PREFERRED TECHNIQUE IN OSSICULOPLASTY

HAROLD H. KIM, MD, RICHARD J. WIET, MD, FACS

Conductive hearing loss of up to 60 dB SL can result from ossicular discontinuity in the presence of an intact tympanic membrane. Reconstruction of the ossicular chain can be curative with preference being given to autologous products. For those cases where reconstruction with autologous products is not possible, synthetic prosthesis is necessary. Ossicular prostheses vary in regards to the construction material. The three most commonly used ossicular prostheses are derived from high density polyethylene sponge, hydroxyapatite, and titanium. This article reviews our techniques in ossicular reconstruction utilizing prosthetic products and reviews the literature regarding postoperative outcomes.

Normal conduction of sound from the ambient air to the cochlea requires the following 3 conditions (1) an intact tympanic membrane, (2) aeration of the middle ear compartment, and (3) an intact ossicular chain. The absence of any of the aforementioned conditions, omitting a canal problem, results in conductive hearing loss. This article discusses those conditions in which there is an absence of an intact ossicular chain to a varying extent, such that the use of prosthetic ossicles is desired. This may be secondary to a complete absence of an ossicle, most commonly, the incus, anatomic variation, or surgeon preference. Discussion of the diagnostic evaluation and treatment of the different pathologic conditions contributing to conductive hearing loss is beyond the scope of this article. We will limit the discussion to those patients in whom ossicular discontinuity is suspected and in whom the use of a prosthetic is necessary to improve hearing.

Synthetic ossicular prostheses are useful for those conditions in which there is a complete absence of the incus. Furthermore, these prostheses allow a reduction in operative time because ossicular sculpting is not needed. Significant advances have been made in the construction of ossicular prostheses regarding the materials used to limit extrusion rates. Currently, ossicular prostheses are available in 3 forms: (1) partial ossicular replacement prostheses (PORP), which extend from an intact stapes capitulum to the malleus or tympanic membrane; (2) total ossicular replacement prostheses (TORP), which are placed between the stapes footplate to the malleus or tympanic membrane; and (3) incus interpositional prosthesis, which connects the stapes capitulum to an eroded incus long process, or from malleus to a stapes prosthesis.

Currently, prostheses are constructed predominantly of 3 compounds: (1) high density polyethylene sponge (Plastipore), (2) hydroxyapatite, and (3) titanium. Figures 1-3 show examples of PORP and TORP prostheses constructed from these compounds. Plastipore (Xomed, Jacksonville, FL), first introduced by Shea in 1976, has a porous construction that facilitates middle ear mucosal ingrowth.[1] This acts to stabilize the prostheses. Extrusion rates have been limited in cases in which the prosthesis is placed against the tympanic membrane with the interplacement of cartilage between the prostheses and the tympanic membrane, with rates ranging from 0.89% to 4.0%.[2-5]

Hydroxyapatite was first used to construct ossicular prostheses in the 1980s, and Grote was the first to report results in 1987.[6] Since then, it gained popularity into the 1990s. Hydroxyapatite is a osseointegrating compound composed of calcium phosphate ceramic.[7] It was believed

