

Decision Support Guide for Hearing Aid Use in Infants and Children with Minimal/Mild Bilateral Hearing Loss

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Abstract

Evidence suggests that the majority of children with minimal/mild, permanent, bilateral hearing loss (MBHL) are at greater risk for academic, speech-language and social-emotional difficulties than their normal hearing peers. It is reasonable to assume that appropriate and timely hearing technology could mitigate the negative impact of such losses. However, there currently is no way to predict which children will experience difficulties and which will follow a typical course of development. This makes early intervention recommendations unclear, leading to several pediatric amplification guidelines recommending hearing aids to these children on a case-by-case basis. The absence of more specific management guidelines presents a challenge to pediatric audiologists who work with families of infants and children with MBHL as they lack the evidence to support clear amplification recommendations. Although comprehensive management of infants and children with MBHL is multifaceted, this paper will focus on the consideration of hearing aids. Specifically, a process is described that is intended to facilitate appropriate case-by-case reasoning when considering amplification for infants and children identified with MBHL.

For the past several decades, evidence has accrued suggesting that a large percentage of children with minimal and mild degrees of bilateral permanent hearing loss (MBHL) have psychoeducational and behavioral difficulties (Bess, Dodd-Murphy & Parker, 1998; Bess & Tharpe, 1984; Most, 2004; Wake, Hughes, Poulakis, Collins & Rickards, 2004). It is reasonable to assume that appropriate and timely hearing technology could assuage the negative impact of such losses. Toward that end, several hearing technology options have been recommended for these children (Tharpe, Ricketts & Sladen, 2003; Tharpe, Eiten & Gabbard, 2008) but

evidence-based guidance regarding these fitting practices has been lacking. Extant consensus-based and evidence-based protocols and guidelines have consistently recommended the selection of amplification for children with MBHL on a case-by-case basis (e.g., Bagatto, Scollie, Hyde & Seewald, 2010) with consideration for whether the degree of loss could interfere with normal development (e.g., American Academy of Audiology [AAA], 2013). However, additional guidance has not been forthcoming. This lack of guidance has resulted in uncertainty about hearing aid recommendations with this group of children (Fitzpatrick, Whittingham & Durieux-Smith, 2013).

A decision support guide is provided herein that is designed to help clinicians compile information that will assist them in deciding whether an infant or child five years of age and younger with MBHL is a good candidate for hearing aids. The rationale for this work is to reduce clinician uncertainty when making hearing aid recommendations for these children. Furthermore, the proposed guide is based on several assumptions. First, it is assumed that audiologic certainty has been obtained. That is, there has been reliable determination of degree, configuration and type of hearing loss for at least two frequencies in each ear (AAA, 2013). Another assumption is that all infants and children with MBHL who are provided with personal hearing aids are also considered candidates for frequency-modulated (FM) technology. Such technology is known to improve listening in environments where distance, noise and reverberation are an issue (Lewis & Eiten, 2011). Guidelines for remote microphone assistance technologies for children and youth are provided in a recent document from the American Academy of Audiology (2008) so will not be discussed herein. Third, the family must be well-informed of the potential benefits and limitations of hearing aids for their infant or child with MBHL. A

family-centred approach to decision making is central to the intervention process. Finally, the decision support guide provided in this document is not intended to be comprehensive, but rather provide guidance to audiologists when considering hearing aids for infants and children with MBHL. Selection of hearing aids is but one part of comprehensive and fluid management of childhood hearing loss, which should also include periodic, comprehensive monitoring of hearing, speech, language and family-focused counseling (Joint Committee on Infant Hearing [JCIH], 2007).

Several elements have been included for consideration in the proposed guide to support clinical decision making (Figure 1).

These factors include:

- 1) configuration and degree of hearing loss;
- 2) ear canal and earmold acoustics;
- 3) hearing aid gain/output and noise floor;
- 4) child factors; and
- 5) family factors.

Details about each of these factors are described in the following sections.

