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Effectiveness of Bone Conduction Device for Hearing Loss in Pediatrics

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Abstract
Background: Hearing loss in children is a problem that needs attention, with around 32 million children in the world experiencing it. One of the most important aspects of hearing loss is bone conduction. Bone conduction devices are very useful for children with hearing loss to receive sound that is not limited to either damaged outer or middle ear.
Aim of the study: to provide an overview of causes of hearing loss, bone conduction hearing physiology, and the use of bone conduction devices for hearing loss in children.
Methods: The study was conducted using some scientific journals from some reputable platforms such as PubMed, Scopus, and Google Scholar to evaluate the effectiveness of bone conduction devices for hearing loss in pediatrics.
Result: Bone conduction technology offers an alternative way to receive sound that can be of great benefit to children with hearing loss.
Conclusion: Bone conduction devices can deliver direct stimulation to the inner ear while bypassing difficulties in the outer or middle ear. The sound quality is also improved since it is not influenced by background noise or other variables that might impair the efficiency of traditional hearing aids. However, sensorineural hearing loss is caused by injury to the inner ear or nerve pathways and does not give many of the advantages of bone conduction devices and other types of hearing aids. In this case, an air-conduction hearing aid or cochlear implant would be more suitable.

Keywords: Hearing Loss, Bone Conduction, Children

1. Introduction

Hearing loss is a condition where an individual experiences challenges in perceiving sounds, so they are unable to perceive sounds accurately [1]. These variations can span from minor to significant and have the potential to impact either one or both ears [2]. Two primary categories of hearing impairment exist: conductive hearing loss and sensorineural hearing loss [3]. When sound transmission to the inner ear is hindered due to issues in the outer or middle ear, it results in conductive hearing loss. Surgical intervention or medication is frequently employed to address this type of hearing impairment [1]. On the other hand, sensorineural hearing loss takes place when the ear's natural components or the nerve pathways responsible for relaying auditory signals from the ear to the brain sustain damage. Typically enduring, this form of hearing loss is commonly managed using hearing aids or cochlear implants [4].

Hearing loss is a common condition in children and can profoundly influence their growth and overall quality of existence. According to the World Health Organization (WHO), globally, it is estimated that around 32 million children have hearing loss [5]. In developed countries, congenital sensorineural hearing loss, which is present at birth, stands as the leading cause of hearing impairment in children. There are 0.1- 0.2% deaf from birth, which means that for every 1,000 live births, there are 12 babies who suffer from deafness [6]. This type of impairment disorder can be caused by genetic mutations, maternal diseases during pregnancy, or complications during childbirth. In developing nations, the primary source of hearing loss among children arises from avoidable factors such as ear infections (otitis media) and meningitis. This can result in conductive hearing loss, a condition that frequently responds well to surgical procedures or medical treatment [4].

Bone conduction devices are one of the solutions that can be used to treat hearing loss [7]. The mechanism operates by sending sound vibrations directly to the inner ear via the skull's bone structure, bypassing the outer and middle ear in the process [8]. Bone conduction proves to be the suitable option for individuals afflicted with conductive hearing loss, a condition attributed to complications in the outer or middle ear and frequently amenable to treatment through surgical procedures or medication [9].

Bone conduction devices can be employed alongside conventional air-conduction hearing aids, or they can serve as a substitute for individuals unable to utilize air-conduction hearing aids owing to issues in the middle ear [1]. Certain prevalent varieties of bone conduction devices include bone conduction headphones, behind-the-ear vertebral conduction devices (BTE), and implantable bone conduction devices [10].

It is important to remember that bone conduction devices are not a one-size-fits-all solution and that their effectiveness can vary greatly from person to person [11]. If you are considering a bone conduction device for hearing loss, it is important to speak with an audiologist or hearing specialist who can help you determine if this type of device is right for you and your personal hearing needs [12]. They can also guide you in choosing the best type of device and make sure it is properly installed and customized to meet your needs.

Based on the background above, we found a problem that we will discuss in this review. Primarily, we will delve into the origins of hearing impairment. Subsequently, we will delve into the science behind bone conduction and its application in addressing hearing loss among children. This will encompass indications, the range of applicability, advantages, and disadvantages associated with the usage of bone conduction devices [13, 14].

2. Methods

The research method used in this study is a qualitative descriptive method. Source of data obtained through research techniques library (library study) such as: scientific journals and books. These sources were collected based on discussion and linked from one piece of information to another. The technique of data collection used in this study is observation, the data is analyzed and then conclusions are drawn. Scientific journals from several leading platforms such as PubMed, Scopus, and Google Scholar were used to evaluate the effectiveness of bone conduction devices for hearing loss in pediatrics. Keywords used for searching were: Hearing loss, bone conduction, and children or pediatric.

