Chapter 11

Cochlear Implants: Determining Candidacy for Young Children Who Are Deaf or Hard of Hearing

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Introduction

Families who have chosen a listening and spoken language outcome for their children who are deaf or hard of hearing—or desire to have sound be a meaningful part of communication—have a variety of options to help their children access speech and environmental sounds. With significant advancements in hearing aid technologies, real-ear fitting techniques, and the use of other hearing assistive technologies (HAT), children can hear better than ever before. There are times, however, that even with an appropriately fitted hearing aid technology, children cannot access critical speech information that can help them with the development of spoken language. At this critical juncture, cochlear implant(s) may be recommended. For Part C coordinators, Early Hearing Detection and Intervention (EHDI) coordinators, and early interventionists, it is critical to understand the cochlear implantation process, especially as more parents choose this procedure for their children who are deaf or hard of hearing.

A primary goal for all children who are deaf or hard of hearing is to obtain communicative competence (Ganek et al., 2012) and minimize the effects of hearing loss on the child's development. For those children who receive limited or no benefit from amplification, cochlear implantation

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is often a viable option with associated positive outcomes in listening, spoken language, literacy, and social/emotional well-being (Fryauf-Bertschy, Tyler, Kelsay, Gantz, & Woodworth, 1997; Geers, 2008; Geers & Moog, 1994; Geers, Tobey, & Moog, 2008). Today, when a family is considering cochlear implantation for their child who is deaf or hard of hearing, key aspects of the candidacy process should be apparent. Because each child must be evaluated from a variety of perspectives, an interdisciplinary approach to determine candidacy is the existing standard of care. That is, to arrive at a candidacy decision, the child undergoes medical, audiological, and speech-language evaluations. These evaluation results, along with the long-term communication and educational goals of the parents, lead to candidacy decisions that are family centered and in alignment with the parents' desired outcomes.

The Process: An Interdisciplinary Approach

The decision to pursue cochlear implantation for a child who is deaf or hard of hearing requires careful consideration and thorough counseling. The success of an interdisciplinary approach depends upon collaboration among an effective team that includes the parents (and family) as equal partners in the decision-making process. There are a number of considerations that may be unique to the child and family. The process includes the collection and consideration of medical and audiological findings and is further supported by evaluation by a speech-language pathologist (SLP), input from other interventionists and educators and, importantly, from the family. Counseling and discussion with the family about the process and short- and long-term goals is essential. When undergoing the evaluation, the following questions should be addressed:

- Are there other noninvasive technologies available that can make sounds accessible to develop listening, spoken language, literacy, and social skills?
- Are there qualified intervention providers and family support services to help maximize the child's ability to learn how to listen and communicate?
- Are there aspects of the child that will require consideration of other forms of communication, and if so, how will they be implemented to supplement benefits from the cochlear implant?
- Are there any safety issues that should be considered to minimize any potential risk for this surgery, programming, and/or intervention?

As the child and the family progress through the cochlear implant candidacy process, in addition to the above questions, the interdisciplinary team members are trying to determine:

- Does the child meet the criteria for a cochlear implant based on the Food and Drug Administration (FDA) labeling (see *Table 1*)?
- If not, based on research and clinical observations, could the child receive more benefits if he or she received the cochlear implant? What are those benefits?
- Does the family have the information needed to plan for the best possible outcome?

To answer these questions, the cochlear implant team will not only consider the audiologic and medical results. The team will be evaluating the "whole" child and family unit (see *Table 2*; Winter & Phillips, 2009). The first step is to obtain a comprehensive history, including:

- Information on the incidence of hearing loss in the family.
- Birth history.
- Review of complications or concerns.
- Results of newborn hearing screening.

Results of previous assessments will dictate the need for further evaluation under the domain of the physician, audiologist, and SLP.

