

Vibrant Soundbridge Implantation prior to Auricular Reconstruction with Unilateral Microtia-Atresia

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Abstract

Herein, we present a new surgical approach for vibrant soundbridge implantation in advance of the plastic reconstruction of the auricle in patient with unilateral microtia-atresia and highlight the importance of cooperation between otologists and plastic surgeons in the performance of this technique.

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Conflict of Interest

Authors declare no conflicts of interest

Ethics Approvals

This study was approved by the Ethics Committee of Shinshu University School of Medicine (jRCTs032190002).

Abstract

Herein, we present a new surgical approach for vibrant soundbridge implantation in advance of the plastic reconstruction of the auricle in patient with unilateral microtia-atresia and highlight the importance of cooperation between otologists and plastic surgeons in the performance of this technique.

Keywords : Vibrant soundbridge; middle ear implant; atresia; microtia

Introduction

Congenital aural atresia (CAA) is diagnosed in 1 in 10,000 to 20,000 newborns¹. Among these cases, unilateral CAA (UCAA) is much more frequently observed than bilateral CAA². Additionally, the middle ear and ossicles are affected to varying degrees in patients with CAA, leading to conductive hearing loss². Although patients with UCAA typically understand speech well in everyday listening situations in quiet, the growing interest in binaural hearing has led to an increased demand for hearing rehabilitation in patients with unilateral aural atresia³. Previously, middle ear and auditory canal reconstructive surgery to restore conductive hearing in patients with CAA was performed; however, that is generally considered one of the most difficult types of otologic surgery, and functional results are often unsatisfactory, leading to the need for an air conduction hearing aid^{3, 4}. The alternative option is to consider a bone conduction (BC) hearing device or middle ear implant (the Vibrant Soundbridge [VSB], MED-EL Corporation, Austria)⁵. For patients with UCAA, the VSB can treat the impaired ear without affecting the contralateral ear, unlike the BC device⁴. The VSB, firstly implanted in children in 2009⁶, is composed of two parts: 1) the implantable vibrating ossicular prosthesis (VORP) and floating mass transducer (FMT), and 2) the externally worn audio processor. It is able to bypass middle ear malformations and provide active auditory support directly to the cochlea. The VSB can be easily attached to a variety of middle ear structures, and it is well suited for implantation in the malformed middle ears of children with CAA⁶. Recently, it has been increasingly used to improve hearing without surgical complications in patients with UCAA⁶.

CAA is often associated with microtia or other forms of craniofacial dysplasia. Therefore, children with atresia and microtia may face multiple surgeries to correct the malformation, indicating that they and their parents require the proper intervention of otologists and facial plastic surgeons⁷. Most children with microtia require plastic reconstruction for cosmetic and functional benefits (i.e., to facilitate wearing glasses or a mask)⁷. Auriculoplasty using a rib graft is preferable to the use of a prosthesis in terms of skin infection and implant extrusion⁸. Correcting the microtia should be performed in patients older than 10 years as treatment at a younger age has unfavorable outcomes in terms of both the reconstructed ear and the donor-site thorax⁹.

For the early intervention in children with unilateral microtia-atresia, Frenzel et al. reported “simultaneous” VSB implantation with plastic reconstruction of the auricle without any negative effects in terms of the

healing process or the cosmetic outcome of the repaired auricle⁶. However, in cases in which patients and their parents desire earlier hearing rehabilitation, the development of a new surgical approach is required. Here, we demonstrate a case of UCAA receiving VSB implantation prior to auricular reconstruction and highlight the importance of cooperation between otologists and plastic surgeons in the performance of the surgical technique presented herein.

Case report

The patient was a 9-year-old boy with congenital CAA and lobule-type microtia on the right ear (Fig. 1A). No associated symptoms were observed. He visited Shinshu University Hospital, Department of Otolaryngology and asked us to treat his conductive hearing loss as early as possible. Preoperative audiometry showed mean air conduction pure-tone thresholds of 70 dB HL at 0.5, 1, and 2 kHz with an air-bone gap of 50 to 90 dB (Fig. 3A). Plastic reconstruction of the auricle was scheduled to be undertaken at age 11. Therefore, we suggested to him and his parents that he undergo VSB prior to the atresioplasty. We, otolaryngologists, consulted the plastic surgeons about the surgical planning so as not to interfere with the costal cartilage grafting associated with the auriculoplasty. This study was approved by the Ethics Committee of Shinshu University School of Medicine (jRCTs032190002).

