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EFFECTIVENESS OF THE ADHEAR BONE CONDUCTION DEVICE FITTED BILATERALLY IN A CHILD WITH CONDUCTIVE HEARING LOSS: CASE STUDY

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Contributions:
A Study design/planning
B Data collection/entry
C Data analysis/statistics
D Data interpretation
E Preparation of manuscript
F Literature analysis/search
G Funds collection

Abstract

Introduction: Frequently, bone conduction hearing aids on a softband are not tolerated by children due to pressure on the head or visual esthetics. By way of contrast, a non-surgical hearing system – Adhear (Med-El, Innsbruck, Austria) – allows the sound processor to be attached using a noninvasive adhesive adapter. The objective of this study was to evaluate the effectiveness of the Adhear system and assess its subjective benefits in a child who had bilateral conductive hearing loss.

Case report: The Adhear system was tested in a 13-year-old child with bilateral conductive hearing loss. Pure tone audiometry and speech audiometry in quiet were performed without and then with a pair of devices placed bilaterally. Word recognition scores (WRS) at 50 and 65 dB SPL in quiet were measured using the Pruszewicz monosyllabic Polish word test. After 4 weeks, subjective hearing benefit and experience with the Adhear system was done using the APHAB (*Abbreviated Profile of Hearing Aid Benefit*) questionnaire.

Results: With Adhear, WRS at 50dB SPL increased significantly from an unaided score of 10% to 80%. The result of free-field audiometry with Adhear on both sides indicated a hearing level within the normal range.

Conclusions: Adhear is an effective rehabilitation option for children with bilateral conductive hearing loss.

Keywords: Adhear • bone conduction hearing aid • bilateral conductive hearing loss

SKUTECZNOŚĆ URZĄDZENIA NA PRZEWODNICTWO KOSTNE ADHEAR ZAŁOŻONEGO OBUSTRONNIE U DZIECKA Z NIEDOSŁUCHEM PRZEWODZENIOWYM: OPIS PRZYPADKU

Streszczenie

Wprowadzenie: Aparaty słuchowe na przewodnictwo kostne na elastycznej opasce często nie są tolerowane przez dzieci ze względu na ucisk na głowę lub estetykę wizualną. Natomiast niechirurgiczny system słuchowy – Adhear (Med-El, Innsbruck, Austria) – umożliwia przymocowanie procesora dźwięku za pomocą nieinwazyjnego, samoprzylepnego elementu mocującego. Celem niniejszego badania była ocena skuteczności systemu Adhear i subiektywnych korzyści z jego stosowania u dziecka z obustronnym niedosłuchem przewodzeniowym.

Opis przypadku: System Adhear został przetestowany u 13-letniego dziecka z obustronnym niedosłuchem przewodzeniowym. Audiometrię tonalną i audiometrię mowy w ciszy wykonano najpierw bez urządzeń, a następnie z parą urządzeń, umieszczonych obustronnie. Wyniki rozpoznawania słów (WRS) przy 50 i 65 dB SPL w ciszy mierzono za pomocą testu identyfikacji polskich słów jednosylabowych Pruszewicza. Po 4 tygodniach subiektywne korzyści słuchowe i doświadczenia z systemem Adhear zostały ocenione za pomocą kwestionariusza APHAB (*Abbreviated Profile of Hearing Aid Benefit*).

Wyniki: Dzięki systemowi Adhear wynik WRS przy 50 dB SPL wzrósł znacząco – z 10% do 80%. Wynik audiometrii w polu swobodnym z Adhear po obu stronach wykazał poziom słyszenia w zakresie normy.

Wnioski: Adhear jest skuteczną opcją rehabilitacji dla dzieci z obustronnym niedosłuchem przewodzeniowym.

Słowa kluczowe: Adhear • aparat słuchowy na przewodnictwo kostne • niedosłuch przewodzeniowy obustronny

Introduction

Early identification of hearing loss and ear diseases is key. According to hearing aid guidelines, a child with hearing impairment should be diagnosed before 3 months of age and fitted with a hearing aid before 6 months [1]. The selection and fitting of hearing aids for young patients is a complex diagnostic process that requires the cooperation of specialists in various areas [2,3]. The most important element in the selection of hearing aids is proper fitting and assessing the device's effectiveness.

Not all patients can be compensated for their hearing loss with classic air-conduction hearing aids. They include those with defects in the outer or middle ear, chronic otitis, or other inflammatory conditions. Typically, these subjects will have conductive or mixed hearing loss and require the use of bone conduction to allow the external sound to reach the inner ear directly, in this way bypassing damaged structures at the level of the outer and/or middle ear.