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Table 1
General FDA Cochlear Implant Guidelines

Company	Device Name	Pediatric Approval Guidelines
Advanced Bionics	HiRes 90K/Naida CI Q70/Neptune	**12 months to 17 years** Profound, bilateral sensorineural hearing loss. Used appropriately fit hearing aids and receives little or no benefits. **<4 years** Failure to reach appropriate developmental milestones as measured by IT-MAIS or MAIS and/or <20% word recognition testing. **>4 years** <12% on word recognition testing and <30% on sentence recognition testing.
Cochlear Corporation	Nucleus CI24RE Cochlear Implant/ Nucleus 5	**2 to 17 years** Severe-to-profound sensorineural hearing loss. Limited benefits from binaural hearing aid trial with word recognition scores ≤30%. **12 to 24 months** Profound sensorineural hearing loss. Limited benefits from binaural hearing aid trial.
MED-EL	MAESTRO Cochlear Implant Systems – MED-EL CONCERT/RONDO/ OPUS 2	**12 months to 17 years** • Bilateral, profound sensorineural hearing loss. • Little or no benefits from appropriately fit binaural hearing aids. • Lack of progress in developing auditory skills. • Scoring <20% on speech recognition tests.

There are many tools that can guide the cochlear implant team to help families understand the potential benefit of cochlear implantation.

With a family's consent, the early intervention program, child care program, and/or school of choice should be consulted to review the child's response to current services and determine the educational needs of the child. There may be additional assessments required to determine candidacy for the cochlear implant—depending on the needs of the child or family. *Table 2* provides a brief description of the evaluations the child and family may undergo to determine candidacy. The family—and the child (if old enough)—may be asked to complete an expectation questionnaire to assist the professionals in realistic counseling. Once the evaluations are completed, the cochlear implant team members review the findings and make a recommendation to the family.

There are many tools that can guide the cochlear implant team to help families

Table 2
Description of Cochlear Implant Candidacy Evaluations

Candidacy Evaluation	Description
Audiological Evaluation	A comprehensive hearing assessment completed with and without the child's hearing aids. This may require more than one visit. It is essential that the child brings his hearing aids and ear molds to the evaluation. If he does not have a hearing aid, then the cochlear implant center should have loaner hearing aids available to complete the aided testing.
Sedated Auditory Brainstem Response and Otoacoustic Emissions Tests	Per the JCIH statement, the child should have at least one objective measure of hearing sensitivity. Some children require sedation to obtain these test results. If an ABR has not been completed, then one may be recommended by the cochlear implant team.
CT Scan/MRI	A specialized X-ray to evaluate the anatomy of the inner ear. Some children are sedated for this procedure. It is important to determine the status of the internal auditory meatus.
Medical Examination	The otologist/otolaryngologist will take a medical history, review the CT scan, and determine if there are any medical contraindications that would prohibit surgery.
Speech-Language Evaluation	Formal and informal assessment of the child's communication abilities with his/her hearing aids. Communication goals are usually discussed at this appointment.
Developmental/Cognitive/ Psychological Evaluation	For children, formal and informal assessment of the child's developmental milestones and capacity to learn.
Social Work Evaluation	To evaluate parent stressors and family support, the social worker will work with the family to navigate services needed to maximize the child's outcomes. Family expectations also will be discussed.
Educational Assessment	The child's school will be contacted regarding educational placement, support, and the need, if any, for inservice on cochlear implants.
Other Assessments	A genetic evaluation and ophthalmology examination may also be recommended. Since 40% of children with hearing loss may have additional special needs, genetic testing may assist the family in making a decision about how to proceed.

understand the potential benefit of cochlear implantation and participate in the planning of ongoing support and intervention. While cochlear implants have been approved by the FDA based on published research guidelines, families and cochlear implant team members can decide to pursue cochlear implantation, even if the child performs outside of the FDA guidelines. Obtaining a complete medical and audiological history and gaining an understanding of the family's resources and challenges is essential. Counseling that addresses many factors that affect outcomes can be reviewed and discussed. These may include aspects of the child, including:

- Anatomical, physiological, and cognitive.
- Developmental and behavioral characteristics.
- Hearing history, including age at onset of hearing loss, degree of loss, and age at diagnosis.
- Use of technology, including age at hearing aid fitting and consistency of use.
- Educational and therapeutic services that have been in place.
- Considerations of the family and environment.