Preoperatively, a film pattern was copied from the contralateral ear (Fig. 1B). With the film attached to his face, the ear position was determined by comparison with the contralateral ear from the frontal view and in a sitting position (Fig. 1C). Using glasses with a scale enabled us to design the ideal ear position (Fig. 1D). Surgery was performed under general anesthesia with facial nerve monitoring. First, we determined the position of the drill site for the mastoidectomy with the aid of a navigation system (Medtronic, Dublin, Ireland) and the outline of the desired position of the implant 1.5 cm from the edge of the intended mastoid cavity. An arc-shaped incision line was marked 2 cm away from the proposed ear (Fig. 2A). We incised the skin to the level of the periosteum and made a single layer flap. The temporal bone was exposed to allow access to the mastoid cavity. Mastoidectomy to the point where the atretic plate was visible was performed. The atretic plate was then gently drilled, and the incus and malleus were fused into a malformed complex which was strongly adhesive to surrounding structures (Fig. 2B). After removing the complex, the tympanic facial nerve and stapes were identified (Fig. 2C). In accordance with the manufacturer's protocols, the implant (VORP 503) was placed in the prepared bone bed and fixed to the cortical bone with screws (Fig. 2E). A Vibroplasty-Clip-Coupler was attached to the FMT, and the Coupler-FMT assembly placed onto the head of the stapes superstructure (Fig. 2D) and secured with fascia. The skin flap was sutured with a drain (Fig. 2F) that was removed 2 days after the surgery.

Eight weeks post-surgery, the initial activation of the audio processor was performed. He has been able to comfortably wear the VSB all day. As a result, his hearing thresholds with the VSB at 6 months after activation indicated sufficient amplification. The mean aided pure-tone thresholds (at frequencies of 0.5, 1, and 2 kHz) was 25 dB HL, implying a functional gain of 25 dB to 45 dB (Fig. 3C,E). Additionally, bone conduction thresholds were stable between the pre- and post-operative evaluations. His score on the Japanese monosyllable test at 0, -5, -10 dB SNR was improved remarkably (Fig. 3F). The results of sound localization testing are described in Figure 3B,D showing the time course of the *deviation* (d) score. The d scores showed improvement in this case from 18.75 to 7.92. He will receive the auriculoplasty with costal cartilage grafting at age 11.

Discussion

The use of a VSB in patients with unilateral hearing loss is known to improve the ability of speech understanding in noise and sound localization^{6, 10}. We have consistently observed that VSB implantation results in significantly greater hearing ability without impairing auditory function in the case of UCAA. Compared to the VSB, BC devices transfer auditory information to both cochleae, indicating that the monaural benefit provided by the VSB is lost⁴. Also, there is general consensus that congenital and early childhood hearing loss should be treated as soon as possible⁴. Taken together, the above findings indicate that it is ideal to address conductive hearing loss in children with UCAA via VSB, which means intervention prior to the

plastic reconstruction of the ear which is generally performed at age 10 or older.

However, since the temporal bone, middle ear structures and facial nerve are often affected to varying extents in UCAA children, preoperative evaluation via CT scans is needed¹¹. In this case, the stapes as well as adequate middle ear and mastoid pneumatization were identified, allowing us to place the FMT on the stapes superstructure. Even if the malformation was markedly more severe, a BC device or a cartilage conduction hearing aid¹², which are approved in Japan, might have been an alternative solution to restore auditory function.

Plastic reconstruction of the auricle follows a standard procedure with autologous rib cartilage in two operative steps based on the technique of Nagata¹³. Although some modifications have been reported^{9, 14, 15}, these operations predominantly include (1) costal cartilage harvest and implantation of the sculpted framework in a subcutaneous pocket and (2) elevation of the auricle with skin grafting. When performing VSB implantation in advance of the auriculoplasty, otologists must ask plastic surgeons to design the proposed ear preoperatively. Additionally, both the skin undermined around the proposed ear for creation of the ear and the temporoparietal and mastoid fascia potentially utilized in the second step must be preserved during VSB implantation. Therefore, we selected a retroauricular incision through “all” layers at about 20 mm from the outline of the prospective ear, leaving the tissues used in the auriculoplasty intact. Hence, our surgical procedure will not interfere with the future plastic reconstruction.

Conclusion

In summary, we presented the first successful application of VSB implantation prior to auricular reconstruction and demonstrated that this intervention can provide substantial hearing improvement in safe conditions and open new strategies for earlier hearing rehabilitation in UCAA children. To achieve a successful outcome, cooperation between otologists and plastic surgeons is essential.

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Figure Legends

Fig. 1. Preoperative preparation

(A) Preoperative appearance of lobule-type microtia. (B) Copying a film pattern from the contralateral normal ear. With the film attached to the patient's face, the proper position of the ear to be created was determined by comparison with the opposite ear from the frontal (C) and side (D) view using glasses.

Fig. 2. Surgical procedure

(A) Design of the skin incision indicated by arrows. Arrowheads shows the outline of the proposed ear. (B-D) Endoscopic images showing the VSB implantation. MIC: malleus-incus complex, FN: facial nerve, S: stapes. (E) Fixation of the VORP 503. (F) Skin closure. Arrowheads shows the drain.

Fig. 3. Pre- and 6 months post-operative auditory assessments

Pre- (A) and post-operative (C) pure-tone audiograms. (B,D) The scatter diagrams with the deviation score show the results of the sound localization test pre- and post-operatively. (E) Hearing threshold with the VSB. (F) Comparison of Japanese monosyllable scores. Sound was presented at a signal-noise ratio of +10, 5, 0, -5, -10, -15 dB.



