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The Benefit of Trans-Attic Endoscopic Control of Ossicular Prosthesis After Cholesteatoma Surgery

Hassan Haidar, MD ©; Zaid Abu Rajab Altamimi, MD; Aisha Larem, MD; Waqar Aslam, MD; Ali Elsaadi, MD; Hassanin Abdulkarim, MD; Emad Al Duhirat, MD; Ashraf Nabeel Mahmood, MD; Abdulsalam Alqahtani, MD

Objective: To show the efficiency of using transmastoid atticotomy (TMA) endoscopy on the outcome of ossiculoplasty in patients with cholesteatoma. TMA is often performed as part of the surgical management of patients with middle ear cholesteatoma extending to the epi-tympanum. TMA can also be used as an access for endoscopic view to confirm the right alignment and stability of the ossicular prosthesis because the reconstruction of the tympanic membrane will obscure the visualization of the prosthesis.

Methods: A retrospective study was done at a tertiary referral institute, including 133 ears with cholesteatoma that underwent canal wall-up tympanomastoidectomy (CWU) with ossicular reconstruction using titanium prosthesis between August 2013 and August 2015. Post packing of the ear canal and position, stability, and axis of the prosthesis were checked using endoscope positioned in the attic through TMA. A postoperative pure-tone average air–bone gap (ABG) of 20 dB or less was considered as a successful hearing result. Results are compared with historical control groups.

Results: Of the 133 ears, 88 patients underwent reconstruction with partial ossicular replacement prosthesis (PORP), whereas the rest (45 patients) had total ossicular replacement prosthesis (TORP). A postoperative ABG ≤ 20 dB was obtained in 77.4% of all the patients (79.5% for PORP; 73.3% for TORP).

Conclusion: Endoscopic assessment of the ossicular prosthesis via the attic, after repositioning of the tympanomeatal flap and packing the ear canal, decreases the risk of immediate ossiculoplasty failure and improves the functional outcome after ossicular chain reconstruction in cholesteatoma surgery.

Key Words: Cholesteatoma, mastoidectomy, ossicular chain reconstruction, partial ossicular replacement prosthesis, atticotomy, total ossicular replacement prosthesis.

Level of Evidence: 4

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INTRODUCTION

Adequate hearing restoration in ears with cholesteatoma, where ossicular chain interruption is frequent, has been always a challenge for otologist. Obtaining optimum ossiculoplasty results depend on several factors; the major factors include the biomechanical properties of the prosthesis, techniques of reconstruction, and the severity of the middle ear disease. Certain variables such as middle ear fibrosis, adhesive otitis, and significant Eustachian tube dysfunction are not easily controlled by the otologist. However, variables that can be controlled by the surgeons are the type of prosthesis used and the surgical technique applied.

The introduction of titanium prosthesis over the last decade has given it a cutting edge due to its favorable features of tissue compatibility, durability, rigidity, lightweight, and excellent acoustic transmission capability.1–7

Immediate ossiculoplasty failure is most likely due to technical factors. Positioning the prosthesis is a key step to achieve ideal audiological results. The prosthesis may be displaced, dislodged, or bent after repositioning of the tympanomeatal flap and packing the external auditory canal, especially in cholesteatoma surgery for which the use of a large tragal graft to reinforce the tympanic membrane is necessary to reduce the risk of recurrence of cholesteatoma and prevent prosthesis extrusion. The displacement of the prosthesis cannot be visualized through the external auditory canal after placement of the cartilage graft and repositioning of the tympanomeatal flap.

In canal wall-up (CWU) procedures that preserve the outer auditory canal wall, a transmastoid atticotomy (TMA) is always done to control the attic area and ensure attic micoventilation pathways. We propose to take benefit of this trans-attic window, which permits controlled placement of prosthesis over the steps head or its footplate after repositioning the tympanomeatal flap and packing the ear canal.
In this article, we describe an original technique in order to assess the befitting alignment and stability of ossicular reconstruction, after repositioning of the tympanomeatal flap and filling the ear canal with Gelfoam, using a 30-degree endoscope, through TMA.

Our hypothesis is that, this technique will decrease the risk of immediate ossiculoplasty failure after cholesteatoma surgery.

MATERIALS AND METHODS

Population
We conducted a retrospective study review in our ear, nose, and throat department in the period running between August 2013 and August 2015. We included all patients with chronic otitis media with cholesteatoma, who underwent CWU mastoidectomy with primary or secondary titanium ossicular reconstruction using a partial ossicular prosthesis (PORP) or total ossicular prosthesis (TORP). We excluded ossiculoplasty cases without mastoidectomy or canal wall down (CWD) mastoidectomy, and cases with incomplete documentation.