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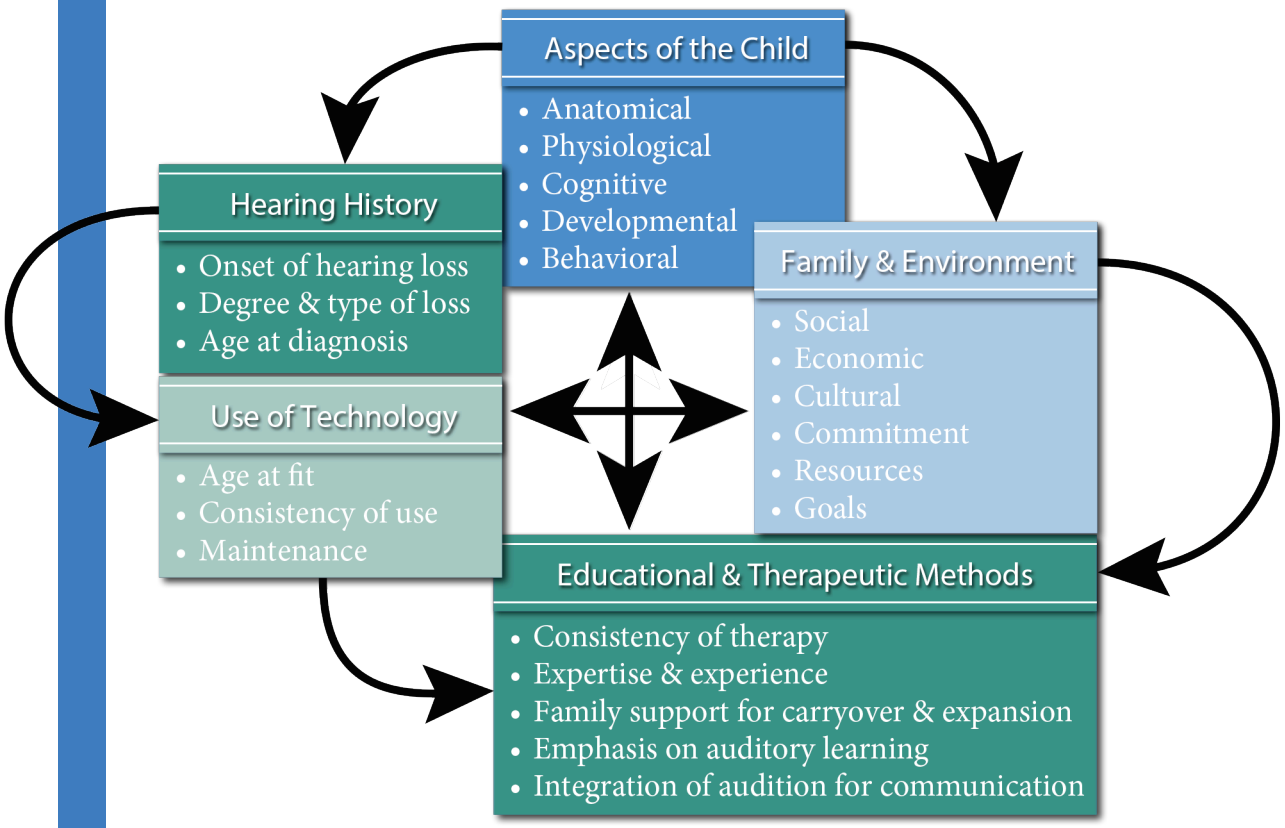
The interdependence of these predictors is summarized in *Figure 1* (Teagle & Eskridge, 2010). Using a candidacy checklist can help identify factors that may influence the outcomes. The Graded Profile Analysis (GPA; Daya et al., 1999), Children's Implant Profile (CHIP; Hellman et al., 1991), the Cochlear Implant

Figure 1
Interdependence of Predictors for Pediatric Cochlear Implantation Candidacy



Candidacy–Children (CICC; Bradham, Lambert, Turick, & Swink, 2003), or the Modified ChIP (Barnes, Lundy, Schuh, Foley, & Maddern, 2000) are such tools that guide the team in their discussions to identify strengths and needs as the family considers cochlear implantation. It is important to note that these tools are not meant to "grade" the family but to identify potential issues that could negatively impact meeting the family's goals and expectations. Furthermore, in the era of having to justify payment for services, these measures can serve as an "objective" tool in making the case for reimbursement for services rendered.

The decision to pursue cochlear implantation is made once the evaluation is complete and families have been counseled on the potential benefits and risks of proceeding. With a thorough understanding of the process, the need for ongoing intervention, and the potential benefits to the child, families should be well equipped to make a decision that will have a profound impact on their child's future. The recommendations fall into three categories:

- Proceed with the cochlear implant.
- Do not proceed (and why).
- Wait (and why).

It is also not uncommon for families to get a second opinion. Every effort should be made to assist the family when seeking additional advice from other health care providers.

