A Review on the Pediatric Hearing Aid Developments

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Abstract: Thanks to the excellent technology combined with improving living conditions, a pediatric intervention for hearing loss, is faster and easier In addition to the normal hearing aids, the cartilage conduction, the adhesive-based, the Bone Conduction, and the Bonebridge hearing aids, show that there are multiple options to compensate the hearing loss in children. The main reasons for using such interventions are the gapless continuation of the child's hearing, language, and speech development. A subject's ability to understand language they can listen to, improves significantly their ability to understand speech and to distinguish between sounds. This manuscript presents the major types of Hearing Aids, which are available for various clinical hearing impairment startegies.

Keywords: Hearing loss, Pediatric, Hearing aids, Pediatric hearing aid types, Rehabilitation

Introduction

Hearing loss, in its most general definition, is a complete or partial decrease in hearing. Hearing Aids (HA) are electronic devices which amplify sounds and they are recommended for hearing losses that cannot be treated medically or surgically. The HA basic functions are to collect, to process and to amplify sounds coming from the external environment. Signal processing and fitting methods in hearing aids are designed primarily to ensure an optimal speech intelligibility. Cochlear implants, on the other hand, are surgically placed prostheses that provide electronic stimulation and are used in the auditory rehabilitation of individuals with severe and profound hearing loss who cannot benefit from traditional hearing aids. They convert the acoustic signal into electrical stimuli for the activation of auditory nerve fibers and thus fulfill the function of the inner hair cells. It has been reported that individuals can have near-normal hearing sensitivity with electrical stimulation after implantation (Turk, Koseoglu, & Zeren, 2021).

In order to improve hearing, speech intelligibility is the first priority in the HA intervention strategy (Turk, Koseoglu, & Zeren, 2021). Also, in order to establish a correct implementation of this strategy in the pediatric groups with hearing loss, all problems related to a delay of the verbal language development, must be resolved. Linguistical delays are reflected in the child's cognitive, social and emotional development and can cause scholastic academic failure the child reaches school age (Marschark, 2007; Marschark, Green, Hindmarsh, and Walker, 2000; Rieffe, Terwogt, and Smith, 2003; Tufekcioglu, 2010). All of these limit the ability of the individual with hearing loss to live an autonomous life (Marschark, 2007).

In a pediatric context, after the detection and identification of the hearing loss the parents discuss with the appropriate professionals: the nature of the hearing loss, the effects

of the loss on the hearing system, the function of the hearing aids, the responsibilities of the parents during the intervention process obtaining the appropriate device, ensuring that the child uses the device regularly, protecting the hearing aid etc (Munoz et al., 2014, Cankuvvet, 2015). Data from the literature underline the importance of informing well the interested parties, showing that competent parents participate more actively in the intervention process (Calderon, 2000; Cankuvvet, 2015; Duncan, 2009; Hintermair, 2006; Munoz et al., 2014; Munoz et al., 2016). The rate and impact of family involvement varies depending on the type of hearing aid. Therefore, hearing professionals usually establish a good relationship with the parents in order to increase their problem-solving skills (Cankuvvet Aykut and Cinar, 2018).

2. Methods

The following sections provide a summary of HA interventions available to children with hearing loss. The research on developments and innovations in pediatric hearing aids spans the period 2015 to 2023.

3. Data in the Literature

3.1. A Non-Implantable, Adhesive-Retained Bone Conduction Hearing Aid (AB-CCs)

The study conducted by Osborne, Child-Hymas, Gill, Lloyd, and McDermott (2019) evaluated the audiological results, practicality, and impact on the quality of life of a new, non-implantable, adhesive-retained bone conduction hearing aid in children. The study was conducted as a prospective, single-subject repeat measurement, cohort study. Twenty-one children, aged between 5 and 15 years, with a conductive hearing loss of >/=25 dB HL in the better hearing ear, were evaluated at the pediatric assessment center. Audiological comparisons were made using pure-tone thresholds; unaided, with a softband aid, and with the new adhesive retained bone conducting system. A statistically significant improvement in threshold values of 7.3 dB HL was demonstrated with the adhesive system compared to soft band-aids. After 4 weeks of use, the average hearing thresholds of the adhesive hearing system increased from 55 dB HL ± 2.4 to 31 dB HL± 7.9 in the unaided and assisted conditions.

