Michigan Ear Institute

Cochlear Implant

www.michiganear.com

WELCOME

Welcome to the Michigan Ear Institute, one of the nation's leading surgical groups specializing in hearing, balance and facial nerve disorders. The Michigan Ear Institute is committed to providing you with the highest quality diagnostic and surgical treatment possible.

Our highly experienced team of physicians, audiologists and clinical physiologists have established international reputations for their innovative diagnostic and surgical capabilities, and our modern, attractive facility has been designed with patient care and convenience as the foremost criteria.

It is our privilege to be able to provide care for your medical problems and we will strive to make your visit to the Michigan Ear Institute a positive and rewarding experience.

COCHLEAR IMPLANTS

Loss of hearing is America's most prevalent, yet least recognized, physical ailment. More people suffer from it than from heart disease, cancer, blindness, tuberculosis, multiple sclerosis, venereal disease and kidney disease combined.

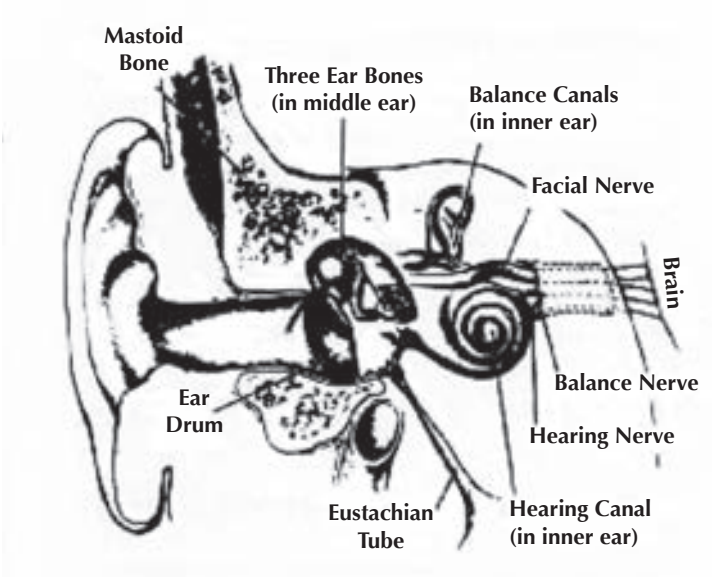
One of every ten persons in the country is affected to some degree. Of self reported health problems in adults age 65 years or older, hearing loss is the third most commonly reported. 1 - 4/1,000 children have hearing loss sufficient to prevent unaided language development. Nearly 1 % of people have extreme difficulty understanding speech. Despite the magnitude of the problem, we pay less attention to hearing loss than to any other major affliction and hearing studies attract less than one percent of the dollars spent on medical research in America today.

Perhaps this is because hearing loss is invisible and usually painless. It is a hurt that does not show; therefore, it seems less important than other disabilities. But for those who are profoundly hard of hearing or deaf, and who live in a world of silence, the emotional pain is often devastating.

THE COCHLEAR IMPLANT

Approximately one in a thousand persons are born deaf. Almost an equal number of persons born with hearing will develop deafness during their lifetime. This booklet is concerned with the cochlear implant for restoration of some hearing to the severely or profoundly hearing impaired.

The cochlear implant is an electronic instrument. Part of the device is implanted in the temporal (ear) bone and part is worn externally. The external part is similar to a behind-the-ear hearing aid. The cochlear implant, however, is not a hearing aid. With few ex



ceptions, cochlear implant users hear environmental sounds. The majority experience dramatic improvement in speech understanding. Many can use the telephone to communicate.

FUNCTION OF THE NORMAL EAR

The ear is divided into three parts: external ear, middle ear and inner ear. Each part performs an important function in the process of hearing.

The external ear consists of an auricle and the ear canal. After they gather sound, these structures direct the sound toward the eardrum.

The middle ear space lies between the external ear and the inner ear and consists of the eardrum and three small bones (ossicles): malleus (hammer), incus (anvil), stapes (stirrup). These structures transmit sound vibrations to the inner ear. By so doing they act as a transformer, converting sound vibrations in the external ear into fluid waves in the inner ear.

