HEARING BENEFIT IN MIDDLE EAR RECONSTRUCTIVE SURGERY : A COMPARATIVE STUDY OF THE CURRENT METHODS

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CERTIFICATE

This is to certify that the dissertation titled **"HEARING BENEFIT IN MIDDLE EAR RECONSTRUCTIVE SURGERY : A COMPARATIVE STUDY OF THE CURRENT METHODS"** is the bonafide research work done by **Dr. S. HASAN ABDUL CADER** under my guidance supervision, and to my satisfaction during the period 2005-2007 and submitted to The Tamil Nadu Dr.M. G. R. Medical University towards the partial fulfillment for the degree of Master of Surgery in the subject Otorhinolaryngology.

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CONTENTS

INTRODUCTION

Discharging ear and deafness are perpetual source of misery to humankind. Chronic suppurative otitis media is found to be the single major cause of conductive deafness manifesting in 66.3% of cases. The other causes being trauma, otosclerosis, congenital malformations, neoplastic causes etc. Auditory sensation is one of the vital sensations for existence. Deafness upsets the tranquility of life. When such a great vital sensation is lost, life naturally loses its charm.

In last 50 years, various researches have been carried out for repair of ossicular chain defects alone or those associated with tympanic membrane perforations. A number of materials have been used with varying results. Right from Hall and Rytzer of 1957 till today, several pioneers have revolutionized the outlook of ossiculoplasty.

Several materials have been used for ossiculoplasty. Some of the materials are autograft/homograft ossicles, autograft/homograft cartilage, teflon, hydroxyapatite, titanium, gold, bioglass etc.

The goal of otologists performing middle ear surgery to correct conductive hearing loss is to improve hearing as well as to provide a functional benefit to the patient. Unilateral conductive hearing loss is associated with various disabilities including difficulty in sound localization and in hearing and understanding speech.

Traditionally, otologists have reported the results of middle ear surgery as the closure of the air - bone gap or the reduction in air conduction thresholds. The closure of the air-bone gap refers to improvement of the air conduction thresholds (involving conductive and sensorineural components) to the level of the bone conduction thresholds (sensorineural component). While these provide a measure of the technical success of the operation, they may not always translate into real life benefit for the patient. Hence standardization of results of treatment should be by a method based on subjective perception which benefits patients in real life.

Other methods have been used to evaluate the effectiveness of middle ear surgery including questionnaires that evaluate a patient's subjective benefit from surgery. Using questionnaires to evaluate benefit is complicated by the fact that both surgeons and patients want to believe that the operation has succeeded. The two most common methods found in the otologic literature to evaluate benefit from middle ear surgery are the Belfast 15/30 dB rule of thumb and the Glasgow benefit plot. These methods facilitates the assessment of subjective benefit as well as objective achievement, we have employed these two most common methods to estimate patient benefit from middle ear surgery in our study.

AIMS AND OBJECTIVES

(1) To compare two methods of predicting the level of hearing benefit following middle ear surgery, namely Glasgow benefit plot and Belfast 15/30 dB rule of Thumb.

(2) To correlate hearing benefit as measured by using the above methods with patients' self assessment of his/her hearing status

(3) To analyze the differences in hearing improvement by various ossiculoplasties like incus interposition, tragal/ conchal cartilage and autograft malleus.

(4) To compare the success rates with surgery on dry and wet ears.

(5) To compare success rates with cavity mastoidectomy cases versus those without cavity.

HISTORICAL REVIEW

- Moritz (1950) used pedicled flaps to reconstruct middle ear cavity in chronic suppurative otitis media cases to provide sound shielding
- Hall & Rytzer performed the first ossicular chain reconstruction using autologous ossicular bone in 1957.
- Irradiated homograft ossicles and cartilage were first introduced in 1960s.
- Utech (1960) introduced sculptured auricular cartilage autografts for tympanic membrane - stapes head and tympanic membrane - footplate interposition.
- Jansen (1963) introduced autologous tragal cartilage and autologous nasal septal cartilage grafts.
- Marquet (1969) and Jako (1972) employed stainless steel microscrews and wire to aid in stabilizing ossicular bone assemblies and tympano ossicular allografts.
- Wehrs (1974) introduced the notched incus autograft or allograft technique.
- Janeke and Shea (1975) first used proplast I (prepared by combination of polytetra fluoro ethylene.
- Shea (1976) successful used plastipore (porous polyethylene) for the first time as a TORP.

ANATOMY

EMBRYOLOGY

The middle ear cleft develops from the endoderm of the tubo tympanic recess. The Malleus and Incus are derived from the dorsal end of Meckels' cartilage. The stapes is formed from the dorsal end of Reichert's cartilage. The footplate of stapes is formed primarily from the otic capsule. The ossicles of the ear fully ossify in the fourth month of intrauterine life. Opposition of the tubotympanic recess and the first ectodermal cleft forms the tympanic membrane. The tensor tympani is derived from the mesoderm of the first pharyngeal arch and the stapedius muscle from that of the second arch.

The Middle Ear Cleft

The middle ear cleft consists of the tympanic cavity (tympanum), the eustachian tube and the Mastoid air cell system.

The middle ear cavity is an irregular, air filled space within the temporal bone. It can be divided into mesotympanum, epitympanum or attic and hypotympanum.

The Contents of the middle ear cavity are :

1. Three bones - Malleus, Incus and Stapes.
2. Two Muscles - Tensor tympani and stapedius.
3. Nerves - Chorda tympani, tympanic plexus of nerves.
4. Air

The Malleus

The Malleus is the largest of the three ossicles. It comprises a head, neck and processes arising from below the neck. The head lies in attic and it has an elongated saddle shaped facet on its posteromedial surface for articulation with the incus. The handle (manubrium) runs downwards, medially and slightly backwards between the mucosal and fibrous layers of the tympanic membrane. The lateral process receives the anterior and posterior malleolar folds from the tympanic annulus.

The Incus

The incus is anvil shaped and it articulates with the malleus. It has a body, a short process and a long process. The body lies in attic and it has a facet for articulation with that of the malleus. The short process lies in fossa incudis. The long process descends behind and medial to handle of malleus and at its tip, a lenticular process is present which articulates with capitulum on head of stapes.

The stapes

The stapes consists of a head, neck, two crura and a base or foot plate. The head articulates with lenticular process of incus. The stapedius tendon inserts into neck of stapes. The footplate has a convex superior margin and an almost straight inferior margin. The footplate lies in the fenestra vestibuli where it is attached by annular ligament.

PHYSIOLOGY

MECHANISM OF HEARING

A sound signal in the environment is collected by the pinna, passes through external auditory canal and strikes the tympanic membrane. Vibrations of the tympanic membrane are transmitted to stapes footplate through a chain of ossicles coupled to the tympanic membrane. Movements of stapes footplate cause pressure changes in the labyrinthine fluids that move the basilar membrane. This stimulates the hair cells of the organ of corti. It is these hair cells, which act as transducers and convert the mechanical energy into electrical impulses that travel along the auditory nerve.

Theories of Hearing

1. Von Helmholtz Resonance Place Theory
2. Rutherford's Telephone Theory
3. Von Bekesy's Travelling Wave Theory.

Von Helmholtz Resonance Place Theory

He proposed that the basilar membrane was constructed of segments that resonated in response to different frequencies, and that these segments were arranged according to location along the length of

the basilar membrane. According to this, high frequencies are perceived at the base and lower frequencies at the apex.

Rutherford's Telephone Theory

He claimed that the entire cochlea responds as a whole to all frequencies instead of being activated on a place-by-place basis. Here, all aspects of the stimulus waveform would be transmitted to the auditory nerve (like a telephone receiver connected to the telephone wire), and then the frequency analysis is accomplished at higher levels in the auditory system.

Von Bekesy's Travelling Wave Theory

Bekesy found that the basilar membrane is not under any tension, but that its elasticity is essentially uniform. Because the basilar membrane gets wider starting from the top to the apex, the result is a gradation of stiffness along its length, going from stiffest at the base (near the stapes) to least stiff at the apex (near the helicotrema). As a result of this stiffness gradient, sounds transmitted to the cochlea develop a special kind of wave pattern on the basilar membrane that always travels from the base up toward the apex, called the travelling wave.

The normal human middle ear couples sound from the low impedance sound energy in the ear canal through the tympanic membrane

and ossicles to the relatively high impedance of fluid within the cochlea. Recent investigations of human middle ear mechanics indicate that traditional teaching of middle ear mechanisms should be modified. To provide a more comprehensive description, both traditional and recent discussions of the physiology of middle ear sound transmission are briefly discussed in this section.

Traditional teaching states that the acoustic transformer system of the middle ear is divided into 3 systems: the catenary lever (due to the tympanic membrane), the ossicular lever (due to ossicular action), and the hydraulic lever (due to the difference in area between the tympanic membrane and the stapes footplate).

Catenary Lever

The attachment of the tympanic membrane at the annulus amplifies the energy at the malleus because of the elastic properties of the stretched drumhead fibers. Because the annular bone surrounding the tympanic membrane is immobile, sound energy is directed away from the edges of the drum towards the centre of the drum. The malleus receives the redirected sound energy from the edge of the drum because of the central location of the manubrium. The catenary lever provides at least a 2-fold gain in sound pressure at the malleus.

Ossicular Lever

The ossicular lever is based on the concept that the malleus and incus act as a unit. The malleus and incus rotate around an axis running between the anterior malleolar ligament and the incudal ligament. The ossicular lever is the length of the manubrium of the malleus divided by the length of the long process of the incus (approximately 1.3:1). Since the malleus and tympanic membrane act as coupled system, some authors believe that the ossicular lever value of 1.3:1 should be reduced to 1.15:1. The reduction can be supported because of the different areas of curvature of the drum and how this affects the lever ratio. Together, the ossicular and catenary levers provide a sound pressure advantage of 2.3:1, which is more than twice that of the ossicular lever acting alone.

Hydraulic Lever

The hydraulic lever acts because of the size difference between the tympanic membrane and the stapes footplate. Sound pressure collected over the area of the tympanic membrane and transmitted to the area of the smaller footplate results in an increase in force proportional to the ratio of the areas (also known as the areal ratio). The average ratio has been calculated to be 20.8:1.

According to traditional teaching, the acoustic transformer theory predicts a middle ear gain of approximately 27-34decibels (dB). This

figure is derived as a product of the action of the catenary, ossicular, and hydraulic levers. Implied in the transformer analogy is the expectation that this gain is independent of frequency.

Recent investigations of the human middle ear indicate that the acoustic transformer theory should be modified. Merchant et al (1997) summarized the latest reports of human middle ear sound transmission. They proposed that middle ear sound transmission is the result of ossicular coupling, acoustic coupling, and stapes-cochlear input impedance. Middle ear aeration also is considered essential for proper middle ear sound conduction.

Ossicular Coupling

Ossicular coupling refers to the sound pressure gain that occurs through the actions of the tympanic membrane and the ossicular chain. The pressure gain provided by the normal middle ear with ossicular coupling is frequency dependent. The mean middle ear gain is approximately 20 dB at 250-500 Hertz (Hz), it reaches a maximum of about 25 dB around 1 kilo Hertz (kHz), and it then decreases at about 6 dB per octave at frequencies above 1 kHz.

The changes in gain above 1kHz are caused by portions of the tympanic membrane moving differently than other portions, depending on the frequency of vibration. At low frequencies, the entire tympanic

membrane moves in one phase. Above 1 kHz, the tympanic membrane divides into smaller vibrating portions that vibrate at different phases. Another factor for the change in gain above 1 kHz is slippage of the ossicular chain, especially at frequencies above 1-2 kHz. Slippage is due to the translational movement in the rotational axis of the ossicles or flexion in the ossicular joints. In addition, some energy is lost because of the forces needed to overcome the stiffness and mass of the tympanic membrane and ossicular chain.

Acoustic Coupling

Acoustic coupling is the difference in sound pressures acting directly on the oval and round windows. Movement of the tympanic membrane produces a sound pressure in the middle ear that is transmitted to the oval and round windows. The pressure at each window is different because of the small distance between windows and the different orientation of each window relative to the tympanic membrane. In normal ears, the difference in pressures between the oval and round windows (acoustic coupling) is negligible.

In some diseased and reconstructed ears, the difference becomes significant and can greatly affect hearing. Specifically, when the ossicular chain is interrupted or absent, shielding of the round window results in redirection of all sound energy into the oval window, such as in Wullstein

type IV tympanoplasty. When this is performed, acoustic coupling plays a significant role in sound pressure conduction for cochlear stimulation.

Stapes -Cochlear Input Impedance

Stapes footplate motion is normally impeded by several anatomic structures, including the annular ligament, the cochlear fluids, the cochlear partition, and the round window membrane. Together, these structures result in stapes-cochlear input impedance. The round window impedance contribution is negligible in the normal ear. When the round window niche is filled with fluid or fibrous tissue, round window impedance increases, resulting in an increase in stapes-cochlear input impedance. Increases in this impedance cause conductive hearing loss.

Middle Ear Aeration

Ossicular coupling is impaired when the middle ear space (the air space of both the middle ear and the mastoid cavity) is reduced. The difference in sound pressures between the external auditory canal and the middle ear facilitates tympanic membrane motion. In the normal ear, the middle ear air pressure is less than the pressure in the external canal. When the middle ear space is reduced (e.g., by chronic ear disease or canal wall down surgery), the impedance and pressure of the middle ear increase relative to the external canal because the impedance of the middle ear space varies inversely with its volume. The pressure

difference between the external canal and the middle ear leads to a subsequent reduction in tympanic membrane and ossicular motion. The minimal amount of air required to maintain ossicular coupling within 10 dB of normal has been estimated to be 0.5 mL.

Acoustics and Mechanics of Diseased Middle Ears

Air-bone gap measure is a matter of ease and convenience since the gap can be easily calculated from a clinical audiogram and allows one to compare ears with disparate levels of sensorineural function.

However, air-bone gap is not always an accurate measure of middle ear sound transmission loss because bone conduction thresholds can be influenced by middle ear pathologies.

When there is ossicular interruption in the presence of an intact drum, ossicular coupling is lost. Since acoustic coupling is about 60 dB smaller than ossicular coupling, one would predict that complete ossicular interruption would result in a 60-dB conductive hearing loss.

In cases in which the tympanic membrane, malleus, and incus are lost, the conductive hearing loss is on the order of 40 to 50 dB. The 40 to 50dB loss can be explained by a loss of ossicular coupling together with an enhancement of acoustic coupling by about 10 to 20 dB as compared to the normal ear. The enhancement of acoustic coupling results from loss

of the shielding effect of the tympanic membrane which in the normal ear attenuates middle ear sound pressure by 10 to 20dB relative to ear canal sound pressure.

Perforations of the tympanic membrane cause a conductive hearing loss that can range from negligible to 50dB. The primary mechanism of conductive loss caused by a perforation is a reduction in ossicular coupling caused by a loss in the sound pressure difference across the tympanic membrane. The sound pressure difference across the tympanic membrane provides the primary drive to the motion of the drum and ossicles. Perforation - induced physical changes such as reduction in tympanic membrane area or changes in coupling of tympanic membrane motion to the malleus do not appear to contribute significantly to the hearing loss caused by a perforation.

Perforations cause a loss that depends on frequency, perforation size, and middle ear air space volume. Perforation - induced losses are greatest at the lowest frequencies and generally decrease as frequency increases. Perforation size is an important determinant of the loss; larger perforations result in larger hearing losses. Identical perforations in two different ears can have conductive losses that differ by up to 20 to 30 dB if the middle ear air space volumes differ substantially.

Although tympanomastoid surgery for chronic otitis media is quite successful in controlling infection with reported success rates in excess of 80 to 90%, it is well recognised that post-tympanoplasty hearing results are often unsatisfactory, especially with advanced lesions of the ossicular chain or when there is inadequate aeration of the middle ear. When the ossicular chain has to be reconstructed, long-term closure of the air-bone gap to $\leq$ 20 dB occurs in only 40 to 70% of cases when the stapes in intact and only in 30 to 60% of cases when the stapes superstructure is missing.

Factors contributing to unsatisfactory post surgical hearing results are:

1. Lack of quantitative understanding of structure-function relationships in the mechanical response of reconstructed ears.

2. Incomplete knowledge of the biology of chronic middle ear disease (including pathology of middle ear aeration and eustachian tube function) and,

3. Lack of control over the histopathologic and tissue responses of the middle ear to surgery.

Reconstruction of the Sound Conduction Mechanisms

The goal of tympanoplasty is to restore sound pressure transformation at the oval window by coupling an intact tympanic membrane with a mobile stapes footplate via an intact or reconstructed ossicular chain and to provide sound protection for the round window membrane by means of a closed, air-containing, mucosa-lined middle ear. As previously mentioned, the mean sound pressure gain provided by the normal ear is only about 20 dB. Consequently, a mechanically mobile but suboptimal tympanoplasty, combined with adequate stapes mobility, adequate middle ear aeration, and round window sound protection, can result in no middle ear gain but still produce a relatively good hearing result.

Type III Tympanoplasty - Acoustic Mechanics

A classic type III or stapes columella tympanoplasty involves placement of a tympanic membrane graft such as temporalis fascia directly onto the stapes head; that is, the ossicular chain is replaced by the single columella of the stapes. This tympanoplasty is typically performed in conjunction with a canal wall down mastoidectomy. The hearing results after this procedure vary widely, with air-bone gaps ranging from 10 to 60 dB. Large air-bone gaps (40 to 60 dB) occur as a result of stapes fixation, nonaeration of the middle ear, or both. When the stapes is

mobile and the middle ear is aerated, the average postoperative air-bone gap is on the order of 20 to 25 dB, suggesting that there is little middle ear sound pressure gain occurring through the reconstruction. Interposing a disk of cartilage between the graft and the stapes head improved hearing in the lower frequencies by 5 to 10 dB. The cartilage acts to increase the "effective" area of the graft that is coupled to the stapes, which leads to an increase in the middle ear gain of the reconstructed ear.

Type IV Tympanoplasty - Acoustic Mechanics

A type IV tympanoplasty is a surgical option in cases in which the tympanic membrane and ossicles are missing, the stapes footplate is mobile, and there is a canal wall down mastoid cavity. Incoming sound from the ear canal impinges directly on the stapes footplate while the round window is shielded from the sound in the ear canal by a tissue graft such a temporalis fascia. If the stapes footplate is ankylosed, it is removed and replaced by a fat graft, and this arrangement constitutes a type V tympanoplasty. In both type IV and type V procedures, there is no ossicular coupling, and residual hearing depends on acoustic coupling. The introduction of a tissue graft to shield the round window from sound enhances acoustic coupling by increasing the sound pressure difference between the oval and round windows.

Type IV constructions results in maximum acoustic coupling with a predicted residual conductive hearing loss of only 20 to 25dB. Since the literature demonstrates that less than 50% of ears after type IV surgery have air-bone gap of less than 30dB, it is clear that many type IV reconstructions are nonoptimum.

TYMPANOPLASTY & MASTOIDECTOMY

Definition : Tympanoplasty is an operation performed to 'eradicate disease' in middle ear and to reconstruct the hearing mechanism, without mastoid surgery, with or without tympanic membrane grafting.

Wullstein in 1956 classified tympanoplasty into 5 types. It was established to predict outcomes.

Type I - Performed when all the ossicles are present and mobile. It involves repair of a tympanic membrane perforation / retraction without ossicular reconstruction.

Type II - Performed when malleus is eroded, this is used. It is grafting the tympanic membrane to an intact incus and stapes or remnant of malleus. (Myringoincudopexy)

Type III - Performed when the lateral ossicles are eroded. Stapes must be intact and mobile. Tympanic membrane / graft or if a PORP is used is placed in contact with the stapes supra structure. (Myringostapediopexy)

Type IV - Performed when all ossicles are missing. Graft / Tympanic membrane is placed over a round window exposing oval window to exterior. Resulting middle ear consists of hypotympanum and eustachian tube orifice only.

Includes cavum minor technique or sound protection techniques.

Type V - Performed when stapes footplate is fixed.

Va - Involves grafting over a fenestration created in lateral semicircular canal.

Vb - Involves stapedectomy / platinectomy with a fixed footplate and no ossicles.

Wullsteins' classification is only of historical importance today because of the significant advances in middle ear reconstruction techniques and prostheses that occurred during 1960s and 1970s.

Farrior's Classification (1968):

Type I - Performed in cases with an intact ossicular chain or myringoplasty.

Type II - Myringoincudopexy

Type III - Interposition of a bone graft between the intact stapes and the drum or the malleus handle.

Type IV - Myringostapediopexy

Type V - Fenestration of the lateral semicircular canal

Type 2 tympanoplasty can be divided into :

1. **Interposition :** Placing an ossicle, a bony or cartilagenous graft, or any other prosthesis, between the stapes or stapedial arch and the malleus handle or drum.

2. **Transposition** : Refers to procedures in which an ossicle is still partly attached to its origin. They are seldom used. They consist of transposition of the incus, transposition of the neck of the malleus or of the umbo, or transposition of the entire malleus onto the head of the stapes.

3. **Pexis** : Various types include myringoincudopexy, myringostapediopexy, and ossicular wiring.

Sheehy's Classification:

Type 1 Myringoplasty alone.