Improvements in quality of life were shown through surveys. Four children reported mild skin reactions. Eighty six percent reported increased self-confidence. The adhesive-retained bone conduction hearing aid seems to produce audiological results comparable to the commercial hearing aids. It provides an excellent alternative in the treatment of conductive hearing loss without the possible complications and costs of a surgical intervention. Furthermore, it preserves the skin envelope over the mastoid for those who wish to proceed with an autologous pinna reconstruction in the future.

Figure 1: Example of a AB Hearing Aid. Image source : www.medel.pro/products/adhear

3.2. Cartiladge Consuction Hearing Aids (CC-HAs)

These are novel hearing aids that use the third hearing pathway of cartilage conduction. Nishiyama, Oishi, and Ogawa (2021) evaluated the effectiveness and hearing effects of CC-HAs in children with hearing loss and the safety of additional band compression on the transducer. Patients (n = 42) underwent a one-month free trial of CC-HA. Of these, 40 were patients with auditory canal atresia or stenosis. CC-HA assisted and unaided hearing thresholds (48 attached ears) were determined using standard audiograms, and participants were then able to choose whether to purchase the device. Purchase rates were calculated and patient characteristics were compared between purchase and non-purchase groups by reason for purchase (or not). The authors applied additional band compression

on the CC-HA transducer and evaluated the hearing effects and side effects. CC-HA led to improvements in hearing at all frequencies. Overall, 72.92% of participants purchased CC-HA after the trial. By applying additional band compression on the CC-HA transducer, stability and hearing gains were improved mainly at low frequencies, and no side effects such as dermatitis were observed. CC-HAs are effective in providing hearing recovery in children, especially in patients with atresia or canal stenosis who cannot use air-conduction hearing aids. Additionally, additional band compression on the transducer has been found to be an easy and safe method to improve the hearing effects and stability of CC-HA.

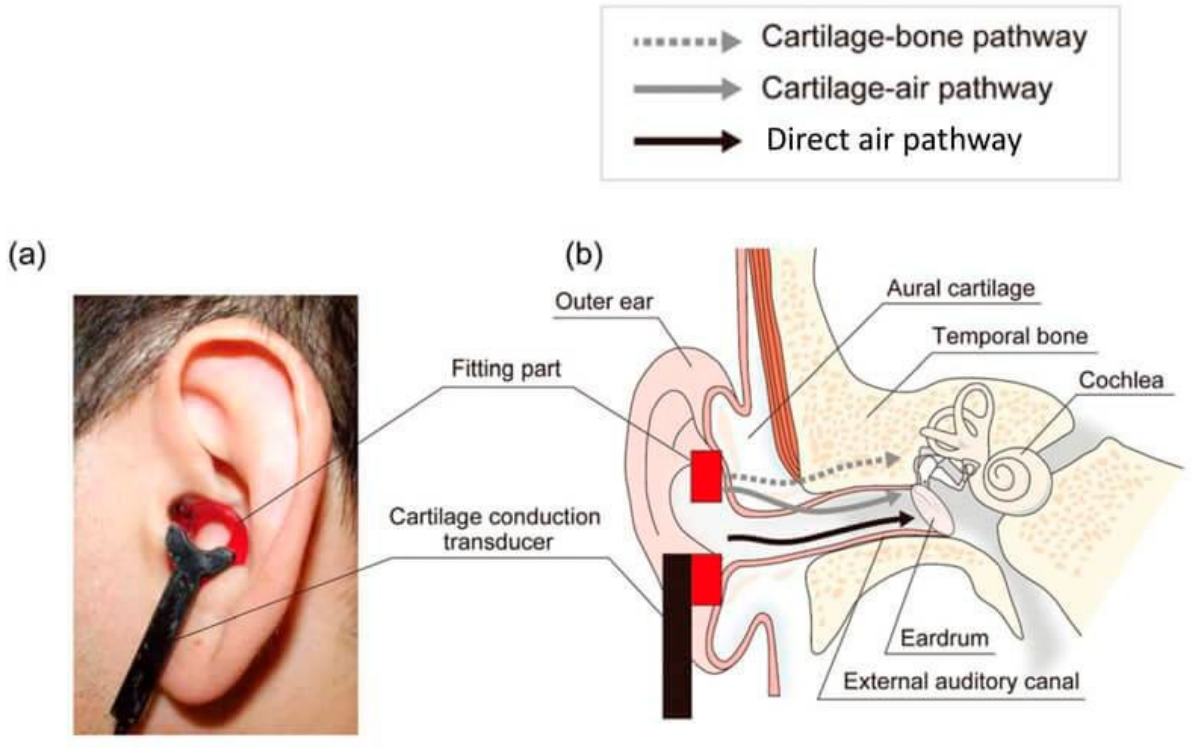

Figure 2: Example of a CC Hearing Aids. Image source: www.entandaudiologynews.com