From an initial group of 189 patients with intact wall mastoidectomy and titanium ossiculoplasty, 129 patients, with a total of 133 ossiculoplasties, had a complete documentation and were included in our study.

Methods

Surgical Technique. All patients were operated with CWU mastoidectomy under general anesthesia. After disease clearance and tympanic membrane reconstruction with tragal cartilage, ossicular reconstruction was done using titanium TTP®-VARIO SYSTEM Adjustable Length prostheses (Kurz, Germany). Accurate sizing of the PORP or TORP prosthesis was determined using the disposable plastic Kurz implant dummy sizer.

In ears with missing incus and mobile stapes, a PORP was used; whereas for those with obliquely oriented or missing stapes and mobile footplate, a TORP was used.

While sizing the Vario prosthesis (Kurz), we kept a 0.5 mm pin above the prosthesis plate to be inserted in tympanic membrane cartilage graft; this ensured a stable coupling of the prosthesis into the neo-tympanic membrane. In case of PORP, we crimped the cup of the prosthesis to the head of stapes, whereas in TORP we used cartilage shoe to stabilize the prosthesis in the oval window niche. The tympanomeatal flap was then repositioned, and the external auditory canal (EAC) was packed with medicated Gelfoam; Pfizer Inc, New York, NY, USA.

A 4-mm 30-degree endoscope was placed in the attic through the mastoid, looking to the position and axis of the prosthesis (Fig. 1), while pushing the gelfoam in the EAC using a pick and at the same time checking the stability and mobility of the prosthesis. In cases of improper axis or displaced prosthesis, the middle ear was re-entered, and the prosthesis was re-adjusted with subsequent transmastoid endoscopic examination confirming adequate montage.

Outcome Measures
The main outcome measures early postoperative hearing improvement 6 months after the surgery because we aimed in our study to assess the immediate outcome. It is mainly affected by the surgical technique rather than long-term outcome, which is affected more by the pathology and the disease process. Each patient underwent appropriate pure-tone audiometry (PTA) and speech audiometry preoperatively and 6 months postoperatively.

The average PTA for bone conduction (BC) and air conduction (AC) and air–bone gap (ABG) of 0.5, 1, 2, and 3 kHz, respectively, were calculated according to the reporting guidelines from the American Committee on Hearing and Equilibrium. Word recognition score (WRS) was calculated preoperatively and postoperatively, measured using a validated recording in the patient’s native language, a minimum 50-word list, and a standardized presentation level of 40 dB sensation level.

Statistical Analysis
Descriptive statistics in the form of mean and standard deviation for interval variables, counts, and percentages for categorical variables were performed. Student paired t-tests were performed to see a significant difference within pre-observations and post-observations of ABG, WRS, AC, and BC for overall and according to surgery type. One-way analyses of variance were performed to see mean differences of ABG, WRS, AC, and BC according to surgery type (P value 0.05, two-tailed). SPSS 21.0 statistical package (IBM Corp., Armonk, NY) was used for analysis.

RESULTS
PORP ossiculoplasty was used in 88 cases (66%), whereas TORP were used in 45 cases (34%). Table I
Table II compares the postoperative hearing levels to preoperative ones for all ears, as well as for each type of ossiculoplasty. Overall, there was significant improvement in ABG. Whereas the mean preoperative ABG was 30.8 ± 11, the postoperative mean ABG became 14.8 ± 11.8, showing a statistically significant reduction in the ABG (P < 0.001). Preoperative and postoperative BC in total cases was maintained, with 20.8 ± 12.5 dB and 20.3 ± 13.3 dB, respectively (P value = 0.54).

Immediate postoperative ABG ≤ 20 dB was obtained in 103 ears (77.4%). A successful postoperative hearing was achieved in 70 of PORP procedures (79.5%). The mean ABG for PORP preoperatively was 29.6 ± 10.6 dB, which became 12.9 ± 11 postoperatively; the mean improvement in ABG for PORP was 16.7 ± 14 dB (range: 0 to 45 dB) with P value = 0.0001. A successful postoperative hearing was achieved in 33 of TORP procedures (73.3%). The mean ABG for TORP preoperatively was 33.3 ± 11.4 dB, which became 18.7 ± 12.3 postoperatively. The mean improvement in ABG for TORP was 14.7 ± 13 dB (range: 0 to 50 dB) with P value = 0.0001.