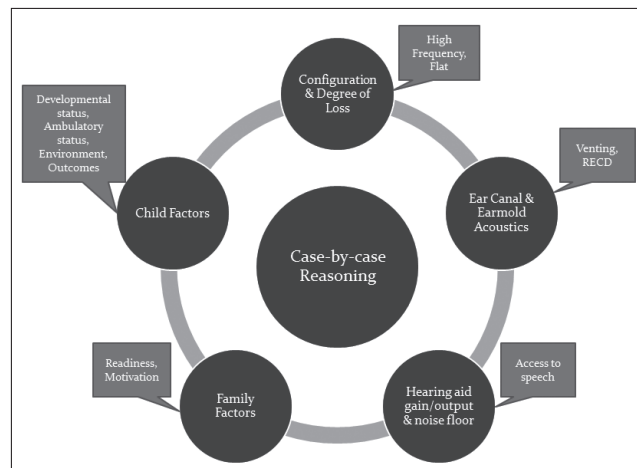


Figure 1: Factors to consider when determining the appropriateness of a hearing aid for an infant or child with MBHL.

Configuration and Degree of Hearing Loss

Minimal/mild bilateral hearing loss in children is defined as (Bess et al., 1998):

- a) Permanent Mild Bilateral: pure tone average (500, 1000, 2000 Hz) between 20 and 40 dB HL
- b) Permanent High Frequency: pure tone thresholds > 25 dB HL at two or more frequencies above 2000 Hz

These definitions are supported by the National Workshop on Mild and Unilateral Hearing Loss (2005) and are used to categorize different configurations of MBHL: flat and high frequency. The degree of hearing loss in the high frequencies can range from mild to profound for the purposes of this guide. With both configurations, the hearing losses should be defined in each ear by at least one low and one high frequency threshold, as is required by several pediatric hearing aid fitting protocols (e.g., AAA, 2013; Bagatto et al., 2010).

Ear Canal and Earmold Acoustics

The external ears of infants and young children are significantly smaller than those of adults (Bagatto, Scollie, Seewald, Moodie & Hoover, 2002; Feigin, Kopun, Stelmachowicz, & Gorga, 1989; Kruger, 1987) and the size changes as the child grows. This growth has substantial implications when defining accurate hearing levels as well as when measuring hearing aid output in devices that are calibrated with reference to an average adult ear canal. It is therefore essential to measure the real-ear-to-coupler difference (RECD) in infants with MBHL and use this measurement to convert the audiogram (referenced in dB HL) to sound pressure level (SPL; Seewald & Scollie, 1999). This will provide a more accurate description of the infant's hearing levels that can be directly compared to hearing aid output on an SPL scale. As the infant grows, the ear canal changes thus changing the SPL delivered to the ear. Therefore, the RECD must be measured on a regular basis over time for a given infant so that changes to the ear canal acoustics can be applied when comparing sequential audiograms and defining the amount of output provided by a hearing aid.

Small infant ears can also impact the earmold acoustics of a potential hearing aid fitting for a child with MBHL. In many instances, the ear canals of infants and young children are too small to accommodate a vent in

the earmold. An earmold vent provides an outlet for sound up to about 1000 Hz, depending on vent diameter (Dillon, 2012). The ability to provide venting has implications for some degrees and configurations of MBHL where amplification may not be required (see Figure 2).