3.3. Bone Conduction Hearing Devices (BCHD)

Congenital aural atresia, which is commonly associated with microtia, is the failure of the development of the external auditory canal. Due to the absence of an external auditory canal, amplification options are limited to bone conduction hearing devices (BCHD), either worn on a softband, cap or utilizing surgically placed abutment or magnetic systems. For bilateral atresia patients, the BCHD can initially be worn on a soft band from birth to provide adequate stimulation for the development of the central auditory system. More definitive surgical solutions are considered when the patient grows older (Kulasegarah, Burgess, Neeff, and Brown, 2018).

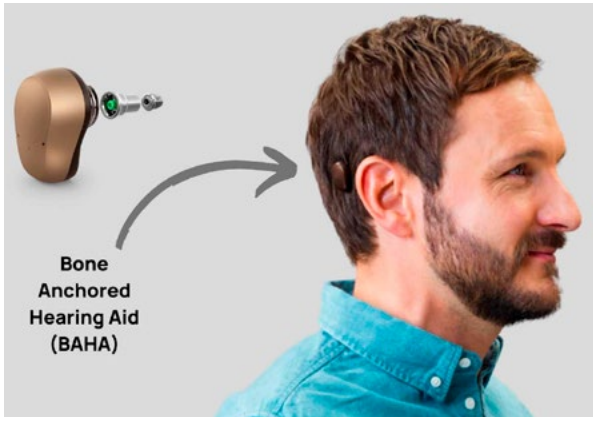

Figure 3: Example of a BC Hearing Devices. Image source: www.soundly.com/blog/boneanchored-hearing-aids

3.4. The Bonebridge (BB) Hearing Devices

The Bonebridge is an option for children age 5 and older who have conductive, mixed hearing loss, or single-sided deafness with bone conduction thresholds at 45 dBHL or better across frequencies. The advantages especially in children include the lack of a skin-penetrating abutment, which substantially removes the need for medical follow-up, the external device is compact, simple to use, and is considerably better cosmetically for children who may have other deformities such as microtia or craniofacial microsomia (Kulasegarah, Burgess, Neeff and Brown, 2018).

A study, conducted by Kulasegarah, Burgess, Neeff, and Brown (2018), aimed to compare the audiological results of the Bone Conduction Hearing Aid (BCHA) and the Bonebridge (BB) implant on a rigid test tape in children with microtia and atresia. It also aimed to demonstrate the effectiveness, safety, and durability of BB as a treatment option in children and adolescents with conductive hearing loss, atresia, and microtia. The study was a retrospective review of patients with microtia and atresia who received BB implants. Preoperative audiological testing using a powered BCHA (Oticon Medical Ponto Pro Power) on a hard test band was used to compare postoperative hearing assessments with the BB. Ten microtia and atresia patients were treated with a BB of whom 3 were treated bilaterally. The children were aged between 5 and 15 and all had moderate to moderately severe conductive hearing loss. For each ear tested and subsequently implanted, BB-aided speech scores were equivalent to those obtained by a BCHA. The mean improvement of speech reception threshold level between unaided and BB was statistically significant ($p > 0.0001$). Subjective questionnaire data indicated that BB-implanted patients were performing within the norms of overall listening, both in quiet and in noise. In audiological assessments, BB performs comparably to BCHA among children with microtia and atresia. In the last decade, the development of implantable hearing devices has brought a slow change from once preferred atresiaplasty for patients with microtia and atresia.

Figure 4: Example of a BB Hearing Aids. Image source: www.medel.com/hearing-solutions/bonebridge

4. Result

The results obtained from the hearing aids used have varied depending on the studies conducted. Because there are factors that affect the performance of the devices. For example; insertion/not placement under the skin, risk of infection, age of children, type and degree of hearing loss, price, etc. For this reason, the yield rates may vary. With advancing technology, innovations have been brought to the problems encountered and new devices have been applied.

Pediatric hearing aids can be discussed under many subheadings. Because hearing, language and speech are areas that affect each other. It is possible to address these areas separately or together. The effects on each other are enormous. It is a subject very suitable for research, comparison and support with findings on new subjects. Being constantly updated enables new research and contributions to the literature.

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