Medical/Physical Component

The role of the neuro-otologist/pediatric otolaryngologist/otologist precedes and extends far beyond performing the surgery. It includes, in collaboration with the audiologist, the diagnosis of hearing loss, the degree and type of loss, and etiology. In addition, based on the physical evaluation and medical history, the surgeon considers the need for other laboratory tests, imaging (Computerized Tomography [CT] scan and/or Magnetic Response Imaging [MRI]) to evaluate the anatomical structures of the ear and brain, medical interventions and referrals, and discusses with the parents treatment options and ways to prevent further hearing loss or other related complications. The search for etiology and identification of other medical conditions can impact the sequence and timing of treatment. For children with complex medical histories and co-morbid conditions or syndromes, referrals to neurology, genetics, ophthalmology, and other specialists are common (Buchman et al, 2008).

Radiographic imaging is an important topic both before and after surgery. With a combination of CT scanning and MRI, it is possible for the surgeon to visualize both the bony and soft tissues of the ear and neural anatomy. A cochlear implant cannot overcome the limitations of a severe cochlear malformation or an absent or diminished auditory nerve. Therefore, it is critical for the surgeon to obtain and share this information with the team and parents, as it can significantly affect cochlear implant outcome (Adunka et al., 2006; Adunka et al., 2007). Because the presence of an implanted device can impact future imaging needs, discussion of the contraindications to future imaging studies must take place with the parents.

The risks of surgery are typically discussed with the family by the surgeon (see *Table 3*). While it is rare to have complications in the hands of an experienced surgeon, parents must consider the possibilities during the decision-making process, and informed consent requirements dictate this discussion. Of particular importance is the increased risk of meningitis. Bacterial meningitis is a serious infection of the brain and the fluid surrounding it. Children who are deaf or hard of hearing and have cochlear implants have a higher risk for meningitis, and additional vaccines are recommended. The Centers for Disease Control and Prevention (CDC) provides detailed information on this topic (http://www.cdc.gov/vaccines/pubs/vis/downloads/vis-pcv.pdf).

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Table 3
Risks of Surgery

Cochlear Implant or Any Ear Surgery

The following list details the potential risks—while small—of cochlear implant surgery. Also listed are risks associated with any ear surgery, although relatively safe when compared to other surgeries.

Cochlear Implant	Any Ear
• Loss of remaining hearing in the implanted ear. • Higher risk for meningitis. • Facial nerve stimulation/ involuntary facial movement. • Inflammation/extrusion/swelling. • Soreness, redness, or breakdown of skin in area around the implant, which may need more medical treatment, surgery, and/ or removal of device. • Failure of surgery, possibly requiring removal of the implant. • Failure of implanted pieces, which may need replacing. • The CI may not work correctly , or it may cause your child to feel or hear odd or uncomfortably loud sounds.	• Numbness/tenderness around implant site. • Neck pain. • Loss of feeling in face. • Change in taste. • Fluid leak. • Dizziness (vertigo). • Tinnitus or "ringing in the ears." • Blood, fluid, or infection at the site or close to the site of surgery. • Skin reactions (rashes). • Pain, scarring, bleeding, and infection. • Anesthetic risks (medicines used to put the child to sleep) associated with the heart, lungs, kidneys, liver, and brain.

While all members of the interdisciplinary team interact with a family, an audiologist often serves as the initial or primary point of contact once a child has been identified as deaf or hard of hearing.

As the evaluation of candidacy upfolds, discussion among the team includes the ear of implant, type of electrode array, and determination of whether the child should be a unilateral, bimodal (i.e., a hearing aid in one ear and a cochlear implant in the other ear), or a bilateral recipient (i.e., receive cochlear implants in both ears). If it is decided to proceed with two cochlear implants, the family and surgeon will need to discuss sequential versus simultaneous cochlear implantation. Factors that will determine how to proceed include:

- Age of the child.
- Degree of residual hearing.
- Family choice.
- Financial coverage/reimbursement rates.

Recent studies suggest that outcomes for bilateral cochlear implantation are impacted by the child's age and time between surgeries (Galvin et al., 2014; Spareboom et al., 2014). In the presence of severe-to-profound hearing loss, earlier implantation—whether the first or second ear—yields better results.

