Nucleus® CI500 Series Implants Important Information

United States of America

For CI522 and CI532 Recipients

Hear now. And always

Cochlear®

Contents

Glossary

Terms used in this document

- Best-aided listening condition – Best-aided is the best listening condition for a particular person in relation to their hearing loss. For example, if they have bilateral hearing loss, the best-aided condition might be having implants or hearing aids in both ears.
- Bilateral – Relating to both ears.
- Bimodal – Use of a hearing aid with a cochlear implant.
- Cochlea – Part of the inner ear that converts mechanical vibrations into electrical impulses.
- Cochlear™ Nucleus® CI500 Series implant system – The Cochlear Nucleus CI500 Series implant with a compatible sound processor including coil/cable, battery module, Cochlear Remote Assistant and Nucleus Smart App.
- Cochlear Nucleus 24 cochlear implant system – The Cochlear Nucleus cochlear implant and sound processor including coil/cable, battery module, and remote controls.
- Moderate hearing loss – Hearing loss in the range of approximately 40–55 dB HL.
- Moderately severe hearing loss – Hearing loss in the range of 56–70 dB HL.
- Perilinguistic – During language acquisition.
- Postlinguistic – After language acquisition.
- Prelinguistic – Before language acquisition.
- Profound hearing loss – Hearing loss of approximately 90 dB HL or greater.
- Severe hearing loss – Hearing loss in the range of approximately 71–90 dB HL.
- Single Sided Deafness – Profound hearing loss in one ear and normal or near normal hearing loss in the other ear.
- Unilateral – Relating to one ear.

Acronyms used in this document

- AEs – Adverse events
- BKB-SIN – Bamford Kowall Bench Sentences in Noise test
- CNC – Consonant Nucleus Consonant
- HINT – Hearing in Noise Test
- MRI – Magnetic resonance imaging
- NH – Normal hearing
- SSQ – Speech, Spatial, and Qualities
- SD – Standard deviation
- UHL – Unilateral hearing loss

Why read this document?

Cochlear devices are designed to be safe and effective. However when using the devices it is essential you take care.

This document has important information for people with cochlear implants, their families and carers. The information is about safe use of Cochlear Nucleus cochlear implants, sound processors, remote assistants, and remote controls.

Very important safety information about device use and medical treatments is included. Before starting any medical treatment, tell your physician you have an implant and show them *Medical procedures that can cause harm* on page 14.

This document also covers what the Cochlear implant is, how it works, and how it is implanted.

User guides and other documents are supplied with your device. Please read these documents carefully—they could also contain important safety information.

Symbols used in this document

Note

Important information or advice.

Caution (no harm)

Special care to be taken to ensure safety and effectiveness.

Could cause damage to equipment.

Warning (harmful)

Potential safety hazards and serious adverse reactions.

Could cause harm to person.

What are Cochlear Nucleus CI500 Series implants?

Cochlear Nucleus cochlear implant systems are designed to provide useful hearing. The system works by converting the sounds around you into electrical signals. These signals stimulate nerve endings in the cochlea, allowing the brain to perceive sound.

The Cochlear Nucleus cochlear implant system has external and implanted components.

External components

External components include a battery-operated sound processor with associated accessories and cables.

The sound processor is worn outside the ear and converts sounds into electrical signals. It is programmed to work with the implant using a Cochlear proprietary programming software.

Implanted component

The cochlear implant is surgically implanted under the skin behind the ear. The implant includes:

- a receiver/stimulator to decode electrical signals from the sound processor, and
- an electrode to deliver electrical signals to the cochlea.

Caution

Federal law restricts this device to sale by or on the order of a physician.

Why doctors use Cochlear Nucleus CI500 Series implants – Indications

Doctors use Cochlear Nucleus CI500 Series implants for people with sensorineural hearing loss. This type of hearing loss occurs when parts of the inner ear, the cochlea and hair cells, don't work properly.

With sensorineural hearing loss, sounds are softer and may be muffled or garbled, and harder to separate from each other. This type of hearing loss can make it difficult to understand the meaning of speech and sounds. Even the most powerful hearing aids may not assist.

Sensorineural hearing loss is typically total hearing loss in the mid to high pitches and partial to total hearing loss in the low pitches.

The cochlear implant is designed to restore hearing by bypassing the non-working parts of the inner ear and electrically stimulating the auditory nerve.

Cochlear Nucleus implants are approved to treat adults and children with bilateral sensorineural hearing loss. They are also approved to treat adults and children with deafness on one side. Deafness on one side with normal hearing in the other ear is known as single sided deafness, or SSD.

Bilateral sensorineural hearing loss

Adults

The Cochlear Nucleus 24 cochlear implant system is intended for use in individuals aged 18 years and older who have bilateral, prelinguistic, perilinguistic or postlinguistic sensorineural hearing loss and compromised functional benefit with appropriately fit amplification.

These individuals typically have moderate to profound hearing loss in the low frequencies and profound (≥ 90 dB HL) hearing loss in the mid to high speech frequencies. Limited benefit from amplification is defined by test scores of 50% correct or less in the ear to be implanted (60% or less in the best-aided listening condition) on recorded tests of open set sentence recognition.

Children

The Cochlear Nucleus 24 cochlear implant system is intended for children 9 months to 24 months of age who have bilateral profound sensorineural hearing loss and demonstrate limited benefit from appropriate bilateral hearing aids.

Children 2 years of age or older may demonstrate severe to profound hearing loss bilaterally.

In younger children, limited benefit is defined as lack of progress in the development of simple auditory skills with appropriate amplification and participation in intensive aural habilitation over a 3 month to 6 month period. It is recommended that limited benefit be quantified on a measure such as the Meaningful Auditory Integration Scale or the Early Speech Perception test.

In older children, limited benefit is defined as ≤ 30% correct on the open set Multisyllabic Lexical Neighborhood Test (MLNT) or Lexical Neighborhood Test (LNT), depending upon the child's cognitive and linguistic skills. A three to six month hearing aid trial is recommended for children without previous aided experience.

Unilateral Hearing Loss (UHL) / Single Sided Deafness (SSD)

Adults and children

The Cochlear Nucleus 24 cochlear implant system is indicated for individuals with unilateral hearing loss who meet the following criteria:

- Individuals 5 years or older who have one ear with a severe to profound sensorineural hearing loss and obtain limited benefit from an appropriately fitted unilateral hearing device and one ear with normal or near normal hearing.
  - In the ear to be implanted, a severe to profound sensorineural hearing loss defined as a PTA at 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz of greater than 80 dB HL; and
  - In the contralateral ear, normal or near normal hearing is defined as a PTA at 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz less than or equal to 30 dB HL.
- Limited benefit from an appropriately fit unilateral hearing device is defined as a score of less than or equal to 5% on a Consonant Nucleus Consonant (CNC) word test. For individuals between 5 years and 18 years of age, insufficient functional access to sound in the ear to be implanted must be determined by aided speech perception test scores of 5% or less on developmentally appropriate monosyllabic word lists when tested in the ear to be implanted alone.
- It is recommended that prior to cochlear implantation, individuals with SSD have at least two (2) weeks to one (1) month experience wearing appropriately fit Contralateral Routing of Signal (CROS) hearing aid or another suitable hearing device.

Who cannot receive a Cochlear Nucleus CI500 Series implant – Contraindications

A Cochlear Nucleus cochlear implant is not suitable for individuals with the following conditions:

- Absence of cochlea development
- Absence of a cochlear nerve
- Active middle ear infections
- Tympanic membrane perforation in the presence of active middle ear disease.

For individuals with single sided deafness the following contraindications are also applicable:

- Duration of profound sensorineural hearing loss greater than ten years.

Note

- For patients who meet the indication and have an acoustic neuroma, cochlear implantation should be considered simultaneously or following removal of pathology.
- In certain cases, such as congenital single-side deafness, the presence of a cochlear nerve should be confirmed by an MRI examination prior to surgery.
- Outcomes are more variable for children with congenital single-sided deafness who are over the age of 5.

