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Hearing devices for children with unilateral hearing loss: Patient- and parent-reported perspectives

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Abstract

Objective—Management of children with unilateral hearing loss is not standardized. The primary goal of this study was to elicit patient- and parent-reported perspectives regarding usage of hearing devices in pediatric UHL and to suggest a basic algorithmic approach to management.

Methods—Our tertiary care center recruited families of youth ages 5 to 19 years with unilateral hearing loss from January 2014 through October 2015. Parents of all youths completed a 36-item survey, and some youth ages 11 to 19 years participated in hour-long interviews. We assessed patterns of hearing device usage among participants, and performed qualitative data analysis to understand factors considered by youths when deciding whether or not to use a hearing device.

Results—Survey information was collected for 50 patients. Distribution of hearing loss severity in affected ear was mild 14%, moderate 26%, severe 22%, and profound 38%. The majority of children had sensorineural hearing loss (57%), followed by mixed (32%), and then conductive (11%). 34 children (68%) had tried a hearing device; 20 continued to use the device. Retention rates were similar among children with different degrees of hearing loss: mild 66%, moderate 50%, severe 60%, profound 64%. Sixteen children tried a wireless contralateral routing of signal (CROS) device, and 15 tried a behind-the-ear (BTE) hearing aid. Retention rates for CROS and BTE devices were 69% and 47%, respectively. The most common reason for cessation of use was discomfort, followed by lack of benefit.

Conclusion—A majority of children with unilateral hearing loss who tried a hearing device continued to use it, and retention rates were similar across all degrees of hearing loss. These findings suggest that personal hearing devices should be included in management protocols.

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Keywords

Unilateral hearing loss; hearing device; amplification

Introduction

Newborn hearing screening has improved our ability to detect unilateral hearing loss (UHL) at an early age[1]. Reported prevalence of UHL among children 6 to 19 years ranges from 3 to 6.3% depending on case definition[2], and the prevalence of UHL may be increasing among adolescents[3]. Children with UHL have been found to have worse performance on speech and language tests than normal hearing siblings[4]. In addition, there is emerging evidence that early identification and intervention may improve speech and language skills of young children with UHL[5]. However, there are no evidence-based guidelines for management of pediatric UHL[6].

Options for management of pediatric UHL include monitoring without intervention, classroom accommodations such as preferential seating and frequency modulation (FM) systems, and individual hearing devices[7]. Some of the most common hearing devices include behind-the-ear (BTE) hearing aids, contralateral routing of signal (CROS) devices, and bone conduction sound processors (BCSP). Questions have been raised regarding how strongly to recommend individual-level hearing devices. For example, in 1994 Updike suggested that conventional BTE aids and CROS devices may be detrimental to hearing based upon a case series of 6 children with UHL[8]. However, a slightly larger pilot study of 8 children with UHL found participants to report a subjective benefit with BTE hearing aids, but the group was limited to patients with mild to moderately severe UHL[9].

Overall, there have been few large studies evaluating benefit of hearing devices in pediatric UHL; therefore, there is limited evidence upon which providers can base their recommendations for management. The primary goal of this study was to elicit patient- and parent-reported perspectives regarding usage of hearing devices in pediatric UHL and to suggest a basic algorithmic approach to management.

Methods

This is a mixed-methods study utilizing both quantitative and qualitative approaches to exploring outcomes related to hearing device usage in pediatric UHL. The study was conducted at Seattle Children’s Hospital, a pediatric tertiary care facility. Institutional Review Board approval was obtained prior to data collection (IRB#14753).

The institutional audiometric database was queried to identify all children diagnosed with UHL between January 2007 to July 2014. UHL was defined using the following criteria determined by behavioral audiogram: Normal hearing in one ear with 4-tone pure-tone average (PTA) of less than 30 dB HL, and contralateral 4-tone PTA of greater than or equal to 30 dB HL. Patients with conductive hearing loss, sensorineural hearing loss and mixed hearing loss were included, as long as audiogram results and medical history were consistent with permanent hearing loss.

