrinth. If the two sound energies arriving at the two windows is 180 degrees out of phase (push—pull), there is maximum transfer of energy to the cochlear fluids. The middle ear provides phase protection to the windows. It has been shown that the cochlea is equally sensitive to sound entering the scala vestibuli via the stapes or entering the scala tympani via the round window.[19] Nature has located the round window membrane deep within a niche in the posterior and inferior region of the middle ear and perpendicular to the plane of the stapes footplate.[18]

In the normal ear, sound is transmitted preferentially to the oval window arriving with much greater energy and with an earlier phase than at the round window. The tympanic membrane also blocks the entrance of sound into the middle ear, reducing its level by an average 17 dB.[19] Schmidt[22] by his extensive mathematical treatment of these factors concluded that sound pressure transformation is the greatest factor influencing hearing efficiency. Even partial transformation makes sound protection (attenuation of arriving sound energy) of the round window less important. This is an important finding as applied to planning of surgical repair of the sound conduction system. Stated in different terms, it is better to reconstruct the ossicular system than to provide sound protection for the round window (Wullstein type IV tympanoplasty or fenestration type surgery).[18]

The two elements playing the most important roles in phase protection are the tympanic membrane and the ossicular system. The tympanic membrane

attenuates the sound energy passing directly into the middle ear by an average of 17 dB and slightly alters its phase angle. This effect prevents the simultaneous arrival of sound waves at both windows with equal intensity and phase. The ossicular chain directs the sound to the oval window with minimum loss from impedance mismatch. Both of these mechanisms have the effect of minimizing phase cancellation in the middle ear and cochlea.[18]

BONE CONDUCTION AND THE MIDDLE EAR

Current concepts out lined by Tonndorf[23] consider three routes to contribute to bone-conduction hearing. The external meatal air column is responsive to low frequencies, apparently owing to vibration of the bony canal and to the lag between vibration of the skull and the mandible, whose condyle lies just anterior to the cartilaginous canal.[18]

The inertial component of bone conduction is due to the lag of the conductive apparatus in following the vibrations of the skull, thus creating a relative movement of the stapes in the oval window. This is most important between 500 and 2000 Hz. Fixation or interruption of the ossicular canal reduces this energy transfer and causes falsely low scores on bone conduction testing.[18]

TRANSFER FUNCTION OF THE MIDDLE EAR

The middle ear together with the mastoid space constitutes a complex vibrating system whose impedance is made of several stiffness, mass, and frictional components. Together these determine the transfer function of the middle ear. Studies of this function show that the middle ear acts as a

low-pass filter, allowing frequencies below the network resonance of 1000Hz to pass while attenuating higher frequencies at a slope of 16 dB per octave.[18]

SOUND CONDUCTION OF THE DISEASED EAR

A) TYMPANIC MEMBRANE PERFORATION:

The hearing loss associated with a perforation is directly proportional to the size of the perforation. Most observers agree that the site of the perforation does not have a consistent effect on the hearing loss. Semilunar perforations that detach the malleus from the tympanic membrane cause a greater hearing loss than would be predicted from reduction of the hydraulic lever ratio alone, probably owing to the decoupling of a portion of the catenary lever.[18]

B) PERFORATION WITH OSSICULAR INTERRUPTION

Approximately 60% of patients undergoing surgery for chronic ear disease have perforation with ossicular interruption.[24] Austin's[25] analysis of the problem in his study indicated that the typical hearing loss is worse at the lower frequencies and averages 38 dB. This was attributed to the loss of hydraulic lever (26.5 dB), centenary lever (7.3 dB) and phase cancellation (5 dB) making the total loss of 38.3 dB.[18]

C) TOTAL LOSS OF TYMPANIC MEMBRANE AND OSSICLES

Much less frequent is this form of pathology. Austin[25] reported that the contour of the hearing loss is the same as the previous group but more severe, averaging 50 dB. The greater hearing loss is probably due to increased phase cancellation at the round window.[18]

D) OSSICULAR INTERRUPTION WITH AN INTACT TYMPANIC MEMBRANE

Interruption of the ossicular chain in the presence of an intact eardrum is seen more often as a consequence of surgery than a disease process. It is most often due to disarticulation of the incudostapedial joint either from a prosthesis problem or from erosion of the long process of the incus. The components of this loss are firstly, the loss of middle ear transformer mechanism caused by ossicular erosion (38 dB) and secondly an added loss by obstruction to the sound passage (air conduction) by intact drum (15 dB). In other words, the obstruction is same as that seen in ossicular chain erosion (38 dB) plus an additional loss of 15 dB due to the blockage by presence of intact TM. The result is a flat hearing loss averaging 54 dB.[18]

E) OSSICULAR INTERRUPTION, INTACT TYMPANIC MEMBRANE AND CLOSURE OF THE OVAL WINDOW

This combination is encountered in a variety of congenital ossicular deformity in which the stapes footplate has not formed. The hearing loss averages 60 dB.[18]

F) OBSTRUCTION OF THE EXTERNAL AUDITORY CANAL

Occlusion of the external auditory canal by cerumen produces a flat 30 dB hearing loss. It is therefore important to test hearing after the cerumen is removed, because the 30 dB improvement will be noticed by the patient where as a residual loss due to middle ear disease may not then be noted.[18]

CHRONIC SUPPURATIVE OTITIS MEDIA AND OSSICULAR CHAIN EROSION:

Chronic otitis media (COM) is a common condition, affecting 0.5% to 30% of any community[26] and ossicular chain erosion is the commonest complication of chronic suppurative otitis media. The commonest ossicle which is eroded is the long process of incus followed by stapes suprastructure. This occurs either as a result of osteoclastic activity in relation to granulation tissue or by avascular necrosis. Also the location and their delicate structure make them more vulnerable for erosion.[27] Erosion of the body of the incus and the head of the malleus is rare unless a cholesteatoma is present. Studies clearly demonstrate that bone erosion occurs in COM with or without the presence of cholesteatoma.[28][29] Although the true mechanism is not fully understood, it is generally accepted that inflammation is a major factor since granulation tissue is often associated with ossicular erosion.[30] The inflammatory process is thought to lead to infiltration and activation of osteoclasts and mononuclear cells containing various proteolytic enzymes. Microscopically, a subepithelial layer of granulation tissue has been identified adjacent to eroded bone.[31]

The cellular components of this layer are identical in cases with and without cholesteatoma. The higher frequency of bone destruction in the setting of cholesteatoma may be related to the excellent environment cholesteatomas provide for persistent bacterial infection and chronic inflammation. Resorption of bone is a feature of active mucosal and active squamous epithelial COM (cholesteatoma). Evidence suggests that the mechanism of bone erosion is similar in both types of COM.[27] It appears that number of different triggers such as infection, inflammation, pressure and keratin can lead to elaboration of a variety of molecular factors including cytokines such as interleukin (IL)-I, interleukin-6 and tumour necrosis factor (TNF), other protein mediators such as growth factors, and non-protein mediators such as prostaglandins, neurotransmitters and nitric oxide. These molecular factors are believed to provide the initiating signals that lead to the recruitment, development and activation of osteoclasts. These activated osteoclasts then result in bone resorption. Regardless of which factor (or factors) initiates the molecular cascade, there is a final common pathway of osteoclast activation and bone resorption. Elucidation of the precise relationship between initiating triggers in COM and known osteoclastogenic factors of the final common pathway may enable the development of new approaches for therapeutic intervention and prevention of bone resorption in COM.[27] These patients usually present with chronic intermittent or persistent discharging ear with a moderate to moderately severe degree of conductive hearing loss depending on the severity of the disease. Otoscopy, or preferably examination with an operating microscope, reveals a tympanic membrane perforation and, in active disease, mucoid or mucopurulent discharge. The

presence of an aural polyp or malodorous otorrhea should raise the clinician's suspicion regarding the presence of cholesteatoma. After careful aspiration of any debris, the status of the middle ear mucosa can be accessed through the perforation and can appear only slightly thickened, with ciliary activity visualized, or can be markedly thickened, with polypoid degeneration.[32] The ossicular chain erosion can be visualised in cases of larger or posterosuperior marginal perforations, with the long process of the incus most prone to resorption.

AUSTIN'S CLASSIFICATION OF OSSICULAR CHAIN DEFECTS:

On the basis of a study done in 1151 consecutive ears with chronic suppurative otitis media, Austin in 1971 presented classification of the anatomic defects found in ossicular chain. . In all the cases included in the classification, the incus was eroded either partially or completely and the four types of ossicular defects were therefore described depending on the presence or absence of malleus handle and stapes superstructure.[24]

Group A – Malleus and stapes present

Group B – Malleus and footplate of stapes present

Group C – Malleus absent and stapes present

Group D – Malleus and stapes suprastructure absent

Kartush added two more classes to the above classification depending on ossicular fixity

Type E: Ossicular head fixation

Type F: Stapes fixation

The present techniques of ossiculoplasty are based on the above classified type of ossicular chain defects. When Malleus handle and stapes suprastructure are present (Austin type A), a sculpted autologous or homologous incus or malleus head or alternatively a PORP can be used to bridge the gap between malleus and stapes. This type of assembly is known as *Malleus-stapes* assembly[33] or Interposition ossiculoplasty. In cases where malleus handle is present and stapes superstructure absent (Austin type B), a sculpted autologous or homologous incus is interposed between handle of malleus and stapes footplate or alternatively a TORP can be used. This type of assembly is called *Malleus-footplate* assembly. Similarly when stapes is present and malleus absent (Austin type C), this type of assembly is tympanic membrane to stapes assembly [33] or Myringostapediopexy and in cases where malleus and stapes super-structure both are absent (Austin type D), then it is tympanic membrane to footplate assembly.[33].

In our present study, we are dealing with the management of Austin type A and type C ossicular defects by reconstruction using sculptured autologous incus, cartilage or bone.

TYMPANOPLASTY

Tympanoplasty is a procedure to eradicate the disease in the middle ear and to reconstruct the hearing mechanism, without mastoid surgery, with or without tympanic membrane grafting.[34]

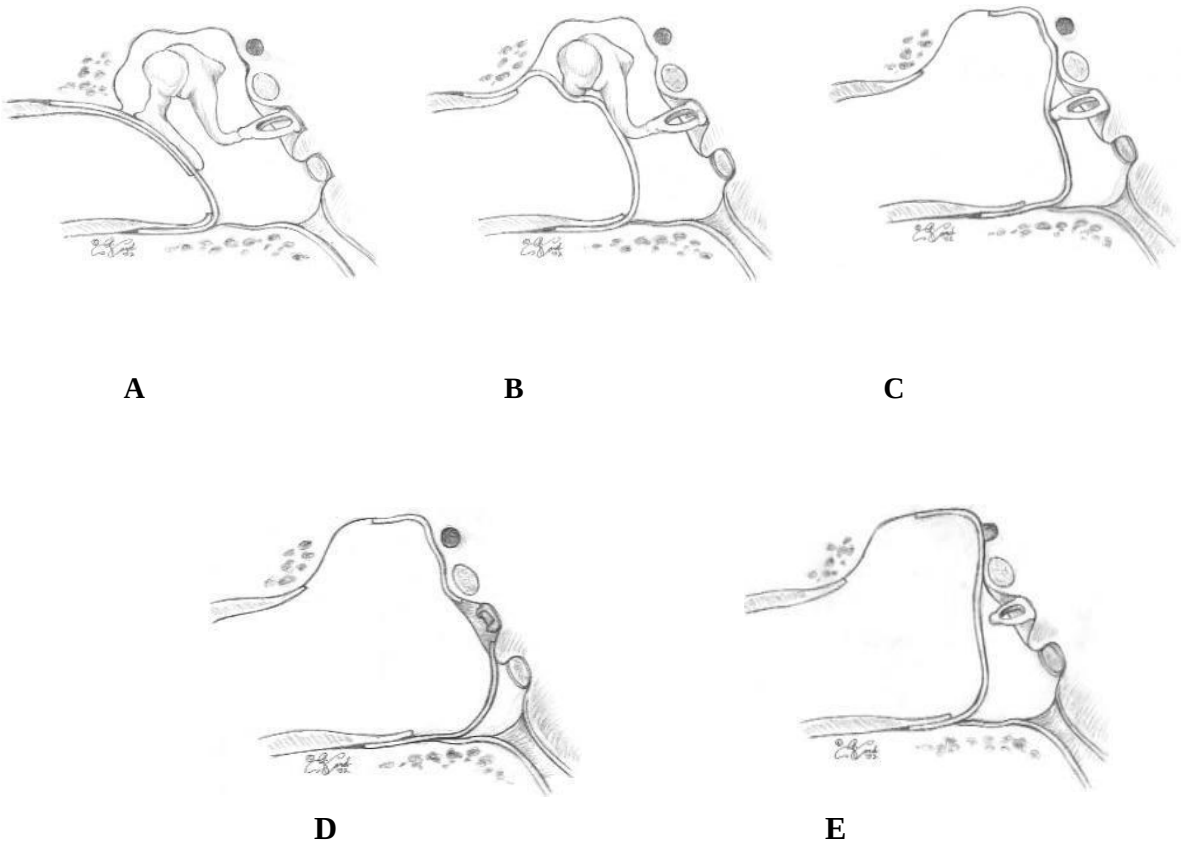

FIG 6: Types of Tympanoplasty[35]

Types of tympanoplasty according to Wullstein

Type I tympanoplasty [Fig 6A] is performed when all three ossicles are present and mobile and involves repair of tympanic membrane perforation or retraction without ossicular chain reconstruction.[36]

Type II tympanoplasty [Fig 6B] is utilized when the malleus is eroded and involves grafting the tympanic membrane to an intact incus and stapes or remnant of the malleus.[36]

Type III tympanoplasty [Fig 6C] 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. Myringostapediopexy produces a shallow middle ear and a columella effect.[36]

Type IV tympanoplasty [Fig 6D] describes an absent or eroded suprastructure with the graft or tympanic membrane overlying a mobile stapes footplate. The resulting middle ear consists of hypotympanum and Eustachian tube orifice only.[36]

Type V tympanoplasty [Fig 6E] 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.[36]

OSSICULOPLASTY

EVOLUTION OF OSSICULOPLASTY:

The earliest recorded attempt to re-establish the connection between the tympanic membrane and oval window in cases of missing or damaged ossicles dates to Matte's myringostapediopexy in 1901.[37] Since then numerous techniques have been proposed to reconstruct the ossicular chain. In 1957, Hall and Rytzner performed the first ossicular chain reconstruction by repositioning the patient's own incus after accidentally fracturing the stapes superstructure during stapes mobilization surgery for otosclerosis.[3] Homograft ossicles for reconstructing the ossicular chain in tympanoplasty became

popular in the early 1960's.[33] Realizing the need to find a new material to reconstruct the ossicular chain in patients without the ossicles or with severe infection or cholesteatoma involving the ossicles, House, Patterson and Linthicum (1966) introduced homograft incus which were acquired from healthy middle ears of patients undergoing surgery for removal of an acoustic neuroma that were preserved in 70% ethyl alcohol prior to their use. Histological examination of extruded incus, 9 months post-operatively, showed no inflammatory response in and around the graft. The marrow spaces were vascularised but there was no new bone formation.[34] House (1969), recommended the use of ossicles acquired from post-mortem ears provided the donor did not have malignant disease, hepatitis, syphilis, HIV or CSOM. Ken and Smyth (1971), examined 19 incuses (9 autologous and 10 homograft) and 4 mallei (1 autologous and 3 homologous) removed at time of revision surgeries 3 to 39 months post-operatively and found no macroscopic evidence of erosion. Histologically, both allografts and autografts were similar, with vascularisation and plasma cell infiltration of marrow spaces together with small areas of new bone formation. The authors concluded that there was no evidence of allograft bone rejection in the middle ear and that in time the grafts would be incorporated into the ossicular chain as vital structures.

The *'popular'* loose interposition techniques i.e. TM to stapes head interposition and tympanic membrane to footplate interposition did not produce consistently good results (Guilford, 1966; Hildyard, 1967; Armstrong, 1969; Hough, 1970). The problems encountered included displacement of the graft, lateral retraction of stapes head or footplate, consequent on lateral

retraction of neo-tympanic membrane during healing and fibrous and bony ankylosis between the graft and posterior bony annulus, facial canal or promontory. The grafts were also too bulky and filled the space between the facial canal and the annulus blocking the epitympanic isthmus resulting in obstruction and mucus accumulation and continued inflammation.[24] Guilford in 1966 found that interpositions between malleus handle and stapes i.e Malleus-stapes interposition and malleus- footplate interposition were more stable and produced better post-operative hearing gains than TM-to-stapes and TM-to-footplate interpositions. These sentiments were strongly supported by the experiences of Hildyard (1967), Armstrong (1969), Hough (1970) and confirmed by Elbrond and Elpern (1965) in an experimental study of stability and acoustic properties of various incus interposition techniques in cadaver temporal bone models.

Pennington (1973) improved the design of the Austin malleus-stapes assembly to deal with the two basic anatomical malleus-stapes relationship encountered in tympanoplasty. He designated the vertical malleus- stapes head relationship and horizontal malleus- stapes head relationship.[34] Wehrs (1974) introduced the notched incus autograft or homograft technique. For malleus- stapes assembly, the incus long process was amputated, a notch was drilled into the short process to accommodate the malleus neck or handle and the incus body was dowelled to fit the stapes head *[notched incus with short pocess]*[38]. For malleus-footplate assembly, the incus short process was drilled in a similar fashion and the long process placed directly onto the stapes footplate *[notched incus with long process]*.[38] These basic sculpturing techniques for malleus-stapes and malleus-footplate assemblies using

autograft or homograft incus or malleus with minor modifications are used by most surgeons today.

Also sculpted columellae of autologous cortical bone from the outer mastoid cortex, bony external auditory meatus and spine of Henle have been used in reconstruction of the ossicular chain defects by Hough (1958), Zollner (1960,1969), Wright (1967) and Tos (1974), but long term hearing results have not been reported by them.[34]

Utech (1960) introduced sculptured auricular cartilage autografts for TM to stapes [short columella] and TM to footplate interposition [long columella] and Jansen (1963) found autologous tragal cartilage and autologous or preserved homologous septal cartilage suitable for the short and long columella reconstruction.

The risk of disease transmission, imaginary or real, as well as the need for an easily available prosthesis, led to the development of alloplastic ossicular prosthesis.[33]

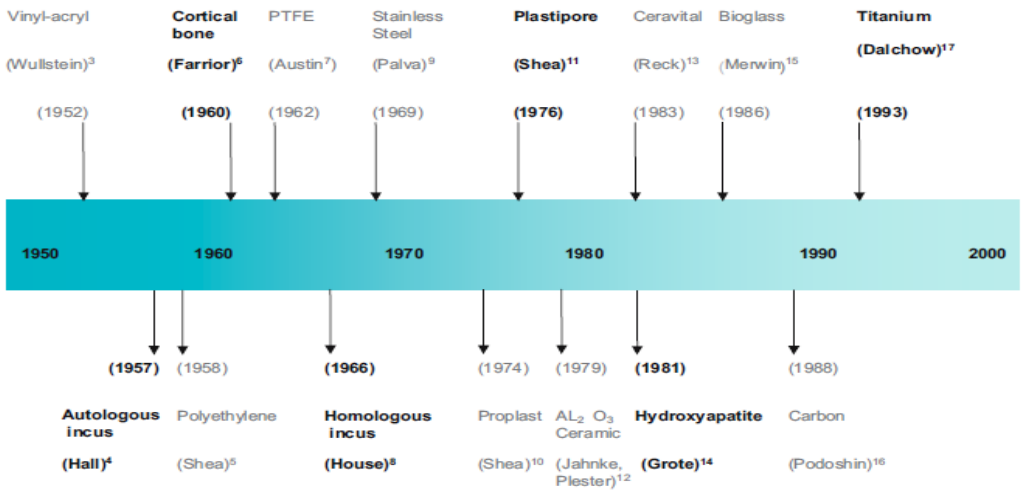

FIG 7: Evolution of alloplastic ossicular prosthesis.[39]

GRAFT MATERIALS USED IN OSSICULAR CHAIN RECONSRUCTION:

Over the years various biomaterials have been used in the reconstruction of ossicular chain. The qualities that are to be considered in selecting the optimal prosthetic material are biocompatibility, risk of infection, time required for preparation, storage requirements, need for interposition grafting and sound conduction. Also the ease of availability and cost are important factors.[40]

Transplant terminology: Table 2 shows the various terminologies in relation to transplants.[34]

TABLE 2: Transplant terminology and their definitions

NOUN	ADJECTIVE	DEFINITION
AUTOGRAFT	AUTOLOGOUS/ AUTOGENIC	Tissue transplanted from one part or of the body to another in the same individual, eg, a temporalis fascia or tragal perichondrial graft used to repair the tympanic membrane

ISOGRAFT	ISOGENIC	Tissue transplanted between genetically identical individuals, eg, an incus graft between rats of the same inbred strain
ALLOGRAFT	ALLOGENIC	Tisue transplanted between genetically non-identical members of the same species, eg, a preserved human cadaver acquired tympanomeatal graft used to reconstruct the tympanic membrane, or a preserved human cadaver acquired incus used to repair an ossicular chain defect
XENOGRAFT	XENOGENIC	Tissue transplanted between members of different species, eg, a preserved bovine vein graft used to repair a human tympanic membrane.