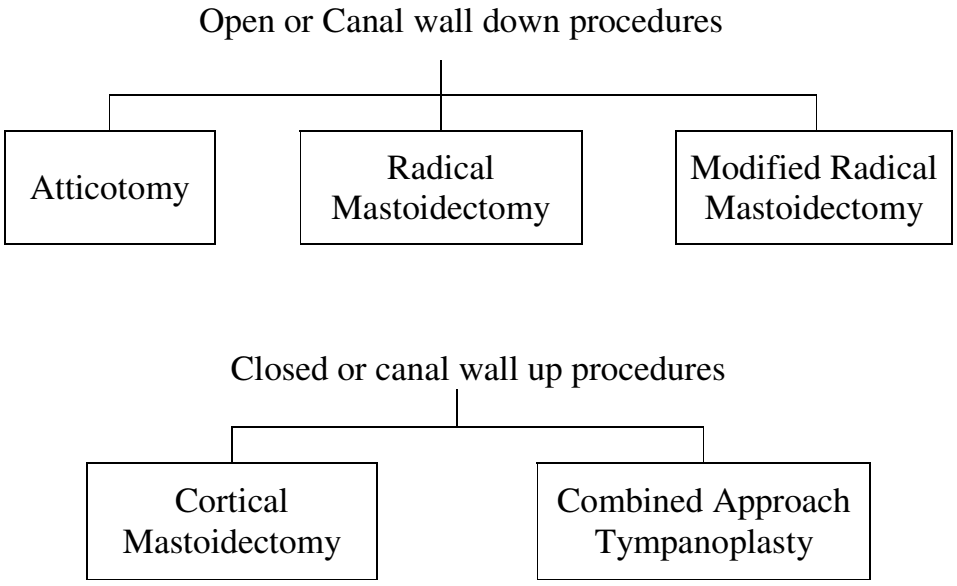
Type 2 Tympanoplasty without mastoidectomy.

Type 3 Tympanoplasty with mastoidectomy

(a) With modified radical mastoidectomy

(b) Combined approach tympanoplasty

Types of Mastoidectomy



Atticotomy

It is an operation performed to remove all or part of the outer attic wall (scutum) and adjacent deep posterior meatal wall, to expose the attic and, when necessary, the aditus ad antrum in order to gain access to these sites and their contents and / or remove disease limited to these sites.

Radical Mastoidectomy

It is an operation performed to eradicate all middle ear and mastoid disease, in which the mastoid cavity, aditus, attic and middle ear are converted into a common cavity, exteriorized to the external acoustic meatus. Tympanic membrane, malleus and incus are removed leaving only the stapes in situ.

Modified Radical Mastoidectomy

This operation differs from the Radical Mastoidectomy in that the tympanic membrane or remnants thereof and ossicular remnants are retained.

Cortical Mastoidectomy

This is an operation performed to remove disease from the mastoid antrum and air cell system (when present) and the aditus, with preservation of an intact posterior bony external auditory canal wall, without disturbing the existing middle ear contents.

Combined Approach Tympanoplasty

This is an operation performed to remove disease from the middle ear and mastoid by way of (a) the mastoid, (b) a posterior tympanotomy, and (c) the transcanal route, followed by reconstruction of the middle ear transformer mechanism.

Tympanoplasty with Mastoidectomy

This is an operation performed to eradicate disease from the middle ear and mastoid and to reconstruct the hearing mechanism with or without tympanic membrane grafting e.g.,

1. Combined Approach Tympanoplasty or cortical mastoidectomy with tympanoplasty.

2. Muscle or other obliteration of an open mastoid cavity with tympanoplasty.

3. Reconstruction of the outer attic and posterior canal wall of an open mastoid cavity, with tympanoplasty.

4. Open or canal wall down mastoidectomy with tympanoplasty.

TYPES OF OSSICULOPLASTY

Definition

Ossiculoplasty is defined as the reconstruction of the ossicular chain.

Many materials have been used for ossicular reconstruction, including biologic and alloplastic materials.

Ideal Prosthesis

It should be

- Safe
- Biocompatible
- Stable
- Easily insertable
- Capable of yielding optimal sound transmission.
- Non toxic

The goal of ossicular reconstruction is better hearing, most typically for conversational speech. The aim of ossiculoplasty is not to close the air bone gap per se but to improve the patients overall hearing. Small improvements in hearing are more likely to be appreciated by patients with bilateral hearing loss.

Indications, Contraindications for Ossiculoplasty

The various causes for conductive hearing loss due to ossicular chain abnormalities:

1. Cholesteatoma or chronic suppurative otitis media (80% of patients).
2. Trauma, either blunt or penetrating.
3. Congenital malformations.
4. Otosclerosis (Stapedial)

Conductive hearing loss from ossicular chain abnormalities may result from either discontinuity or fixation of the ossicular chain.

In order of frequency,

Discontinuity most commonly occurs because of

1. An eroded Incudo stapedial joint (in approximately 80% of patients with ossicular abnormality).
2. An absent Incus.
3. An absent Incus and stapes superstructure.

Ossicular fixation occurs due to

1. Stapedial otoselerosis
2. Malleus Head ankylosis
3. Ossicular tympanosclerosis

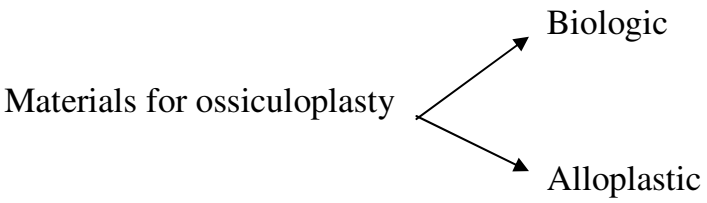
CONTRA INDICATIONS

True

Acute infection of the ear is the only true contraindication. Acute infection would most likely result in poor healing, prosthesis extrusion, or both.

Relative

1. Persistent middle ear muscoal disease.
2. Tympanic membrane perforation.
3. Repeated unsucccessful use of same or similar prosthesis.



I. BIOLOGIC MATERIALS

1. Autograft or homograft ossicles
2. Cortical bone
3. Teeth
4. Cartilage

II. ALLOPLASTIC MATERIALS

1. Biocompatible (Eg:Teflon, Silastic, Titanium, Gold)
2. Bioinert (Eg: Aluminium Oxide Ceramic)
3. Bioactive (Eg:Bioglass, Ceravital, Hydroxyaptite)

Autograft Bone/Cartilage

- The most commonly used autograft material is Incus body, which is often shaped to fit between handle of malleus and stapes capitulum.
- Malleus also can be shaped and used as autograft.
- Conchal Cartilage, tragal cartilage and Nasal septal spur cartilage also can be used.

Advantage

1. Can be obtained usually from same incision. (Except for spur cartilage).
2. Can be shaped as required.

Disadvantages

1. Lack availability in chronically diseased ears.
2. Prolonged operation time to obtain and shape the material.
3. Resorption

4. Loss of rigidity (especially, with cartilage).
5. Fixation to the walls of middle ear.
6. Osteitis may exist within ossicles.

Homograft Ossicles / Cartilage

- Irradiated homograft ossicles and cartilage were first introduced in 1960's.
- They can be stored in 70% alcohol.

Advantages

1. Can be sculptured to the shape required.
2. Operative time can be reduced.

Disadvantages

Risk of disease transmission like AIDS, Creutzfeldt -Jakob disease.

Teeth

- Roots of healthy bicuspids and tricuspids can be used.
- It can be moulded to the desired size and shape and stored in 70% alcohol.
- Wherever the tooth root opposes the tympanic membrane, a small piece of autograft tragal cartilage is interposed between the root surface and tympanic membrane graft.

Advantages

1. Stable, long lasting.
2. Bio-inert
3. No rejection even when used in open mastoid cavities.

BIOCOMPATIBLE MATERIALS

These were introduced in 1950s and 1960s.

1. Teflon, Polyethylene tubing and Proplast were introduced in 1950s and 1960s.

Disadvantages

1. Migration
2. Extrusion
3. Penetration into inner ear
4. Significant middle ear reactivity

2. In late 1970's HDPS (High Density Polyethylene Sponge) was introduced.

Advantages

1. Has Sufficient porosity to encourage tissue ingrowth.
2. Non reactive.

It exists in 2 forms

a. Plasti pore (original form)

b. Polycel (More versatile thermal fused HDPS)

Disadvantages

High Incidence of extrusion occurs when placed in direct contact with TM. (Extrusion can be reduced by placing cartilage between TM and the prosthesis).

3. Other Examples

Silastic, Stainless Steel, Titanium, Gold.

BIO INTERT MATERIALS

- These are the materials that do not release detectable trace substances.
- These were introduced in 1970s.
- Prototype example is: Dense Aluminium oxide ceramic (Al_2O_3)

Advantages

The implant can be fit to the undersurface of TM without cartilage coverage.

BIOACTIVE MATERIALS

- These were introduced in 1970's
- These react favourably with the body's tissues to promote soft tissue attachment.
- This attachment is a direct chemical bond to the surface of the material, not merely a mechanical attachment that occurs with bioinert and biocompatable materials.

Eg. bioglass, Ceravital

Advantages

1. Lower Incidence of extrusion.
2. React favourably with body's tissues.

Disadvantages

1. Difficulty in trimming the glass prosthesis.
2. Instability in infected environment.

Hydroxyapatite

- This is another bioactive material which is currently the most common alloplastic material used for ossicular reconstruction.

- It is polycrystalline calcium phosphate ceramic that has the same chemical composition as bone.
- It chemically attaches to bone and is osteo conductive.
- It forms a direct bond with bone at the hydroxy apatite/tissue interface.
- An epithelial covering resembling that in the normal middle ear forms over the implant within few weeks of implantation. This indicates good biocompatibility.
- It is in 2 forms
  - Porous (Pore size > 100 μm)
  - Dense (Pore size <100 μm)

Advantages

- It resists penetration by granulation tissue
- Can be place directly under TM without increased risk of extrusion.
- Good Biocompatibility
- Composition similar to bone.

Disadvantages

- Costly
- If placed next to scutum, osseointegration can occur, with subsequent conductive hearing loss.

The various prostheses are:

1. Applebaum Incudo Stapedial Joint Prosthesis

It is made from hydroxyapatite. It is an elongated cube with a trough on one face to receive the residual incus long process and a hole on the opposite face for stapes neck and capitulum. Placement is accomplished by centering the hold of the prosthesis on the stapes capitulum while fitting the long process of incus into the trough.

2. Kurz Augular Prosthesis

- It is made of gold shaft, gold cup and titanium clips.
- Gold cup is placed initially on the head of the stapes. Next, the clips are crimped to the long process of incus.
- The shaft comes in various lengths to accommodate different size remnants of long process of incus.
- It is used as a Incudo stapedial joint prosthesis.

3. Wehr's single notched Incus Prosthesis

- It is used as Incus replacement prosthesis.
- It is made of Hydroxyapatite except for the base of the prosthesis, which is made of HAPEX.

- HAPEX is a composite material made up of 40% Hydroxyapatite and 60% Polyethylene by volume.
- HAPEX can be trimmed easily with a scalpel.

4. Weh'r Double Notched Incus prosthesis

- Its composition is similar to that of single notched prosthesis.
- It is used as incus replacement prosthesis.
- A notch to accommodate the stapes tendon may be fashioned in the inferior portion of the shaft.

5. Black Spanner Strut

- It is used as incus replacement prosthesis.
- It is made of Hydroxyapatite except for the shaft, which is made of Fluoroplastic.
- The crural notches on the base of the shaft are aligned on the stapes, the malleus is lifted with a pick, and the head is engaged on the mid portion of the manubrium.

6. Wehr's HAPEX Incus-Stapes Prosthesis

- This is kept between manubrium and the foot plate of stapes.
- The shaft is centered on the foot plate of stapes. While lifting the manubrium, the prosthesis is brought into place under the midportion of manubrium.
- The usual length of this prosthesis is 4-6 mm.

7. Goldenberg HAPEX PORP

- It is partial ossicular replacement prosthesis.
- It has a rounded hydroxyapatite head and a trimmable shaft.
- It has a malleable connection between the shaft and head that tilts to confirm to the orientation of TM.
- The cannulated shaft is placed over the head of the stapes and the prosthesis is supported with gelfoam on all sides.
- The usual length of this PORP is 2-4.5 mm in canal wall up cases and approximately 1 mm in canal wall down cases (shaft)

8. Kurz Dusseldorf type BELL PORP

- It is entirely made of titanium.
- It has a flat head, a shaft, and a cup with 4 malleable bands at the bottom of the shaft.
- The opening between the bands is designed to accommodate the stapedial tendon.
- A cartilage covering over the head of the prosthesis is necessary to prevent extrusion.

9. Kurz Dusseldorf type titanium Aerial TORP

- It is a Total ossicular replacement prosthesis.
- It consists of a head, a shaft and a base which consists of a piston that rests on the foot plate.
- The head is the same as that for the PORP.
- A Cartilage covering is required over the head of this prosthesis.

HEARING OUTCOMES IN OSSICULOPLASTY

The status of the tympanic membrane and middle ear has a significant influence on the prognosis of hearing outcomes in ossiculoplasty.

For this reason, Kartush developed the Middle Ear Risk (MER) Index. The MER index is a means to improve the accuracy of reporting of ossiculoplasty results and a means to allow meaningful comparisons among studies.

MIDDLE EAR RISK INDEX

Risk Factor	Risk Value
Otorrhea (Bellucci)	
I. Dry	0
II. Occasionally wet	1
III. Persistently wet	2
VI. Wet, cleft palate	3
Perforation	
Absent	0
Present	1
Cholesteatoma	
Absent	0
Present	1

Risk Factor	Risk Value
Ossicular Status (Austin/Kartush)	
O : M+I+S + (intact ossicular chain)	0
A : M+S+ (malleus present, stapes present)	1
B : M+S- (malleus present, stapes absent)	2
C : M-S+ (malleus absent, stapes present)	3
D : M-S- (malleus absent, stapes absent)	4
E : Ossicle head fixation	2
F : Stapes fixation	3
Middle ear - Granulations or effusion	
No	0
Yes	1
Previous Surgery	
None	0
Staged	1
Revision	2

MIDDLE EAR RISK INDEX DETERMINATIONS

Prognosis / Risk	MER Index
Best Prognosis (normal ear)	0
Mild Risk	2
Moderate Risk	5
Severe Risk	7
Worst Prognosis (end stage)	12

Bellucci dual classification:

Incorporates pathology of middle ear conductive mechanism and middle ear infections

Group I - Good prognosis; dry ear for a long period.

Group 2 - Fair prognosis; ear stabilized but discharging during upper respiratory tract infection.

Group 3 - Poor prognosis, persistent discharge.

Group 4 - Very poor prognosis, with chronic discharge and nasopharyngeal malformations.

For the prognosis of hearing improvement, Bellucci includes a modified Wullstein classification:

Type 1 - Intact ossicles

Type 2 - Minor ossicular defects

Type 3 - Severe ossicular defects but stapes arch intact

Type 4 - Cavum minor

The following is a list of situations that generally have a more favorable prognosis for improved hearing compared to their anatomic counterpart :

- Malleus handle present versus handle absent
- Intact stapes arch versus absent arch
- Canal wall up versus canal wall down
- Mastoidectomy not necessary versus mastoidectomy performed.

In addition, hearing results generally worsen as the number of revisions increases. The worst results typically occur in patients with congenital ossicular abnormalities.

In general, the better the air conduction and the smaller the preoperative air-bone gap, the greater the chance for a successful hearing result. Goldenberg suggests that this may be because patients with these characteristics have better eustachian tube function, healthier mucosa, and less ossicular damage compared to patients with a poor preoperative air-bone gap (Goldenberg, 2000)

MATERIALS AND METHODS

Sixty patients undergoing middle ear surgery were selected at random with no age or sex bias. Only patients with conductive hearing loss were selected. The minimum age was 11 years and maximum age was 48 years. Those cases requiring myringoplasty were excluded from the study. Any allergic or septic focus was ruled out preoperatively.

Cases with bilateral ear disease were also taken up and revision cases were also subjected to surgery on 7 occassions.

Both wet and dry ears were taken up. Patients were admitted one day before the surgery. Mastoid shaving and local preparation were done in the ward. All cases were operated under general anaesthesia. The types of surgery included in the study were mastoid exploration, tympanoplasty and ossiculoplasty. Apart from a detailed case history, patients were assessed clinically with the help of otoscopy, tuning fork tests, pure tone audiometry, free field hearing tests, X-ray Mastoids and CT Temporal bone were done where applicable. A detailed questionnaire was used (separately to be filled in by the patient and the close first relative of the patient) pre and post operatively, to assess the level of hearing. Patients were followed post operatively for 3 & 6 months.

The assessment of hearing benefit after middle ear surgery was done using two methods.

1. Glasgow plot - by Browning et al 1991
2. Belfast 15/30 dB - by Smyth & Patterson rule of thumb 1985

Glasgow benefit plot

The first step is to plot each patient's preoperative hearing threshold on graph as in which vertical axis represents the mean air conduction (AC) in the ear to be operated upon and the abscissa represents the mean air conduction threshold in the non-operated ear. In this study the mean threshold was taken over 0.5, 1, 2 kHz. On the graph the solid diagonal line indicates identical hearing in both ears.

Pre operative impairment groups

Patient's preoperative AC threshold is likely to fall into one of the three main preoperative impairment groups.

Group 1 : Unilateral hearing impairment : Asymmetric threshold
Group 2 : Bilateral hearing impairment : Asymmetric threshold
Group 3 : Bilateral hearing impairment : Symmetric threshold

At three months post surgery, patient's postoperative AC threshold was plotted. As the hearing in the non-operated ear should not have

changed, each patients hearing status in the operated ear has been represented by a vertical line. The length of this line represents the change in AC thresholds.

Post Operative Categories

Post operatively, the patients hearing could change into one of the four categories.

Category a : Bilateral normal hearing

Category b : Unilateral normal hearing

Category c : Operated ear improves but is still impaired

Category d : Symmetric but impaired thresholds

Belfast 15/30 dB rule of thumb

Patients are likely to derive significant benefit post operatively if the air conduction threshold in speech frequencies (0.5, 1, 2 kHz) was less than or equal to 30 dB or if the inter aural difference is reduced to less than or equal to 15 dB.

RESULTS AND OBSERVATIONS

There were 38 males and 22 females. Age range was from 11-48 years. The younger patients were more aware of their hearing loss and consisted of 76.6 % of all the patients. The commonest disease was CSOM - tubotympanic (14 cases) and atticoantral (46 cases).

Group 1 : Unilateral hearing impairment, asymmetric threshold

12 patients were included in this group. All had pure tone average above 30 dB in one ear; all had interaural difference of more than 10 dB.

Preoperative self assessment of hearing loss by patients : Patients presented with varying degrees of subjective hearing impairment, such as diminished hearing from a distance, in group conversation, on telephone, discharge and diminished hearing.

Post operatively: Hearing from operated and non-operated ear was same in 6 patients (3 patients had inter aural difference of 12, 12 & 18 dB but claimed symmetric hearing).

Group 2 : Bilateral hearing impairment, asymmetric threshold.

40 patients were included in this group and 37 patients had pure tone averages above 30 dB in both ears. 29 patients had inter aural difference of more than 10dB. Patients claimed significant benefit post

operatively. Hearing from operated and non-operated ear was same in 33 patients. The prediction by both methods in this group was 100%. 19 patients fell in category 'c' and claimed significant benefit.

Group 3 : Bilateral hearing impairment - symmetric threshold

8 patients were included in this group. Pure tone average was less than 30 dB in six cases and interaural difference within 10 dB in 2 cases and 12,12,15,16,25,28,26 dB in 6 patients. They had significant benefit following surgery and claimed that the operated ear was the better hearing ear.

As per audiometry, 2 patients fell in category 'c' and claimed significant benefit. As per subjective benefit all these patients claimed significant benefit. Comparing the same with 15/30 dB rule of thumb as per audiometry, the overall positive predictive value was 80% and as per subjective benefit 84%.

Applying Z test for significance of difference between the predictive values by pure Tone Audiometry and subjective benefit in both the methods, the difference is not significant since Z is <1.96 at 95% confidence interval.

10 out of 12 patients (83%) in Group I had no difficulty in localizing sound, as only one ear is actually sufficient to localize sound.

According to Browning GG (1993), minor head movement can achieve the necessary variation in speech perception level.

In Group 3, 8 patients had bilateral symmetric hearing loss as per pure tone audiometry. Pure tone averages in the 0.5,1,2 kHz were same in both ears. This correlates with observations of G.G.Browning (1993), audiometric tests do not measure all aspects of hearing; hence the ear being operated upon should be as per patient's choice.

3 patients in Group 1 did not appreciate any benefit from middle ear surgery though their air conduction thresholds improved by 30 dB to 11 dB with closure of air bone gap. This correlates well with the studies of G.G.Browning, S Gatehouse and IRC Swan (1991), and Smyth GDL and Patterson CC, that mere closure of air-bone gap is not sufficient to improve hearing. In both the studies by Browning et al (1991) and Toner et al (1993) there is no place for patients having hearing loss less than 30 dB air conduction thresholds.

A study by Toner JG and Smyth GDL (1993) was carried out to compare two methods of predicting the level of subjective improvement following reconstructive middle ear surgery. The two methods studied were the 15/30 dB rule of thumb (Smyth and Patterson, 1985) and the Glasgow plot. (Browning et al 1991). The percentage agreement between rule of thumb and patient's assessment was 78 percent and the agreement

between Glasgow plot and patient's assessment was 62 percent. In the present study, the predictive value of the two methods as per pure tone audiometry was 80 percent with Glasgow benefit plot and 84 percent with 15/30 dB rule of thumb.

2 patients in Group 3 had air conduction thresholds above 30 dB (in postoperative category 'b') but claimed significant benefit.

Pre-operative hearing assessment and post-operative results - Glasgow benefit plot (n=60)

Pre op Groups		Post operative categories			
Groups	**Numbers**	**a**	**b**	**c**	**d**
1	12	6	6	NA	NA
2	40	9	12	19	NA
3	8	1	5	2	NA

NA - Not Applicable

Predictive value by the two methods as per pure tone audiometry

	Glasgow	**Rule of Thumb**
Group 1	95%	75 %
Group 2	50%	83 %
Group 3	88 %	95 %
Overall	80 %	84 %

Predictive value by the two methods as per subjective benefit

	Glasgow	**Rule of Thumb**
Group 1	88 %	82 %
Group 2	95%	93 %
Group 3	92 %	80 %
Overall	93 %	83 %

DISCUSSION

The aim of ossiculoplasty is to restore the ossicular chain as near to normal as possible or to achieve continuity and transmission in an entirely different way after abandonment of natural system. In the last three decades, various ossiculoplasty methods have evolved and good results were achieved, nevertheless ossicular reconstruction continues to be a process in evolution.