Deciding whether to get a Cochlear Nucleus CI500 Series implant

Before deciding on implantation, you should discuss the known benefits, risks and alternatives to Cochlear Nucleus CI500 hearing technology with your surgeon and audiologist.

Benefits

Potential benefits of receiving a Cochlear Nucleus cochlear implant relate to the following:

- better understanding of speech in quiet
- better understanding of speech in noise
- increased satisfaction based on hearing capabilities.

Risks

Certain risks are part of all surgery. You should discuss the known risks, benefits and alternatives to Cochlear Nucleus CI500 hearing technology with your surgeon and audiologist.

Known limitations associated with cochlear implantation, which may also apply to the Cochlear Nucleus CI500 Series implant, are:

- Speech and other sounds will not sound the same as they would for a normal-hearing person, though most recipients accommodate to the sound in a relatively short period of time.
- Some people may not have sufficient auditory nerve fibres to allow successful electrical stimulation.
- Some people may not experience useful understanding of speech.

Loss of residual hearing is a risk of receiving the Cochlear Nucleus CI500 Series implant.

What happens during the implantation procedure?

Before implantation

To decide if you can get a Cochlear Nucleus CI500 Series implant, your hearing healthcare professional will do a hearing test. They will also test your speech understanding while using your hearing aids.

During implantation

During implant surgery, the surgeon:

- makes an incision behind the ear,
- creates a pocket in the bone for the implant's receiver/stimulator, and
- threads the electrode into the cochlea.

You should discuss the length of your postoperative hospital stay with your surgeon as it can vary.

After implantation

To stimulate your implant you'll need an external sound processor.

After a healing period, you'll return to your audiologist to have your implant system activated and programmed. The audiologist will also explain how to use and care for your sound processor.

Please read:

- your Sound Processor and Remote Assistant User Guides for instructions on operation, care and maintenance of your external components.
- the rest of this guide for important safety information on how to avoid personal harm and damage to system components.

Avoiding serious harm – Warnings

This section has important warnings about personal safety. You should also refer to your external product user guides for additional warnings and cautions about those components.

Medical procedures that can cause harm

Before any medical or surgical treatment, tell your doctor you have a cochlear implant and show them this information. Some treatments that could injure you or damage your implant are listed below.

Medical treatments generating induced currents, heat and vibration

Below are some medical treatments that generate induced currents which could cause damage to tissue or the implant.

Diathermy	Do not use therapeutic or medical diathermy (thermopenetration) using electromagnetic radiation (magnetic induction coils or microwave). High currents induced into the electrode lead can cause tissue damage to the cochlea or permanent damage to the implant. Medical diathermy using ultrasound may be used below the head and neck.
Electroconvulsive therapy	Do not use electroconvulsive therapy on an implant patient under any circumstances. Electroconvulsive therapy can cause tissue damage or damage to the implant.

Electrosurgery	Electrosurgical instruments can induce radio frequency currents that could flow through the electrode. Do not use monopolar electrosurgical instruments on the head or neck of an implant patient as induced currents could cause damage to cochlear tissues or permanent damage to the implant. When using bipolar electrosurgical instruments on the head and neck of a patient, the cautery electrodes must not contact the implant and should be kept more than 1 cm (~½ in) from the electrodes.
Ionising radiation therapy	Do not use ionising radiation therapy directly over the implant. It may cause damage to the implant.
Neurostimulation	Do not use neurostimulation directly over the implant. High currents induced into the electrode lead can cause tissue damage to the cochlea or permanent damage to the implant.
Therapeutic ultrasound	Do not use therapeutic levels of ultrasound energy directly over the implant. It may inadvertently concentrate the ultrasound field and cause tissue damage or damage to the implant.

MRI safety information

Cochlear Nucleus CI500 Series implants are MR Conditional. MRI examinations can be performed safely on a person with this implanted device only under very specific conditions. MRI examinations performed under different conditions may result in severe injury or device malfunction.

Full MRI safety information is available:

- in the *Cochlear Nucleus Implants MRI Guidelines*
- by visiting www.cochlear.us/mri
- by calling your regional Cochlear office – contact numbers are available on the back cover of this guide.

Refer to the *Cochlear Nucleus Implants MRI Guidelines* for a complete list of Warnings and Cautions.

All external components of the Cochlear implant system (for example, sound processors, remote assistants and related accessories) are MR Unsafe. The recipient must remove all external components of their Cochlear implant system before entering a room where an MRI scanner is located.

What is an MRI?

Radiologists and MR technologists are medical specialists experienced in diagnosing disease and injuries using a range of imaging techniques. One of these imaging techniques is magnetic resonance imaging (MRI).

MRI is a diagnostic tool to obtain images of organs and tissues using a very powerful magnetic field measured in tesla (T). MRI scans can range in strength from 0.2 T to 7 T, with 1.5 T being the most common.

Safety concerns for medical device implants and MRI

Due to the powerful magnetic and radio-frequency fields, medical device implants with metallic or ferromagnetic components such as pacemakers, defibrillators, catheters, pumps and cochlear implants can create problems for MRI scans. The risks include the potential for device repositioning, localised heating, unusual sounds or sensations, pain or injury and distortion of the MR image.

Cochlear Nucleus implants and MRI compatibility

A Cochlear Nucleus implant is a medical treatment for moderate to profound hearing loss or single sided deafness. Inside each Cochlear Nucleus implant is a magnet.

To ensure MRI compatibility, Cochlear Nucleus implants feature a removable magnet. The magnet is easy to remove and replace if needed. In the rare case that a recipient needs serial MRI scans, a non-magnetic plug is available to prevent fibrous tissue growing in the implant magnet recess.

Cochlear Nucleus implants are approved for MRI scans under specific conditions at 1.5 T with the magnet in place and at 3 T with the magnet removed.

Head trauma

A blow to the head in the area of the implant may damage the implant and result in its failure. For recommendations on how to minimise the chance of experiencing head trauma refer to:
https://www.cdc.gov/traumaticbraininjury/prevention.html

Sound processor

Small parts

Caregivers should be counselled that the external sound processor contains small parts that may be hazardous if swallowed or may cause choking if ingested or inhaled.

Batteries and battery chargers

Battery use and ingestion

When using disposable batteries with the sound processor, only use battery types recommended by your clinician or Cochlear. Other types may not have enough energy to allow your sound processor to operate for a long time.

Cochlear does not recommend the use of silver oxide or alkaline batteries.

Batteries can be harmful if swallowed. Ensure that batteries are kept out of reach of young children. If batteries are swallowed, seek prompt medical attention at the nearest emergency centre.

Rechargeable batteries

In certain circumstances, rechargeable batteries can become VERY HOT, and could cause injury. Remove your sound processor immediately if it becomes unusually warm or hot, and seek advice from your clinician.

Caregivers should touch the recipient's sound processor to check for heat if the recipient is showing signs of discomfort.

Rechargeable batteries should NEVER be worn beneath clothing, including scarves and headwear covering the ears.

The rechargeable battery should not be used by patients who cannot remove the device by themselves, or cannot notify a caregiver that the device has become hot.

Overheating

Remove your sound processor immediately if it becomes unusually warm or hot, and seek advice from your clinician. Caregivers should touch the sound processor to check for heat if the recipient is showing signs of discomfort.

The manufacturer recommends only the use of Cochlear rechargeable battery modules and zinc air disposable batteries.

Silver oxide batteries should **not** be used with your sound processor. In some circumstances, use of these batteries could result in severe burns. A dangerous amount of heat can be generated by these batteries in conditions where heat cannot dissipate, especially if the device is being held against the skin by clothing or a retention device.

Also, use of silver oxide batteries may damage your sound processor.

Sleeping

Do not wear your sound processor while sleeping, as you may not become aware of it becoming unusually warm or hot.

