IOSR Journal of Dental and Medical Sciences (IOSRJDMS)
ISSN: 2279-0853 Volume 1, Issue 3 (Sep-Oct. 2012), PP 32-36
www.iosrjournals.org

Behaviour of Ossicular Grafts in Otitis Media

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Abstract: *The aim of any functional reconstruction of sound transfer mechanism in ossiculoplasty is to obtain a permanent and maximum possible restoration of hearing. A thorough knowledge of the principles of ossicular reconstruction, different ossicular grafts, their merits and pitfalls and various causes of failure is mandatory for any otologist. There are innumerable graft materials available, like autologous, homologous and allograft to choose from. Nature has given such a wonderful mechanism of hearing that whatever we try to accomplish, one cannot give perfect normal hearing.*

Keywords*: ossicular grafts, ossiculoplasty, cholesteatoma, creeping substitution*

I. Introduction

The aim of any functional reconstruction of sound transfer mechanism in ossiculoplasty is to obtain a permanent and maximum possible restoration of hearing. The last few decades have witnessed many changes and modifications in techniques of ossiculoplasty. A thorough knowledge of the principles of ossicular reconstruction, different ossicular grafts, their merits and pitfalls and various causes of failure is mandatory for any otologist.

There are innumerable graft materials available, like autologous, homologous and allograft to choose from. Autologous ossicles have established their universal acceptability, whereas some have yet to prove their sustained efficacy. Success of ossicular reconstruction is determined by the nature of middle ear disease, Eustachian tube dysfunction and the surgical expertise and technique of the otologist. The most common middle ear pathology causing ossicular chain discontinuity is chronic suppurative otitis media resulting in either ossicular necrosis, erosion, dislocation or fixation due to single or combined defect of inflammation, ischemia, trauma, adhesions, granulation tissue, tympanosclerosis or cholesteatoma. In the presence such multiple variables, which influence the final outcome of ossiculoplasty and the absence of any fixed and universally acceptable protocol for reporting of results, there is need for comprehensive analysis of the merits and demerits of the different graft materials over the short and long term and needs multicentric study.

II. Aims And Objectives

1. To review literature on use of various ossicular graft in otitis media patients.
2. To collect important notes of histopathology of ossicular grafts.
3. To compare the study of ossicular chain reconstruction procedures with some of the studies of other authors
4. To discuss the behaviour of various ossicular grafts over the short and long term.

III. Materials And Methods

The present study comprises a group of 100 patients who underwent ossiculoplasty in the last five years i. e. 2007 to2011 coming with a primary complaints of chronic ear discharge and decrease hearing. A detailed history of the patients was taken. A history would give idea of either cholesteatoma or non-cholesteatomatous chronic otitis media. A thorough ENT examination would give a clue to the status of the tympanic membrane, middle ear and ossicles. Beside routine haematological and radiological investigations including x- ray mastoid Schuler's view, microscopic examination and pure tone audiogram of all the patients were done both preoperatively and postoperatively. HRCT temporal bone of some patients was done postoperatively to check out the ossicular assembly and position of graft. Of the 100 cases, 45 cases were with cholesteatoma and the rest were with non cholesteatomatous chronic otitis media. Patients with cholesteatoma were subjected to mastoidectomy with a primary or staged ossiculoplasty depending upon the extent of disease and probability of the patients reporting for follow-up, whereas patients with safe type of chronic suppurative otitis media were rendered dry prior to tympanoplasty.

Horizontal or vertical ossicular assemblies of type-IIa, IIb, IIc tympanoplasty were performed depending upon the ossicular disruptions, i.e. malleus present stapes present, malleus present stapes absent,

malleus absent stapes present, malleus absent stapes absent. Whenever required, cartilage interposition was done between ossicular graft and tympanic membrane.