Grafts of any genetic origin are further defined according to their new anatomical site, pattern of vascularisation and functional capacity. Grafts placed in an anatomical position normally occupied by such tissue are *Orthotopic grafts (*Greek orthos= right or correct), e.g. tympano-ossicular allograft used to reconstruct the TM and ossicular chain. The graft placed in unnatural recipient location are *Heterotopic grafts* (Greek heteros= other or different), e.g. sculptured nasal septal cartilage for reconstruction of ossicular chain. A graft placed directly onto a vascular pedicle is a *vascularised graft*, whereas a *free or non-vascularised graft* vascularises indirectly from the recipient bed e.g. a preserved dura mater graft used to repair the TM defect. Those grafts expected or intended to fulfil their normal physiological functional capacity are *vital grafts,* e.g a kidney transplant; while *static grafts* serve a mechanical function that does not require 'physiological viability'. Such grafts act as a scaffolding or matrix onto and into, which the host tissues extend.[34]

A wide variety of autograft, homograft and synthetic materials has been used for reconstructing the ossicular chain. Due to easy availability, very low extrusion rate, biocampatibility and better graft uptake autograft prosthesis are preferred when compared to synthetic material.[1] Autologous ossicle and cartilage graft beside being cost effective show varing amount of conversion into viable bone and maintain their size and contour over an extended period of time showing no tendency to resorb and incite prolific growth.**[6]** . Cortical bone grafts are readily obtained from the mastoid cortex through a postauricular or endaural incision. The behaviour of autologous cortical bone struts is

histologically similar to that of ossicular bone grafts, and cortical bone is a useful and viable alternative for ossiculoplasty.[27]

Patient selection (Indications) for ossiculoplasty:

1) Any patient with chronic otitis media with clinical, audiological or radiological evidence of ossicular chain erosion.

2) Hearing loss resulting from ossicular problems associated with trauma, adhesive otitis media and congenital ear malformations

3) As a second stage procedure following surgery for extensive cholesteatoma which is done after 6 to 12 months from the primary surgery.[41]

4) Patients with mixed hearing loss, actively discharging ear and children less than 7 years of age (immature eustachian tube function) are poor candidates for ossiculoplasty.[42]

Preoperative evaluation.[41][42]

1) A complete history and thorough ear, nose and throat examination should be performed in all patients. The otoscopic examination is best accomplished with the operating microscope.

2) Audiological evaluation should be done by pure tone audiometry which should include air and bone conduction thresholds with masking as well as speech discrimination scores. All hearing should be confirmed by tuning fork tests.

3) Tympanometry may be done to differentiate between ossicular fixation and discontinuity and also to know the eustachian tube function. Acoustic reflex testing is helpful in distinguishing hearing losses resulting from otosclerosis versus an inner ear hearing loss associated with superior semicircular canal dehiscence wherein the reflex is present.

4) Thin sections of Computed tomography (CT) scan of temporal bones may be helpful, particularly in cases with cholesteatoma, in determining the ossicular status, degree of mastoid pneumatisation, possible intracranial involvement, labyrinthine fistula and fallopian canal dehiscence.

SURGICAL STEPS OF OSSICULOPLASTY

Anaesthesia:

Surgery may be performed either under local anaesthesia or general anaesthesia.

Pre-medication for local anaesthesia:

Pethidine: 1.0 – 1.5 mg/kg body weight, intra muscular (analgesic and sedative)

Promethazine: 25 mg, intra muscular (antiemetic)

Atropine : 0.6 mg, intra muscular (anti-vagal and cardioprotective)

The premedication is given 30 minutes before surgery.

Surgical steps

i)Preparation of part:

The patient is made to lie down in supine position with the operating ear facing upwards and towards the operating surgeon. Ear canal is instilled with 4% lignocaine. The ear and adjacent areas are painted with 5% povidone iodine solution. The patient is then draped with sterile surgical towels.

ii) Infiltration:

It is done 10 minutes prior to the incision. Infiltration solution is prepared using 10 ml of premixed 2% lignocaine + adrenaline 10 ml of normal saline.

About 0.5 cc of the prepared solution is infiltrated each into the bony cartilaginous junction of the external auditory canal at 3, 6, 9 and 12 O' clock positions, without creating blebs.

The auricular branches of the auriculotemporal nerve which supplies the upper part of the auricle and skin above the meatus are blocked by injection of 1 ml of solution at several points into the skin and periosteum of the incisura terminalis, upward to the upper attachment of the auricle.

The branches of the great auricular nerve to the auricle and meatus are blocked by injection of 1 ml of solution at several points behind the auricle over the mastoid process.

The auricular branch of the vagus nerve is blocked by injection of the periosteum of the anterior surface of the mastoid process and of the skin of the floor of the meatus.

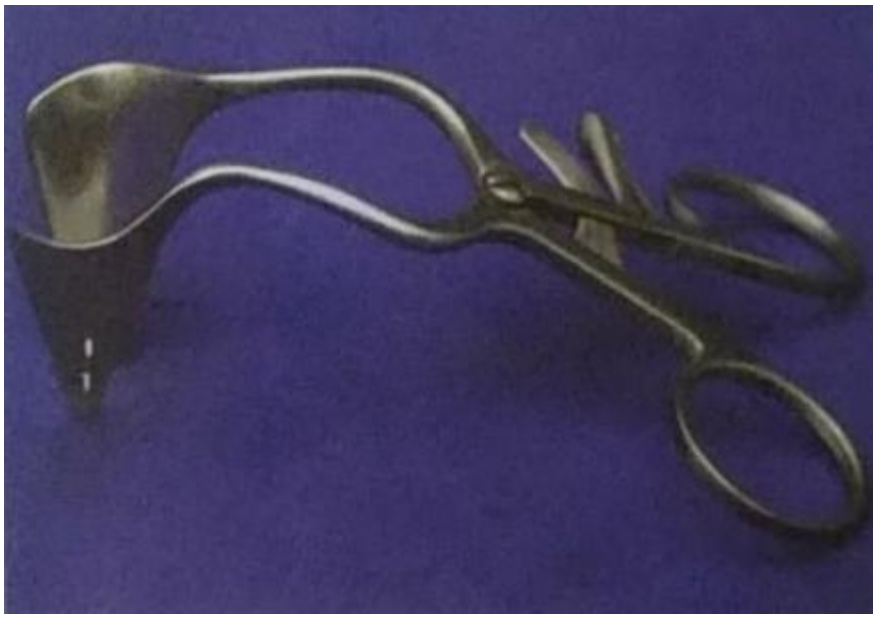

FIG 8:Dr. MAHADEVAIAH'S CANAL RETRACTOR

iii) Canal Incisions and Elevation of Posterior Meatal Skin Flap

The external auditory canal and the tympanic membrane are exposed using Dr. Mahadevaiah's canal retractor. Through the external auditory meatus initial inferior vertical canal incision is made starting about 5 mm lateral to the fibrous annulus at about 7 o'clock position (5 o'clock position for left ear) and a superior canal incision was made at about 10 o'clock position (2 o'clock position for left ear) using canal side knife. The medial ends of the incisions are joined by a horizontal incision using circular angled knife parallel to fibrous annulus. A rectangular posterior meatal skin flap between the above incisions is elevated laterally up to bony cartilaginous junction to develop a laterally based posterior meatal skin flap.

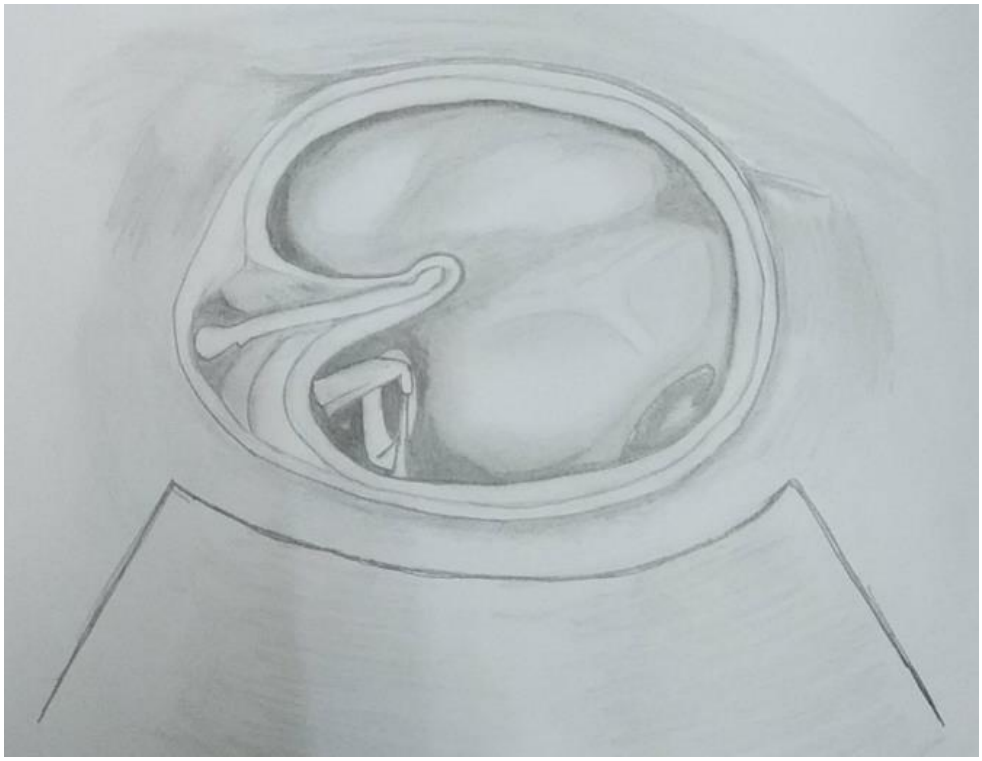

FIG 9: CANAL INCISION FOR POSTERIOR MEATAL SKIN FLAP

iv) Post aural incision

Post-auricular William Wilde's incision is taken from the mastoid tip to the superior temporal line, the soft tissue and the loose areolar tissue is dissected out to reach the temporalis fascia.

v) Harvesting temporalis fascia

The areolar tissue over the temporalis fascia is stretched/teased by blunt dissection by artery forceps to identify the plane of temporalis fascia. The fascia is elevated from the underlying temporalis muscle by injecting saline underneath the fascia to facilitate easy removal of uniform thin fascia without underlying muscle or fat. The temporalis fascia was then harvested under direct vision by sharp dissection using 15 number blade and dissecting scissors.

vi) Exposure of the mastoid

Two incisions are made over the subcutaneous tissue with the curvilinear vertical limb along the posterior bony canal wall close to the meatal skin and the horizontal incision just above the spine of Henle along the linea temporalis. The soft tissue with periosteum over the mastoid was elevated posteriorly by Lempert's periosteal elevator. The cartilaginous canal along with posterior meatal skin flap is separated from its attachment at spine of Henle by Lempert's periosteal elevator. The posterior meatal skin flap is separated from the attachments along the tympanomastoid and tympanosquamous sutures by sharp dissection using periosteal elevator and a 15 number blade. The posterior meatal skin flap and subcutaneous tissue over the mastoid is retracted by modified Perkin's mastoid retractor.

vii) Cortical mastoidectomy

The drilling begins in the Mac Ewan's triangle (marked by linea temporalis superiorly, posterior bony meatus anteriorly and a line tangential to bony meatus perpendicular to linea temporalis posteriorly), till the mastoid antrum was reached. Drilling is continued till the demarcation of the tegmen plate superiorly, the posterior wall of the external auditory canal anteriorly, the sigmoid sinus posteriorly and lateral semicircular canal medially.

viii) Freshening the Margins of Perforation

The mucosa in the undersurface of remnant tympanic membrane is scraped through the perforation using Plester's side knife. The margins are excised by small sickle knife and micro scissors. Freshening the margins facilitates faster healing and epithelialization over

the temporalis fascia in postoperative period and prevents formation of epithelial pearls between the undersurface of tympanic membrane and the graft.

ix) Elevation of the tympanomeatal flap and entry into the middle ear

The tympanomeatal incision is extended superiorly and inferiorly based on the size and location of the perforation. The semicircular tympanomeatal flap was now elevated first from the posterior bony canal wall in a lateral to medial fashion till the fibrous annulus was reached using oval angulated canal elevator. The middle ear mucosa is entered below 9 o'clock position (3 o'clock for left ear) by separation of fibrous annulus using a sickle knife, with caution not to injure the underlying chorda tympani nerve. The handle of malleus is then skeletonised using a sickle knife.

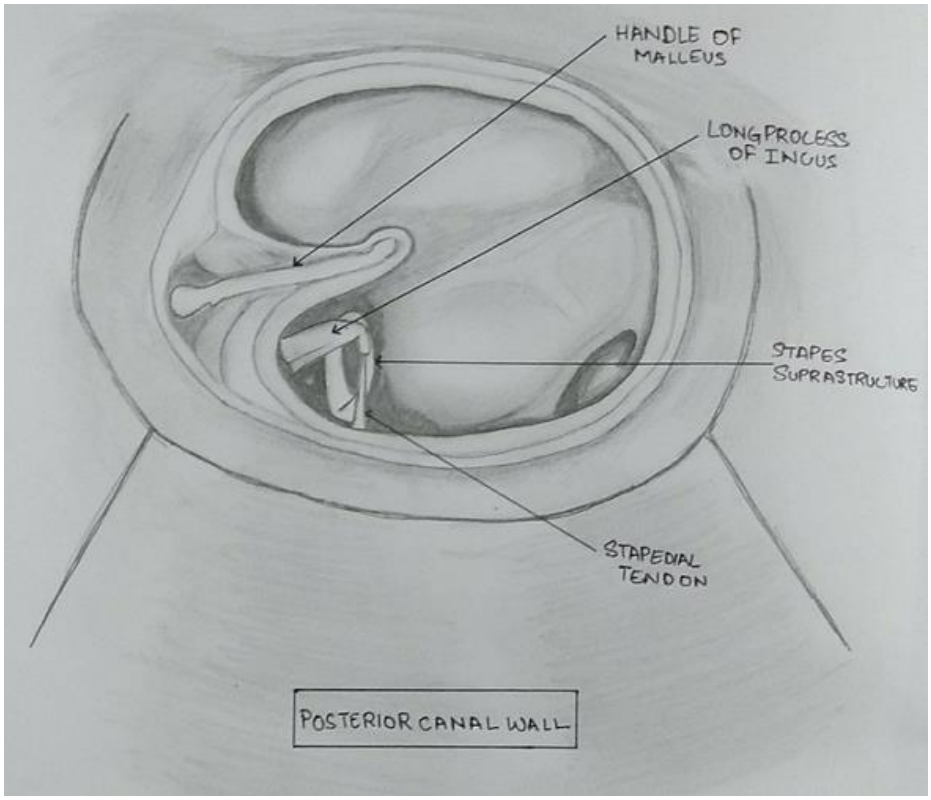

FIG 10: INCISIONS FOR ELEVATION OF TYMPANOMEATAL FLAP

x) Assessment of ossicular chain and ossiculoplasty.

Ossicular chain is checked for mobility and erosion. Depending on the availability and viability autologus incus, tragal cartilage or cortical bone is harvested and sculptured for ossiculoplasty.

a) Removal and sculpturing of Incus

The incus with necrosed lenticular/long process is detached from the incudomaleal joint and taken out. It is then held with Derlacki's ossicle holding forceps. Drilling of incus is performed using 0.6mm diamond burr.

For Interposition ossiculoplasty, the short process is drilled to make it flat and a socket is drilled in the remodelled short process area for the head of stapes. A slit is made to accommodate the stapedial tendon. A notch is drilled towards the long process to fit the handle of malleus.

For Myringostapediopexy, the remnant long process is drilled out to make it cylindrical with a flat base.[43] A socket is drilled in under surface of remodelled long process to fit the head of stapes. Part of short process and the articular facet of the body is removed to avoid ankylosis with the posterior canal wall. The superior border of the body was then flattened to favour its attachment with TM.

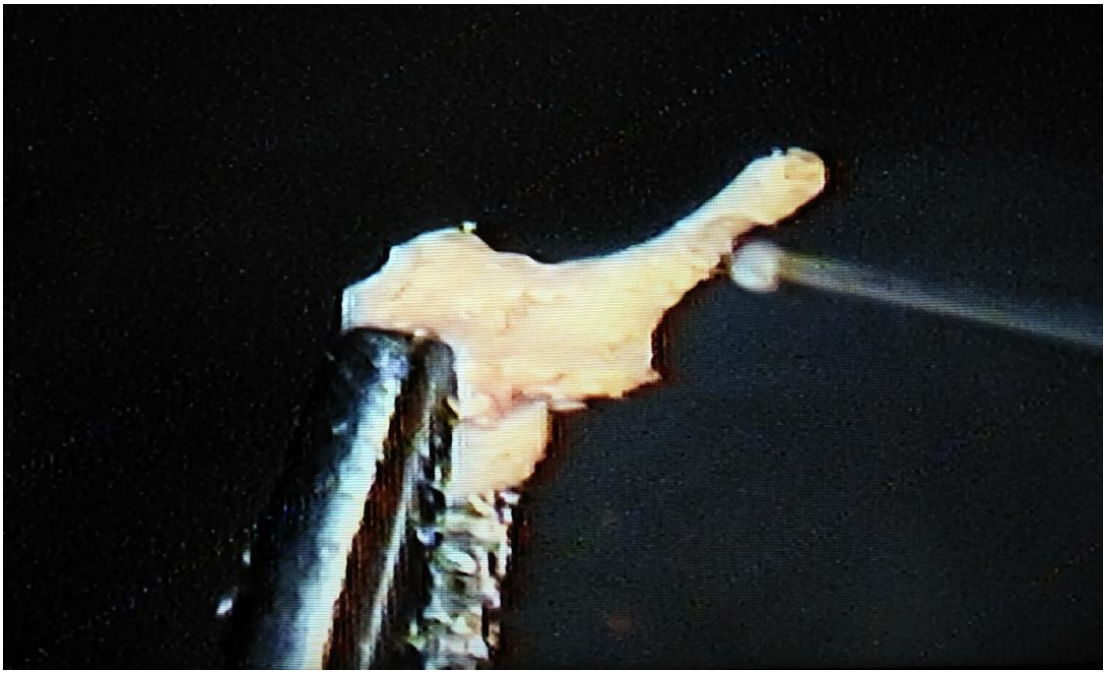

FIG 11: SCULPTURING OF INCUS FOR INTERPOSITION OSSICULOPLASTY

b) Harvesting and reshaping of cortical bone

When the incus is either necrosed upto the bony annulus or is too fragile for drilling or is lost during sculpturing, cortical bone graft may be harvested from the mastoid region for interposition ossiculoplasty and myringostapediopexy.

