Ossiculoplasty: Indications, Contraindications and Materials Used for It: Review Article

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Abstract:

Contemporary surgical techniques for treating various pathologies affecting the middle ear address not only eradication of the underlying disease process but also restoration of normal auditory function. Trauma, neoplasms, inflammatory processes, and cholesteatomas can erode and alter normal middle ear components and relationships vital for the transmission of auditory energy to the inner ear. Restoration of normal tympanic membrane and ossicle function has its roots in the 1950s when surgeons performed and examined the role of tympanoplasty in the treatment of chronic otitis media. Over the last five decades, various ossiculoplasty techniques and prostheses have been studied and reported in the literature. Unfortunately, the multitude of reconstructive techniques attests to the fact that none of the currently available methods are ideal.

Keywords: OCR, Ossiculoplasty, Middle ear.

Introduction:

Ossiculoplasty or (OCR) represents an attempt to restore the mechanical transmission of sound from the tympanic membrane to the oval window (inner ear) when the ossicular chain has been affected by a pathological process or trauma **(1).** Ossiculoplasty can be also defined as the reconstructionof the middle ear ossicular chain which has been disrupted or destroyed by the use of some interpositioned devices which helps in regaining the original mechanics of the ossicular chain to transfer the sound energy to the inner ear **(2).**

The earliest recorded attempt to reestablish a connection between the tympanic membrane and the oval window in the case of missing ossicles was in 1901 **(3).**

In 1957, the first ossicle reconstruction was done by Hall and Ryztner by means of autograft ossicles **(4).** House et al., in (1966) introduced ossicular repair with homograft ossicles by sculpting the ossicles and fixing properly, this has been over seeded by use of synthetic biomaterials, gold and titanium which are claimed to have equally good results.

In the late 1950s and the 1960s, biocompatible material, such as polyethylene tubing, Teflon, and Proplast, were used. In the late 1970s, a high-density polyethylene sponge (HDPS) that had nonreactive properties was developed. Wehrs in 1972used homograft ossicles for reconstruction of ossicular chain **(5).**

Luetje and Denninghoff in 1987 (6) introduced cartilage ossiculoplasty especially suited for atelectatic retraction problems; with no fear of extrusion. This technique involves the incomplete incision through the cartilage, leaving the perichondrium on one side intact. **Mundada and Jaiswal in 1989 (7)** solved the problems of cartilage ossiculoplasty like displacement, loss of stiffness of the graft and maintenance of firm contact with the ossicles by creation of perichondrial pocket one side, which accommodates remnants of the incus or the handle of malleus. The presence of perichondrium with the graft helps to maintain nutrition, stiffness and the ossicular defects, with commendable hearing results **(2)**.

Aim or Goal of Ossiculoplasty:

The anatomic goal of OCR is to restore the middle ear transformer mechanism **(8).**

The goal of functional ossicular reconstruction is to obtain permanent restoration of hearing while minimizing residual conductive loss and avoiding sensorineural hearing loss **(9).**

The goal of ossicular chain reconstruction is better hearing, most typically for conversational speech. Ossiculoplasty is used to improve or to maintain the conductive portion of hearing loss. The aim of ossiculoplasty is not only to close the air bone gap but also to improve the patient's overall hearing (ie, improve the air conduction score). A patient's perceived hearing improvement is best when the hearing level of the poorer-hearing ear is raised to a level close to that of the better hearing ear. Small improvements in hearing are more likely to be appreciated by patients with bilateral hearing loss **(10).**

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 **(11).**

Indications:

The conductive hearing loss which may be the result of ossicular erosion or fixation from chronic ear disease, blunt or penetrating trauma, or congenital or neoplastic causes. It may also be associated with inner ear causes. These inner ear causes include superior semicircular canal dehiscence and an enlarged vestibular aqueduct **(2).**

Contraindications:

OCR is not performed if cochlear function is poor, particularly with regards to word discrimination. OCR is also contraindicated in an only hearing ear; a hearing aid is the preferred option in this instance. Patients with bilateral CHL should have the worse hearing ear operated on first **(2).**

Preoperative Evaluation And Prognosis Assessment:

A thorough preoperative history is performed first. Comorbidities (e.g., diabetes, coronary artery disease, and so forth) must be considered.

