

Hearing Technologies

Importance of Hearing Aids

No child is too young to be fit with hearing aids! Even infants can be fit with hearing aids. Early hearing aid use increases the chances that a child with hearing loss will develop his listening and language skills.

A child born with normal hearing typically begins using single words at around 12 months of age. In reality, a great deal of listening and language development occurs before your child speaks his first words. Hearing loss delays language development because spoken language depends on the ability to hear speech. Language delay can be minimized by fitting hearing aids as soon as possible once the hearing loss is diagnosed.

It is critical that the audiologist is familiar with the special needs of fitting hearing aids on infants and young children. A pediatric audiologist is someone who specializes in children's hearing needs.

What is a hearing aid?

A hearing aid is a device that amplifies sound. It consists of a microphone that picks up sound, an amplifier that makes the sound louder, and a speaker (receiver) that delivers the sound to the ear. A hearing aid is an effective tool to provide your child with access to sound, but it does not correct the hearing loss.

What are the benefits of hearing aids?

Hearing aids compensate for the hearing loss by amplifying sound through the ear. Ideally, hearing aids will provide an amplified signal enabling detection of all speech sounds and conversational speech to be heard at a comfortable level. The success of achieving this goal depends on the degree and configuration of the hearing loss.

When severe-to-profound hearing loss is present, hearing instruments may not be able to amplify speech to levels where it can be understood clearly. However, hearing instruments may still improve awareness of speech and environmental sounds as well as provide helpful additions to visual and facial cues. In this case, a child may be referred for an assessment for cochlear implantation. Please refer to the cochlear implant section for more information.

Hearing instruments do not restore hearing to normal and may not be effective in all listening situations such as noisy backgrounds or listening to speech at a distance. In more difficult listening situations, an FM system or a similar assistive device may be beneficial (see Assistive Listening section).

How do you fit a child with hearing aids?

Once the hearing loss is determined, hearing aids can be selected.

First, it is necessary to have medical clearance from your child's pediatrician or ear, nose and throat doctor before the hearing aids can be fit by the audiologist. Most pediatric facilities can provide this medical consultation for you.

Second, once medical clearance is obtained the audiologist will take ear mold impressions of the child's ears. The ear molds are made from this impression to design a custom-fit mold to be used with the hearing aid.

Then hearing aids are selected by style and type. This will be determined by the degree and configuration of the hearing loss. The audiologist will work with the family to choose the best type and style of hearing aids for your child.

Your child will be fit with the ear molds and hearing aids, and benefits of the hearing aid is verified by the audiologist.

What are the different styles of hearing aids?

There are many different styles of hearing aids that vary in the way the components are designed and housed. The most common types used with children are listed below.

Behind-the-ear hearing aids, also called BTEs, are hearing aids that fit behind the ear. The hearing aid is connected to a soft ear mold that is fitted into your child's ear. The ear mold holds the hearing aid in place and directs the amplified sound down your child's ear canal. The majority of young children and especially babies are fit with this style. This type of hearing aid is very durable and the ear mold is replaced often as your child's ear grows. It is necessary for the mold to fit tightly in the ear to prevent acoustic feedback, which is the high-pitched whistling that occurs when the ear mold is loose or not correctly in the ear. BTEs can be fit on any degree or type of hearing loss as long as the external ear and ear canal are fully formed. Both earmolds and the hearing aids themselves are available in a variety of colors. Children often learn to accept their hearing loss more easily when they are able to choose a color they like, rather than clear or beige, as this sends a positive message of acceptance to the child.



A Behind-the-ear hearing aid, courtesy of Phonak.



A Behind-the-ear hearing aid, image courtesy of Oticon.

In-the-ear hearing aids, also called ITEs, are hearing aids that fit inside the external ear. All of the components are built into a custom hard shell that is made from an ear mold impression. ITEs can be made in a variety of sizes, some fit deep in the ear canal. ITEs are generally not used in children. Their ears are too small to handle the size of the hearing aid components and the size of their ears are continually growing. ITEs can be fitted in older children with mild or moderate degrees of hearing loss. ITEs are limited in the amount of amplification they provide and therefore are not appropriate for children with moderate-severe losses or profound losses.