Following identification, electronic medical records were reviewed to ensure that patients met the following criteria for participation: Age between 5 to 19 years, presence of permanent hearing loss, and absence of complex medical conditions that could potentially impact response to hearing device. In addition, families who expressed a preference to not be contacted for research were not approached.

After potential participants were identified, our research team contacted families by telephone to explain the details of the study and conduct telephone surveys. Additional patients who met the above criteria were also recruited from clinic. Parents of children ages 5 to 17 years were surveyed, along with youths who were 18 and able to consent for themselves over the telephone. The survey was developed by a panel of hearing health providers, including otolaryngologists, audiologists and an education consultant for children who are deaf or hard-of-hearing (D/HH). The survey consisted of 36 questions regarding health history, school performance and hearing device usage.

Survey data were collected and managed using REDCap (Research Electronic Data Capture) electronic data capture tools hosted at University of Washington's Institute for Translational Health Sciences[10]. REDCap is a secure, Web-based application designed to support data capture for research studies, providing an interface for data entry, audit trails for tracking data manipulation, and procedures for exporting data to common statistical packages. Following survey completion, data were exported from REDCap to Stata 13.1 (Stata Inc., College Station, TX).

In addition to the telephone survey, our research team also invited youths ages 11 to 19 years with UHL to participate in on-site interviews at Seattle Children's Hospital. Semi-structured interviews were conducted to explore multiple facets of their experiences living with UHL, some of which were specifically related to hearing device usage.

Analysis

Univariate analysis was carried out to calculate means and medians for continuous variables such as age, and proportions for categorical variables such as hearing loss severity. Logistic regression models controlling for age at diagnosis were created to assess the likelihood that a child would have exposure to a hearing device based upon degree of hearing loss and to determine whether duration of usage was associated with retention rates. In addition, comparisons were made between the most common hearing devices using a Student's t-test for continuous outcomes and Chi-square test for categorical outcomes. For all tests, $p < 0.05$ was considered statistically significant. Stata 13.1 (Stata Inc., College Station, TX) statistical software was used for all analyses.

The responses to the qualitative interviews were audio-recorded, transcribed and thematically analyzed using Dedoose software, a secure system for performing qualitative data analysis[11]. A codebook of 11 codes was developed based upon excerpts contained within the first 5 interviews. Following codebook development, two members of the research team independently coded the initial interviews. Discrepancies between code application were resolved through discussion among research team members. Once there was greater than 90 percent agreement in code application, remaining transcripts were coded by a single

research team member. All transcript excerpts that related to patients' experiences with hearing devices were reviewed for this study.

Results

Our initial query identified 418 children with a behavioral audiogram meeting criteria for UHL between January 2007 and July 2014, with 187 children meeting criteria for inclusion. Common reasons for exclusion were 1) the presence of a reversible conductive loss, 2) development of bilateral hearing loss over time, and 3) presence of a syndrome or comorbid condition associated with major developmental delay.

Our research team surveyed 50 parents and conducted 16 interviews with youths from January 2014 to October 2015. Distribution of hearing loss severity in affected ear was mild 14%, moderate 26%, severe 22%, and profound 38%. The majority of children had sensorineural hearing loss (57%) followed by mixed (32%) and then conductive (11%). Characteristics of children and youths with UHL are included in Table 1. In summary, median age at diagnosis was 5 years. Age at time of diagnosis ranged from birth to age 10. There were 11 children who were diagnosed at birth. The most common reasons for diagnosis after birth were abnormal school hearing screen (27%) and parental concern for hearing problem (24%). Almost 1/3rd of the patients (31%) had progression of UHL over time.

Nineteen of the participants (38%) had been enrolled in an Individualized Education Plan (IEP) at their school at some point in time. Only 7 of the 19 children (37%) were enrolled in an IEP specifically for hearing impairment; 4 were enrolled for speech/language concerns (21%). None of the participants worked with a teacher for the deaf or hard-of-hearing, and all were participating in general education classrooms at the time of survey.

