Selecting appropriate technology: Hearing aids, FM, and cochlear implants

By Jane R. Madell

One important role of the audiologist is to help children and their families select appropriate technology. To do this successfully the audiologist needs to know a great deal about the patient's auditory performance in various listening situations. In addition, s/he needs to understand the individual's auditory and communication needs. If, for example, a child is in a sign language program and does not rely on audition for communication, hearing aids that provide sound awareness but are not loud enough to permit the child to have good speech perception may be sufficient. If that same child is being mainstreamed, auditory access to the teacher and to others in the classroom will be critical.

Hearing aids are the technology system of choice for most infants, children, and adults with hearing loss. Patients with mild to moderately severe hearing loss will do well with hearing aids. Some patients with severe hearing loss also will do well with hearing aids, but others will find themselves struggling in many communication environments, including on the telephone. Most patients with profound hearing loss who use hearing aids will struggle if they rely on hearing for daily communication.

By fully evaluating auditory performance in various listening situations and discussing listening needs with the child and family, the audiologist can help the child and family evaluate what the person with hearing loss is hearing and, more importantly, what he or she does not hear. This will permit all involved to make an educated decision about keeping current technology or the need for a change.

THE IMPORTANCE OF AUDITORY ACCESS

Children who are learning language through audition must be able to hear and understand normal and soft conversation in quiet and in competing noise in order to develop speech-language, academic, and social skills that will allow them to participate fully with their peers. Hearing at normal conversational levels (50 dB HL) will permit a child to hear within 4 to 6 feet when it is quiet. Not hearing well at normal conversational levels will result in problems hearing peers in many situations, including the classroom and on the playground. (It is assumed that the teacher is wearing an FM transmitter so the child will be able to hear the teacher.)

A child who hears soft speech (35 dB HL) well will be able to hear at about 10 feet in quiet and will have an easier time hearing classmates as well as "overhearing" parents and others in daily life, thereby permitting the incidental learning that is so critical for language development. A child who does not hear soft speech will miss incidental learning, which will reduce the amount of auditory language input available and make it difficult to communicate when the listener and talker are not close.

A child who hears well in competing noise will be able to manage in many situations and can rely on hearing for learning both speech-language and academics. In addition, this child will be able to manage smoothly in many social situations. While there will certainly still be some situations where listening is difficult, requiring effort, and in

Table 1. *Test protocol for assessing auditory performance. Empty boxes indicate recommended testing. Shaded boxes indicate information that need not be obtained.*

	Right Technology	Left Technology	Binaural Technology	Binaural + FM
Thresholds (NBN/ Warble)				
250 Hz				
500 Hz				
1000 Hz				
2000 Hz				
3000 Hz				
4000 Hz				
Speech Perception				
50 dB HL				
35 dB HL				
50 dB HL + 5 SNR				

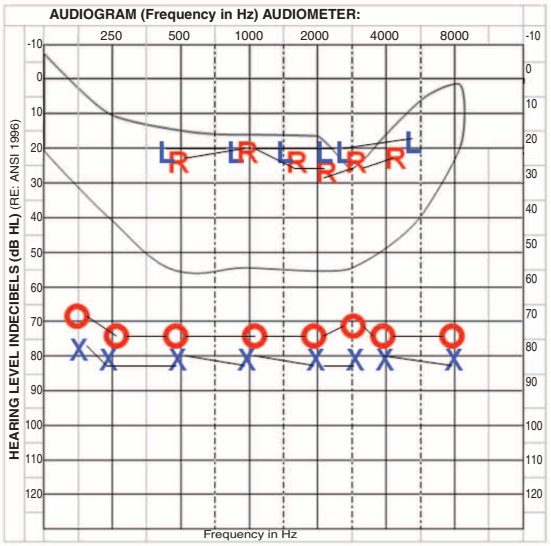
which an FM system would be of benefit, this child can be expected to manage well using audition much of the time.

Access to high frequencies with technology is absolutely critical. High-frequency information provides access to sibilants and fricatives, which, in addition to improving speech perception, facilitates access to significant grammatical markers, including possessives and plurals.

