SPOKANE EAR, NOSE & THROAT
A Division of Columbia Surgical Specialists

Cochlear Implants - Single Sided Deafness and Asymmetric Hearing Loss

How Natural Hearing Works

Before going into details of how a cochlear implant (CI) works, it is important to understand the structure of the ear and how it works.

Sound waves enter the ear canal and impact the ear drum (tympanic membrane). After the ear drum picks up the sound, it transmits sound wave vibrations through the hammer (malleus), anvil (incus), and stirrup (stapes). The hammer, anvil, and stirrup make up the chain of three middle ear bones. The stirrup passes the vibrations to the inner ear fluids within the cochlea. Fluid waves travel through two and a half turns of the cochlea, bending the cochlea hair cells as it goes by. The hair cells correspond to the frequency of the original sound waves, initiating signals within their corresponding nerve endings prior to sending them to the brain.



1. Sounds enter the ear canal and travel to the eardrum.
2. These sound waves cause the eardrum to vibrate, setting the bones in the middle ear into motion.
3. This motion is converted into electric impulses by tiny hair cells inside the inner ear (cochlea).
4. These impulses are sent to the brain, where they are perceived by the listener as sound.

What is a Cochlear Implant?

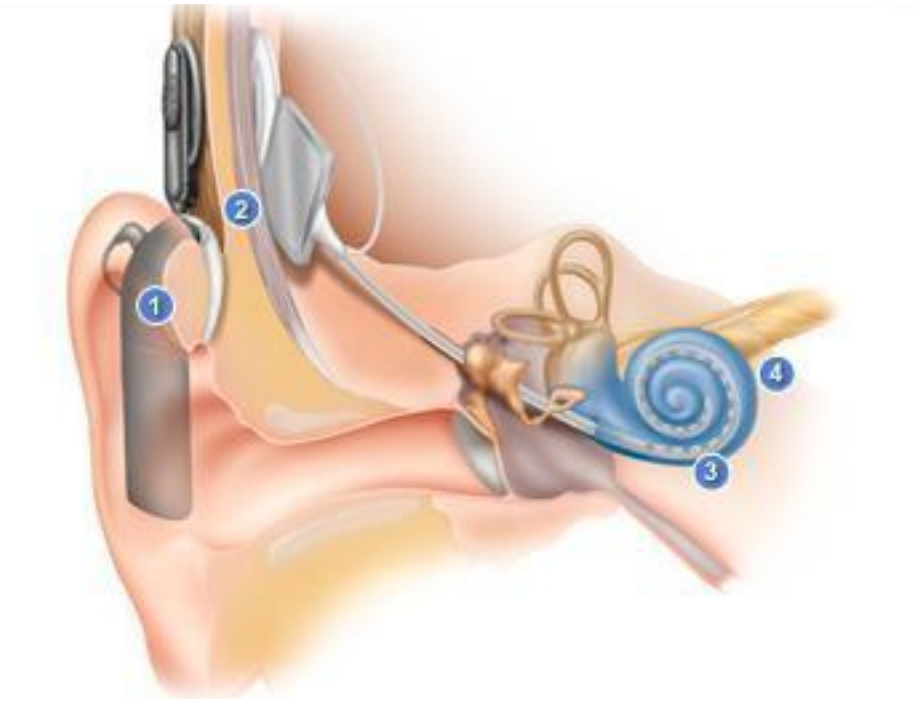
The use of cochlear implants for the treatment of severe to profound hearing loss is one of the most revolutionary treatments of our time. The cochlear implant is a prosthetic replacement for the inner ear (cochlea) which was developed over 20 years ago, based on the idea that profoundly hearing impaired individuals have auditory nerve fibers remaining that can be electrically stimulated to produce a sense of hearing. A multichannel cochlear implant is an electronic device developed to restore auditory sensation

through electrical stimulation of the auditory nerve for individuals age 9 months and older with severe to profound sensorineural hearing impairment. The stimulation provides a wide range of auditory information needed for recognizing environmental and speech sounds to expand communication ability. The cochlear implant bypasses damaged parts of the inner ear and electronically stimulates the nerve of hearing. The cochlear implant system consists of two parts:

1. The internal part consists of wires that are surgically implanted into the cochlea through the skull behind the ear
2. The external part consists of a microphone, a speech processor (that converts sound into electrical impulses), and connecting cables

Individuals who receive little to no benefit from hearing aids are usually considered to be candidates for a cochlear implant.