Families also reported on whether appropriate accommodation protocols were being carried out in schools. The vast majority, 40 (80%), reported that their child currently had access to preferential seating at school. However, a smaller proportion (40%) reported that schools were currently utilizing FM systems, either personal or soundfield, for classroom instruction. There were 26 children (52%) that had 504c plans outlining accommodation protocols.

Among the youths who completed interviews, 12 of 16 (75%) stated that they had access to preferential seating in class. However, half of these youth reported difficulties associated with preferential seating, such as stigma associated with always sitting at the front of the class, problems with obtaining a necessary seat, or hesitancy to request a new seating assignment. Ten of the 16 youth (63%) had tried an FM system in class, and 7 (43%) were currently using a system. Among the 10 who had tried an FM system, 4 reported disliking the sound quality of the system, and 3 complained of stigma associated with using the device.

In terms of individual hearing devices, 34 children (68%) had ever tried a hearing device, and 20 of the 34 (59%) continued to use their devices. Figure 1 contains a breakdown of hearing device usage by degree of hearing loss. Controlling for age at diagnosis, a logistic regression model suggested that children with severe or profound loss may be more likely to

try a hearing device than children with mild or moderate loss, OR 4 [95% CI 0.95, 17.2]; however, this result did not reach statistical significance, p=0.06, likely due to inadequate power. Retention rates were similar among children with different degrees of hearing loss: mild 66%, moderate 50%, severe 60%, profound 64%.

Sixteen children tried a wireless contralateral routing of signal (CROS) device, and 15 tried a behind-the-ear (BTE) hearing aid. One child with unilateral SNHL had an osseointegrated implant retained bone conduction sound processor for transcranial routing of sound. Two had used more than one type of device or were transitioning between devices. At time of survey, retention rates for the CROS and BTE devices were 69% and 47%, respectively. However, users of BTE hearing aids were more likely to have used their device longer, p=0.02. This is likely because BTE hearing aids have been available at our institution for a longer period of time. Our institution established a trial bank for CROS devices in 2012. Among all 34 youth who had ever used a device, 6 (18%) had used it for 5 or more years, while 10 (29%) reported usage for less than 6 months. Logistic regression model suggested that duration of usage was associated with retention, so that children who had used their device longer were more likely to be using it at time of survey, OR 2.1 [1.1, 3.9], p = 0.03. All 6 children who had a history of 5+ years of usage were still using their devices at time of survey.

Not surprisingly, audiometric profiles were quite different between the children fitted for CROS and BTE hearing devices. Twelve of 16 children (75%) who tried a CROS device had profound UHL, while only one child (7%) who tried a BTE hearing device had profound UHL. In addition, unaided word recognition scores (WRS) were much lower for children with CROS device, p<0.0001. Mean WRS for CROS users was 6% (SD=13), while mean WRS for BTE utilizers was 68% (SD=38).

Among the 15 children who had stopped using their devices, parents reported that the most common reason for cessation of use was discomfort (47%), followed by lack of benefit (33%). One survey reported social stigma as being the primary reason for cessation of use.

During the interviews, some of the youths described these concerns in more detail. Twelve of the 16 youths who were interviewed had tried a hearing device, and 5 had decided not to continue using it. Table 2 contains transcript excerpts describing why some of the youths chose to not use a hearing device. Of the 4 who had never tried a device, 3 cited social stigma as the primary reason for not wanting to use one. Seven of the youths continued to use a hearing device.

Because usage patterns may be influenced by parent and teacher expectations, qualitative information from the youths can provide important information for hearing health providers. Youths who continued to use their hearing device did perceive some benefits. They stated that their device helped them to listen in class, was an asset to learning, and allowed them to sit in other areas of the classroom. Table 3 provides illustrative quotations describing what they liked about their hearing devices, and why they continued to use them.

