

Cochlear Implant Information Booklet (For Families)





Dear Parent,

Welcome to our Cochlear Implant Programme!

Since our programme started in 1999, we have been committed in providing comprehensive and individualised care for over 230 patients that require cochlear implantation.

You may be considering cochlear implantation for your child if he/she has severe to profound permanent hearing loss and hearing aids are currently insufficient for normal speech and language development.

This booklet aims to provide you with some basic and balanced information about cochlear implants. In addition, our dedicated team of professionals (audiologists, speech therapists and ENT doctors) will work with you to provide more personalised information, advice, and recommendations to help you make an informed decision for your child.

The decision to embark on the cochlear implant journey is not an easy one, and you are at the beginning of an incredible process to help your child hear well. Our team is here to journey with you and your child, to help him/her achieve the best possible outcomes and reach his/her full potential.

Sincerely,

NUH Cochlear Implant Team

Centre of Hearing Intervention & Language Development (CHILD)

National University Hospital Singapore

The information provided in this publication is meant purely for educational purposes and may not be used as a substitute for medical diagnosis or treatment. You should seek the advice of your child's doctor or a qualified healthcare provider before starting any treatment or if you have any questions related to your child's health, physical fitness, or medical conditions.

Information is correct at time of printing (2022) and is subjected to revision without prior notice.

Copyright (2022). National University Hospital.

All Rights reserved. No part of this publication may be reproduced without permission in writing from National University Hospital.



Credits

Acknowledgements:

**We would like to express our sincere gratitude to all parents who have consented for their child to be photographed for this booklet.
Thank you for sharing photos of your child's cochlear implant journey!**

Editorial committee:

Audiologists: Chin Ee Ling, Jenny Loo, Kek Tze Ling and Lee Zheng Zheng

Speech therapists: Dave Lai Junxian and Low Fang Yin

ENT doctors: Dr Loh Woei Shyang and Dr Tay Sok Yan

Photography:

**Angeline Teo and Lee Zheng Zheng (Audiologists)
Dr Loh Woei Shyang**

Contents

Section A: Hearing and Cochlear Implants

1. The Hearing Pathway.....	5
2. Types of Hearing Loss.....	6
3. Degree of Hearing Loss.....	8
4. About Cochlear Implants.....	10

Section B: Assessment and Selection

5. Cochlear Implant Assessment.....	14
6. Candidacy.....	16
7. Cochlear Implant Selection.....	21
8. Funding.....	24

Section C: Surgery

9. Surgical Risks.....	25
10. Cochlear Implant Surgery Procedure.....	26

Section D: Post-surgery Rehabilitation

11. Cochlear Implant Switch-on.....	30
12. Speech Therapy.....	36
13. Ways to Achieve Good Outcomes with Cochlear Implants.....	39

Section E: Useful Resources and FAQs

14. Useful Resources and FAQs.....	41
------------------------------------	----

Section A: Hearing and Cochlear Implants

The Hearing Pathway

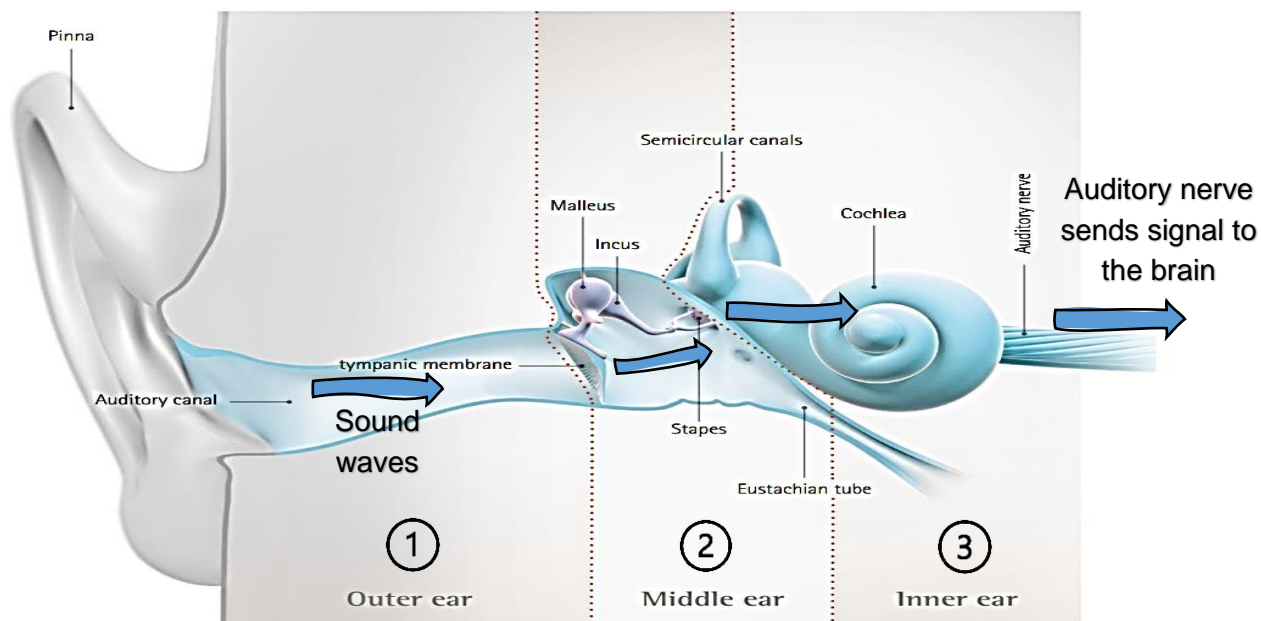


Figure 1: The Ear Anatomy

Source: <https://www.funkidslive.com/learn/hallux/hearing-helpdesk/whats-structure-ear/>

Our ear has three major parts (Figure 1):

1. The **outer ear**: consisting of the pinna and auditory canal.
2. The **middle ear**: consisting of the eardrum (tympanic membrane), ossicles (malleus, incus, and stapes) and the eustachian tube.
3. The **inner ear**: consisting of the cochlea, auditory nerve, and the balance organ (which includes the semicircular canals).

How do we hear?

Sound waves pass through the outer ear, causing vibrations in the eardrum. The vibrations are transmitted through the ossicles (three tiniest bones in the body) in the middle ear, and then to the cochlea in the inner ear. The vibrations in the fluid-filled, snail-shaped cochlea causes tiny hair cells in the cochlea to move. The movement of each hair cell in the cochlea sends messages to the brain via the auditory nerve, thus creating sound.

Section A: Hearing and Cochlear Implants

Types of Hearing Loss

Hearing loss occurs when there are disruptions along the auditory pathway. The type of hearing loss depends on which part of the auditory pathway the disruptions occur at. The common types of hearing loss and some possible causes found in children are as follows.

Conductive hearing loss

Arises from problems in the outer and/or middle ear. Often, conductive hearing losses can be resolved through medication or surgery, and may not result in permanent hearing loss.

Possible causes of **conductive hearing loss**:

- Outer and/or middle ear infections
- Ear drum perforations
- Excessive ear wax
- Birth defects of the outer and/or the middle ear

Sensorineural hearing loss

Arises from problems in the inner ear due to issues with the cochlea and/or issues with the auditory and neural pathway from the cochlea to the brain. In most cases, sensorineural hearing loss is caused by damaged hair cells in the cochlea, which could happen either before birth or later in life (Figure 2).