How A Cochlear Implant Works:



1 The external sound processor captures sounds, then filters and processes the sounds.
2. The sound processor translates the filtered sounds into digital information, which is then transmitted to the internal implant.
3. The internal implant converts the digital information into electrical signals, and sends them to a tiny, delicate curl of electrodes that sits gently inside the cochlea.
4. The electrical signals from the electrodes stimulate the hearing nerve, bypassing the damaged cells that cause hearing loss, allowing the brain to perceive sound.

A cochlear implant is designed to bypass damaged or degenerating cochlear hair cells (within the inner ear that correspond to the sound wave frequencies). The hair cells are the "spark plugs" of the inner ear nerve endings. The vast majority of nerve deafness is usually the result of non-functioning hair cells, however, with the nerve endings still purposeful in the majority of those cases, it makes it possible for cochlear implants to work.

Candidate Evaluation

Saying that a patient is a candidate for a cochlear implant means they should obtain significantly better hearing ability from a cochlear implant than they can from the most optimally fitted hearing aids. Current cochlear implant technology works so well that the candidacy criteria are expanding rapidly. Although most patients receive a cochlear implant on the basis of advanced hearing loss in both ears, the FDA approved CI for patients with advanced hearing loss in only one ear in 2019. This allows access to CI for a wider range of patients, but also introduces a new set of expectations for these potential CI users. Candidacy criteria for this group of patients, who have single sided deafness or asymmetric hearing loss, include:

- Age: 5 years or older
- Ear to be implanted: severe to profound hearing loss, with a pure tone average of >80 dB (at 500, 1k, 2k, and 4kHz) and CNC word scores of <5% despite amplification. Duration of deafness must be fewer than 10 years and the cochlear nerve must be free of an acoustic tumor.
- Contralateral ear: no worse than moderately severe hearing loss, with a pure tone average of <55 dB (at 500, 1k, 2k, and 4kHz).
- No medical contraindications
- High motivation and appropriate expectations
- Involved in an educational or training program that emphasizes auditory skills and oral communication.

The Cochlear Implant Process - Explanation of Evaluation Steps

Phase I

1. Initial Audiology Testing and Counseling- Your first visit will involve extensive testing of your or your child's hearing with tests performed in a sound booth with and without hearing aids. This information combined with the history of hearing loss is used by the audiologist to determine if a cochlear implant is likely to be helpful to you or your child. If so, the audiologist will spend time counseling and educating you about cochlear implants so that you understand all that is involved before you decide to proceed with the rest of the process.
2. Otologic Medical Evaluation- An otologic surgeon will take a full medical history, perform a physical exam, and review the hearing tests performed in step 1. If he agrees that a cochlear implant is the best option the next phase of evaluations will be scheduled.

Phase II

1. MRI Scan - This is required on all patients to evaluate inner ear anatomy and to screen for any brain conditions prior to the placement of the implant. Children usually require sedation or anesthesia for the scan and therefore it is performed in the hospital setting. Adults and older children can have their scan performed in an outpatient facility. Often, imaging studies of the head obtained in the past are sufficient for this evaluation and new studies are unnecessary.
2. Auditory/Verbal Evaluation (*only used in some circumstances*)
    a. For adults, this assesses
        i. the affects of hearing loss on the patient's listening and speaking skills at home, work, educational and in social settings
        ii. the possible benefits of a cochlear implant
        iii. the need for hearing therapy or hearing and speech therapy after the cochlear implant is activated.