Pressure

Do not apply continued pressure to the coil when in contact with the skin as this may result in pressure sores. For example, sleeping or lying on the coil, or wearing tight fitting headwear.

If the coil magnet is too strong or is in contact with the skin, pressure sores may develop at the coil site. If this happens or if you experience any discomfort in this area, contact your clinician.

Uncomfortable sound levels

If the sound becomes uncomfortable, remove your external equipment immediately (sound processor, coil, monitor earphones, acoustic component) and contact your clinician.

If you have two sound processors (one for each ear), always wear the sound processor programmed for your left ear on the left and the sound processor programmed for your right ear on the right. Using the wrong sound processor could result in loud or distorted sounds that, in some instances, could cause extreme discomfort.

Adverse environments

Operation of your cochlear implant system could be adversely affected in environments of high magnetic field strength and high electric field strengths, for example, close to high power commercial radio transmitters.

Seek medical advice before entering any environment that may adversely affect the operation of your cochlear implant, including areas with a warning notice preventing entry by patients fitted with a pacemaker.

Avoiding other harm – Cautions

This section includes information about safe and effective use of your cochlear implant system, and how to avoid damaging components.

General use

- Use your cochlear implant system only with approved devices and accessories listed in the user guide.
- If you experience a significant change in performance, turn off your sound processor and contact your implant centre.
- Your sound processor and other parts of the system contain complex electronic parts. These parts are durable but must be treated with care.
- No modification of external equipment is allowed. If your sound processor is modified or opened by anyone other than Cochlear's qualified service personnel, the warranty is invalid.

Sound processor

- Each sound processor is programmed specifically for each implant. Never wear another person's sound processor or lend yours to another person. Using the wrong sound processor could result in loud or distorted sounds that may cause extreme discomfort.
- Do not operate your sound processor at temperatures above +40 °C (+104 °F) or less than +5 °C (+41 °F).
- Do not store your sound processor at temperatures above +50 °C (+122 °F) or less than -20 °C (-4 °F).
- Your sound processor's sound quality may be intermittently distorted when you are approximately 1.6 km or 1 mile from a radio or television transmission tower.

  Additional sources of interference include, but are not limited to:

  – Security systems
  – Industrial machinery and power systems
  – Mobile communications equipment, including cellular telephones and certain kinds of hand-held, two-way radios (including Citizen Band, Family Radio Service, and Amateur Band).

  To reduce or stop interference, move away from the source. If your sound processor stops working, turn the power switch off and then back on. The effect is temporary and will not damage your sound processor.

Theft and metal detection systems

Devices such as airport metal detectors and commercial theft detection systems produce strong electromagnetic fields. Some implant recipients may experience distorted sound sensation when passing through or near these devices. To avoid distortion, turn off your sound processor when near one of these devices.[1]

The materials used in the implant may activate metal detection systems. For this reason, always carry your Cochlear Implant Patient Identification Card with you.

1 Cochlear performed Radio Frequency Identification (RFID) testing using the applicable Federal Communications Commission (FCC) Part 15 limit for electronic article surveillance in the USA and Canada. Frequency ranges typical of commercial theft detection systems were tested and demonstrated that implants operated normally when 20 cm (0.66 ft) away from the detection devices.

Mobile telephones

Some types of digital mobile telephones may interfere with the operation of external equipment, such as Global System for Mobile communications (GSM) as used in some countries. You may perceive a distorted sound sensation when within 1–4 m (~3–12 ft) of a digital mobile telephone in use.

Scuba diving

Implant type	Maximum depth
CI500 Series implant	40 m (~131 ft)

Table 1: Maximum diving depths when wearing implants

The sound processor must be removed before diving. You should seek medical advice for conditions that might contraindicate diving, such as middle ear infection. When wearing a mask, avoid pressure over the implant site.

Air travel

Transmitting devices such as mobile/cell phones sometimes need to be switched off on aircraft. If you have a remote control (Remote Assistant) for your sound processor, check with the airline if you can use it. Your remote transmits high frequency radio waves so it might need to be switched off. You can wear your sound processor.

Retention aids

When using retention aids such as the Snugfit or LiteWear, it may take longer to remove the sound processor if it becomes unusually warm or hot.

Do not attach the LiteWear beneath layers of clothing.

Electrostatic discharge (ESD)

Remove the sound processor before engaging in activities that create extreme electrostatic discharge, such as playing on plastic slides. In rare cases, a discharge of static electricity can damage the electrical components of the cochlear implant system or corrupt the program in the sound processor.

If static electricity is present (for example when removing or putting on clothes over your head, or getting out of a vehicle), before the cochlear implant system contacts any object or person you should touch something conductive, such as a metal door handle.

If you stop hearing and suspect your sound processor received a discharge of static electricity, turn it off and then on again.[1] If the problem continues, contact your clinician or a Cochlear representative.

Electromagnetic interference with medical devices

Cochlear Nucleus Remote Assistants meet defined international Electromagnetic Compatibility (EMC) and emission standards. However, because the Remote Assistant radiates electromagnetic energy it could interfere with other medical devices, such as cardiac pacemakers and implantable defibrillators, when used nearby.

The Remote Assistant should be kept at least 6 in (~15.2 cm) away from devices that could receive electromagnetic interference. For added assurance, please also check the recommendations of the device manufacturer.

Magnetic fields

Magnetic fields that are very close to a cochlear implant can affect the operation of the implant. These magnetic fields can be created by magnets that are stronger than Cochlear sound processor coil magnets.

If you stop hearing and suspect that you have a strong magnetic field close to the location of the cochlear implant, move away from the source of the magnetic field. Hearing will then return. If the problem continues, contact your clinician or a Cochlear representative.

1 During Cochlear electrostatic discharge testing, the sound processor stopped working when a discharge was applied directly to the upper or lower button. Loss of sound was temporary, with sound returning after the sound processor was turned off and on again.

Electromagnetic compatibility (EMC)

Guidance and manufacturer's declaration

Cochlear Nucleus Sound Processors, Remote Assistants and Remote Controls are intended for use in the electromagnetic environments specified in this document.

They have been tested and found to be in compliance as shown. You should take care to use your sound processor as described.

Electromagnetic emissions

Emission test	Compliance	Guidance
RF emissions CISPR 11	Group 1	RF energy is only used for its internal function. The RF emissions are very low and not likely to cause any interference in nearby electronic equipment.
RF emissions CISPR 11	Class B	The device is suitable for use in all establishments, including domestic establishments and those directly connected to public low-voltage power supply network that supplies buildings used for domestic purposes.
Harmonic emissions IEC 61000-3-2	Not applicable	
Voltage fluctuations/ flicker emissions IEC 61000-3-3		

Table 2: Electromagnetic emissions

Electromagnetic immunity

Immunity test	IEC 60601 test level	Compliance level	Guidance
Electrostatic discharge (ESD) IEC 61000-4-2	±8 kV contact ±2 kV, ±4 kV, ±8 kV and ±15 kV air	±8 kV contact ±2 kV, ±4 kV, ±8 kV and ±15 kV air	Refer to ***Electrostatic discharge (ESD)*** on page 24.
Electrical fast transient/burst IEC 61000-4-4	Not applicable		
Surge IEC 61000-4-5			
Voltage dips, short interruptions and voltage variations on power supply input lines IEC 61000-4-11			
Power frequency (50/60 Hz) magnetic field IEC 61000-4-8	30 A/m	1200 A/m	Power frequency magnetic fields be at levels characteristic of a typical location in a typical commercial or hospital environment
Conducted RF IEC 61000-4-6 Radiated RF IEC 61000-4-3	Not applicable 10 V/m 80 MHz to 2.7 GHz	Not applicable 20 V/m 80 MHz to 3.0 GHz	Refer to ***Avoiding serious harm – Warnings*** on page 14, ***Avoiding other harm – Cautions*** on page 21, and ***Guidance*** on page 25.