Discussion

In the 1980s, Bess and Tharpe were among the first to report the deleterious effects of UHL on grade-school performance, finding that 35% of children with UHL were required to repeat a grade, compared with 3% among normal hearing peers[12]. Two decades later, Lieu et al. generated more interest in the management of pediatric UHL by noting that children with UHL had lower speech and language scores than normal hearing siblings[13]. In addition, a recent meta-analysis found that children with UHL may be more likely to have lower IQ scores than normal hearing peers[14]. UHL has a potential negative impact on development; however, hearing health providers are often faced with the challenge of making management decisions on a case-by-case basis when counseling families of children with UHL[15].

There appears to be a changing emphasis on the role of hearing devices in management of pediatric UHL. As recently as 2009, guidelines called for school accommodations to be first-line intervention for children with severe or profound unilateral SNHL[16]. In 2013, the American Academy of Audiology released an update to their Pediatric Amplification Guideline stating that 1) children with aidable unilateral hearing loss should be considered candidates for amplification in the impaired ear and 2) CROS or bone conduction devices may be considered for children with severe or profound unilateral hearing loss. However, the guideline noted that there is a paucity of data available to support any recommendations[17].

This mixed methods study supports the shift in treatment guidelines toward increased utilization of hearing devices, particularly for children with single-sided deafness (SSD). This is one of the largest studies to evaluate parent- and patient-reported perspectives related to hearing device usage among youth with UHL. We found that more than half of children with UHL who tried a hearing device continued to use it. Retention rates were similar among children with different degrees of hearing loss, and there was no significant difference in retention rates between BTE hearing aids and CROS devices. These findings provide further evidence that individuals with UHL, including SSD, may perceive a benefit from hearing devices, and providers should consider offering them as a management option when counseling families.

Of the 16 youths who were interviewed for this study, almost half were currently using a hearing device. Those that viewed hearing devices favorably described improved awareness of their surroundings, more freedom to position themselves where they would like, and improved ability to learn in school. Our study did identify barriers to hearing device usage, particularly discomfort, lack of perceived benefit and social stigma. By identifying common areas of concern, hearing health providers may be able to counsel patients more effectively. It is likely that assistive listening technology will continue to improve, and over time youth may find hearing devices to be more tolerable and more beneficial.

Unfortunately, our study included only one youth with an osseointegrated implant-retained BCSP. The patient has continued to use the device, but we are unable to comment generally on patterns of usage for BCSP or make comparisons to CROS device usage among children with SSD. In adults with SSD, BCSPs have been found to improve hearing thresholds as well as, if not better than, CROS devices[18]. In addition, BCSPs may be among the only

amplification options for children with congenital anomalies of the ear, such as microtia and aural atresia, and hearing outcomes in this population have been found to be favorable[19]. Clearly there is a role for BCSP in management of UHL. However, more research is needed to guide decision-making between BCSP and CROS devices among children with SSD.

There has also been growing interest in the option of cochlear implant (CI) for SSD. A recent systematic review did not find sufficient high-quality evidence to recommend CI in this population[20], although there have been individual case series describing significant benefit and high levels of utilization among adults[21]. Additional research should be conducted to determine the role of CI in pediatric UHL.

In addition to individual hearing devices, school accommodations play an important role in management of pediatric UHL. Preferential seating places the student in a position that favors their better hearing ear. Research has found that individuals with UHL must sit approximately half the distance away from a speaker as an individual with normal hearing to have similar speech discrimination[22]. There is also evidence to support the role of personal FM systems in improving speech recognition in noisy conditions[23]. Somewhat surprisingly, less than half the families in our study responded that their child currently had access to an FM system in the classroom.

While school accommodations would seem relatively low risk in terms of impact, several of the youths who were interviewed perceived social stigma associated with preferential seating and personal FM systems. This stigma could be as great as that experienced with some of the smaller, more discreet individual-level hearing devices. We found that there is an opportunity to improve the ease with which students with UHL access school accommodations, and efforts could be made to reduce stigma. For example, the adoption of soundfield systems in all classrooms may make an individual student's usage less noticeable.