    b. For infants, children and teens, this evaluation assesses the patient's potential for learning to
        i. hear and comprehend spoken language with a cochlear implant and
        ii develop speech to use as a primary means of communication. The roles of the parent and the child's educational setting are discussed as they impact benefit from implantation.
3. Vestibular testing (*only used in some circumstances*)- This is performed for adults in whom surgery may affect long-term balance function. It involves a series of balance tests to determine the amount of balance function in each ear. The results of these tests can affect the choice of ear for implantation and help detect certain patients who may be prone to balance difficulties after implant surgery.
4. Insurance Precertification- Obtaining approval from your insurance company for cochlear implantation can take several weeks. The Spokane ENT surgery scheduling team will be hard at work to obtain precertification for the surgery and will keep you up to date on the progress.
5. General Medical Preoperative Exam by your Primary MD- If you are age 40 or older or if you are any age but have other medical conditions (high blood pressure, heart conditions, diabetes, etc), you may need to see your primary physician for an exam that may include an EKG, Chest X-ray, and general blood tests before we can schedule your surgery. Your physician's office must fax us these results with a note stating that you are in reasonable condition to undergo the implant surgery. Some patients require evaluation by additional internal medicine subspecialists (cardiologists, pulmonologists, etc.). If this is necessary, your PCP will coordinate those referrals and summarize the findings/recommendations and fax them to us.
6. Vaccination – Patients with cochlear implants are at a slightly higher risk than members of the general population for bacterial meningitis. This risk can be mitigated by the pneumococcal vaccine, a measure recommended by the FDA. Please see the attached handout and bring it to the attention of your PCP so that your vaccination status can be confirmed or an appropriate booster dose can be given. Vaccines should not be given within 2 weeks of surgery – either preoperatively or postoperatively.

Phase III

1. Preoperative Appointment with the cochlear implant team - When all of the above steps are complete, a surgery date will be scheduled. You will be asked which cochlear implant brand you have selected. Decisions will also be made regarding the ear to be implanted.
2. Cochlear Implant surgery- The surgery takes approximately 1 hour to perform. The majority of patients go home the same day of surgery. Very young children may be monitored in the hospital overnight.
3. Postoperative Check and Switch-on! - You will return to see your surgeon about 2 weeks after surgery to check the incision for proper healing. You will also see the audiologist who will perform electrical checks on the implant and activate the device. That day, you or your child will have the processor programmed and leave the office with the implant functioning. This is the beginning of learning to hear with the implant. You will be returning to the audiologist for programming of the implant processor at regular intervals to slowly increase the strength of the implant stimulation.

Cochlear Implant Surgery

The surgical placement of cochlear implants has been performed for over 40 years. Newer implant designs and surgical techniques allow us to place these devices with very few complications and excellent cosmetic results.

The procedure is performed on an outpatient basis, with most patients going home the same day. General anesthesia is administered in the operating room, and a small amount of hair behind the ear is shaved. An incision is made behind the ear, which makes the scar very inconspicuous once it has healed. A pocket is created under the skin to accommodate the receiver-stimulator portion of the implant. This part of the implant has a very flat design so that the associated bulge is minimal. An opening is then made into the air-filled bone called the mastoid. One boundary of the mastoid is the brain lining, which contains spinal fluid. Leakage of this fluid postoperatively is rare. This mastoidectomy allows access to the cochlea without disturbing the ear canal or eardrum. The dissection is carried through a 1-2 mm space bounded by the nerves for taste and facial movement; consequently a small risk of deficits in either is assumed. A very small opening is made into the cochlea, and the implant electrode is threaded in as far as possible. Most cochleas can accommodate the complete electrode unless meningitis is the cause of deafness, in which case a partial insertion may be necessary. The incision is closed with absorbable stitches that do not require removal. A head wrap dressing is placed on the ear and remains in place for 1 day. Patients usually leave the hospital 3 to 4 hours after surgery is completed. Pain is mild-to-moderate for 1 to 2 days and can be controlled with oral pain medicines. Some patients experience vertigo or imbalance for a few days after surgery, but this resolves spontaneously within the first week in the vast majority of patients. Most patients are able to return to work or school 1 week after surgery. The initial activation of the device and placement of the external equipment is performed about 2 weeks after surgery. The incision can tolerate shower water 2 days after surgery, but do not submerge it until the postoperative visit with your surgeon. Contact sports and vigorous exercise should be suspended until the postoperative appointment. After that, there are no activity restrictions.