Table 3: Electromagnetic immunity

Guidance

Portable and mobile RF communications equipment should be used no closer to any part of the devices, including cables, than the recommended separation distance calculated from the equation applicable to the frequency of the transmitter.

Recommended separation distance (d):

$d = 1.2\sqrt{P}$ 80 MHz to 800 MHz

$d = 2.3\sqrt{P}$ 800 MHz to 3.0 GHz

where P is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer and d is the recommended separation distance in metres (m). Field strengths from fixed RF transmitters, as determined by an electromagnetic site survey,[a] should be less than the compliance level in each frequency range.[b]

Interference may occur in the vicinity of equipment marked with the following symbol:

Note

1. At 80 MHz and 800 MHz, the higher frequency range applies.
2. These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.

Explanatory notes:

a. Field strengths from fixed transmitters, such as base stations for radio (cellular/cordless) telephones and land mobile radios, amateur radio, AM and FM radio broadcast and TV broadcast cannot be predicted theoretically with accuracy. To assess the electromagnetic environment due to fixed RF transmitters, an electromagnetic site survey should be considered. If the measured field strength in the location in which the sound processor is used exceeds the applicable RF compliance level above, the sound processor should be observed to verify normal operation. If abnormal performance is observed, additional measures may be necessary, such as reorienting or relocating the sound processor.

b. Over the frequency range 150 kHz to 80 MHz, field strengths should be less than 3 V/m.

Recommended separation distances

Your sound processor is intended for use in an electromagnetic environment where the radiated RF disturbances are controlled.

To prevent electromagnetic interference, maintain a minimum distance between the portable and mobile RF communications equipment (transmitters) and the device as recommended below, according to the maximum output power of the communications equipment.

Rated maximum output power of transmitter (W)	Separation distance according to frequency of transmitter (m)		
	150 kHz to 80 MHz $d = 1.2\sqrt{P}$	80 MHz to 800 MHz $d = 1.2\sqrt{P}$	800 MHz to 3.0 GHz $d = 2.3\sqrt{P}$
0.01	0.12	0.12	0.23
0.1	0.38	0.38	0.73
1	1.2	1.2	2.3
10	3.8	3.8	7.3
100	12	12	23

Table 4: Recommended separation distances

For transmitters rated at a maximum output power not listed above, the recommended separation distance d in metres (m) can be estimated using the equation applicable to the frequency of the transmitter, where P is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer.

Note

1. At 80 MHz and 800 MHz, the separation distance for the higher frequency range applies.
2. These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.

Adverse effects

Prospective Cochlear Nucleus cochlear implant recipients should be advised of the following possible effects of receiving an implant:

- Normal risks associated with surgery and general anaesthesia.
- Increased surgical and anaesthetic risks for certain populations.
- Complications most frequently associated with this surgical procedure - stimulation of the facial nerve, taste disturbance, and tinnitus.
- Complications that may require additional medical treatment, surgery, and/or removal of the device, such as:
  - Acute Otitis Media (AOM)
  - facial nerve injury leading to temporary facial nerve weakness
  - perilymph fistula
  - concurrent Cerebrospinal Fluid (CSF) leakage
  - vestibular dysfunction
  - subdural injury
  - subcutaneous haematoma
  - irritation, inflammation or breakdown of the skin flap, infection, and in some cases, extrusion of the device caused by the presence of a foreign body under the skin
  - decreased hearing ability caused by the electrode array migrating partially or completely out of the cochlea
  - perforation of external ear structures, such as the tympanic membrane or canal wall, by the electrode lead
  - perception of non-auditory sensations and poorer performance than expected from misplacement of the electrode array.

- Electrical stimulation may result in increased tinnitus, temporary facial nerve stimulation, temporary dizziness, or temporary pain.
- The long-term effects of electrode insertion trauma or chronic electrical stimulation are unknown. Such effects may include new bone growth in the cochlea or deterioration of the nerve cells. These effects may preclude replacement of the electrode array or may lead to eventual deterioration of cochlear response.
- Failure of component parts (both external and internal) could result in the perception of an uncomfortably loud sound sensation, intermittent sound, or no sound.
- Failure of various component parts of the implanted device could require removal or replacement of the implant, or a reduction in the number of electrodes used.

Meningitis

Before implantation, candidates should consult their primary care physician and implanting surgeon regarding vaccination status against micro-organisms that cause meningitis.

Meningitis is a known risk of inner ear surgery and candidates should be appropriately counselled of this risk. Certain preoperative conditions may increase the risk of meningitis with or without an implant. These conditions include:

- Mondini's syndrome and other congenital cochlear malformations
- CSF shunts or drains
- recurrent episodes of bacterial meningitis before implantation
- perilymph fistulas and skull fracture/defect with CSF communication.

For information on the use of vaccines to prevent meningitis in persons with cochlear implants refer to:
https://www.cdc.gov/vaccines/vpd/mening/hcp/dis-cochlear-gen.html

How we studied the Cochlear Nucleus cochlear implant system

Clinical studies were performed to test whether the Cochlear Nucleus cochlear implant system was safe and effective for use. Participants who were part of the studies had either bilateral sensorineural hearing loss or single sided deafness (SSD). Safety data and effectiveness data from the clinical studies are provided below.

The following information summarises adverse events for adults and children implanted with the Cochlear Nucleus 24 cochlear implant system. The studies referenced below included individuals with bilateral sensorineural hearing loss and single sided deafness (SSD); however, safety information may apply to any person who receives a cochlear implant.

1. Summary of safety data - adults

Adult safety data are based on a total of 133 patients implanted with the Cochlear Nucleus 24 cochlear implant during the adult clinical investigation at 27 US sites.

- 20 patients experienced either a medical or surgical complication, or a device-related complication.
- 11 of the 20 complications were medical or surgical in nature and the remaining nine were device-related.
- 18 of the 20 adverse events (AEs) resolved without surgical or extensive medical intervention.

Medical or surgical complications[1]

- One patient experienced device migration which required revision surgery to reposition the device.
- One patient experienced a wound haematoma which required minor surgery to resolve.
- One patient experienced a slightly compressed electrode array and the surgeon elected to remove the device and replace it with a second one during the initial surgery.
- Four patients experienced facial nerve stimulation. All cases of facial nerve stimulation were resolved through reprogramming.
- Two patients experienced tinnitus related to cochlear implant use.
- One case resolved without intervention and the second case was resolved through reprogramming.
- One patient experienced short-term postoperative dizziness which resolved without medical treatment.
- One patient experienced fluctuating psychophysical levels related to a relatively thick (10+ mm) skin flap. This case was resolved through replacement of external equipment.

Device-related complications

No device failures or other serious device malfunctions occurred during this study.

- Four patients experienced electrode insulation faults (short circuits) that were resolved through reprogramming.
- Two patients were inadvertently overstimulated during device programming.
- One patient reported a nonauditory sensation during device programming.
- Two patients experienced a mild skin reaction to the sound processor cable. These were resolved completely with topical medical treatment.

1 Medical or surgical complications would be classified today as a procedure related adverse event.

2. Summary of safety data - children 12 months and older

Paediatric safety data are based on a total of 234 children implanted with the Cochlear Nucleus cochlear implants for two clinical investigations.

For the first clinical investigation, 150 children were implanted with Cochlear Nucleus 24 cochlear implants:

- 24 patients experienced 27 medical or surgical complications, or device related complications.
  - 9 of the 27 complications were medical or surgical in nature.
  - The remaining 18 were device-related complications.
  - 24 of the complications resolved without surgical or extensive medical intervention.

