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Vibrant Soundbridge and Bonebridge: Bilateral Application in a Child with Bilateral Congenital Ear Canal Atresia

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Authors' contributions

This work was carried out in collaborations between all authors. Author MJFDW modified the manuscript during the revisions and prepared the figures. Author MJHA performed the localization measurements. Author AFMS was responsible for the audiological measurements and performed extensive literature searches. Author EAMM coordinated the study. Author MKSH evaluated the surgical outcomes and was assisting during the surgeries. Author JMH performed the surgeries. All authors read and approved the final manuscript.

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Case Study

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ABSTRACT

A 12-year-old child with bilateral congenital microtia and ear canal atresia was bilaterally implanted with a Vibrant Soundbridge (VSB) on the right side and a Bonebridge on the left side. Prior to these surgeries the child was using percutaneous bone conduction devices (BCDs) on a headband for more than 9 years. No complications occurred during the surgeries. Sound field audiological testing showed cumulative benefit when both devices were used simultaneously. Directional hearing was tested in a sound-attenuated room. To ensure that the subject could only use acoustic information to localize sounds, the test was performed in complete darkness. The ability to localize

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sounds was poor when listening with either the VSB or Bonebridge, but increased significantly when both devices were used simultaneously. To our knowledge this is the first case report about the bilateral implantation of a VSB and Bonebridge.

Keywords: Atresia; auditory implants; bone-conduction; hearing loss; directional hearing.

ABBREVIATIONS

BB: Broadband; BCD: Bone conduction device; HL: Hearing level; PTA: Pure-tone average; SPL: Sound pressure level; VSB: Vibrant soundbridge.

1. INTRODUCTION

Patients with bilateral ear canal atresia and microtia have poor access to hearing because of conductive hearing loss. It is essential to identify these subjects early, as they need rehabilitation by means of bone conduction hearing device aiming at adequate speech and language development. Atresia repair is not feasible at young age and often not considered at all in patients with such severe anomalies. Besides the risk of complications, hearing results are often poor and not stable over time [1].

In 1987 a new, more effective type of bone conduction device (BCD) was introduced, the percutaneous Baha device. Drawback of percutaneous BCD might be implant loss and adverse skin reactions [2]. More recently, new types of auditory implants have been introduced, not only a new generation of percutaneous BCDs [3], but also new transcutaneous applications. This latter application can be divided into passive transcutaneous BCDs (e.g. Baha® Attract [4], Cochlear BAS, Göteborg, Sweden and Sophono Alpha device [5]. SophonoInc Boulder, USA) and active transcutaneous BCDs (Bonebridge [6]; Med-El, Innsbruck, Austria and the BCI [7], not commercially available yet). As shown by Colletti et al. (2011), active middle ear implants like the Vibrant Soundbridge [6] (VSB; Med-El, Innsbruck, Austria) can also be used in (most) patients with ear canal atresia.

2. PRESENTATION OF CASE

A 12-year-old Dutch boy has been under our care for bilateral congenital microtia and ear canal atresia type 3 (Altmann-Cremers classification [7]). Initially, he was successfully aided with a conventional BCD on a softband. Cortical bone thickness should at least be 2-3 mm before a percutaneous BCD can be considered; normally around 4 years of age [8]. At an age of 3 years he switched to using bilaterally BCDs kept in place by a softband. Percutaneous BCDs were offered, however, his parents were reluctant because of the risk of skin reactions and implant loss. He kept using his BCDs on a steel headband as over time the softband became too small for the size of his head.

At the age of 8 years the desire for auricular reconstruction emerged and the parents contacted LMU Clinicum in München for further treatment. A CT-scan of the petrosal bone showed an adequately aerated middle ear with ossicles and a normal cochlea on the right side. The left side showed a malformed middle ear without ossicles and a normally developed cochlea. Audiometry showed symmetrical conductive hearing loss of 60 dB HL with a maximum air-bone gap and normal sensorineural hearing on either side, see (Fig. 1).

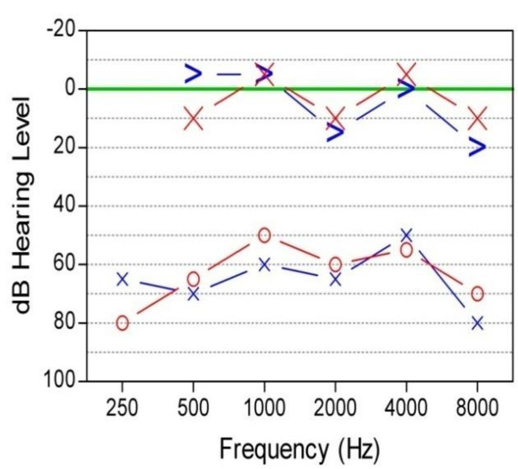

Fig. 1. Unaided audiogram showing bilateral maximal air-bone gap with a hearing threshold of around 55 dB on both sides. Red line right ear, blue line left ear