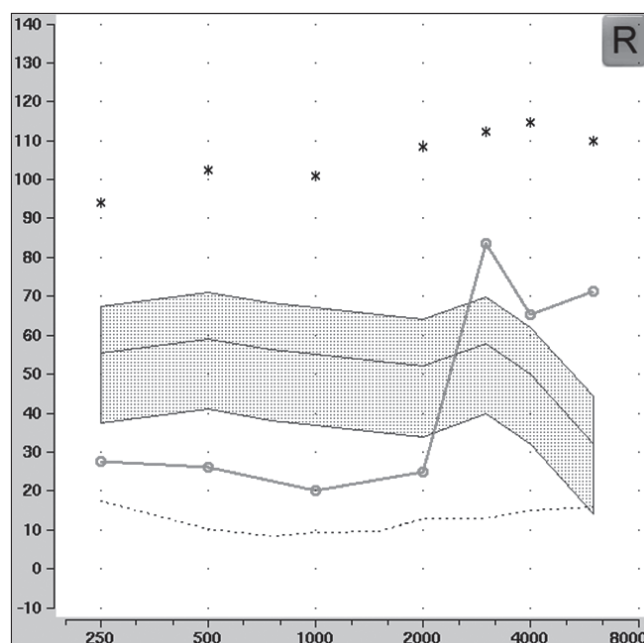


Figure 2: An example of unaided speech (shaded region) audibility for a child with a mild high frequency hearing loss (open circles). The x-axis is frequency (Hz) and the y-axis is sound pressure level (SPL) at the eardrum. Note that no amplification is required in the low frequency region, but is needed in the high frequency region. A vented earmold will help reduce the impact of upward spread of masking.

An occluding earmold will not allow sound to escape in the low-frequency region thus providing amplification in an area where little or no hearing aid gain is needed. This may interfere with the hearing aid benefit necessary in the high frequency region because of upward spread of masking. When considering a hearing aid recommendation for infants and children with MBHL, it is important to weigh the implications of potentially masked high frequency speech cues resulting from an unvented earmold compared to the potential high frequency benefit provided with the same fitting. The small ear canals of infants impact the assessment of hearing sensitivity in this population as well as the ability to provide a vented earmold in the hearing aid fitting. As such, ear canal size and earmold acoustics are important factors when considering whether to pursue a hearing aid fitting with an infant or child with MBHL.

Hearing Aid Gain/Output and Noise Floor

Confirmation that a broad frequency range of speech is audible at various input levels and ensuring loud inputs to the hearing aids are comfortable for the infant are explicit goals of a pediatric hearing aid fitting, regardless of degree of hearing loss. Easy and safe access to speech supports a child's development of language. This is achieved by employing coupler-based verification techniques and RECD measures to assess the output of the hearing aid to be provided. In the case of MBHL, minimal hearing aid gain may be required and could interact with the low-level hearing aid noise floor (Figure 3). Consequently, the noise could be heard by the child and may mask speech sounds amplified by the hearing aid. With venting, an improvement in performance may result. However, careful consideration of hearing aid benefit compared to the unaided condition is necessary when considering a hearing aid for an infant or child with MBHL.

Consideration of the Speech Intelligibility Index (SII; ANSI S3.5-1997) values during verification of hearing aids means that support is given on whether providing a hearing aid will result in benefit compared to the unaided

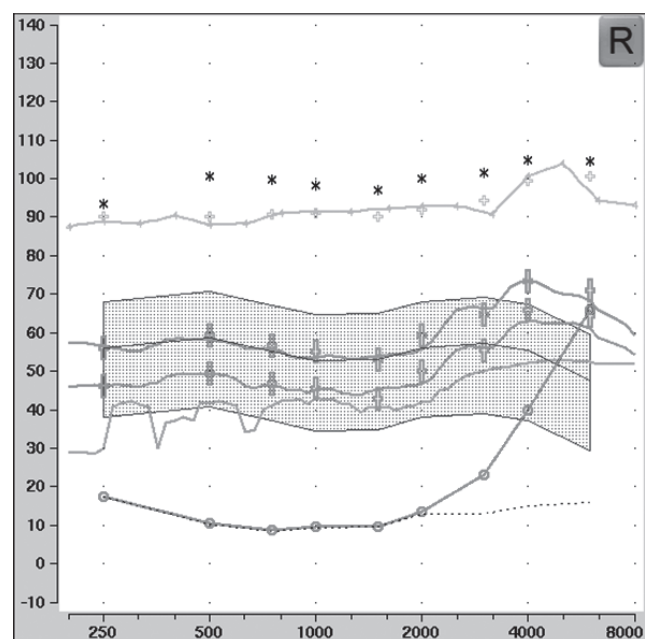


Figure 3: An example of a low-gain hearing aid fitting. The x-axis is frequency (Hz) and the y-axis is sound pressure level (SPL) at the eardrum. The SII values for average aided speech is 94% and the SII values for soft aided speech are 89%.

condition. The SII values shown in Figure 3 for both the unaided and aided conditions are high (89% and 94% respectively). At these levels, ease of listening is more prominently impacted than performance (Scollie, 2008). Speech audibility may be improved for some children with MBHL without hearing aids by increasing the vocal effort of the talker, decreasing speaker-listener distance, and reducing background noise. Conducting appropriate outcome measurements that evaluate access to speech in various conditions (e.g., Ling 6(HL) Detection Task; Scollie, Glista, Tenhaaf, Dunn, Malandrino, Keene & Folkeard, 2012) might provide important information when considering providing hearing aids to an infant or child with MBHL.