The challenge during ossiculoplasty has been how to achieve a stable, reliable connection between the tympanic membrane and mobile stapes footplate that will provide the best long term hearing results, without complications, in the inimical nature of the chronically infected ear.

There are several variables in middle ear surgery that affect the results.

(i) Most significant variable is the function of eustachian tube. It affects the long term survival of the various grafts in middle ear surgery.

(ii) The second variable is the status of the middle ear mucosa. The presence of active infection, polypoid changes, granulation tissue,

or bare bone can affect the subsequent function of an implanted middle ear processes.

(iii) The condition of the tympanic membrane is the third variable. Ossicular reconstruction when the tympanic membrane is intact gives better results than when there is perforation in tympanic membrane.

(iv) The fourth variable is the status of the ossicular chain. The presence of stapes suprastructure is a very important factor to improve hearing in ossiculoplasty. Brackmann reported long term results as 86% of success rate in adults and 92% in children with a postoperative air-bone gap of 15 dB or less, when the stapes was intact.

(v) The underlying process itself (disease or trauma) that has caused a specific ossicular defect is a fifth variable. Congenital ossicular abnormalities, cholesteatoma cases and traumatic ossicular discontinuities are difficult to manage.

(vi) Finally the material being used for ossicular reconstruction is a major variable. PORPs and TORPs entirely made of hydroxyapatite are found to be superior to other implant materials.

Traditionally otologists report the results of middle ear surgery in terms of closure of air bone gap. While these provide a measure of technical success of the operation, they may not translate into real life benefit for the patient. The current method used to estimate benefit from surgery are the Glasgow benefit plot and Belfast 15/30 dB rule of thumb, both are based on perceived subjective benefit to patients.

CONCLUSION

1. The overall success rate of ossiculoplasty in the present study is 80%.

2. In this study its found that Glasgow benefit plot is more sophisticated, graphical, providing a good visual impression whereas Belfast Rule of thumb is easy and simple to use, but, it suffers from the disadvantages of 'all or none phenomenon' with no place for marginal benefit.

3. Hearing improvement with Incus transposition is better followed by tragal and conchal cartilage ossiculoplasty, Homograft Malleus (in descending order).

4. Hearing improvement is better when minimal ossicular disruption is present. (All present > Incus absent > M-I-> M-I-S-)

5. Hearing improvement is better when cholesteatoma is absent (when compared to cholesteatoma cases).

6. Hearing improvement is better with dry ears.

7. Hearing improvement is better when cavity mastoidectomy was not done (when compared to cavity mastoidectomy cases.)

8. Fresh cases do better than revision cases.

9. Cases without granulations do better than those with granulations.

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PROFORMA

Name of the Patient :

Age / Sex :

OP/IP No. :

PRESENTING COMPLAINTS Side Duration

1) Ear discharge
2) Hard of hearing

H/o. Any previous surgeries

Family H/o. deafness

Local Examination : Right Ear Left Ear

Ears

Pinna Preauricular / post auricular region

External auditory canal

Tympanic Membrane :

Pars tensa

Pars flaccida

Tunning fork test

Nose

Throat

General Examination

Investigations

Procedure done

Follow up

Introduction

Aims & Objectives

Literature Review

Materials & Methods

Results & Observations

Discussion

Conclusion

Bibliography

Charts & Graphs

Proforma

Master Charts

Photographs

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AIMS AND OBJECTIVES

(1) To compare two methods of predicting the level of hearing benefit following middle ear surgery, namely Glasgow benefit plot and Belfast 15/30 dB rule of Thumb.

(2) To correlate hearing benefit as measured by using the above methods with patients' self assessment of his/her hearing status

(3) To analyze the differences in hearing improvement by various ossiculoplasties like incus interposition, tragal/ conchal cartilage and autograft malleus.

(4) To compare the success rates with surgery on dry and wet ears.

(5) To compare success rates with cavity mastoidectomy cases versus those without cavity.

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(ii) The second variable is the status of the middle ear mucosa. The presence of active infection, polypoid changes, granulation tissue, or bare bone can affect the subsequent function of an implanted middle ear processes.

(iii) The condition of the tympanic membrane is the third variable. Ossicular reconstruction when the tympanic membrane is intact gives better results than when there is perforation in tympanic membrane.

(iv) The fourth variable is the status of the ossicular chain. The presence of stapes suprastructure is a very important factor to improve hearing in ossiculoplasty. Brackmann reported long term results as 86% of success rate in adults and 92% in children with a postoperative air-bone gap of 15 dB or less, when the stapes was intact.

(v) The underlying process itself (disease or trauma) that has caused a specific ossicular defect is a fifth variable. Congenital ossicular

abnormalities, cholesteatoma cases and traumatic ossicular discontinuities are difficult to manage.

(vi) Finally the material being used for ossicular reconstruction is a major variable. PORPs and TORPs entirely made of hydroxyapatite are found to be superior to other implant materials.

Traditionally otologists report the results of middle ear surgery in terms of closure of air bone gap. While these provide a measure of technical success of the operation, they may not translate into real life benefit for the patient. The current method used to estimate benefit from surgery are the Glasgow benefit plot and Belfast 15/30 dB rule of thumb, both are based on perceived subjective benefit to patients.

CONCLUSION

1. The overall success rate of ossiculoplasty in the present study is 80%.

2. In this study its found that Glasgow benefit plot is more sophisticated, graphical, providing a good visual impression whereas Belfast Rule of thumb is easy and simple to use, but, it suffers from the disadvantages of 'all or none phenomenon' with no place for marginal benefit.

3. Hearing improvement with Incus transposition is better followed by tragal and conchal cartilage ossiculoplasty, Homograft Malleus (in descending order).

4. Hearing improvement is better when minimal ossicular disruption present. (All present > Incus absent > M-I-> M-I-S-)

5. Hearing improvement is better when cholesteatoma is absent (when compared to cholesteatoma cases).

6. Hearing improvement is better with dry ears.

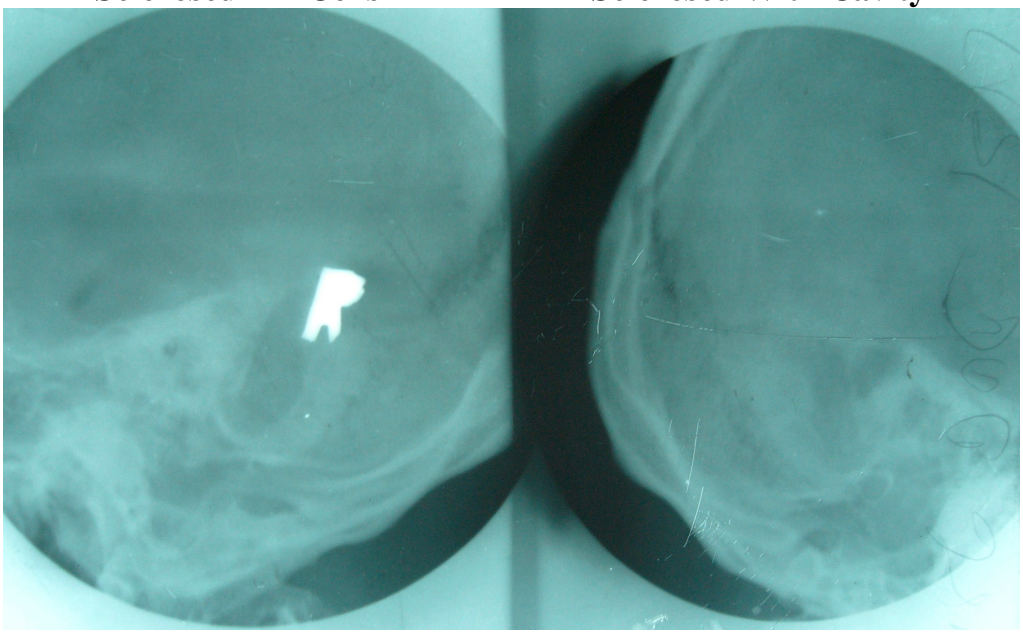
7. Hearing improvement is better when cavity mastoidectomy was not done (when compared to cavity mastoidectomy cases.)

8. Fresh cases do better than revision cases.

9. Cases without granulations do better than those with granulations.

X-RAY MASTOIDS

Sclerosed Air Cells **Sclerosed With Cavity**



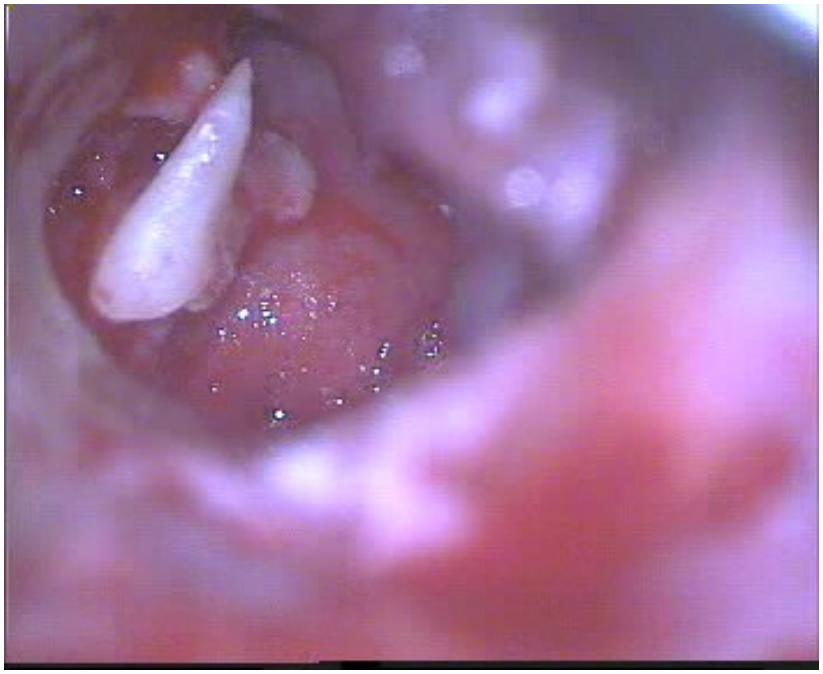
HRCT - Attic Cholesteatoma With Ossicular Erosion