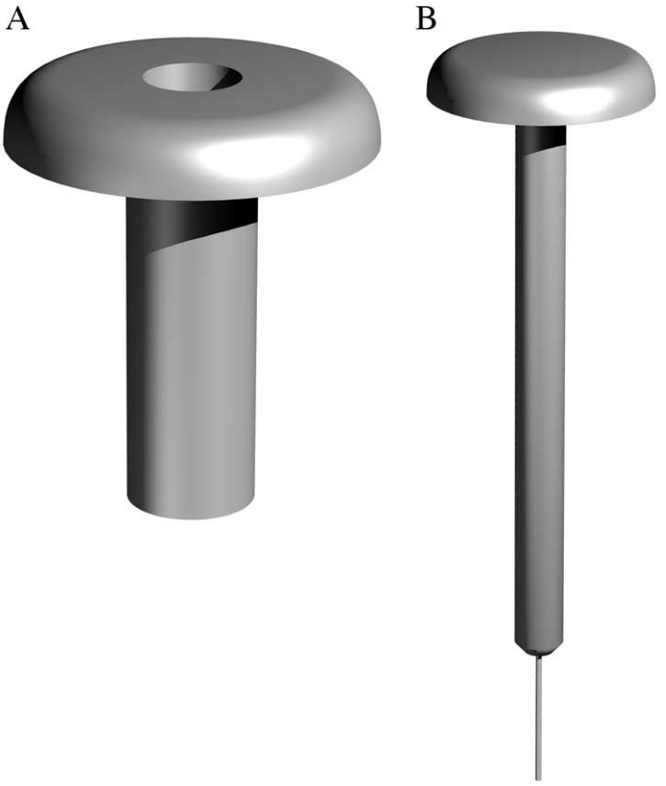

FIGURE 1. (A) Plastipore partial ossicular replacement prosthesis (PORP). (B) Total ossicular replacement prosthesis (TORP).

From the Chicago Otology Group, LLC, Hinsdale, IL; and the Department of Otolaryngology/Head and Neck Surgery, Northwestern University School of Medicine, Chicago, IL.

Address reprint requests to Harold H. Kim, MD, 950 York Rd., Ste. 102, Hinsdale, IL 60521.

1043-1810/03/1404-0004$30.00/0
doi:10.1053/S1043-1810(03)00096-4

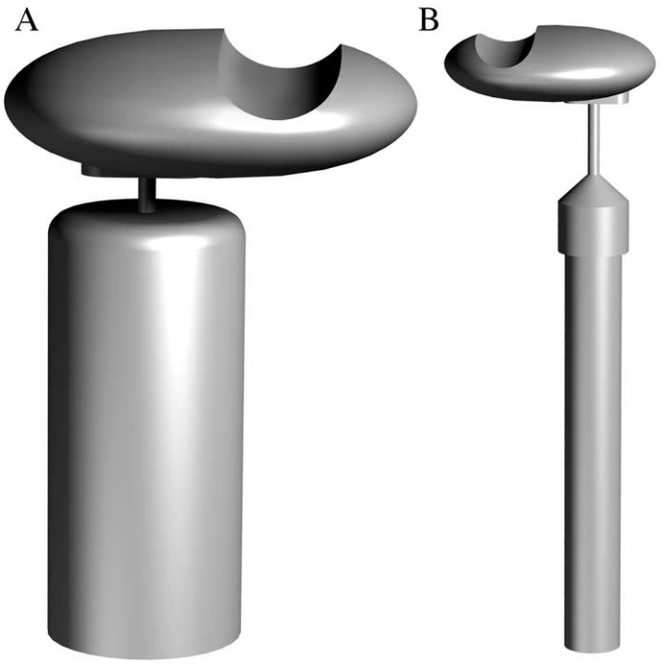

FIGURE 2. (A) Hydroxyapatite partial ossicular replacement prosthesis (PORP). (B) Total ossicular replacement prosthesis (TORP).

that osseointegration of this compound with the ossicular chain would maximize stabilization, optimizing bone air gap closure. Furthermore, its ability to be used without cartilage interposition against the tympanic membrane made these prostheses more attractive, with reported prosthetic extrusion rates varying from 5% to 14%.[4,6,8-10] When cartilage is placed between the prosthesis head and the tympanic membrane, extrusion rates decrease to less than 2%.[10] The bulkiness of the prostheses makes accurate placement difficult. Furthermore, the brittleness of the compound makes the shaping of the prosthetic head difficult. Additionally, despite its osseointegrative construction, the method by which the prosthetic is immobilized is by fibrous encapsulation.[11]

Titanium ossicular prostheses have recently been introduced. First developed in Germany in 1993, these inert compounds have presented themselves as easily shaped,