Bone graft is held with a Derlacki's ossicle holding forceps and drilled into appropriate size. A socked is drilled on one surface for the head of stapes and the opposite surface is made flat or a socket is drilled to accommodate the handle of malleus.[43]

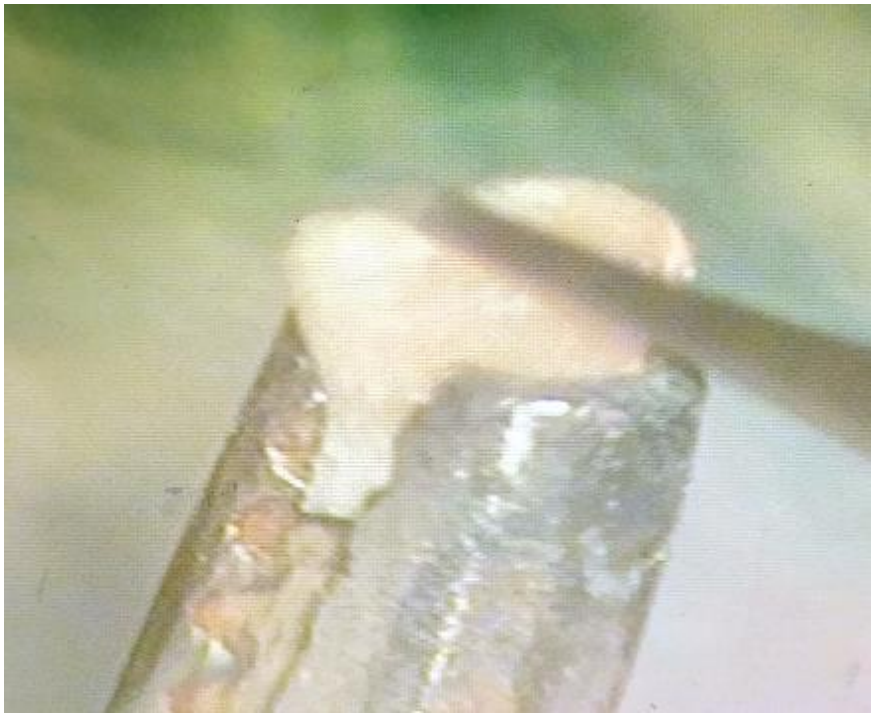

FIG 12: SCULPTURING OF CORTICAL BONE

c) Shaping of cartilage graft

Autologous tragal cartilage is shaped using a 11 number blade. The inferior portion of cartilage is drilled using 0.6mm diamond burr to form a socket for the head of stapes. The superior surface is made into a slant to provide greater surface of contact with the temporalis fascia graft.

xi) Clearance of Middle Ear Disease

Now the middle ear hypertrophied mucosa and squamous epithelium is completely cleared. Specially in performing a second look procedure, it is essential to check carefully for any residual or recurrent cholesteatoma before considering ossicular chain reconstruction**.**

xii) Placement of graft

The mobility of the footplate is first confirmed by gentle touch over the stapes superstructure and looking for round window reflex. The middle ear cavity is packed with gel foam soaked with antibiotic-steroid solution to make the bed for the graft. The temporalis fascia graft is then placed. The fascia and the tympanomeatal flap is secured anteriorly. Then the temporalis fascia is gently elevated till the oval window area is visualised. The refashioned ossicle, cartilage or cortical bone is interposed between the handle of malleus and the stapes head (interposition ossiculoplasty) or placed between the neotympanum and the head of stapes(myringostapediopexy) [43]

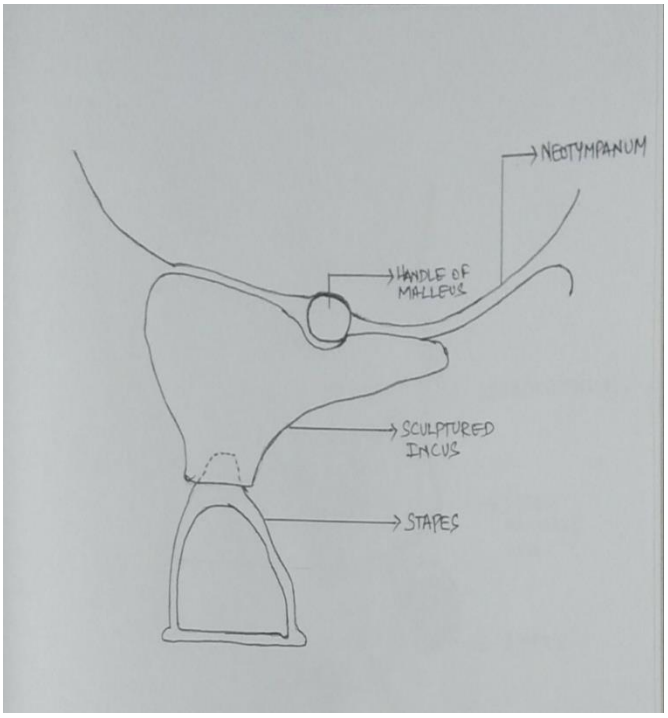

FIG 13: RESCULPTURED INCUS ASSEMBLY FOR INTERPOSITION OSSICULOPLASTY

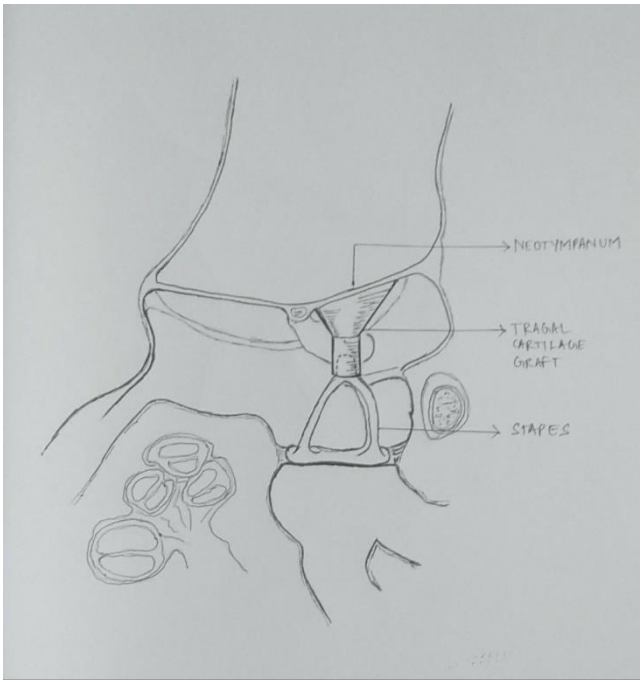

FIG 14: TRAGAL CARTILAGE ASSEMBLY FOR MYRINGOSTAPEDIOPEXY

The temporalis fascia and the tympanomeatal flap is repositioned in place. The canal is packed with gelfoam and canal pack is placed. The postauricular wound is sutured and mastoid dressing is done.

RESULTS AND OUTCOMES IN OSSICULOPLASTY:

Till 1995 there was a lack of standard protocol for reporting results of treatment for condutive hearing loss. This made it difficult to assess different treatment methods and case series. The prime areas of concern were audiometric evaluation and description of disease and surgery.

To overcome these problems the American Academy of Otolaryngology – Head and Neck Surgery (AAO-HNS), committee on hearing and equilibrium

released guidelines to standardize reporting formats for ossiculoplasty and related surgeries.

The recommendations from the committee are as following:[44]

Two levels of reporting are suggested by the committee.

Level 1: Summary data to be reported for technical results.

Level 2 : Raw data to be recorded for meta-analysis.

a) Hearing Thresholds:

The committee recommended reporting the pure tone average as the mean of the thresholds at 0.5, 1, 2, 3 KHz frequencies.

Air-Bone gap (ABG) is reported as the difference between the pure-tone average of Air conduction (AC) and Bone conduction(BC).

b) Air-Bone gaps

The ABG closure is reported as the difference between the pre-op and post-op ABG.

The committee suggests reporting the mean, SD, range and the number of decibel of change in the post-op ABG.

Some investigators may use decibel bins as 1-10, 11-20, 21-30 and 31+ dB.

c) Disease considerations

The report should include Ossicular status, middle ear aeration, whether the surgery was staged and whether cases were included in the study.

d) Postoperative reporting time

For clinical outcome post-treatment interval should be one year or more. Technical/ graft efficiency are reported at 2 months interval and sensorineural variations at 6 weeks interval.

COMPLICATIONS OF OSSICULOPLASTY

The intraoperative complications of ossiculoplasty may be dislocation of the stapes, fracture of the stapes suprastructure, perilymphatic fistula due to tear of annular ligament.[45]

Other complications include graft extrusion, sensorineural hearing loss, dizziness, infection, ipsilateral taste disturbance, tinnitus and facial nerve paralysis.[46]

METHODOLOGY

METHODOLOGY

SOURCE OF DATA

A minimum of 64 patients diagnosed with chronic otitis media, 32 patients in each group undergoing interposition ossiculoplasty (Group A) and myringostapediopexy (Group B), satisfying the inclusion and exclusion criteria, presenting to the department of otorhinolaryngology and head and neck surgery of R.L Jalappa hospital, Tamaka, Kolar, from December 2015 to July 2017 were included in this study.

INCLUSION CRITERIA

Patients diagnosed with chronic otitis media with hearing loss and undergoing interposition ossiculoplasty or myringostapediopexy using autologous incus, tragal cartilage or cortical bone graft with intact canal wall tympanoplasty with or without mastoidectomy.

EXCLUSION CRITERIA

1. Patients with sensorineural hearing loss.

2. Patients with otosclerosis.

3. Patients with chronic otitis media undergoing type I tympanoplasty.

METHOD OF COLLECTION OF DATA

Patients diagnosed with chronic otitis media with hearing loss undergoing interposition ossiculoplasty (Group A) or myringostapediopexy (Group B) using autologous incus,

tragal cartilage or cortical bone graft in intact canal wall tympanoplasty with or without cortical mastoidectomy were included in the study.

This diagnosis of chronic otitis media with hearing loss was made by detailed history and routine ENT examination. Once the diagnosis was made, these patients were subjected to microscopic ear examination and pure tone audiometry. A written informed consent was taken to include the patient into the study. All patients were informed about the techniques of ossiculoplasty using autologous incus, tragal cartilage or cortical bone graft depending upon the need, availability and viability of the graft.

Patients with acute infection were treated with a course of antibiotics, analgesics and local ear drops for the ear to become dry and were then planned for surgery.

Surgical preparation:

Pre-operative Evaluation:

The patients with chronic otitis media were clinically evaluated in the out-patient department. The affected ear was examined including microscopic ear examination for discharge, site of tympanic membrane defect, retraction pockets, presence of squamous epithelium and keratin debris, disruption of ossicular chain, presence of inflammatory polyp, granulation tissue and ostietis.

Preoperative tuning fork tests and pure tone audiometry and routine hematological investigations were done for all the patients. Radiological examination included lateral oblique X-Ray of bilateral mastoids and HRCT temporal bone was done when indicated.

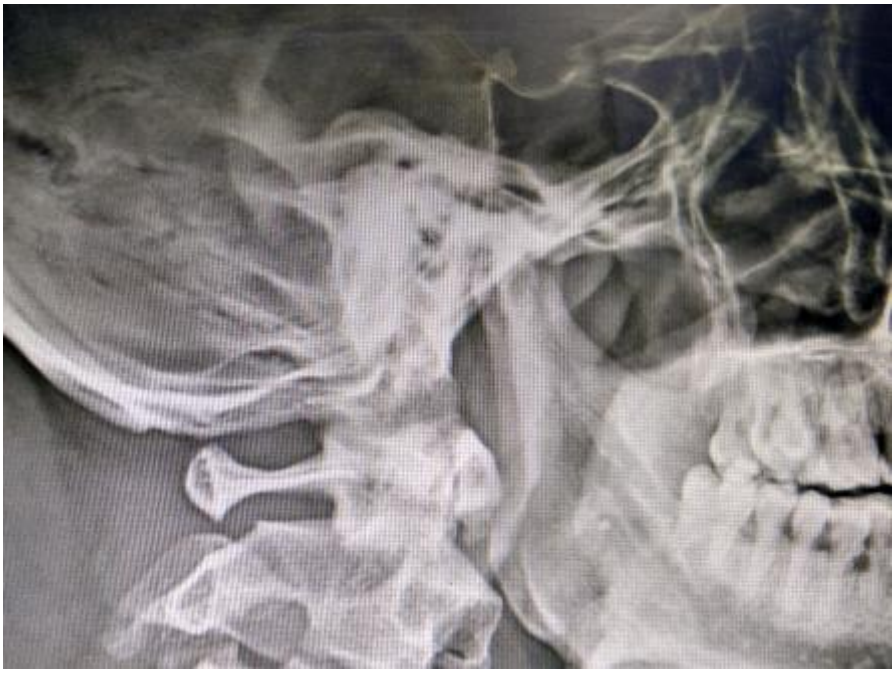

FIG 15: X-RAY MASTOID SCHULLER'S VIEW SHOWING SCLEROTIC MASTOID

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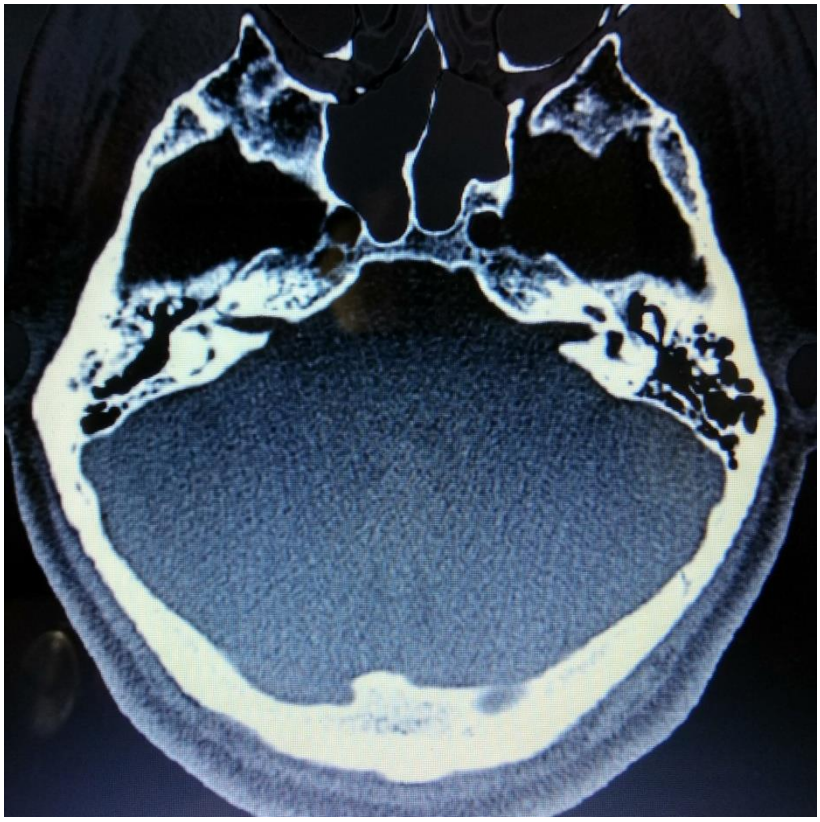


FIG 16: HRCT TEMPORAL BONE - AXIAL CUT

Preparation of the patient:

- The patient was kept nil orally for a period of 6 hours prior to the surgery.
- Injection Tetanus Toxoid 0.5cc intra muscular was given the previous day.
- Injection Lignocaine sensitivity test was done previous day (0.1ml intra dermal).
- Tablet Diazepam 10 mg oral, previous night and 5 mg early in the morning.
- Part preparation: The hair was shaved, about half an inch above and behind the auricle on the side of surgery for the purpose of good surgical field exposure.

Anesthesia:

In this series all patients were operated under general anesthesia.

Surgical technique:

Preparation of part:

The patient was made to lie down in supine position with the operating ear facing upwards and towards the operating surgeon. Ear canal was instilled with 4% lignocaine. The ear and adjacent areas were painted with 5% povidone iodine solution. The patient was then draped with sterile surgical towels.

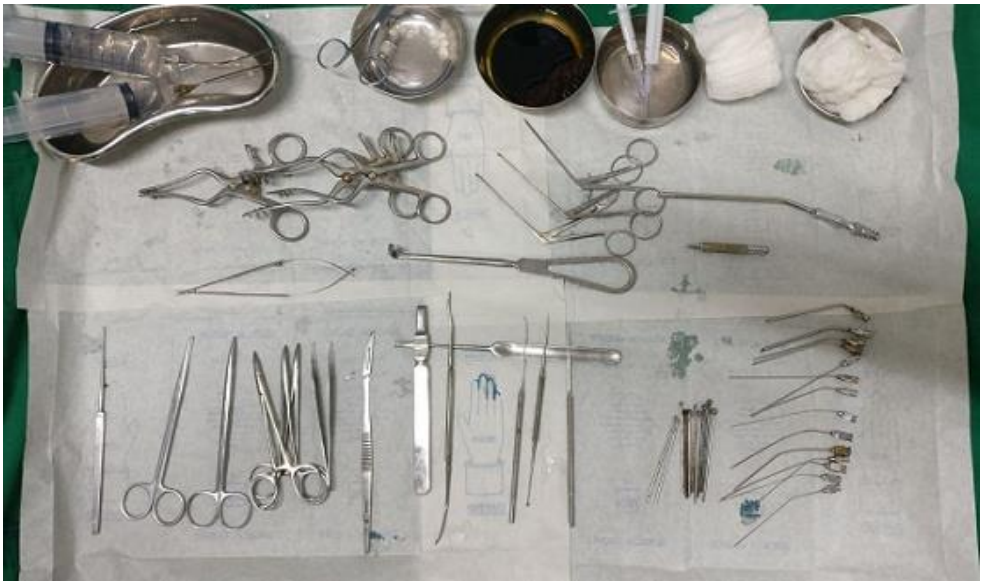


FIG 17: INSTRUMENTS USED FOR EAR SURGERY

Infiltration:

It was done 10 minutes prior to the incision. Infiltration solution was prepared using 10 ml of premixed 2% lignocaine + adrenaline and 10 ml of normal saline.

About 0.5 cc of the prepared solution was infiltrated each into the bony cartilaginous junction of the external auditory canal at 3, 6, 9 and 12 O' clock positions, without creating blebs.

The auricular branches of the auriculotemporal nerve which supplies the upper part of the auricle and skin above the meatus were blocked by injecting 1 ml of solution at several points into the skin and periosteum of the incisura terminalis, upward to the upper attachment of the auricle.

The branches of the great auricular nerve to the auricle and meatus were blocked by injection of 1 ml of solution at several points behind the auricle over the mastoid process.

The auricular branch of the vagus nerve was blocked by injection of the periosteum of the anterior surface of the mastoid process and of the skin of the floor of the meatus.