In April 2012, at an age of 12, the right auricle was reconstructed, using a porous polyethylene framework (Medpor®, Stryker, Kalamazoo, MI, USA) and a temporoparietal fascia flap. Better hearing rehabilitation was achieved by replacing the BCDs with headband by a VSB with its actuator coupled to the stapes by a clip coupler (bess, Berlin, Germany; surgery performed by JMH). In order to achieve optimal hearing results, in terms of speech recognition in noise and sound localization, bilateral implantation was discussed. Due to the congenital malformed middle ear and mastoid on the left side it was concluded that a VSB actuator could most probably not be placed in that middle ear. Therefore, a new type of auditory implant was considered, the Bonebridge, which comprises an implanted bone-conduction actuator in the mastoid area. This device became available in 2012. The VSB and Bonebridge are produced by the same company, and the externally worn audio processors are built in a similar housing (Figs. 2A, B). As the Bonebridge had no CE-mark for the use in patients under 8 years, the ethics committee and health inspection were consulted and gave their approval. Nine months after VSB surgery a Bonebridge was implanted at the left side (surgery performed by MKSH and JMH).Surgery was uneventful.

2.1 Outcome

One week postoperatively slight redness of the skin occurred lateral to the Bonebridge implantation site, there was no evident sign of infection. Oral antibiotics were prescribed pragmatically and the redness disappeared gradually. Four weeks after implantation the audio processor could be fitted. During the follow-up (16 months for the Bonebridge, 25 months for the VSB) no further problems occurred.

When only the Bonebridge was used, the mean aided threshold (PTA; mean at 0.5, 1, 2, 4 kHz) was 27 dB HL. With the VSB only, the mean aided threshold was also 27 dB HL (Fig. 3). Sound-field testing showed the theoretical maximum summation effect of 6 dB, when both devices were used simultaneously resulting in a PTA of 21 dB HL. The (virtually) remaining air-bone gap, averaged over the same frequencies is 26 dB for the left ear (with Bonebridge) and 28 dB for the right ear (with VSB).

Sound localization was tested in a completely dark sound attenuated room. Broadband noise bursts (BB; 0.5-20 kHz) of 150 ms were used. Horizontal localization was assessed between -75º and +75º azimuth. The 36 noise bursts had randomly selected sound levels of 45, 55 or 65 dB SPL [9]. Each sound level was used 12 times.

Fig. 2. The implantable part of the vibrant soundbridge with on one end the transmission coil which is placed under the skin and the transducer at the end of the wire which is placed on the incus in the middle ear (A). The implantable part of the Bonebridge with the transducer at the end of the wire. Note the transmission coil on one side and the transducer on the other side. This is placed in the temporal bone (B)

Fig. 4 shows the stimulus-response relationships for the noise burst presentations. If a measured point lies on the diagonal (lower left to upper right), localization was correct. The figure demonstrates that when listening only with the VSB, most stimuli were perceived on the right side (where the VSB device is worn; Fig. 4A). Interestingly, all stimuli that were perceived at the left side were the stimuli with the lowest (45 dB SPL) sound level (not shown in the figure). The sound localization ability was also poor when listening only with the Bonebridge (Fig. 4B). The figure shows that now most stimuli are perceived on the left side, where the Bonebridge device is worn. However, when listening in the bilateral aided condition (Fig. 4C) the subject performed much better (data points closer to the diagonal), especially for the stimuli originating from the right side. Stimuli from the left side were localized less precisely.

In May 2014, two years after implantation of the Bonebridge and more than one year after implantation of the VSB, the parents report that the child is using both devices more than twelve hours a day. Both the parents and the child report to be satisfied with the devices.

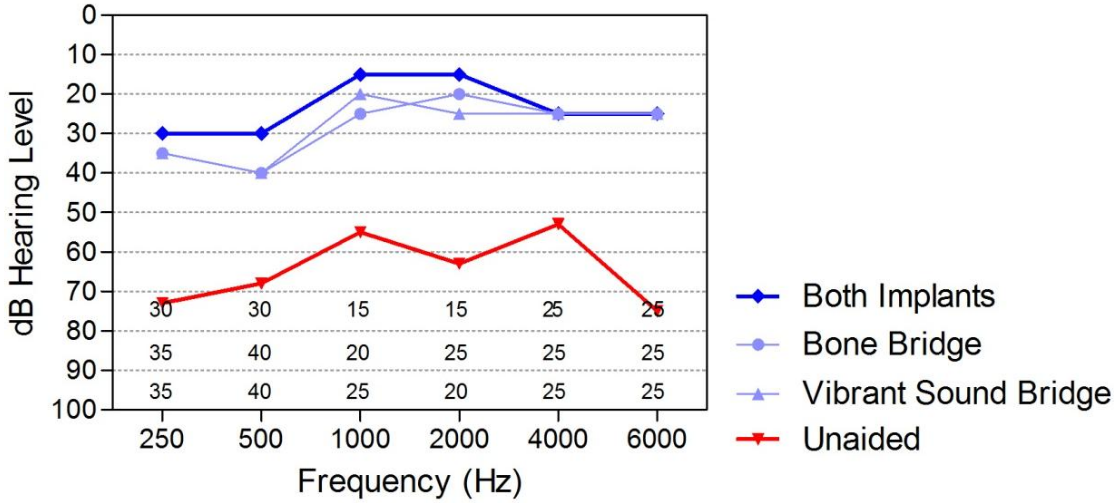

Fig. 3. Aided thresholds showing a cumulative effect of both implants working together