ERODED OSSICLES

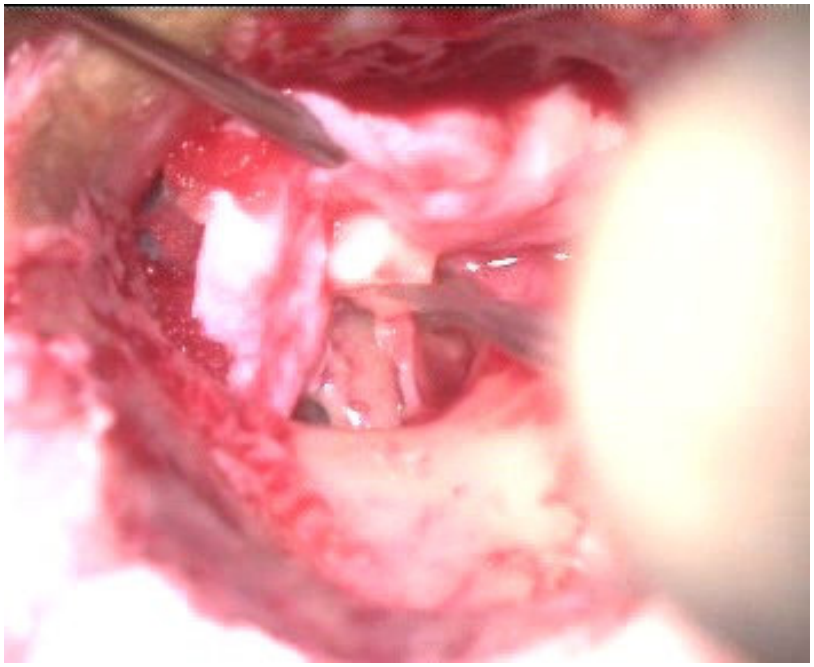
NECROSED HANDLE OF MALLEUS &
LONG PROCESS OF INCUS

NECROSED SHORT PROCESS OF INCUS

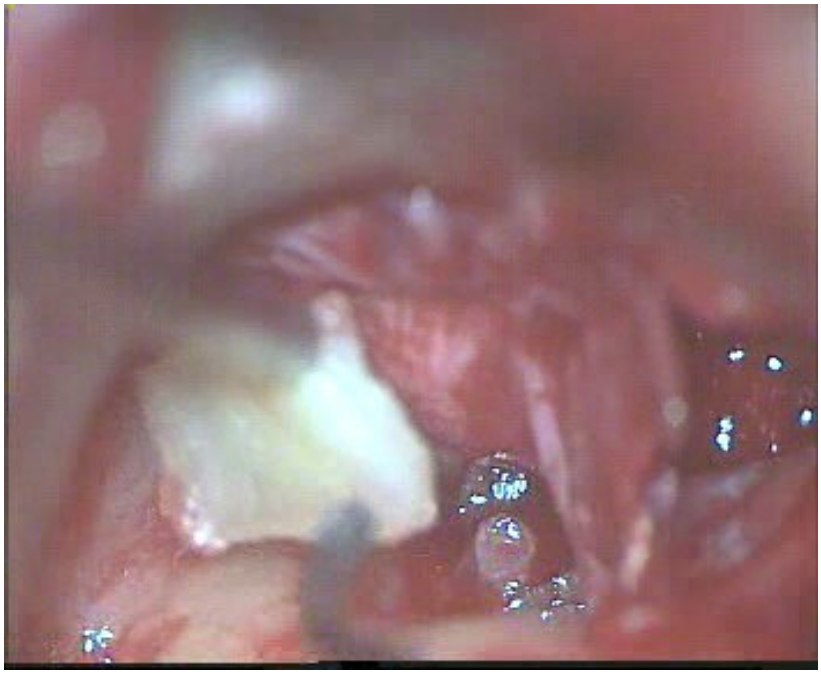
INCUS TRANSPOSITION

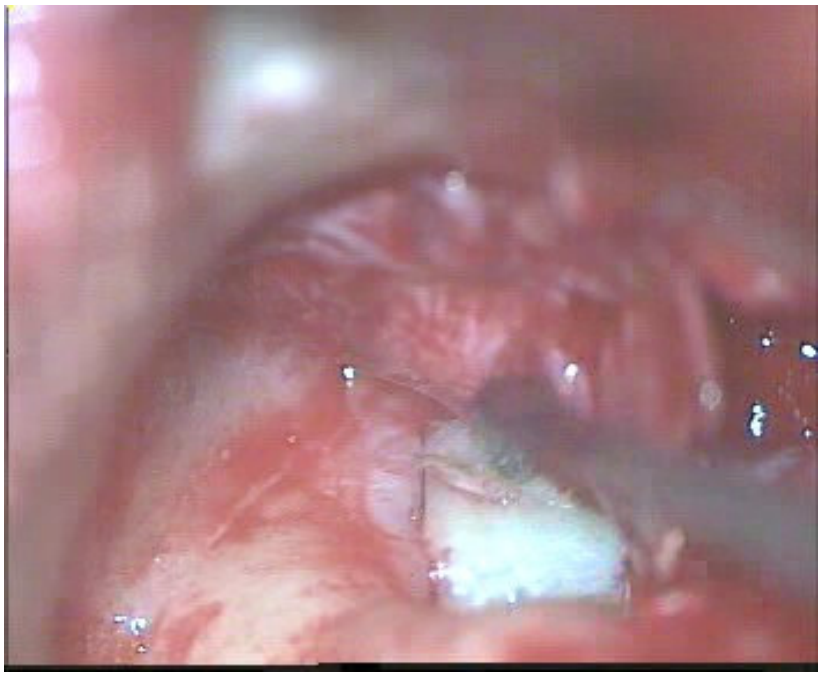


COLUMELLA MALLEUS CAPITULUM AUGMENTED

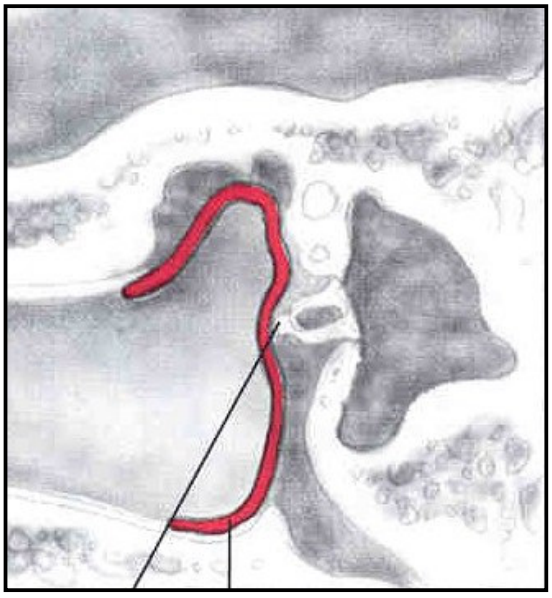


COLUMELLA CARTILAGE AUGMENTED

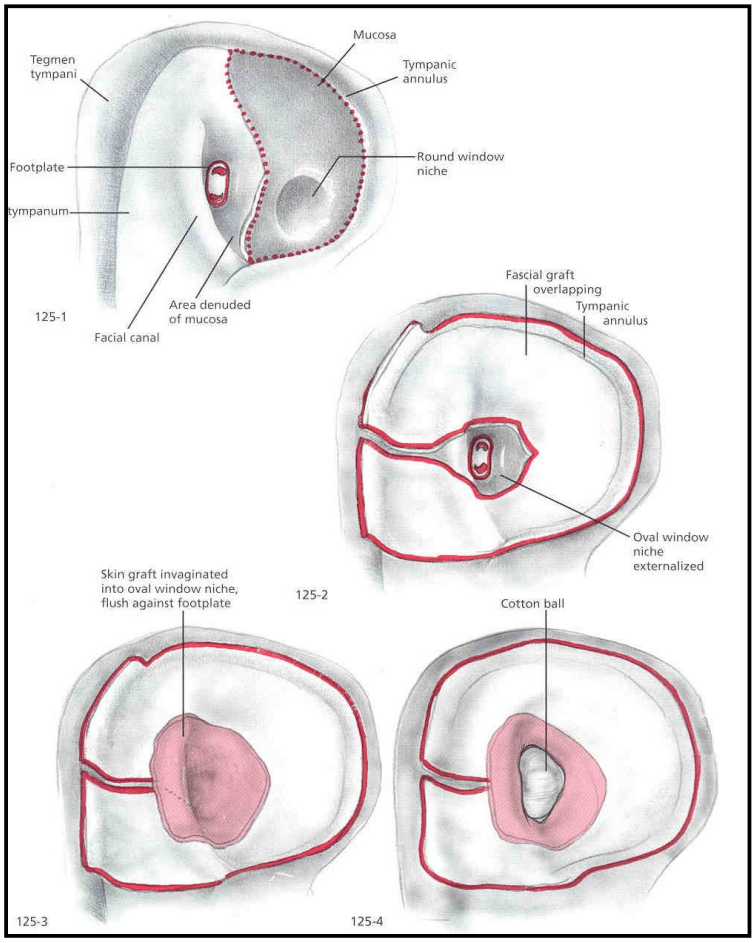


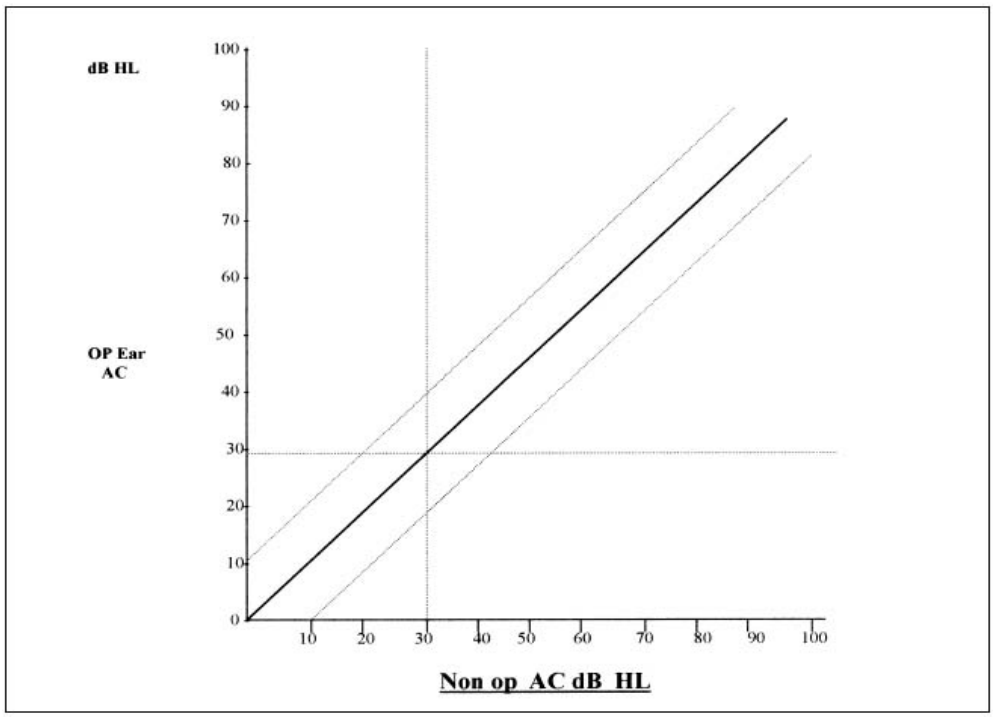


TYPE 3 TYMPANOPLASTY

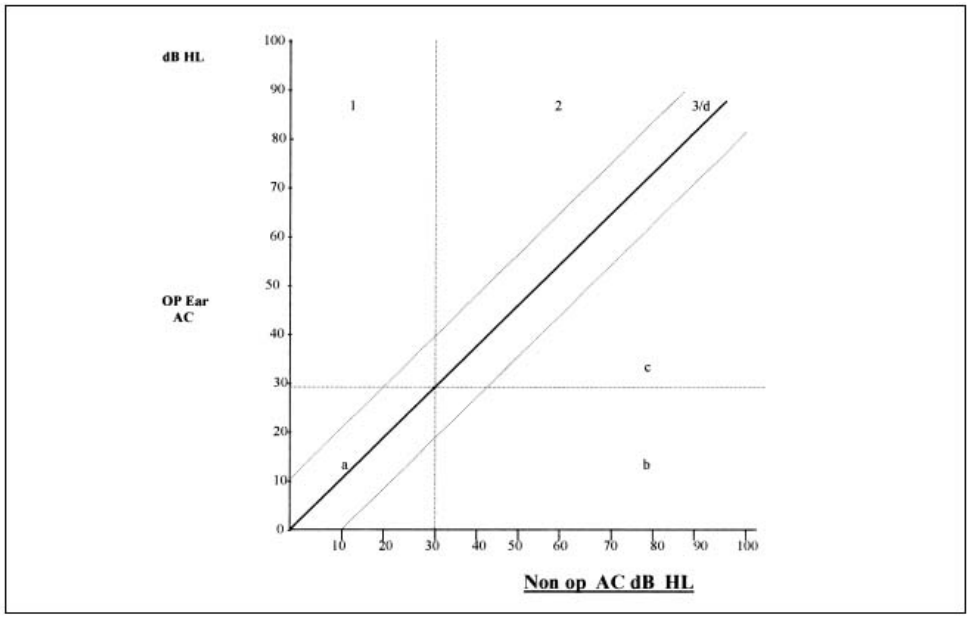


TYPE 4 TYMPANOPLASTY





GLASGOW BENEFIT PLOT



PRE OPERATIVE IMPAIRMENT GROUPS AND POST OPERATIVE CATEGORIES

NECROSED INCUS

CARTILAGE INTERPOSITION

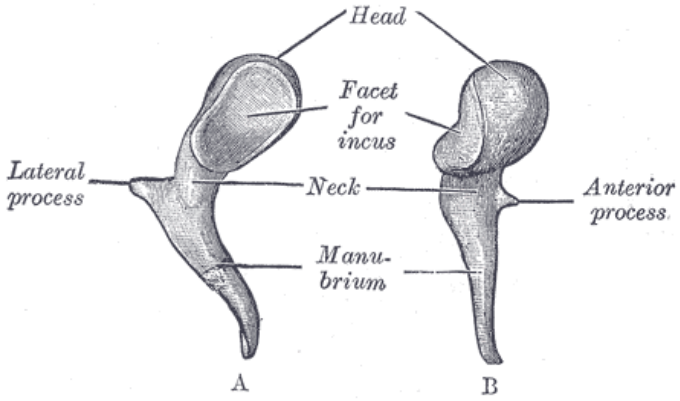
TRAGAL CARTILAGE TYMPANOPLASTY

CARTILAGE INSITU

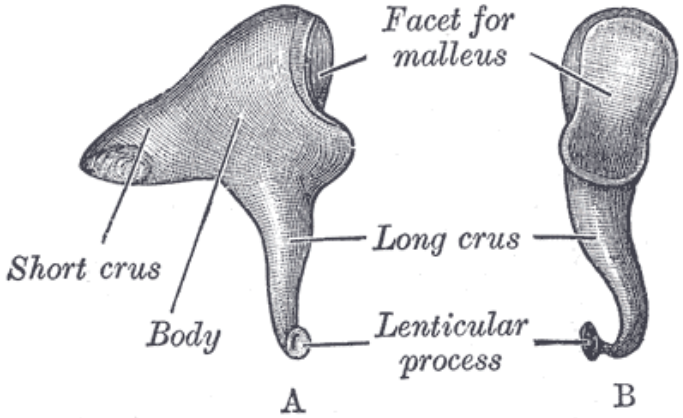
TEMPORALIS GRAFTING

OSSICLES

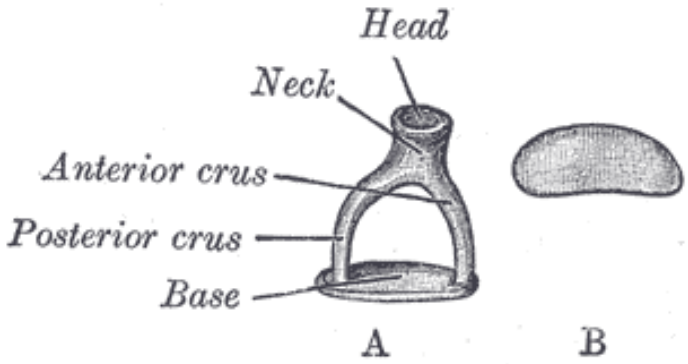
Left Malleus A From Behind B. From within



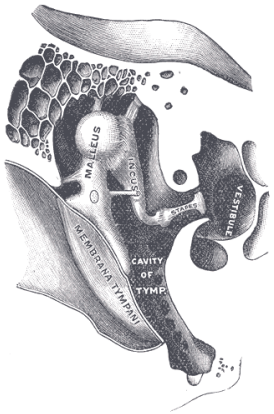
Left Incus A From within B. From front

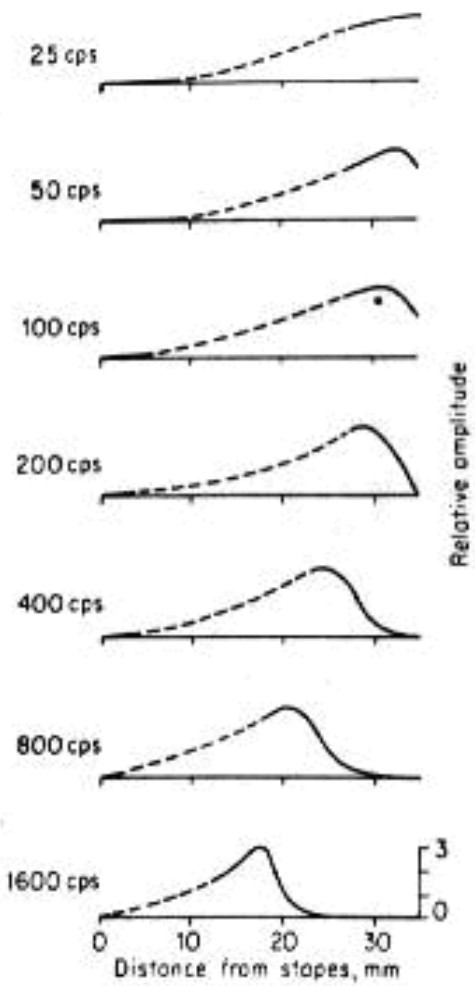


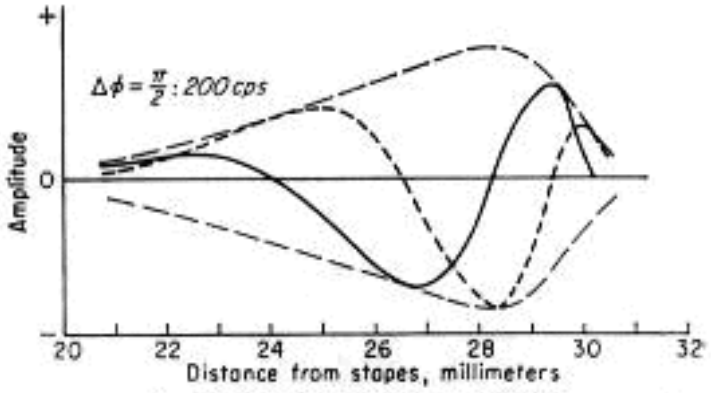
A.Left Stapes. B Base of Stapes, Medial Surface



Chain of Ossicles and their Ligaments





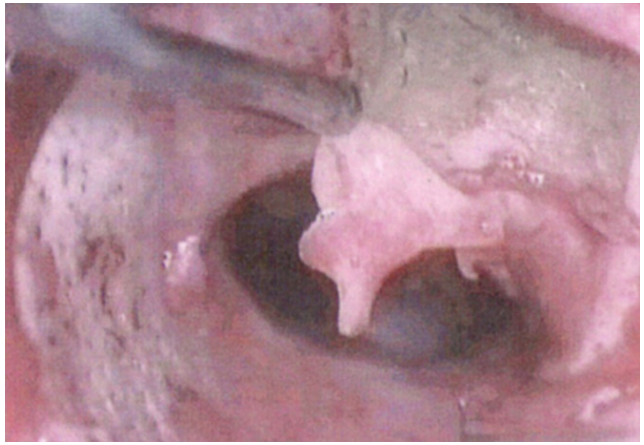


TRAVELLING WAVE THEORY

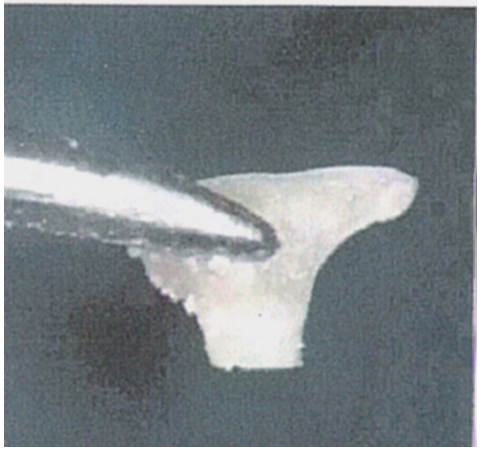
TRAGAL CARTILAGE SPLIT

AFTER SPLITTING TRAGAL CARTILAGE INTO TWO

INCUS REMOVED DURING SURGERY



RESHAPED HOMOGRAFT INCUS



VARIOUS PROSTHESES

Dusseldorf-type titanium Aerial Total Ossicular reconstruction prosthesis

Goldenberg HAPEX partial ossicular reconstruction prosthesis

Wehrs HAPEX incus-stapes prosthesis

Titanium incudostapedial joint prosthesis

	No. of Cas	Hearing Gain (dB)
Incus Tran	20	19.5
Tragal Car	13	13.25
Conchal Ca	20	8
Autograft M	7	6

	No. of Cas	Hearing Gain (dB)
With Cavity	44	18
Without Ca	16	21.5

Intact	46	Body Erode	1	Superstruc	24
Head Erod	5	Short Proc	3	Superstruc	36
Handle Erc	3	Long Proce	41		
Total Abse	6	Totally Ero	15		

Age (in yea	No. of Patients
10-20	26
21-30	20
31-40	10
41-50	4

Sex Ratio	
Male	38
Female	22

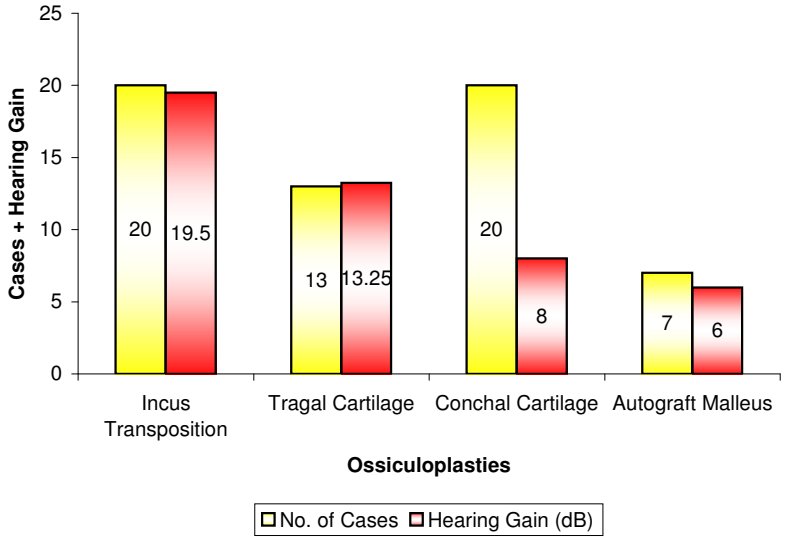
	PREOP AC GROUP
Group 1	12
Group 2	40
Group 3	8

	POST OP AC CATEGORY
Category A	14
Category B	35
Category C	10
Category D	1

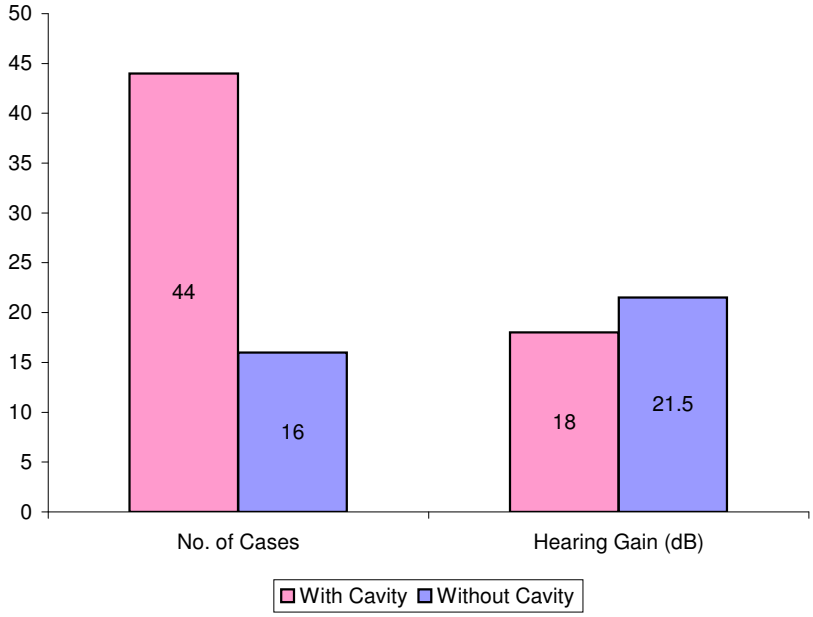
	Surgical Procedures
MRM	36
Cortical	14
Atticotomy	2
Atticoantro	4
ICW	1