3. Discussion

A. Causes of Hearing Loss

Hearing loss can stem from various factors, encompassing age, gender, exposure to high volumes, specific medications, infections, genetic conditions, and physical injuries [15, 16]. Children with hearing loss can have difficulty hearing, understanding, and processing sounds [17]. They may also have difficulty communicating verbally and socially. Early detection and intervention are important for successful treatment and positive outcomes [18]. Promptly seeking treatment for hearing loss holds great significance, given that untreated auditory impairment can substantially affect an individual's well-being, potentially resulting in social isolation, depression, and various adverse outcomes [19].

An additional research investigation revealed the participation of twenty-six children aged between 3 and 11 years (with a median age of 5 years), constituting 82% of those listed for local grommet (tympanostomy tube) surgery. Prior to the March 2020 lockdown, the collective displayed an average mild hearing impairment across frequencies of 0.5, 1.2, and 4 kHz, spanning from 0 to 65 dB [20].

Detecting hearing impairment in a child as soon as feasible is crucial, as timely intervention can profoundly influence a child's growth and progress [18]. Hearing-impaired children can derive advantages from hearing aids, cochlear implants, and other assistive devices, along with speech and language therapy and specialized educational services [21]. Screening for hearing loss in newborns is becoming more common in many countries, and early identification and treatment of hearing loss in children can help minimize the negative impact of these conditions on their development and quality of life [22]. There are several reasons why children have hearing loss, some common ones include:

1. Genetics: Hearing loss can be inherited from the elderly. If a parent has hearing problems, it is more likely that their child will also have hearing loss [23].
2. Specific illnesses like meningitis, mumps, rubella, cytomegalovirus, and various others can result in hearing impairment in children [5].
3. Prematurity: Children born prematurely are at higher risk of hearing loss due to complications that can occur during the birth process [24].
4. Noise exposure: Children who are often exposed to loud noises can experience hearing loss, especially if they attend concerts, wear earbuds, or live in noisy environments [25].
5. Ototoxic drugs: Certain medications such as certain antibiotics, chemotherapy drugs, and others can be toxic to the ears and cause hearing loss [26].
6. Middle ear infections, referred to as otitis media, can lead to the accumulation of fluid within the middle ear, resulting in hearing loss [27].
7. Ear disorders: Children with abnormal structures of the ear canal or middle ear may experience hearing loss [28].

B. Bone Conduction Device

Bone conduction is a technique that conveys sound vibrations to the inner ear by utilizing the skull's bone structure, bypassing the middle ear and eardrum in the process [29]. Bone conduction devices, such as headphones and hearing aids, leverage this technology to directly convey sound vibrations to the cochlea, the auditory component within the inner ear accountable for the sense of hearing. This makes it a useful solution for individuals with certain types of hearing loss or those who want their ear canals to remain open, such as swimmers or military personnel [30]. The device can also be used to listen to music, make phone calls, and perform other audio-related activities. Overall, bone conduction technology provides an innovative approach to ease of hearing and audio [31].

Air-conduction devices have become a common solution for children with hearing loss [32]. These air-conduction devices can help children hear sounds clearly and better experience various audio experiences such as music, speech, and instruction. However, for children with more serious hearing loss or impairments in the traditional hearing system, bone conduction devices offer significant advantages [33]. These devices for bone conduction send sound vibrations directly to the cheekbone or skull, avoiding pathways through the air that might contribute to further hearing impairment [34, 35]. The main advantages of using bone-conduction devices are that they allow children to hear sounds more naturally, reduce the risk of eardrum damage that may occur from air-conduction devices, and provide better awareness of the surrounding environment. As such, bone conduction devices are an innovative and safe option for children with hearing loss, improving their quality of life through a better hearing experience [21].

Bone conduction devices have several advantages over traditional air conduction devices (such as traditional headphones or hearing aids). Some of these advantages include: [21, 36]

1. Passing through the eardrum: For individuals with middle ear problems, such as a perforated eardrum or

otitis media, a bone conduction device can provide a way to hear sounds passing through a damaged eardrum.
2. Keeping the ear canal open: Bone conduction devices allow the ear canal to remain open, which is useful for individuals who need to be aware of their surroundings, such as military personnel or cyclists. This is not possible with traditional air-conduction headphones that cover the ears.
3. Suitable for certain types of hearing loss: Bone conduction devices can be beneficial for individuals with conductive hearing loss, where they cannot be effectively transmitted to the inner ear. This is because the bone conduction device can conduct sound directly to the cochlea, passing through the damaged part of the middle ear.
4. Comfortable to wear: Bone conduction devices are often designed to be comfortable to wear, even for extended periods. This is not always the case with traditional air conduction devices, which are heavy and impractical.

For more than twenty years, bone conduction implants have been effectively employed [37]. This type of bone conduction is said to provide effective and safe hearing rehabilitation for people with mild to severe conductive mixed hearing loss [22]. However, bone conduction devices are not a one-size-fits-all solution, where the effectiveness of these devices can vary widely for each person. Bone conduction devices can be effective in treating hearing loss in children, but their effectiveness depends on the type and severity of hearing disorders, as well as the specific needs and preferences of each child. For children with conductive hearing loss, bone conduction devices can be a good solution, as they can solve problems in the outer or middle ear and provide stimulation directly to the inner ear. Unlike the sensorineural, Cochlear implants are a more appropriate choice for patients with severe to profound sensorineural hearing loss [38].