Total cases- 100

A. One stage total cases – 91
1. Ossiculoplasty + Graft – 41
2. Ossiculoplasty + Intact canal mastoid + Graft -24
3. Ossiculoplasty + Modified Radical mastoidectomy + Graft= 26

B. Second stage total cases -9
1. Ossiculoplasty- 7
2. Ossiculoplasty + Posterior wall reconstruction -2

Following table shows the distribution of the different graft materials used for Ossiculoplasty:

Type of graft material	One stage	Second stage
Autologous ossicle	69	3
Homologous ossicle	7	1
Autologous cartilage	12	3
Gold Prosthesis	3	2

Revision cases: Pure tone audiometry detected failure in hearing improvement in 6 out of 100 cases after 1 year. These patients needed revision surgery at one year interval after primary surgery. These cases are tabulated as-

Type of graft material	Our series	Other studies
Autologous ossicle	1.4% (1/72)	2% English, 1971
Homologous ossicle	12.5%(1/8)	3% English, 1971 2% Schuring, 1983
Autologous cartilage	13.3%(2/15)	3.5% Mundada, 1989
Gold Prosthesis	20%(1/5)	Negligible, Pusalkar,1991

In our series, the percentage of ossicular discontinuity was much more because incidence of cholesteatoma is rampant in our country.

Austin's Classification

Ossicular chain defects	World Literature	Our Study
1. M+S+I-	59.2%	55%
2. M-S+I-	7.8%	15%
3. M+S-I-	23.2%	17%
4. M-S-I-	8.2%	13%

The best results were obtained in incus replacement by any implant and the second improvement was in type III columellar prosthesis. The worst results were when footplate was present and with any prosthesis from footplate to drum, was not more than 40%. Hence, the gain in decibel was more than 30db in incus replacement, next gain was 20db in type three columellar prosthesis and the gain was not more than 10 db when only footplate was present.

It has also been noted that the second stage ossiculoplasty gives far better results than stage one ossiculoplasty. This is because the middle ear cavity is dry and without any infection.

IV. Discussion

The objectives of any surgical procedures on the middle ear are two-fold, the eradication of the disease and achievement of hearing gain. The success rate any of the grafts used for restoration of hearing is determined to a great extent by the nature of middle ear pathology.

Most common pathology in middle ear causing ossicular chain dysfunction is chronic suppurative otitis media. This study includes only cases of infective variety.

Ideal Graft:

An ideal graft would be one which is easily available, inexpensive, inert, non-toxic, easy to sterilize, store and mould, is not extruded or absorbed, maintains its strength and does not induce any foreign body reaction. The last three decades have seen many attempts to find the most suitable grafting material, i.e. autograft and homograft ossicular bone and cartilage and the newer alloplastic materials like gold, plastics and ceramics and still the newer composite prosthesis.

Our study:

In our study of 100 cases, who underwent ossiculoplasty , in the last five years, air bone gap closure in all cases were analysed and graded as excellent, good, fair and no improvement. All the cases were followed up

once in 3 month for pure tone audiometry and microscopic examination. Pure tone audiometry detected failure in hearing improvement in 6 out of 100 cases after 1 year. These patients needed revision surgery at one year interval after primary surgery.

Type of graft material	3 months					6 months					1 year				
	No	E	G	F	N	No	E	G	F	N	No	E	G	F	N
Autologous ossicle	72	40	23	9	0	60	36	15	8	1	48	30	8	7	1
Homologous ossicle	8	5	2	1	0	7	4	2	1	0	5	3	1	0	1
Autologous cartilage	15	9	4	2	0	13	7	4	1	1	11	4	4	1	2
Gold prosthesis	5	1	3	1	0	5	1	2	2	0	5	1	2	1	1

Causes of chronic otorrhoea with a large permanent tympanic membrane perforation are the result of acute necrotic otitis media. Four types of chronic otorrhoea occur from this disease depending upon the extent of the original necrosis of tissue:

1. A benign type of chronic suppurative otitis media with central perforation, mucous membrane lining the exposed tympanic cavity, and the odourless mucoid discharge. Many of these patients have an allergic sensitization of exposed mucosa.
2. A bone invading secondary acquired cholesteatoma with marginal perforation, skin lining the tympanic cavity and extending into the epitympanum, and foul, non-mucoid discharge.
3. A bone invading chronic osteitis, chronic osteomyelitis or sequestrum with a persistently foul purulent discharge.
4. A bone invading attic retraction cholesteatoma that arises insidiously in a previously normal ear by invagination of the pars flaccida of the tympanic membrane.

Of these, the benign type of chronic otorrhoea is the most common. The secondary acquired cholesteatoma is next in frequency. Chronic osteitis without cholesteatoma is comparatively rare.

Behaviour of ossicular grafts in otitis media:

1. Autologous ossicles -

In our study of 69 cases, we utilized autologous incus and malleus and observed an extrusion rate of 1.4% (one case). The tympanic membrane healed totally in all except one case where there remained a small residual perforation due to persistent mucosal disease which was controlled and reconstructed with homologous ossicle. Hearing improvement was observed in good to excellent category.

Auto-incus and auto-malleus are best tolerated and are most easily available as compared to any of the other graft materials. They are easily available and maintain their size and shape inducing no foreign body reaction. Long term hearing gain is observed with autologous ossicles. The demerits are refixation, atrophy, revascularisation of marrow spaces and recurrence of disease due to residual micro-disease on ossicles. Plester has found histologic evidence of microscopic residual cholesteatoma in as high as 75% of his specimens.

2. Homologous ossicles-

Of 8 cases in our study, only one case (12.5%) failed on revision was found to be due to recurrence of cholesteatoma with infection. Nearly 87 % cases survive without any extrusion. These show good to excellent hearing improvement over long term. The reposited auto-ossicle appears to produce variable amount of new bone formation by vascularisation of Haversian canal marrow spaces, called creeping substitution, more quickly and to a greater extent than the homologous bone.

Prior preparation and treatment of the homologous ossicle with boiling, formaldehyde, cialit solution resulting in reduced antigenicity and also ensuring minimal contact of the graft material with host tissue are probably responsible for the good immunotolerance of the middle ear to the homograft. In special case, properly sterilized homograft from HIV- infected person could be used but it needs further study and evaluation to establish its veracity and acceptance.

3. Autologous cartilage graft-

In our series of 15 cases, an extrusion rate of 13.3%(2 cases) was observed.

The study by Mundada et al (1989) reveals that the use of tragal cartilage with its attached perichondrium gives better results, the attached perichondrium flap anchors to the remnant ossicles and thus provides enough nutrition for the survival of the grafts. Encouraging long term results are obtained with these grafts.

Revision surgery cases reveal the following effects:

Curling, thinning, loss of rigidity and in a few cases erosion, resorption and fibrosis. Steinbach and Pusalkar have found the cartilage to be covered by normal mucosa with no evidence of inflammatory reaction and minimal vascular proliferation.

4. Gold Prosthesis-

Of 5 cases in our study, only one case (20%) failed. The gold prosthesis (bell and antenna types) available for ossicular reconstruction; provides excellent results as far as hearing gain is concerned. Interposition of cartilage buffer between the prosthesis and tympanic graft is suggested to reduce the extrusion rate as observed by us. It has been observed that cartilage implant loses rigidity, it maintains mass and therefore serves satisfactorily as buffer between the alloplast prosthesis and the host tissues.

Histopathology 0f Ossicular Grafts

Middle ear ossicular grafts and prosthesis are unique in many ways compared with implants placed elsewhere in the body. Ossicular grafts must couple well at their ends to bone or soft tissue, but most remain suspended in air elsewhere to avoid unwanted ankylosis. They must not only maintain their size and shape; but also their acoustic transmission properties over long periods. Furthermore persistent or recurrent infection can predispose to breakdown and resorption of implant and tubal insufficiency can accelerate extrusion.