Child Factors

The individual characteristics of a child with MBHL and his or her listening environment are an integral part of hearing aid management decisions. Evidence suggests that 25 to 40% of children with hearing loss have additional handicapping conditions that might further impact their capacity to develop normally (Tharpe, Fino-Szumski & Bess, 2001). The presence of comorbidity can result in poorer functional auditory outcomes when compared to typically-developing children who have been

fitted with hearing aids (Bagatto, Moodie, Malandrino, Richert, Clench & Scollie, 2011). For example, as seen in Figure 4, the auditory development of children with MBHL who have not been provided with hearing aids was assessed using the LittleEARS Auditory Questionnaire (Tsiakpini, Weichbold, Kuehn-Inacker, Coninx, D'Haese & Almadin, 2004). Those children who did not meet auditory development milestones (represented by the encircled scores) were noted to have disabilities in addition to hearing loss that impacted their auditory development. It is therefore important to conduct outcome measures in the aided as well as unaided conditions to inform the decision to recommend hearing aids for infants and children with MBHL. Alternative functional auditory assessments are available for clinical use and have been described for use with infants and young children (e.g., Bagatto, Moodie, Seewald, Bartlett & Scollie, 2011; Tharpe & Flynn, 2005).

Another factor to consider is the ambulatory status of the child, as opposed to just the age of a child, when contemplating hearing aids for an infant or child with MBHL. Whether a child is crawling, walking, or otherwise able to distance him/herself from the talker of interest is a relevant consideration because distance will directly impact the SII as well as signal-to-noise ratio. A tool that takes speaker-listener-distance into consideration is the Situational Hearing Aid Response Profile (SHARP; Brennan, Lewis, McCreery, Creutz & Stelmachowicz, 2013). The SHARP is a software application used to characterize the audibility of speech signals across a wide range of realistic listening situations with varying acoustic environments. Applying this tool to a hearing aid selection procedure can provide useful information to guide case-by-case reasoning when managing MBHL in children. Figure 5 provides SHARP examples of the audibility of speech for a given hearing loss in SPL at various levels and distances and provides SII values to inform the amount of speech audibility. As demonstrated, if the source of speech is close to the child (e.g., hip position), a hearing aid may not be required due to the high SII value. However, for distant sounds (e.g., average conversation at four meters) the ambulatory abilities of the child matters.

One final child factor for consideration is the child's listening environment. This can be described as the acoustics of a room (noisy versus quiet) or a group or a non-group situation. The environment in which the child spends most of his/her waking hours should be considered when managing infants and children with MBHL. For example, some infants will be in a quiet home

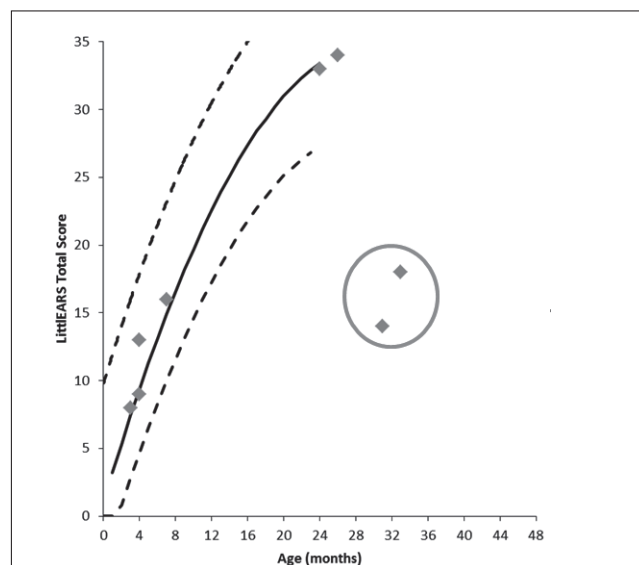


Figure 4: An example of LittleEARS scores (y-axis) by age (x-axis) for children with unaided MBHL. The solid line represents the average LittleEARS scores for normal hearing children and the dashed lines are the upper and lower 95% confidence intervals. The diamonds represent individual child's LittleEARS scores. The diamonds that are circled are children with comorbidities.