For most pediatric cochlear implant recipients, once postoperative recovery is complete, the surgeon has less frequent interactions with the child and family relative to the SLP and audiologist. It is important, however, to maintain this relationship should concerns about ear and hearing health or the need for future surgeries arise. Of course, everyone likes to share and celebrate individual progress and

the opportunity to have a meaningful role in the child and family's life. Team dynamics and practices are shaped by retrospective knowledge of each child's outcome.

Audiology Component

The audiological assessment should include both physiologic and behavioral assessments to determine ear-specific degree and type of hearing loss.

While all members of the interdisciplinary team interact with a family, an audiologist often serves as the initial or primary point of contact once a child has been identified as being deaf or hard of hearing. For children who are identified with significant hearing loss at birth through a newborn hearing screening, there may be several audiologists involved in diagnosis, hearing aid fitting, and objective and ongoing behavioral assessment of hearing. The general goal of audiological management is to determine and monitor hearing thresholds and to provide the best access to sound possible through hearing aids. If degree of hearing loss is severe to profound, and the development of early communication milestones is delayed, a cochlear implant evaluation should be recommended, so parents can begin to consider this option as the child approaches the first birthday. While the FDA guidelines recommend cochlear implantation after 1 year of age, there are times when a cochlear implant will be recommended prior to the first birthday (e.g., child develops hearing loss as a result of bacterial meningitis). Children who are older with progressive or acquired hearing loss are often referred when communication challenges become difficult to address through the use of conventional amplification. An audiologist who serves on a cochlear implant team is typically responsible for:

- Collecting information about the child and family.
- Assessing hearing loss and benefit from amplification.
- Providing counseling about the implantation process, technology, and considerations for device use and follow-up care.

As mentioned previously, the FDA-approved criteria for pediatric cochlear implantation, which has been unchanged since 1990 (see *Table 1*), includes children who are 1 year of age or older, have severe-to-profound hearing loss (often interpreted as a pure tone average [PTA] of 90 dB HL or poorer), and/or demonstrate a lack of development in audition skills. Less conservative criteria have been advocated for and supported by several studies. Not only are children with lesser degrees of hearing loss and better speech perception performance being considered (Carlson et al., 2015; Dettman et al., 2004; Gantz et al., 2000), but children under 12 months of age are being implanted (Tajudeen, 2010). As more children receive cochlear implants and the benefits are documented, the candidacy criteria have expanded in practice. Consideration of the individual child and his or her unique circumstances and implementation of best clinical practices should drive decision making.

The audiological assessment should include both physiologic and behavioral assessments to determine ear-specific degree and type of hearing loss. A diagnostic auditory brainstem response (ABR) assessment can provide a good estimate of hearing levels for children with sensorineural hearing loss. Typically, reliable behavioral testing of babies is possible using Visual Reinforcement Audiology (VRA) techniques starting at about 6 months of age. Hearing aids can be fit on the basis of ABR results and refined once behavioral information is obtained. Cochlear implantation is usually deferred until a hearing aid trial has been completed. However, there is evidence that children who have no response ABR results are very likely to become cochlear implant recipients (Hang et al., 2015). Ideally, the family has the opportunity to explore the child's use of noninvasive technologies in an environment that includes auditory intervention by a qualified therapist. For children with very limited residual hearing, the length of the hearing aid trial should not be extended beyond the time it takes to resolve other considerations addressed in the cochlear implant evaluation, including acquiring medical information, treatment, and counseling.