Finally homografts and synthetic ossicular grafts are potentially subject to immune- mediated rejection. Histopathplogic study of ossicular grafts can provide insight into some of these factors that determine success rate for ossicular reconstruction.

1. Ossicles- Autograft incus and malleus maintain their contour, size, shape and physical integrity for long periods, at last upto 11 years. After implantation, graft becomes nonvital because of loss of blood supply, which is characterised histopathologically by drop out of osteocytes and empty Haversian canals devoid of blood vessels. It is critical to avoid thermal injury when sculpturing such grafts and the generous of irrigation is recommended. After implantation, grafts undergo new bone formation and remodelling by a slow process of creeping substitution, the rate of which depends upon revascularisation of the graft and not on duration of implantation. Neo-osteogenesis and remodelling of an ossicular autograft are not necessary, from functional standpoint.

Nonvital grafts appear to maintain their morphology, structure and integrity and therefore transmit sound. Middle ear grafts, however, are subject to resorption by rarefying osteitis when there recurrent middle ear suppuraton.

Histopathologic changes in homograft are similar to those in autograft except that creeping substitution occurs much rapidly.

2. Cartilage- The longetivity of this graft is more than bone grafts. Cartilage grafts are unsatisfactory as ossicular grafts. Loss of stiffness probably results from chondromalacia. Ingrowth of blood vessels and accompanying chondritis occur, which would eventually lead to resorption. Such vascularisation can also lead to calcification. The risk of a specific immune rejection response in homograft cartilage specimens may be related to the known ability of cartilage to be relatively immunoprivilaged by virtue of its avascularity and possibly due to rejection of chondrocytes provided by its matrix. Such grafts generally retain viability and remain functional in short term. With increasing duration or in the presence of recurrent disease or tubal dysfunction, there is a high incidence of degeneration of chondrocytes and resorption of cartilage.

3. Gold Prosthesis- In ears with chronic supppurative otitis media, surface of implant was infiltrated with blood vessels, lymphocytes and round cells. Extruded prosthesis showed fibrous tissue lining the implant and carbon powder particles deposited in tissue lining the implant and in adjacent middle ear mucosa.

Light microscopy revealed small numbers of macrophages and multinucleated giant cells at the implant- tissue interface with implant derived material in the cytoplasm of cells, indicating microscopic biodegradation.

V. Summary And Conclusion

The success of ossiculoplasty is dependent on various factors like the proper selection of patients, nature and extent of middle ear disease, Eustachian tube function and the appropriate type of graft material used as well as proper preparation, treatment and the presentation of the graft selected. Today there is a place for biologic and synthetic implants for use in ossicular reconstruction. Cost effective material most freely available include autologous and homologous ossicular bone and cartilage. Autologous ossicles and cartilage grafts show varying amount of conversion to viable bone; but even after extended period of time, large amount of viable remain. Bone and cartilage graft maintain their size and the contour showing no tendency to resorb and incite prolific growth. Cartilage graft maintain their volumetric integrity; but loose rigidity over period of time.

Because of multiple variables which influence the final outcome of the ossiculoplasty and the absence of any fixed and universally accepted protocol for reporting of results, there is no need for comprehensive analysis of the merits and demerits of different graft materials over the short and long term and needs multicentric study.

An ideal graft is that which is biocompatible, inexpensive, easy to sterilize, readily available, techniqually easy to use, and gives good hearing results. More research needs to be done to study the histologic fates of all type of ossicular grafts in the human middle ear, especially "In Situ" human temporal case studies.

Nature has given such a wonderful mechanism of hearing that whatever we try to accomplish, one cannot give perfect normal hearing. The surface area ratio, the tension flexibility and mobility of ossicles are a marvellous combination, which a human being cannot achieve by their sources at its hand.

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