The inner ear chamber (labyrinth) contains both the auditory (hearing) and vestibular (balance) mechanisms and is filled with fluid. The auditory chamber is called the cochlea. This term comes from Latin and means snail shell, which the cochlea resembles.

Fluid waves initiated by movement of the three small ear bones are transmitted to the cochlea where they in turn stimulate the delicate hearing cells (hair cells) of which there are over sixteen thousand. The cochlea wraps around and incorporates the end of the auditory nerve. Impulses from the hair cells stimulate the auditory nerve that, in turn, transmits the signal through a series of relays in the brain to the auditory cortex, which recognizes these impulses as sound.

TYPES OF HEARING IMPAIRMENT

The external ear and middle ear conduct sound vibrations. The inner ear receives these vibrations and transforms them into electrical impulses.

When there is some disease or obstruction in the external ear or the middle ear, a conductive hearing impairment results. This impairment may be due to a variety of problems and is frequently correctable by medical or surgical treatment.

When the hearing impairment is due to some problem in the inner ear, a sensorineural (nerve) impairment results. A sensorineural hearing impairment is generally not correctable by medical or surgical treatment but can be helped by the cochlear implant in selected cases.

A third type of hearing disorder, not commonly encountered, is the central hearing loss, so called because the problem is not in the ear but in the complicated interconnections in the brainstem or in the auditory cortex (hearing center of the brain).

DIAGNOSIS

Hearing is measured in decibels (dB), with quiet sounds having a small dB measurement. The quietest sound a person can hear is called their threshold. Individuals with normal hearing individuals can hear sounds between 0 and 25 dB. A threshold of 30 to 35 dB is considered to be mild impairment. A threshold of 60 to 85 dB is called severe. A threshold of 90 dB or more is considered to be a profound impairment. Candidates for a cochlear implant have a threshold of 70 dB or greater in both ears, i.e. a severe to profound sensorineural hearing loss.

Speech testing determines how well the patient understands spoken words. To be considered a candidate for implantation, prospective patients generally understand only 25 - 30% of words even with their hearing aids. More sophisticated speech testing to determine implant candidacy is described later in this booklet.

In most cases of hearing loss it is not difficult to determine the type of impairment. Carefully administered hearing tests (of pure tone and speech) and tuning fork tests allow the otologist (ear specialist) to decide whether the problem is conductive or sensorineural.

SENSORINEURAL DEAFNESS

Fortunately, hearing impairment rarely progresses to deafness (profound or total loss of hearing). Deafness may result though from a variety of causes such as hereditary factors, infections (bacterial meningitis), lifesaving drugs, or a head injuries. Congenital deafness (present at birth) usually results from unknown causes but may result from hereditary factors or a viral infection.

Most cases of sensorineural deafness are due to damage of the hair cells in the cochlea, the cells that initiate electrical current in the auditory nerve. Unfortunately, these cells, once destroyed, do not regenerate, in the same way that a finger lost through an accident does not regrow.

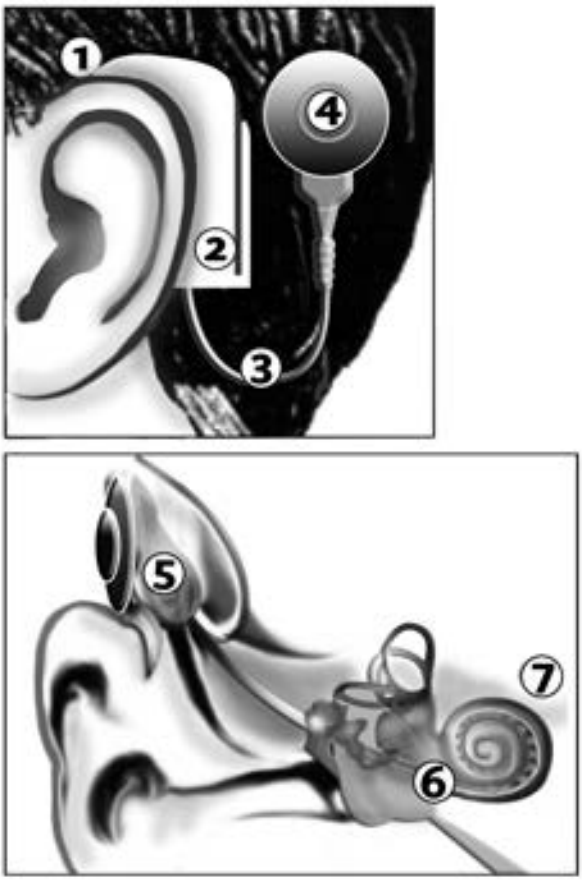
If fluid waves in the cochlea have no hair cells to stimulate, the nerve fibers, regardless of how normal they may be, do not transmit an electrical impulse. It is exactly as if there were a telephone wire but not a receiver; no amount of shouting at the wire would result in transmission of sound.