It is important to mention the limitations of this study. First, survey responses rely on recall from parents who may have difficulty remembering certain details of health history or school performance, and there is a self-selection bias in that we relied upon families' willingness to participate. Second, our sample size may have limited our ability to detect a significant difference in some cases, and as mentioned, we had only one child with BCSP and none with CI. Finally, we have limited our study to describing the experiences of school-age children, though we appreciate that early intervention should begin years before a child enrolls in school. In fact, there is some evidence that age at implementation may make a difference in terms of impact of a hearing device. For example, Johnstone et al. found that older children with UHL experienced a decrement in their ability to localize sound when they were fit with a BTE hearing aid[24].

Based upon our findings and review of the literature, we have generated a basic algorithm for the management of children with UHL, see Figure 2. In summary, we believe that all children with UHL should be provided with school accommodations to include preferential seating and FM amplification systems. In addition, we also recommend that hearing health providers counsel patients and family members regarding options for hearing devices. Children and youth with less severe UHL and appropriate speech perception could try a BTE

hearing aid, while children with SSD would more likely benefit from CROS or BCSP devices. Children with microtia/atresia or other craniofacial anomalies may only be able to use a BCSP.

In a recent study, parents of children with UHL reported that uncertainty regarding the role of intervention remained one of their greatest concerns[25]. We offer a basic algorithm for management, but future research is needed to understand the impact of interventions on outcomes for this population and to refine treatment protocols.

Conclusion

This study found that a majority of children with UHL who tried a hearing device continued to use it, suggesting that hearing devices should be included in protocols for management of UHL. Retention rates were similar across all degrees of unilateral hearing loss. However, hearing health providers should also be aware that youths with UHL express concerns regarding discomfort, effectiveness and stigma associated with hearing devices.

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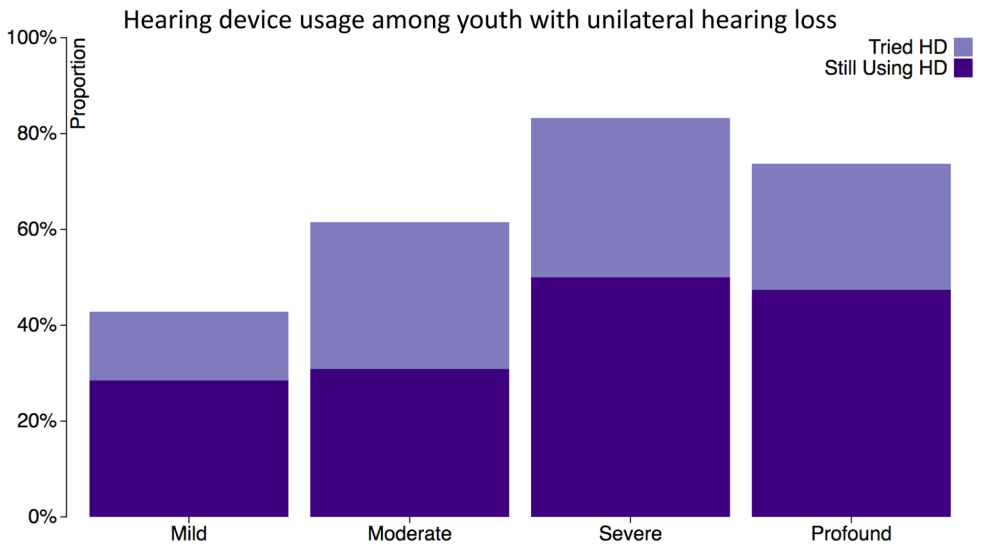

Figure 1.

Bar chart depicting hearing device (HD) usage by degree of hearing loss among children with unilateral hearing loss (UHL). In total, 34 children tried a device, and 20 continued to use it. Retention rates were similar among children with different degrees of hearing loss: mild 66%, moderate 50%, severe 60%, profound 64%.