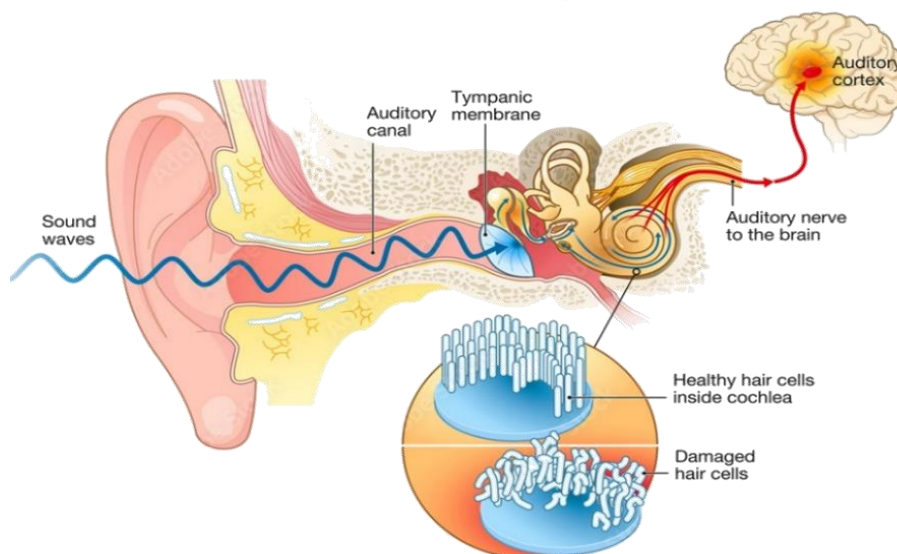


Figure 2: Healthy and Damaged Hair Cells

Source: <https://stock.adobe.com/au/search/images?k=cochlea>

The extent of damage to the hair cells can result in different degrees of hearing loss. Severe to profound hearing loss occurs when the amount of surviving hair cells in the cochlea is so few that very limited sound signals can be sent to the brain. Although damaged hair cells are unable to regenerate, a cochlear implant can bypass the severely damaged hair cells and deliver sound signals through the auditory nerve to the brain.

Auditory Neuropathy Spectrum disorder (ANSD)

ANSD is a type of sensorineural hearing loss that causes sound signals at the hearing nerve to be distorted and be poorly transmitted to the brain. Individuals with ANSD can have varying levels of hearing (from normal hearing to profound hearing loss) and they tend to have more difficulty understanding speech, especially in noisy environment. Common solutions for ANSD include hearing aids and cochlear implants (if benefit of hearing aid is limited).

For more information regarding ANSD, refer to Section E: Useful Resources.

Possible causes of **sensorineural hearing loss**:

- Genetics
- Abnormal inner ear structure (cochlea malformation, thin/absence of auditory nerve)
- Maternal infections during pregnancy (cytomegalovirus)
- Prematurity
- Birth complications (lack of oxygen and severe jaundice)
- Serious infections (bacterial meningitis, viral infections)
- Ototoxic medications (selected chemotherapy drugs and antibiotics)

Mixed hearing loss

A combination of conductive and sensorineural hearing loss, which arises due to problems in both the outer and/or middle ear, and the inner ear.

Section A: Hearing and Cochlear Implants

Degree of Hearing Loss

The amount of speech and sounds that a child can process depends on the severity of the hearing loss. A **child with normal hearing can hear soft speech sounds at ≤ 15 decibels (dB)** that are crucial for normal speech and language development. A hearing-impaired child (even with slight/mild hearing loss) can be at risk of speech and language delays, and struggle academically.

The communication concerns for different degrees of hearing losses are described below:

Degree of Hearing Loss	Decibels	Communication Concerns
Slight	20 - 25dB	Difficulty hearing soft speech, distant speech, and fast-paced conversations.
Mild	25 - 40dB	May miss up to 40% of speech, especially soft speech, word endings and unstressed words.
Moderate	40 - 55dB	May miss up to 80% of speech, especially in noisy environment.
Moderately severe	55 - 70dB	May miss 100% of speech at normal conversational levels. Speech must be loud and at close distance.
Severe	70 - 90dB	May receive limited speech or environmental sounds at very loud levels.
Profound	>90dB	Cannot receive any speech or environmental sounds (unless extremely loud).

Figure 3: Communication Difficulties of Various Degrees of Hearing Loss

Source: <https://www.hearingfirst.org/m/resources/7734>

To understand more about how to interpret your child's audiogram, please refer to Section E: Useful Resources (Familiar Sounds Audiogram eBook).

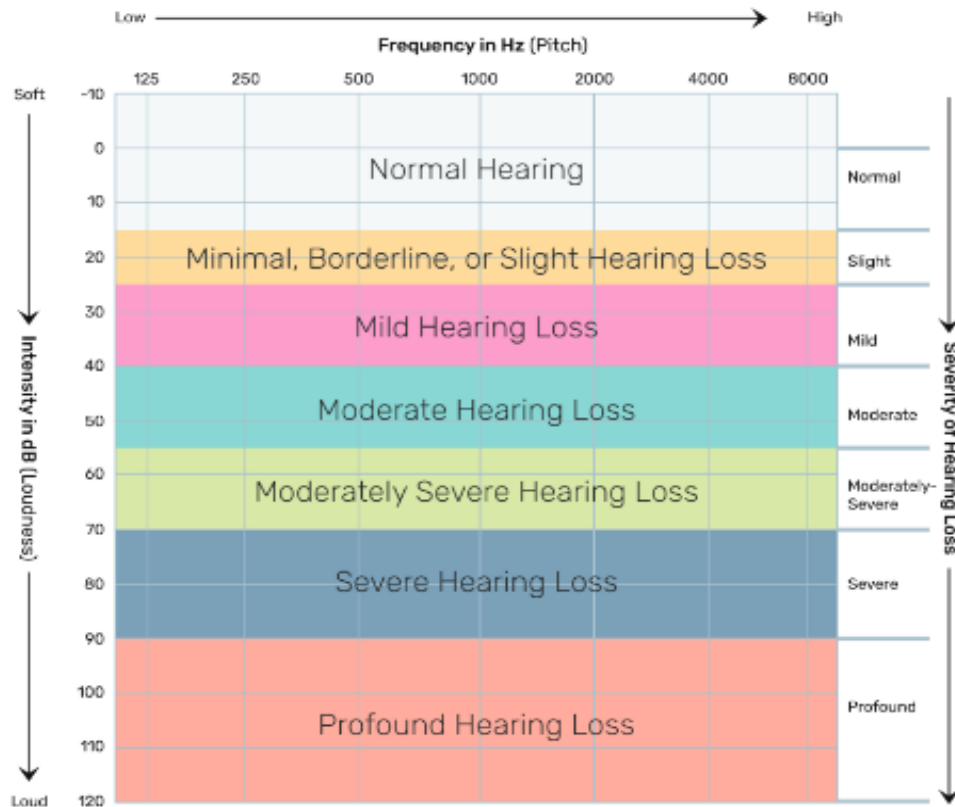


Figure 4: Audiogram indicating degrees of hearing loss

Source: <https://www.hearingfirst.org/m/resources/7734>

For majority of the hearing-impaired population, hearing aids are the device of choice. However, the greater the hearing loss, the harder it is for one to detect sounds at soft levels using hearing aids, and this affects the development of speech and language capabilities.

With severe to profound hearing loss, hearing aids can only provide limited awareness to loud environmental sounds and certain very loud speech signals. For individuals who are unable to benefit from the use of hearing aids, cochlear implants may be a better option to consider.

Section A: Hearing and Cochlear Implants
About Cochlear Implants

What are the differences between hearing aids and cochlear implants?

The hearing aid and cochlear implant system provides sound differently.

	Hearing aids	Cochlear implants
Sound generation	Converts acoustic signals to digital signals	Converts acoustic signals to electrical signals
Sound transmission pathway	Sends amplified digital sounds through the outer, middle, and inner ear.	Electrically stimulates the auditory nerve directly, bypassing the outer ear, middle ear, and damaged hair cells in the cochlea.