Medical or surgical complications[1]

- One postmeningitically deafened child with bilaterally ossified cochleae failed to experience auditory stimulation through the fully functional cochlear implant
- One patient developed streptococcal meningitis less than 24 hours following cochlear implant surgery. The infection was successfully managed with medical treatment
- One patient experienced a wound infection that was resolved through surgical explantation of the device
- One patient experienced extracochlear electrode placement related to a congenital malformation of the inner ear. This complication was resolved through surgical explantation of the device

1 Medical or surgical complications would be classified today as a procedure related adverse event.

- Two patients experienced slight compression of the electrode array which resulted in two short-circuited electrodes in one case and no electrode anomalies in the other. The case with electrode short circuits was resolved through reprogramming
- One patient experienced facial nerve stimulation related to a severe congenital malformation of the inner ear. This complication was resolved through reprogramming, however, the patient continues to experience occasional slight facial nerve stimulation
- Two patients experienced mild short-term postoperative dizziness. Both cases resolved without medical intervention.

Device-related complications

No device failures or other serious device malfunctions were observed.

- 13 patients experienced electrode faults (short-circuit or open-circuit electrodes) on one or more electrodes. All of these cases were resolved through reprogramming.
- One patient experienced non-auditory sensations during psychophysical testing. This case was resolved through reprogramming.
- One patient experienced an unanticipated overstimulation. This complication was resolved through replacement of external equipment.
- Three patients experienced mild skin reactions to the sound processor cable:
  - One case was resolved through covering the cable.
  - One case was resolved through an alternative polyurethane coating of the cable.
  - One case resolved spontaneously without intervention.

3. Summary of safety data - children 9 months to 12 months old

3.1 Premarket study

Cochlear performed a premarket, prospectively-designed, retrospective analysis from its own registry data to establish a reasonable assurance of safety of implantation with the Cochlear Nucleus 24 cochlear implant system for paediatric patients between the ages of 9 months and 12 months.

The retrospective review of 83 children that were between 9 months and 12 months of age and implanted with Cochlear Nucleus cochlear implants was completed for this analysis.

Device-related complications, such as electrode faults, were not captured in this study.

Twenty-four patients experienced 28 medical or surgical complications and 26 of the complications were resolved without major surgical or medical intervention:

- Six patients experienced minor postoperative complications, four of which were resolved without medical intervention.
- Two patients experienced cerebral spinal fluid leakage perioperatively. These were repaired during the cochlear implant surgery.
- One patient required a revision surgery with reimplantation.
- Two patients experienced postoperative infections including mastoiditis, postauricular abscess, and surgical site infection. All the infections were medically managed.
- Two patients developed seromas and one of these patients was reimplanted.
- Two patients experienced temporary facial weakness which resolved with steroid administration. There were no reports of postoperative meningitis.

Overall, the above AEs are typical surgical, procedure or device events observed in children implanted at a relatively young age.

Additionally, in February 2020, Cochlear performed a systematic literature search in PubMed and EMBASE databases to assess safety of implantation with a Cochlear Nucleus cochlear implant in children between the ages of 9 months and 12 months.

A multi-step literature search process resulted in a final set of studies (49 peer-reviewed articles) representing additional relevant research on cochlear implantation for patients less than 12 months old.

Safety studies that included children implanted at less than 12 months old covered a broad range of topics from surgical complications including:

- anaesthesia
- blood loss
- postoperative pain and dizziness
- wound healing problems
- infections.

The research literature reviewed on surgical and postoperative outcomes reported specific to the population under the age of 12 months at implantation did not identify an elevated incidence of complications.

3.2 Post-approval study

Summary of the post-approval study methods

Cochlear performed a post-approval, prospectively-designed, retrospective analysis among 83 patients who were enrolled in the premarket study and 50 additional patients – data collected out to two years postoperatively – to assess long-term safety of cochlear implantation in children between 9 months and 12 months of age.

The purpose of this study was to supplement the premarket study with:

- additional patient profiles of children implanted more recently
- longer-term outcomes data. Data was collected from medical records and chart notes.

Summary of the post-approval study results

Adverse events (AEs) included any device, procedure, and otologic-related unexpected medical occurrences occurring from time of surgery through two years postoperatively.

The AEs were classified as major or minor AEs using well-established criteria (Cohen & Hoffman, 1991).

- Major AEs were defined as those requiring hospitalisation and/or additional surgical intervention.
- Minor AEs were defined as those using the expected route of treatment and/or medication.

Seventeen new AEs were reported in this post-approval dataset of 133 total patients.

- Six AEs were reported for the extended study group of 83 patients for either:
  - AEs spanning between 6 months to 24 months postoperatively
  - or AEs that had not been previously reported in the original dataset.
  - 11 AEs were reported for the 50 new patients.

Of the 17 new AEs, five were considered major AEs and 12 were considered minor AEs:

- Four patients experienced postoperative complications.
- Eight patients experienced ear-related infections, four of which were considered major AEs:
  - One patient developed seroma and was reimplanted.
  - One patient with bilateral acute otitis media was re-hospitalised for myringotomy and tubes.
  - One patient was noted to have recurrent ear infections.
  - One patient reported chronic middle ear dysfunction.
- One patient was readmitted to the hospital postoperatively with a fever and received fluids and antibiotics, categorised as a major AE.
- One patient experienced cerebral spinal fluid leakage during surgery.
- Three patients experienced minor AEs that did not fall into the categories above.

There were no unanticipated AEs reported in this new dataset of 133 patients. All 17 AEs were reported as resolved.

Primary safety endpoint

The combined dataset of 133 patients demonstrates the overall safety of cochlear implantation in children between 9 months and 12 months of age. The rate of AEs gathered in the post-approval study is qualitatively similar to the AEs reported in the original pre-market study from 6 months to 24 months. There were differences seen between the groups 0 months to 6 months, with a higher rate of AEs for the premarket study group. Refer to ***Table 5***.

Group	0-6 months postoperative	6-24 months postoperative	0-24 months postoperative
83 premarket study patients (N=143 ears)	42 AEs (29.4%)	5 AEs (3.5%)	47 AEs (32.9%)
50 new patients (N=82 ears)	9 AEs (11.0%)	2 AEs (2.4%) AEs	11 AEs (13.4%)
133 combined patients (N=223 ears)	51 AEs (22.7%)	7 AEs (3.1%)	58 AEs (25.8%)

Table 5: Primary safety endpoint

Group: premarket study patients

A total of 42 AEs for patients initially enrolled during the premarket study were collected and resolved between 0 months and 6 months postoperatively, yielding a complication rate of 29.4%.

An additional five AEs were collected and reported as resolved during the expanded 6 month to 24 month postoperative time window for this patient group.

Of the five AEs reported during this time window:

- two were new AEs
- three were previous AEs that began during the 0 month to 6 month postoperative window, but were not resolved until 6 months to 24 months postoperatively.

These five AEs yield a complication rate of 3.5%.

There was a total complication rate of 32.9% for the 47 AEs collected 0 months to 24 months for this group.

Group: new patients

A total of nine AEs were reported for the new patients during the 0 months to 6 months postoperative time period, yielding a complication rate of 11%.

- Two AEs began during the 0 months to 6 months reporting window but were not resolved until the 6 month to 24 month period, yielding a complication rate of 2.4%.
- No AEs beginning beyond the 6 month time period were reported for this new patient group.

There was a total complication rate of 13.4% for AEs collected 0 months to 24 months for this group.

Complication rates for the premarket study were collectively higher than the new patients, especially in the 0 months to 6 months range. However, there is evidence of surgical protocol improvement for the postmarket study, leading to improved surgical outcomes and decreased reported complication rates.

Group: combined

Of the 58 AEs reported across the combined group of 133 patients, with data collected 0 months to 24 months postoperatively:

- 13 AEs met criteria as a major AE equating to an incidence rate of 5.8%.
- 45 AEs met criteria as a minor AE, equating to an incidence rate of 20.0%.

Findings of this post-approval study align with published cochlear implant literature specific to the paediatric population for major AEs related to cochlear implants, which ranges between 1.5% and 6.6% of all cases across variable postoperative time periods.

Minor AEs in this combined dataset were reported at a higher incidence rate than published literature due to variation in categorisation criteria and reporting timelines.