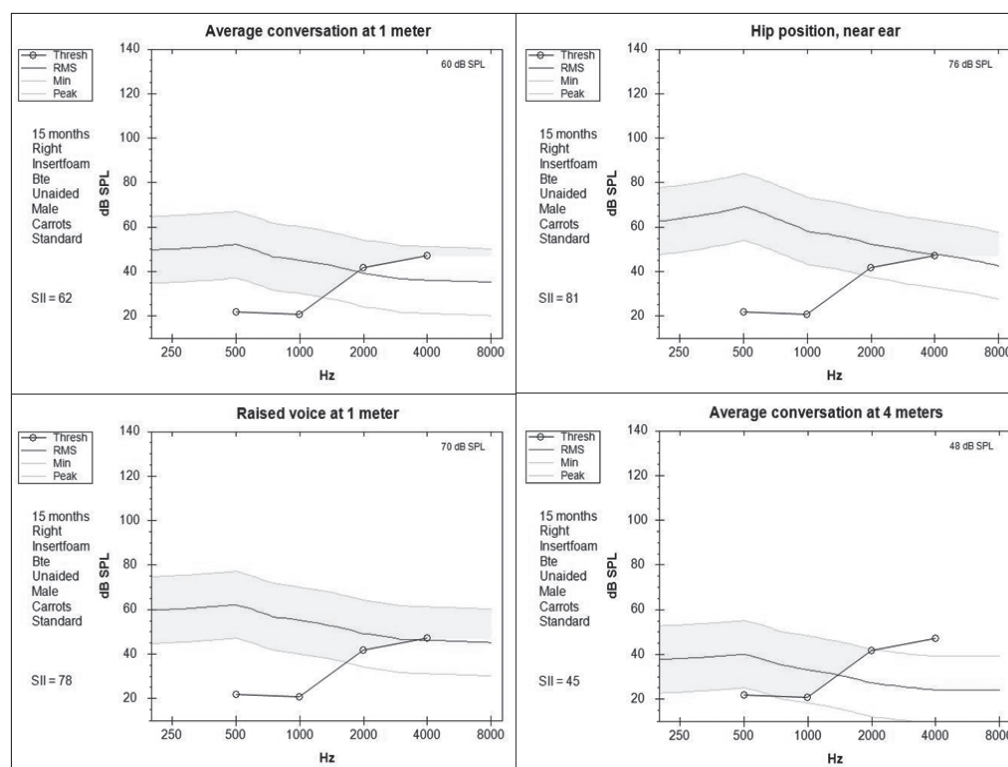


Figure 5: Examples of the audibility of speech for a given hearing loss in SPL at various levels and distances for a child with MBHL. SII values are provided to inform the index of speech audibility.

setting throughout the day while others may be in a day-care or school setting where signal-to-noise ratios are not ideal. The presence of distance, noise and reverberation in the child's listening environment impacts development and performance in several areas. Listening in the presence of background noise can affect the development of speech and language skills, social-emotional functioning and educational performance in children with and without hearing loss (Lewis & Eiten, 2012). It has been demonstrated that children with MBHL have better speech perception ability in noise when wearing an FM system compared to the unaided condition (Tharpe et al., 2003). Remote microphone hearing assistance technologies can provide a clear, audible input signal and reduce the impact of noise and reverberation. They are available in a variety of configurations (e.g., ear-level FM only, sound field) regardless of whether the child with MBHL uses hearing aids (AAA, 2008). The child's listening environment is an important consideration when selecting hearing technology for children with MBHL.