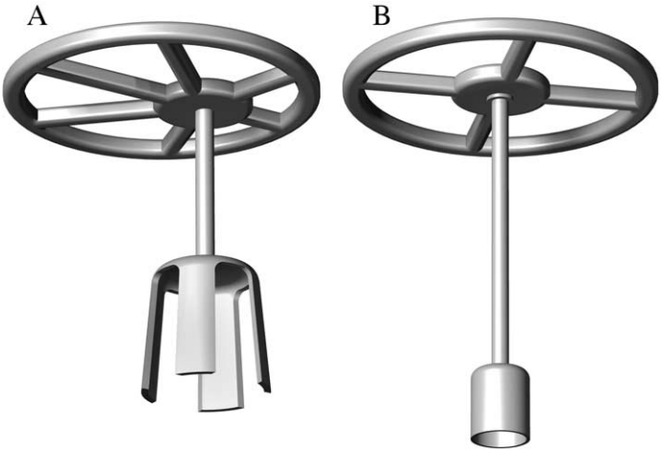

FIGURE 3. (A) Titanium partial ossicular replacement prosthesis (PORP). (B) Total ossicular replacement prosthesis (TORP).

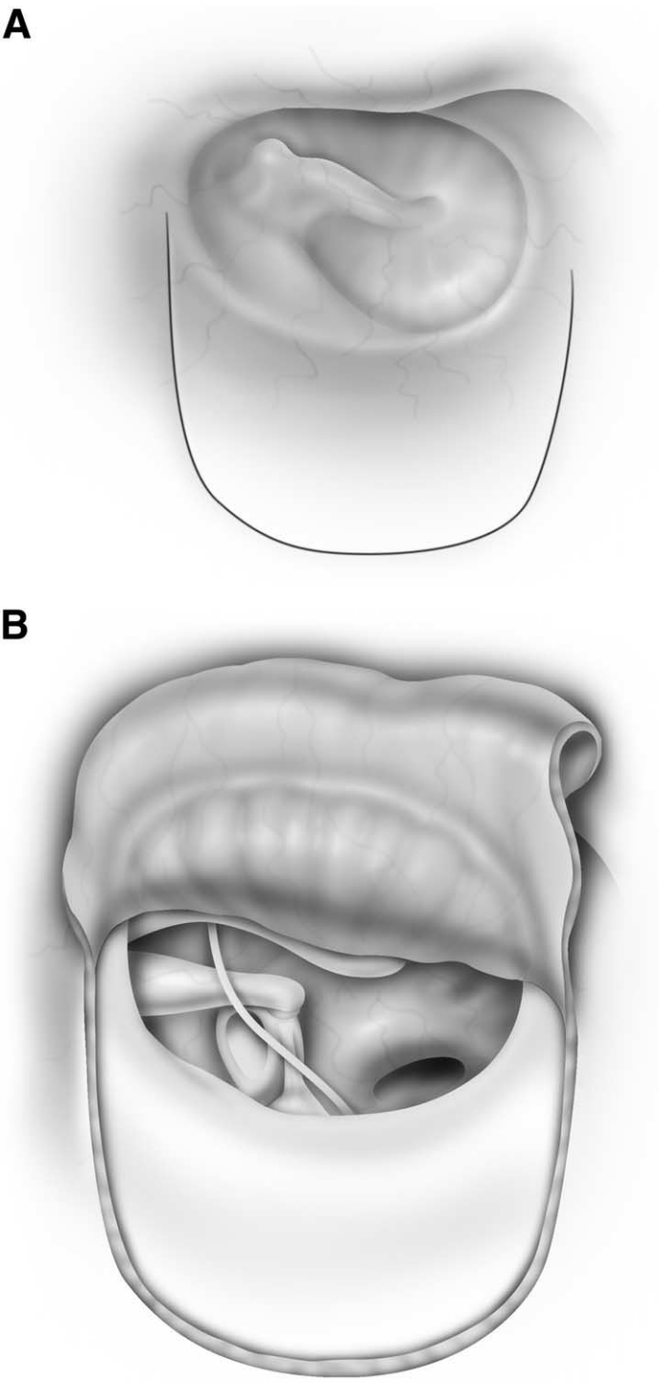

FIGURE 4. Incision design for tympanomeatal flap with appearance after elevation.

trimmable, lightweight implants that theoretically better transmit sound through lesser impedance. Its trim design also facilitates accurate placement. Extrusion is still a problem unless cartilage is interposed between the prosthesis and the tympanic membrane. Although there are exceptions, today, we are using the titanium prosthesis in the majority of cases. In some instances, when available, we still sculpt the incus to fit as an interposition.

