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Original Article

Post-operative Auditory Gain in Patients Undergoing Intact Canal Wall Mastoidectomy and Ossiculoplasty with Primary Malleus Transposition (Rotation) Ossiculoplasty

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Abstract

Background: The absence of the long process of the incus with or without the absence of the stapes superstructure accounts for >80% of the ossicular deformities encountered during surgery for chronic suppurative otitis media. Instead of using various interposing prosthesis in vogue to simplify ossicular reconstruction, to reduce time and cost, and to improve functional outcomes by retaining the catenary lever function of the handle of malleus, malleus is used by repositioning it. The present study evaluates auditory gain after 1-year post-operative follow-up.

Aim of the Study: This study aims to conduct audiological evaluation of patients who underwent malleus repositioning ossiculoplasty over a period of 36 months.

Materials and Methods: A total of 56 patients undergoing cortical mastoidectomy and ossiculoplasty in a tertiary care hospital in Kerala over a period of 3 years were included in the study. Pure tone audiometry done, pure tone average (PTA) was calculated for the speech frequencies (500 HZ, 1000 HZ, and 2000 HZ). Air-bone gap was calculated and tabulated. Ossicular status during surgery was typed according to Austin[17] and Kartush[18] classification.

Procedure: Malleus transposition and assembly with stapes were done. All the data were tabulated and analyzed using standard statistical methods.

Observations and Results: Among 56 patients, 29 (51.78%) were males and 27 (48.21%) were females. The mean auditory gain in PTA among all the operated patients was 24.65 ± 1.20 dB. Mean air-bone gap closure was 26.30 ± 3.10 dB.

Conclusions: Malleus relocation is a safe and efficient technique for ossicular reconstruction. The ideal position of the relocated malleus allows easier and more stable placement of middle ear ossicular grafts or prostheses. It helps to reduce operative time and cost and to improve functional outcomes by retaining the catenary lever function of the handle of malleus.

Key words: Autograft, Catenary lever, Chronic suppurative otitis media, Malleus, Ossiculoplasty, Prosthesis, Stapes, Tympanoplasty

INTRODUCTION

Post-ossiculoplasty results of auditory gain depend on the presence or absence of malleus particularly in the absence of a stapes superstructure.[1] Malleus has a catenary lever mechanism in enhancing the sound pressure levels of the sound arriving at the tympanic membrane.[2] Review of literature shows emphasize by many authors about the importance of the malleus in successful ossiculoplasty.[1-4] Recreation of the malleus has been used by many authors to enhance middle ear prosthesis stability.[5-7] Sometimes, the presence of an anteriorly positioned malleus presents a difficult situation to the otologist. Where an absent or a severely deformed anterior malleus is present, the usual methods of ossiculoplasty described in literature are using reconstruction from the stapes head (or footplate) directly

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to the eardrum;[8,9] however, placement of stapes head directly under the medial surface of the eardrum increases the possibility of both perforation and extrusion.[8,10] Many authors believe that an acoustic benefit can be achieved by repositioning the malleus to assemble with head of stapes as opposed to attaching the remnant tympanic membrane directly to the stapes head, due to the catenary lever action of the malleus-tympanic membrane assembly. There is large evidence in literature confirming the presence of the malleus as an important prognostic factor in ossiculoplasty, leading to better hearing results and lower rates of extrusion due to its role in preventing tympanic membrane lateralization.[11] As cited by Miller "De Vos, Gersdorff, and Gérard confirmed that the absence of the malleus as an adverse prognostic factor because its presence not only gives stability to the reconstruction but also acts as catenary lever, thereby contributing to acoustic gain," malleus transposition seems to play a resourceful method of ossiculoplasty.[12] One should also appreciate that not only the presence of malleus but also its position and angle of contact with the stapes also that affects hearing outcomes.[13] Vlaming and Feenstra have demonstrated with their work; the ideal position of malleus was when the malleus was positioned directly over the stapes. However, in practice, this anatomic configuration is very rare. It can be easily achieved with malleus relocation techniques, especially after cutting the tensor tympani tendon.[14] The theory of sound transmission in such assemblies was that all of the force of vibration through the malleus would be converted into an efficient piston-like motion at the footplate.[15] Whereas in ossiculoplasty procedures, where the malleus is malpositioned, it would be often unstable and mechanically inefficient, particularly if the malleus is angulated >45° from the axis of the stapes superstructure or footplate.[16] Malleus relocation acts to reduce the angle to zero as the relocated malleus is positioned over the stapes head or footplate, allowing ideal placement of the prosthesis. In addition, this configuration allows an almost perpendicular direction of forces to the footplate, with optimal transfer of function and minimal dissipation of energy. Pre-reconstruction ossicular status classified by Austin[17] and modified by Kartush[18] shows in Group A: Malleus and stapes intact and mobile, in Group B: Malleus and stapes footplate present and mobile, stapes superstructure absent. In this study auditory gain in patients 1 year after malleus transposition was evaluated. In this study, auditory gain obtained following malleus transposition in patients after 1 year of study was evaluated.