Bone conduction involves the transmission of sound through the bones of the skull to the inner ear. A bone conduction hearing aid changes the captured sound signal into vibrations of the bones of the skull, stimulating the fluids in the inner ear directly [4]. Unlike the many different models of classic hearing aids, there are only a few bone conduction devices available. They can be mounted on the patient's head using soft bands or eyeglass frames. These solutions are often not well accepted by children with conductive hearing loss because of head pressure, skin irritation, sweating, discomfort during long use, poor sound quality, or cosmetic stigma [5,6].

Another solution for patients with conductive hearing loss is a non-surgical hearing system, Adhear. The Adhear system (Med-El, Innsbruck, Austria) is a nonsurgical bone conduction hearing aid, available since 2017, which uses an adhesive patch to connect the sound processor to the skull. The device has a symmetrical design so it can be used on either ear. It is intended for patients with conductive hearing loss or unilateral deafness, either temporary or permanent. There are no age restrictions to using the device, and it is suitable for children as young as a few months. The Adhear system consists of a bone conduction audio processor that is held in place with an adhesive adapter placed over the mastoid behind the auricle (**Figure 1**). An integrated transducer in the sound processor converts sound into mechanical vibrations, which are carried by the adhesive adapter and transmitted through the skin to the mastoid and then directly to the inner ear.

The audio processor has dual microphones and is powered by a single P13 battery. A button allows the user to switch between programs, the number depending on the age and expectations of the user. There is a volume control, which can be turned off for the youngest users. The signal processor uses an automatic classifier to control the adaptive directional microphone system and suppress feedback. The proprietary adhesive adapter uses a non-toxic, non-allergenic medical adhesive tape to attach the adapter to the skin and provide good sound quality without pressure on the head or skin. It is water resistant and breathable, and can be used continuously for 3–7 days [7,8]. In comparison, bone conduction hearing aids on soft bands are often not well accepted by children because of head pressure, sweating, or visual stigma. The lack of a headband makes the system less conspicuous and more comfortable.

Figure 1. Right ear showing Adhear adapter (left) and processor in place (right)

Westerkull and colleagues presented the principles of a self-adhesive adapter and its capabilities and advantages in 2018 [9]. During development, the device was called Adjoin, but later marketed under its current name, Adhear. Two papers discussing the physics of adhesive transmission in bone conduction and summarising results from several other authors have confirmed its effectiveness [7,10]. These two works set out the results of pre-clinical testing and provide comparisons to the established soft-band arrangement.

Implantable devices using bone conduction of sound can also be used to improve hearing in patients with conductive hearing loss. Bone conduction implants are indicated for candidates who could not benefit from conventional hearing aids. The available implantable hearing devices nowadays are subdivided into two major categories: passive (e.g., BAHA – either Connect/Attract – or the Ponto device by Oticon) and active (e.g., Med-El Bonebridge and the Osia system by Cochlear). These devices are indicated in patients with stable bone conduction hearing thresholds within the recommended manufacturer's range. Bone conduction implants are a solution for patients over 5 years old [11]. Bilateral bone conduction fitting was successfully done and audiological benefits and patient satisfaction were shown [11].

For patients for whom previous surgical procedures have not given adequate benefits and for whom classic hearing aids cannot be used (or for various reasons decide against implantable solutions), bone conduction hearing aids are the only option to improve hearing.

For both non-invasive and implantable devices, research has emphasized the importance of early auditory rehabilitation for normal age-appropriate quality of life. Each case needs to be analyzed individually, looking at audiological aspects as well as the patient's subjective assessment. The emotional and behavioral difficulties involving children and adolescents with mild to profound hearing loss are primarily linked to concerns about relationships with peers. In this context, language and communication are important for the psychosocial development of children, as they are the main means of establishing and maintaining social interactions [12].

This paper presents a case report. Due to the specificity of the disorder, it is difficult to collect large material, and at present only a few papers have been published showing the bilateral use of the Adhear system in children. There is a need for more detailed research in this area. The purpose of this study was to evaluate the safety and efficacy of bilateral fitting of the non-invasive Adhear bone conduction device in a child with conductive hearing loss.