Parts of a cochlear implant system

The cochlear implant system consists of two main parts:

1. **External speech (sound) processor**
2. **Internal implant**

External speech processor

The speech processor sits outside the body, either behind-the-ear or off-the-ear (on the head). The battery on the external speech processor powers the cochlear implant system.

Behind-The-Ear processor

Off-The-Ear processor

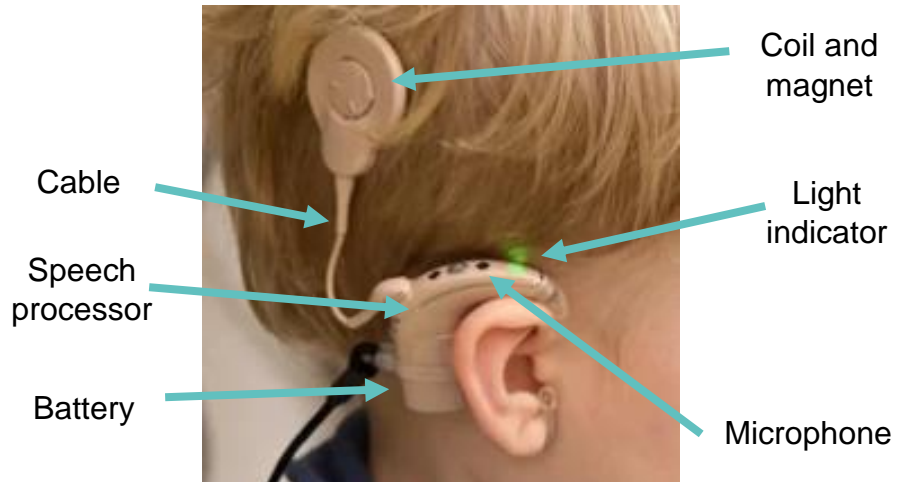


Figure 5: Speech processors

Source: <https://depositphotos.com/stock-photos/bionic-ear.html> and <https://www.cochlear.com/me/en/home/products-and-accessories/cochlear-nucleus-system/nucleus-sound-processors/nucleus-kanso-2>

Parts of a speech processor

Behind-The-Ear



Off-The-Ear



Figure 6: External speech processor

Source: <https://www.dreamstime.com/photos-images/hearing-loss-children.html> and <https://www.youtube.com/watch?v=epdAxINQaUM>

Internal implant

The internal implant consists of two parts:

1. The **receiver-stimulator** surgically placed under the skin and behind the ear
2. The **electrode array** that is inserted in the cochlea

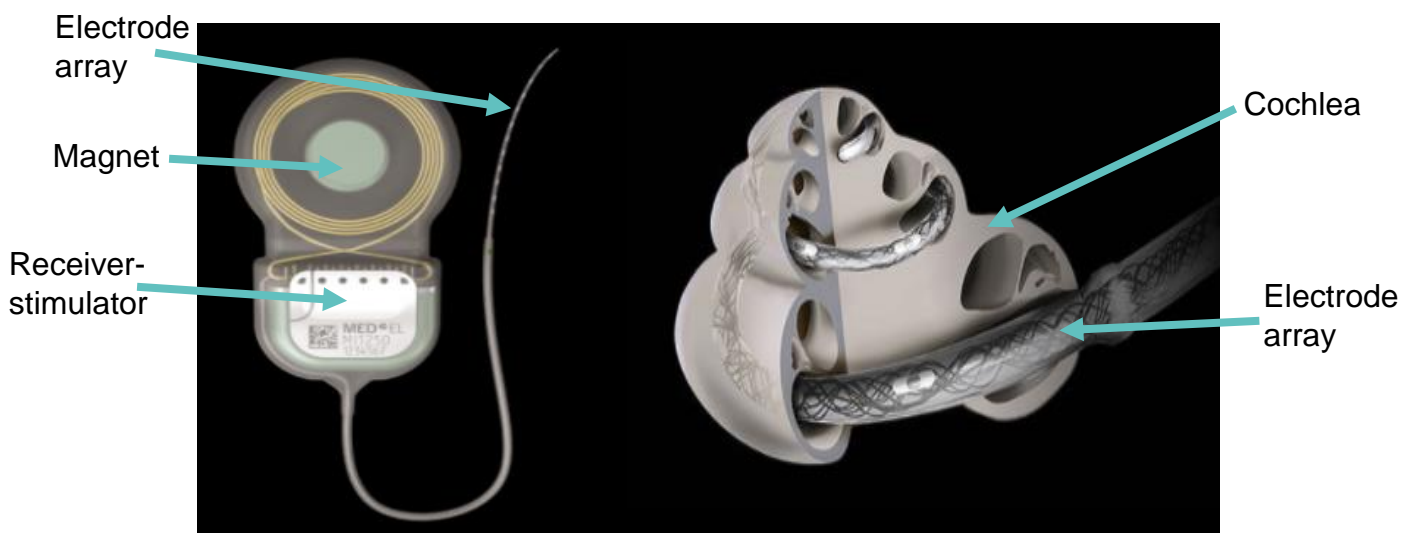


Figure 7: Internal implant

Source: <https://www.medel.com/hearing-solutions/cochlear-implants/synchrony2> and <https://www.medel.com/no/hearing-solutions/cochlear-implants/hear-the-difference>

How does a cochlear implant work?

1. **Microphones** on the speech processor picks up surrounding sounds and converts them into digital signals.
2. The coil, held on the head with a **magnet**, receives the digital signals before transferring them to the **receiver-stimulator** under the skin.
3. The **receiver-stimulator** converts the digital signals to electrical signals that are transmitted via a thin wire to the **electrodes on the electrode array** to stimulate specific locations of the cochlea.
4. These signals reach the brain via the auditory nerve, where they are recognised as sound. This process happens very quickly, with no noticeable time delay.

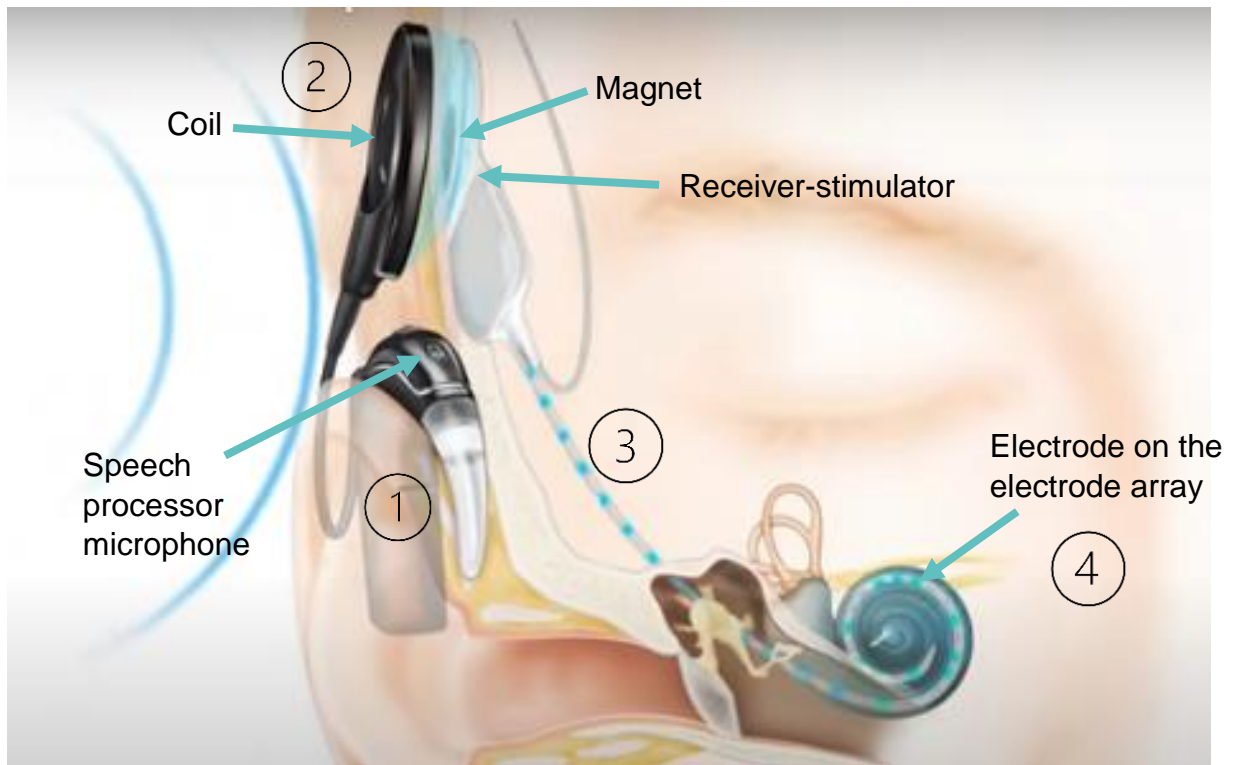


Figure 8: How does a cochlear implant work?