Safety is the overriding concern for the choice of BTE vs. ITE hearing instruments for children. BTE hearing instruments can be used with ear molds made of soft material as a safety precaution with physically active children.

In general, BTE hearing instruments also require fewer repairs than ITE hearing instruments, and they are more compatible with assistive devices such as FM systems. Although assistive devices are not typically used with infants and toddlers, many children with hearing loss use FM systems and other assistive devices when they begin school.

Bone conduction hearing aids are an appropriate instrument to use for children that have conductive type hearing losses particularly when the ear canal is atretic, or closed. Bone conduction aids use an oscillator placed behind the ear to stimulate through the bone. The oscillator serves as a transmitter and is typically coupled to a headband and BTE hearing aid that serves as a receiver.

What is the technology inside a hearing aid?

Digital hearing aids now employ digital technology, in which incoming acoustic signals are converted to digital signals. This “digitalization” makes it possible to precisely analyze and filter the signals through a computer software program. The signals can be processed in one or more frequency channels. Digital hearing aids use digital processing, not analog. **Digital hearing aids provide better quality with less distortion than older analog hearing aids.** They also provide flexibility for easy changes over time. Some hearing aids can be "programmable" which means that the audiologist uses a computer to fit them to the patient. Other hearing aids are called "conventional" which means that they are fit without the use of a computer, and often have less sophisticated technology than programmable hearing aids.

How to verify the hearing aids are fitted appropriately

Audiologists may use one of several assessment methods when evaluating hearing instruments for children. Regardless of the technique used, the goal is to enable conversational speech to be heard at a comfortable level. These assessment methods may include:

- **Probe-Tube Microphone Testing** – During probe-tube microphone testing, a tiny, soft microphone is placed in the ear next to the earmold. The amplification provided by the hearing instrument is then measured while in place in the ear. The measured response is evaluated in order to estimate the instrumented benefit. Adjustments to the hearing instrument are made as needed.
- **Real-Ear-to-Coupler-Difference (RECD) Measures** – In RECD testing, a tiny, soft microphone is also placed in the ear next to the ear mold. The effect of the child’s ear and ear mold are measured without the hearing instrument. The hearing instrument is evaluated separately and its response added to the RECD measurement. This allows different hearing instruments and settings to be compared without having to test each one on the child. While the importance of RECD testing has been proven, a child may not be able to initially tolerate the amount of gain that the computer deems appropriate. In this case, an audiologist may decrease the gain and gradually help

work-up to the real-ear targets. It is important to use both objective and subjective measurements to appropriately fit a child with hearing aids.

- **Behavioral Testing** – When probe-tube measures cannot be completed, behavioral testing methods can be used to assess a child’s performance with hearing instruments. The softest level at which a child responds to sound while wearing the hearing instrument is compared to the softest level of response without the hearing instrument to estimate instrumented benefit. This type of evaluation does not require the placement of measuring equipment on the child, but provides less comprehensive information.

NOTE: Probe-tube microphone or RECD measurements are usually the methods of choice for fitting hearing instruments for children for several reasons. First, they allow hearing instrument performance to be measured at typical speech levels so that performance in conversational situations can be predicted. Second, they allow direct measurement of the maximum level of sound provided by the hearing instrument to the child’s ear. The hearing instrument then can be adjusted to a safe and comfortable level. Third, they provide more comprehensive information and can be completed quickly.

Additional facts about hearing aids

Hearing aids do not last forever – it is likely they will need to be replaced in 4 to 6 years. Reasons they may need to be replaced: everyday wear and tear of the hearing aids, they need to be taken care of and may need to be repaired out-of-warranty once or twice. The main reason for replacing hearing aids is because technology is always getting better. By the time 5 years have passed, there will be better hearing aids on the market.

Hearing aids are not always covered by health insurance. It is likely there will be some out of pocket expenses. Your audiologist should provide you with information on the cost of the hearing aids, ear molds, and office visits.