SURGICAL TECHNIQUE

Ossicular reconstruction can be performed either through a postauricular incision or transcanal, and this should be

decided based on the surgical procedure performed. When an accompanying mastoidectomy is performed or if the patient's anatomy better facilitates a postauricular approach, a postauricular incision may be preferable. For transcanal cases, a tympanomeatal flap similar to that seen in Figure 4 is incised and raised. When the postauricular route is chosen, a laterally based vascular strip incision (Figure 5) is first made and raised before entering the middle ear. The status of the other ossicles and their mobility, especially of the stapes footplate, should be ensured. If a stapes capitulum is present, a PORP should be used. If only the stapes footplate is present, a TORP should be used. A portion of tragal cartilage should be harvested if the prosthesis will be placed between the stapes and the tympanic membrane.

If one is using the hydroxyapatite prosthesis, or the prosthesis is to be placed between the stapes to the malleus, no cartilage is necessary. If the malleus is present, one should estimate if the malleus is posterior enough to avoid angles higher than 60° between the stapes capitulum or footplate and the prosthesis as it reaches the malleus. If the angle is less than 60°, the surgeon should consider placing the prosthesis straight up from the stapes capitulum or footplate to the tympanic membrane. This is a basic principle to optimize sound conduction and prosthesis stability. The distance from the stapes capitulum or footplate to the bony annulus should be measured and the prosthesis trimmed to the appropriate length. Five tenths of a millimeter should be allowed for the cartilage when it is used. Figure 6 shows the ossicular prostheses in appropriate position when the prosthesis is placed onto the tympanic membrane from either the stapes capitulum or the footplate.

In those cases in which Plastipore or hydroxyapatite prostheses are used, the middle ear should be packed with an absorbable gelatin sponge (Gelfoam, Pharmacia & Upjohn, Peapack, NJ) around the stapes to help stabilize the prosthesis until a fibrous capsule grows around it. With the titanium PORP, the shaft can be crimped onto the stapes capitulum, obviating the need for stabilizing Gelfoam. We choose to apply the prosthesis to the stapes capitulum or footplate using a middle ear suction. Based on the study by Asai and coworkers[12] that showed maximal round window excursion on depression of the TORP prosthesis when it is placed at the center of the stapes footplate, we attempt to place the prosthesis at the center. Once in place, the cartilage is placed over the head of the prosthesis, with the tympanomeatal flap being replaced over the prosthesis-cartilage complex. Antibiotic ointment is then placed over the entire tympanomeatal flap to immobilize it. In those cases in which the prosthesis is interposed between the stapes and the malleus, we place the prosthesis first onto the stapes capitulum or footplate, then gently lift the malleus handle, while rotating the prosthesis under it.