THE COCHLEAR IMPLANT

The cochlear implant consists of an internal coil, embedded under the skin behind the ear, and a wire (active electrode) introduced into the fluid filled spiral of the cochlea. The implant uses small electrical currents applied through the cochlea to the end of the auditory nerve, bypassing the damaged or missing hair cells.

How the Cochlear Implant System Works:

1. Sound is picked up by the small microphone in the processor.
2. The processor filters and digitizes the sound into coded signals.
3. The signals are sent from the processor to the transmitting coil.
4. The transmitting coil send the signals as FM radio signals to the cochlear implant under the skin.
5. The cochlear implant delivers the appropriate electrical energy to the electrodes in the cochlea.
6. The electrodes stimulate the remaining hearing nerve fibers in the cochlea.
7. The electrical sound information is sent through the auditory system to the brain for interpretation.



Predicting How Well Implanted Patients Will Hear. Adults:

The broad range of hearing experienced by implanted patients cannot be stressed enough. For example, for some patients the implant may give only improved awareness of environmental sounds and improved speech reading ability. Others will be `transparent' users, able to converse with hearing individuals with little evidence of hearing loss, use a telephone, and perform well in other difficult hearing environments. While increasing numbers of implant users perform like the latter group, most occupy an area between the two extremes.

While the strongest predictors of performance include duration of hearing impairment (people deafened longer than 10 years tend not to do as well) and age at implantation (the very old tend not to do as well as younger patients) these factors account for only part of the variance in cochlear implant performance. Generally, patients implanted sooner after the onset of profound hearing loss perform better than those implanted later. Other factors that favor good performance in adult cochlear implant candidates include lip-reading ability and residual hearing before implantation (patients with some hearing in an implanted ear tend to do better than those with no hearing). Factors associated with poor use of the implant include implantation of patients as adults with hearing loss occurring prior to the development of speech and patients who rely primarily on signing for communication.

Predicting How Well Implanted Patients Will Hear. Children:

Three factors are important in determining the outcome of implanted children: 1) Age at onset of deafness and duration of deafness before implantation: 2) Progression of hearing loss; and, 3) Educational setting. Generally, earlier implantation favors more rapid development of oral communication ability. Progressive hearing loss, which allows for development of speech-reading skills, favors post-implant performance. Placement in a school setting that stresses oral (versus signed) communication is important for the best outcome of implantation. However, many variables remain unknown since about 50% of the variance in post-implant performance cannot be predicted from these factors.

Understanding Speech

Many implanted patients are now able to understand a portion of speech without the aid of speech reading. While some obtain only limited speech understanding, with an implant they can detect their own

voices and are therefore better able to monitor the loudness of their own speech. Most have improvement in the quality of their voice. They are aware of the conversation of others and may understand some words. Most implant users can tell the difference between a man's and a woman's voice, but they describe speech as sounding artificial. Speech reading (lip-reading) is improved in implant users. They are able to use clues from the sounds and rhythms of speech to combine these with what they see.

Telephone Communication

Some implanted patients can converse over the telephone but many are still denied easy access to the telephone for full communication because word understanding is not normal. They are able to determine if there is a dial tone, a busy signal, a ringing tone, or if someone has answered at the other end. Communication codes may be devised with family and friends to help in the use of the telephone. Simple messages about urgent problems may be transmitted.

Environmental Sounds

One of the cochlear implants principal advantages at this stage of development has been to enable the user to hear more environmental sounds.