THE EVALUATION

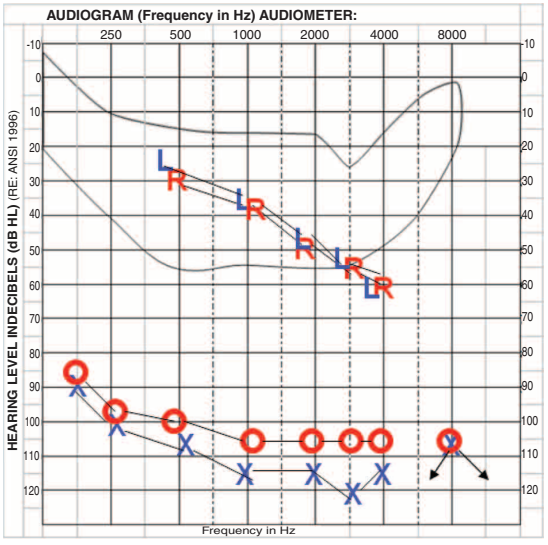
To determine if a child has sufficient auditory access, the evaluation should measure thresholds with technology across the frequency range, giving special attention to the ability to hear high frequencies (3000, 4000, 6000 Hz). Speech-perception abilities using linguistically appropriate tests should be measured at normal and soft conversational levels in quiet and in competing noise (see Table 1).

Monosyllabic word tests are the best test stimuli because they provide a realistic estimate of what the child is likely to hear in daily living. Sentence tests, commonly used in cochlear implant evaluations, are much easier because they offer more opportunity for guessing by permitting children to "fill in the blanks" when they don't hear all of the sentence. When testing with competing noise, it is important to use a competing noise stimulus that will be a good indicator of daily performance. Speech noise from the audiometer is not typical of the sounds that are likely to interfere with daily listening situations and is relatively easy to ignore. As a result, it will not provide a good indication of auditory performance. Four-talker babble is a more realistic noise stimulus.



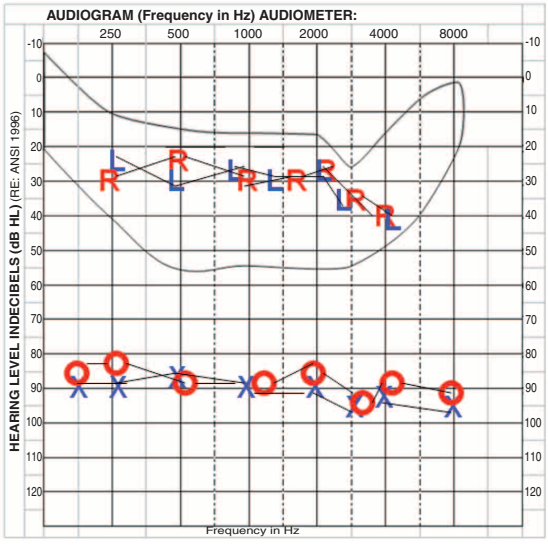
	Right	Left	Binaural	FM
50 dB HL	76%	74%	88%	96%
35 dB HL			64%	88%
50 dB HL+5SNR			24%	84%

Figure 2. *Severe hearing loss with good hearing aid gain and good aided speech perception.*



	Right	Left	Binaural	CI
50 dB HL	12%	8%	16%	66%
35 dB HL			CNT	56%
50 dB HL+5SNR			CNT	64%

Figure 1. *Profound hearing loss with insufficient hearing aid gain, poor speech perception with hearing aids, and good speech perception with a cochlear implant.*



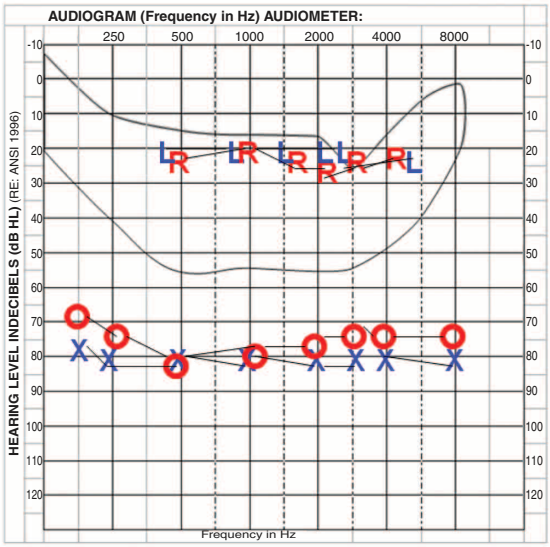
	Right	Left	Binaural	CI
50 dB HL	38%	28%	34%	76%
35 dB HL			12%	72%
50 dB HL+5SNR			24%	64%