In summary, data collected as part of the premarket study and this subsequent post-approval study provide a dataset of over 100 patients who received a Cochlear Nucleus cochlear implant between 9 months and 12 months of age. Data was collected postoperatively out to two years or date of final protocol approval (May 15, 2020).

The data provided continues to support the safety of cochlear implantation with the Cochlear Nucleus device in infants as young as 9 months of age. Findings of this post-approval study demonstrate agreement with previously published literature (Cohen & Hoffman, 1991; Farinetti et al., 2014; Ikeya et al., 2013; Loundon et al., 2010; Petersen et al., 2018) for the primary safety endpoint.

4. Summary of effectiveness data - adults

Unilateral Hearing Loss (UHL) / Single Sided Deafness (SSD)

Cochlear analysed existing data to demonstrate the effectiveness of cochlear implantation in adult participants with single sided deafness, or SSD. In the analysis, data from a Cochlear sponsored multicentre study was combined with data gathered from two cochlear implant centres. Data was analysed from 42 participants.

Effectiveness testing included speech recognition testing using:

- The Hearing in Noise Test (HINT)
- Bamford Kowall Bench Sentences in Noise test (BKB-SIN)
- Localisation testing.

Effectiveness testing also included outcomes reported by the participant. These patient-reported outcomes included the:

- Speech, Spatial, and Qualities (SSQ) Questionnaire
- Iowa Tinnitus Handicap Questionnaire.

Audiometric thresholds were also obtained for each ear.

4.1 Description of Tests

Hearing in Noise Test (HINT)

The Hearing in Noise Test or HINT (Nilsson et al., 1994) is a test made up of 25 10-sentence lists used to test how well an individual understands in noise. The sentences are presented in noise which is filtered to match the long-term average spectrum of the sentences. The HINT is an adaptive test whereby the signal-to-noise ratio (SNR) is increased or decreased by a fixed amount based on the listener's ability to repeat the sentences correctly or not.

Bamford Kowall Bench Sentences in Noise test (BKB-SIN)

The BKB-SIN Test (Etymotic Research, 2005) includes 18 lists of sentences. The sentences are spoken by a single male talker, are 5-6 words in length and are at a 1st grade reading level. The sentences are presented in noise using 4-talker babble. The test starts out easy where the sentences are presented much louder than the noise and depending on a listener's ability to correctly repeat the words in the sentence, the sentences are either made softer or louder until a level is reached where 50% of the words in a sentence are repeated correctly.

Localisation testing

Localisation is the ability to tell where a sound is coming from. Localisation testing was assessed by delivering a noise from one of 12 locations. The locations are numbered one through 12 on a response sheet, from right to left. The sound comes from a speaker positioned to represent an arc from 97.5° (on the right) to 262.5° (on the left) of the participant. There is a 15° separation between each speaker. The participant selects one number to indicate the perceived location of the sound.

4.2 Evaluation methods

Speech, Spatial, and Qualities (SSQ) Questionnaire

The SSQ is a validated self-assessment metric commonly used in hearing aid and cochlear implant research. It is designed to measure self-reported auditory disability across a wide variety of domains, reflecting the reality of hearing in the everyday world. There are 49 questions (SSQ-49) scored by the participant using a scale of 0 through 10, where 0 corresponded to minimal ability and 10 corresponded to complete ability. There are three specific hearing domains assessed:

1. Speech hearing scale – This includes hearing speech in quiet and in noise, in one-on-one conversation and in groups or meetings.
2. Spatial hearing scale – This includes hearing where sounds are coming from, distance, movement, and ability to segregate sounds.
3. Qualities of sound scale – This includes ease of listening, naturalness, clarity, identification of different speakers, musical pieces and instruments, as well as everyday sounds.

Iowa Tinnitus Handicap Questionnaire

The Iowa Tinnitus Handicap Questionnaire was used to assess tinnitus. Tinnitus was assessed before and after the cochlear implant was turned on. There are 27 questions that fall into three factors:

1. Factor 1 examines social, physical and emotional wellbeing.
2. Factor 2 examines hearing abilities.
3. Factor 3 examines an individual's view of tinnitus.

4.3 Understanding Speech in Noise – Speech Recognition Results

Comparison 1: Performance using a cochlear implant and normal hearing (NH) ear compared to performance before surgery

Cochlear compared performance before surgery to performance after 6 months of cochlear implant use. Before surgery, the participant used a hearing aid in the ear to be implanted and their normal hearing ear for testing.

Six months later, the participant used their cochlear implant and their normal hearing ear for testing. During testing, speech was presented from a speaker in front of the participant.

At the same time, noise was presented from a speaker that was on the side of the better hearing ear. Twenty-three participants are included in this analysis.

Results showed that after 6 months of cochlear implant use there was an improvement. Participants had an average improvement of 2.8 dB.

Comparison 2: Performance using a cochlear implant and normal hearing (NH) ear compared to the normal hearing ear alone

Cochlear compared performance for participants using a cochlear implant and the normal hearing ear to performance in the normal hearing alone. Both tests were completed after the participant had used a cochlear implant for at least 3 months.

When normal hearing alone was measured, the cochlear implant was off. Thirty-eight participants are included in this analysis.

Results showed that there was improvement when a cochlear implant was used for speech understanding in noise. Participants had an average 1.5 dB improvement.

To help determine the proportion of participants with 6 months of cochlear implant use who are performing to the same as or better than before receiving a cochlear implant, the following comparisons are provided.

When performance before cochlear implant surgery is compared to performance after cochlear implant surgery, it is found that:

- 18/23 (78%) participants demonstrated a clinically meaningful preoperative to postactivation improvement of 1.0 dB (10% improvement), with a range of -1.2 dB to -9.5 dB, (note that a negative score connotes improvement)
- 3/23 (13%) participants scored equal to their preoperative performance, with a range in difference scores from 0.0 dB to +0.8 dB, which suggests no change
- 2/23 (9%) participants had a difference score ≥ +1.0 dB, consistent with a decline in performance.

When performance with the cochlear implant on was compared to performance with the cochlear implant off, it was found that:

- 25/38 (66%) participants demonstrated a clinically meaningful improvement with cochlear implant on of 1.0 dB (10% improvement) with a range of -1.0 dB to -6.2 dB, (note that a negative score connotes improvement)
- 11/38 (30%) participants scored equal to their normal hearing when the cochlear implant was on, with a range of difference scores from -0.7 dB to +0.8 dB, which suggests no change
- 2/38 (5%) participants had a difference score > +1.0 dB, consistent with a decline in performance.

In the clinical study, 8/38 (21%) experienced a decrease in speech understanding when speech was presented in front and noise was directed to the cochlear implant side. This suggests potential interference with the hearing from the normal ear and the hearing from the cochlear implant.

Additionally, a few published studies (Speck et al., 2020, Deep et al., 2021, and Zeitler et al.,2019) reported that very few people with SSD stop using their cochlear implant. Given these results, it is reasonable to conclude that a small number of recipients experience interference.

Cochlear performed subgroup analyses to see if subgroups were different for the co-primary effectiveness endpoints. The subgroups examined were:

- gender
- median age at implant
- median duration of hearing loss at baseline
- cause of hearing loss
- evaluation interval
- median baseline/preoperative speech in noise score
- median baseline CI off speech in noise score
- preoperative pure tone average (PTA)

Results indicated that the only characteristics that affected the primary endpoint 1 outcomes were:

- Duration of hearing loss

  The mean score for participants below or equal to the median duration of hearing loss of two years was significantly poorer than that for duration of hearing loss above two years.

- Cause of hearing loss

  It was found that those participants with a sudden sensorineural hearing loss performed significantly better than those with any other cause for hearing loss in the participants.

- Preoperative speech in noise score

  It was found that those participants who had poorer preoperative speech in noise scores demonstrated significantly greater improvement.