Type II	20
Type III	37
Type IV	3

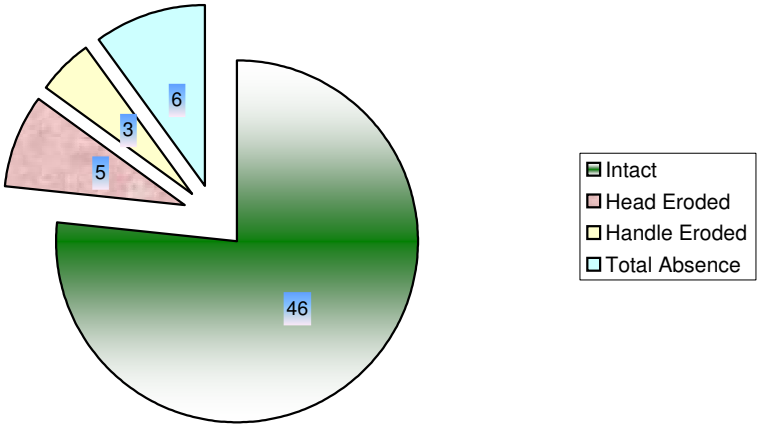
VARIOUS OSSICULOPLASTIES - AVERAGE HEARING IMPROVEMENT



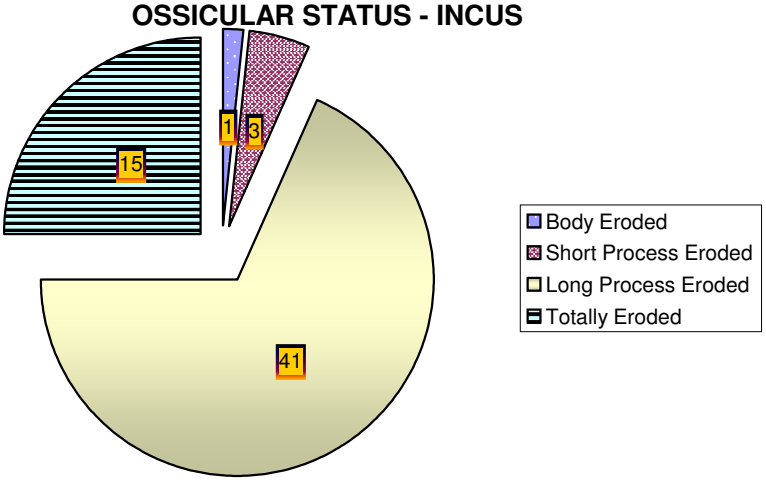
HEARING IMPROVEMENT IN WITH/WITHOUT CAVITY



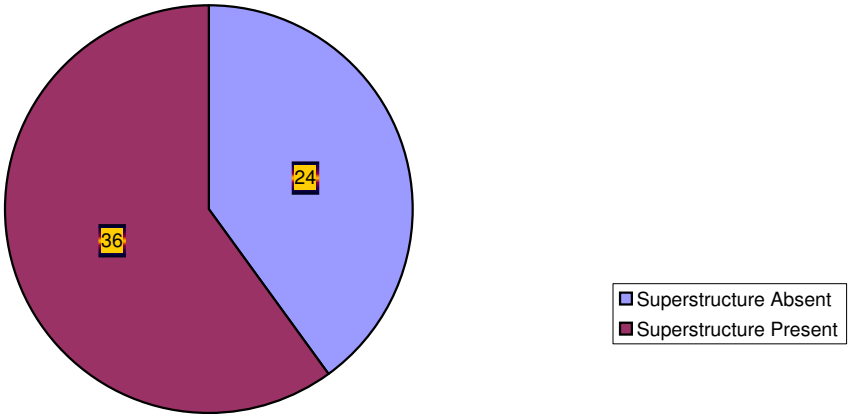
OSSICULAR STATUS - MALLEUS



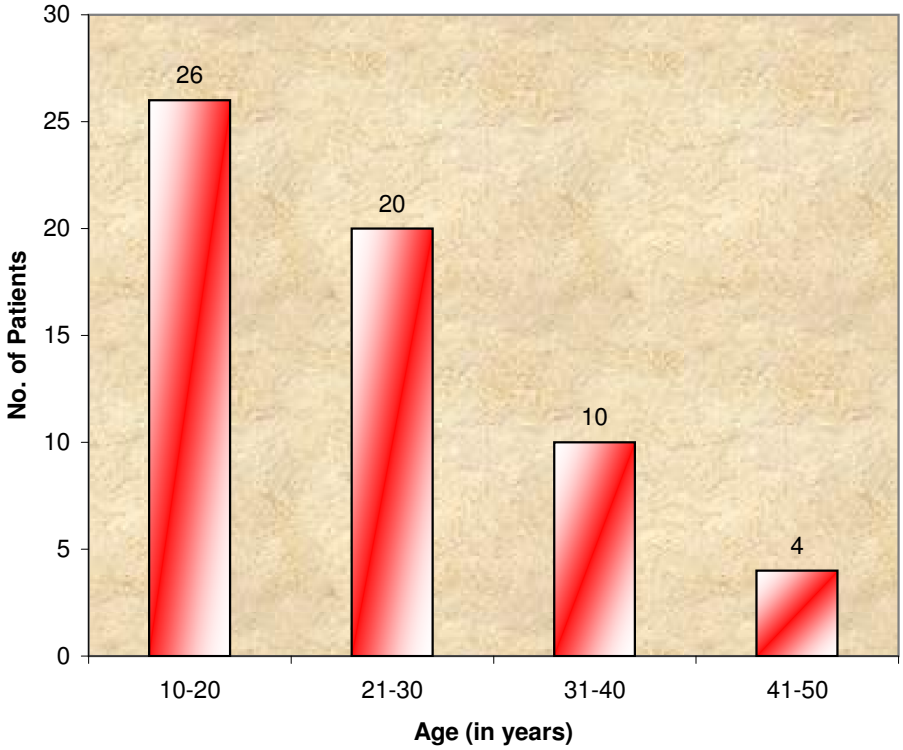
OSSICULAR STATUS - INCUS



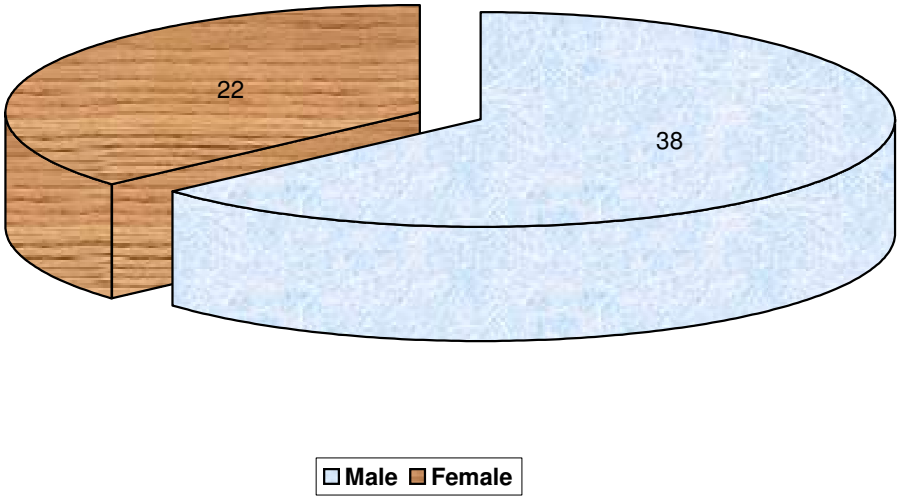
OSSICULAR STATUS - STAPES



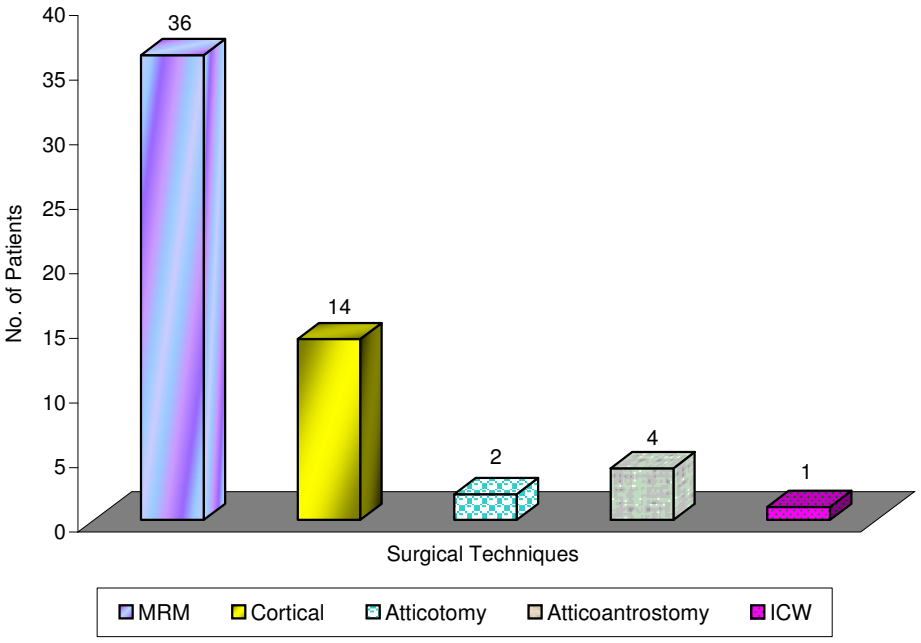
AGE PYRAMID



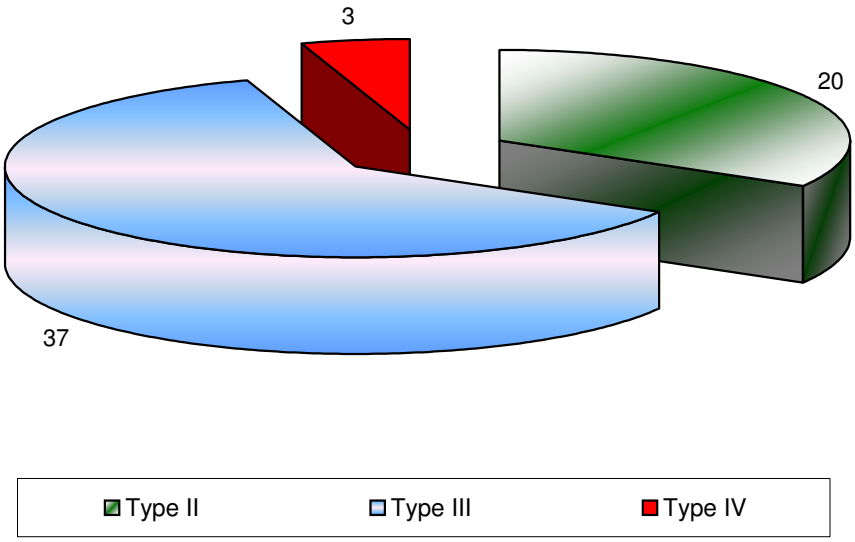
SEX RATIO



SURGICAL PROCEDURES



TYMPANOPLASTY



OSSICULAR STATUS, MERI, PRE AND POST OP PURE TONE AVERAGES AND GLASGOW PLOT CATEGORIES

No	Name	Age/Sex	MERI	Malleus	Incus	Stapes	Preop PTA		Postop PTA		Preop AC Group	Postop AC Category
							RE	LE	RE	LE		
1.	Poongodi	19F	9	-	-	- (FPS+)	30	44	30	30	2	a
2.	Usha Rani	19F	6	+	Body +	+	47	53	47	35	2	c
3.	Anbarasu	42 M	7	+	Body and short process +	- (FPS+)	30	28	20	28	2	b
4.	Hari	30 M	4	+	Body and short process +	- (FPS+)	30	35	30	20	2	b
5.	Riyaz	18 M	5	+	Body and short process +	- (FPS+)	18	50	18	30	1	b
6.	Desarani	29 F	8	+	Body and short process +	- (FPS+)	18	40	18	20	1	a
7.	Sundarraj	43 M	2	+	-	+	55	45	30	45	2	c
8.	Andrew	12 M	5	Head& neck +	Body and short process +	+	30	38	20	38	2	b
9.	Vairaperumal	48 M	1	-	-	- (FPS+)	48	18	30	18	1	b
10.	Rekha	22 F	5	+	Body and short process +	- (FPS+)	45	46	20	46	3	b
11.	Padmavathy	29 F	3	+	Body and short process +	+	35	45	35	30	2	c
12.	Manoj	11 M	4	+	Body and short process +	+	30	40	30	28	2	c

No	Name	Age/Sex	MERI	Malleus	Incus	Stapes	Preop PTA		Postop PTA		Preop AC Group	Postop AC Category
							RE	LE	RE	LE		
13.	Thiagarajan	11 M	6	neck and handle of Malleus +	Short process, long process and lenticular process +	+	18	35	18	20	1	a
14.	Siddhan	18M	3	+	Body and short process +	+	65	45	45	45	2	c
15.	Ramya	15F	3	+	Body and short process and long process +	+	50	37	30	37	2	c
16.	Sivakumar	16F	4	+	Body and short process and long process+	+	45	26	30	26	2	c
17.	Ramkumar	15M	2	+	Body and short process+	+	25	35	25	20	2	c
18.	Laksminarasimhan	33 M	6	+	-	+	40	25	22	25	2	c
19.	Srinivasan	28 M	5	+	Body and short prcoess and long process +	+	62	60	42	60	3	c
20.	Naga	15F	4	+	-	+	57	27	30	27	2	c
21.	Rajaselvam	36M	4	+	Body and short prcoess +	- (FPS+)	20	32	20	20	2	a
22.	Udayakumar	17 M	7	+	-	- (FPS+)	55	78	32	78	2	c
23.	Vincent	38 M	6	+	-	+	42	22	42	16	2	b
24.	Gowri	23 F	6	Neck and handle of Malleus+	Body and short process+	+	38	20	20	20	2	a
25.	Ushamalini	33 F	6	Handle of Malleus+	-	+	40	18	20	18	1	a
26.	Revathy	14F	7	+	-	- (FPS+)	65	18	35	18	1	b

No	Name	Age/Sex	MERI	Malleus	Incus	Stapes	Preop PTA		Postop PTA		Preop AC Group	Postop AC Category
							RE	LE	RE	LE		
27.	Bagyalaxmi	19F	4	+	Body andshort process and long process+	+	35	43	35	20	2	b
28.	Uma Maheswari	17 F	4	+	Body and short process+	+	18	38	18	22	1	b
29.	Mani	45 M	7	+	-	+	70	25	50	25	2	c
30.	Senthamarai	38 F	9	+	-	- (FPS+)	45	18	24	18	1	b
31.	Arumugam	28M	5	+	Body and short process+	- (FPS+)	45	25	20	25	2	b
32.	Mathews	33 M	7	Neck and handle of Malleus +	-	- (FPS+)	60	25	30	25	2	c
33.	Kalidoss	24 M	5	+	Body and short process and long process +	+	60	42	60	22	2	c
34.	Krishnaraj	17 M	3	+	Body and short process and long process +	+	32	32	20	32	3	b
35.	Nagarathnam	29 F	4	+	Body and short process +	+	20	37	20	20	2	a
36.	Syed Abu Thahir	19 M	5	+	Body and short process+	+	20	35	20	20	2	a
37.	Babuji	27 F	8	+	-	- (FPS+)	20	65	20	45	2	a
38.	Prema	35 F	7	Head and neck + Handle of Malleus partially eroded	-	- (FPS+)	28	53	28	30	2	b

No	Name	Age/Sex	MERI	Malleus	Incus	Stapes	Preop PTA		Postop PTA		Preop AC Group	Postop AC Category
							RE	LE	RE	LE		
39.	Malar	21 F	2	+	Body and short process and long process+	+	48	18	24	18	2	b
40.	Komala	25 F	2	+	Body and short process and long process +	+	22	34	22	20	2	b
41.	Palanisamy	32 M	4	+	Body and short process +	- (FPS+)	45	35	20	35	2	b
42.	Devi	26 F	3	+	Body and short process +	+	40	58	40	32	2	c
43.	Santosh	28 M	4	+	Body and short process +	+	33	35	20	35	2	a
44.	Ismail	20M	5	+	Body and short process +	+	63	63	35	63	3	c
45.	Chandrasekar	19 M	6	+	Body and short process +	- (FPS+)	57	28	35	28	2	c
46.	Viji	16 M	3	+	Body and short process +	+	70	27	35	27	2	c
47.	Maheswari	20 F	6	+	-	+	45	42	45	20	2	a
48.	Ponnamaal	35F	8	-	Body and short process +	+	38	62	38	32	2	c
49.	Bathindan	26M	6	+	Body and short process +	- (FPS+)	35	35	20	35	3	b
50.	Egambaram	24 M	5	+	Long process and lenticular process +	+	18	32	18	20	1	a
51.	Senthil	24 M	6	+	Body and short process and long process +	- (FPS+)	30	38	30	22	2	c
52.	Sridhar	18 M	7	Head and neck +	Body and short process +	- (FPS+)	18	38	18	24	1	b
53.	Vijayasarathy	21 M	8	-	Body and short process+	- (FPS+)	22	48	22	22	2	a

No	Name	Age/Sex	MERI	Malleus	Incus	Stapes	Preop PTA		Postop PTA		Preop AC Group	Postop AC Category
							RE	LE	RE	LE		
54.	Mathiyalagan	21 M	6	Neck and Handle of Malleus +	Body and short process +	- (FPS+)	66	24	32	24	2	c
55.	Karpagam	40 M	6	+	Body and short process +	- (FPS+)	50	50	50	25	3	c
56.	Chidambaram	19 M	6	+	Body and short process +	- (FPS+)	25	25	12	25	3	b
57.	Andrew	13 M	3	+	Body and short process +	+	28	30	28	18	3	b
58.	Saravanan	22 M	7	+	Body, short process and long process+	+	42	18	20	18	1	a
59.	Ramu	18 M	5	+	Body and short process +	+	45	40	22	40	2	c
60.	Sridhar	17 M	5	+	Body and short process +	+	18	38	18	20	1	a

- : Absent
+ : Present
FPS : Foot Plate of Stapes

PREOPERATIVE FINDINGS, DIAGNOSIS AND SURGERY DONE

No	Name	Age/Sex	Ear discharge	HOH	RE	LE	Diagnosis	Surgery
1.	Poongodi	19F	LE 3 year	BE 1 Year	Grade, 4 Pars tensa retraction	Attic perforation	CSOM LE AAD	LE MRM Type 4 T' Plasty
2.	Usha Rani	19F	BE 6 Months	BE 6 Months	Posterosuperior perforation with granulation	Central Perforation	CSOM BE RE AAD , LE TTD	LE MRM Type 3 T'Plasty
3.	Anbarasu	42 M	RE 7 Year	RE 6 Year	Posterousuperior retraction pocket with cholesteatoma	TM reaction grade 3	CSOM RE AAD Recurrent	RE Revision MRM Type 3 T'Plasty
4.	Hari	30 M	BE 5 Year	BE 4 Year	Attic perforation with cholesteatoma	Attic perforation with cholesteatoma	CSOM BE AAD	LE Atticoantrostomy with Type 3 T' Plasty
5.	Riyaz	18 M	LE 15 Yrs	LE 2 Year	TM normal	Posterosuperior marginal perforation with cholesteatoma	CSOM LE AAD	LE MRM Type 3 T' Plasty
6.	Desarani	29 F	LE Childhood	LE 15 Years	TM Normal	Subtotal perforation with cholesteatoma	CSOM LE AAD	LE MRM Type 3 T'Plasty
7.	Sundarraj	43 M	RE 2 Yrs	BE 2 Yrs	Grade 3 pars tensa retraction with Posterosuperior retraction pocket with discharge	Grade 3 Pars tensa retraction	CSOM BE LE AAD	RE MRM Type 2 T'Plasty
8.	Andrew	12 M	BE 6 months	BE 5 months	Attic perforation	Attic perforation	CSOM BE AAD	RE MRM Type 2 T' Plasty
9.	Vairaperumal	48 M	RE Childhood	BE 2 yrs	Attic perforation with granulation	TM Normal	CSOM RE AAD Recurrent	RE Revision MRM Type 4 T' Plasty

No	Name	Age/Sex	Ear discharge	HOH	RE	LE	Diagnosis	Surgery
10.	Rekha	22 F	BE Childhood	BE 9 yrs	Posterosuperior retraction pocket with cholesteatoma	Posterosuperior retraction pocket with cholesteatoma	CSOM BE AAD	RE MRM Type 2 T' Plasty
11.	Padmavathy	29 F	LE 3 months	LE 3 months	TM Normal	Posterosuperior retraction pocket with discharge	CSOM LE AAD	LE Atticotomy Type 2 T'Plasty
12.	Manoj	11 M	LE 3 yrs	LE 2 yrs	TM Normal	Posterosuperior marginal perforation with granulation	CSOM LE AAD	LE MRM Type 3 T' Plasty
13.	Thiagarajan	11 M	Le 5 yrs	LE 5 yrs	TM Normal	Attic perforation	CSOM LE AAD	LE MRM Type 3 T'Plasty
14.	Siddhan	18M	RE 10 yrs	RE1½ Yrs	Central perforation	TM Normal	CSOM RE TTD	RE Cortical mastoidecotomy Type 2 T'Plasty
15.	Ramya	15F	RE 1½ YRS	RE 1 YR	Central Perforation	TM Normal	CSOM RE TTD	RE Cortical mastoidecotomy Type 2 T'Plasty
16.	Sivakumar	16F	RE 2 months	RE 1 month	Posterosuperior perforation with cholesteatoma with attic perforation	Grade 2 TM retraction	CSOM RE AAD	RE Atticotomy with marginectomy Type 2 T' Plasty
17.	Ramkumar	15M	LE 3 months	LE 2 months	Grade 2 TM retraction	Posterosuperior retraction pocket with cholesteatoma	CSOM LE AAD	LE Atticotomy with intact canal wall Type 2 T' Plasty
18.	Lakshminarasimhan	33 M	RE 5 YRS	RE 4 YRS	Posterosuperior retraction pocket with cholesteatoma	Posterosuperior retraction pocket with discharge	CSOM BE AAD	RE Revision MRM Type 3 T'Plasty
19.	Srinivasan	28 M	RE2 weeks LE 5 YRS	RE 2 Weeks LE 5 YRS	Posterosuperior perforation with granulations	Posterosuperior retraction pocket with discharge	CSOM BE AAD	RE MRM Type 2 T' Plasty

No	Name	Age/Sex	Ear discharge	HOH	RE	LE	Diagnosis	Surgery
20.	Naga	15F	BE 14 YRS	BE 14 YRS	Central Perforation	Central Perforation	CSOM BE TTD	RE Cortical mastoidectomy Type 3 T'Plasty
21.	Rajaselvam	36M	LE 1 YR	LE 1 YR	Grade 3 pars tensa retraction	Posterosuperior retraction pocket Gd3 Pars tensa retraction	CSOM LE AAD	LE Atticoantrostomy Type 3 T'Plasty
22.	Udayakumar	17 M	BE Childhood	BE 10 YRS	Attic perforation	MRM Cavity with cholesteatoma	CSOM BE AAD LE Recurrent	RE Atticoantrostomy Type 4 T'Plasty
23.	Vincent	38 M	LE 1 YR	BE 1 YR	TM Normal	Attic Perforation with granulations	CSOM LE AAD RE Intact canal wall T' Plasty done	LE MRM Type 3 T'Plasty
24.	Gowri	23 F	RE 1½ YR	RE 1 YR	Central perforation	TM Normal	CSOM RE TTD	RE Cortical mastoidectomy Type 2 T'Plasty
25.	Ushamalini	33 F	LE Childhood	LE childhood	Posterosuperior marginal perforation with cholesteatoma	TM Normal	CSOM RE AAD	RE MRM Type 3 T' Plasty
26.	Revathy	14F	RE 2 yrs	RE 2 MONTHS	Central Perforation with cholesteatoma	TM normal	CSOM RE AAD	RE MRM Type 3 T' Plasty
27.	Bagyalaxmi	19F	LE Childhood	LE 5 YRS	Grade 4 pars tensa retraction	Central perforation	CSOM LE TTD	LE Cortical mastoidectomy Type 2 T' Plasty
28.	Uma Maheswari	17 F	LE Childhood	LE childhood	Gd 3 pars tensa retraction	Posterosuperior marginal perforation with cholesteatoma	CSOM LE AAD	LE Atticotomy Type 2 T' Plasty
29.	Mani	45 M	RE 4 months	RE 2 months	Aural polyp	TM normal	CSOM RE AAD	RE MRM Type 3 T' Plasty
30.	Senthamarai	38 F	RE Childhood	RE Childhood	Gd 3 pars tensa retraction	Gd 3 pars tensa retraction	CSOM RE AAD (Recurrent)	Re Revision MRM Type 3 T' Plasty

No	Name	Age/Sex	Ear discharge	HOH	RE	LE	Diagnosis	Surgery
31.	Arumugam	28M	BE 8 YRS	BE 7 YRS	Posterosuperior retraction pocket	Attic retraction pocket Grade 3	CSOM BE AAD	LE MRM TYPE 2 T'Plasty
32.	Mathews	33 M	LE 5 YRS	LE 5 YRS	Central perforation	Gd 3 para tensa retraction	CSOM RE TTD	RE Cortical mastoidectomy Type 2 T' Plasty
33.	Kalidoss	24 M	LE 7 Months	BE 7 Months	Posterosuperior retraction pocket	Posterosuperior marginal perforation with granulations	CSOM BE AAD	LE MRM Type 2 T' Plasty
34.	Krishnaraj	17 M	BE Childhood	BE Childhood	Central perforation	Central perforation	CSOM BE TTD	LE Cortical mastoidectomy Type 2 T' Plasty
35.	Nagarathnam	29 F	LE 6 months	LE 6 months	TM Normal	Central perforation	CSOM LE TTD	LE Cortical mastoidectomy Type 2 T' Plasty
36.	Syed Abu Thahir	19 M	LE 5 Yrs	LE 5 Yrs	TM Normal	Posterosuperior retraction pocket with cholesteatoma	CSOM LE AAD	LE MRM Type 3 T' Plasty
37.	Babuji	27 F	LE 2 YRS	LE 5 YRS	TM Normal	MRM Cavity with granulations	CSOM LE AAD (Recurrent)	LE Revision MRM Type 3T' Plasty
38.	Prema	35 F	Le 2 YRS	LE 2 YRS	Gd 3 pars tensa retraction	Central perforation	CSOM LE TTD	LE Cortical mastoidectomy Type 3 T' Plasty
39.	Malar	21 F	RE 2 YRS	RE 2 YRS	Grade 4 pars tensa retraction with discharge	TM normal	CSOM RE TTD	RE Cortical mastoidectomy Type 2 T' Plasty
40.	Komala	25 F	LE 1 YR	LE 1 YR	Gd 3 pars tensa retraction	Central perforation	CSOM LE TTD	LE Cortical mastoidectomy Type 2 T' Plasty
41.	Palanisamy	32 M	RE 10 YRS	RE 2 YRS	Posterosuperior retraction pocket	Gd 3 pars tensa retraction	CSOM RE AAD	RE Marginectomy Type 3 T' Plasty
42.	Devi	26 F	BE 10 YRS	BE 2 YRS	Central perforation	Central perforation	CSOM BE TTD	LECortical mastoidectomy Type 2 T' Plasty

No	Name	Age/Sex	Ear discharge	HOH	RE	LE	Diagnosis	Surgery
43.	Santosh	28 M	BE 5 YRS	RE 2 YRS	Posterosuperior marginal perforation with granulations with cholesteatoma	Central perforation	CSOM BE RE AAD, LE TTD	RE Intact canal wall Type 2 T' Plasty
44.	Ismail	20M	RE 18 YRS	RE 10 YRS	Central perforation	Gd 4 pars tensa retraction	CSOM RE TTD	ReCortical mastoidectomy Type 2 T'Plasty
45.	Chandrasekar	19 M	RE 3 Years	RE 2 Years	Central perforation with cholesteatoma	Gd3 pars tensa retraction	CSOM RE AAD	RE MRM Type 3 T'Plasty
46.	Viji	16 M	RE 6 YRS	RE 6 YRS	Central perforation	Gd 3 pars tensa retraction	CSOM RE TTD	RE Cortical mastoidectomy Type 2 T ' Plasty
47.	Maheswari	20 F	BE 5 YRS	BE 3 YRS	Attic perforation	Attic perforation with granulations	CSOM BE AAD	LE MRM Type 3 T' Plasty
48.	Ponnamaal	35F	LE 1 YR	LE 1 YR	Gd 3 pars tensa retraction	Attic perforation with granulations	CSOM LE AAD	LE MRM ype 3 T' Plasty
49.	Bathindan	26M	BE Childhood	BE 10 yrs	Posterosuperior retractio pocket with discharge	Central perforation	CSOM BE RE AAD, LE TTD	RE MRM Type 3 T' Plasty
50.	Egambaram	24 M	LE Childhood	LE10 YRS	TM Normal	Posterosuperior retraction pocket with cholesteatoma	CSOM LE AAD	LE MRM Type 3 T' Plasty
51.	Senthil	24 M	LE 14 YRS	LE 2 months	Central perforation	Attic perforation wtih cholesteatoma	CSOM BE RE TTD, LE AAD	LE MRM Type 3 T' Plasty
52.	Sridhar	18 M	LE 15 YRS	LE 2 YRS	TM normal	Posterosuperior retraction pocket with cholesteatoma	CSOM LE AAD	LE MRM Type 3 T'Plasty
53.	Vijayasarathy	21 M	LE Childhood	LE childhood	Gd 2 pars Tensa retraction	Attic perforation with cholesteatoma	CSOM LE AAD	LE MRM Type 3 T' Plasty

No	Name	Age/Sex	Ear discharge	HOH	RE	LE	Diagnosis	Surgery
54.	Mathiyalagan	21 M	RE 7 yrs	RE 2 Yrs	Posterosuperior retraction pocket with cholesteatoma	Myringitis granulosa	CSOM RE AAD	RE MRM Type 3 T' Plasty
55.	Karpagam	40 M	BE6 months	LE 5 months	Gd.2 pars tense retraction	Central perforation	CSOM BE RE AAD, LE TTD	LE Atticotomy Type 2 T' Plasty
56.	Chidambaram	19 M	BE 5 Yrs	RE 5 yrs	Posterosuperior retraction pocket	Central perforation	CSOM BE RE AAD, LE TTD	RE MRM Type 3 T' Plasty
57.	Andrew	13 M	LE 6 months	LE 6months	Post aural scar + Tm normal	Attic perforation with cholesteatoma	CSOM LE AAD RE Operated	LE MRM Type 3 T' Plasty
58.	Saravanan	22 M	RE 3 yrs	RE 3 yrs	Attic perforation with cholesteatoma	MRM Cavity	CSOM RE AAD LE Operated	RE MRM Type 3 T' Plasty
59.	Ramu	28 M	RE 2 YRS	RE 2 YRS	Gd 4 pars tensa retraction	TM Normal	CSOM RE AAD	RE MRM Type 3 T' Plasty
60.	Sridhar	17 M	LE 5 yrs	LE 4 yrs	TM normal	Attic perforation	CSOM LE AAD	LE MRM Type 2 T' Plasty

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AIMS AND OBJECTIVES

(1) To compare two methods of predicting the level of hearing benefit following middle ear surgery, namely Glasgow benefit plot and Belfast 15/30 dB rule of Thumb.