The benefits of surgery must outweigh the risks of surgery and anesthesia. Patients are advised against smoking, to prevent postoperative wound healing complications and to eradicate the negative effect smoking has on eustachian tube function and middle ear disease. All available outside records, including the prior operative report, should be reviewed **(10).**

CT scanning (in the axial and coronal planes, 0.5 mm or 1 mm cuts, and bone windows) is performed. The scan can assist in determining areas of tegmen erosion, facial nerve dehiscence, otic capsule erosion, and prosthesis position **(12).**

Remnant Ossicular Chain:

The more normal, intact, and mobile the remnant ossicular chain, the better one‘s chance at hearing restoration. Ossicular defects can occur singularly or in combination **(2).**

Discontinuity occurs most commonly as of (1) an eroded incudostapedial (IS) joint (approximately 80% of cases), (2) absent incus (lenticular process, long process, body), (3) absent incus and stapes superstructure, or (4) absent malleus **(13).**

If the malleus is fixed, the attic is inspected. If the malleus head cannot be mobilized by freeing it from its attachments, the head can be resected (at the neck). The tensor tympani tendon can also be lysed if needed. Isolated fixation of the malleus can cause a conductive hearing loss "CHL" of up to 25 dB. If incus fixation is noted intraoperatively, the IS joint is divided first, to prevent transmission of energy to the vestibule, which can cause iatrogenic sensorineural hearing loss and tinnitus. It is best to remove and replace the incus if incus mobility cannot be improved. If the stapes is fixed because of otosclerosis or tympanosclerosis, stapes surgery (mobilization, stapedotomy, or stapedectomy) will need to be performed. Stapes fixation can result in CHL of up to 50 dB. No removal of footplate should ever be performed in the presence of an active ear infection (including a dry TM perforation) because of the risk of labyrinthitis andsubsequent profound hearing loss **(2).**

Materials used for ossiculolasty:

In general, there are two material groups available, biological materials (autograft and homograft ossicles, cortical bone and cartilage) and alloplastics that include a broad variety of all different types of artificial materials **(14).**

Prostheses:

Ideally, implants should be biocompatible, inert, inexpensive, and easy to handle and use; they should resist adhesion formation, resorption, or fixation; and they should allow for tissue ingrowth, and stabilization and long-term hearing improvement **(12).**

The two main categories of prosthetic materials are:

1) Biologic (autografts and homografts), and

2) Synthetic (alloplasts or allografts).

Autograft Materials:

Include cortical bone chips, native ossicles (usually the incus), and cartilage (from tragus or concha). These materials are biocompatible, readily available, low in cost, and has a low risk of extrusion. Although resorption of autograft materials can occur, particularly with cartilage, autografts have shown good success **(15).**

Reconstruction in most cases is performed using the transposed incus. Reducing the long process, creating a hole to fit on the stapes head, and connecting the surface of the incudomalleolar joint toward the handle of the malleus are the common technique **(Figs. 1, 2) (14).**

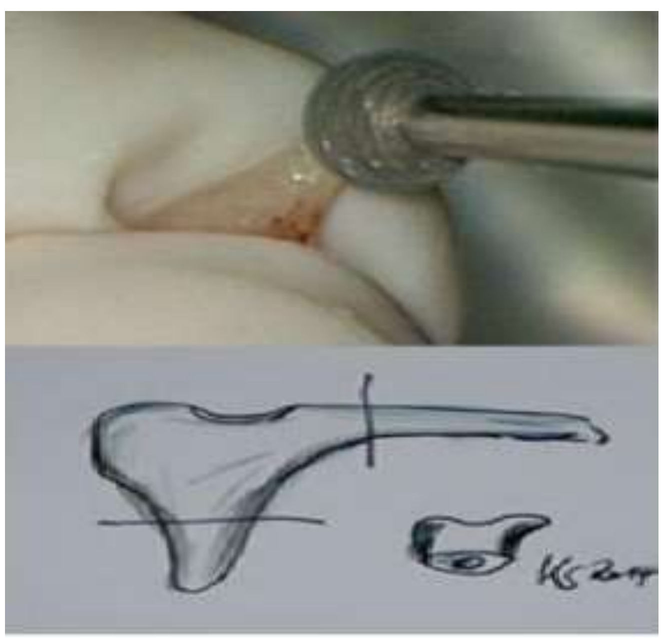

Figure (1): Drilling of either short or long process of incus for placement between head of stapes and malleus **(14).**