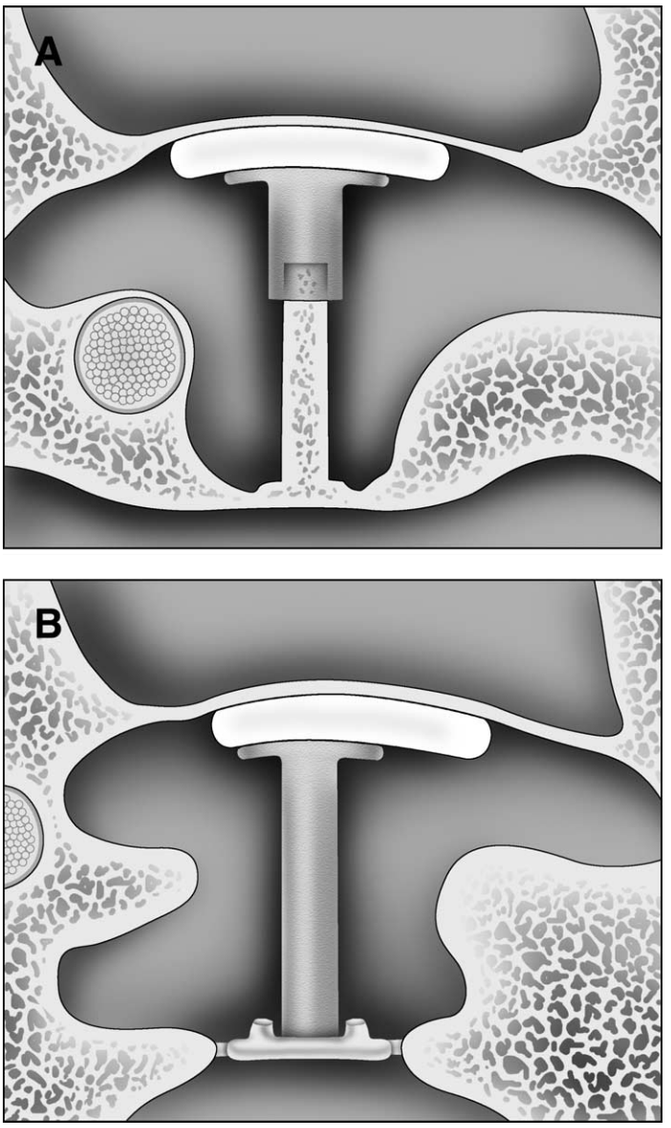

FIGURE 6. Appearance after appropriate placement. (A) Partial ossicular replacement prostheses (TORP). (B) Total ossicular replacement prosthesis (TORP). In this case, the prostheses were placed from the tympanic membrane to the stapes capitulum or stapes footplate. Cartilage is interposed between the head of the prostheses and the tympanic membrane, as for titanium and plastipore prostheses.

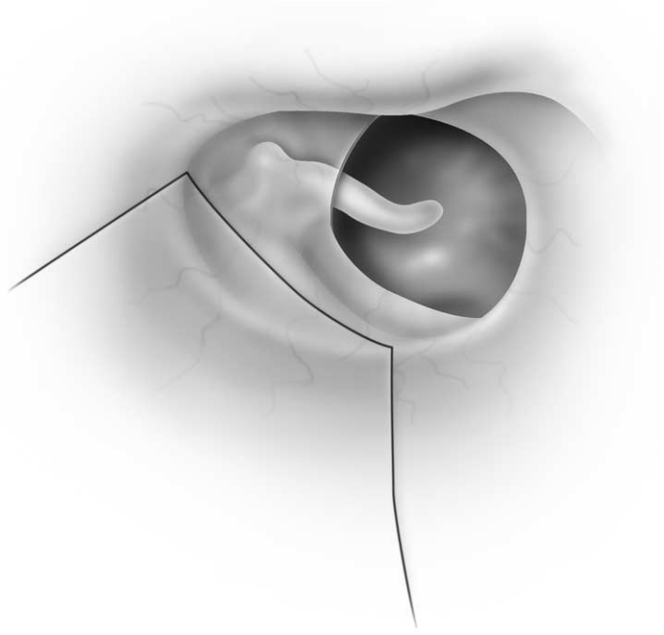

FIGURE 5. Vascular strip incision along tympanomastoid and tympanosquamous suture lines for a laterally based flap in postauricular approaches.

RESULTS

The guidelines set forth by the Committee on Hearing and Equilibrium from the American Academy of Otolaryngology-Head and Neck Surgery provide a uniform process of reporting results of ossicular reconstruction.[13] This provided an easier way of comparing different studies that used different prostheses. Persistent, despite these guidelines, are the heterogeneous populations that are often included when evaluating different ossicular prostheses because patients with canal wall down mastoid cavities will be included with those patients with intact canal wall mastoid cavities. Furthermore, patients with no malleus will often be included with those with a malleus.

When comparing hearing results in those patients who receive PORP versus TORP, several studies show no significant difference in rates of air-bone gap closure.[4,8,14] When considering short-term results, closure of the air-bone gap to less than 20 dB can be achieved in more than 60% of cases regardless of the prosthetic used.[4,8,15] Factors that lead to the failure of ossicular reconstruction include recurrent or residual disease, poor aeration of the middle ear, prosthesis slippage, or inadequate prosthetic length. When controlling for this, it is clear that the 3 available prosthetic compounds yield comparable results. While Plastipore is found to close the air-bone gap to less than 20 dB in 55.8-63% of patients, hydroxyapatite prostheses have been observed to close it in 64-70.5% of cases.[1-6,8-10] Recent studies with the titanium prostheses have shown similar air-bone closures. Extrusion rates are also comparable if cartilage is interposed between the prosthetic head and the tympanic membrane. Our results, reported by Ho and coworkers,[16] showed only a 4% extrusion rate, with an average 20.9 dB closure of air-bone gap.