Family Factors

Another important aspect to the management of children with MBHL is their family. Their readiness and motivation to proceed with the exploration of hearing aids are essential to this process. A family-centred approach is a guiding principle underlying the management of children with hearing loss and should be applied when considering hearing aids for infants and children with MBHL. Caregivers should be apprised of the benefits and limitations of a hearing aid fitting for their child and, where possible, these should be illustrated through the use of outcome measures (e.g.,

LittleEARS, Ling 6(HL) Detection Task). Providing hearing aids on loan to the family for a trial period provides a real-world demonstration that can be invaluable in this process. A supportive and fluid approach to case management will facilitate careful case-by-case reasoning when combined with the previous factors discussed.

Decision Support Guide

With the above factors in mind, a decision support guide in the form of a flow chart has been created to assist clinicians in determining the appropriateness of a hearing aid recommendation for individual children with MBHL (Figure 6). This guidance is based on the definitions of MBHL for both flat and high frequency configurations (Bess et al, 1998) and is intended for children from birth to five years of age. Whether a hearing aid recommendation is pursued or not, caregiver counseling and close monitoring of the child's development and auditory performance is recommended as changing circumstances could support fitting at a later time in the child's life.

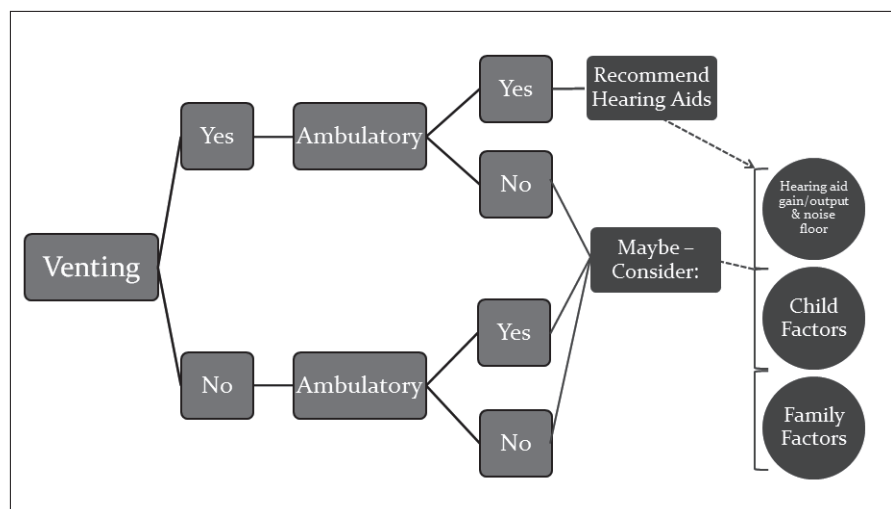


Figure 6: Decision support guide for clinicians considering hearing aids for infants and children with MBHL.

Summary

A significant number of children with MBHL experience difficulties with language, academic, and psychosocial development (Bess et al, 1998; Hicks & Tharpe, 2002; Most, 2004; Wake et al., 2004). Hearing aid management decisions for these children are not well-established, which results in clinical uncertainty (Fitzpatrick et al., 2013). We have proposed a decision support guide in the form of a flow chart to support clinical decision making when dealing with individual infants and children with MBHL and their families. We have described many factors to consider when making case-by-base decisions with this population. Regardless of whether a hearing aid has been recommended for a specific child, it is important to continue to monitor that child's auditory as well as functional development. As the child's ear canal grows and changes, the acoustic properties change which impact hearing thresholds and the gain requirements of the hearing aids to be fitted. In addition, children in the first three years of life often experience otitis media with effusion that can impact hearing thresholds. Therefore, including immittance measures in audiological monitoring protocols is vital. Finally, audiologists should monitor the child's functional auditory abilities, their speech-language skills and educational progress as part of routine evaluation, whether or not hearing aids are provided. Intervention strategies should be adjusted as required, in consultation with the family, as new evidence is gathered.

Further information is needed about the impact of hearing aid use in infants and children with MBHL in their early years. Continuing education for clinicians on how to make decisions about the management of infants and children with MBHL is essential. It is expected that this guide will evolve as it is used by pediatric audiologists but, in the meantime, it serves as a reminder for clinicians to gather the necessary evidence to support their management decisions.

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