Source: <https://www.cochlear.com/us/en/home/diagnosis-and-treatment/how-cochlear-solutions-work/cochlear-implants/how-cochlear-implants-work>

Hearing with a cochlear implant

Although the sounds from the cochlear implant may not sound as 'natural' as they would to a person with normal hearing, infants and young children would nonetheless be able to build new brain pathways to process and make sense of the sounds around them using the cochlear implants.

With early intervention, consistent speech therapy, home practice and good family support, most children can learn to interpret sounds from the cochlear implant to understand and produce speech.

Section B: Assessment and selection

The Cochlear Implant Assessment

Your child will go through a cochlear implant assessment to assess his/her suitability for the implant. This assessment will be made by the implant team, which consists of:

1. ENT doctor
2. Audiologist
3. Speech therapist

ENT doctor

- Performs full examination of the ear to exclude other causes of hearing loss (e.g., ear infections).
- Evaluates your child's fitness for surgery.
- Checks your child's immunisation status.
- Orders and reviews imaging scans to identify abnormalities in the cochlea (via CT scan) and auditory nerve structures (via MRI scan).
- Explains and advises on the risks and benefits of surgery.
- Determines the type of implant most suitable for your child.
- Refers your child to other professionals (see page 15) for further tests (e.g., genetics testing, developmental assessment) where necessary.

Audiologist

- Conducts a hearing aid trial (approximately 3 months) to determine how beneficial hearing aids are for your child.
- Optimises the hearing aids and monitors hearing aid compliance.
- Performs tests to determine your child's pre-implant aided and unaided hearing levels, as well as speech perception abilities.
- Gathers information of your child's aided and unaided auditory skills/responses through informal tests, observations, questionnaires, etc.
- Refers your family to a medical social worker if financial assistance is required.

Speech therapist

- Conducts pre-implant aided speech and language baseline assessment.
- Gathers information on the child's functional listening, as well as play and social skills.
- Discusses therapy goals.
- Discusses the mode(s) of communication suitable for your child.
- Assesses the family's ability to support the child in developing speech, language, and communication skills.

Children with other co-existing developmental issues and health conditions, other than hearing loss, may be referred for further assessment by:

1. Geneticist
2. Paediatrician
3. Doctors from other disciplines
4. Other Allied Health Professionals (Psychologists, Physiotherapists etc.)

As part of the assessment, the implant team will also gather feedback from people who interact closely with your child (e.g., teachers, caregivers). Home and school visits may also be arranged.



Is my child too young for cochlear implants?

Hearing is critical for the brain to develop and form neural connections required for learning of speech and language. The most rapid changes in brain development happen during the first two years of life.

Therefore, hearing loss in children is considered a neurodevelopmental emergency. Should your child have hearing loss that cannot benefit from hearing aids, **cochlear implants should be offered as early as possible to suitable candidates**. Clinical studies have shown that children have the best opportunity to develop normal speech and language abilities with early, sufficient, and consistent auditory stimulation.





Section B: Assessment and selection Cochlear Implant Candidacy

Besides internal assessment, the implant team also takes reference from international guidelines, evidence-based research, input by other professionals, as well as feedback from the family to determine a child's suitability for cochlear implant candidacy.

The following evaluations will help the implant team estimate what the cochlear implant can do for your child. Every child's expected benefit with a cochlear implant is different. Most children who are early implanted are expected to learn to listen and speak close to, if not as well as their age-matched peers with normal hearing.

1. Medical

Medical evaluation:

Ensure no contraindications to surgery or active infections in the ear.

Imaging considerations:

To benefit from cochlear implants, the cochlea and auditory nerve should be present. In rare instances where both structures are absent, the implant team may suggest an Auditory Brainstem Implant. With improved surgical techniques and enhanced implant designs, individuals with abnormal inner ear structures can be implanted too. The severity of the structural abnormalities will be assessed to determine the suitability of cochlear implants.

2. Audiological

Considerations for a good implant candidate:

- Severe to profound sensorineural hearing loss and/or auditory neuropathy spectrum disorder.
- Derive little or no benefit from hearing aids despite good compliance with hearing aid use.

Age of child:

- Around 12 months old on the day of surgery.
- Special considerations to implant at <12 months can be made if the child is medically fit and/or for medical conditions requiring urgent cochlear implantations (e.g., meningitis).
- Older children may also be eligible if they develop sudden severe to profound hearing loss post-lingually (after the acquisition of speech and language) or if they have been using hearing aids but experienced a deterioration of hearing to a level where cochlear implants are recommended.

3. Speech and language

Speech and language considerations:

- A speech therapist will evaluate your child's preferred mode of communication. Based on the needs of your child and the family, a suitable mode of communication will be recommended.
- Speech and language outcomes with the cochlear implant may be poorer than expected if:
 1. Your child is diagnosed with a speech and language disorder (e.g., apraxia, severe oral-motor deficits) in addition to hearing loss.
 2. There is limited family support and compliance for the child's auditory-based training (e.g. attending speech therapy appointments and adhering to recommendations from speech therapists etc.).

4. Additional developmental and medical conditions

Depending on the severity of the child's co-existing condition(s), the implant team will provide counsel on expected outcomes and set realistic expectations with your child's additional needs in mind. Your child may be referred to other relevant professionals (e.g. neurologist, geneticist, education psychologist etc.) where appropriate. With suitable support systems and early intervention, children with additional needs can still benefit from cochlear implants.

5. Social

To help your child adapt to the cochlear implant and reap its maximum benefit, the family should:

1. Engage and encourage the child to use the device at all times when awake to ensure consistent access and adaptation to sounds.
2. Understand the commitment required post-implant and the importance of complying with rehabilitation plans.

6. School

The implant team works closely with other professionals such as paediatricians to recommend the appropriate educational placement for your child. With early intervention and intensive aural rehabilitation, **entering mainstream schools have become a more attainable goal** for children with cochlear implants.

To read about a mother's sharing on her child's experience integrating into mainstream school, please refer to Education (mainstream) under Section E: Useful Resources.

Based on the above evaluations, the implant team will:

1. Determine whether your child is a suitable candidate for cochlear implants.
2. Determine which ear the implant will be on (one or both ears).
3. Highlight issues that will potentially affect post-implant outcomes.
4. Set realistic expectations.
5. Come up with a comprehensive aural rehabilitation plan.

