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Review article

The role of bone conduction hearing aids in congenital unilateral hearing loss: A systematic review

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ABSTRACT

Objectives: To systematically review the literature on the audiological and/or quality of life benefits of a bone conduction hearing aid (BCHA) in children with congenital unilateral conductive or sensorineural deafness.
Methods: A systematic search was performed according to the PRISMA guidelines using the PubMed, Medline, and Embase databases. Data were collected on the following outcomes of interest: speech reception threshold, speech discrimination, sound localization, and quality of life measures. Given the heterogeneity of the data for quantitative analysis, the results are qualitatively summarized.
Results: Eight studies were included in the review. Four studies examined the audiological outcomes associated with bone conduction hearing aid implantation. There was a consistent gain in speech reception thresholds and speech discrimination, especially in noisy environments. Results pertaining to sound localization was inconsistent. The studies that examined quality of life measures reported a high usage rate of BCHAs among children. Quality of life improvements are reported with suggested benefit in the subdomain of learning.
Conclusion: Given the potential benefits of a BCHA, along with the fact that it can be safely trialed using a headband, it is reasonable to trial a BCHA in children with congenital unilateral deafness. Should the trial offer audiological and/or quality of life benefits for the individual child, then BCHA implantation can be considered.

Contents

1. Introduction

The optimal approach for hearing (re)habilitation in children with congenital unilateral deafness, either conductive or

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sensorineural, is unclear. Traditionally, children with congenital unilateral deafness were not offered hearing amplification until there was evidence of issues in school or social settings [1,2]. This approach was informed by the traditional thinking that unilateral deafness does not result in any detrimental effects on language and social development [1,3]. A systematic review performed by Lieu [4], however, concluded that there does appear to be an association between unilateral deafness and an increased incidence of developmental and educational concerns, including grade failures and behavioural issues [4]. These findings suggest that there may be a role for earlier intervention in children with congenital unilateral deafness, prior to the onset of any developmental or academic issues.

In addition to determining whether intervention in children with unilateral deafness is of developmental and academic benefit, it should also be determined whether any of the interventions offer audiological benefit. Furthermore, studies in adults suggest that providing amplification in the setting of unilateral deafness is associated with improved quality of life [5,6], raising the question of whether similar benefits may be experienced by children with unilateral deafness.

Traditionally, the main method of hearing (re)habilitation for unilateral deafness is that of the CROS (contralateral routing of signal) hearing aid, whereby a microphone is placed on the side of deafness and sound is transmitted to the better-hearing ear [7]. A common patient criticism of the CROS aid is that the mold leads to occlusion and impaired hearing in the better-hearing ear [5]. The more recent development of open-fitting aids may be helpful in addressing this issue. A second option is the fitting of a powerful air-conduction hearing aid on the deaf side. Signals can then be transmitted to the contralateral cochlea via transcranial vibrations [8]. Both of the above-mentioned options for hearing (re)habilitation requires the presence of normal anatomy on the side with deafness. As such, their use may be limited in patients who cannot be fitted for or cannot tolerate conventional hearing aids.

A bone conduction hearing aid (BCHA) is an option for hearing (re)habilitation in children with congenital unilateral deafness who are unable to wear conventional hearing aids. BCHAs were traditionally indicated in patients with a conductive hearing loss who are not appropriate for or have failed conventional aids [9–11]. The classic group of patients is those with chronic otitis media [12]. Overtime, however, the indications have expanded to also include those with congenital anomalies, such as external auditory canal atresia [10,11,13].

BCHAs can be worn on a fabric headband, commonly referred to as a soft band, or attached to an implant that is surgically affixed to the skull. A surgically implanted BCHA consists of a titanium fixture, which is osseointegrated into the skull, a sound processor that converts sound waves into vibrations, and an abutment that transmits these vibrations to the implanted fixture [14]. This system allows for sound to be transmitted directly to the cochlea through the skull [9]. With a soft band, the sound processor is mounted on a fabric headband and the signal is transcutaneously conducted through the skull to the inner ear. Soft bands are suitable for children who are younger than four years old, the age under which most physicians would define as too young to receive a BCHA implant [15]. Soft bands can also be used as trial in patients who are contemplating BCHA implantation.

The main benefit of the BCHA is that it circumvents any external or middle ear anomaly or pathology; therefore, they are most commonly used in conductive hearing loss, where the bone conduction thresholds are either normal or near normal. Studies in adults with unilateral sensorineural deafness suggest that BCHA implantation may offer an improvement in sound localization and quality of life. As such, unilateral sensorineural deafness has become an indication for BCHA implantation in children as well, although the evidence has been more conflicting than in the adult population [12].

The objective of this study was to systematically review the literature on the evidence of pediatric BCHAs in congenital unilateral conductive or sensorineural deafness. Specifically, we investigated whether BCHAs offer audiological, general quality of life, and developmental benefits in children with congenital unilateral deafness.

2. Methods

2.1. Search strategy and study selection

A systematic search was performed according to the PRISMA guidelines by two reviewers (C.C.L., D.L.). The PubMed, Medline, and Embase databases were searched using two sets of key terms, one for unilateral deafness/hearing loss and the other for bone conduction hearing aids. The search strategy for each database was developed in consultation with a librarian to maximize efficiency and inclusivity. Fig. 1 outlines the key search terms as well as the overall search strategy. Studies were limited to those published over the past 39 years (01/01/1977 through 07/01/2016), in the English language, and involving human subjects. This timeline was chosen as the first BCHAs were implanted in 1977 [16], thereby rendering studies published prior to this date of limited value. We also hand-searched the reference lists of relevant studies to identify any additional studies.

Title and abstract review was performed of the studies identified from the initial search. Studies remaining after this step were obtained in their full text and reviewed for inclusion. The reviewers met prior to and after study selection to ensure consistency in the application of the inclusion criteria. Studies were selected if they met the following criteria: 1) the study was retrospective or prospective, and was observational or randomized controlled trial in design, 2) participants were children (age <18 years) with congenital unilateral deafness, 3) the study examined and reported audiological and/or quality of life and/or developmental outcomes following BCHA-implantation. We defined sensorineural deafness as profound sensorineural hearing loss (90 dB HL) and conductive deafness as a maximum conductive hearing loss (60 dB HL).

This study contains only data from the published literature and does not contain any patient data; therefore, local institutional review and ethics board approval was not required.

2.2. Data collection and analysis

The outcomes of interest were: speech reception threshold, speech discrimination, sound localization, and developmental and quality of life benefits. Other data points of interest included: study design, number of subjects, demographic information regarding the subjects, and etiology of deafness. In studies that also examined non-criterion-meeting subjects (ie. adults or children with congenital bilateral deafness), we only collected data on the applicable subjects. Two reviewers independently collected the data (C.C.L., D.L.). As the data was heterogeneous and could not be combined in a quantitative analysis, results are qualitatively summarized.

3. Results

A total of 253 studies were identified from the initial search. Two hundred and four studies were excluded following the title and abstract review, leaving 49 studies for full text review. With full text review, a further 41 studies were excluded with one study