Figure (2): Interposition of prepared incus **(14)**

In the instance where the incus is not directly involved with cholesteatoma or is not completely destroyed by middle ear disease, it can be used to reconstruct the ossicular chain. It can either be used immediately or banked, placed in the mastoid cavity for use in ossiculoplasty at the next surgery **(16).**

Most times, the incus will need to be modified to fit the gap between the malleus and stapes. In the case where the stapes suprastructure is intact, an excellent hearing result can be achieved with any method of OCR. However, when the incus is available, it makes a perfect source for graft material. It has identical weight and composition of the same material as the other ossicles, ideally suited for conduction of sound. There is little absorption of the bone over time and it is well tolerated by the patient with low rates of extrusion due to absence of foreign material **(17).**

When the malleus is located more posterior and lateral to the stapes, the modified incus is used as an "ineterposition" graft. A groove is drilled along the joint facet of the incus remnant. A well is drilled at the base of the short process to fit on the capitulum of the stapes. The "neoincus" **(Fig 3). (18)** is then positioned between the manubrium of the malleus and on the capitulum of the stapes **(17).**

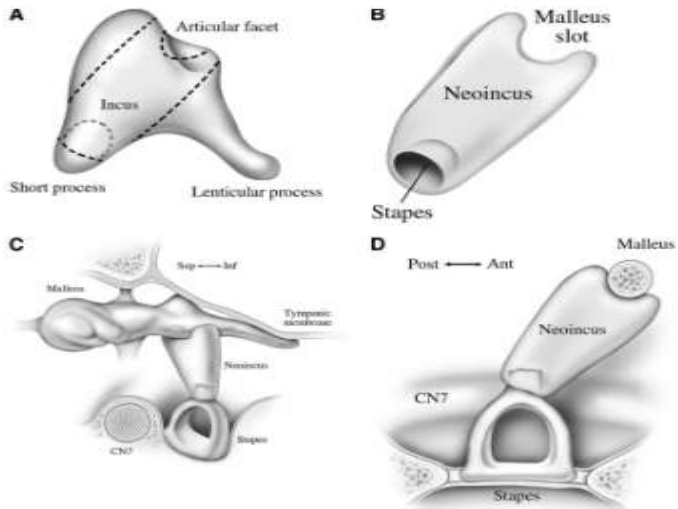

Figure (3): Incus interposition graft. Sculpted autograft incus: (A) Neoincus outline. (B) Product. (C) Lateral view. (D) Inferior view **(18).**

A similar technique is used when the malleus is in a more anterior and medial position. However, it is called an incus transposition as the stapes capitulum and manubrium are often closer in proximity with one another. This necessitates a different sculpting technique with the well placed on the incus to accommodate the stapes capitulum adjacent to the joint facet, and the groove for the malleus drilled at the junction of the short process and the body of the incus **(Fig 4). (18)** This creates a more favorable angle and better fit **(17).**

