



“Cement Bridge Over Troubled Incus” Technique in Patients With Oval Window Atresia and Anomalous Incus: A Preliminary Report

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Congenital oval window atresia (OWA) is a rare congenital ossicular anomaly caused by malformations of pharyngeal arch derivatives. Embryological studies have shown that the malleus handle, long process of the incus (LPI), the stapes suprastructure, and the lateral portion of the stapes footplate or the entire footplate are derived from the second arch. Congenital OWA may thus be accompanied by an absent/hypoplastic incus and a missing stapes suprastructure, given their shared embryologic origin [1].

In cases of OWA or stapes fixation with a dysplastic LPI, malleo-vestibulopexy/stapedotomy [2] and incudostapedotomy after lengthening of the LPI with bone cement [3] have been used because crimping the piston wire prosthesis (PWP) around the rudimentary LPI is not possible. However, malleostapedotomy is technically challenging, and the postoperative hearing improvement is inherently limited because the lever effects of the malleus-incus/incus-stapes connections are bypassed. Incudostapedotomy after lengthening the LPI is also challenging because achieving a desirable shape via lengthening can be technically demanding. The durability of LPIs elongated with bone cement has not been reported.

We present a novel incudostapedotomy technique wherein the PWP and rudimentary LPI are bridged with bone cement (the “cement bridge over troubled incus” [CBTI] technique) and report the hearing outcomes. We screened patients with conductive hearing loss who underwent exploratory tympanotomy by

the same surgeon (JJS). Three patients (four ears) with rudimentary LPI and OWA were included. Patients’ demographics and medical records were reviewed retrospectively. The study was approved by the institutional review board of Seoul National University Bundang Hospital (IRB No. B-2105-687-101), and the requirement for informed consent was waived.

The pure-tone averages (PTAs) were calculated by averaging thresholds at 0.5, 1, 2, and 3 kHz for air conduction (AC) and bone conduction (BC). On temporal bone computed tomography, all subjects showed findings suspicious for dysplastic LPI and suprastructure of the stapes in axial and coronal images. The ossicular chains of all four ears were reconstructed with the same surgical procedures (schematics illustrated in Fig. 1A-D). After elevating a tympanomeatal flap, the ossicular chain was inspected. The mobility of the malleus and incus were checked and then the target site for vestibulotomy was identified based on a rudimentary footplate-like structure (Fig. 1A). Vestibulotomy was performed using a CO₂ laser (Fig. 1B). The distance between the vestibulotomy site and the tip of the LPI was measured, and a Fisch-type piston (Medtronic Xomed, Jacksonville, FL, USA) was adjusted to the distance measured (Fig. 1C). The shaft of the PWP was angulated according to the distance between the vestibulotomy site and the tip of the dysplastic LPI so that the PWP could be inserted perpendicularly to the vestibulotomy site. The PWP loop was placed approximately on the tip of the LPI. The loop was bridged to the tip of the LPI using Mimix Quick Set Calcium Phosphate (Biomet Microfixation, Jacksonville, FL, USA) (Fig. 1D). Intraoperative photographs are summarized in Fig. 1E-H. Next, the vestibulotomy site was sealed with soft tissue and Tisseel (Baxter Healthcare Corp., Westlake Village, CA, USA). The tympanomeatal flap was repositioned, and the external auditory canal was packed with cotton wicks.

The enrolled patients’ ages at the time of surgery were 5, 11, 70, and 71 years, respectively. Two patients were female. All patients