(2) To correlate hearing benefit as measured by using the above methods with patients' self assessment of his/her hearing status

(3) To analyze the differences in hearing improvement by various ossiculoplasties like incus interposition, tragal/ conchal cartilage and autograft malleus.

(4) To compare the success rates with surgery on dry and wet ears.

(5) To compare success rates with cavity mastoidectomy cases versus those without cavity.

DISCUSSION

The aim of ossiculoplasty is to restore the ossicular chain as near to normal as possible or to achieve continuity and transmission in an entirely different way after abandonment of natural system. In the last three decades, various ossiculoplasty methods have evolved and good results were achieved, nevertheless ossicular reconstruction continues to be a process in evolution.

The challenge during ossiculoplasty has been how to achieve a stable, reliable connection between the tympanic membrane and mobile stapes footplate that will provide the best long term hearing results, without complications, in the inimical nature of the chronically infected ear.

There are several variables in middle ear surgery that affect the results.

(i) Most significant variable is the function of eustachian tube. It affects the long term survival of the various grafts in middle ear surgery.

(ii) The second variable is the status of the middle ear mucosa. The presence of active infection, polypoid changes, granulation tissue, or bare bone can affect the subsequent function of an implanted middle ear processes.

(iii) The condition of the tympanic membrane is the third variable. Ossicular reconstruction when the tympanic membrane is intact gives better results than when there is perforation in tympanic membrane.

(iv) The fourth variable is the status of the ossicular chain. The presence of stapes suprastructure is a very important factor to improve hearing in ossiculoplasty. Brackmann reported long term results as 86% of success rate in adults and 92% in children with a postoperative air-bone gap of 15 dB or less, when the stapes was intact.

(v) The underlying process itself (disease or trauma) that has caused a specific ossicular defect is a fifth variable. Congenital ossicular

abnormalities, cholesteatoma cases and traumatic ossicular discontinuities are difficult to manage.

(vi) Finally the material being used for ossicular reconstruction is a major variable. PORPs and TORPs entirely made of hydroxyapatite are found to be superior to other implant materials.

Traditionally otologists report the results of middle ear surgery in terms of closure of air bone gap. While these provide a measure of technical success of the operation, they may not translate into real life benefit for the patient. The current method used to estimate benefit from surgery are the Glasgow benefit plot and Belfast 15/30 dB rule of thumb, both are based on perceived subjective benefit to patients.

CONCLUSION

1. The overall success rate of ossiculoplasty in the present study is 80%.

2. In this study its found that Glasgow benefit plot is more sophisticated, graphical, providing a good visual impression whereas Belfast Rule of thumb is easy and simple to use, but, it suffers from the disadvantages of 'all or none phenomenon' with no place for marginal benefit.

3. Hearing improvement with Incus transposition is better followed by tragal and conchal cartilage ossiculoplasty, Homograft Malleus (in descending order).

4. Hearing improvement is better when minimal ossicular disruption present. (All present > Incus absent > M-I-> M-I-S-)

5. Hearing improvement is better when cholesteatoma is absent (when compared to cholesteatoma cases).

6. Hearing improvement is better with dry ears.

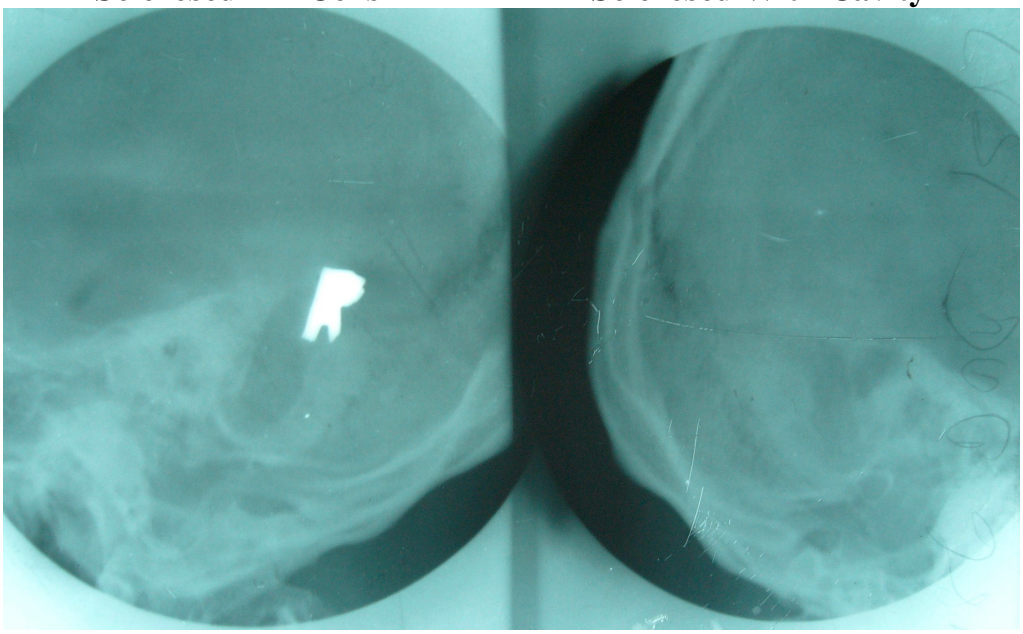
7. Hearing improvement is better when cavity mastoidectomy was not done (when compared to cavity mastoidectomy cases.)

8. Fresh cases do better than revision cases.

9. Cases without granulations do better than those with granulations.

X-RAY MASTOIDS

Sclerosed Air Cells **Sclerosed With Cavity**



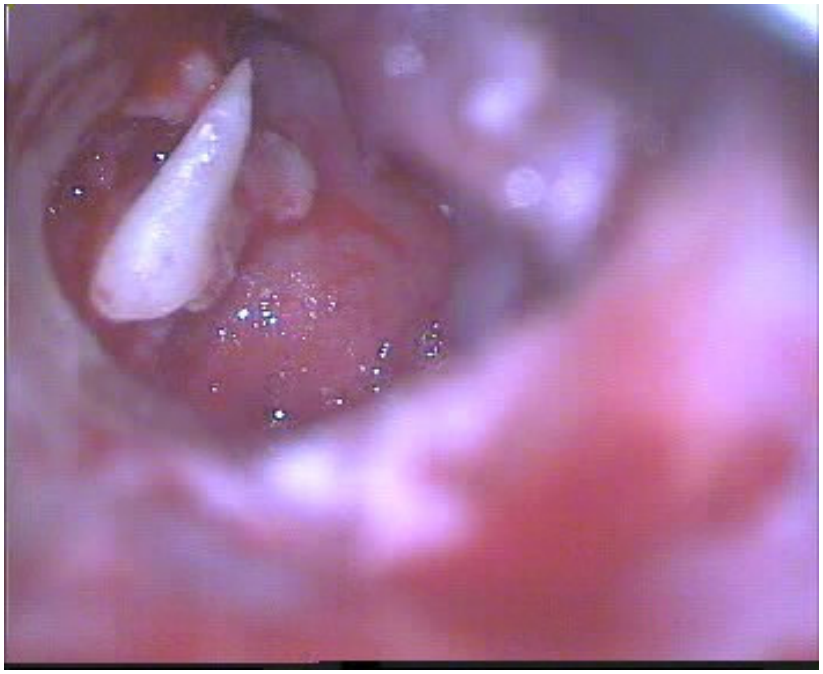
HRCT - Attic Cholesteatoma With Ossicular Erosion

ERODED OSSICLES

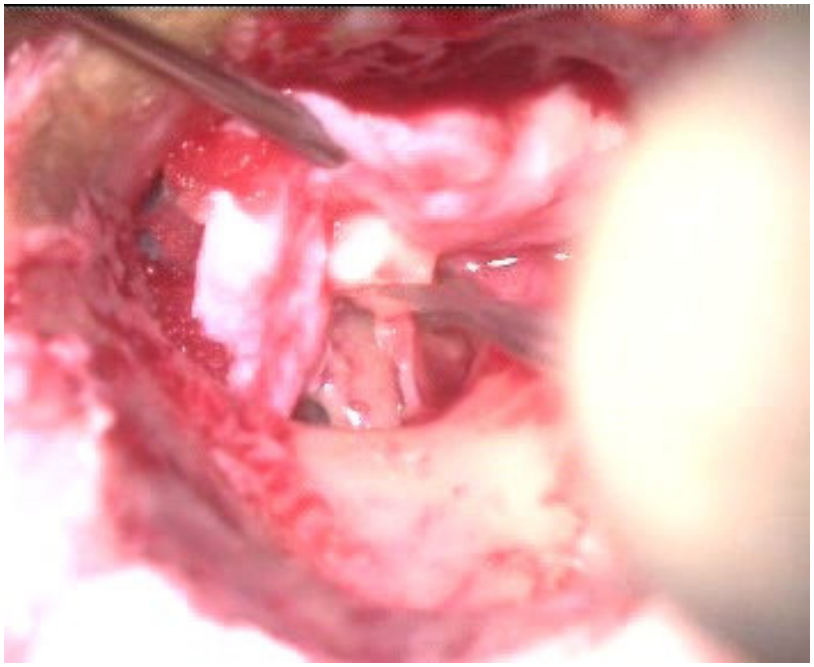
NECROSED HANDLE OF MALLEUS &
LONG PROCESS OF INCUS

NECROSED SHORT PROCESS OF INCUS

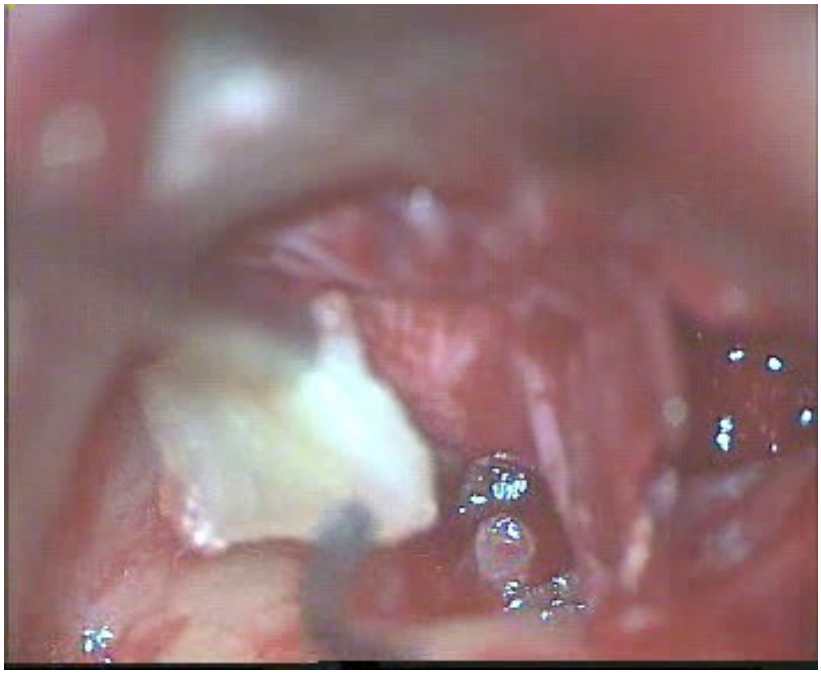
INCUS TRANSPOSITION

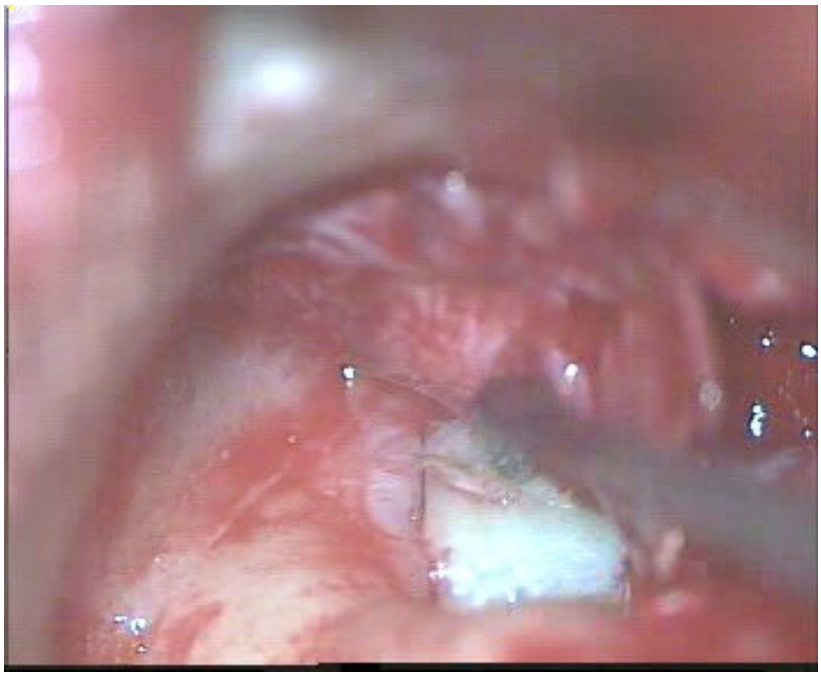


COLUMELLA MALLEUS CAPITULUM AUGMENTED

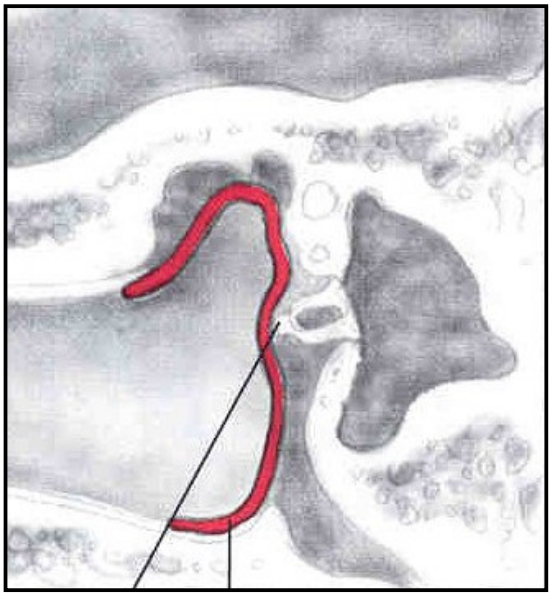


COLUMELLA CARTILAGE AUGMENTED





TYPE 3 TYMPANOPLASTY



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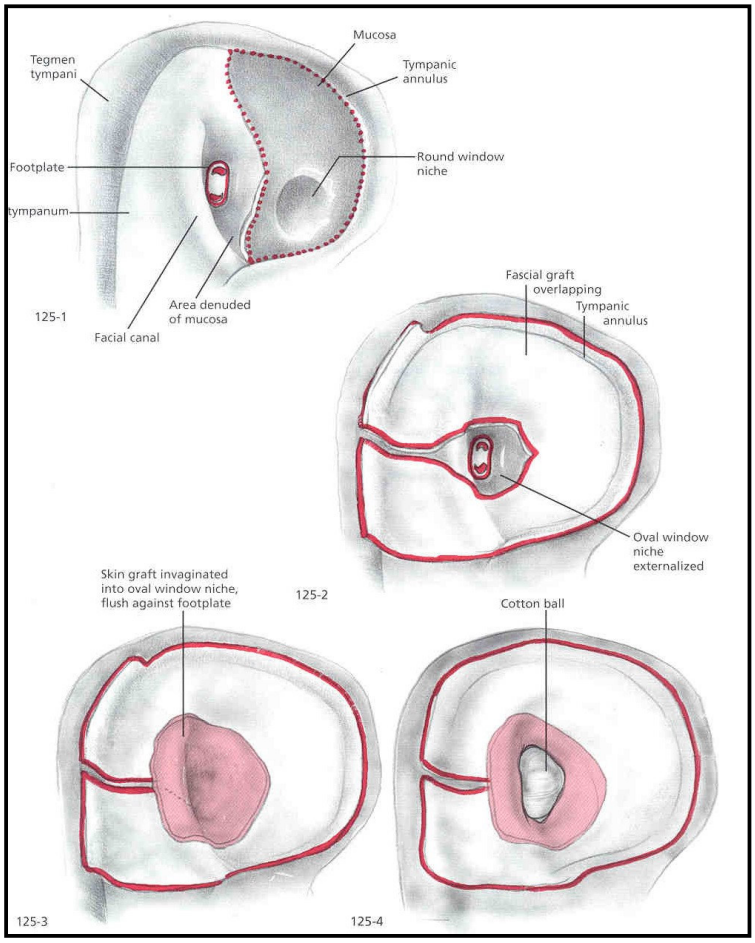
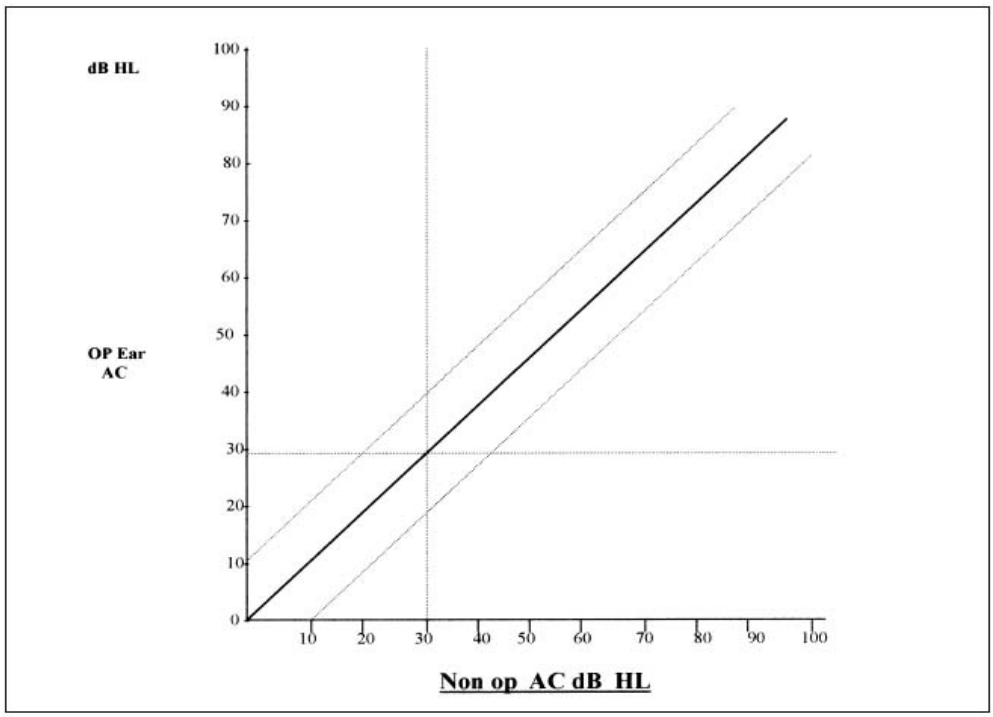
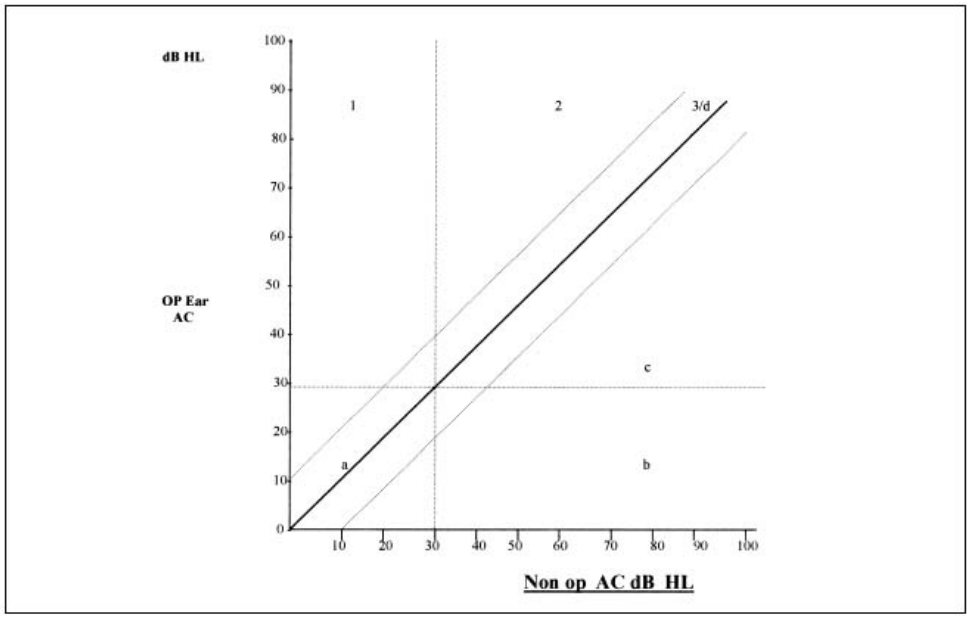