There are many manufacturers of hearing aids. Most companies make a variety of systems from conventional to digital. The general features are the same, but the packaging varies. Most pediatric audiologists work with several companies that can supply the best hearing aids for your child.

*Reviewed by Kerry Roesch, Aud (2010) and Tina Grieco-Calub, Assistant Professor,
Northwestern University (2014).*

Cochlear Implants

What is a Cochlear Implant?

A cochlear implant is a proven medical option for children with severe to profound hearing loss who receive little or no benefit from hearing aids. Cochlear implants can provide better sound detection for greater speech understanding in children. Unlike hearing aids, that increase the volume or loudness of sound, cochlear implants move beyond the damaged parts of the inner ear (called the cochlea) and send sound information directly to the hearing nerve through electrical signals. While a cochlear implant doesn't cure deafness, it does offer a life-enhancing option.



Cochlear implants have been approved for use in children since June 1990.

Today, approximately **38,000 children** in the United States have a cochlear

implant. Today's cochlear implant technology has evolved through more than 20 years of research into a highly advanced system that sends in-depth sound information through multiple channels of stimulation.

By improving hearing, cochlear implants can make communication easier. Cochlear implants give many children a chance to develop spoken language through improved hearing, and they have also been shown to have a positive impact on language in general – both spoken and sign.

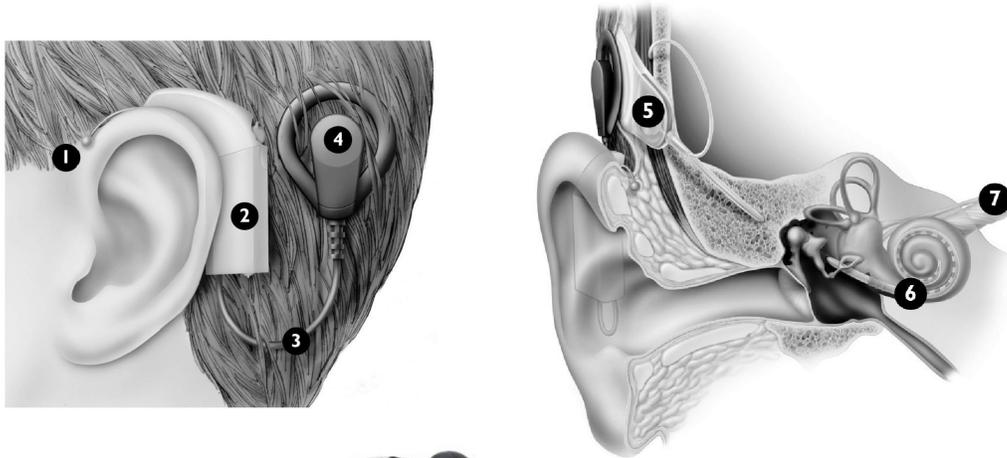


Flex Internal Device

Image provided courtesy of MedEl

How a cochlear implant hears

A cochlear implant changes speech, music and environmental sounds into electrical signals and sends these signals to the hearing nerve and then to the brain where sound is heard. All cochlear implant systems have inside and outside parts or components. The outside components include a microphone, a speech processor or sound processor (choice of body worn or behind the ear), and a transmitter with a magnet. The inside components include a receiver/stimulator (high tech electronics) and an electrode array. The electrode array is placed into the inner ear (cochlea) and contains many electrical contacts (from 12 to 22 electrode contacts depending on the implant manufacturer), which stimulate the hearing nerve fibers and send electrical signals to the brain where sound is heard.



EXTERNAL DEVICE
Cochlear Nucleus® 5
Sound Processor



Photos provided courtesy of Cochlear Americas

How it works:

The Nucleus® cochlear implant system works in the following way:

1. Sounds are picked up by a small, microphone that is located in the front part of the ear level (behind-the-ear) speech processor.
2. The speech processor changes the sound into coded signals.
3. The speech processor sends these signals to the transmitting coil.
4. The transmitting coil sends the signals across the skin to the cochlear implant that is under the skin.
5. The cochlear implant sends the signals to the electrode array inside the inner ear or cochlea.
6. The electrode array stimulates the hearing nerve fibers in the cochlea.
7. The electrical sound is sent from the cochlea to the hearing nerve and to the brain, where it is heard as sound.