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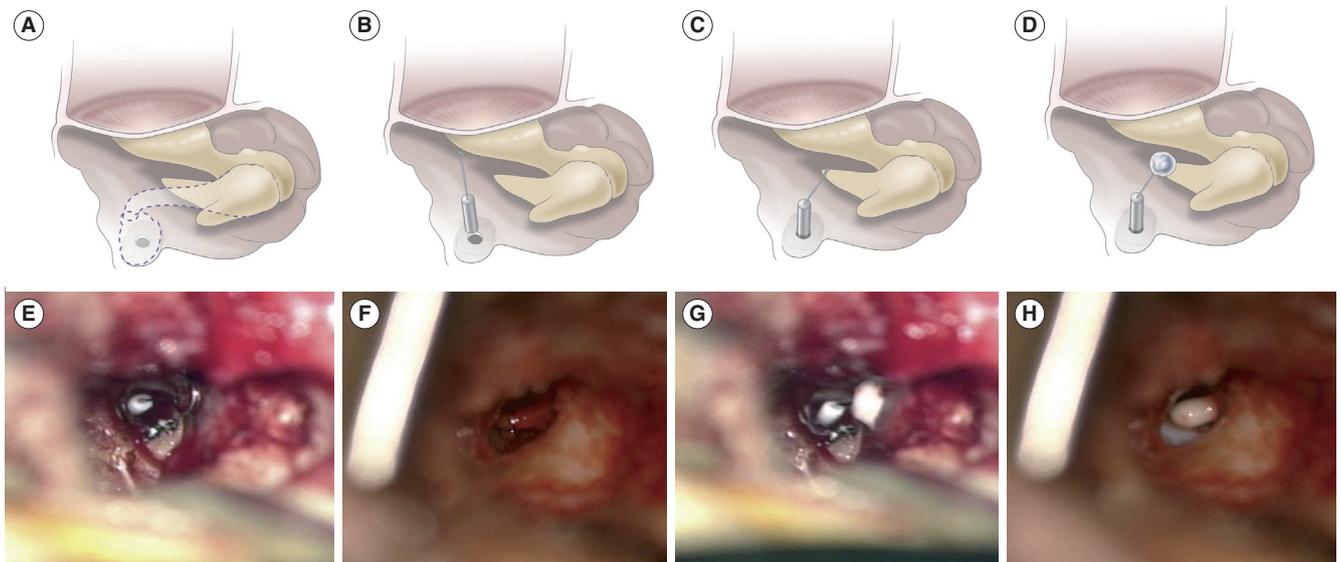


Fig. 1. Schematic illustration of the surgical procedures and intraoperative photographs. (A) A dysplastic rudimentary long process of the incus (LPI) and atresia of the oval window. (B) Vestibulotomy using a CO₂ laser and preparation of a distance-adjusted piston wire prosthesis (PWP). (C) Insertion of the PWP into the vestibulotomy site and approximation of the PWP loop to the tip of the dysplastic LPI. (D) Bridging the PWP loop to the tip of the LPI using bone cement. (E, F) Intraoperative microscopic photographs after PWP insertion and approximation, respectively. (G, H) Intraoperative microscopic photographs after bridging using bone cement.