For coprimary effectiveness endpoint 2 outcomes, the only baseline characteristic that affected the endpoint was when speech was presented from the front and noise was directed to the normal ear while the cochlear implant was off. Participants with poorer speech understanding in noise in this condition demonstrated significantly more improvement when measuring listening with both the cochlear implant and normal ear.

There were no differences in the consistency of primary endpoints across investigational sites.

4.4 Localisation

Twenty-four participants had localisation data available for analysis. Data showed an improvement when a participant had a cochlear implant turned on, compared to when the cochlear implant was turned off. Participants were more able to accurately identify the sound source. There was an average improvement of 18.8 degrees.

4.5 Patient reported outcomes

Speech, Spatial, and Qualities of Hearing Scale (SSQ)

There were 14 participants who completed the SSQ before surgery. There were 10 participants who completed it after 6 months of cochlear implant use.

The Speech Hearing Scale addressed how well participants could hear and understand speech in various quiet and noisy situations. These included one-on-one conversations and speech in small and large groups of people.

- After 6 months of cochlear implant use, scores on the speech and hearing rating scale increased by an average of 2.09 points.

Spatial Hearing Scale

The Spatial Hearing Scale addressed how well participants could judge directionality of sound. This included where a sound was coming from, how far away the sound was, and movement of sound (for example, whether a sound was coming toward them or away from them).

- After 6 months of cochlear implant use, scores on the spatial hearing rating scale increased by an average of 2.38 points.

Sound Qualities Scale

The Sound Qualities Scale addressed how well participants could separate and sort out sounds and how well they could recognise different sounds. It also addressed how clear or natural sounds were, and how much effort listening required.

- After 6 months of cochlear implant use, scores on the sound qualities scale increased by an average of 1.04 points.

A total score for the SSQ, which reflected the average scores over the three subscales, was also reported at each test interval.

- After 6 months of cochlear implant use, total scores on the SSQ increased by an average of 1.84 points.

There was a significant average improvement on each subscale. The largest difference was found on the Spatial Hearing subscale.

Iowa Tinnitus Handicap Questionnaire

Data were available for ten participants.

- After 6 months of cochlear implant use, 6 of the 9 (67%) participants with scores reported an improvement in their tinnitus.
- After 12 months of cochlear implant use, 7/10 (70%) participants reported an improvement in their tinnitus.

5. Summary of effectiveness data - children 9 months to 12 months old

5.1 Premarket study

In February 2020, Cochlear performed a systematic literature search in PubMed and EMBASE databases to assess effectiveness of implantation with a Cochlear Nucleus cochlear implant in children between 9 months and 12 months of age.

A multi-step literature search process resulted in a final set of studies (49 peer-reviewed articles) representing additional relevant research on cochlear implantation for patients less than 12 months old.

Effectiveness outcomes from the literature data support that implantation before 12 months of age supports paediatric cochlear implant recipients' improved speech and language development.

5.2 Post-approval study

5.2.1 Summary of the post-approval study methods

Cochlear performed a post-approval, prospectively-designed, retrospective analysis among 83 patients who were enrolled in the premarket study and 50 additional patients – data collected out to two years postoperatively – to gather effectiveness information on cochlear implantation in a population between 9 months and 12 months of age.

5.2.2 Summary of the post-approval study results

Primary effectiveness endpoint

The primary effectiveness endpoint of this post-approval study was to evaluate the performance of the cochlear implant on commonly validated and used parental questionnaires (Uhler & Gifford, 2014).

Available IT-MAIS and LittlEARS questionnaires data were collected preoperatively and postoperatively out to two years, or date of final protocol approval, for both sets of patients.

Infant Toddler Meaningful Auditory Integration Scale (IT-MAIS)

The IT-MAIS is a parental questionnaire designed to assess the auditory skill development in infants and toddlers. The questionnaire is administered by a clinician to parents/caregivers in an interview style. It consists of 10 probes designed to assess various auditory behaviours. Each probe has a possible score ranging from 0 (never) to 4 (always). Examples of additional follow up questions that can be asked by the clinician are provided for each probe in order to help determine an appropriate ranking for each probe. The questionnaire is scored out of a total of 40 possible points. The questionnaire can be administered before and after cochlear implantation.

LittlEARS

The LittlEARS is a parental questionnaire designed to assess auditory skill development in infants and toddlers. It consists of 35 yes/no questions that ask parents/caregivers to identify whether their child exhibits a certain auditory response or behaviour. Examples are provided for each question. 1 point is provided for each auditory response that is answered as a "yes". The questionnaire is scored out of a total 35 possible points. The questionnaire can be administered before and after cochlear implantation.

Analysis was completed for two population groups:

1. Intent to Treat – consists of all participants who had an available baseline assessment.
2. Per Protocol – consists of only those participants with available assessments at both the preoperative and postoperative time points.

As shown in ***Table 6*** on page 53 and ***Table 7*** on page 54, children in this post-approval study who underwent cochlear implantation between the ages of 9 months and 12 months demonstrated a significant improvement in auditory skill development compared to their preoperative baseline.

The tables provide LittlEARS and IT-MAIS scores reported as a percent correct. Children included in this post-approval study demonstrated significantly improved auditory skill development compared with their baseline performance, with children exhibiting an average improvement of 61.4% at ~9-month post-implantation compared with their preoperative scores.

Questionnaire	Preoperative N Mean ± SD[1], median (min, max)	Postoperative N Mean ± SD, median (min, max)	Change N Mean ± SD, median (min, max)	Change Mean (95% confidence interval)[2]	p-value[2]
LittlEARS	28 15.8 ± 19.1 5.7 (0, 54)	62 81.6 ± 20.3 88.6 (17, 100)	20 61.4 ± 27.4 67.1 (3, 100)	60.7 (38.4, 82.9)	<.0001
IT-MAIS	33 16.8 ± 16.3 12.5 (0, 78)	35 76.9 ± 21.7 85.0 (3, 100)	25 58.5 ± 23.9 62.5 (-3, 100)	55.4 (9.1, 101.8)	0.0308

Table 6: Primary effectiveness endpoint - Intent to Treat

1 SD = standard deviation

2 The mean and confidence interval for change, and p-value, are based on multiple imputation.

Questionnaire	Preoperative N Mean ± SD[1], median (min, max)	Postoperative N Mean ± SD, median (min, max)	Change N Mean ± SD, median (min, max)	Change Mean (95% confidence interval)	p-value[2]
LittlEARS	20 15.7 ± 20.7 5.7 (0, 54)	20 77.1 ± 20.9 82.9 (31, 100)	20 61.4 ± 27.4 67.1 (3, 100)	61.4 (48.6, 74.3)	<.0001
IT-MAIS	25 15.7 ± 16.7 10.0 (0, 78)	25 74.2 ± 24.0 77.5 (3, 100)	25 58.5 ± 23.9 62.5 (-3, 100)	58.5 (48.6, 68.4)	<.0001

Table 7: Primary effectiveness endpoint - Per Protocol

When comparing outcomes of this post-approval study to published literature, please note the literature refers to hearing age – when the cochlear implant was activated – whereas Cochlear's dataset for IT-MAIS and LittlEARS questionnaires refers to time from cochlear implant surgery.

To appropriately compare Cochlear's dataset to published literature, postoperative performance by hearing age has been provided at various intervals, up to 24 months, as shown in ***Table 8*** on page 55 and ***Table 9*** on page 56.