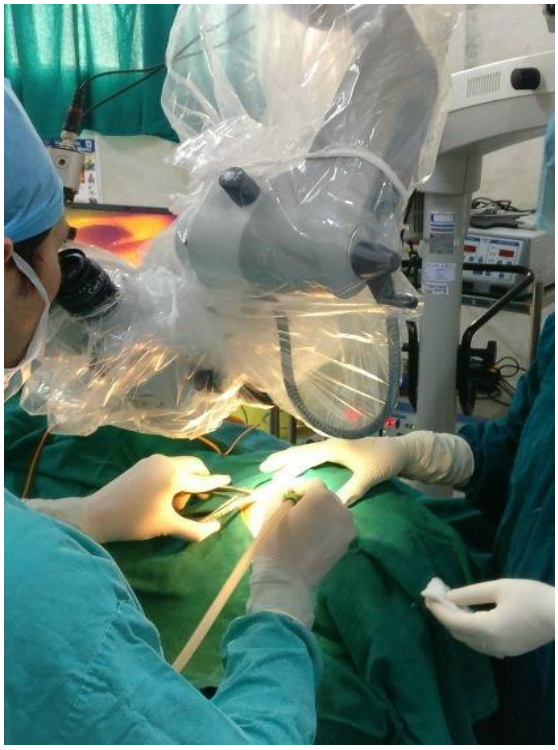


FIG 18: OPERATING MICROSCOPE BEING USED

Canal Incisions and Elevation of Posterior Meatal Skin Flap

The external auditory canal and the tympanic membrane were exposed using a Lempert's aural speculum. Through the external auditory meatus, initial inferior vertical canal incision was made starting about 5 mm lateral to the fibrous annulus at about 7 o'clock position (5 o'clock position for left ear) and a superior canal incision was made at about 10 o'clock position(2 o'clock position for left ear) using canal side knife. The medial ends of the incisions were joined by a horizontal incision using circular angled knife parallel to fibrous annulus. A rectangular posterior meatal skin flap between the above

incisions was elevated laterally up to bony cartilaginous junction to develop a laterally based posterior meatal skin flap.

Post aural incision

Post-auricular William Wilde's incision was taken from the mastoid tip to the superior temporal line, the soft tissue and the loose areolar tissue was dissected out to reach the temporalis fascia.

Harvesting temporalis fascia

The areolar tissue over the temporalis fascia was stretched/teased by blunt dissection by artery forceps to identify the plane of temporalis fascia. The fascia was elevated from the underlying temporalis muscle by injecting saline underneath the fascia to facilitate easy removal of uniform thin fascia without underlying muscle or fat. The temporalis fascia was then harvested under direct vision by sharp dissection using 15 number blade and dissecting scissors.

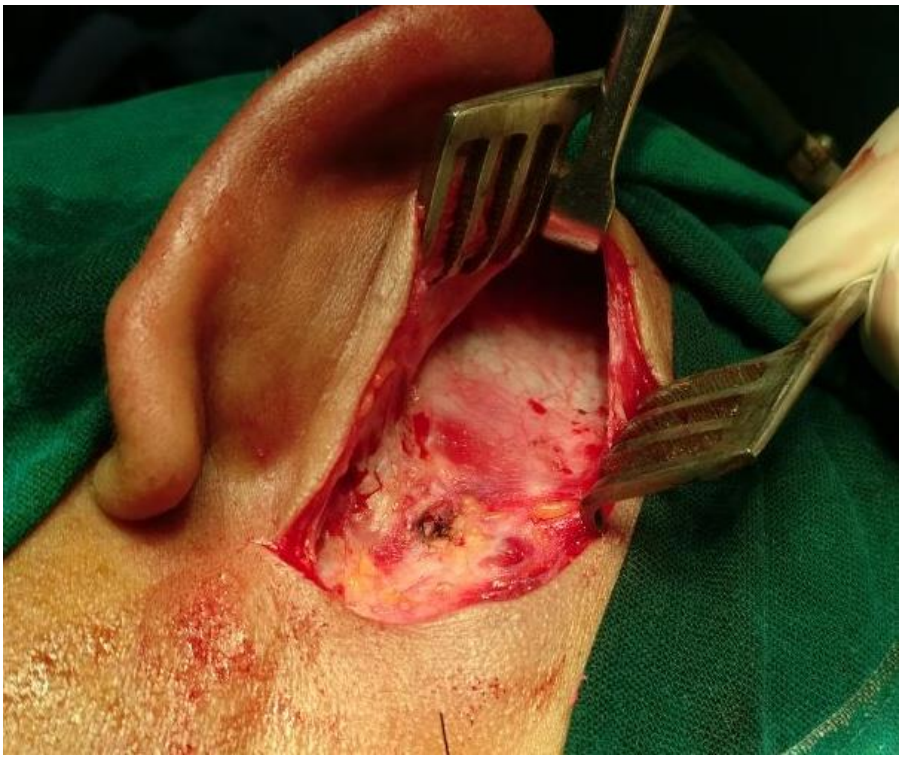


FIG 19: HARVESTING THE TEMPORALIS FASCIA GRAFT

Exposure of the mastoid

Two incisions were made over the subcutaneous tissue with the curvilinear vertical limb along the posterior bony canal wall close to the meatal skin and the horizontal incision just above the spine of Henle along the linea temporalis. The soft tissue with periosteum over the mastoid was elevated posteriorly by Lempert's periosteal elevator. The cartilaginous canal along with posterior meatal skin flap was separated from its attachment at spine of Henle by Lempert's periosteal elevator. The posterior meatal skin flap was separated from the attachments along the tympanomastoid and tympanosquamous sutures by sharp dissection using periosteal elevator. The posterior meatal skin flap and subcutaneous tissue over the mastoid was retracted by modified Perkin's mastoid retractor.

Cortical mastoidectomy

The drilling was begun in the Mac Ewan's triangle (marked by linea temporalis superiorly, posterior bony meatus anteriorly and a line tangential to bony meatus perpendicular to linea temporalis posteriorly), till the mastoid antrum was reached. Drilling was continued till the demarcation of the tegmen plate superiorly, the posterior wall of the external auditory canal anteriorly, the sigmoid sinus posteriorly and lateral semicircular canal medially.

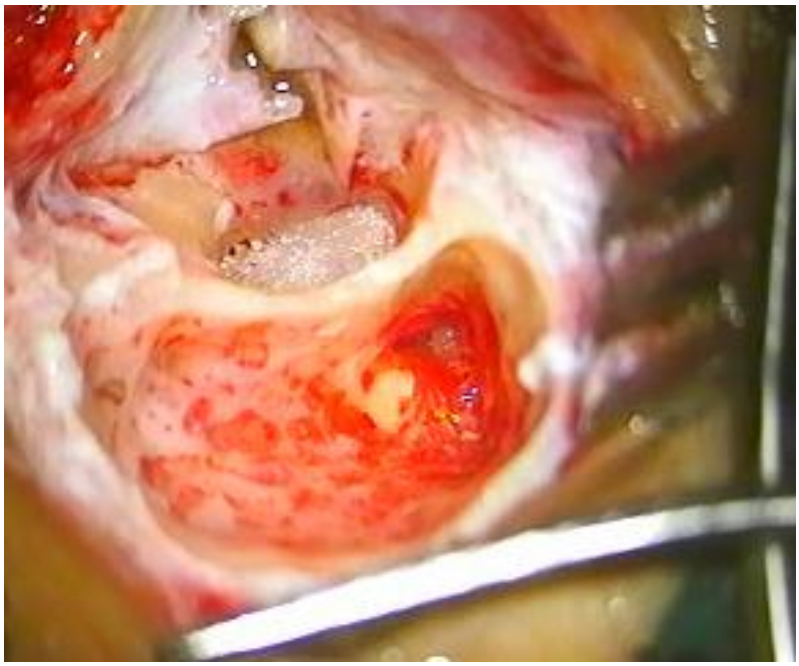


FIG 20: CORTICAL MASTOIDECTOMY DONE IN LEFT EAR

Freshening the Margins of Perforation

The mucosa in the undersurface of remnant tympanic membrane was scraped through the perforation using Plester's side knife. The margins were excised by small sickle knife and micro scissors.

Elevation of the tympanomeatal flap and entry into the middle ear

The tympanomeatal incision was extended superiorly and inferiorly based on the size and location of the perforation. The semicircular tympanomeatal flap was now elevated first from the posterior bony canal wall in a lateral to medial fashion till the fibrous annulus was reached using oval angulated canal elevator. The middle ear mucosa was entered below 9 o'clock position (3 o'clock for left ear) by separation of fibrous annulus using a sickle knife, with caution not to injure the underlying chorda tympani nerve. The handle of malleus was then skeletonised using a sickle knife.

Assesment of ossicular chain and ossiculoplasty:

Ossicular chain was checked for mobility and erosion. Patients with Austin type A (erosion of incus with intact malleus and stapes) and type C (erosion of incus and malleus with intact stapes) ossicular defects were considered for ossiculoplasty.

Depending on the availability and viability autologous incus, tragal cartilage or cortical bone was harvested and sculptured for ossiculoplasty.

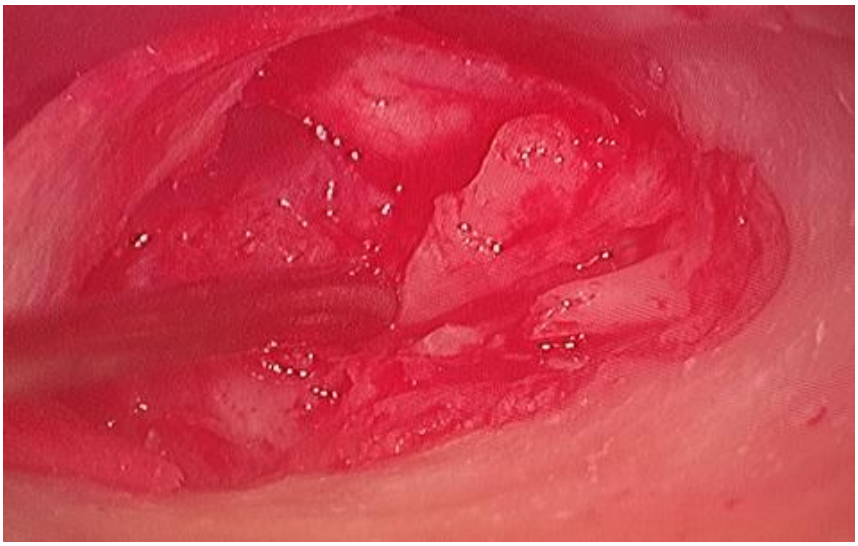


FIG 21: NECROSED LONG PROCESS OF INCUS

Removal and sculpturing of Incus

The incus with necrosed lenticular/long process was detached from the incudomaleal joint and taken out. It was then held with Derlacki's ossicle holding forceps. Drilling of incus was performed using 0.6mm diamond burr.

For Interposition ossiculoplasty, the short process was drilled to make it flat and a socket was drilled in the remodelled short process area for the head of stapes. A slit was made to accommodate the stapedial tendon. A notch is made towards the long process to fit the handle of malleus.

For Myringostapediopexy, the remnant long process is drilled out to make it cylindrical with a flat base. A socket is drilled in under surface of remodelled long process to fit the head of stapes. Part of short process and the articular facet of the body removed to avoid ankylosis with the posterior canal wall. The superior border of the body was then flattened to favour its attachment with TM.

FIG 22: SCULPTURING OF AUTOLOGOUS INCUS

When autologous incus was used for ossiculoplasty and the scutum was curetted, attic reconstruction was done using a piece of periostium and temporalis fascia graft to avoid postoperative retraction of tympanic membrane.

Harvesting and reshaping of cortical bone

A cortical bone graft was harvested from the mastoid region in cases where:

- Necrosed incus was left in place for attic support to prevent postoperative retraction of neo-tympanum
- Incus was eroded upto the bony annulus
- Incus was too fragile for drilling or
- Incus was lost during drilling

Bone graft was held with a Derlacki's ossicle holding forceps and drilled into appropriate size. A socked was drilled on one surface for the head of stapes and the opposite surface was made flat or a notch was drilled to accommodate the handle of malleus.

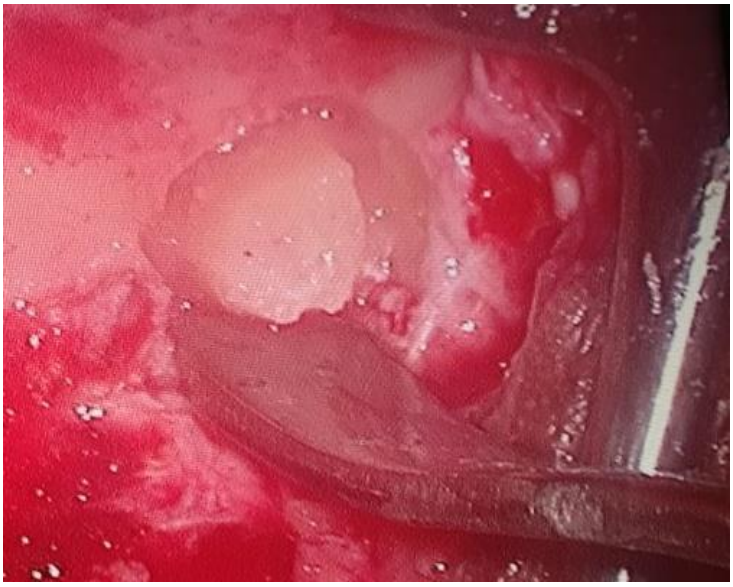


FIG 23: HARVESTING CORTICAL BONE GRAFT

Shaping of cartilage graft

Autologous tragal cartilage was shaped using a 11 number blade. The inferior portion of cartilage was drilled using 0.6mm diamond burr to form a socket for the head of stapes. The superior surface was made into a slant to provide greater surface of contact with the temporalis fascia graft.

Clearance of Middle Ear Disease

Now the middle ear hypertrophied mucosa and squamous epithelium was completely cleared.

Placement of graft

The mobility of the footplate was first confirmed by gentle touch over the stapes superstructure and looking for round window reflex. The middle ear cavity was packed with gel foam soaked with antibiotic-steroid solution to make the bed for the graft. The temporalis fascia graft was then placed. The fascia and the tympanomeatal flap were secured anteriorly. Then the temporalis fascia was gently elevated till the oval window area was visualised. The refashioned ossicle, cartilage or cortical bone was interposed between the handle of malleus and the stapes head (interposition ossiculoplasty) or placed between the neotympanum and the head of stapes (myringostapediopexy).

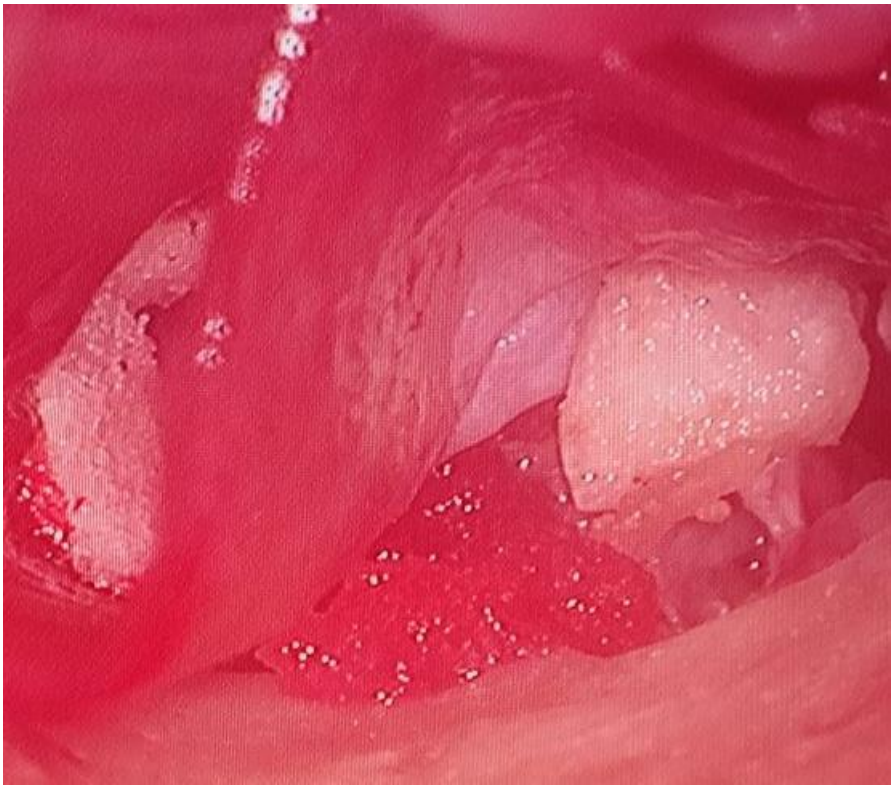


FIG 24: CORTICAL BONE GRAFT USED FOR MYRINGOSTAPEDIOPEXY

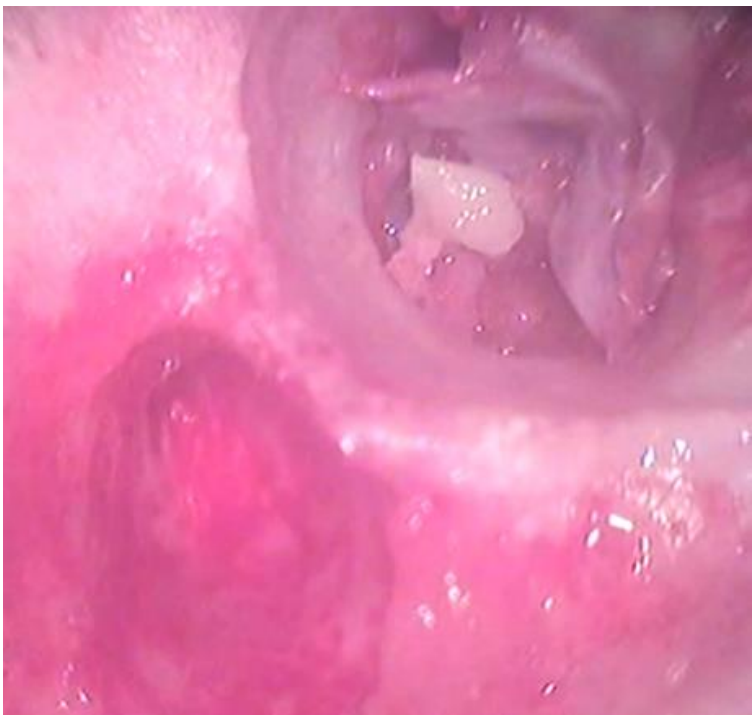


FIG 25: AUTOLOGOUS INCUS GRAFT USED FOR MYRINGOSTAPEDIOPEXY

The temporalis fascia and the tympanomeatal flap is repositioned in place. The canal is packed with gelfoam and canal pack is placed. The postauricular wound is sutured and mastoid dressing is done.

Postoperative care

In the immediate post-operative period patient was checked for any facial nerve palsy, presence of nystagmus, bleeding and treated accordingly. All the patients were treated with a course of antibiotics, analgesics, and antihistaminics for a period of one week.

The mastoid dressing was removed after 4days and the suture removal done on the 7^{th} post-operative day. External auditory canal pack was removed after 3 weeks.

All patients who underwent tympanoplasty and ossicular reconstruction were classified in two groups. Patients who underwent Interposition ossiculoplasty were classified in group A and patients who underwent Myringostapediopexy were classified in Group B.

Follow-up

All the patients were followed up at the end of 3 months after surgery.

During their visit, history regarding earache, ear discharge and subjective improvement in hearing were obtained.

The neo-tympanum was examined and patients were then subjected to tuning fork tests and pure tone audiogram to assess the improvement in hearing.

FIG 26: PTA BEING DONE FOR THE PATIENT

The hearing results were compared in terms of mean pre-op and post-op Air conduction thresholds, Air-Bone gap and hearing gain or ABG closure. Postoperative ABG closure was measured as the difference between the preoperative ABG and postoperative ABG. The audiometric results were reported according to AAO-HNS guidelines, except that threshold at 4 KHz were used in all cases instead of threshold at 3 KHz.