Cochlear Nucleus® 5
Remote Assistant

What are the benefits?

The main benefit of a cochlear implant is better hearing. Children as young as 12 months of age with a profound hearing loss in both ears, who receive little or no benefit from hearing aids (usually determined through a trial period using two hearing aids), may hear better with a cochlear implant. Older children, over 2 years of age, with severe to profound hearing loss in both ears may also benefit from a cochlear implant. Studies have shown that cochlear implants provide much more benefit than hearing aids for children with severe to profound hearing loss. Children who receive a cochlear implant early in life, with appropriate speech therapy, educational programs and family support develop speech and language at a rate that is similar to normal hearing children of the same age. Many of these children are able to go into normal school environments with hearing children.



This is one example of an implanted device.

*Image provided courtesy of
Advanced Bionics.*

Although cochlear implants can't restore normal hearing, according to parents of children with cochlear implants, they make major gains in sound awareness and speech understanding. After six months of using the cochlear implant, the majority of children respond to their names in quiet environments and recognize common sounds in the classroom. Most children with implants continue to improve for several years after receiving their implant.

With a cochlear implant children have a more complete awareness of sounds in the environment, from a car approaching, a friend's whisper, to a shout from near or far away.

The success of a deaf child's speaking and hearing depends on a number of things, including how long the child was deaf before being fit with hearing aids and receiving sound. The earlier hearing loss is recognized and the sooner a child receives a cochlear implant and therapy, the greater chance a child has of gaining speech and language at the same level as hearing children of the same age.

How do I know a cochlear implant will benefit my child?

Although most general doctors and audiologists are familiar with cochlear implants, some may not be up to date with information on who can benefit from cochlear implants. If you are considering a cochlear implant for your child, you are encouraged to go to a professional with cochlear implant experience in children. Only your child's cochlear implant audiologist and surgeon can decide if your child will hear better with this technology. Your child will undergo a hearing test and medical exam which normally takes a couple of hours. The hearing test will determine how much hearing loss your child has and how well your child

can hear with hearing aids. Other tests such as x-rays, CT scans or MRIs are often taken to look at your child's cochlea or inner ear.

Centers who have experience working with children may be able to put you in touch with other parents who have decided to have their child implanted. This is a great chance for parents to share their experiences with others. Many parents of a child with an implant said talking to other parents was very helpful in their decision-making process. The cochlear implant manufacturers may also be able to connect you with other parents who can share their experiences with you.

To locate a center that works with cochlear implants, you may want to ask your child's primary care physician, audiologist, or ENT. It may be necessary to do some research on your own to find a center that meets the needs of your child. Cochlear implant manufacturers are a good resource for locating a center as they all maintain a list of implant centers worldwide. Parents of children who have been implanted are a good resource as well.

Additionally, as parents, you should have a clear understanding of the benefits and limitations of a cochlear implant, and be prepared to devote the necessary time for the pre-implant evaluations and post-operative follow-up services. Some cochlear implant centers ask for assurance from families that the child's home and educational environment will stress listening and spoken communication to ensure the best possible results.

It is important for you to visit and ask for advice from a cochlear implant center during your child's infancy, rather than waiting until your child is 12 months old or older before scheduling the first visit. Visiting a center early will give you a chance to meet with other families, get the names of therapists, complete the hearing aid tests, and determine if your child will benefit from a cochlear implant.

What happens during surgery?

Cochlear implant surgery is typically performed while your child is asleep, under general anesthesia, and takes about 1½ to 2½ hours. The procedure is often done in an outpatient

setting, but may also be done as an inpatient. The day of surgery the area of the head where the cochlear implant will be placed is shaved (only a small amount of hair removal is usually required). The surgeon makes a small cut behind the ear, and then forms a small hollow in a bone behind the ear to hold the cochlear implant in place. The cochlea, which is adult-size at birth, houses the electrode array. The electrode array is fit into the cochlea through the opening the surgeon made through the mastoid bone into the inner ear. The small cut is then closed and a bandage is placed over it. The surgery carries the normal risks associated with ear surgery requiring general anesthesia.