1 SD = standard deviation

2 The p-values are based on two-sided paired t-test.

Study	Preoperative score Mean (% correct)	Postoperative score Mean (% correct)	Change pre- to postoperative score Mean (% correct)
PAS Intent to Treat 9.0 mo-11.99 mo	5.5 (15.8%)	9.9 mo postop: 28.5 (81.6%)	9.9 mo: 21.5 (61.4%)
PAS Per Protocol 9.0 mo-11.99 mo	5.5 (15.7%)	9.0 mo postop: 27 (77.1%)	9.0 mo: 21.5 (61.4%)
May-Mederake et al. (2010) under 12 mo at implant	7 (20%)	6 mo hearing age: 17 (48.6%)	6 mo: 10 (28.6%)
		9 mo hearing age: 23 (65.7%)	8 mo: 14 (45.7%)
		12 mo hearing age: 28 (80%)	12 mo: 21 (60%)
		18 mo hearing age: 35 (100%)	18 mo: 28 (80%)
		24 mo hearing age: 35 (100%)	24 mo: 28 (80%)
May-Mederake et al. (2010) over 12 mo at implant	15 (42.8%)	6 mo hearing age: 21 (60%)	6 mo: 6 (17.2%)
		9 mo hearing age: 24 (68.6%)	8 mo: 9 (25.8%)
		12 mo hearing age: 27 (77.1%)	12 mo: 12 (34.3%)
		18 mo hearing age: 34 (97.1%)	18 mo: 19 (54.3%)
		24 mo hearing age: 35 (100%)	24 mo: 20 (57.2%)
Connix et al. (2009) Normative values	NA	8 mo hearing age: 10-18 (28.6-51.4%)	NA
		9 mo hearing age: 12-20 (34.3-57.1%)	
		12 mo hearing age: 16-24 (45.7-68.6%)	
		6 mo hearing age: 8-9 (22.9%-25.7%)	
		18 mo hearing age: 23-30 (65.7%-85.7%)	
		24 mo hearing age: 26-34 (74.2%-97.1%)	

Table 8: LittlEARS questionnaire pre- to postoperative change scores reported as a standard score and percent correct

Study	Preoperative score Mean (% correct)	Postoperative score Mean (% correct)	Change pre- to postoperative score Mean (% correct)
PAS Intent to Treat 9.0 mo-11.99 mo	6.7 (16.8%)	7.7 mo postop: 30.7 (76.9%)	7.7 mo: 23.4 (58.5%)
PAS Per Protocol 9.0 mo-11.99 mo	6.3 (15.8%)	6.8 mo postop: 29.7 (74.3%)	6.8 mo: 23.4 (58.5%)
Waltzman & Roland (2005) CI under 12 mo	0.7 (1.8%)	6 mo hearing age: 30.4 (76%) (~25% above the mean for NH children at 6 mo)	6 mo: 29.7 (74.2%)
		12 mo hearing age: 34.8 (87%) (~7% above mean for NH children at 12 mo)	12 mo: 34.1 (85.3%)
Robbins et al (2004) CI Group 1: (12 mo-18 mo at implant)	~10%	3 mo hearing age: ~65% (outside normative range)	3 mo: 55%
		6 mo hearing age: ~80% (within normative range)	6 mo: 70%
		12 mo hearing age: ~85% (within normative range)	12 mo: 75%
Robbins et al (2004) CI Group 2: (19 mo-23 mo at implant)	~10%	3 mo hearing age: ~55% (outside normative range)	3 mo: 45%
		6 mo hearing age: ~65% (outside normative range)	6 mo: 55%
		12 mo hearing age: ~75% (within normative range)	12 mo: 65%
Zimmerman-Phillips, Robbins, & Osberger (2000) CI at 18 mo-20 mo	Average 1.4%	3 mo hearing age: 49.2%	3 mo: 47.8%
Robbins et al (2004) Normative Values	NA	6 mo hearing age: ~20-50%	NA
		8 mo hearing age: ~40-65%	
		9 mo hearing age: ~45-70%	
		12 mo hearing age: ~50-75%	
		18 mo hearing age: ~70-85%	
		24 mo hearing age: ~75-95%	

Table 9: IT-MAIS questionnaire pre- to postoperative change scores reported as a standard score and percent correct

A review of the post-approval study data collected reveals that IT-MAIS questionnaire data was obtained between 3 months and 17 months postoperatively, and LittlEARS questionnaire data was obtained between 3 months and 21 months postoperatively.

Neither questionnaire had data out to the 24 month postoperative time point. However, the available data still shows that children who receive a cochlear implant between 9 months and 12 months of age demonstrated improved auditory skill development, which is likely due to improved access to sound through their cochlear implant.

The numbers provided in ***Table 8*** on page 55 and ***Table 9*** on page 56 reflect the mean postoperative time point for each test and condition (Intent to Treat and Per Protocol) for ease of reporting purposes due to the number of available data points and the need to compare results of this study to the published literature.

Results of this study reveal IT-MAIS scores of:

- 76.9% at a mean of 7.7 months postoperatively for Intent to Treat
- 74.3% at a mean of 6.8 months postoperatively for Per Protocol.

These outcomes are aligned with reported scores:

- at 6 months hearing age for children implanted under age 12 months (76%) Waltzman & Roland (2005)
- at 6 months hearing age for children implanted at 12 months to 18 months (approximately 80%) Robbins et al. (2004).

Data for slightly older children implanted beyond 12 months of age are poorer compared to this dataset. Specifically, reported scores:

- at 6 months hearing age for children implanted between 19 months and 23 months (approximately 65%) Robbins et al. (2004)
- at 3 months hearing age for children implanted between 18 months and 20 months (approximately 49%) Zimmerman-Phillips, Robbins, & Osberger (2000).

When reviewing LittlEARS data, children in this study demonstrated a mean score of:

- 81.6% at a mean of 9.9 months postoperatively for Intent to Treat
- 77.1% at a mean of 9.0 months postoperatively for Per Protocol.

This data is slightly higher than scores reported by May-Mederake et al. (2010) who reported scores of approximately 65.7% and approximately 68% for children implanted under 12 months and over 12 months respectively, at a hearing age of 9 months.

Scores in this post-approval dataset better align with 12 month hearing age outcomes reported by May-Mederake et al. (2010), which demonstrated scores of approximately 80% for children implanted under 12 months of age, and approximately 77.1% for children implanted over 12 months of age.

Results of May-Mederake (2010) also showed that children who were implanted before 12 months of age had lower baseline scores, but demonstrated steeper trajectories, such as faster improvement and/or development, compared to children who were older at time of implantation (that is, over 12 months of age).

Data from this study showed that children who receive a cochlear implant between 9 and 12 months of age demonstrated improved auditory skill development as evidenced through these clinically relevant parental questionnaires.

Secondary Effectiveness Endpoint

The secondary effectiveness endpoint of this study was to evaluate the performance of the cochlear implant on aided audiometric thresholds.

Data collected demonstrated a significant improvement in audiometric thresholds following cochlear implantation. This demonstrates that use of the device provides improved access to auditory information.

In summary, this post-approval study provides a dataset of over 100 patients who received a Cochlear Nucleus cochlear implant between 9 months and 12 months of age. Data was collected preoperatively and postoperatively out to two years or date of final protocol approval.

The data provided continues to support the effectiveness of cochlear implantation with the Cochlear Nucleus device in infants as young as 9 months of age. Findings of this post-approval study demonstrate agreement with previously published literature (Connix et al., 2019; May-Mederake et al., 2010; Robbins et al., 2004; Waltzman & Roland, 2005; Zimmerman-Phillips, Robbins, & Osberger, 2000) for both effectiveness endpoints.

Study strengths and weaknesses

Strengths of the post-approval study include the use of data from multiple implanting centres over an 8-year period, which resulted in a large cohort of eligible participants and ears receiving treatment with a cochlear implant.

Weaknesses of this study include the retrospective nature of the study, which can limit the amount of data that is available for review in comparison with a prospective study. An additional limitation to consider is the selection of sites who participated in this study. Sites were specifically chosen to participate in the post-approval study due to their known use of cochlear implantation in children under 12 months of age.

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Reliability reports

Reliability reports are available on www.cochlear.com.

Additional information

For additional information concerning Cochlear Americas and the Cochlear Nucleus cochlear implant:

- visit Cochlear's website
  www.cochlear.com
- call your regional Cochlear office
  contact numbers are available on the back cover of this guide.

Notes

Notes

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