Table 4
Description of Speech Perception Tests

Text	Age Recommendation	Description
Consonant Nucleus Consonant (CNC) Test (Peterson & Lehiste, 1962)	Recommended for older children and teens. This test is used to determine adult CI candidacy and includes less common vocabulary, which makes it more challenging than PB-k or LNT monosyllable word tests.	This test includes 10 lists of 50 monosyllabic words with equal phonemic distribution across lists, with each list having approximately the same phonemic distribution as the English language.
Early Speech Perception Test (ESP) (Moog & Geers, 1990)	Recommended for children with limited vocabulary who cannot participate in open-set word testing. Minimum of 2 years for low verbal version and minimum of 6 years for standard version per test developers but can be attempted for younger ages.	Two versions, including low verbal and standard—both closed-set. Can be presented via live voice or a recording. Lo-verbal test materials consist of objects (toys) instead of pictures. The standard version includes 36 words presented as 3 subtests of 12.
Hearing in Noise Test (HINT-C)	Sentence material that requires child to have vocabulary and auditory memory to repeat. Recommended once these skills exhibited. HINT is used for adult CI candidacy determination.	HINT-C includes multiple lists of 10 sentences that are five to seven words in length. Can be presented in competing noise for more challenging assessment.
Ling Six Sound Test (Ling & Ling, 1978)	Appropriate for any age once the child has learned to repeat on demand. These sounds (Learning to Listen Sounds) are used very often in therapy and therefore familiar to children.	The sounds used in this test are the vowels /a/ as in all, /u/ as in who, and /i/ as in be, and the consonants /m/ as in me, /S/ as in she, and /s/ as in so. These sounds include low-, mid-, and high-frequency components of speech. The ability to detect and discriminate these phonemes is the basis of scoring.
Lexical Neighborhood Test (LNT) (Kirk, Pisoni, & Osberger, 1993)	Appropriate for children age 4-5 and older who can repeat words on demand.	This is a recorded open-set test of monosyllabic word recognition. The word list consists of 25 lexically "easy" words (high-frequency occurring words) and hard words (low-frequency occurring and more confusable). It is scored by both number of words and phonemes correct.
Multisyllabic Lexical Neighborhood Test (MLNT) (Kirk, Pisoni, & Osberger, 1996)	For children age 3 and older who can repeat on demand. It is often used before the LNT, as vocabulary is easier because of redundant cues of multisyllable words.	This is recorded open-set test of multisyllabic word recognition. The word list consists of 12 lexically "easy" words and 12 lexically "hard" words scored by both number of words correct and number of phonemes correct.
Phonetically Balanced Kindergarten Test (PBK-50) (Haskins, 1949)	Recommended age is 4+ years, but children who will repeat what they hear regardless of comprehension can be tested to determine speech sounds perceived.	This is an open-set test of monosyllabic word recognition. Can be presented live voice or recorded. A full list consists of 50 phonetically balanced, one syllable, kindergarten words that the examiner phonetically transcribes to obtain a word and phoneme score.

Table 4 (continued)

Text	Age Recommendation	Description
Pediatric Baby Bio Sentences (Spahr, Dorman, Loiselle, & Oakes, 2011)	As an alternative to HINT sentences, this test requires child to have vocabulary and auditory memory to repeat. Recommended once these skills exhibited. AZBiois used for adult CI candidacy determination.	A pediatric version of the AZBio sentence lists that uses a single female talker to evaluate speech understanding. Can be performed with 10-talker speech babble for noise environment.
Disclaimer	Age is a relative indicator of test appropriateness when children have developmental delays. All open-set tests subject to deflated scores due to articulation errors.	The chance score for open-set testing is 0%, but when highly practiced words are used, this is not valid. Recorded tests are ideal but often not realistic for young children. Testing in noise-controlled environments with calibrated materials is recommended.

Adapted from Advanced Bionics. (2010). *Test reference for cochlear implants candidacy and post-performance test.*

Beyond assessment, the cochlear implant team audiologist provides extensive counseling and information. In the process, he or she establishes a relationship with the child and parents and gains some insight about the family's acceptance of the diagnosis and the stage at which they are entering the decision-making process.

Depending on the child's age and abilities, a battery of speech perception tests are used to document benefit from amplification. While no standard universal pediatric test battery has been recognized among cochlear implant teams, a number of tests have been developed or are routinely used in cochlear implant assessment. The commonly used tests are listed and briefly described in *Table 4*. Importantly, speech perception assessments should be selected that are appropriate for the child and can serve as a baseline to measure future progress. Because many children are too young and lack the communication skills to participate in speech perception assessments during candidacy evaluation, the audiologic assessment should include baseline auditory functional assessments. These functional assessments can include questionnaires, such as the Infant Toddler-Meaningful Auditory Integration Scales (IT-MAIS; Zimmerman-Phillips, Robbins, & Osberger, 2000) and/or LittlEARS (Coninx et al., 2009), as well as aided testing in the sound booth and real-ear measures. The collaborative efforts of the audiologist, SLP, and early interventionist can combine to determine the benefit from amplification.

If the child is considered to be a cochlear implant candidate, a determination must be made regarding which device to use. Currently there are three manufacturers with established histories who produce the technology (see *Table 1*). Some centers only offer the option of a cochlear implant system available from one manufacturer, while others offer systems from multiple manufacturers. In some cases, the surgeon may recommend a particular device based on the medical and radiologic examination.