Importance of wearing hearing aids while waiting for the surgery

It is important to allow your child to use hearing aids in the interim, despite its current limitations, before the cochlear implantation surgery. While your child may not hear as clearly using hearing aids, there are several benefits of doing so during the wait:

1. Your child will still be able to hear some sounds, which is important for sound awareness. They may begin to associate loud environmental sounds with objects (e.g., dog barking) and become aware of different sound durations (e.g., long/short sounds) which will be key to understanding speech patterns with the cochlear implant later on.
2. Sounds received through the hearing aids can help stimulate the hearing nerve and brain. This will better prepare the hearing pathway to receive electrical stimulation from the subsequent cochlear implant.
3. Your child may have an easier time adapting to the cochlear implant speech processor on the ear/head if he/she is already used to the sensation of wearing hearing aids.



Section B: Assessment and selection

Cochlear Implant Selection

Once your child is deemed a suitable candidate for cochlear implant, your audiologist will help you choose a cochlear implant brand and model that best meets your child's needs.

Regardless of brand, all cochlear implant systems work the same way to provide access to sounds. Below are some **similarities**:

1. Automatic features

Based on the environment (e.g., general noise, listening to music, windy places etc.) the speech processors will filter out unwanted noise and **optimise the speech signals without manual adjustments**.

Data logging technology in the speech processor can automatically track important information like:

- The number of hours the cochlear implant is used per day.
- The number of hours of speech sounds the child receives per day.
- The different types of sound environments the child experiences per day.
- How many times the speech processor is removed or dropped per day.

2. Warranty period

Generally, in Singapore, cochlear implants have a **10-year implant warranty and 5-year speech processor warranty period**.

3. Access to future technology

The **internal implant is meant to last a lifetime** unless it malfunctions due to head trauma, device failure, etc. Regardless of brands, the internal implant is able to withstand all technological upgrades and changes to future speech processor upgrades.

Speech processors are typically upgraded every 5 years. Your audiologist will provide you with more information on processor upgrades during their consultations.

4. Waterproof solutions

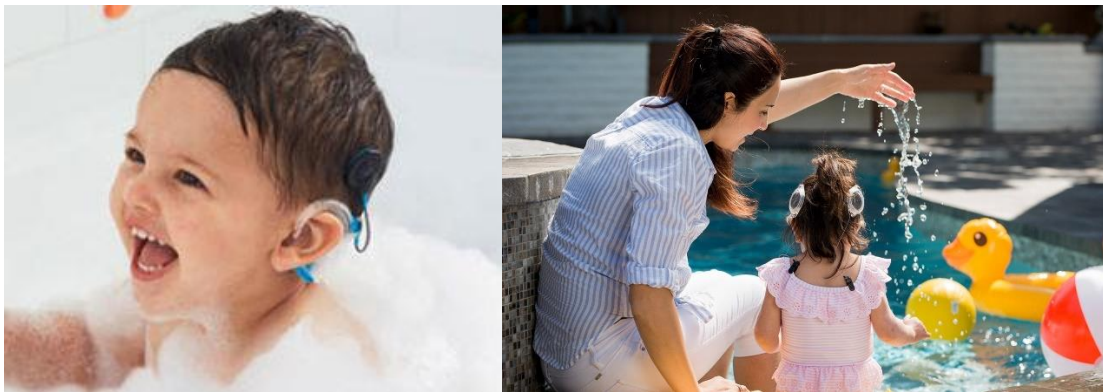


Figure 9: Waterproof kits

Source: <https://www.cochlear.com/sg/en/home/products-and-accessories/our-accessories/nucleus-water-safe-accessories>

The nano-coated speech processors are **water-resistant, but not waterproof**. To protect the speech processors during water activities, waterproof kits are available for separate purchase. These waterproof kits are usually not included in the standard subsidised order package.

5. Magnetic Resonance Imaging (MRI) compatibility

MRI scans involve the use of powerful magnetic field, measured in Tesla (T), to create detailed images of internal organs and tissues. The cochlear implant has a specially designed magnet that allows safe MRI scanning with the magnet in place for up to 3.0 Tesla. However, if the magnet obstructs the MRI area of interest or if the scan is over 3.0 Tesla, the internal magnet can be surgically removed before the scan.

Image obstruction
(black area) caused
by the implant magnet
that blocks the area of
interest in the MRI
scan image.

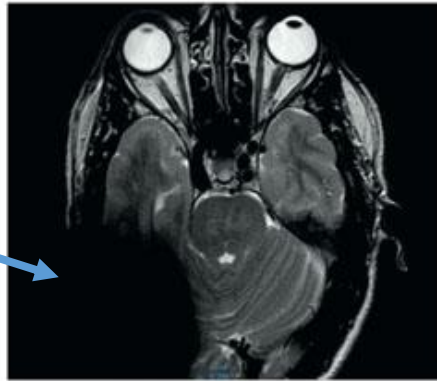


FIGURE 3: MRI pattern of the axial plain of a 1.5 T scanning Advanced Bionics 3D Implant.

Figure 10: Image artifact by internal magnet

Source: <https://www.hindawi.com/journals/bmri/2020/5086291/>

The following features in the cochlear implant system may not be available across all brands. You may wish to consider if these features are important for your child:

1. **Placement options** (behind-the-ear and off-the-ear).

2. **Wireless connectivity**

- Connects the speech processors wirelessly to remote microphones/ FM systems (typically used in classrooms) without any cables.

- Streams sounds directly from Bluetooth-enabled devices to the speech processor.

3. **Manage information and settings via mobile apps**

- Monitors battery life.

- Receive notifications when the speech processor is faulty or has fallen off child's head.

- Help locate the speech processor using GPS.

- Set daily hearing goals etc.

Section B: Assessment and selection Funding

Based on the recommendations by the Ministry of Health's Medical Technology Advisory Committee:

- All children below 18 years old (except non-residents) will be eligible for government subsidy for their first cochlear implant inserted in any of the restructured hospitals.
- Funding for bilateral cochlear implants is only for children below six years old unless there are special considerations (e.g., large vestibular aqueduct syndrome (LVA), meningitis, irradiated ears).
- The amount of government subsidy depends on the ward class selected, and family household income.
- Subsidies apply only to the standard packages or replacement packages of cochlear implant devices listed in the MOH's Agency for Care Effectiveness (ACE) website.
- Subsidies do not apply to devices and accessories that are not included in the standard, replacement or upgrade packages of the cochlear implant.

Financial assistance

You will be advised on the total estimated bill (after government subsidies) for the surgery and implants. However, if you require additional financial assistance, your audiologist may refer you to a medical social worker who can provide you with more information.

Section C: Surgery

Surgical Risks

What are some risks and potential surgical complications?

- Bleeding
- Infection
- Pain
- Scar behind the ear
- Swelling of the ear or scalp

Less common potential risks and complications:

- Facial nerve injuries or temporary weakness (although the facial nerve is closely monitored during surgery)
- Post-surgery dizziness for a few days
- Loss of hearing on the implanted ear, ringing in the ear (tinnitus)
- Loss of taste (temporary or permanent)
- Meningitis and leakage of cerebrospinal fluid into the ear or nose
- Anaesthetic complications
- Implant device failure
- Migration of the implant electrode array out of the cochlea

Before the surgery, please notify the surgeon of the following:

- Your child's health problems (e.g., allergies), if any.
- Your child's up-to-date immunisation records.
- Regular medications your child is taking, if any.

Section C: Surgery

Cochlear Implant Surgery Procedure

Pre-surgery instructions

1. Seven days before the surgery: Do not give your child any medication (e.g., aspirin), or traditional herbs (e.g., ginseng) that may increase risk of bleeding.
2. One to two days before the surgery: The hospital will contact you to advise on the fasting time required before surgery.
3. The night before the surgery: Wash your child's hair.
4. Morning of the surgery: Do not apply anything on your child's skin and make sure they do not wear any jewellery.
5. Morning of the surgery: If your child is on regular medications, the dose might need to be adjusted on the morning of surgery (refer to anaesthesia instructions).

Cochlear Implant Surgery Procedure

Duration: The cochlear implant surgery is performed under general anaesthesia, and takes around two to four hours per ear.