Photo provided courtesy of Cochlear Americas ©2009 Cochlear Americas

Activation of the implant and device fitting

Around three to four weeks after the surgery you and your child will return to the clinic for the “turn on” or “hook-up” of the implant and fitting of the speech processor. It is during this time that your child will hear his/her first sounds with the new implant. You and your child will meet with the audiologist to program the speech processor. The audiologist will use a computer with special software for programming the speech processor.

Once the programming is finished, your child can take the implant system home. Your audiologist will work with you to develop a schedule of follow-up visits for “fine tuning” the speech processor. Implant programming is performed a lot more often during the first months of implant use, then there will be fewer visits required later on. Typically these visits occur every six to twelve months for monitoring and program adjustments.



Photo provided courtesy of Cochlear Americas ©2009 Cochlear Americas

What type of early intervention or therapy should my child receive?

This is a question you should discuss with your child’s cochlear implant center. The center may be able to recommend an experienced therapist who has worked with young children before and after cochlear implantation and can customize therapy to the child’s individual needs. The decisions you make regarding therapy can have a large impact on your child’s progress with the cochlear implant. Research has shown that for children to make major progress learning to listen and speak with a cochlear implant, their homes and school environments must provide hearing experiences that provide lots of opportunities for children to listen and use their own voices. While some parents may chose to use sign language as part of the therapy, hearing therapy should also be considered an important part of the therapy goal.

How much do cochlear implants cost?

Cochlear implants are covered by most medical insurance policies, including Medicaid. In the state of Illinois, the **Division of Specialized Care for Children (DSCC)** also covers cochlear implants for eligible families. Included in costs are hearing tests, medical exams, surgical fees, anesthesiologist, operating room, hospital charges and follow-up. Hearing and speech training is not always covered by medical insurance.

Edited by Cochlear Americas, Dr. Nancy Young, Beth Tournis of Children’s Memorial Hospital (2010) and Tina Grieco-Calub, Assistant Professor, Northwestern University (2014).

Bone-Anchored Hearing Aids (Baha)

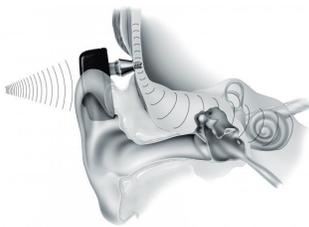
What is a Bone-Anchored Hearing Aids?

Bone-anchored hearing devices/systems transmit sound to the cochlea through direct bone conduction. The system is used for people with conductive and mixed loss hearing loss. The hearing loss may be due to chronic infection in the ear, people with absence of or a very narrow ear canal as a result of a congenital ear malformation, infection, or surgery. It may also be used for people with a profound unilateral hearing loss.



Baha 4 Connect
Photos and illustrations provided courtesy of Cochlear Americas ©2014 Cochlear Americas

The system can be used with a headband-like strap or surgically implanted.



The system works by enhancing natural bone transmission as a pathway for sound to travel to the inner ear, bypassing the external auditory canal and middle ear. The vibrating implant vibrates the bones of the skull which then stimulates the nerve fibers of the inner ear, to aid in sound detection.

When surgically implanted, the bone-anchored hearing system is placed behind the ear leaving the canal open. The implant is integrated with the skull bone and connects directly to the sound processor via an abutment or magnet. Thus, there is no need for a headband and/or pressure against the skin of the head.

Types of hearing loss that use bone-anchored hearing devices

CONGENITAL HEARING LOSS – Congenital conductive hearing loss caused by a malformation of the middle or external ear resulting in a missing or incomplete ear canal (external auditory canal atresia) is effectively managed with bone conduction devices. The bone-anchored hearing device sound processor is directly integrated to the skull bone.