RESULTS

STATISTICAL ANALYSIS

STUDY DESIGN:

Prospective observational study

SAMPLE SIZE:

Was estimated based on the difference in proportion of hearing improvement < 20 db Air bone gap at post-operative period between Interposition and Myriginostapediopexy. By using the formula

$$\text{Sample size} = \frac{r+1}{r}\frac{(p^*)(1-p^*)(Z_\beta + Z_{\alpha/2})^2}{(p_1 - p_2)^2}$$

r = Ratio of control to cases, 1 for equal number of case and control
p^* = Average proportion exposed = proportion of exposed cases + proportion of control exposed/2
Z_β = Standard normal variate for power = for 80% power it is 0.84 and for 90% value is 1.28. Researcher has to select power for the study.
$Z_{\alpha/2}$ = Standard normal variate for level of significance as mentioned in previous section.
$p_1 - p_2$ = Effect size or different in proportion expected based on previous studies. p_1 is proportion in cases and p_2 is proportion in control.

From the Study by Amith I Naragund et al (Interposition) p1 = 58%, from the study by Nicola Quaranta (Myriginostapediopexy) p2 = 83.3% at 80% confidence level and 80% power, with equal ratio of cases and controls

N = $\underline{2 \times 0.706 \times 0.2935 (1.28 + 0.84)^2 = 29}$ in each group

0.253x 0.253

P* = P1 + P2 / 2

P* = 58 + 83.3 / 2 = 70.65

Considering Non response rate of 10% 29 + 3 = 32 patients in each group will be selected.

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. **Paired t test** is the test of significance for paired data such as before and after surgery for quantitative data.

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.

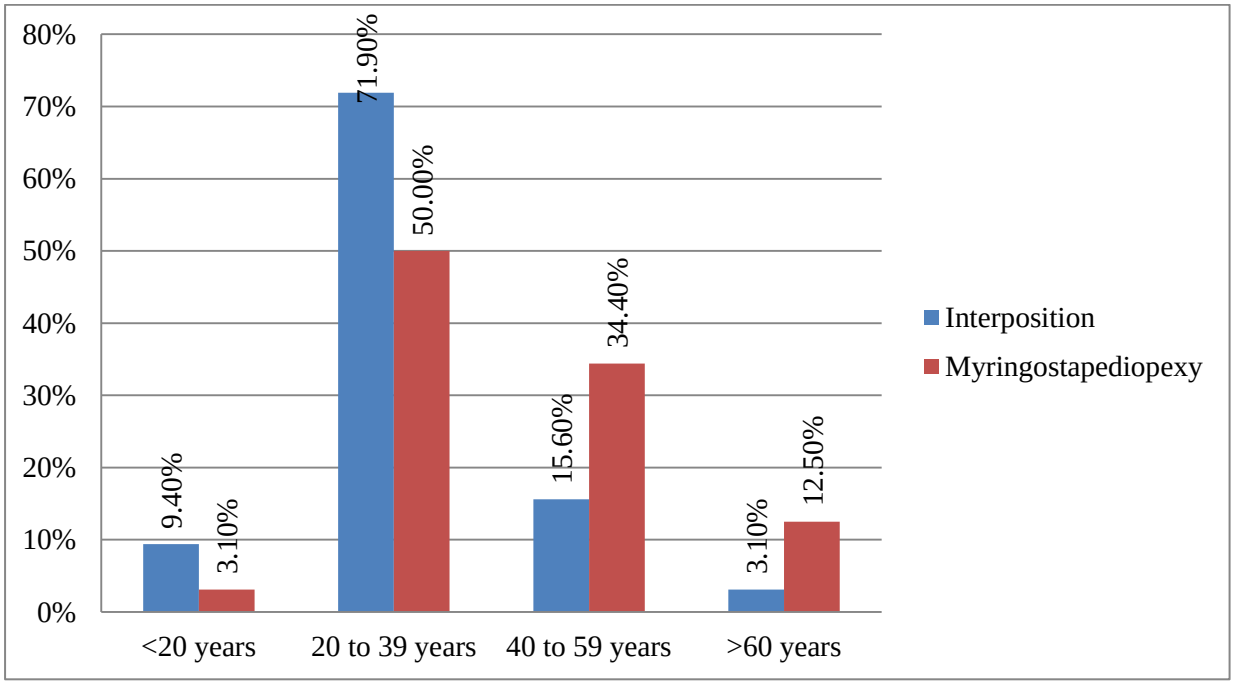
Statistical software: MS Excel**,** SPSS version 22 **(**IBM SPSS Statistics, Somers NY, USA) was used to analyze data.

Table 3: Age distribution of subjects and comparison between two study groups

		Group			
		Interposition (Group A)		Myringostapediopexy (Group B)	
		Number (n=32)	%	Number (n=32)	%
Age	<20 years	3	9.4	1	3.1
	20 to 39 years	23	71.9	16	50.0
	40 to 59 years	5	15.6	11	34.4
	>60 years	1	3.1	4	12.5

$\chi 2 = 6.306$, df = 3, p = 0.098

The age of the subjects ranged from 16 to 65 years in Group A and 18 to 67 in Group B. Majority of subjects in both the groups belonged to the age group of 20 to 39 years (71.9% in Group A and 50% in Group B).



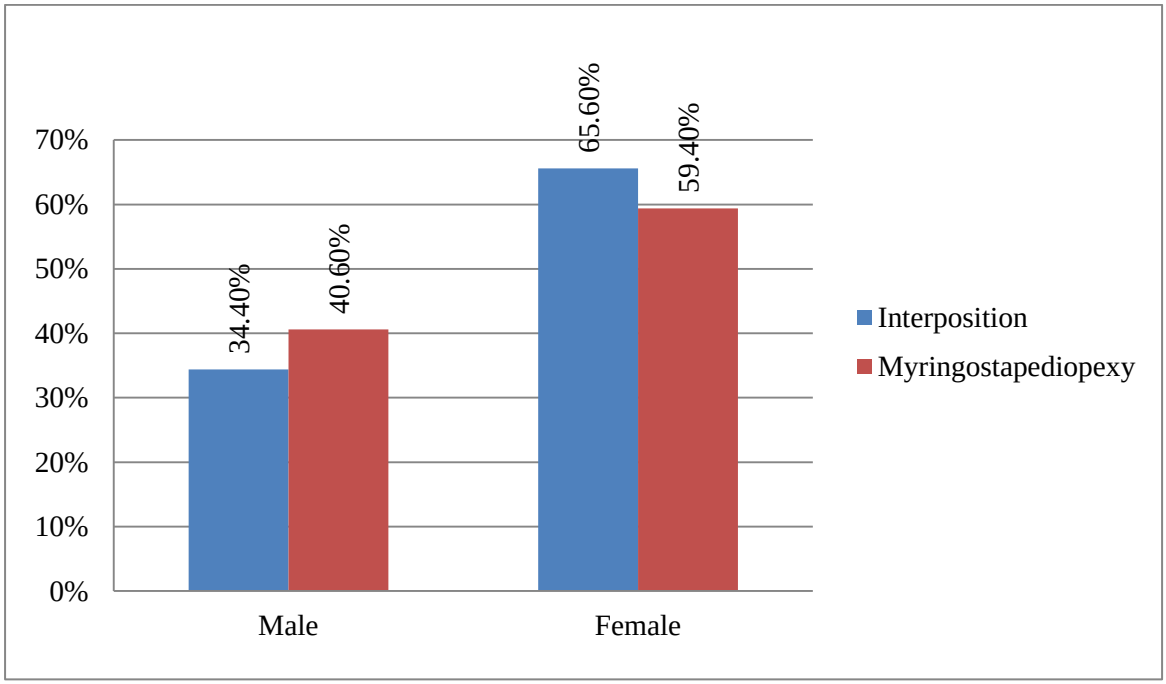
Graph 1: Bar diagram showing Age distribution of subjects and comparison between two study groups

Table 4: Gender distribution of subjects and comparison between two study groups

		Group			
		Interposition (Group A)		Myringostapediopexy (Group B)	
		Number (n=32)	%	Number (n=32)	%
Gender	Male	11	34.4	13	40.6
	Female	21	65.6	19	59.4

$\chi 2 = 0.267$, df = 1, p = 0.606

In Group A 65.6% were females and 34.4% were males and in Group B, 59.4% were females and 40.6% were males. There was no significant difference in gender distribution between two groups.



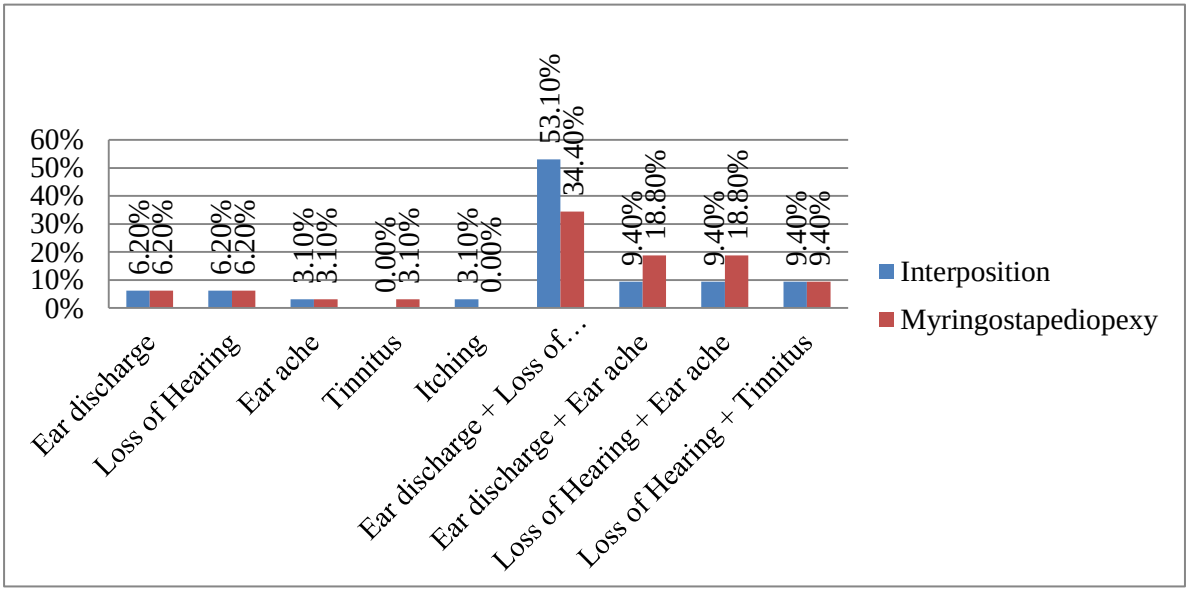
Graph 2: Bar diagram showing Gender distribution and comparison between two study groups

Table 5: Distribution according to presenting complaints and comparison between two study groups

		Group			
		Interposition (Group A)		Myringostapediopexy (Group B)	
		Number (n=32)	%	Number (n=32)	%
Presenting Complaints	Ear discharge	2	6.2	2	6.2
	Loss of Hearing	2	6.2	2	6.2
	Ear ache	1	3.1	1	3.1
	Tinnitus	0	0.0	1	3.1
	Itching	1	3.1	0	0.0
	Ear discharge + Loss of Hearing	17	53.1	11	34.4
	Ear discharge + Ear ache	3	9.4	6	18.8
	Loss of Hearing + Ear ache	3	9.4	6	18.8
	Loss of Hearing + Tinnitus	3	9.4	3	9.4

$\chi 2 = 5.086$, df = 8, p = 0.748

Most common presenting complaint was Ear discharge + Hearing loss in both groups, 53.1% in Group A and 34.4% in Group B. There was no significant difference in presenting complaint between two study groups.



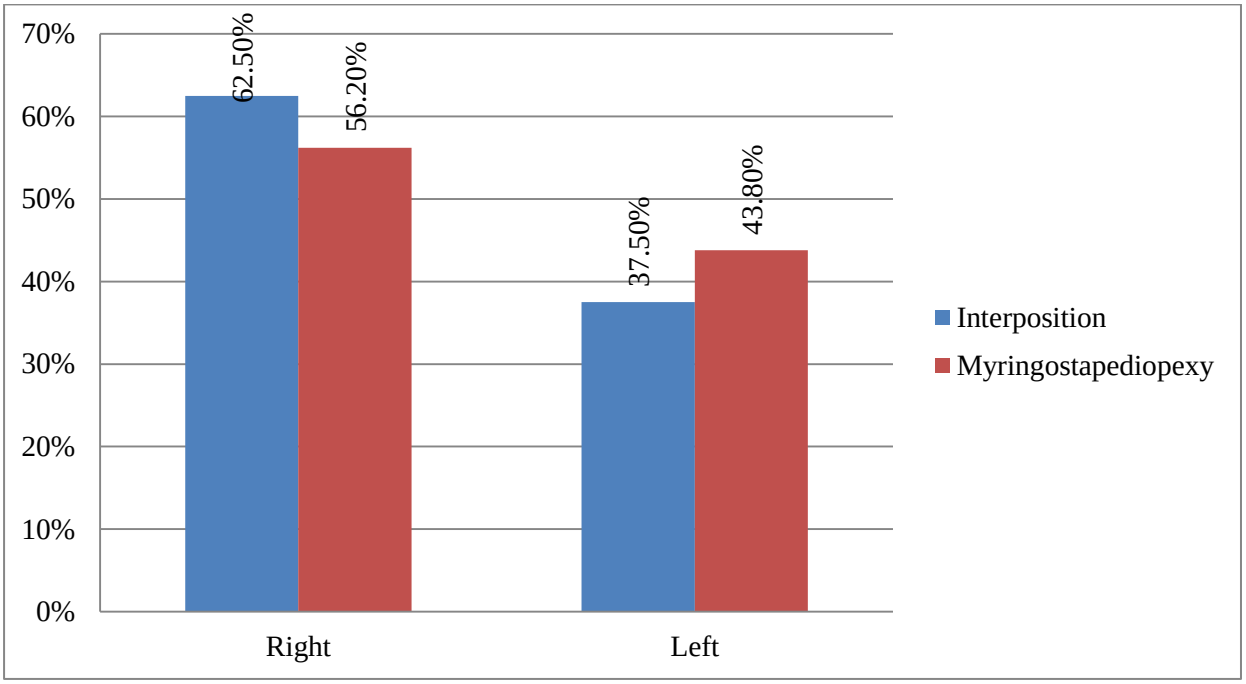
Graph 3: Bar diagram showing distribution according to presenting complaints and comparison between two study groups.

Table 6: Distribution according to side of ear involved between two study groups

		Group			
		Interposition (Group A)		Myringostapediopexy (Group B)	
		Number (n=32)	%	Number (n=32)	%
Ear	Right	20	62.5	18	56.2
	Left	12	37.5	14	43.8

$\chi 2 = 0.259$, df = 1, p = 0.611

The disease involved both the ears, with more right ear involvement in both groups that is 62.5% and 56.2% in Group A and Group B respectively. There was no significant difference in distribution according to side of ear involved between two study groups.



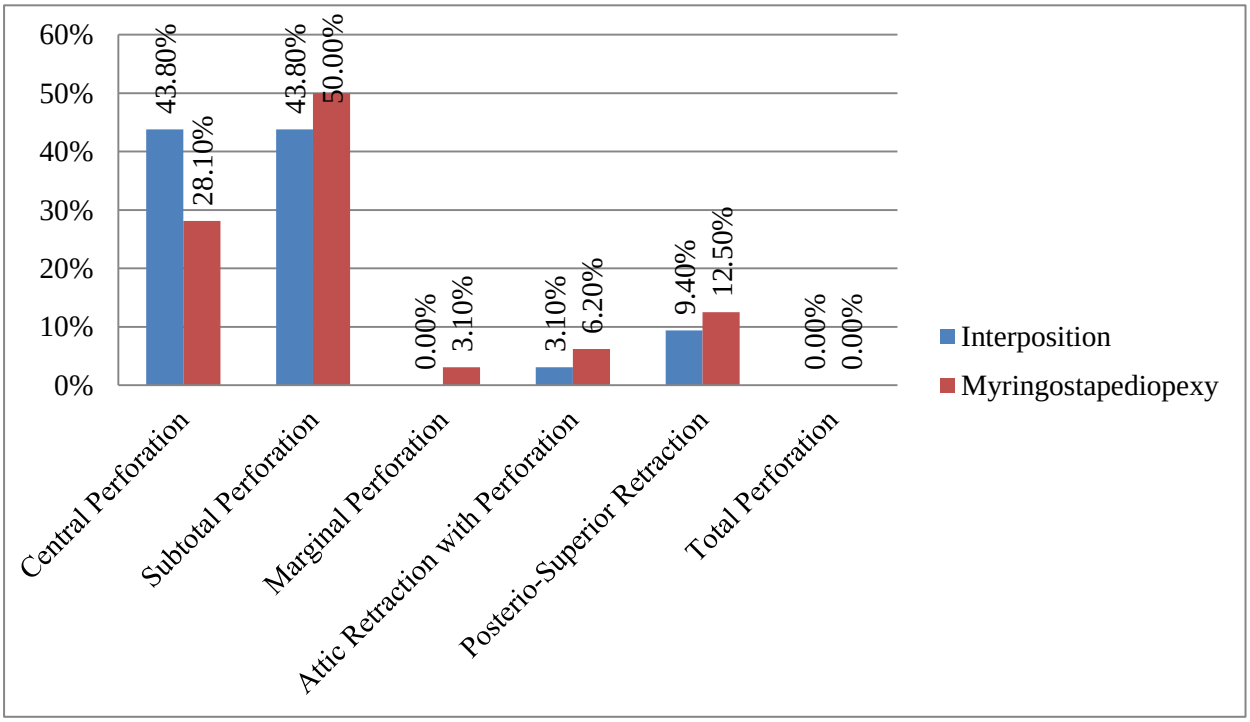
Graph 4: Bar diagram showing Distribution according to side of ear involved between two study groups.

Table 7: Distribution of various pathology of Tympanic Membrane findings and comparison between two study groups

		Group			
		Interposition (Group A)		Myringostapediopexy (Group B)	
		Number (n =32)	%	Number (n =32)	%
Pathology Tympanic Membrane	Central Perforation	14	43.8	9	28.1
	Subtotal Perforation	14	43.8	16	50.0
	Marginal Perforation	0	0.0	1	3.1
	Attic Retraction with Perforation	1	3.1	2	6.2
	Posterior-Superior Retraction	3	9.4	4	12.5
	Total Perforation	0	0.0	0	0.0

$\chi 2 = 2.696$, df = 4, p = 0.610

Central perforation (43.8%) and subtotal perforation(43.8%) were common in Group A and subtotal perforation(50.0%) in Group B which was not statistically significant.