It is incumbent on the cochlear implant team to ensure that the family has access to unbiased information about each of the cochlear implant systems available and approved by the FDA. There is an abundance of information available to families via the Internet, including manufacturer websites and social networking sites. Support groups and other cochlear implant recipients can also share personal experience and perspective. It is important to note that

not all sources of information will provide accurate and unbiased information. In the interest of preparing effectively for surgery and device programming, and for achieving outcomes that meet the family's expectations, counseling from members of the cochlear implant team and shared decision making among the team members and the family is essential.

Beyond assessment, the cochlear implant team audiologist provides extensive counseling and information. In the process, he or she establishes a relationship with the child and parents and gains some insight about the family's acceptance of the diagnosis and the stage at which they are entering the decision-making process. Based on these observations and in communication with other team members lies the opportunity to consider some of these questions:

- Is the family responding from grief or anger?
- Have they idealized the process and created expectations of normal hearing?
- Are they cognizant of other developmental or medical issues the child might have, and does the team appreciate what these might be?
- Is the family's preference for communication mode realistic, and are services in place to support this plan?

Counseling and support needs can be shared with the team to help resolve these and other important issues.

Finally, plans for appointments and services for the next year and beyond should be discussed. During the first year following surgery, frequent device programming visits are necessary to optimize the program and ensure audibility is maximized. The typical child adapts to the electrical signal over time; tolerance increases; and as experience in hearing grows, children can play a larger role in providing feedback about hearing. At minimum, the following schedule is recommended for children:

- Initial stimulation (IS) occurs approximately 2 to 4 weeks after surgery
- 2 weeks post IS
- 1 month post IS
- 3 months post IS
- 6 months post IS
- 9 months post IS
- 1 year post IS
- Semiannual visits thereafter

During these appointments, hearing tests and speech perception assessments are completed to guide programming, validate settings, and ensure appropriate progress is made. Families gain experience and confidence in managing the technology with time, but the audiologist continues to be a source for new information and problem solving on issues related to device use, such as troubleshooting and device retention.

Speech-Language Pathology Component

For children who are deaf or hard of hearing being evaluated for possible cochlear implantation, it is vital that the SLP have the knowledge and skills to accurately assess the child's present level of functioning to determine whether the child's communication development can be enhanced with cochlear implants. These assessments will yield standard scores to determine if the child is reaching age-appropriate communication milestones, especially when compared to same-age normal hearing peers. If the child is delayed or is at risk for delayed language development, then cochlear implantation may be the best option available.

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When determining candidacy, most experienced SLPs serving children who are deaf or hard of hearing will use speech and language assessments that are standardized on typically hearing children—with only a few exceptions. If the child who is deaf or hard of hearing is acquiring spoken language, the SLP should use assessments that compare the child's performance to what is considered typical development.

In addition to having current and accurate audiological assessments on the child who is deaf or hard of hearing, SLPs also must obtain measures of functional listening skills, especially if the expectation is to use audition to develop spoken language. SLPs must document how the child is using his or her aided hearing in conjunction with amplification (e.g., digital hearing aids and/or personal FM system), and how the child is responding to both environmental sounds and speech. For infants and toddlers, these auditory skills can be measured through play activities and in conjunction with parental or caregiver interviews and questionnaires. For children aged 3 and above, more formal speech perception measures can be used, such as the Early Speech Perception Test for Profoundly Hearing-Impaired Children (ESP) developed by Moog and Geers (1990). As well, clinicians may wish to use the Auditory Perceptual Test for the Hearing Impaired-Revised (Allen, 2008).

Determining if a child is a candidate for cochlear implantation requires an interdisciplinary team approach that places the family at the center of the decision-making process.

Speech development can be measured in terms of overall intelligibility, as well as segmental (i.e., phonemes) and suprasegmental errors (i.e., speech rhythm and prosody; Tye-Murray, 1994). Speech intelligibility is a critical area of assessment that may be overlooked by most SLPs. Formal measures of speech intelligibility are limited, and the most common assessment is the CID Picture SPINE: Speech Intelligibility Evaluation (Monsen, Moog, & Geers, 1988). Many SLPs, however, develop their own assessments of speech intelligibility and will obtain a percent-correct of words, phrases, and sentences that are spoken by the child who is deaf or hard of hearing and understood by familiar and unfamiliar listeners.