GLASGOW BENEFIT PLOT



PRE OPERATIVE IMPAIRMENT GROUPS AND POST OPERATIVE CATEGORIES

NECROSED INCUS

CARTILAGE INTERPOSITION

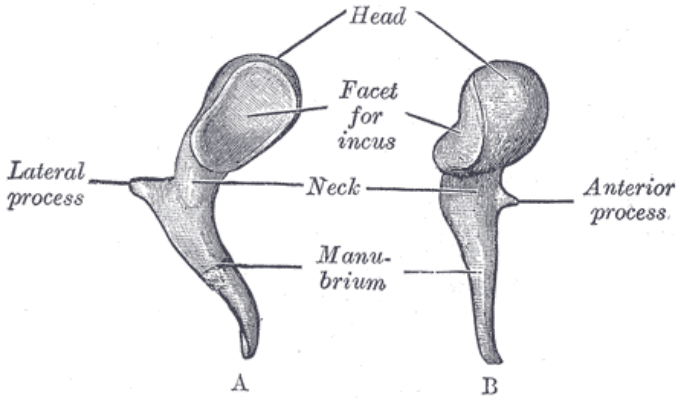
TRAGAL CARTILAGE TYMPANOPLASTY

CARTILAGE INSITU

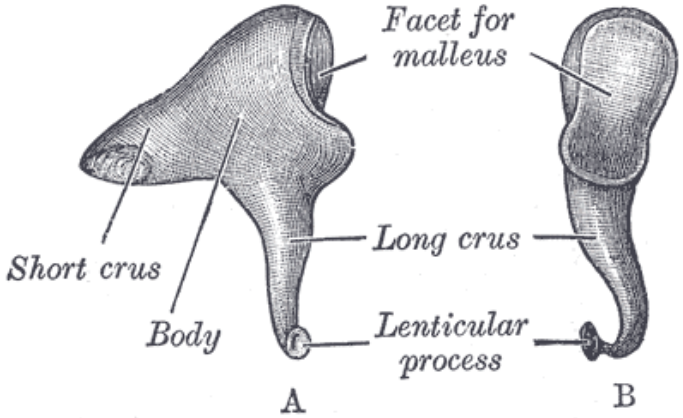
TEMPORALIS GRAFTING

OSSICLES

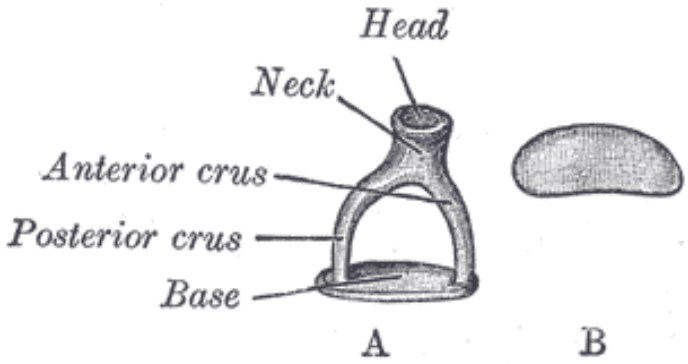
Left Malleus A From Behind B. From within



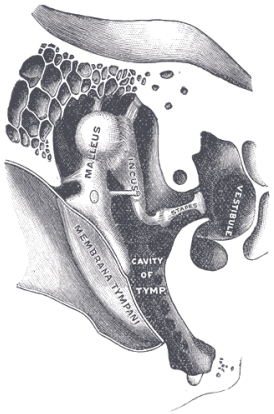
Left Incus A From within B. From front

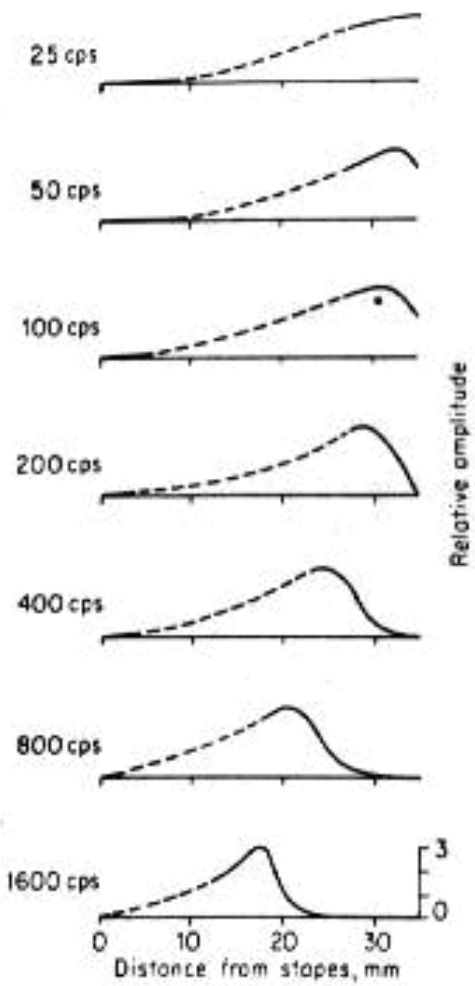


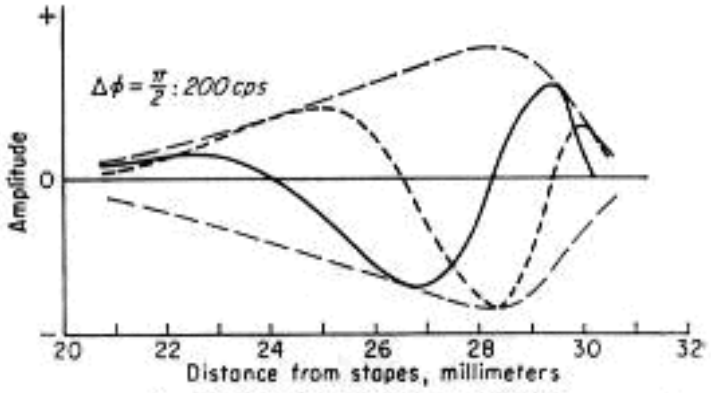
A.Left Stapes. B Base of Stapes, Medial Surface



Chain of Ossicles and their Ligaments





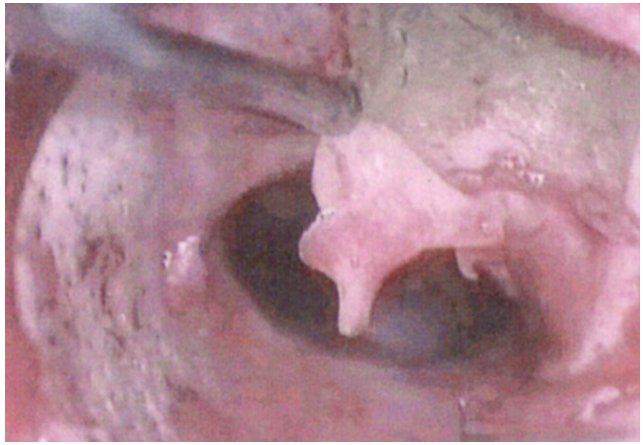


TRAVELLING WAVE THEORY

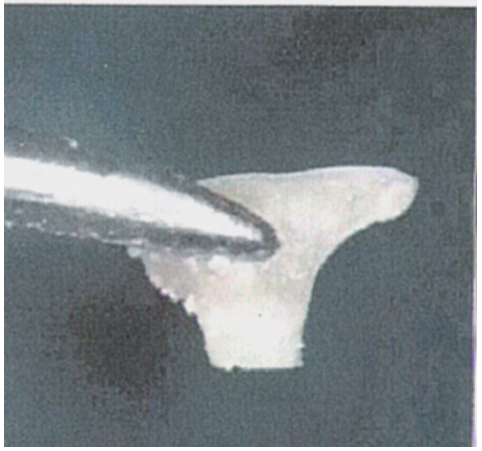
TRAGAL CARTILAGE SPLIT

AFTER SPLITTING TRAGAL CARTILAGE INTO TWO

INCUS REMOVED DURING SURGERY



RESHAPED HOMOGRAFT INCUS



VARIOUS PROSTHESES

Dusseldorf-type titanium Aerial Total Ossicular reconstruction prosthesis

Goldenberg HAPEX partial ossicular reconstruction prosthesis

Wehrs HAPEX incus-stapes prosthesis

Titanium incudostapedial joint prosthesis

	No. of Cas	Hearing Gain (dB)
Incus Tran	20	19.5
Tragal Car	13	13.25
Conchal Ca	20	8
Autograft M	7	6

	No. of Cas	Hearing Gain (dB)
With Cavity	44	18
Without Ca	16	21.5

Intact	46	Body Erode	1	Superstruc	24
Head Erod	5	Short Proc	3	Superstruc	36
Handle Erc	3	Long Proce	41		
Total Abse	6	Totally Ero	15		

Age (in yea	No. of Patients
10-20	26
21-30	20
31-40	10
41-50	4

Sex Ratio	
Male	38
Female	22

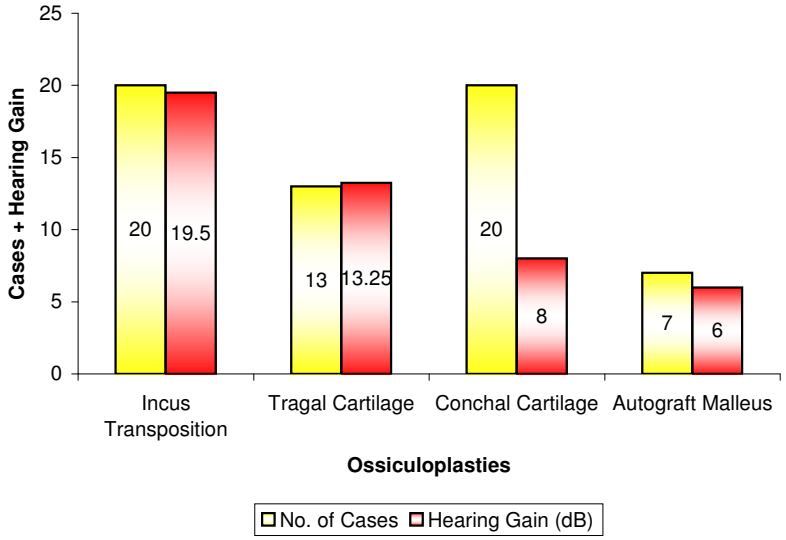
	PREOP AC GROUP
Group 1	12
Group 2	40
Group 3	8

	POST OP AC CATEGORY
Category A	14
Category B	35
Category C	10
Category D	1

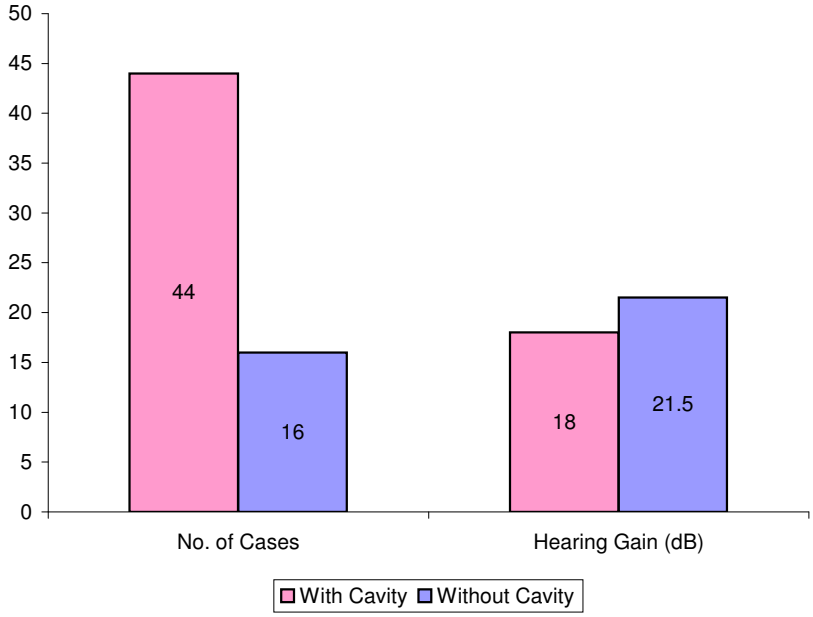
	Surgical Procedures
MRM	36
Cortical	14
Atticotomy	2
Atticoantro	4
ICW	1

Type II	20
Type III	37
Type IV	3

VARIOUS OSSICULOPLASTIES - AVERAGE HEARING IMPROVEMENT



HEARING IMPROVEMENT IN WITH/WITHOUT CAVITY



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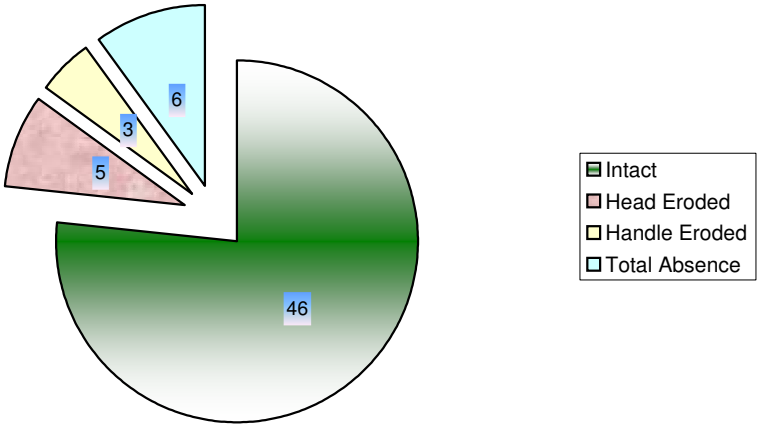

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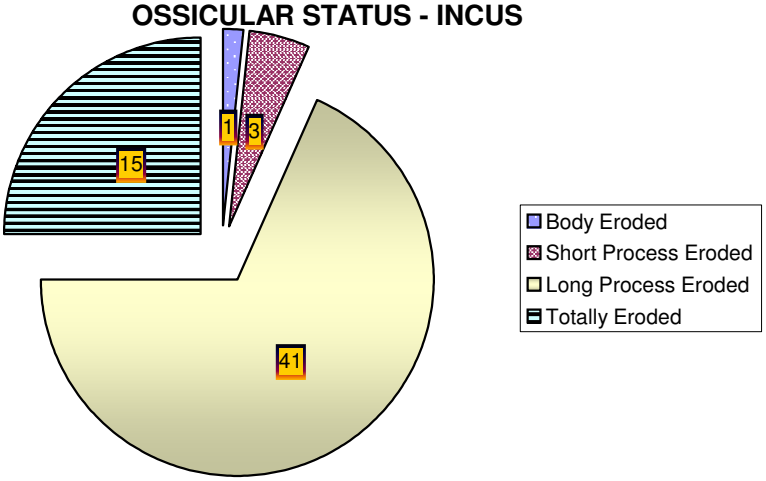

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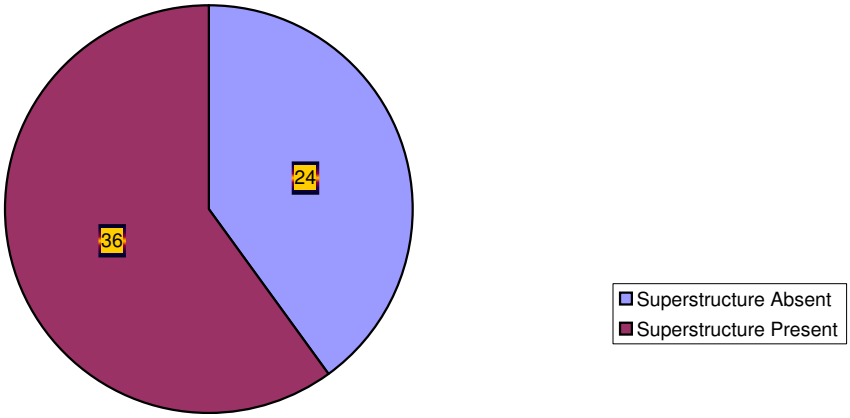

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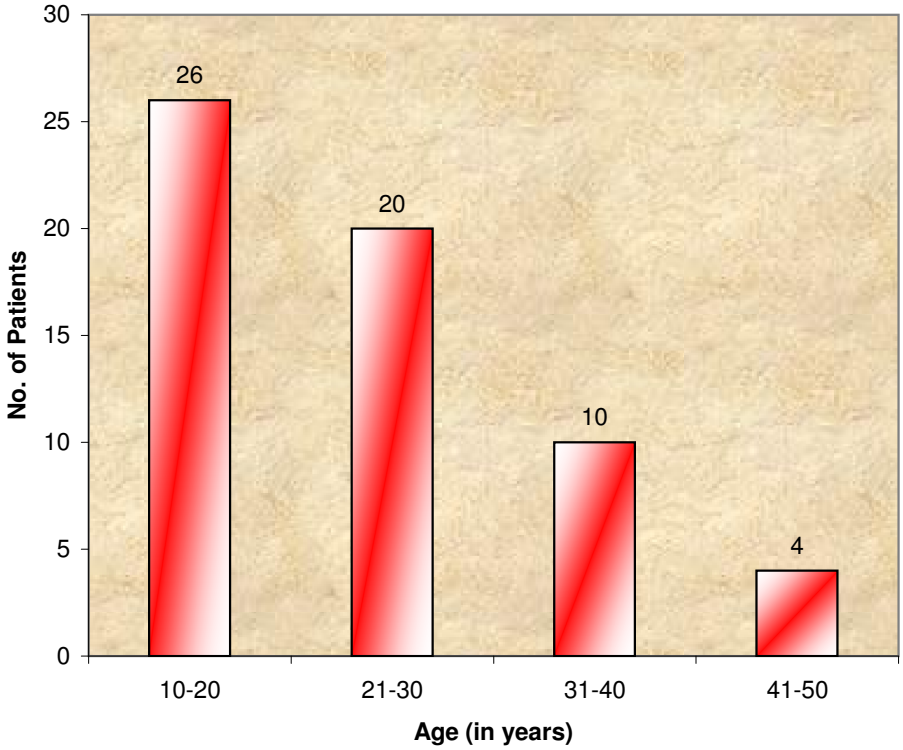

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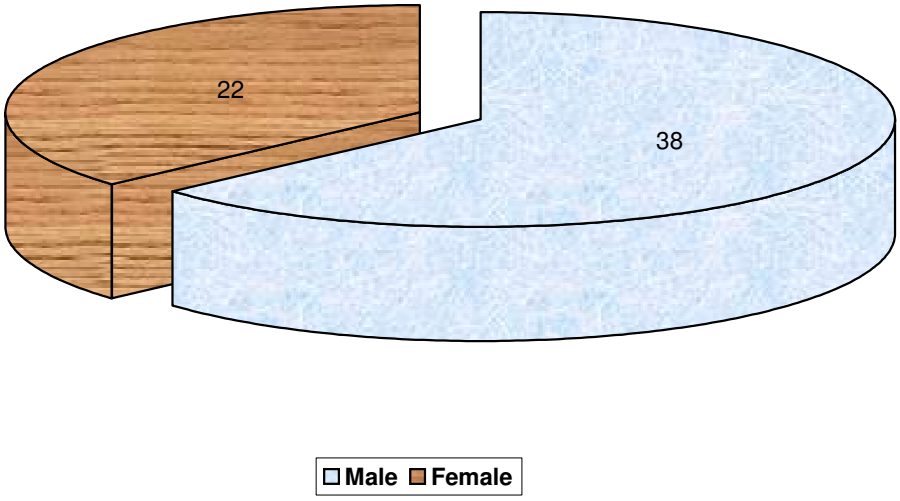
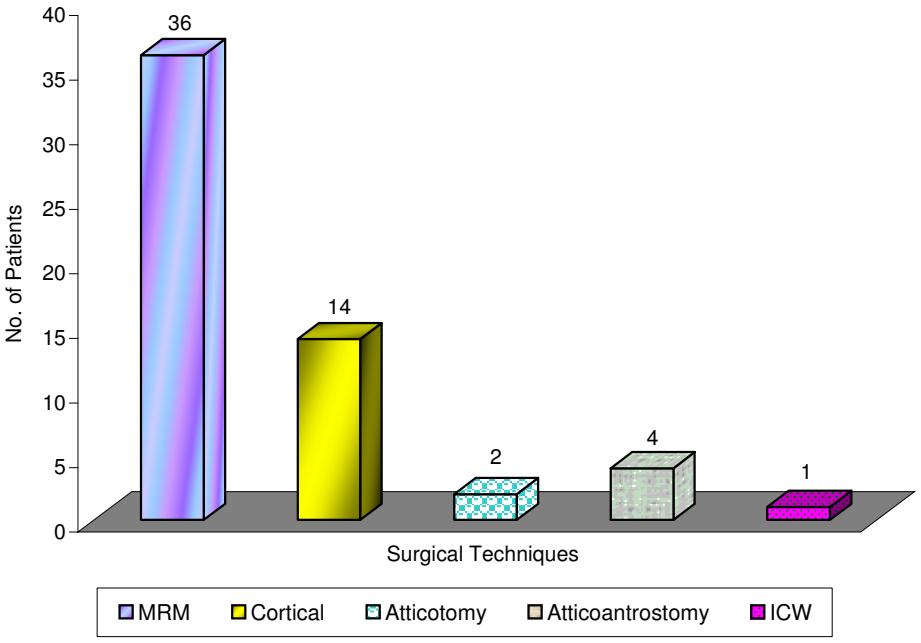