Before using a bone conduction device in a child with hearing loss, there are some preparations to consider, which differ from adult use [5]. Consult a doctor or hearing professional to assess the child's condition thoroughly. Ensure the device fits the child's head size and provide proper instruction on how to use it. Monitoring and supervision during use are also important for the child's comfort and safety [36]. With proper preparation, bone conduction devices can help improve the hearing quality of children with hearing loss [39].

C. The Effectiveness of Bone Conduction Device for Hearing Loss in Children

Hearing loss is a common condition that affects many children and can have a significant impact on their development and quality of life [29]. While traditional hearing aids may be effective for some children with hearing loss, others may require more innovative solutions. This is where bone conduction technology comes in, offering an alternative way to receive sounds that can be of great benefit to children with hearing loss [37].

Bone conduction works by transmitting sound waves through the bones of the skull, passing through the outer ear and mid-ear, and directly stimulating the inner ear [40]. This makes it an ideal solution for children with hearing loss caused by problems in the outer or middle ear, such as otitis media or damage to the eardrum. By avoiding these problem areas, bone conduction can provide clearer and more consistent sound quality, allowing children with hearing loss to better understand speech and other sounds in their environment [37, 38].

Children with conductive hearing loss can benefit from bone conduction devices that are easy to wear, comfortable, and provide clear sound quality [41]. Bone conduction devices may not be successful for children with sensorineural hearing issues since this form of hearing loss is caused by damage to the inner ear or nerve pathways that transfer sound from the ear to the brain. In these cases, other types of assistive devices, such as traditional air-conduction hearing aids or cochlear implants, may be better suited [22, 33].

It is important to remember that children have different auditory needs and preferences than adults and that they may need different types of devices or different adjustments to those devices to ensure their best performance [22, 42]. An audiologist or hearing specialist can work closely with you and your child to determine the best solution for your child's individual needs and ensure that the device is properly installed and adjusted. Overall, the use of bone conduction devices for hearing loss in children can be effective, but the best solution for a particular child will depend on the needs and hearing loss of each. Audiologists or specialists can provide personalized guidance and support to help find solutions for children with hearing loss [20].

Another benefit of bone conduction technology is that it is unaffected by background noise and other circumstances that might reduce the efficiency of traditional hearing aids [36]. This is especially important for children in noisy environments, such as in class or when playing with friends. With bone delivery, children with hearing loss can receive sound more effectively, even in challenging conditions. In addition to improving communication skills and speech development, the use of bone conduction can also have a positive impact on the overall quality of life of the child [41].

Regarding the position or placement, there are three most common positions, namely on the temple, mastoid, and condyle. The stimulation of bone conduction devices placed on condyles is often superior to other sites examined in terms of sensitivity, clarity, and clarity, and that occlusion with conventional headphones increases the BC signal [34].

A research found that using the B one Conduction headset in conjunction with a remote microphone dramatically improved speech discrimination in both quiet and noisy for children with Otitis Media with Effusion [41]. Thus, children with hearing loss who use bone conduction devices can participate more fully in social activities, such as playing with friends, and get a better educational experience, such as in the classroom [41].

Screening for hearing loss in preschoolers and school-age children with audiometry is a reliable and useful technique for guiding early diagnosis and management [21]. One type of application is bone conduction assessment, which is an important aspect in the selection and operation of bone-conduction hearing aids, which have been demonstrated to improve the quality of life of young patients with diverse forms of hearing loss [36].

So, bone conduction technology is an important solution for children with hearing loss, it can offer an alternative way to receive sound that can provide clearer and more consistent sound quality and improve communication and overall life quality [42]. The use of bone conduction devices as a tool for

hearing loss in children has its drawbacks. Sound reinforcement may be limited, the hearing experience differs from conventional methods, and comfort and safety issues may arise due to the child's changing head size [38]. It is important that adults play a role in the supervision and adjustment of the device to avoid potential problems during use [20].

4. Conclusion

Bone conduction devices can be effective in treating hearing loss in children, but their effectiveness varies depending on the type and severity of hearing loss. Children with conductive hearing loss can benefit from bone conduction devices that bypass problems in the outer or middle ear and provide stimulation directly to the inner ear. However, children with sensorineural hearing loss, caused by damage to the inner ear or nerve pathways, may not benefit much from bone conduction devices, and other types of hearing aids, such as airborne hearing aids or cochlear implants, might be a better fit. Furthermore, because it is not impacted by background noise or other variables that might interfere with the function of standard hearing aids, bone conduction can provide greater sound quality for children with hearing loss. In children with hearing loss, the use of bone conduction devices can aid enhance communication skills, speech development, and general quality of life.

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