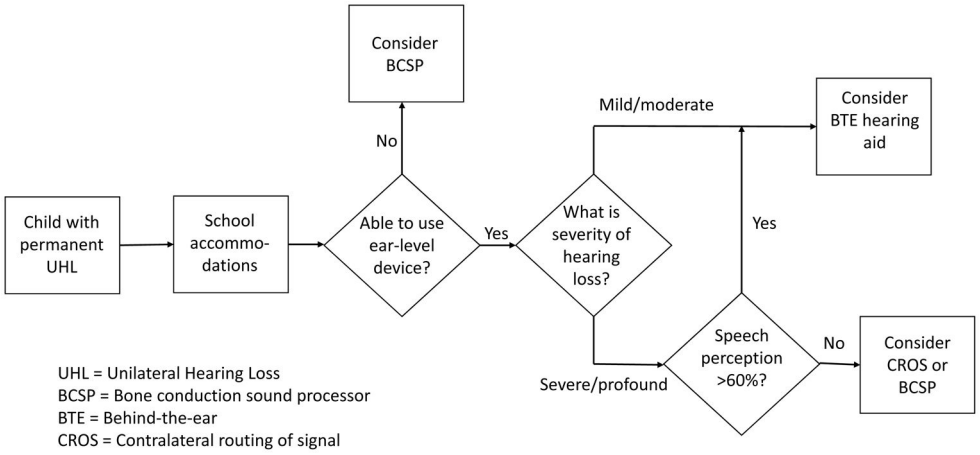

Figure 2.

Algorithm for management of children with unilateral hearing loss (UHL). School accommodations are recommended for all children with UHL. Children who have mild/moderate HL, or who have more severe HL but speech perception greater than 60%, may benefit from behind-the-ear (BTE) hearing aid. Children with single-sided deafness (SSD) may benefit from contralateral routing of signal (CROS) device or bone conduction sound processor (BCSP). Children who are unable to wear an ear level device, for example those with microtia/atresia, may benefit from BCSP.

Table 1

Characteristics of patients with unilateral hearing loss

Degree of UHL	Number	Median age in years at diagnosis (range)	No. (%) using preferential seating	No. (%) using FM system	No. (%) with IEP	No. (%) who have tried HD
Mild (30 – 40 dB HL)	7	5 (4 – 10)	4 (57%)	3 (43%)	1 (14%)	3 (43%)
Moderate (41 – 70 dB HL)	13	6 (0 – 8)	11 (85%)	2 (15%)	3 (23%)	8 (62%)
Severe (71 – 90 dB HL)	11	4.5 (0 – 6)	9 (82%)	6 (55%)	7 (64%)	9 (82%)
Profound (>90 dB HL)	19	4 (0 – 9)	17 (89%)	9 (47%)	7 (37%)	14 (74%)
Total	50	5 (0 – 10)	41 (82%)	20 (40%)	18 (36%)	34 (68%)

UHL = unilateral hearing loss

FM = frequency modulation

IEP = individualized education plan

HD = hearing device

Table 2

Youths with UHL explain why they do not use hearing devices

Social stigma
“I didn’t want like these big headphones to wear all the time.”
“I’m planning to get a hearing aid when I turn 50… because that’s the appropriate time to get one.”
“I just don’t want to have a hearing aid. Like I said before, I’m already set apart having the deaf ear.”
Lack of perceived benefit
“I didn’t really like [my hearing device] that much; I don’t think it really helped me in any way.”
“When I had the CROS, it felt kind of like a speaker. It would just bring in all the background noise.”
Discomfort
“If there was a hearing aid that was comfortable, … then I absolutely would use it.”
“They’re kind of uncomfortable to have those things pushing in your ears.”

Table 3

Positive responses from youths with UHL who use a hearing device

Positive impressions
“I love to learn, so I try to wear my hearing aid to school.”
“I love getting that feeling of, ‘Oh gosh I can hear things now!’”
“If I don’t have my hearing aids with me … I can’t understand and I can’t concentrate as well.”
“I think the hearing aid releases me from the chains of, ‘I have to sit here because it’s the best place.’”