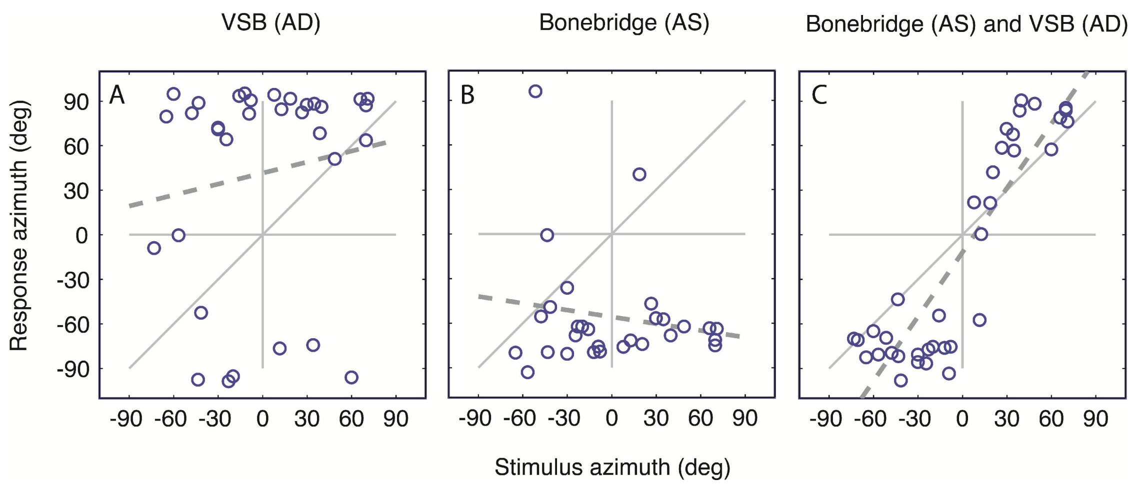

Fig. 4. The stimulus-response relationships for BB noise bursts. The figure demonstrates pour sound localization with the Vibrant Soundbridge (Fig. 2A) and the Bonebridge (Fig. 2B) used apart, but sound localisation increases when both implants are used simultaneously. AS = left; AD = right

3. DISCUSSION

Nowadays, often rehabilitation with percutaneous BCDs is considered in patients with aural atresia [1]. There is extensive knowledge of this treatment with minimal invasive surgery. However, it is known that children might have a 10-15% chance of implant loss [2]. Owing to improved implant and abutment designs, the number of lost implants is dropping [3].

The literature concerning the Bonebridge in aural atresia is still limited [10,11]. Manrique et al. [12] reported on four adult patients with chronic otitis media with aided thresholds of 31.3±6.7 dB HL. Another report described four patients who were aided with a Bonebridge; they had a gain of 36,5 dB (HL, PTA) [13].

Concerning bilateral VSB in children, two case reports were found. The first is about a six-year-old boy with bilateral atresia and microtia. Aided PTA of 32 dB HL and 35 dB HL was reported for the two ears respectively [14]. Another case report describes a 13-month-old patient also with bilateral atresia. Aided PTAs of 21 dB HL were reported, on either side. Hearing result (aided PTA) in our patient is in between. Data on bilateral summation or sound localization were not presented. Dun et al. reported on directional hearing in young patients with bilateral atresia using bilateral percutaneous Baha devices [15]. They also reported a highly significant improvement in directional hearing when changing from unilateral to bilateral Baha application.

Fig. 3 shows aided hearing thresholds around 20 dB HL with both devices active in the 1 to 4 kHz range, the most important frequency range for speech perception. Remarkably, symmetric aided thresholds were found (within 5 dB see Fig. 3), suggesting good compatibility of the two devices in audiometric terms, For each ear, a remaining air-bone gap of approx. 27 dB was found (aided thresholds minus bone-conduction thresholds). As shown elsewhere a partially remaining air-bone gap after device fitting is a general finding and can be ascribed to the relative low maximum output of all amplification options for conductive and mixed hearing loss [16-18]. The present aided thresholds are close to those reported for percutaneous BCDs in children with bilateral conductive hearing loss [19].

In contrast to listening with one device, when the two devices were used simultaneously most sounds were rather well localized. Sound localization was subnormal (Fig. 4). Still, it can be concluded that the present unique combination of two different auditory implants can result in real binaural benefit (sound localization, binaural summation).

4. CONCLUSION

The VSB and Bonebridge were effectively combined in a teenager with aural atresia on both sides. It should be noted that from age 3 until the time of implant surgery, the patient had used bilateral BCDs on headbands, so he had almost 10 years of experience with bilateral auditory input. That might have been beneficial with respect to binaural hearing.

CONSENT

All authors declare that ‘written informed consent was obtained from the patient for publication of this case report and accompanying images.

ETHICAL APPROVAL

Surgery was approved by the ethics committee and health inspection.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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