Cochlear implants are extremely reliable. It is expected that a patient will never need to have their implant replaced. Less than 1% of implants have malfunction, infection, or extrusion that requires replacement. Thankfully, if necessary, implants can be surgically replaced with minimal risk to hearing performance. This also means that in the future patients can be upgraded to newer technology if warranted by the expectation of improved performance.

Activation of the Device

The initial activation of the device and placement of the external equipment is performed 1 month after surgery. At that time, the patient will be fitted with the external parts of the device, which requires "programming" of the external speech processor by the audiologist. During this process, the patient will begin to hear their first sounds generated by the implant.

The programming of the external speech processor is a procedure that must be repeated after a brief interval and then periodically thereafter. The reason for this is because the implant system must be programmed to suit each individual's needs. Each patient's tolerance of sound improves with time. Therefore, the implant stimulation level can be adjusted to suit each patient's needs. The implant team is committed to work with the implant recipient as long as it is necessary to ensure optimal benefit from the device. For many patients, this entails several visits annually!

Benefits

Patients who receive cochlear implants for single sided deafness or asymmetric hearing loss have a very different functional outcome when compared to patients who receive implants for bilateral advanced hearing loss. In the latter group, patients notice a dramatic improvement in their ability to communicate under all circumstances. This is because, before implant surgery, they were functionally deaf. Even holding a conversation in a quiet room, with one companion, presented a major challenge before implant surgery.

For those patients who have serviceable hearing contralaterally, the benefit of the cochlear implant is more nuanced. These patients often struggle to hear conversation in the presence of background noise.

They find it difficult to localize sounds. They struggle when sound is presented from the "bad" side of their head. Cochlear implants are indeed helpful in all these circumstances, but the benefit does not come immediately after activation and the improvement is NOT a restoration of normal hearing in the implanted ear. While most patients do improve in these domains, carefully setting expectations is critical for patient satisfaction. It is important to remember that understanding conversational speech in restaurants and at parties can be difficult for people with normal hearing, and it remains difficult for patients with cochlear implants!

(Content borrowed and adapted from dallasear.com)

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Cochlear Implant Checklist

As you progress through the implant process, there are several steps for which you are responsible. You should bring this checklist along to all relevant appointments.

1. Device selection appointment
   a. Time and date:
   b. Location: 217 W Cataldo Ave
   c. Audiologist: Ziegler, AuD Polensky-Bonser, AuD Jones, AuD
2. Preoperative surgical appointment
   a. Time and date:
   b. Location: 217 W Cataldo Ave 13414 E Mission Ave 9922 N Nevada Ave
   c. Surgeon: William Schmitt, MD Eric Babajanian, MD
3. Preoperative medical review *(to be completed by your PCP)*
   a. PCP name:
   b. PCP phone number:
   c. Pneumococcal vaccine administered: none PCV13 PCV20 PCV15 PPSV23
   d. IM subspecialty (cardiology, pulmonology, etc.) referral? Yes No
   e. Anticoagulation management plan? (INR needs to be <1.5 at the time of surgery; OK to resume warfarin the day after surgery. Anti-platelet agents should be discontinued 5 days before surgery; OK to resume 3 days after surgery.) Yes N/A
   f. OSA/hypoxemia management plan? (At-risk patients should be evaluated by PSG. Known OSA patients should be under PAP treatment. Any baseline hypoxemia should be addressed and home oxygen arrangements made if necessary.) Yes N/A
   g. Patient is OK for 90 minutes of general anesthesia; all evaluations have been completed and interpreted: Yes No
4. Perioperative considerations
   a. Imaging: MRI CT
   b. Steroid prescription (to begin 3 days before surgery): Yes No