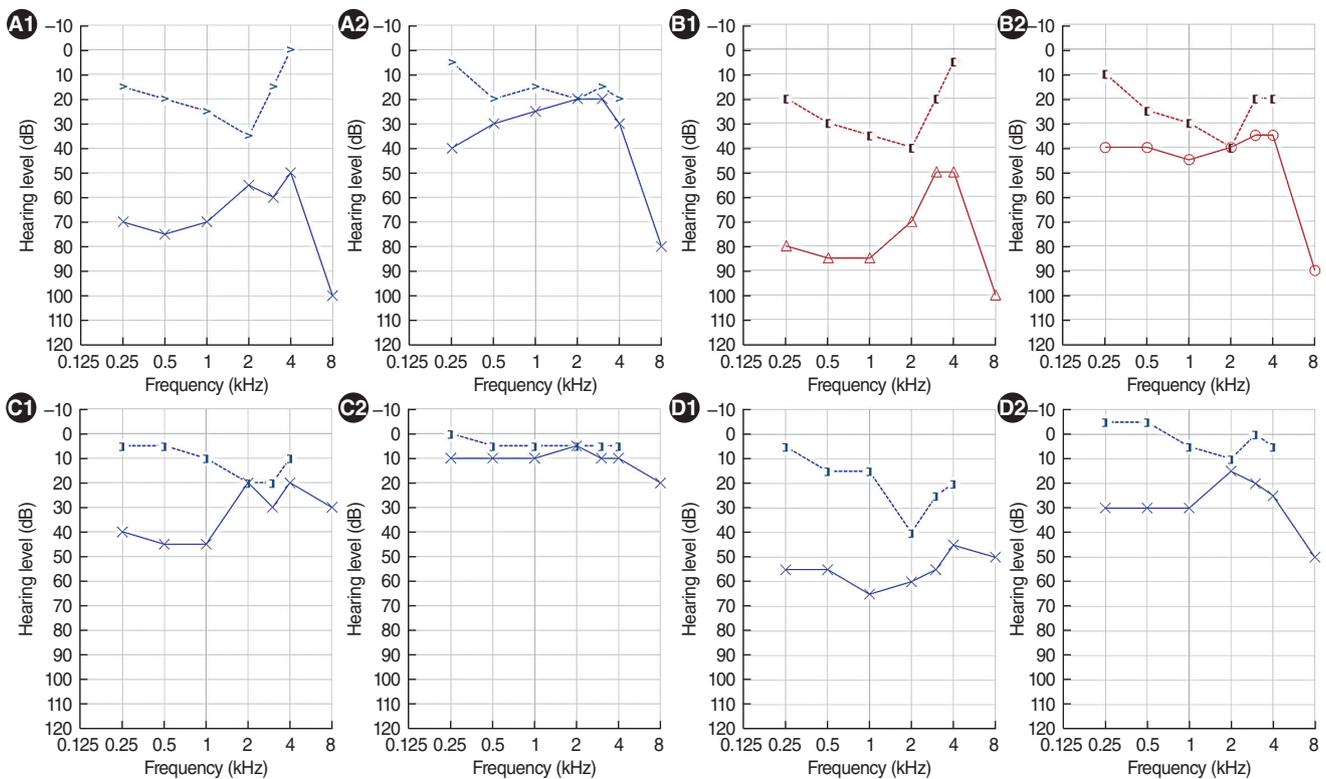


Fig. 2. (A-D) Preoperative (A1, B1, C1, and D1) and postoperative (A2, B2, C2, and D2) pure-tone audiograms of the three patients (four ears). Dotted line, bone conduction thresholds; solid line, air conduction thresholds.

were followed up at the outpatient clinic 1, 3, 6, and 12 months after surgery, and audiometric tests were also performed at each

follow-up visit. All four ears showed improved postoperative BC-PTA (except the right ear of patient 1) and AC-PTA, as well as

positive air-bone gap (ABG) closure (Fig. 2). The median postoperative improvements in BC-PTA, AC-PTA, and the ABG were 6.3 dB (0–20 dB), 33.0 dB (24.2–37.5 dB), and 24.6 dB (12.5–33.3 dB), respectively.

The median postoperative follow-up period was 9 months (range, 3–18 months). During postoperative follow-up, no patient experienced any major complications. This study investigated the feasibility and effectiveness of CBTI in subjects with a dysplastic rudimentary LPI and OWA. All three subjects (four ears) achieved good audiologic outcomes without any major complications. Malleostapedotomy/malleovestibulopexy is an option that can skip the incus and restore the ossicular continuity in subjects with a rudimentary LPI and OWA. However, it is technically demanding, has a higher possibility of PWP displacement, and the hearing improvement may be limited.

Successful outcomes following incudostapedotomy after lengthening of the LPI with bone cement were also reported [3]. The authors extended the dysplastic LPI using glass-ionomer cement. A PWP was then anchored around the extended long process and inserted into the vestibulotomy site. However, glass-ionomer cement may not show long-term durability, and some researchers reported possible adverse tissue reactions when using glass-ionomer compounds, such as sequestration and potential neurotoxicity because of their aluminum base [4]. Goebel and Jacob [5] reported 25 cases of ossicular chain reconstruction using Mimix. However, one patient had worsened postoperative ABG, and surgical exploration revealed that the PWP had sawed through the augmented LPI and was displaced out of the oval window. Thus, the long-term efficacy of elongating the LPI using glass ionomer cement or bone cement is still questionable.

Our CBTI technique in subjects with OWA and dysplastic LPI may be superior to the aforementioned surgical procedures in several aspects. First, it has audiologic advantages over malleostapedotomy because a lever action is included. In addition, it is easier than extending the LPI using glass-ionomer cement or bone cement because the length of the PWP can easily be adjusted by angulating the PWP loop according to the length of the natural LPI. Finally, the risk of possible dislocation of the PWP from the incus due to sawing action is much lower.

This study had some limitations. First, a small number of patients were included because of the rarity of the anomaly. Follow-up studies should be conducted on larger cohorts to confirm the feasibility and audiological outcomes of the technique presented herein. In addition, the maximum follow-up period was 18 months in our series. To confirm the durability of the reconstructed ossicular chain, future studies with longer follow-up periods are mandatory.

Incudostapedotomy using our CBTI technique may be a relatively easy, safe, and audiological advantageous surgical option and could replace surgical procedures such as malleo- or incudostapedotomy after elongating the LPI. Future long-term fol-

low-up studies on a larger cohort are warranted to confirm our observations.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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AUTHOR CONTRIBUTIONS

Conceptualization; JJS. Data curation; PJ. Formal analysis; all authors. Funding acquisition; JJS. Writing—original draft; PJ, JJS. Writing—review & editing; all authors.

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