Preparation: A small amount of hair at the surgical site will be shaved and a small cut is made behind the ear.

Surgical procedure:

The mastoid bone is drilled until the cochlea is exposed. The electrode array is then inserted into the cochlea. A 'well' is made in the bone behind the ear to hold the receiver-stimulator. The surgeon will identify important facial structures, such as the facial nerves, to avoid.

To ensure that the implant is in good working condition and in the correct position, intra-operative testing of the implant and X-ray imaging will be done at the end of the surgery before your child wakes up from general anaesthesia.

What happens after the surgery?

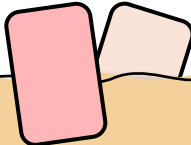
There will be a large pressure bandage around your child's head for the first 24 to 48 hours after surgery. Your child will be warded for approximately one to two days.

Your child's ear may protrude for a week. This is normal and is due to the swelling of the tissues after surgery. It is also normal to have some swelling in the tissues at the front of the ear and/or around the eye



Your child can be discharged the day after the surgery if there are no surgical complications. Post-surgery medications (e.g., analgesia, antibiotics, antacids etc.) will be prescribed on the day of discharge. The surgeon will check on the surgical wound(s) again during a follow-up session at the outpatient clinic approximately one week later.

Post-surgery tips

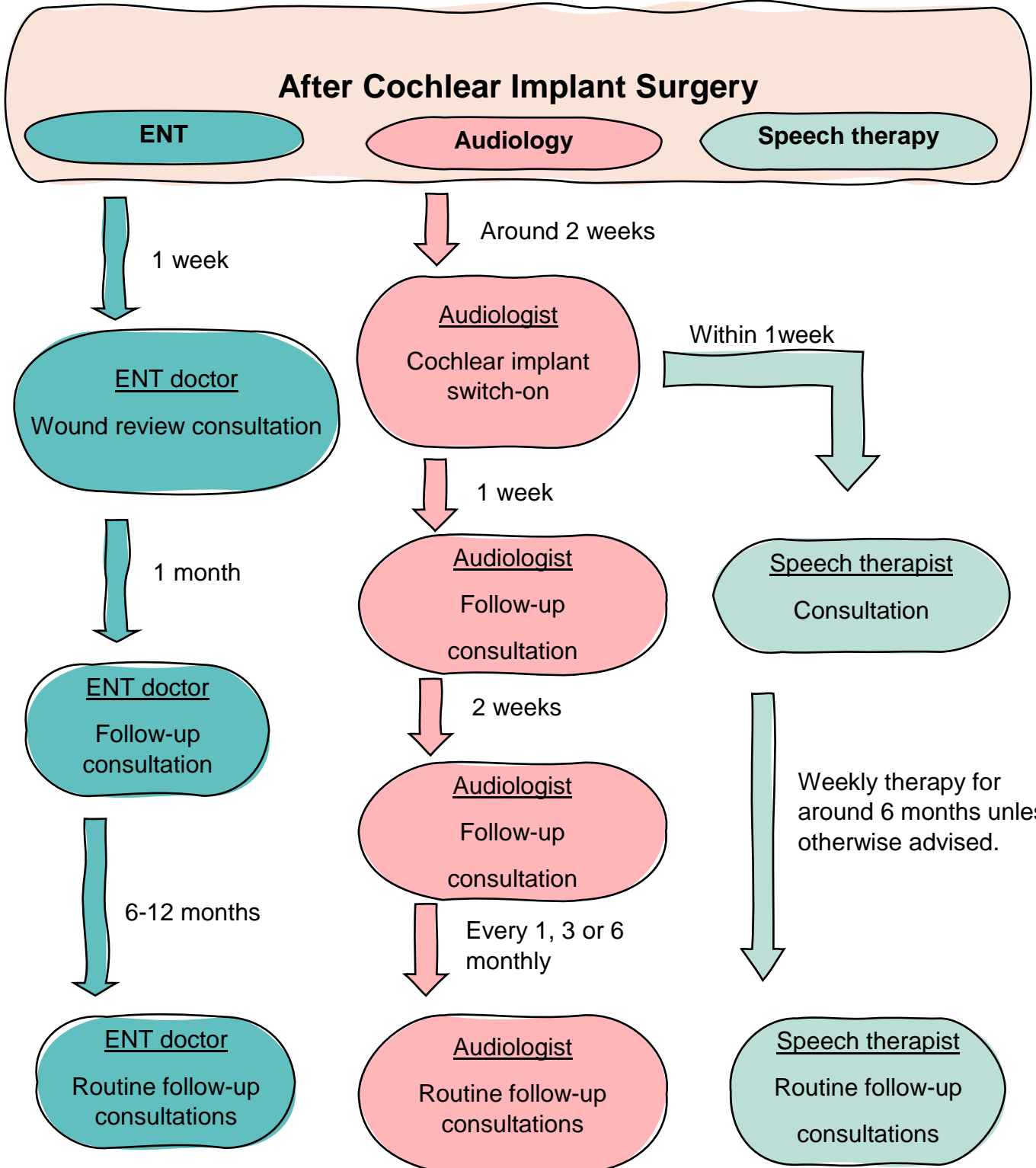
- 
1. Ensure your child has adequate rest four to five days after being discharged (quiet indoor play is still encouraged). Thereafter, your child can resume most normal activities. Vigorous activities such as heavy lifting and high-intensity exercises (e.g., jogging, tennis, aerobics, physical education lessons) should still be avoided for two weeks.
 2. Check with the doctor before resuming swimming or other water sports.
 3. Your child may return to school seven days from the date of surgery.
 4. Start your child with soft foods in case of temporary side effects like jaw pains or stomach sensitivity.
 5. Ensure your child sleeps with his/her head slightly elevated to help alleviate swelling.

Call the clinic or go to NUH Emergency Department (ED) or the nearest ED immediately if your child experiences any of the following:

1. Fever (oral temperature above 38 degrees Celsius).
2. New weakness or numbness of the face.
3. Pain that is not alleviated by pain medication and/or gets worse.
4. Severe headache, redness, swelling around the incision, giddiness and vomiting.

Call us at **6772 4135 / 4551** between **9am and 5pm on weekdays** for any **enquiries regarding post-surgery care.**

Post-surgery rehabilitation with the implant team



This schedule may vary depending on your child's progress, surgical complications (if any), as well as the caregiver's comfort and ability in maintaining the equipment and administering support.

Section D: Post-surgery Rehabilitation

Cochlear Implant Switch-on

What to expect during cochlear implant switch-on

The cochlear implant switch-on marks the beginning of your child's hearing journey. It will be at this session that your child will start to hear more sounds. The cochlear implant will initially be programmed at very soft levels so your child may not display strong reactions to sounds. Your child's brain will also need some time to adapt and make sense of sounds around him/her.

Some typical reactions at switch-on include:

- Smiling, laughing, and/or turning towards sounds
- Blinking and/or widening of eyes
- 'Freezing' and not moving when there is sound
- Crying
- Startled by loud sounds
- Attempts to remove the speech processor (e.g., by rubbing the head)
- Being more clingy than usual.
- Some children may have no response at all, and this is perfectly normal at the beginning.



Hearing age

Your child's hearing age starts on the day of the cochlear implant switch-on appointment, since that would be the first time they hear sounds. This hearing age (i.e., the length of time since the cochlear implant is implanted) will be used to monitor speech and language milestones, as compared with the chronological age of children with normal hearing. For example, a child with a one-year hearing age should have similar abilities as a one-year-old child with normal hearing. Refer to section E: useful resources (developmental milestones after implantation).