The acquisition of suprasegmental and segmental skills can be assessed using instruments that were designed to evaluate the spoken language of children who are deaf or hard of hearing. The Ling Phonetic-Phonological Speech Evaluation (Ling, 2002) is commonly used for this purpose.

Another assessment developed specifically for children who are deaf or hard of hearing and acquiring spoken language is the instrument Identifying Early Phonological Needs in Children with Hearing Loss (Paden & Brown, 1992). And finally, if the child has acquired some spoken language, most clinicians will use standard assessments, such as the Goldman-Fristoe Test of Articulation (2nd edition; Goldman & Fristoe, 2000) or the Arizona Articulation Proficiency Scale (3rd edition; Fudala, 2000).

For most SLPs, as Tye-Murray (1994) notes, the assessment of a child's language usually involves the evaluation of form (syntax and morphology), content (semantics and vocabulary), or pragmatics (use). For infants and toddlers who are deaf or hard of hearing, practitioners may use assessments that measure performance across several developmental domains, such as:

- Carolina Curriculum for Infants and Toddlers (3rd edition; Johnson-Martin, Hacker, & Attermeier, 2004)
- MacArthur-Bates Communicative Development Inventories (Fenson et al., 1993)
- Rossetti Infant-Toddler Language Scale (Rossetti, 1990)
- Receptive-Expressive Emergent Language Scale (REEL; 3rd edition; Bzoch, League, & Brown, 2003)
- Cottage Acquisition Scales for Listening, Language, and Speech (CASLLS; Wilkes, 2003)

Other common assessments include:

- Preschool Language Scale (5th edition; Zimmerman, Steiner, & Pond, 2002)
- Clinical Evaluation of Language Fundamentals – Preschool (2nd edition; Wiig, Secord, & Semel, 2004)
- Reynell Development Language Scales (Reynell & Gruber, 1990).

These are broad-based receptive and expressive language evaluations that provide standard and/or percentile scores If the child has developed some language and is a preschooler or older, other assessments may be employed, such as:

Once the child has received the cochlear implant(s), and it has been activated, the real journey begins.

- Peabody Picture Vocabulary Test (4th edition; Dunn & Dunn, 2006)
- Test of Auditory Comprehension of Language (3rd edition; Carrow-Woolfolk, 1999)
- Bracken Basic Concept Scale (3rd edition; Bracken, 2006)
- Comprehensive Test of Spoken Language (Carrow-Woolfolk, 1999).
- Expressive Vocabulary Test (2nd edition; Williams, 2006)
- [a] Oral-Written Language Scales (Carrow-Woolfolk, 1995)
- Test of Pragmatic Skills (2nd edition; Phelps-Terasaki & Phelps-Gunn, 2007)

While this list of language assessments is not exhaustive, most practitioners who assess the language acquisition of children who are deaf or hard of hearing to determine candidacy for cochlear implantation will use at least some of these evaluations in their preferred diagnostic protocol. Of course, preferences based on clinical and professional experiences, as well as other factors related to a child's unique case history and learning needs, also influence the selection of communication measures and assessments.

Photo courtesy of Advanced Bionics

Conclusion

Determining if a child is a candidate for cochlear implantation requires an interdisciplinary team approach that places the family at the center of the decision-making process. Once the child is identified with a significant hearing loss, parents should be informed about all of the technological options available to them, especially cochlear implants. The cochlear implant team—comprised of at least a surgeon (i.e., otolaryngologist, otologist), audiologist, and SLP—will complete comprehensive medical, audiological, and speech-language assessments to ascertain if cochlear implantation would be beneficial for the child. Additionally, the team will determine if cochlear implantation will allow the child to achieve the desired communication and academic outcomes that were expressed by the family. If so, the child may be a candidate for cochlear implantation.

Once the child has received the cochlear implant(s), and it has been activated, the real journey begins. Consistent audiological support with cochlear implant programming is required to ensure that the device is working optimally. Additionally, the child should receive appropriate early intervention services that will focus on teaching the child to associate meaning with the auditory information provided by the cochlear implant(s). As hearing with a cochlear implant(s) is quite different than listening with hearing aids, the newly implanted child and family should receive weekly speech-language therapy that has a strong auditory component. These services should be provided by an early interventionist or clinician who is well trained and experienced in delivering these services. The goal is to assist the family to integrate listening and communication into the daily routines that occur in the home. Through consistent, timely, and well-coordinated early intervention, young children with cochlear implants often can achieve language outcomes that rival their hearing peers.

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