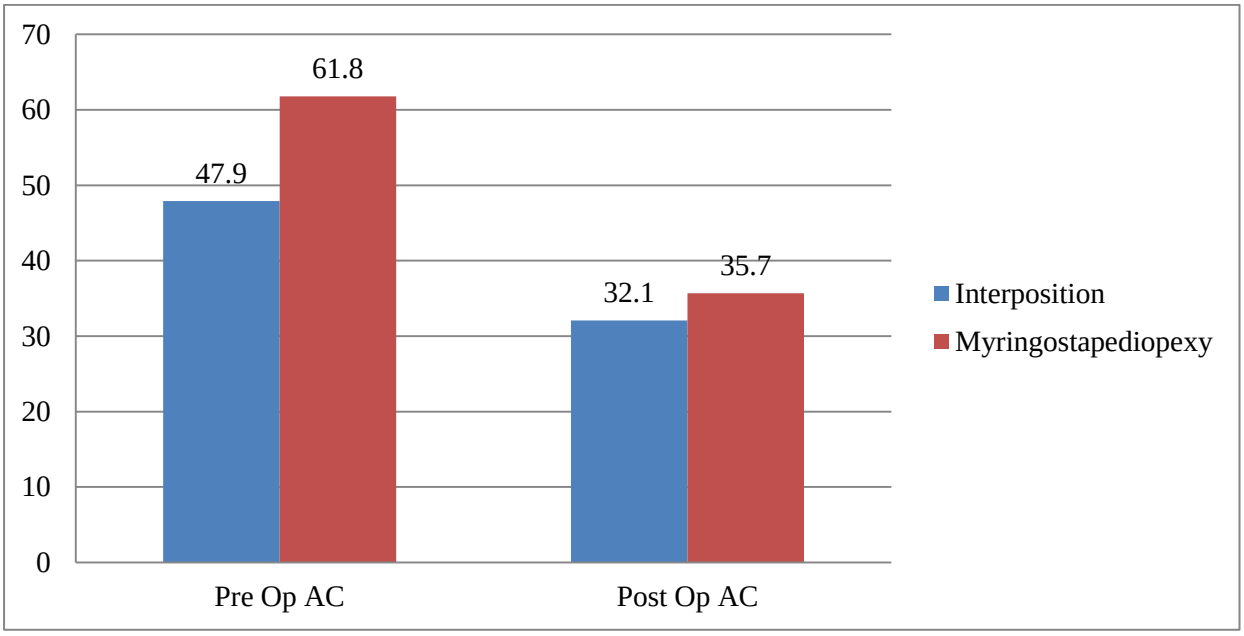
Graph 5: Bar diagram distribution of various pathology of Tympanic Membrane findings and comparison between two study groups

Table 8: Pre Op and Post Op AC distribution and comparison between two study groups

	Group						p value b/w two groups
	Interposition (Group A)			Myringostapediopexy (Group B)			
	Mean	SD	p value with in group	Mean	SD	p value with in group	
PRE OP AC	47.9	5.3		55.9	7.7		<0.001*
POST OP AC	32.1	6.7	<0.001*	34.5	7.7	<0.001*	0.190

The mean pre-op AC for Group A and Group B was 47.9 ± 5.3 dB and 55.9 ± 7.7 dB, respectively which shows the mean pre-op AC for group B was higher than the mean pre-op AC for Group A which was statistically significant.

There was gain in post-op AC in both groups. The mean post-op AC for group A was 32.1 ± 6.7 dB and the mean post-op AC for Group B was 34.5 ± 7.7 which was not statistically significant.



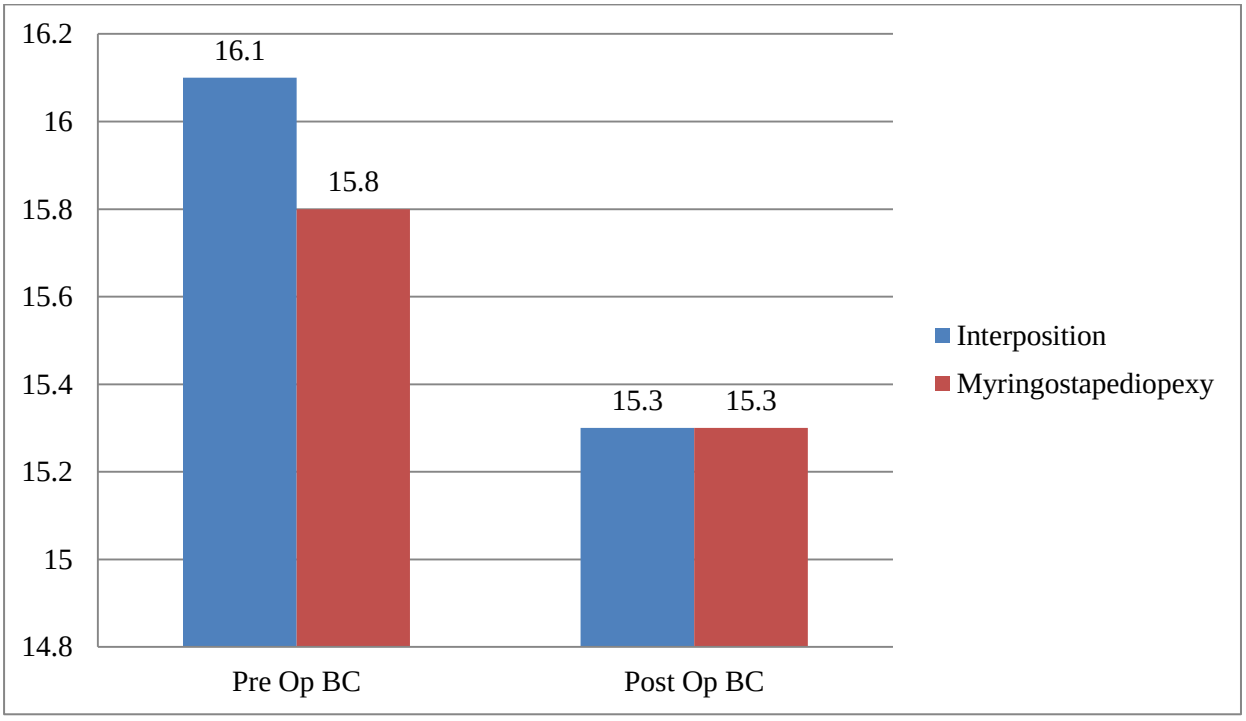
Graph 6: Bar diagram showing Pre Op and Post Op AC distribution and comparison between two study groups

Table 9: Pre Op and Post Op BC distribution and comparison between two study groups

	Group						p value b/w two groups
	Interposition(Group A)			Myringostapediopexy(Group B)			
	Mean	SD	p value with in group	Mean	SD	p value with in group	
PRE OP BC	16.1	4.2		15.8	2.6		0.719
POST OP BC	15.3	3.6	0.023*	15.3	2.2	0.083	1.000

The mean pre-op BC and post-op BC in Group A was 16.1 ± 4.2 dB and 15.3 ± 3.6 dB, respectively which showed a statistically significant decrease of BC.

The mean pre-op BC and post-op BC in Group B was 15.8 ± 2.6 dB and 15.3 ± 2.2 dB, respectively which was not statistically significant.



Graph 7: Bar diagram showing Pre Op and Post Op BC distribution and comparison between two study groups

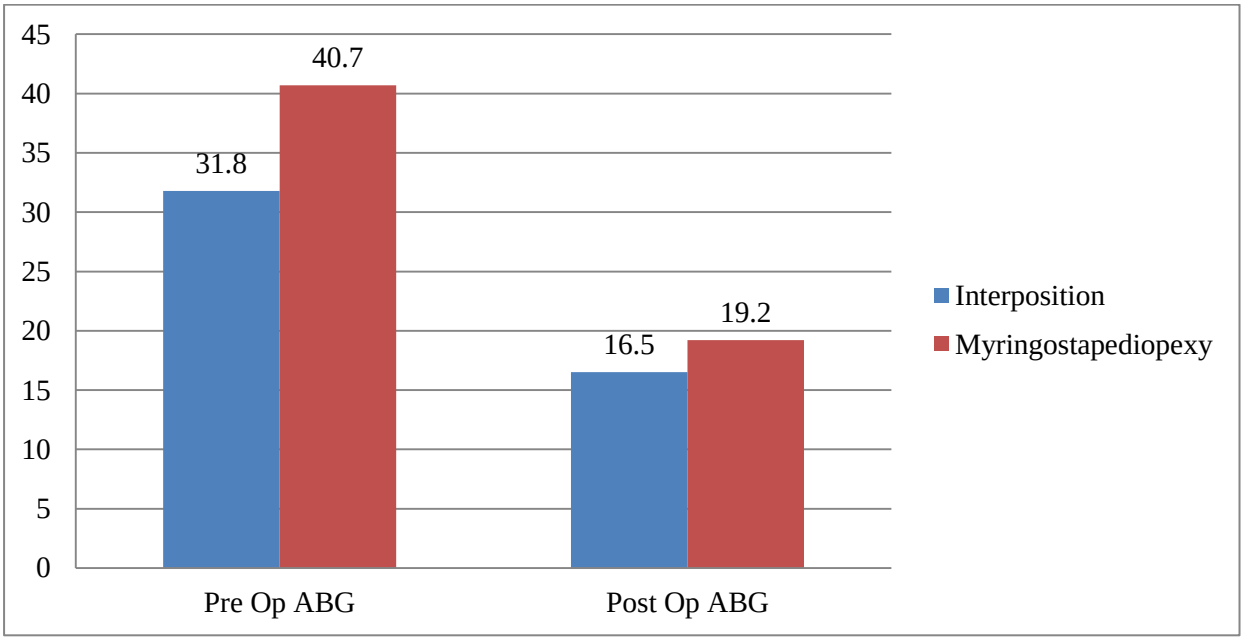
Table 10: Pre Op and Post Op ABG distribution and comparison between two study groups

	Group						P value b/w two groups
	Interposition(Group A)			Myringostapediopexy(Group B)			
	Mean	SD	p value with in group	Mean	SD	p value with in group	
Pre Op ABG	31.8	3.8		40.7	6.9		<0.001*
Post Op ABG	16.5	4.8	<0.001*	19.2	7.6	<0.001*	0.094

There was improvement in post-op ABG in both groups which was statistically significant.

In Group A the mean pre op ABG was 31.8 ± 3.8 dB and the mean post op ABG was 16.5 ± 4.8dB. In Group B, mean pre op ABG was 40.7 ± 6.9dB and mean post op ABG was 19.2 ± 7.6dB.

Average post-op ABG closure of less than 20 dB was seen in 71.87% of subjects in Group A and 59.37% of subjects in Group B.

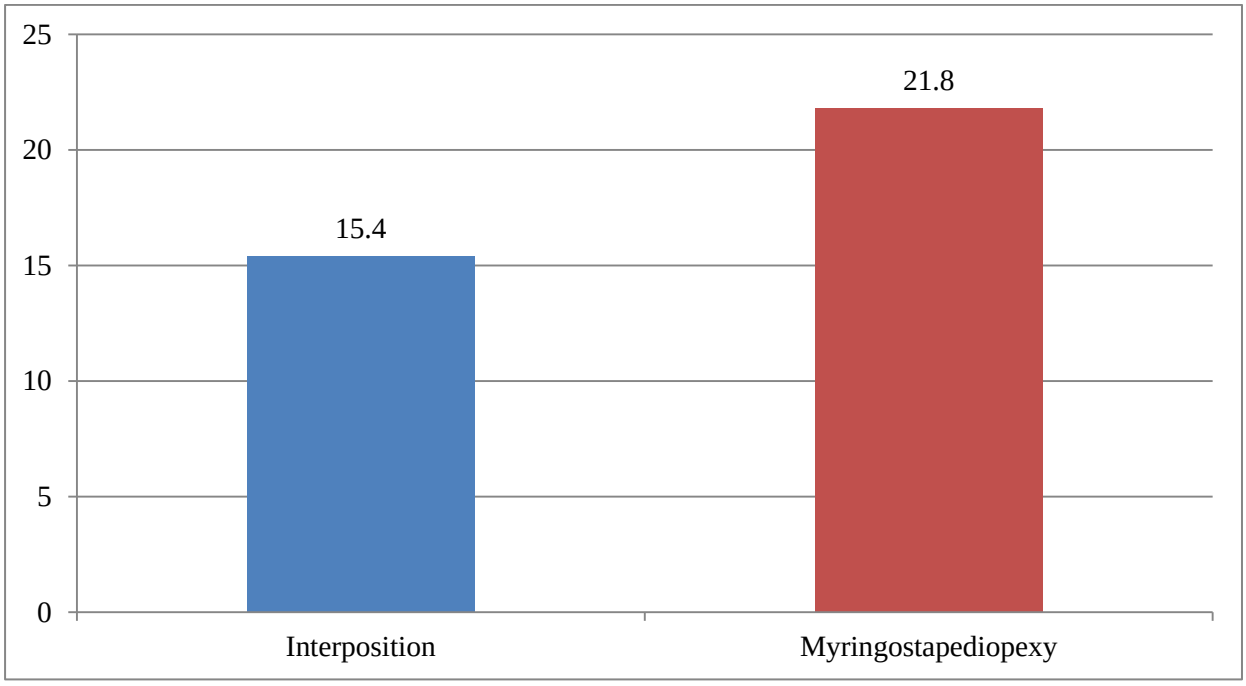


Graph 8: Bar diagram showing Pre Op and Post Op ABG distribution and comparison between two study groups

Table 11: Distribution according to ABG closure and comparison between two study groups

	Group				p value b/w two groups
	Interposition (Group A)		Myringostapediopexy (Group B)		
	Mean	SD	Mean	SD	
Net Improvement	15.4	4.0	21.8	6.4	<0.001*

There was a statistically significant difference between ABG closure of the two groups. Group B had higher ABG closure of 21.8dB compared to ABG closure of Group A i.e 15.4 dB.



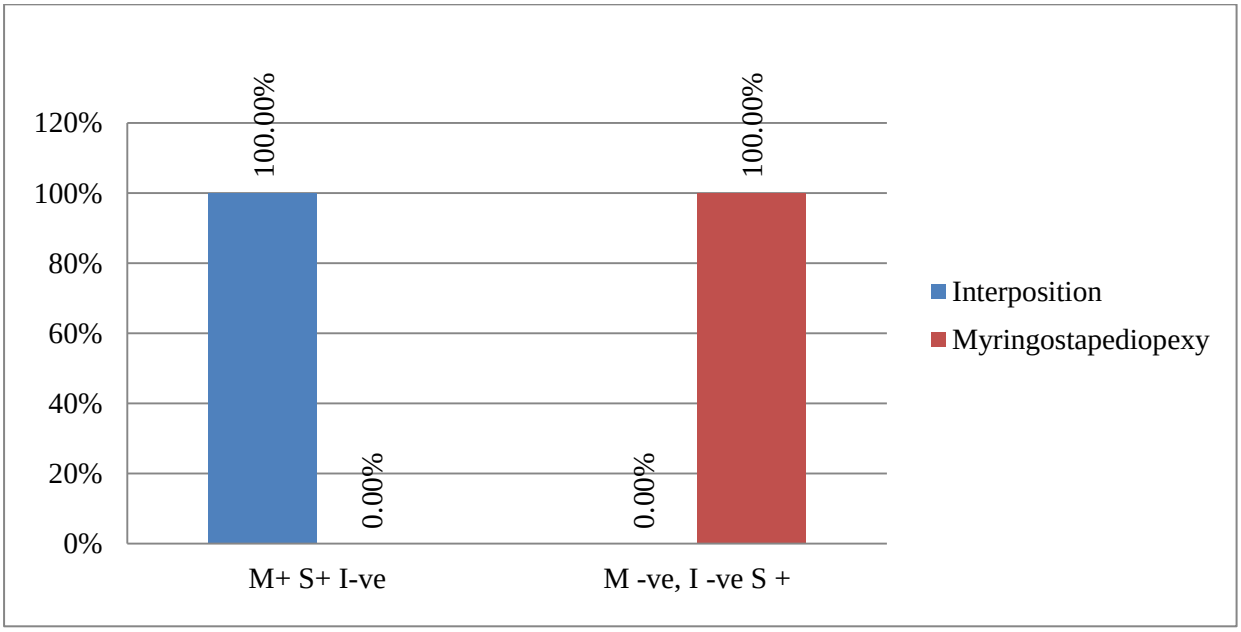
Graph 9: Bar diagram showing distribution according to ABG closure and comparison between two study groups

Table 12: Distribution by Ossicular Status (according To Austin-Kartush Classification) and comparison between two study groups

		Group			
		Interposition (Group A)		Myringostapediopexy (Group B)	
		Number (n =32)	%	Number (n =32)	%
Ossicular Status According To Austin-Kartush Classification	M+ S+ I- (Class A)	32	100.0	0	0.0
	M - I – S. suprastructure + S. Footplate + (Class B)	0	0.0	0	0.0
	M -, I - S + (Class C)	0	0.0	32	100.0
	M – I – S. Suprastructure – S. Footplates + (Class D)	0	0.0	0	0.0

χ 2 = 64, df = 1, p <0.001*

Subjects in Group A belonged to Class A while subjects in Group B belonged to Class C of Austin-Kartush classification.



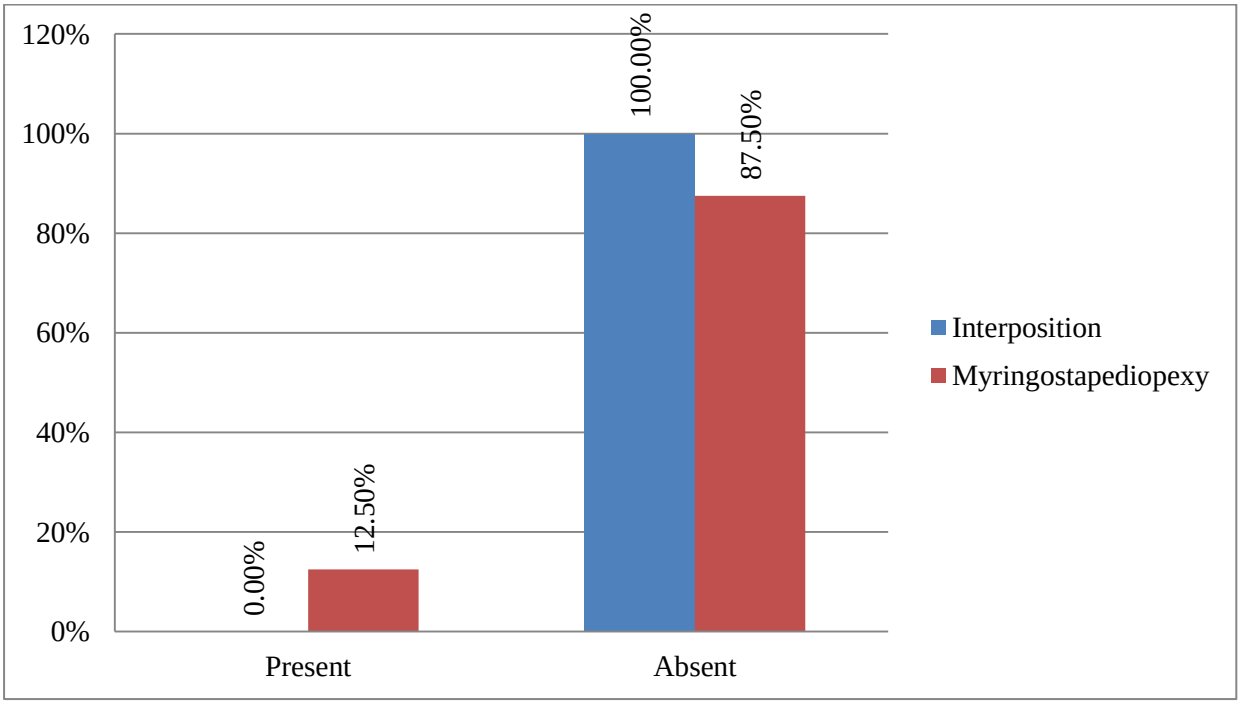
Graph 10: Bar diagram showing distribution by Ossicular Status (according To A-K Classification) and comparison between two study groups

Table 13: Distribution of subjects according to the presence of Cholesteatoma and comparison between two study groups

		Group			
		Interposition (Group A)		Myringostapediopexy (Group B)	
		Number (n=32)	%	Number (n=32)	%
Cholesteatoma	Present	0	0.0	4	12.5
	Absent	32	100.0	28	87.5

$\chi 2 = 4.267$, df = 1, p = 0.039*

In Group A none had Cholesteatoma and in Group B 12.5% subjects had Cholesteatoma which was statistically significant.