MATERIALS AND METHODS

A total of 56 patients were included in this study who underwent cortical mastoidectomy and ossiculoplasty in department of ENT, KMCT Medical college, Manassery, Kozhikode, Kerala over a period of 3 years. An ethical committee clearance was obtained from the institute before the commencement of the study. An ethical committee approved consent form was used or the study.

Inclusion Criteria

1. Patients of all age groups were included in the study.
2. Patients undergoing only cortical mastoidectomy and ossiculoplasty were included in the study.
3. Patients who had absent or gross necrosis of long process of incus were included in the study.
4. Patients undergoing malleus repositioning were included in the study.
5. Patients who had intact stapes or stapes with loss of superstructure were included in the study.

Exclusion Criteria

1. Patients undergoing modified radical mastoidectomy surgery for cholesteatoma were excluded from the study.
2. Patients with intense scarring of the middle ear mucosa were excluded from the study.
3. Patients with complications of chronic suppurative otitis media were excluded from the study.
4. Patients with pre-operative retraction pockets in the tympanic membrane were excluded from the study.

All the patients were subjected to thorough history taking and ENT clinical examination. Audiological evaluation using pure tone audiometry was done. Pure tone average (PTA) was calculated for the speech frequencies (500 HZ, 1000 HZ and 2000 HZ). Air-bone gap was calculated and tabulated. Cortical mastoidectomy with intact canal wall procedure was adopted to clear the disease inflammatory tissue for all the cases. Aditus patency was obtained in all the cases to ensure graft uptake. During surgery, ossicular status was noted and typed according to Austin[17] and Kartush[18] classification. Group A: Malleus and stapes intact and mobile, Group B: Malleus and stapes footplate present and mobile, stapes superstructure absent.

Procedure

After dissecting the malleus free from the tympanic membrane, the tensor tympani tendon was sectioned as close as possible to its insertion to the malleus handle. If a deformed incus with a necrosis long process is present, it needs to be removed before division of the tensor tympani tendon. Using a strong right angle hook placed anterior to the neck, the malleus is then progressively retracted posteriorly until it lies directly above the stapes capitulum or footplate. To avoid subsequent anterior retraction of

the malleus, the anterior malleal ligament needs to be overstretched which can be achieved by stretching the malleus until the umbo reaches the posterior canal wall. The position of the malleus is maintained by the superior ligament of the malleus, which is preserved. Initially, the distance from malleus to stapes footplate is determined using the measuring rod which is used in stapes surgery, before relocating the malleus. The malleus is posteriorly relocated to connect the handle of malleus to the head of stapes in the presence of superstructure. In the absence of superstructure an interposed homograft cartilage or reshaped incus is used. The relocated malleus should lie immediately above the stapes footplate (0 degree alignment). Post operatively, the patients were discharged the next day and reviewed on day 5 for suture removal, then followed up every 2 weeks for the first month and then after 2 months. Post operative evaluation with pure tone audiometry and calculation of PTA was done after 1 year. All the data was tabulated and analysed using standard statistical methods.

OBSERVATIONS AND RESULTS

A total of 56 patients included in the study underwent malleus transposition ossiculoplasty by a single surgeon. There were 29 (51.78%) males and 27 (48.21%) females in the study. Patients belonged to the age group ranging from 18 years to 66 years with a mean age of 35.40 ± 4.15 years [Table 1].

Pre-operative auditory evaluation showing mean PTA and air-bone gap in different age groups is tabulated in Table 2.