Many implant patients report a greater sense of security since they can now hear approaching footsteps, a fire alarm at their place of employment, doors open and close, etc. They feel less isolated.

Tinnitus

Severe tinnitus (head noise) may be decreased by the implant, but is often unchanged. Rarely tinnitus is worse.

BECOMING A COCHLEAR IMPLANT PATIENT

Becoming a cochlear implant patient involves an evaluation that includes otologic, audiologic, radiographic and psychological tests.

Cochlear implant surgery is performed under general anesthesia. While some patients can be discharged the day of surgery, most spend the night after surgery in the hospital.

Programming and use of the implant begins about 3 - 5 weeks following surgery.

Otologic (ear) Evaluation

An examination must be performed to determine that there is no active infection or other problem within the middle or inner ear that would preclude the surgical placement of the implant

Audiologic (hearing) Evaluation

Extensive hearing tests are performed to determine the degree of hearing with and without a hearing aid. In addition to the routine hearing tests described earlier, tests of speech understanding in sentences are now routinely used as the primary means of determining implant candidacy. These tests of speech understanding are done with the patient wearing hearing aids in both ears appropriate for his/her hearing loss.

Radiographic (x-ray) Evaluation

A CT scan, and/or a MRI of the inner ears are performed to evaluate the condition of the inner ear.

Electric Promontory Testing

While only occasionally required, this test involves stimulation of the inner ear through an electrode inserted through the eardrum. Small electrical currents are passed through the electrode to determine if a sensation of sound is produced.

Physical Examination

A general physical examination may be performed by an internist or pediatrician to determine if there are any contraindications to general anesthesia or surgical implantation of the electrode assembly.

Special Cases

Meningitis: Meningitis causes about 9% of childhood deafness and a much smaller proportion of adult deafness. Because some hearing may be recovered in at least one ear after meningitis, a 6-month observation period is common. In some cases, however, the inner ears may begin to fill with tissue or bone (labyrinthitis ossificans). If scanning during the initial period after meningitis suggests this is the case early implantation is recommended since labyrinthitis ossificans can make implantation less successful or even impossible. If labyrinthitis ossificans is diagnosed in an implant candidate, a conventional electrode or modified implant electrode can sometimes be placed in a part of the cochlea that has not been filled with bone or tissue.

Inner Ear Malformations: Hearing impaired patients are occasionally found to have congenital malformations of their cochleas on pre-operative scanning. While complete lack of a cochlea (luckily a rare malformation) makes implantation impossible, many patients with milder malformations may still be candidates. Depending on the nature of the malformation, such patients may be at higher risk of meningitis than normal individuals. Cerebrospinal fluid leakage may also occur. The outcome of implantation in such patients is also extremely variable and is generally less successful than patients with normal inner ears.

Auditory neuropathy: A rare cause of hearing loss is auditory neuropathy. In auditory neuropathy, the hair cells of the inner ear work, but the hearing nerve or relay stations in the brain do not. This condition can

only be detected with special testing. While not a contraindication to cochlear implantation, patients with auditory neuropathy who undergo implantation often do not perform as well as other implant patients.

COCHLEAR IMPLANT SURGERY

While ultimately the choice of which ear to implant is made by the patient, generally the ear with better speech understanding is recommended since residual hearing predicts better post-implant performance. If both ears are equally impaired, implantation of the ear with the shorter duration of deafness is encouraged.

Cochlear implant surgery is performed under general anesthesia through an incision behind the ear and involves opening the mastoid and middle ear. Surgery lasts about two and a half hours. Hair is shaved several inches above and behind the ear.

A coil (internal receiver) is embedded under the skin behind the ear and a wire (active electrode) is placed into the fluid, which fills the cochlea (inner ear). As a result of surgery any residual hearing in the implanted ear will be lost. Hearing in the opposite ear is not affected.

The patient is usually discharged from the hospital the day of surgery or after a night in the hospital and can return home by air or ground transportation.

REHABILITATION AND TRAINING WITH THE COCHLEAR IMPLANT

3 - 5 weeks following surgery the patient returns and is fitted with the external speech processor, similar to a hearing aid with a coil (external transmitter) which sits over the internal coil (internal receiver).