Despite the introduction of ossicular prostheses constructed of different compounds with different designs, the same factors hamper successful ossicular reconstruction with prosthetic devices. Extrusion of the prostheses continues to occur secondary to recurrent disease or tympanic membrane atelectasis. Furthermore, despite the introduction of progressively biocompatible compounds, slippage of the prostheses is still observed. Therefore, when considering possible ossicular reconstruction, one must consider the pathology present. If middle ear aeration is not present, one can consider the type IV tympanoplasty or the use of a pressure equalization tube in concert with ossicular reconstruction. When pursuing surgery for conductive hearing loss, it is pursuant on the clinician to counsel realistically the patient as to the likelihood of success and the alternatives available. Case selection, the option of a hearing aid, and analysis of risk benefit is owed to each and every patient.

REFERENCES

1. Shea J: Plastipore total ossicular replacement prosthesis. Laryngoscope 86:239-240, 1976
2. Slater PW, Rizer FM, Schuring AG, et al: Practical use of total and partial ossicular replacement prostheses in ossiculoplasty. Laryngoscope 107:1193-1198, 1997
3. Bayazit Y, Goksu N, Beder L: Functional results of plastipore prostheses for middle ear ossicular chain reconstruction. Laryngoscope 109:709-711, 1999
4. House JW, Teufert KB: Extrusion rates and hearing results in ossicular reconstruction. Otolaryngol Head Neck Surg 125:135-141, 2001
5. Murphy TP: Hearing results in pediatric patients with chronic otitis media after ossicular reconstruction with partial ossicular replacement prostheses and total ossicular replacement prostheses. Laryngoscope 110:536-544, 2000
6. Grote JJ: Reconstruction of the ossicular chain with hydroxyapatite prostheses. Am J Otol 8:396-401, 1987
7. Van Blitterswijk CA, Grote JJ: Biocompatibility of clinically applied hydroxylapatite ceramic. Ann Otol Rhinol Laryngol Suppl 99:3-11, 1990
8. Goldenberg RA, Driver M: Long-term results with hydroxyapatite middle ear implants. Otolaryngol Head Neck Surg 122:635-642, 2000
9. Vrabec JT, Stierman K, Grady JJ: Hydroxyapatite prosthesis extrusion. Otol Neurotol 23:653-656, 2002
10. Kobayashi T, Gyo K, Shinohara T, et al: Ossicular reconstruction with hydroxyapatite prostheses with interposed cartilage. Am J Otolaryngol 23:222-227, 2002
11. Meijer AG, Segenhout HM, Albers FW, et al: Histopathology of biocompatible hydroxyapatite-polyethylene composite in ossiculoplasty. ORL J Otorhinolaryngol Relat Spec 64:173-179, 2002
12. Asai M, Huber AM, Goode RL: Analysis of the best site on the stapes footplate for ossicular chain reconstruction. Acta Otolaryngol 119: 356-361, 1999
13. Monsell EM: New and revised reporting guidelines from the Committee on Hearing and Equilibrium. American Academy of Otolaryngology-Head and Neck Surgery Foundation, Inc. Otolaryngol Head Neck Surg 113:176-178, 1995
14. Moretz WH Jr: Ossiculoplasty with an intact stapes: Suprastructure versus footplate prosthesis placement. Laryngoscope 108:1-12, 1998
15. Dalchow CV, Grun D, Stupp HF: Reconstruction of the ossicular chain with titanium implants. Otolaryngol Head Neck Surg 125:628-630, 2001
16. Ho SY, Battista RA, Wiet RJ: Early results with titanium ossicular implants. Otol Neurotol 24:149-142, 2003