The per-operative ossicular status of the patients according to Austin-Kartush classification is shown in Table 3.

The post-operative audiological evaluation of the patients after a follow-up of 12 months was recorded and tabulated in Table 4.

The mean auditory gain in PTA among all the operated patients was 24.65 ± 1.20 dB. Mean air-bone gap closure was 26.30 ± 3.10 dB.

DISCUSSION

Catenary Lever

The attachment of the tympanic membrane at the annulus amplifies the energy at the malleus due to the elastic properties of the stretched drumhead fibers producing a catenary lever effect. As the bone surrounding the

Table 1: The age and gender incidence of the study group (*n*=56)

Age groups/gender	18–33 years	34–48 years	49–64 years	65 and above
Male - 29 (51.78%)	8	11	7	3
Female - 27 (48.21%)	6	9	8	4

Table 2: PTA and air-bone gap values preoperatively in the study group (*n*=56)

Age groups/PTA	18–33 years	34–48 years	49–64 years	65 and above
25–35 dB - 23	6	9	6	2
36–45 dB - 23	5	10	5	3
46–55 dB - 10	3	1	4	2
Mean air-bone gap	24 dB	28 dB	32 dB	26 dB

PTA: Pure tone average

Table 3: The ossicular status of the study subjects (*n*=56)

Type of ossicular status	18–33 years[14]	34–48 years[20]	49–64 years[15]	65 and above[7]
Type A	05	08	06	03
Type B	09	12	09	04

Table 4: PTA and air-bone gap values postoperatively in the study group (*n*=56)

Age groups/PTA	18–33 years	34–48 years	49–64 years	65 and above
25–35 dB	1	2	2	1
36–45 dB	2	3	3	1
46–55 dB	2	2	1	0
Mean air-bone gap	24 dB	28 dB	32 dB	26 dB

PTA: Pure tone average

tympanic membrane annulus is immobile, sound energy is directed away from the edges of the drum and toward the center of the drum. The malleus receives the redirected sound energy from the edge of the drum due to the central location of the manubrium. The catenary lever provides at least a 2-fold gain in sound pressure at the malleus. In the malleus relocation technique, according to Vlaming and Feenstra,[14] all of the force of vibration through strut prosthesis would be converted into an efficient piston-like motion at the footplate. Vector analysis of the resultant forces at the stapes demonstrates that in the presence of a malleus-stapes offset, some of the energy is converted into an inefficient rocking motion at the footplate. At the point of contact with the malleus handle, the prosthesis will make an angle alpha with the force F exerted by the tympanic membrane. The force component F1 along the prosthesis will have a magnitude to cosine alpha. Greater the angle alpha, lesser is the efficient mechanism. Tilting is minimized when the angle alpha is small at least <30°. With greater angle, most of the energy is lost due to tilting of the footplate. Ideally, an angle of zero would enable the prosthesis to transmit the entire force to the stapes without dissipation. When the malleus is malpositioned, ossiculoplasty is often unstable and mechanically inefficient, particularly if angulated >45° from the axis of the stapes superstructure or footplate. Our technique of malleus relocation is supported by the work of Vlaming and Feenstra.[14] The malleus relocation technique reduces the angle alpha to zero as the relocated malleus is easily positioned over the stapes head or footplate, allowing ideal placement of the prosthesis.[14] Audiometric assessment included pre and postoperative audiometric evaluation using pure tone audiogram and air-bone gap. Overall auditory gain was appreciable by the patient subjectively. To simplify ossicular reconstruction, the present method is adopted which makes use of patient's intact malleus. The malleus is posteriorly relocated to connect the handle of the malleus to the head of stapes in the presence of superstructure. In the absence of superstructure an interposed homograft cartilage or reshaped incus is used. Audiometric assessment included pre- and post-operative audiometric evaluation using conventional audiometry (PTA) and air-bone gap. Overall, auditory gain was appreciable by the patient subjectively.

CONCLUSIONS

Malleus relocation is a safe and efficient technique for ossicular reconstruction. The ideal position of the relocated malleus allows easier and more stable placement of middle ear ossicular grafts or prostheses. It helps to reduce operative times and cost and to improve functional outcomes by retaining the catenary lever function of the handle of malleus.

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