Regarding the complication that we faced, we had two cases (1.5%) with prosthesis dislocation, which was due to tympanic lateralization in one case and short prosthesis in the other case; extrusion in three cases (2.2%), two TORP and one PORP; one (0.8%) sensorineural hearing loss (SNHL) in a TORP case; and one (0.8%) residual cholesteatoma with re-perforation of the drum.

### DISCUSSION

Ossiculoplasty is an effective surgical intervention to treat conductive hearing loss due to ossicular chain discontinuity. Ossicular chain reconstruction has been a challenge for many years.
The present study showed that using the TMA endoscopic view in cholesteatoma surgery to confirm the position of an ossicular prosthesis improves the success of hearing reconstruction.

Satisfactory hearing results following ossiculoplasty mainly depend on the total eradication of disease, good aeration of the middle ear, and a stable and proper connection between the tympanic membrane and the stapes.9

TABLE II.
Description of Audiological Parameters According to Type of Ossiculoplasty.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total Ears (133)</th>
<th>Ossiculoplasty With PORP (88)</th>
<th>Ossiculoplasty With TORP (45)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABG Mean ± SD</td>
<td>30.8 ± 11</td>
<td>29.6 ± 10.6</td>
<td>33.3 ± 11.4</td>
</tr>
<tr>
<td>Postoperative</td>
<td>14.8 ± 11.8</td>
<td>12.9 ± 11</td>
<td>18.7 ± 12.3</td>
</tr>
<tr>
<td>Closure</td>
<td>16 ± 13</td>
<td>16.7 ± 14</td>
<td>14.7 ± 13</td>
</tr>
<tr>
<td>P value</td>
<td>0.001</td>
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<tr>
<td>WRS Mean ± SD</td>
<td>93.4 ± 8.1</td>
<td>94.4 ± 7.2</td>
<td>91.4 ± 9.3</td>
</tr>
<tr>
<td>Preoperative</td>
<td>94.7 ± 7.2</td>
<td>95.3 ± 6.7</td>
<td>93.6 ± 8</td>
</tr>
<tr>
<td>P value</td>
<td>0.001</td>
<td>0.03</td>
<td>0.005</td>
</tr>
<tr>
<td>AC Mean ± SD</td>
<td>50.9 ± 16.2</td>
<td>49.2 ± 15.6</td>
<td>54 ± 17.1</td>
</tr>
<tr>
<td>Preoperative</td>
<td>30.6 ± 17.7</td>
<td>28.9 ± 16.7</td>
<td>33.9 ± 19.3</td>
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<tr>
<td>P value</td>
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</tr>
<tr>
<td>BC Mean ± SD</td>
<td>20.8 ± 12.5</td>
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Certain variables such as middle ear fibrosis, adhesive otitis, and significant Eustachian tube dysfunction are not easily controlled by the surgeon. However, variables that can be controlled by the surgeon are the type of prosthesis used and the surgical technique applied.

Different type of materials have been used to get the optimal results. Titanium is favored because of its rigidity, light weight, low impedance, and biocompatibility—and due to the open design of the prosthesis, which allow good viewing when the TORP or PORP is placed.10–15 Coffey et al. report that titanium ossicular prostheses provide superior hearing outcomes when compared to nontitanium prostheses.10 In our study, we have only used the Kruz titanium prosthesis. Ossiculoplasty with CWU mastoidectomy showed a better result than those obtained with ossiculoplasty without mastoidectomy.16

In the optimal conditions, the prosthesis should have its center of gravity perpendicular to its intended movement. This would lead to a center of gravity located directly over the capitulum or the oval window. Such a center of gravity would provide maximum resultant force in the intended direction of the hearing mechanism. This would also decrease any risk of the prosthesis slipping off the capitulum or oval window. Goode and Nishihara suggested that the angle formed by the prosthesis on the tympanic membrane should be less than 30° because a larger angle can result in rotational rather than up-and-down motion of the stapedial footplate, which leads to loss of energy.17 The two-point stabilization concept is critical in maximizing the hearing result. Replacement of the tympanomeatal flap and packing the ear canal may displace the perfectly placed prosthesis.

Immediate ossiculoplasty failure is most likely due to technical factors, such as improper alignment of the prosthesis intraoperatively. The prosthesis may be displaced, dislodged, or bent after repositioning of the tympanomeatal flap and packing the ear canal.

Atticotomy has multiple objectives: The main objectives are to eradicate the cholesteatoma from the epitympanum and avoid a CWD procedure. Also, the atticotomy allows for an intraoperative view of the prosthesis after it is covered by the cartilage graft. Some authors have assessed the positioning of the prosthesis postoperatively by cone beam imagery.18,19 They suggest that cone beam imagery has the potential for intraoperative assessment. Its assessment has been performed postoperatively to date, which does not allow for an easy replacement of the prosthesis when necessary. When a misplaced prosthesis is diagnosed postoperatively, the patient may be advised a revision surgery.