Figure 3. *Severe hearing loss with poor speech-perception performance with hearing aids and good performance with a cochlear implant.*

Normal hearing for a child is considered to be 15 dB across the frequency range. This should be our goal for technology thresholds also. Children who hear at 15-20 dB with technology (including in high frequencies) can be expected to hear normal and soft conversation. Children with aided thresholds at 30-40 dB will not hear soft speech, which is at about 35 dB HL, and will probably be unable to hear speech in noise comfortably. Children with good aided thresholds in the low frequencies but poor aided thresholds in high frequencies will miss significant amounts of auditory information and most likely have difficulty hearing in competing noise. The first goal of the audiologist would be to try to improve auditory access by changing the hearing aid settings or, if necessary, changing the hearing aids to ones that provide more gain in the frequencies the child is missing.

Speech-perception testing will also provide critical information to consider if the current technology is providing sufficient benefit. Testing only at normal conversation in quiet will not provide sufficient information about daily performance because, unfortunately, speech is not always comfortably loud and daily life is rarely quiet. If testing in soft speech indicates that the child is not hearing, it is fairly certain that the child is struggling in everyday listening situations and missing a great deal. Testing with an FM system may indicate that a child is hearing sufficiently well when using the FM, but testing without the FM indicates that the child is struggling. The audiologist must determine how much the child is missing and how much s/he is struggling.

If testing indicates that hearing aids are not providing sufficient auditory access and if it is impossible to improve the



	Right	Left	Binaural
50 dB HL	28%	24%	34%
35 dB HL			12%
50 dB HL+5SNR			24%

Figure 4. *Severe hearing loss with good hearing aid gain and poor speech perception.*

situation by changing hearing aid settings or getting different hearing aids, consideration should be given to cochlear implantation. The research indicates that the great majority of children with cochlear implants receive good auditory access, with thresholds at 20-25 dB throughout the frequency range, including at high frequencies.[1,2] The benefit that improved auditory access has on language, academic, and social skills is clear.

Figures 1 to 4 demonstrate the auditory performance of four children. Figure 1 shows a child who is clearly not receiving sufficient auditory access with hearing aids and for whom cochlear implantation is easily justified. Test results with the implant demonstrate the improvement in performance after implantation.

Figure 2 shows a child who is doing well with hearing aids in most situations and excellently when using an FM system. This child would not be a candidate for an implant.

Figure 3 is a little more difficult. This child is hearing well with technology in the low frequencies, but is receiving insufficient gain in the high frequencies. Speech perception at normal conversational levels is fair, but poor for soft speech and in competing noise. Her parents report that she comes home from school exhausted by trying to follow what is happening in the classroom. When the FM is not available, she becomes upset because she knows she will miss too much. This child is clearly struggling and might be an implant candidate. She was, in fact, implanted, and the results with the implant demonstrate the significant improvement.

Figure 4 shows test results for a child who is receiving good aided gain but has poor speech-perception skills in all conditions. Even though speech perception is poor, this child would not be a cochlear implant candidate, at least not at this moment. Hearing aid threshold scores indicate he is receiving sufficient access to sound while speech-perception testing indicates that, even with access, he is not using the information. For this child, intensive auditory therapy would be a good first step in trying to improve auditory access.

CONCLUSION

By carefully evaluating performance in a variety of situations, the audiologist can develop a good profile for each child determining how they are performing and in what situations they are struggling. It will then be clear what needs to be tried to improve auditory access. If hearing aids cannot be programmed to provide appropriate access, cochlear implantation should be considered as a means of improving access to sound and thus improving access to language and academic learning, as well as improved socialization.

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