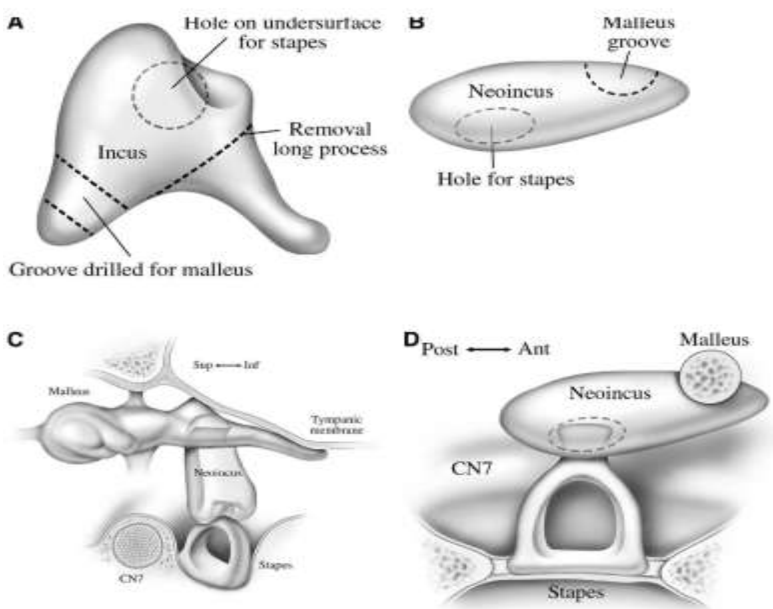

Figure (4): Incus transposition graft, Sculpted autograft incus: (A) Neoincus outline. (B) Product. (C) Lateral view. (D) Inferior view **(18)**

Harvesting of Cartilage:

Cartilage may be obtained from the tragus (most commonly) or the conchae (cymba or cavum). Tragal cartilage is ideal because it is thinner and flatter than conchal cartilage. In order to harvest tragal cartilage, the initial incision is made on the medial surface of the cartilage and extending through the medial skin, medial perichondrium, cartilage, and lateral perichondrium. A 2 mm strip of cartilage at the dome is preserved for cosmesis. Scissors are then used to dissect in the plane between the skin and the perichondrium. Dissection is extended as far as possible in each direction in order to deliver the largest piece of cartilage possible (typically 15 mm – 10 mm in children and slightly larger in adults) **(19).**

Homograft Ossicles and Cartilage:

Were first used in the 1960s.They are not as popular in the US as they once were because of concerns about Human immune deficiency virus (HIV) transmission and prion spread (and subsequent CreutzfeldtJakob disease). However, some surgeons state that autoclaving or treating the homografts with formaldehyde should eradicate viruses, and residual cholesteatoma. Homografts are typically available as cadaveric TM and ossicles, cartilage, and cortical bone. Although they have many of the same advantages and disadvantages as autografts, they arguably have a higher resorption rate **(20).**

Alloplastic Materials

Alloplastic materials have been used since 1952 for OCR **(21).** Typically, studies have shown no significant differences among synthetic prostheses in extrusion risk, failure rates, and short and long term hearing results, when comparing ears similar in ossicular defects and disease. In the presence of ear disease (i.e., CSOM), these prostheses do not function as well in OCR as when used for non-diseased ears. Compared with autografts or homografts, synthetic prostheses have a higher incidence of extrusion. Prostheses are made of numerous artificial substances, including Teflon, polyethylene, metal wire, polycel, carbon, bioactive glass, Ceravital, and aluminum oxide ceramic (**22**). Most current prostheses are made of titanium, plastipore, and hydroxyapatite "HAP" (singly or in combination) **(23).**

HAP is well tolerated, can have overgrowth of mucosa, and resists infection and resorption **(20).** HAP prostheses are the only prostheses that currently do not require placement of cartilage to prevent extrusion (extrusion rate of 5%–10%). Problems with HAP include difficulty in trimming (it requires use of a drill with irrigation) and risk of shattering. HAP has also been used in a malleable fashion as bone cement, instead of preformed prostheses **(23).**

The Appelbaum HAP prosthesis **(Figure 5)** introduced in 1993, and used to reconstruct the (IS) joint and the lever mechanism (instead of using an incus interposition graft). It is available in two sizes and connects the remnant incus long process to the stapes head. It has also been used successfully in pediatric cases with an average ABG of 15dB at 2.5 years of follow-up **(12).**

Figure (5): Applebaum incudostapedial joint prosthesis **(12).**

High density polyethylene sponge is available as plastipore, which has been used since the 1970s and was the first alloplast sold commercially worldwide **(21).** It requires the use of cartilage when in contact with the TM, to prevent extrusion. Plastipore is nonreactive and allows tissue ingrowth because of its porosity. Thus, it is used most often as a shaft material in a hybrid or combination prosthesis (eg, with HAP head). It is easy to trim and modify **(24).**

Titanium is another alloplastic material that is newer, increasingly used, and has shown much promise. It is inert, light, and rigid. Titanium was first used in 1993 **(25).** It has been reported that visibility is improved over other types of prostheses because of fenestrations in the head. Titanium requires cartilage to prevent extrusion but, overall, its success rate and extrusion rate (5%) approximates that of HAP prostheses **(21).**

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