Case report

This case concerns a 13-year-old female with bilateral conductive hearing loss due to congenital defect of the middle ears (**Figure 1**). The patient had used bilateral hearing aids. She had a history of chronic middle ear disease and interventions including ventilation tubes, but with no improvement in hearing. Due to chronic inflammation, the child could not use conventional hearing aids during treatment. Attempts were made to use bone conduction hearing aids on a soft band, but these were rejected due to the child's discomfort and reluctance. Due to deformity of the auricles, the parents are considering reconstruction and they do not want an implantable solution at this stage. After reviewing various bone conduction hearing aids, and based on audiometry and medical history, the Adhear system was selected bilaterally.

Methods

Hearing tests for air and bone conduction were done. After the bone conduction devices were selected and set up, sound field thresholds and a word recognition test with and without the device were done. Sound field thresholds with the devices on both sides were measured using warble tones at 0.25, 0.5, 1, 2, 3, and 4 kHz with loudspeakers placed 1 m in front of the patient. Word recognition scores at 50 and 65 dB SPL in quiet were measured with speech coming from the front using the Pruszewicz monosyllabic Polish word test. Subjective evaluation of benefits from the Adhear were assessed using the APHAB questionnaire (*Abbreviated Profile of Hearing Aid Benefit*). APHAB comprises 24 questions about auditory functioning grouped into four categories: EC (*Ease of Communication*); BN (*Background Noise*); RV (*Reverberation*); and AV (*Aversiveness*). The patient completed the questionnaire before the devices were fitted and again one month after the Adhear system was fitted.

Results

Results of pure tone audiometry, free-field audiometry, and speech audiometry in quiet are shown in **Figures 2**, **3**, and **4**. The result of free-field audiometry with Adhear on both sides indicated a hearing level within the normal range, with results better than 25 dB HL (**Figure 3**). With Adhear in place, WRS at 50 dB SPL increased significantly from an unaided score of 10% to 80% (**Figure 4**).

The results of the APHAB questionnaire confirm the benefits of the Adhear system (**Figure 5**). The most significant benefit was in the category of speech understanding in difficult acoustic conditions (RV), a factor that is particularly important for children. The AV scores were higher with the device, probably because the child needed more than a month to adapt to the new sounds. Adaptation time is individual and can take several months.

Discussion

The audiological performance of the new device benefits from the low weight of the adhesive adapter, improved mechanical transmission, and, compared to a softband, a better position for stimulation close to the ear canal [13]. In 2019, Neumann and colleagues presented the first study evaluating the audiological and clinical outcomes of Adhear [14], where, in short- and mid-term follow-ups in children under 10 years of age, it was compared with conventional bone conduction devices integrated in softbands. The comparisons established that sound field thresholds (in quiet and noise) and WRSs were statistically indistinguishable between the devices. However, compared to the softband users, the Adhear children achieved