This device receives incoming environmental and speech sounds through a microphone and transforms them into electrical currents. By means of magnetic coupling between the implanted and external coils, the current is able to stimulate the inner ear fluids and the nerve fibers, which results in a sensation of sound.

The external device differs from a hearing aid in that a hearing aid amplifies the environmental and speech sounds and delivers this amplified sound to the ear canal. The cochlear implant, on the other hand, is not a hearing aid because it does not stimulate the inner ear by amplified sound vibrations, but rather through direct electrical stimulation of the remaining hearing nerve fibers.

The first few sessions of rehabilitation involve using a computer to program the speech processor to the patient's own responses. It often takes several sessions to fine tune the device, making it suitable for the patient.

For most adults, learning to use the implant to communicate comes with practice in real-world situations. For children rehabilitation with a speech pathologist is often recommended. For both adults and children remember that learning to effectively and comfortably use the signals provided by the implant takes considerable time and effort. For adults who have had hearing before being deafened, it may take up to a year to achieve the maximum benefit. For children, especially those who have had only limited experience with hearing before being deafened or who have never heard, the process may take longer. During this process the implant user, the family, and acquaintances require patience. Six months and one year after beginning use of the implant, the patient returns for further testing and training. These follow up visits continue annually (every 6 months for young children).

RISKS AND COMPLICATIONS OF IMPLANT SURGERY

There are risks and complications associated with any operation. With regard to implant surgery, these are related to the mastoid surgery and to long-term use of the implant.

The long-term risks of electrical stimulation are unknown. One patient has had an implant since 1973 and many others for lesser periods of time. There have been no discernible or obvious problems related to this stimulation, but long-term tolerance remains to be proven.

There have been failures of the internal coil. Fortunately, design changes over the years of experience with the implant have eliminated most of these failures. If problems do occur, or if new devices are later developed, the implant can be removed and another inserted.

After implantation, certain electrical surgical cautery (monopolar cautery) should be avoided, especially in the area of the head and neck. Patients may wish to obtain a MedAlert bracelet indicating that they have a cochlear implant to avoid problems related to the use of cautery.

In some cases, static discharge can affect the processor, necessitating reprogramming.

Infection

Infection is a risk of any surgery. Despite the fact that the cochlear implant is a foreign object implanted in the body, infection is a rare complication of surgery. If infection occurs, antibiotics may be effective treatment. In some cases removal of the implant is required.

Extrusion

Another rare complication is extrusion of the implant where the scalp overlying the implant breaks down, exposing the implant. Surgery to cover the implant with new tissue or removal of the implant may be required. Injury to the skin covering the implant may lead to extrusion. Factors that impair blood supply to the skin, such as smoking may contribute to the problem.

Taste Disturbance and Mouth Dryness

Taste disturbances and mouth dryness are common for a few weeks following surgery. These are rarely long-lasting problems.

Numbness of the Ear

Temporary loss of skin sensation in and about the ear is common following surgery. This numbness may involve the entire outer ear and may last for six months or more.

Weakness of the Face

The facial nerve travels through the ear bone in close association with the middle ear bones, eardrum and the mastoid. An uncommon postoperative complication of ear surgery is temporary paralysis of one side of the face. This may occur as a result of an abnormality or a swelling of the nerve.

This is a remote possibility, but should it happen, the eye on the side of surgery would fail to close and the mouth would pull over to the opposite side. Further treatment may be required.

Dizziness

This is a rare complication that usually resolves spontaneously.

Hematoma

A hematoma (collection of blood under the skin) develops in a small percentage of cases, prolonging hospitalization and healing. Reoperation to remove this clot may be necessary if the complication occurs.

Meningitis

The risk of meningitis in implant patients is slightly greater than that of individuals without implants, particularly during the first 1 - 2 years after implantation. You may wish to check with your surgeon or family doctor about immunization against bacteria (streptococcus) that commonly cause meningitis. Patients with inner ear malformations are at higher risk of meningitis, both before and after implantation.

Complications Relating to Anesthesia

Anesthesia complications are very rare, but can be serious. You may discuss these with the anesthesiologist if desired.

Should any questions arise regarding your hearing impairment, feel free to call or write the Institute at anytime.