The TMA view may allow for the use of a large graft while maintaining the ability to confirm the position of the prosthesis. The use of large cartilage to reinforce the neotympanic membrane dramatically decreases the risk of cholesteatoma recurrence and prevents prosthesis extrusion.

Our study showed a postoperative ABG ≤ 20 dB in 103 ears (77.4%), with an ABG gain of 16 dB. A successful postoperative hearing was achieved in 70 out of 88 PORP procedures (79.5%), and in 33 out of 45 TORP procedures (73.3%).

**Fig. 3.** Scatter gram of postoperative hearing results of study patients. Most patients have improvement in their hearing, predominantly in their pure-tone averages.

**TABLE II.**
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ABG = air-bone gap; AC = air conduction threshold; BC = bone conduction threshold; PORP = partial ossicular replacement prosthesis; SD = standard deviation; TORP = total ossicular replacement prosthesis; WRS = word recognition score.
Many studies about titanium ossiculoplasty showed that the success rate ranges from 43.8% to 76% of cases, with PORP success rate ranges between 60% to 76% and TORP success rate ranges of 40% to 60%. In comparison to 79.5% success rate in our PORP and 73.3% in our TORP. We refer these preferable results to the diagnosis of the immediate change in the prosthetic access, including dislocated and bent prosthesis, which were 16 in TORP and six in PORP cases.

In our study, 16 of 45 TORPs (35.5%) required re-adjustment; one (2.3%) was bent; eight (17.7%) were dislocated; and in seven (15.5%) the axis was changed. Our study showed that after packing, PORP was never dislocated because of its robust attachment to the stapes head; however, it changed its axis in six (6.8%) cases, and that change will decrease the hearing outcome.

The shaft of the TORP needs to be displaced by only a fraction of a millimeter for it to get disconnected from the footplate and fall down. Alternatively, a slight movement of a PORP can result in changes in the axis or fullcrum of the ossicular chain and affect the sound transfer process. PORP results showed a better success and hearing outcome than TORP, which could be explained by poor stability and inadequate coupling at the TORP–footplate interface of the prosthesis, but it was statically insignificant, which is agreed with other studies.

In recent study done by Roux et al. on 68 patients that compared the hearing outcome between two groups who underwent titanium ossiculoplasty in CWU cases due to cholesteatoma, the results showed that the control of ossicular prosthesis positioning via the posterior tympanotomy does not improve hearing results after ossicular chain reconstruction in cholesteatoma surgery. The overall success was 42% in the posterior tympanotomy group (62% in PORP, 25% in TORP) and 50% in cases without posterior tympanotomy group (56% in the subgroup PORP, 44% in the subgroup TORP), whereas in our study we used endoscopy placed in the attic through the mastoid and directed toward the middle ear to assess and adjust the positioning with a significantly higher success rate. We observed that controlled and proper ossicular prosthesis positioning via the endoscopic exam post-prosthesis application and during or following packing of the ear canal lowered the immediate failure rates.

One of the aims of the present study was to examine a group of factors that could have a significant influence on the hearing outcome of the ossiculoplasty. Our study showed that the only statistically significant factor was the stage of the disease; the analysis of the stage of the operation showed that the primary reconstruction has a better outcome than secondary and revision ossicular reconstruction. In agreement with a Meulemans et al. study, which found a significant correlation to hearing outcome, these findings are in contradiction with the analysis of De Vos et al., which found that the best results were obtained with planned staged surgery more than the primary one, but it was statistically insignificant.

We are aware of the limitations of this study: being a descriptive study and lacking a control group, we could not generalize the results, and we were not able to comment on surgery comparison due to selection bias in the procedures. Another limitation of the study is the relatively short follow-up period, which may not be adequate to judge stability of hearing results.

CONCLUSION

In our study of 133 ears, we have demonstrated that a robust prosthesis stability leads to a better ossicular coupling and more satisfactory hearing outcome compared to the conventional techniques. Control of prosthesis positioning, alignment, and stability using trans-axial endoscopy improves the hearing results after ossicular chain reconstruction in cholesteatoma patients and decrease the risk of immediate ossiculoplasty failure. Although our technique showed a favorable outcome in comparison to other literature, we recommend doing a prospective study with a control group to compare the efficacy of this technique.

In CWU mastoidectomy, we recommend performing atticotomy for cholesteatoma eradication as well as for proper ossicular prosthesis application and positioning.

BIBLIOGRAPHY