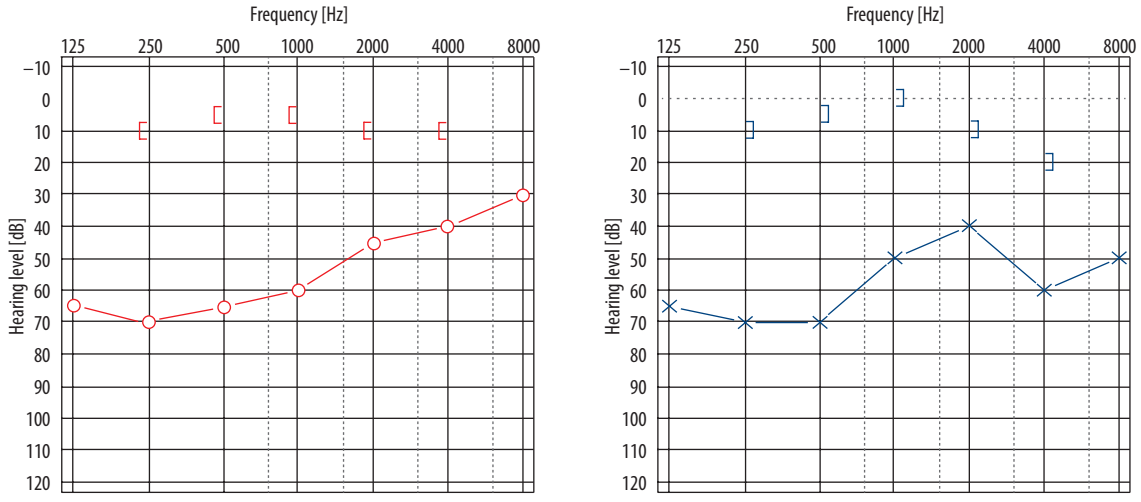

Figure 2. Pure-tone audiometry

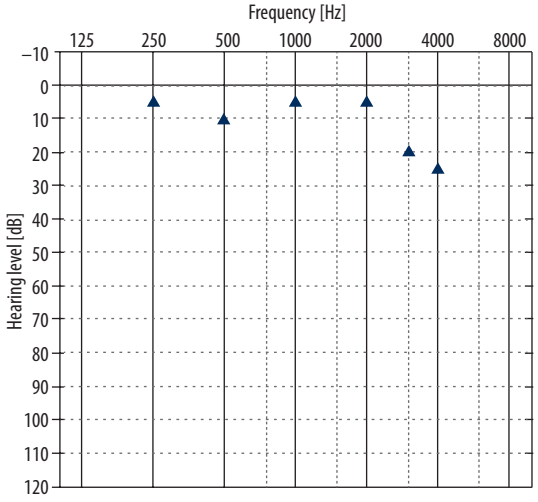

Figure 3. Free-field audiometry with Adhear system on both sides

significant improvements in thresholds at 1 and 8 kHz immediately after the first attachment, and needed no acclimatization time. The Adhear users achieved a mean WRS within normal limits (91%) in quiet and experienced only slight difficulties (78%) in noise.

Dahm et al. also reported good hearing benefits in 12 cases of Adhear use [15]. The aided threshold averaged 30.8 dB HL (*SD* ± 7.1) compared to an unaided threshold of 45.1 dB HL (*SD* ± 7.0). Speech reception threshold in quiet was 56.8 dB (± 6.1) and improved to 44.5 dB (± 6.4) in the aided condition, while WRS improved by about 30% at 65 dB SPL. Two questionnaires, SSQ12 and AQoL-8D, demonstrated a statistically significant improvement following 2 weeks of device use.

A clinical study by Skarzynski and colleagues [7] compared Adhear with a softband solution as well as with a magnetically attached bone conduction implant. Users of the implant received comparable hearing benefits to those who used Adhear. Mean aided sound field thresholds and speech understanding in quiet and noise were similar.

A study by Urik et al. [16] compared the results of patients with Bonebridge implants and with those using the Adhear system. There were 15 children with conductive hearing loss and using the Adhear device who were included in the study. In 5 cases, the Adhear device was used bilaterally. In this group, mean free-field outcomes improved from the unaided condition of 28.1 ± 0.9 dB HL to 17.3 ± 2.9 dB HL. In our presented case, free-field outcomes with bilateral Adhear were also within the range of normal hearing (**Figure 3**). Urik and colleagues also measured speech outcomes in quiet in 13 of their Adhear patients and this revealed a mean benefit of 23.1 ± 2.6. Speech-in-noise outcomes resulted in a mean benefit of 16.4 ± 12.0 for the Adhear group. Patient quality of life was also assessed and, as in the present study, confirmed the benefits of the device: the AQoL-6D utility score for the Adhear group was 0.75 ± 0.17 and improved to 0.85 ± 0.15 with use of the device.

A study by Liu et al. [17] has demonstrated the high effectiveness of the Adhear device in children with bilateral conductive hearing loss. The aim of their study was to characterize the auditory benefit and sound localization accuracy of bilateral bone conduction adhesives devices compared to unilateral devices. The mean unaided sound field hearing threshold was 57.9 ± 5.1 dB HL, while the mean aided hearing threshold for the right ear was 32.4 ± 5.3 dB HL, for the left ear it was 32.0 ± 5.6 dB HL, and for both ears it was 27.8 ± 5.3 dB HL. The mean unaided WRS was 4.6 ± 13.1%, while the mean aided WRS was 83.0 ± 10.1% for the right ear, 81.6 ± 14.5% for the left ear, and 90.3 ± 10.2% for both ears. In terms of sound localization accuracy, the MAE (mean absolute error) was 43.5 ± 19.0° in the unaided condition, 70.0 ± 8.5° for the right ear, 69.3 ± 9.4° for the left ear, and 51.2 ± 14.8° for both ears. It is worth noting that the average MAEs increased (worsened) significantly under unilateral fitting conditions. The results of Liu et al., like the present paper,