SURGICAL PROCEDURES



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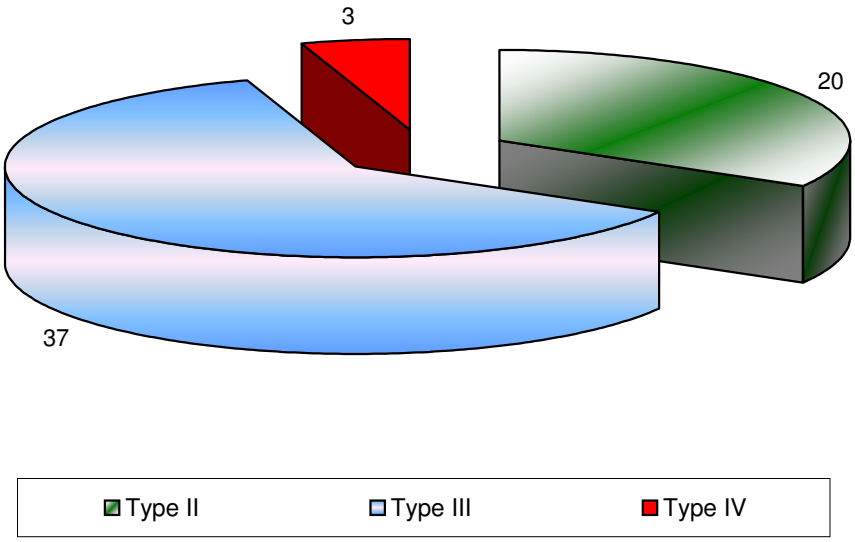

OSSICULAR STATUS, MERI, PRE AND POST OP PURE TONE AVERAGES AND GLASGOW PLOT CATEGORIES

No	Name	Age/Sex	MERI	Malleus	Incus	Stapes	Preop PTA		Postop PTA		Preop AC Group	Postop AC Category
							RE	LE	RE	LE		
1.	Poongodi	19F	9	-	-	- (FPS+)	30	44	30	30	2	a
2.	Usha Rani	19F	6	+	Body +	+	47	53	47	35	2	c
3.	Anbarasu	42 M	7	+	Body and short process +	- (FPS+)	30	28	20	28	2	b
4.	Hari	30 M	4	+	Body and short process +	- (FPS+)	30	35	30	20	2	b
5.	Riyaz	18 M	5	+	Body and short process +	- (FPS+)	18	50	18	30	1	b
6.	Desarani	29 F	8	+	Body and short process +	- (FPS+)	18	40	18	20	1	a
7.	Sundarraj	43 M	2	+	-	+	55	45	30	45	2	c
8.	Andrew	12 M	5	Head& neck +	Body and short process +	+	30	38	20	38	2	b
9.	Vairaperumal	48 M	1	-	-	- (FPS+)	48	18	30	18	1	b
10.	Rekha	22 F	5	+	Body and short process +	- (FPS+)	45	46	20	46	3	b
11.	Padmavathy	29 F	3	+	Body and short process +	+	35	45	35	30	2	c
12.	Manoj	11 M	4	+	Body and short process +	+	30	40	30	28	2	c

No	Name	Age/Sex	MERI	Malleus	Incus	Stapes	Preop PTA		Postop PTA		Preop AC Group	Postop AC Category
							RE	LE	RE	LE		
13.	Thiagarajan	11 M	6	neck and handle of Malleus +	Short process, long process and lenticular process +	+	18	35	18	20	1	a
14.	Siddhan	18M	3	+	Body and short process +	+	65	45	45	45	2	c
15.	Ramya	15F	3	+	Body and short process and long process +	+	50	37	30	37	2	c
16.	Sivakumar	16F	4	+	Body and short process and long process+	+	45	26	30	26	2	c
17.	Ramkumar	15M	2	+	Body and short process+	+	25	35	25	20	2	c
18.	Laksminarasimhan	33 M	6	+	-	+	40	25	22	25	2	c
19.	Srinivasan	28 M	5	+	Body and short prcoess and long process +	+	62	60	42	60	3	c
20.	Naga	15F	4	+	-	+	57	27	30	27	2	c
21.	Rajaselvam	36M	4	+	Body and short prcoess +	- (FPS+)	20	32	20	20	2	a
22.	Udayakumar	17 M	7	+	-	- (FPS+)	55	78	32	78	2	c
23.	Vincent	38 M	6	+	-	+	42	22	42	16	2	b
24.	Gowri	23 F	6	Neck and handle of Malleus+	Body and short process+	+	38	20	20	20	2	a
25.	Ushamalini	33 F	6	Handle of Malleus+	-	+	40	18	20	18	1	a
26.	Revathy	14F	7	+	-	- (FPS+)	65	18	35	18	1	b

No	Name	Age/Sex	MERI	Malleus	Incus	Stapes	Preop PTA		Postop PTA		Preop AC Group	Postop AC Category
							RE	LE	RE	LE		
27.	Bagyalaxmi	19F	4	+	Body andshort process and long process+	+	35	43	35	20	2	b
28.	Uma Maheswari	17 F	4	+	Body and short process+	+	18	38	18	22	1	b
29.	Mani	45 M	7	+	-	+	70	25	50	25	2	c
30.	Senthamarai	38 F	9	+	-	- (FPS+)	45	18	24	18	1	b
31.	Arumugam	28M	5	+	Body and short process+	- (FPS+)	45	25	20	25	2	b
32.	Mathews	33 M	7	Neck and handle of Malleus +	-	- (FPS+)	60	25	30	25	2	c
33.	Kalidoss	24 M	5	+	Body and short process and long process +	+	60	42	60	22	2	c
34.	Krishnaraj	17 M	3	+	Body and short process and long process +	+	32	32	20	32	3	b
35.	Nagarathnam	29 F	4	+	Body and short process +	+	20	37	20	20	2	a
36.	Syed Abu Thahir	19 M	5	+	Body and short process+	+	20	35	20	20	2	a
37.	Babuji	27 F	8	+	-	- (FPS+)	20	65	20	45	2	a
38.	Prema	35 F	7	Head and neck + Handle of Malleus partially eroded	-	- (FPS+)	28	53	28	30	2	b

No	Name	Age/Sex	MERI	Malleus	Incus	Stapes	Preop PTA		Postop PTA		Preop AC Group	Postop AC Category
							RE	LE	RE	LE		
39.	Malar	21 F	2	+	Body and short process and long process+	+	48	18	24	18	2	b
40.	Komala	25 F	2	+	Body and short process and long process +	+	22	34	22	20	2	b
41.	Palanisamy	32 M	4	+	Body and short process +	- (FPS+)	45	35	20	35	2	b
42.	Devi	26 F	3	+	Body and short process +	+	40	58	40	32	2	c
43.	Santosh	28 M	4	+	Body and short process +	+	33	35	20	35	2	a
44.	Ismail	20M	5	+	Body and short process +	+	63	63	35	63	3	c
45.	Chandrasekar	19 M	6	+	Body and short process +	- (FPS+)	57	28	35	28	2	c
46.	Viji	16 M	3	+	Body and short process +	+	70	27	35	27	2	c
47.	Maheswari	20 F	6	+	-	+	45	42	45	20	2	a
48.	Ponnamaal	35F	8	-	Body and short process +	+	38	62	38	32	2	c
49.	Bathindan	26M	6	+	Body and short process +	- (FPS+)	35	35	20	35	3	b
50.	Egambaram	24 M	5	+	Long process and lenticular process +	+	18	32	18	20	1	a
51.	Senthil	24 M	6	+	Body and short process and long process +	- (FPS+)	30	38	30	22	2	c
52.	Sridhar	18 M	7	Head and neck +	Body and short process +	- (FPS+)	18	38	18	24	1	b
53.	Vijayasarathy	21 M	8	-	Body and short process+	- (FPS+)	22	48	22	22	2	a

No	Name	Age/Sex	MERI	Malleus	Incus	Stapes	Preop PTA		Postop PTA		Preop AC Group	Postop AC Category
							RE	LE	RE	LE		
54.	Mathiyalagan	21 M	6	Neck and Handle of Malleus +	Body and short process +	- (FPS+)	66	24	32	24	2	c
55.	Karpagam	40 M	6	+	Body and short process +	- (FPS+)	50	50	50	25	3	c
56.	Chidambaram	19 M	6	+	Body and short process +	- (FPS+)	25	25	12	25	3	b
57.	Andrew	13 M	3	+	Body and short process +	+	28	30	28	18	3	b
58.	Saravanan	22 M	7	+	Body, short process and long process+	+	42	18	20	18	1	a
59.	Ramu	18 M	5	+	Body and short process +	+	45	40	22	40	2	c
60.	Sridhar	17 M	5	+	Body and short process +	+	18	38	18	20	1	a

- : Absent
+ : Present
FPS : Foot Plate of Stapes

PREOPERATIVE FINDINGS, DIAGNOSIS AND SURGERY DONE

No	Name	Age/Sex	Ear discharge	HOH	RE	LE	Diagnosis	Surgery
1.	Poongodi	19F	LE 3 year	BE 1 Year	Grade, 4 Pars tensa retraction	Attic perforation	CSOM LE AAD	LE MRM Type 4 T' Plasty
2.	Usha Rani	19F	BE 6 Months	BE 6 Months	Posterosuperior perforation with granulation	Central Perforation	CSOM BE RE AAD , LE TTD	LE MRM Type 3 T'Plasty
3.	Anbarasu	42 M	RE 7 Year	RE 6 Year	Posterousuperior retraction pocket with cholesteatoma	TM reaction grade 3	CSOM RE AAD Recurrent	RE Revision MRM Type 3 T'Plasty
4.	Hari	30 M	BE 5 Year	BE 4 Year	Attic perforation with cholesteatoma	Attic perforation with cholesteatoma	CSOM BE AAD	LE Atticoantrostomy with Type 3 T' Plasty
5.	Riyaz	18 M	LE 15 Yrs	LE 2 Year	TM normal	Posterosuperior marginal perforation with cholesteatoma	CSOM LE AAD	LE MRM Type 3 T' Plasty
6.	Desarani	29 F	LE Childhood	LE 15 Years	TM Normal	Subtotal perforation with cholesteatoma	CSOM LE AAD	LE MRM Type 3 T'Plasty
7.	Sundarraj	43 M	RE 2 Yrs	BE 2 Yrs	Grade 3 pars tensa retraction with Posterosuperior retraction pocket with discharge	Grade 3 Pars tensa retraction	CSOM BE LE AAD	RE MRM Type 2 T'Plasty
8.	Andrew	12 M	BE 6 months	BE 5 months	Attic perforation	Attic perforation	CSOM BE AAD	RE MRM Type 2 T' Plasty
9.	Vairaperumal	48 M	RE Childhood	BE 2 yrs	Attic perforation with granulation	TM Normal	CSOM RE AAD Recurrent	RE Revision MRM Type 4 T' Plasty

No	Name	Age/Sex	Ear discharge	HOH	RE	LE	Diagnosis	Surgery
10.	Rekha	22 F	BE Childhood	BE 9 yrs	Posterosuperior retraction pocket with cholesteatoma	Posterosuperior retraction pocket with cholesteatoma	CSOM BE AAD	RE MRM Type 2 T' Plasty
11.	Padmavathy	29 F	LE 3 months	LE 3 months	TM Normal	Posterosuperior retraction pocket with discharge	CSOM LE AAD	LE Atticotomy Type 2 T'Plasty
12.	Manoj	11 M	LE 3 yrs	LE 2 yrs	TM Normal	Posterosuperior marginal perforation with granulation	CSOM LE AAD	LE MRM Type 3 T' Plasty
13.	Thiagarajan	11 M	Le 5 yrs	LE 5 yrs	TM Normal	Attic perforation	CSOM LE AAD	LE MRM Type 3 T'Plasty
14.	Siddhan	18M	RE 10 yrs	RE1½ Yrs	Central perforation	TM Normal	CSOM RE TTD	RE Cortical mastoidecotomy Type 2 T'Plasty
15.	Ramya	15F	RE 1½ YRS	RE 1 YR	Central Perforation	TM Normal	CSOM RE TTD	RE Cortical mastoidecotomy Type 2 T'Plasty
16.	Sivakumar	16F	RE 2 months	RE 1 month	Posterosuperior perforation with cholesteatoma with attic perforation	Grade 2 TM retraction	CSOM RE AAD	RE Atticotomy with marginectomy Type 2 T' Plasty
17.	Ramkumar	15M	LE 3 months	LE 2 months	Grade 2 TM retraction	Posterosuperior retraction pocket with cholesteatoma	CSOM LE AAD	LE Atticotomy with intact canal wall Type 2 T' Plasty
18.	Lakshminarasimhan	33 M	RE 5 YRS	RE 4 YRS	Posterosuperior retraction pocket with cholesteatoma	Posterosuperior retraction pocket with discharge	CSOM BE AAD	RE Revision MRM Type 3 T'Plasty
19.	Srinivasan	28 M	RE2 weeks LE 5 YRS	RE 2 Weeks LE 5 YRS	Posterosuperior perforation with granulations	Posterosuperior retraction pocket with discharge	CSOM BE AAD	RE MRM Type 2 T' Plasty

No	Name	Age/Sex	Ear discharge	HOH	RE	LE	Diagnosis	Surgery
20.	Naga	15F	BE 14 YRS	BE 14 YRS	Central Perforation	Central Perforation	CSOM BE TTD	RE Cortical mastoidectomy Type 3 T'Plasty
21.	Rajaselvam	36M	LE 1 YR	LE 1 YR	Grade 3 pars tensa retraction	Posterosuperior retraction pocket Gd3 Pars tensa retraction	CSOM LE AAD	LE Atticoantrostomy Type 3 T'Plasty
22.	Udayakumar	17 M	BE Childhood	BE 10 YRS	Attic perforation	MRM Cavity with cholesteatoma	CSOM BE AAD LE Recurrent	RE Atticoantrostomy Type 4 T'Plasty
23.	Vincent	38 M	LE 1 YR	BE 1 YR	TM Normal	Attic Perforation with granulations	CSOM LE AAD RE Intact canal wall T' Plasty done	LE MRM Type 3 T'Plasty
24.	Gowri	23 F	RE 1½ YR	RE 1 YR	Central perforation	TM Normal	CSOM RE TTD	RE Cortical mastoidectomy Type 2 T'Plasty
25.	Ushamalini	33 F	LE Childhood	LE childhood	Posterosuperior marginal perforation with cholesteatoma	TM Normal	CSOM RE AAD	RE MRM Type 3 T' Plasty
26.	Revathy	14F	RE 2 yrs	RE 2 MONTHS	Central Perforation with cholesteatoma	TM normal	CSOM RE AAD	RE MRM Type 3 T' Plasty
27.	Bagyalaxmi	19F	LE Childhood	LE 5 YRS	Grade 4 pars tensa retraction	Central perforation	CSOM LE TTD	LE Cortical mastoidectomy Type 2 T' Plasty
28.	Uma Maheswari	17 F	LE Childhood	LE childhood	Gd 3 pars tensa retraction	Posterosuperior marginal perforation with cholesteatoma	CSOM LE AAD	LE Atticotomy Type 2 T' Plasty
29.	Mani	45 M	RE 4 months	RE 2 months	Aural polyp	TM normal	CSOM RE AAD	RE MRM Type 3 T' Plasty
30.	Senthamarai	38 F	RE Childhood	RE Childhood	Gd 3 pars tensa retraction	Gd 3 pars tensa retraction	CSOM RE AAD (Recurrent)	Re Revision MRM Type 3 T' Plasty

No	Name	Age/Sex	Ear discharge	HOH	RE	LE	Diagnosis	Surgery
31.	Arumugam	28M	BE 8 YRS	BE 7 YRS	Posterosuperior retraction pocket	Attic retraction pocket Grade 3	CSOM BE AAD	LE MRM TYPE 2 T'Plasty
32.	Mathews	33 M	LE 5 YRS	LE 5 YRS	Central perforation	Gd 3 para tensa retraction	CSOM RE TTD	RE Cortical mastoidectomy Type 2 T' Plasty
33.	Kalidoss	24 M	LE 7 Months	BE 7 Months	Posterosuperior retraction pocket	Posterosuperior marginal perforation with granulations	CSOM BE AAD	LE MRM Type 2 T' Plasty
34.	Krishnaraj	17 M	BE Childhood	BE Childhood	Central perforation	Central perforation	CSOM BE TTD	LE Cortical mastoidectomy Type 2 T' Plasty
35.	Nagarathnam	29 F	LE 6 months	LE 6 months	TM Normal	Central perforation	CSOM LE TTD	LE Cortical mastoidectomy Type 2 T' Plasty
36.	Syed Abu Thahir	19 M	LE 5 Yrs	LE 5 Yrs	TM Normal	Posterosuperior retraction pocket with cholesteatoma	CSOM LE AAD	LE MRM Type 3 T' Plasty
37.	Babuji	27 F	LE 2 YRS	LE 5 YRS	TM Normal	MRM Cavity with granulations	CSOM LE AAD (Recurrent)	LE Revision MRM Type 3T' Plasty
38.	Prema	35 F	Le 2 YRS	LE 2 YRS	Gd 3 pars tensa retraction	Central perforation	CSOM LE TTD	LE Cortical mastoidectomy Type 3 T' Plasty
39.	Malar	21 F	RE 2 YRS	RE 2 YRS	Grade 4 pars tensa retraction with discharge	TM normal	CSOM RE TTD	RE Cortical mastoidectomy Type 2 T' Plasty
40.	Komala	25 F	LE 1 YR	LE 1 YR	Gd 3 pars tensa retraction	Central perforation	CSOM LE TTD	LE Cortical mastoidectomy Type 2 T' Plasty
41.	Palanisamy	32 M	RE 10 YRS	RE 2 YRS	Posterosuperior retraction pocket	Gd 3 pars tensa retraction	CSOM RE AAD	RE Marginectomy Type 3 T' Plasty
42.	Devi	26 F	BE 10 YRS	BE 2 YRS	Central perforation	Central perforation	CSOM BE TTD	LECortical mastoidectomy Type 2 T' Plasty

No	Name	Age/Sex	Ear discharge	HOH	RE	LE	Diagnosis	Surgery
43.	Santosh	28 M	BE 5 YRS	RE 2 YRS	Posterosuperior marginal perforation with granulations with cholesteatoma	Central perforation	CSOM BE RE AAD, LE TTD	RE Intact canal wall Type 2 T' Plasty
44.	Ismail	20M	RE 18 YRS	RE 10 YRS	Central perforation	Gd 4 pars tensa retraction	CSOM RE TTD	ReCortical mastoidectomy Type 2 T'Plasty
45.	Chandrasekar	19 M	RE 3 Years	RE 2 Years	Central perforation with cholesteatoma	Gd3 pars tensa retraction	CSOM RE AAD	RE MRM Type 3 T'Plasty
46.	Viji	16 M	RE 6 YRS	RE 6 YRS	Central perforation	Gd 3 pars tensa retraction	CSOM RE TTD	RE Cortical mastoidectomy Type 2 T ' Plasty
47.	Maheswari	20 F	BE 5 YRS	BE 3 YRS	Attic perforation	Attic perforation with granulations	CSOM BE AAD	LE MRM Type 3 T' Plasty
48.	Ponnamaal	35F	LE 1 YR	LE 1 YR	Gd 3 pars tensa retraction	Attic perforation with granulations	CSOM LE AAD	LE MRM ype 3 T' Plasty
49.	Bathindan	26M	BE Childhood	BE 10 yrs	Posterosuperior retractio pocket with discharge	Central perforation	CSOM BE RE AAD, LE TTD	RE MRM Type 3 T' Plasty
50.	Egambaram	24 M	LE Childhood	LE10 YRS	TM Normal	Posterosuperior retraction pocket with cholesteatoma	CSOM LE AAD	LE MRM Type 3 T' Plasty
51.	Senthil	24 M	LE 14 YRS	LE 2 months	Central perforation	Attic perforation wtih cholesteatoma	CSOM BE RE TTD, LE AAD	LE MRM Type 3 T' Plasty
52.	Sridhar	18 M	LE 15 YRS	LE 2 YRS	TM normal	Posterosuperior retraction pocket with cholesteatoma	CSOM LE AAD	LE MRM Type 3 T'Plasty
53.	Vijayasarathy	21 M	LE Childhood	LE childhood	Gd 2 pars Tensa retraction	Attic perforation with cholesteatoma	CSOM LE AAD	LE MRM Type 3 T' Plasty

No	Name	Age/Sex	Ear discharge	HOH	RE	LE	Diagnosis	Surgery
54.	Mathiyalagan	21 M	RE 7 yrs	RE 2 Yrs	Posterosuperior retraction pocket with cholesteatoma	Myringitis granulosa	CSOM RE AAD	RE MRM Type 3 T' Plasty
55.	Karpagam	40 M	BE6 months	LE 5 months	Gd.2 pars tense retraction	Central perforation	CSOM BE RE AAD, LE TTD	LE Atticotomy Type 2 T' Plasty
56.	Chidambaram	19 M	BE 5 Yrs	RE 5 yrs	Posterosuperior retraction pocket	Central perforation	CSOM BE RE AAD, LE TTD	RE MRM Type 3 T' Plasty
57.	Andrew	13 M	LE 6 months	LE 6months	Post aural scar + Tm normal	Attic perforation with cholesteatoma	CSOM LE AAD RE Operated	LE MRM Type 3 T' Plasty
58.	Saravanan	22 M	RE 3 yrs	RE 3 yrs	Attic perforation with cholesteatoma	MRM Cavity	CSOM RE AAD LE Operated	RE MRM Type 3 T' Plasty
59.	Ramu	28 M	RE 2 YRS	RE 2 YRS	Gd 4 pars tensa retraction	TM Normal	CSOM RE AAD	RE MRM Type 3 T' Plasty
60.	Sridhar	17 M	LE 5 yrs	LE 4 yrs	TM normal	Attic perforation	CSOM LE AAD	LE MRM Type 2 T' Plasty