UNILATERAL HEARING LOSS – Patients with severe hearing loss on one side, but normal hearing in the other ear may have difficulty understanding speech in background noise (such as group conversations and restaurants) and determining which direction sound comes from.

The device is now an FDA-cleared solution for unilateral deafness, and provides a completely unique benefit. The device is placed on the side of the deaf ear, transfers sound through bone conduction, and stimulates the cochlea of the normal-hearing ear. The bone-anchored hearing device effectively transmits sounds from the bad side to the normal ear and ultimately results in a sensation of hearing from a deaf ear. The system can assist in understanding of speech, especially in background noise, and aids in the localization of sound.

At the time of this publication, there are two FDA-approved bone-anchored hearing devices. Information on each device may be found online at:

Cochlear Americas: <http://products.cochlearamericas.com/baha>

Oticon Medical: www.oticonmedical.com

Sophon: <https://sophon.com/>

Supporting Environmental Awareness in a Deaf or Hard of Hearing Child

For a young child who is deaf or hard of hearing it is very important to make sure that the environment in which he/she spends time is friendly, accessible, safe and predictable. Fostering a supportive and accessible environment will help even young babies become aware of the safe and secure place in which they live. Once your baby begins to understand his/her environment, your baby begins to understand how to interact with it. The following items will help your baby better understand the world around him/her. Many of the items are inexpensive.

Doorbell Flashers and Telephone Visual Alert Systems

PICTURE THIS SCENARIO: A young hard of hearing toddler is playing on the floor with his mother. They are playing with his cars and running them up and down a ramp and the child is very engaged. The doorbell rings and his mother gets up and goes into the other room to answer the door. The child looks up to find mother gone. He is scared because he has no idea of where she went or why she left so suddenly. The young child with hearing loss does not have access to all of the clues in the environment around him that signal why his mother went to answer the door. He did not hear the doorbell or knock, the sound of his mother getting up off the floor, or her footsteps, the door unlocking, or if his mother was talking to the neighbor.

A doorbell flasher can be a great way to help even a very young deaf or hard of hearing child gain the assurance that comes with knowing what will happen next. The child may connect the flashing light to mother going to answer the door or to the exciting anticipation of a new visitor.

Similar to the visual signal for the doorbell, the visual alert system for the telephone will help a child come to associate the visual stimulus with an action or response from the family. Families can also use the visual cues to call attention to sounds that the child may be able to hear with or without the use of other technology. This will help the child develop some awareness of the auditory signals as well.

Lighting

A child who is deaf or hard of hearing tends to be more visually aware of his/her surroundings and tends to depend much on visual information even if he/she has access to sound through the use of hearing aids or a cochlear implant. Therefore, it is important to be aware of the lighting in your baby's environment. A few examples of things to consider:

- Make sure your child can see you when you are talking.
- Make sure there is enough light on your face but not so much that there is a glare or that it is uncomfortable for you or your child.

- Be aware of backlighting which may cause a shadow on your face.
- Use lights to get your child's attention by flicking them off and on.

Alarm Systems

Visual signals that accompany smoke and fire alarms are very important. Sometimes, even with hearing aids, a child cannot hear these important sounds. In addition, it may be important to alert the child to certain events when he/she is not typically wearing his/her hearing aids (while asleep). You may purchase a smoke alarm that has a strobe light that flashes throughout your home and all hotels will have them for your room upon request. An older child needs awareness of these events as he/she starts to stay home alone and increase his/her independence. Devices are available to provide either visual or vibratory signals to the child who is deaf or hard of hearing.

Other Examples of Assistive Technology

- **Telephone Flasher** – A visual alerting system that signals when the phone is ringing.
- **Telephone Ringers and Amplifiers** - Telephone amplifier devices may work with a hearing aid or independently from it. Amplifiers may increase the volume of the phone.
- **Wake-up Alarm** – A clock that flashes a light, vibrates or has a loud buzzer tone.
- **Closed Captioning** – Most TV's have this built in. Visual text known as captioning will show up on the screen. Captioning is also available in select movie theatres and in other entertainment venues such as Walt Disney's parks.

Edited by Wisconsin Sound Beginnings.