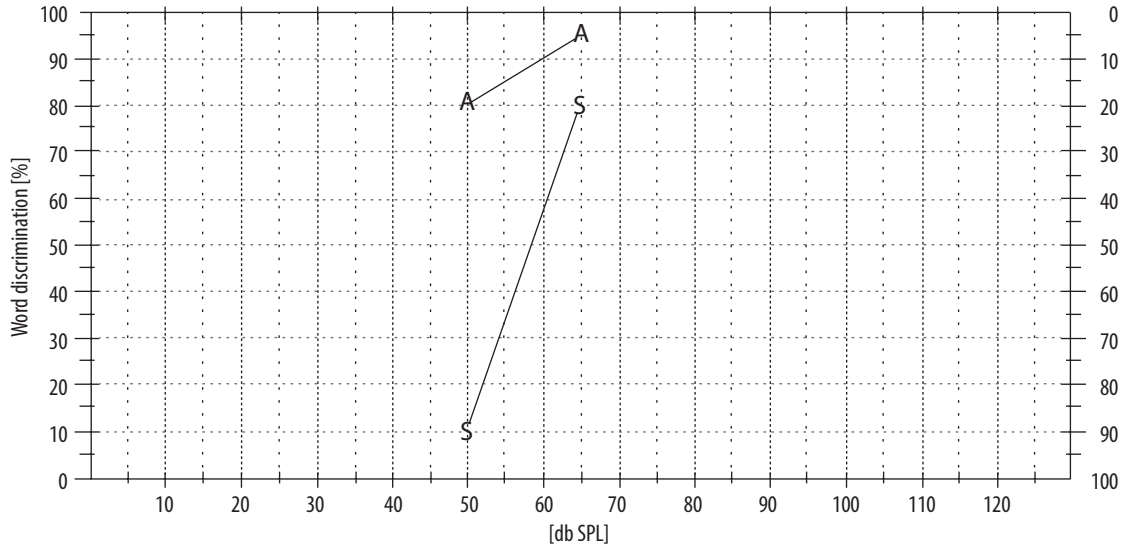

Figure 4. Speech audiometry. **A**, with Adhear on both sides; **S**, without the devices

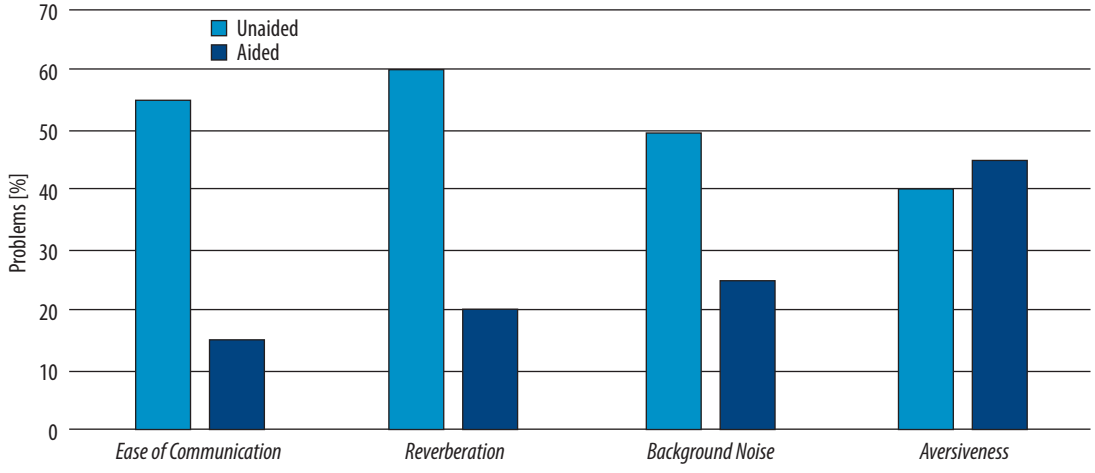

Figure 5. Results of APHAB questionnaire after 1 month of Adhear use

suggest that bilateral use of the Adhear system has a significant beneficial effect on speech perception; in addition, the study showed a better ability to localize sound in the bilateral mode compared to unilateral.

There are now many papers showing the results of using the Adhear system in children and adults [7,8,14,18–22]. Our results complement existing studies in the area of bilateral use of Adhear in children, and confirm the system's effectiveness in improving hearing, speech understanding, and quality of life.

Conclusions

With the Adhear device, the 13-year-old child in this report showed significant improvements in hearing thresholds, speech recognition in quiet, and quality of life, confirming the effectiveness of the system. The Adhear device appears to be a good alternative to other bone conduction devices for children with conductive hearing loss.

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