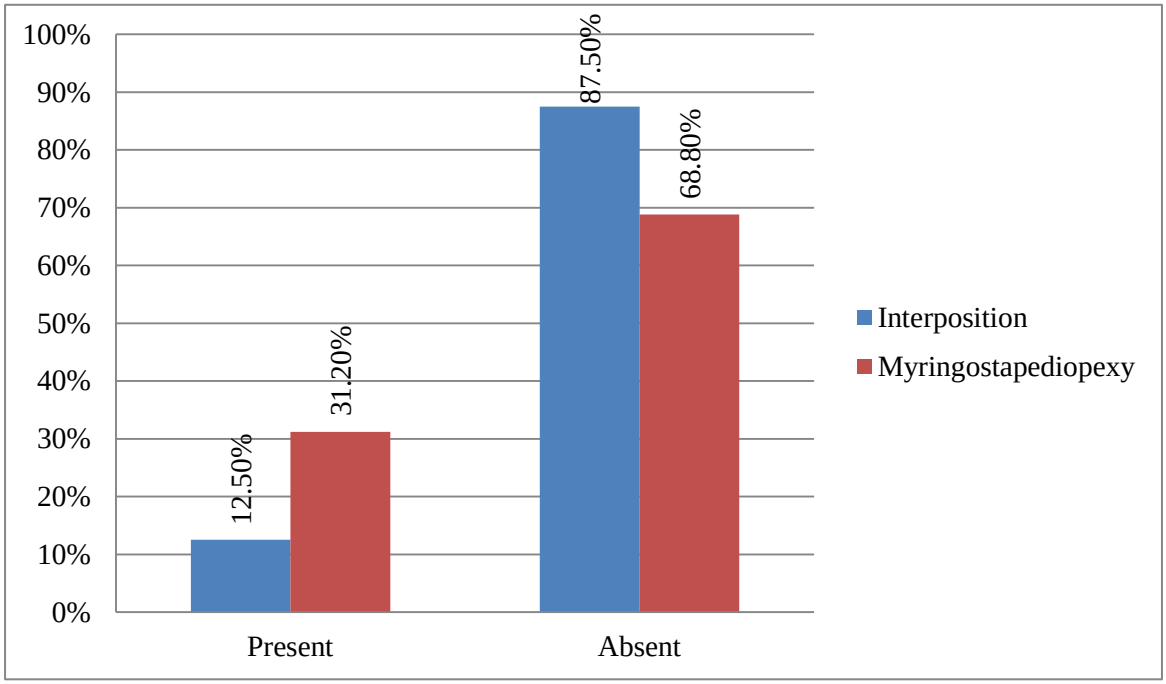
Graph 11: Bar diagram showing Distribution of subjects according to the presence of Cholesteatoma and comparison between two study groups.

Table 14: Distribution according to presence of granulation tissue and comparison between two study groups

		Group			
		Interposition (Group A)		Myringostapediopexy (Group B)	
		Number (n=32)	%	Number (n=32)	%
Granulation Tissue	Present	4	12.5	10	31.2
	Absent	28	87.5	22	68.8

$\chi 2 = 3.291$, df = 1, p = 0.07

In Group A 12.5 % subjects had granulation tissue and in Group B 31.2% had granulation tissue .The difference was not statistically significant between two study groups.



Graph 12: Bar diagram showing distribution according to presence of granulation tissue and comparison between two study groups

Table 15: Distribution according to mastoid findings and comparison between two study groups

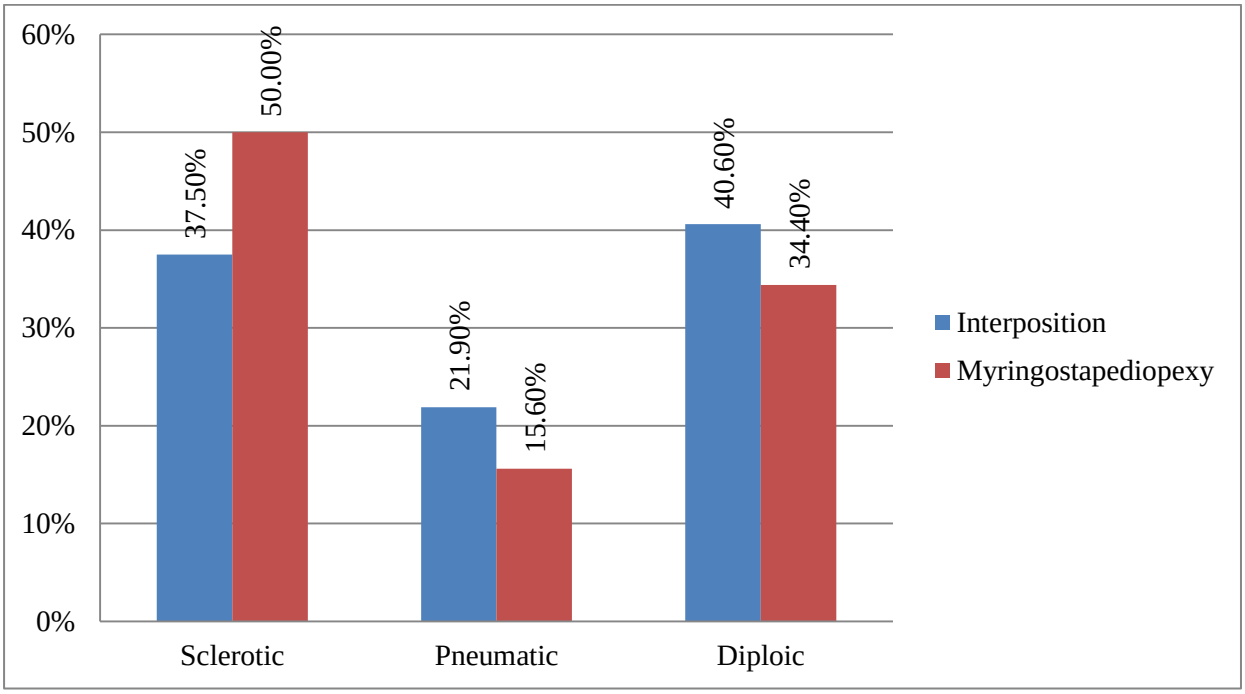
		Group			
		Interposition (Group A)		Myringostapediopexy (Group B)	
		Number (n=32)	%	Number (n=32)	%
Mastoid	Sclerotic	12	37.5	16	50.0
	Pneumatic	7	21.9	5	15.6
	Diploic	13	40.6	11	34.4

$\chi 2 = 1.071$, df = 2, p = 0.585

Lateral oblique X-ray of mastoid showed, sclerotic mastoid in 37.5%, pneumatic in 21.9% and diploic in 40.6% of subjects in Group A.

In Group B, mastoid was sclerotic in 50%, pneumatic in 15.6% and diploic in 34.4% of subjects.

There was no significant difference between two study groups.



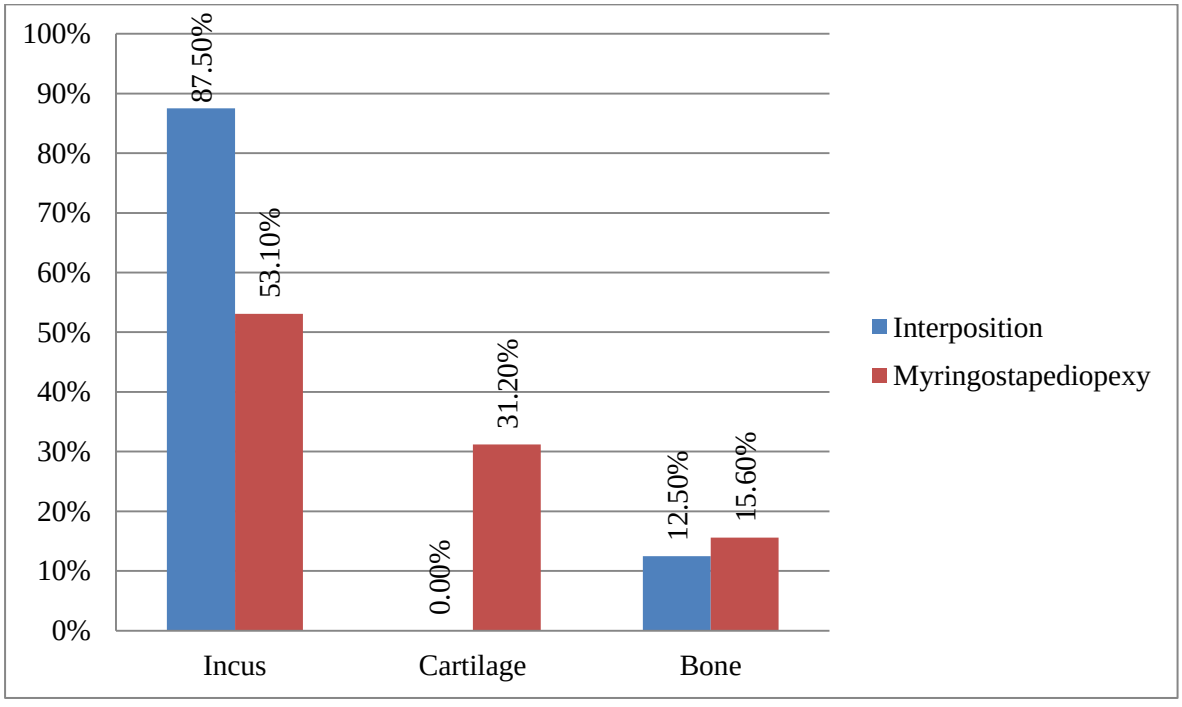
Graph 13: Bar diagram showing distribution according to mastoid findingsand comparison between two study groups

Table 16: Distribution according to material used for ossicular reconstruction and comparison between in two study groups

		Group			
		Interposition		Myringostapediopexy	
		Count	%	Count	%
Material Used	Incus	28	87.5%	17	53.1%
	Cartilage	0	0.0%	10	31.2%
	Bone	4	12.5%	5	15.6%

In Group A Autologous Incus was used for ossicular reconstruction in 28 (87.5%) subjects, and cortical bone was used in 4 (12.5%) subjects.

In Group B autologous incus was used in 17 (53.1%) subjects, tragal cartilage was used in 10 (31.2%) subjects and cortical bone was used in 5 (15.6%) subjects.

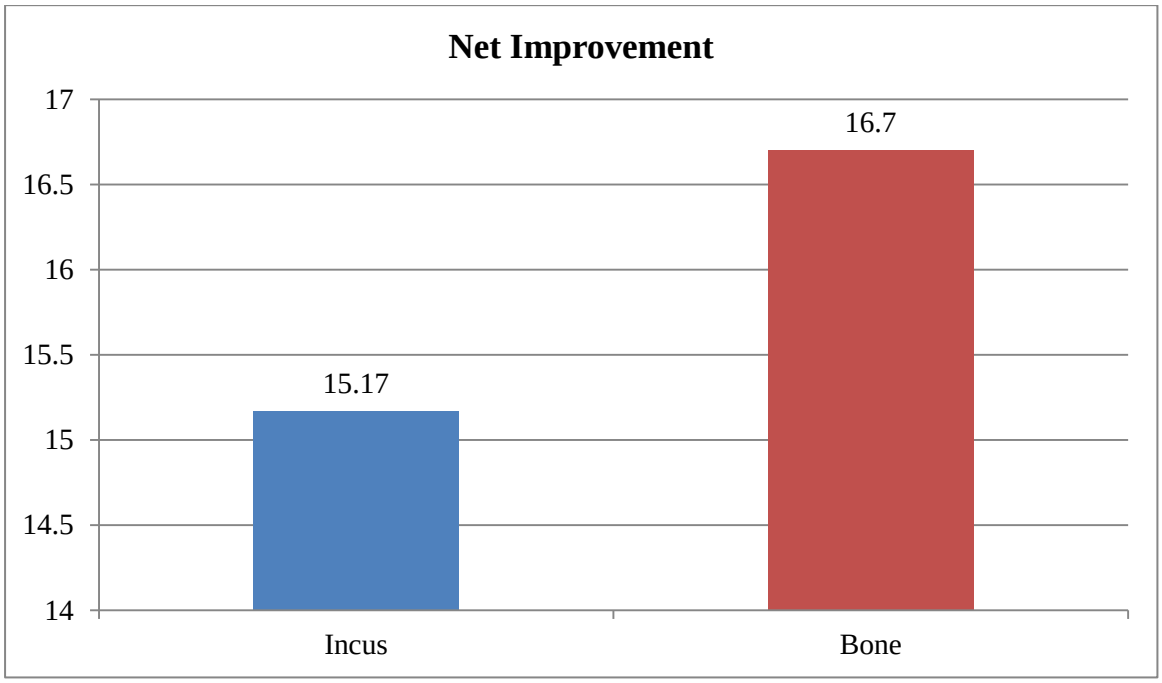


Graph 14: Bar diagram showing distribution according to material used for ossicular reconstruction and comparison between two study groups

Table 17: ABG closure in Interposition group with respect to material used for ossicular reconstruction

		Net Improvement	
		Mean	SD
Material Used	Incus	15.17	4.22
	Bone	16.70	2.40
P value		0.487	

In Interposition group, Mean ABG closure was 15.17 dB when incus was used and the mean ABG closure was 16.70 dB when cortical bone was used. There was no significant difference in ABG closure with respect to material used.

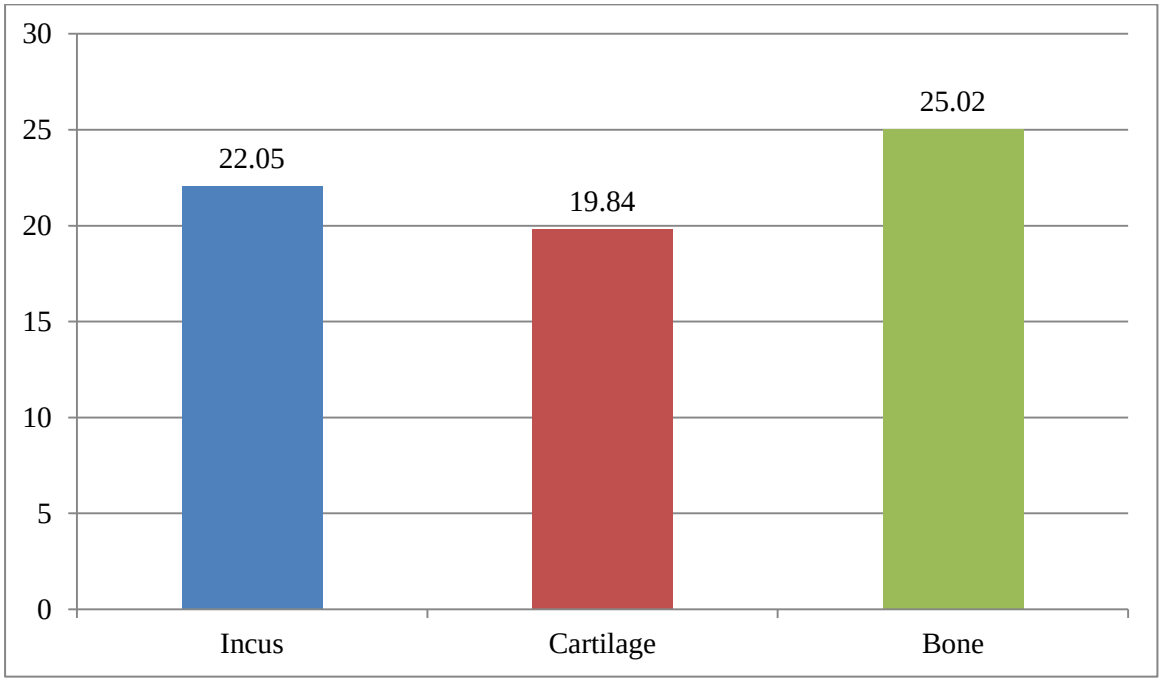


Graph 15: Bar diagram showing ABG closure in Interposition group with respect to material used

Table 18: ABG closure in Myringostapediopexy group with respect to material used for ossicular reconstruction.

		Net Improvement	
		Mean	SD
Material Used	Incus	22.05	6.91
	Cartilage	19.84	5.79
	Bone	25.02	5.64
P value		0.344	

In Myringostapediopexy group, Mean ABG closure was 22.05 dB when incus was used , ABG closure was 19.84 dB when tragal cartilage was used and with cortical bone ABG closure was 25.02 dB. There was no significant difference in ABG closure with respect to material used.



Graph 16: Bar diagram showing ABG closure in Myringostapediopexy group with respect to material used

DISCUSSION

DISCUSSION

Chronic otitis media may lead to partial or complete loss of tympanic membrane and erosion of the ossicular chain. The goal of ossiculoplasty is to restore the hearing to normal or near normal levels.

In this study, 64 patients underwent tympanoplasty with Ossiculoplasty for COM, in which 32 patients in Group A underwent interposition ossiculoplasty and 32 patients in Group B underwent myringostapediopexy .

In our study patients were in the age group of 16 to 67 years. Majority of the patients in both the groups belonged to the age group of 20 to 39 years, followed by 40 to 59 years.

The gender distribution in Group A was males 34% (11), and females 65.6% (21) and in Group B males 40.6% (13) and females 59.4% (19).

In a study conducted by Shrikrishna BH, the highest incidence of COM was noted in the age group of 21 to 30 years followed by the age group of 10 to 20 years [47]. Though majority of the patients in our study were from the same age group a significant number of patients were a decade older.

A Brazilian study on various factors that influence the surgical results of tympanoplasty shows that, age does not affect the success rate of tympanoplasty.[48]

The most common presenting complaint in patients with COM was ear discharge and hearing loss in both the groups. In group A ear discharge and hearing loss were seen in 59.4% patients and in Group B ear discharge and hearing loss were seen in 40.6% patients. Other symptoms included ear ache, tinnitus and itching in the ear.

Similar symptoms were reported in a study done in England where hearing impairment and disability from recurrent ear discharge were found to be the most frequent symptoms of COM.[49]

In the present study, at 3 months following surgery all patients had well healed neo-tympanum with no evidence of retraction.

In a study done in Kolkata, 20 patients underwent interposition ossiculoplasty using autologous incus. Their mean pre-op and post-op AC thresholds were 47.7 dB and 38.05 dB respectively. An average of gain of 9.65 dB was seen in the post-op AC thresholds.[10]

In an Italian study, patients with mean pre-op AC thresholds of 49.9 dB underwent myringostapediopexy using autologous incus or cartilage. On follow –up the mean post-op AC threshold was 36.6 dB and an average gain of 13.3 dB was seen after surgery.[13]

In the present study, the mean pre-op AC thresholds for Group A and Group B were 47.9 dB and 55.9 dB respectively which was statistically significant and higher in Group B. These results were similar to the above mentioned studies. At 3 months follow-up post-op AC threshold showed improvement in both groups which was statistically significant and higher than the above mentioned studies. Mean post-op AC threshold in Group A (32.1 dB) showed a gain of 15.8 dB and the mean post-op AC threshold in Group B (34.5 dB) showed a gain of 21.4 dB.

The mean pre-op BC threshold for Group A and Group B was 16.1 dB and 15.8 dB respectively. Post-operatively it was 15.3 dB for both Group A and Group B.

In our study, the average pre-op Air Bone Gap (ABG) in Group B was higher than Group A and was statistically significant (31.8 dB in Group A and 40.7 dB in Group B). At the end of 3 months of surgery, 100% patients in both groups showed an improvement in

ABG which was statistically significant. The mean improvement in post-op ABG for Group A and Group B was 15.4 dB and 21.8 dB respectively.

A study conducted at the university of Pittsburgh medical centre showed that Interposition ossiculoplasty using autologous graft achieved a post-op ABG of 18.6 dB.[5] In a retrospective study by Iurato S et al, it was concluded that post-op ABG was 12 dB at 12 months follow-up for patients undergoing Interposition ossiculoplasty for Austin-Kartush class A defects with the use of autologous incus.[9] Our study achieved a mean post-op ABG of 16.5 dB in Group A which was similar to the above mentioned studies.

Various studies in literature show, post-op ABG ranging from 15.8 dB to 22.5 dB for patients who underwent myringostapediopexy using autologous grafts with better results shown by Quaranta et al from their series of staged tympanoplasty and ossiculoplasty[11][12][50]. Our study shows similar results with a mean post-op ABG of 19.2 dB for Group B.

The average post-op ABG for Group B was higher than Group A but was not statistically significant.

A study conducted at Belgaum, Karnataka shows an ABG closure of 18.8 dB in patients who underwent interposition ossiculoplasty by using autologous incus.[1]

A retrospective study conducted in Italy revealed an ABG closure of 14.89 dB in patients who underwent myringostapediopexy using autologous incus or cartilage.[13]

Another study comparing myrigostapediopexy and interposition ossiculoplasty conducted in Uttarakhand inferred that ABG closure for myrigostapediopexy and interposition ossiculoplasty was 10.7 dB and 18.0 dB respectively.[14]

In our present study, it was concluded that mean ABG closure for Group A and Group B was 15.4 dB and 21.8 dB respectively. This was comparable to the study conducted at Belgaum when interposition ossiculoplasty was taken into consideration.[1]

The mean ABG closure for Group B was higher than Group A and was statistically significant. This may be due to higher pre-op ABG in Group B as reported in other studies.[9][50]

When patients with similar preoperative hearing loss in either groups of our study were compared hearing gain was marginally better with myringostapediopexy than interposition ossiculoplasty.

In a study done by Cook et al, it was found that presence or absence of cholesteatoma did not have a significant difference in the outcome of hearing after ossicular reconstruction.[12]

Similarly in our study, cholesteatoma was present in 12.5% cases of Group B and none in Group A .This was statistically significant but did not affect the hearing outcome.

A review article from Belgaum, Karnataka on ossiculoplasty documented incus as the most common autologous material used for ossiculoplasty[45] which was similar to our study where 87.5% (28) patients in Group A and 53.1% (17) patients in Group B underwent ossiculoplasty using sculptured autologous incus.

A study done in Finland reported higher improvement in post-op ABG with cortical bone (13.9 dB) when compared to incus (7.2 dB) [51]. Other studies reported no significant difference in hearing results when incus or cortical bone grafts was used for ossiculoplasty[52][53].

In our study, the mean ABG closure for the patients who underwent interposition ossiculoplasty using autologous incus was 15.17 dB and the ABG closure with cortical bone graft was 16.70 dB.

In myringostapediopexy Group the mean ABG closure was 22.05 dB when autologous incus was used, 19.84 dB with tragal cartilage and 25.02 dB with cortical bone graft.

Improvement in post-op ABG was better with cortical bone graft in both the groups but was not statistically significant.

CONCLUSION

CONCLUSION

COM constitutes a large proportion of patients presenting to the ENT OPD with ear discharge and hearing impairment. The aim of management in such cases is to provide a safe and dry ear with restoration of hearing.

The conclusions drawn from our study are:

- Ossicular reconstruction by interposition ossiculoplasty and myringostapediopexy using autologous grafts provide significant hearing improvement in patients with COM.
- Improvement in hearing is better in patients with higher preoperative hearing loss when compared to patients with lesser preoperative hearing loss.
- Myringostapediopexy provides marginally better hearing gain compared to interposition ossiculoplasty. However the marginal gain was not statistically significant in this study.
- Both incus and cortical bone grafts are suitable autologous materials for ossiculoplasty and hearing improvement is similar when either of them is used for interposition ossiculoplasty and myringostapediopexy. However in practice incus is more frequently used as it is readily available in the surgical field and does not involve harvesting an additional graft.

The technique of ossiculoplasty should be mastered by health care providers in all tertiary institutions so that a common condition like COM can be treated with improvement in hearing and quality of life of the patient.

SUMMARY

SUMMARY

Middle ear surgeries for chronic ear disease have been in debate since years which can give reliable hearing results.

Interposition ossiculoplasty or myringostapideopexy are one among the techniques for ossicular chain reconstruction in chronic otitis media.

Our present study was an observational study which was done in RLJH Tamaka Kolar which included 32 subjects each in Group A and Group B of interposition ossiculoplasty and myringostapediopexy respectively after following inclusion and exclusion criteria and appropriate indication for surgery.

Our objectives were:

1) To determine the hearing results and the long-term stability of sculptured autologous incus, cartilage or bone in interposition ossiculoplasty and myringostapediopexy in intact canal wall tympanoplasty with or without cortical mastoidectomy.

The main indication for surgery was chronic otitis media with ossicular chain erosion.

Majority of the subjects in both the groups belonged to age group of 20-39 years and female and male had no statistical significant distribution in the both the groups.

Mostly the subjects presenting in our health care centre came with the complaints of ear discharge with loss of hearing with right ear being more involved than left ear in both the groups, but the results were not statistically significant.

When the parameters like various pathology of the tympanic membrane findings were taken into account we found that the most common type of pathology was subtotal perforation in both the groups which was not significant.

Preoperatively, all subjects underwent pure tone audiometry and pre-op AC, BC and ABG values were noted. The same was done 3 months after surgery to get post-op AC, BC and ABG values. The same values were then compared. ABG closure was calculated as the difference between the pre-op and post-op ABG.

It was concluded that the mean pre-op AC of subjects undergoing myringostapediopexy was found to be higher than those undergoing interposition ossiculoplasty, which was statistically significant. It was also found that there was an equivalent gain in the mean post-op AC in both the groups.

When pre-op and post-op ABG were compared, there was a significant difference in the post-op ABG which was shown as improvement in ABG in both the groups.

We found that the ABG closure was significantly higher in Group B than Group A, which was due to higher pre-op ABG in Group B than Group A.

When patients with similar preoperative hearing loss in either groups of our study were compared hearing gain was marginally better with myringostapediopexy than interposition ossiculoplasty.

When subjects were compared taking into account the presence of cholesteatoma ,it was found that 12.5% subjects in Group B had cholesteatoma which was statistically significant with no cases in Group A. Presence of choleateatoma did not affect hearing outcome.

The presence of granulation tissue was compared between Group A and B and was found not to be statistically significant.

We took a lateral oblique X- ray of mastoid which showed were either sclerotic , pneumatic or diploic pattern in both the groups.

In our present study autologous incus, tragal cartilage and cortical bone were used for the ossicular reconstruction in which incus was used most commonly in both the groups. Sculptured autologous incus and cortical bone grafts provided equally good outcome of hearing in both interposition ossiculoplasty and myringostapediopexy.

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BIBLIOGRAPHY

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ANNEXURES

SRI DEVARAJ URS MEDICAL COLLEGE
INTERPOSITION AND MYRINGOSTAPEDIOPEXY
OSSICULOPLASTY
PROFORMA

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-

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

Sensation of imbalance/ rotation of self/surroundings: 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

MASTOID TENDERNESS

PINNA

TRAGUS SIGN

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

FISTULA TEST

VESTIBULAR FUNCTION TEST

FACIAL NERVE EXAMINATION

NOSE AND PARANASAL SINUSES

ORAL CAVITY AND OROPHARYNX:
SYSTEMIC EXAMINATION:

INVESTIGATIONS:

X RAY MASTOID:

PRE-OPERATIVE PTA FINDINGS
AIR CONDUCTION THRESHOLD

BONE CONDUCTION THRESHOLD

AIR-BONE GAP

DIAGNOSIS:

OPERATIVE PROCEDURE:

Intact canal wall tympanoplasty with or without mastoidectomy with interposition/myringostapediopexy ossiculoplasty.

INTRAOPERATIVE FINDINGS:

POST OPERATIVE FOLLOW UP

TUNING FORK TESTS **RIGHT**
LEFT

RINNES TEST:
- 128 HZ
- 512 HZ
- 1028 HZ

WEBERS TEST
ABC TEST

PTA FINDINGS

AIR CONDUCTION THRESHOLD

BONE CONDUCTION THRESHOLD

AIR-BONE GAP

INFORMED CONSENT

I have read this consent form/have been read to me and I understand the purpose of this study, the procedures that will be used, the risks and benefits associated with my involvement in the study and the confidential nature of the information that will be collected and disclosed during the study.

I understand that I remain free to withdraw from the study at anytime and this will not change my future care.

I have had the opportunity to ask questions regarding various aspects of the study and my questions have been answered to my satisfaction.

I, the undersigned agree to participate in this study and authorize the collection and disclosure of my personal information as outlined in this consent form.

SUBJECT/GUARDIAN'S NAME AND SIGNATURE/THUMB IMPRESSION:

DATE:

PATIENT INFORMATION SHEET

Study title: Comparison of hearing results in interposition versus myringostapediopexy ossiculoplasties.

Study location: R.L Jalappa Hospital and Research Centre attached to Sri Devaraj Urs Medical College, Tamaka, Kolar.

Aim: To compare the hearing improvement after interposition and myringostapediopexy ossiculoplasties.

Details

Patients presenting with hearing loss due to chronic otitis media and ossicular chain disruption will be taken up for tympanoplasty and ossicular chain reconstruction.

Ossicular chain repair will be done using autologous incus or cartilage and the patients will be grouped depending upon those undergoing interposition or myringostapediopexy ossiculoplasty. Post operative hearing improvement of the two groups will be compared.

A detailed clinical history and ENT examination will be done. Clinical and audiological assessment will be done preoperatively to report the type and extent of hearing loss along with routine blood investigations. Clinical and audiological assessment for improvement in hearing will be done on the follow up visit after 3 months of surgery.

Please read the following information and discuss with your family members. You can ask any questions regarding the study. If you agree to participate in the study we will collect information (as per proforma) from you or a person responsible for you or both. This information collected will be used only for dissertation and publication.

All the information collected from you will be kept confidential and will not be disclosed to any outsider. Your identity will not be revealed. This study has been reviewed by Institutional Ethics Committee and you are free to contact the members of Institutional Ethics Committee. There is no compulsion to agree to this study. The care you will get will not change if you don't wish to participate. You are required to sign/ provide thumb impression only if you voluntarily agree to participate in this study.

For further information contact

Dr. Shashank Chaudhary (post graduate)

Department of otorhinolaryngology and head and neck surgery

SDUMC, Kolar

KEY TO MASTER CHART

AGE

< 20 YEARS – 0

20-39 YEARS -1

40- 59 YEARS – 2

> / = 60 YEARS - 3

SEX

MALE -0

FEMALE -1

SIDE OF EAR INVOLVED-

RIGHT -0

LEFT-1

PRESENTING COMPLAINTS-

EAR DISCHARGE-0

LOSS OF HEARING-1

EARACHE-2

TINNITUS-3

ITCHING-4

EAR DISCHARGE + LOSS OF HEARING -5

EAR DISCHARGE + EARACHE -6

LOSS OF HEARING+ EARACHE -7

LOSS OF HEARING + TINNITUS -8

PRE – OPERATIVE PTA-

AC:

BC:

ABG:

TYMPANIC MEMBRANE PATHOLOGY-

CENTRAL PERFORATION - 0

SUBTOTAL PERFORATION – 1

MARGINAL PERFORATION - 2

ATTIC RETRACTION WITH PERFORATION – 3

POSTERIO-SUPERIOR RETRACTION – 4

TOTAL PERFORATION - 5

OSSICULAR STATUS ACCORDING TO AUSTINE KARTUSH CLASSIFICATION -

M+ /S+ / I - (Class A) - 0

M+ / S FOOTPLATES +/ I - / S. SUPRASTRUCTURE - (Class B) -1

M-/ I - / S + (Class C) -2

M- / I - / S. SUPRASTRUCTURE - /S. FOOTPLATE + (Class D) -3

CHOLESTEATAOMA-

PRESENT-0

ABSENT-1

GRANULATION TISSUE-

PRESENT-0

ABSENT-1

MASTOID-

SCLEROTIC-0

PNEUMATIC-1

DIPLOIC-2

OSSICULOPLASTY-

INTERPOSITION-0

MYRINGOSTAPEDIOPEXY-1

MATERIALS USED FOR OSSICULAR RECONSTRUCTION-

INCUS-0

CARTILAGE-1

BONE-2

POST OPERATIVE PTA-

AC:

BC:

ABG:

ABG CLOSURE-

SERIAL NUMBER	AGE	SEX	PRESENTING COMPLAINTS	SIDE OF EAR INVOLVED	PRE OP AC	PRE OP BC	PRE OP ABG	PATHOLOGY TYMPANIC MEMBRANE	OSSICULAR STATUS ACCORDING TO A-K CLASSIFICATION	CHOLESTEATOMA	GRANULATION TISSUE	MASTOID	OSSICULOPLASTY	MATERIAL USED FOR OSSICULAR RECONSTRUCTION	POST OP AC	POST OP BC	OST OP ABG	ABG CLOSURE
1	0	0	0	0	46.6	15	31.6	0	0	1	0	0	0	0	28.3	15	13.3	18.3
2	0	0	0	0	43.3	20	23.3	0	0	1	0	0	0	0	31.6	20	11.6	11.7
3	0	0	1	0	45	15	30	0	0	1	0	0	0	0	31.6	15	16.6	13.4
4	1	0	1	0	48.3	20	28.3	0	0	1	0	0	0	0	38.3	15	23.3	5
5	1	0	2	0	53.3	25	28.3	0	0	1	1	0	0	2	35	20	15	13.3
6	1	0	4	0	46.6	20	26.6	0	0	1	1	0	0	0	33.3	15	18.3	8.3
7	1	0	5	0	55	20	35	0	0	1	1	0	0	0	43.3	20	23.3	11.7
8	1	0	5	0	46.6	15	31.6	0	0	1	1	0	0	0	26.6	15	11.6	20
9	1	0	5	0	41.6	10	31.6	0	0	1	1	0	0	0	23.3	10	13.3	18.3
10	1	0	5	0	46.6	10	36.6	0	0	1	1	0	0	0	26.6	10	16.6	20
11	1	0	5	0	50	15	35	3	0	1	1	0	0	0	33.3	15	18.3	16.7
12	1	1	5	0	50	20	30	1	0	1	1	0	0	0	35	20	15	15
13	1	1	5	0	58.3	20	38.3	4	0	1	1	1	0	0	45	20	25	13.3
14	1	1	5	0	55	20	35	1	0	1	1	1	0	2	36.6	20	16.6	18.4
15	1	1	5	0	48.3	15	33.3	1	0	1	1	1	0	0	30	15	15	18.3
16	1	1	5	0	43.3	10	33.3	1	0	1	1	1	0	0	26.6	10	16.6	16.7
17	1	1	5	0	46.6	10	36.6	4	0	1	1	1	0	0	28.3	10	18.3	18.3
18	1	1	5	0	58.3	20	38.3	1	0	1	1	1	0	0	40	15	25	13.3
19	1	1	6	0	38.3	15	23.3	1	0	1	1	1	0	0	21.6	15	6.6	16.7
20	1	1	6	0	48.3	15	33.3	1	0	1	1	2	0	0	30	15	15	18.3
21	1	1	6	1	51.6	20	31.6	4	0	1	1	2	0	0	45	20	25	6.6
22	1	1	7	1	46.6	15	31.6	1	0	1	1	2	0	0	28.3	15	13.3	18.3
23	1	1	7	1	45	10	35	1	0	1	1	2	0	2	36.6	10	16.6	18.4
24	1	1	7	1	41.6	10	31.6	0	0	1	1	2	0	0	21.6	10	11.6	20
25	1	1	5	1	43.3	15	28.3	1	0	1	1	2	0	0	30	15	15	13.3
26	1	1	5	1	53.3	20	33.3	1	0	1	1	2	0	0	40	15	25	8.3
27	2	1	5	1	41.6	15	26.6	0	0	1	1	2	0	0	26.6	15	11.6	15
28	2	1	5	1	45	15	30	1	0	1	1	2	0	2	28.3	15	13.3	16.7
29	2	1	5	1	53.3	20	33.3	1	0	1	1	2	0	0	35	20	15	18.3
30	2	1	8	1	40	10	30	0	0	1	1	2	0	0	23.3	10	13.3	16.6
31	2	1	8	1	56.6	20	36.6	1	0	1	1	2	0	0	41.6	20	21.6	15
32	3	1	8	1	46.6	15	31.6	0	0	1	1	2	0	0	26.6	15	11.6	20
33	0	0	0	0	53.3	15	38.3	0	2	1	0	0	1	0	28.3	15	13.3	25
34	1	0	0	0	65	20	45	0	2	1	0	0	1	0	33.3	20	13.3	31.7
35	1	0	1	0	46.6	15	31.6	1	2	1	0	0	1	0	26.6	15	11.6	20
36	1	0	1	0	53.3	15	38.3	0	2	1	0	0	1	2	31.6	15	16.6	21.7
37	1	0	2	0	51.6	15	36.6	0	2	1	0	0	1	0	38.3	15	23.3	13.3
38	1	0	3	0	45	15	30	4	2	1	0	0	1	0	31.6	15	16.6	13.4
39	1	0	5	0	66.6	15	51.6	3	2	1	0	0	1	2	38.3	15	23.3	28.3
40	1	0	5	0	56.6	15	41.6	1	2	1	0	0	1	0	25	15	10	31.6
41	1	0	5	0	48.3	15	33.3	1	2	1	0	0	1	0	33.3	15	18.3	15

42	1	0	5	0	53.3	20	33.3	4	2	1	0	0	1	1	36.6	20	16.6	16.7
43	1	0	5	0	63.3	15	48.3	1	2	1	1	0	1	0	46.6	15	31.6	16.7
44	1	0	5	0	63.3	15	48.3	1	2	1	1	0	1	1	33.3	15	18.3	30
45	1	0	6	0	50	15	45	1	2	1	1	0	1	2	31.6	15	16.6	28.4
46	1	1	6	0	68.3	20	48.3	4	2	0	1	0	1	1	48.3	15	33.3	15
47	1	1	6	0	50	15	45	2	2	1	1	0	1	1	38.3	15	23.3	21.7
48	1	1	6	0	46.6	15	31.6	1	2	0	1	0	1	1	23.3	15	8.3	23.3
49	1	1	7	0	65	15	50	1	2	1	1	1	1	0	33.3	15	18.3	31.7
50	2	1	7	0	56.6	10	46.6	0	2	1	1	1	1	1	35	10	35	21.6
51	2	1	7	1	46.6	15	31.6	1	2	1	1	1	1	0	26.6	15	11.6	20
52	2	1	7	1	43.3	15	28.3	1	2	1	1	1	1	1	28.3	15	13.3	15
53	2	1	8	1	51.6	10	41.6	1	2	1	1	1	1	0	23.3	10	13.3	28.3
54	2	1	5	1	58.3	15	43.3	0	2	1	1	2	1	1	41.6	15	26.6	16.7
55	2	1	5	1	55	15	40	0	2	1	1	2	1	1	43.3	15	28.3	11.7
56	2	1	5	1	41.6	15	26.6	0	2	1	1	2	1	0	21.6	15	6.6	20
57	2	1	8	1	63.3	20	43.3	3	2	1	1	2	1	2	46.6	20	26.6	16.7
58	2	1	8	1	51.6	15	36.6	4	2	1	1	2	1	0	33.3	15	18.3	18
59	2	1	5	1	60	15	45	0	2	0	1	2	1	0	46.6	15	21.6	23.4
60	2	1	5	1	65	20	45	1	2	1	1	2	1	0	30	15	15	30
61	3	1	6	1	63.3	15	48.3	1	2	1	1	2	1	0	38.3	15	23.3	25
62	3	1	6	1	56.6	15	41.6	1	2	1	1	2	1	2	26.6	15	11.6	30
63	3	1	7	1	65	20	45	1	2	0	1	2	1	0	48.3	15	33.3	11.7
64	3	1	7	1	63.3	20	43.3	1	2	1	1	2	1	1	36.6	20	16.6	26.7