Cochlear implant programming during switch-on

The audiologist will connect the speech processor to the computer and run some checks on the implant to ensure that it is functioning. Based on the neural responses measured from electrical stimulation of the auditory nerve at each electrode, the audiologist will set the stimulation levels of the implant at a comfortable level and this setting is saved as a 'map' in the sound processor. The 'map' is usually set at a soft level during switch-on for your child to adapt to the sounds comfortably. The stimulation levels of the 'map' will be gradually increased over time based on your child's comfort and adaptation level.

What is a 'map'/'mapping'?

'Mapping' is a term that describes the programming of the speech processor to enable your child to hear a wide range of sounds comfortably. To determine the stimulation levels of the implant, the audiologist will adjust the levels of each electrode based on the softest and loudest sounds your child can hear, and store the settings in the sound processor as a 'map'.

What to expect after switch-on?

Monitor for skin redness and/or swelling at the magnet area

Skin redness following the shape of the magnet may be observed in some children for the following reasons:

1. Overly strong magnet strength
2. Prolonged pressure (e.g., lying on the magnet when resting, tight-fitting head wear) on the magnet area resulting in pressure sores.

Inform your audiologist immediately if you observe skin redness and/or swelling around the magnet.

Retention of the processor

Children may pull out the processor out of discomfort or curiosity, especially when their motor skills are still developing. For your child's continued hearing and brain development, ensure that he/she keeps the speech processor on **at all waking hours**.

There are many retention solutions available - hair clips, headbands, safety clips, retention cords, ear moulds, adhesive tapes etc. Your audiologist can recommend suitable options based on your child's needs.



Retention tips:

1. **Distract:** Draw attention away from the device with another activity.
2. **Consistency:** If you are consistent in putting on the speech processor for your child during all waking hours, he/she will eventually get used to and accept it.
3. **Decorate** and personalise the speech processors (e.g., stickers).

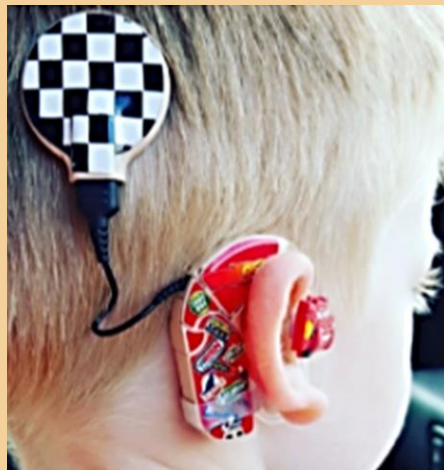


Figure 11: Decorated speech processor

Source: <https://blog.medel.com/10-cochlear-implant-gift-ideas-for-the-holidays/>

For more age-appropriate retention tips, refer to Section E: useful resources (hearing device retention).

Most children will eventually stop attempting to pull their speech processors off, especially when they start to relate to sound meaningfully. If they continue to refuse the device, this might indicate an underlying problem and **your audiologist should be informed.**

Monitor your child's responses

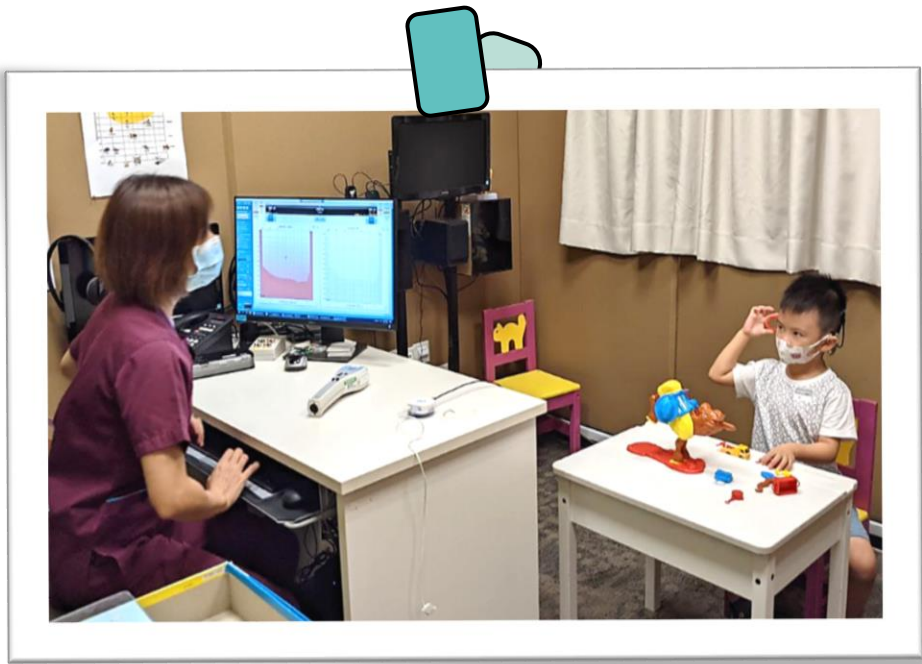
Some signs of progress in the first few weeks after switch-on include:

1. **Able to tolerate the speech processor for longer hours per day** (cochlear implants should be worn at all waking hours).
2. **Increases in vocalisation when the speech processor is worn.** Children tend to babble more if they can hear themselves and may explore different sounds and loudness).
3. **Reactions to loud sounds** (e.g., startling, eyes widening, sudden halts in movements).
4. **Experiments with sounds** (e.g., banging on toys or other objects)
5. **Quietens down when someone is talking or when there is music**
6. **Tolerates changes in the cochlear implant programmes/volume.** Your audiologist may give you instructions to increase the volume of the cochlear implants gradually after the switch-on.



Mapping during follow up

During follow-up sessions, the stimulation levels are progressively increased to ensure your child gradually and comfortably adapts to more sounds and their sound processor. During mapping, your child will participate in fun listening activities, similar to a hearing test, to ensure the stimulation levels are set optimally. Creating a map may take several sessions and your child's map will change over time. Therefore, routine mapping sessions are required.



Section D: Post-surgery Rehabilitation

Speech Therapy

Immediately after switch-on, your child will likely have very little sound knowledge. It takes time for your child to adapt and learn to interpret sound signals generated by the cochlear implant. Speech therapy is essential to facilitate this adjustment towards better listening and communication. It is important to supplement your child's speech therapy sessions with adequate caregiving and support systems (e.g., teachers). When necessary, speech therapists will conduct home and school visits to help facilitate a good communication environment for your child.

How frequently should my child attend speech therapy sessions?

Speech therapy for children needs to be intensive and frequent because they are learning language for the first time, without any foundation of language systems. A newly implanted child would typically require weekly therapy sessions over the first six months at least. Depending on your child's progress, the frequency of sessions may decrease thereafter.

Post-cochlear implant rehabilitation focuses on three main aspects:

1. Audition

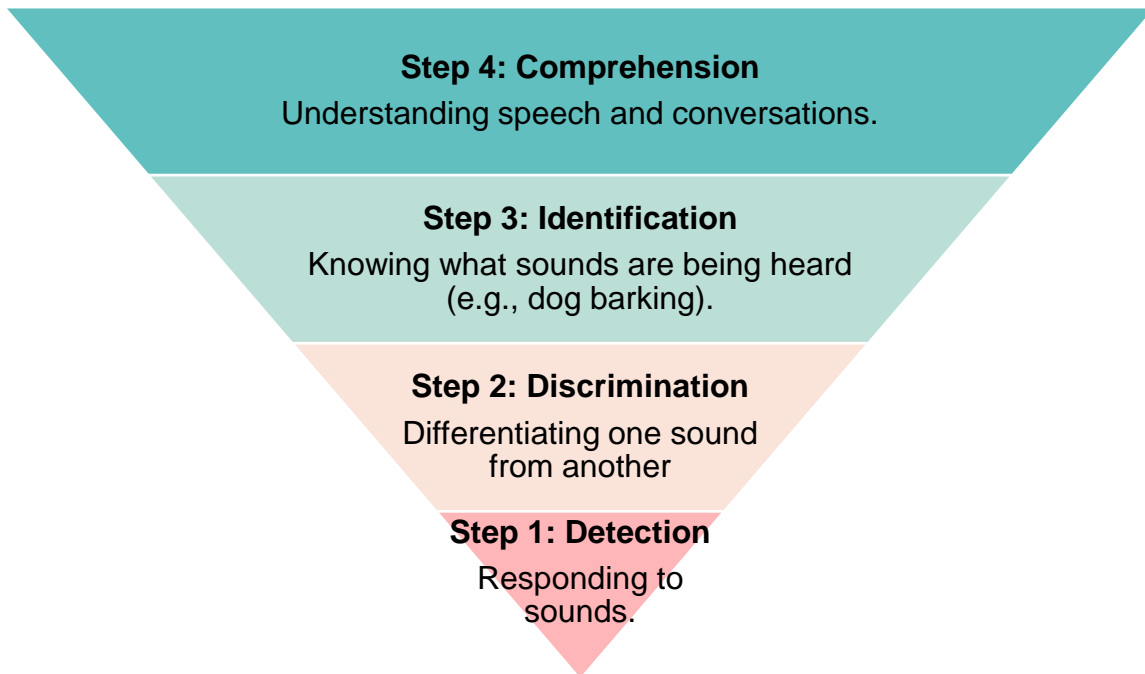
Your child must be able to hear well to develop good speech and language skills. If your child's audition is suboptimal, the speech therapist will refer your child back to the audiologist to check on and fine-tune the cochlear implant.

2. Brain development

Hearing is about building connections in the brain to process and make sense of sounds. The speech therapists will guide you on everyday strategies to teach your child to listen, talk and become an effective communicator. When you are interacting meaningfully with your child, their brains make connections that help develop understanding, vocabulary, literacy, problem solving skills, social skills, and more.

3. Communication

The speech therapist will guide your child to develop their auditory skills based on the **four-step auditory hierarchy**:



The Auditory-Verbal Approach

The auditory-verbal approach is one of the various proven methods to facilitate speech and listening for children with cochlear implants. This approach involves caregivers **as the primary facilitator**. The speech therapist will guide caregivers to help the child develop **verbal language as their main mode of communication** (also known as aural communication). Caregivers will learn to reproduce the techniques taught and harness opportunities for the child to listen and learn in a **fun and natural way**.

We also support children who may use other modes of communication (e.g., aural, signing, cued speech, total communication etc.) as their primary mode of communication, to develop audition. The outcomes may vary depending on your child's progress.

The Rehabilitation Process

Regardless of your child's mode of communication, we will, together with your family, set goals for your child's listening needs and formulate a coherent therapy plan through:

- a. Language development
- b. Speech development and expressive communication
- c. Pragmatics, cognition, social skills, play skills and conversational skills
- d. Auditory skills training
- e. Parent training – You are the best teacher and therapist for your child whom you know best!
- f. Joint goal setting and setting of realistic expectations
- g. Education
 - Teaching your child to self-advocate, build social connections and interact with people around them.
 - Teaching caregivers, support systems (e.g., teachers) and those around the child how they can enhance communication with your child.
- h. Fun, fun fun! – Children learn best through having fun. It is our commitment to make our sessions enjoyable for the best learning to take place.



Section D: Post-Surgery Rehabilitation

Ways to Achieve Good Outcomes with Cochlear Implants

The cochlear implant provides access to sounds but your child must learn how to use and adapt to this new sound signals. To achieve optimal outcomes, all of the following must be in place:

1. **Daily device use during all waking hours.**
2. **Perform regular checks on the device.**
3. **Use assistive listening devices (e.g., FM system) in school and in difficult listening environments.**
4. **Attend all scheduled audiology and speech therapy appointments.** This is to ensure that the cochlear implant is always fully optimised and sufficient auditory training is in place to ensure that the brain interprets incoming speech signals more accurately and efficiently.
5. **Perform daily auditory skills training at home.**
6. **Create a conducive listening environment for your child.**
7. **Be open about discussing joint goals and management plans with the implant team.**

The child may derive limited benefit from cochlear implants due to some factors:

- Limited use of the cochlear implant.
- Inadequate language stimulation.
- Significant malformation of the cochlea and/or hearing nerve.
- Late implantation.
- Presence of other disabilities.

**Section D: Post-Surgery Rehabilitation
Overview of the Cochlear Implant (CI) Journey**



Section E: Useful resources and FAQs

About Cochlear Implants

1. <https://www.ndcs.org.uk/documents-and-resources/cochlear-implants-information-for-families/> (Need to register with NDCS to download resource)
2. <https://www.med.unc.edu/earandhearing/wp-content/uploads/sites/754/2018/11/Handbook.12.2018.pdf>
3. <https://www.nextsense.org.au/assets/downloads/NextSense-Cochlear-Implant-Handbook.pdf>

Auditory Neuropathy Spectrum Disorder

1. <https://www.ndcs.org.uk/information-and-support/childhood-deafness/causes-of-deafness/auditory-neuropathy-spectrum-disorder-ansd/>
2. <https://www.babyhearing.org/auditory-neuropathy-spectrum-disorder>

How to Interpret an Audiogram (Familiar Sounds Audiogram eBook)

<https://www.hearingfirst.org/m/resources/7734>

Developmental Milestones after Implantation

<https://advancedbionics.com/content/dam/advancedbionics/Documents/libraries/Tools-for-Toddlers/Using%20Normal%20Developmental%20Milestones.pdf>

Education (Mainstream)

<https://www.advancedbionics.com/com/en/home/contact-us/blog/articles/how-our-mainstream-school-embraced-our-child-tinsman.html>

Hearing Device Retention

<https://www.oticon.com/-/media/oticon-us/main/download-center/family-support-materials/professional-all/35537-keeping-hearing-aids-on-young-children.pdf>

Frequently Asked Questions (FAQs)

Will the cochlear implant restore normal hearing?

Although the cochlear implants can improve quality of life through better speech understanding and recognition of environmental sounds, they **cannot fully restore normal hearing**.

Will my child outgrow the internal implant and require surgery for a replacement?

No. The cochlea is fully formed at birth, and it will not continue to grow bigger (i.e., the position of the electrode array in the cochlea will not change with age). Although your child's skull will continue to grow, it will not affect the position or function of the implant.

Does cochlear implant involve brain surgery?

No, the cochlear implant surgery is an inner ear surgery and does not involve the brain.

Will I see immediate benefits after my child is implanted?

After switch-on, the brain takes time to adjust and learn to hear through daily listening and therapy. Some responses to sounds (e.g., crying, eyes widening) are observed initially but significant improvements will take time.

How long should my child wear their speech processors?

Your child should wear their speech processors daily and at all waking hours so as to optimise listening opportunities and brain development.

It is common for children to try to take off or remove things such as hats or glasses if they are not accustomed to it. This includes hearing devices. Consistent wear and use is key in allowing your child to become accustomed to the device as soon as possible.

Should I expose my child to music and musical instruments?

Definitely! According to research, musical activities like singing, dancing, and playing musical instruments can help to improve a child's ability to appreciate pitch and rhythm, which will help develop speech and language too!



Figure 12: CI and music exposure

Source: <https://www.cochlear.com/in/en/home/products-and-accessories/cochlear-nucleus-system/nucleus-sound-processors/nucleus-kanso-2?fg->

<https://www.cochlear.com/in/en/home/products-and-accessories/cochlear-nucleus-system/nucleus-sound-processors/nucleus-kanso-2?fg-agp=gZbw%252FkcxixKka3NRAGjUHYnM846ZR3oMablg0uv3GwxcC1ycl%252FhjrKl4YwaZLqDGLAI5qGMtdtgSir173CV9ELsF%252FjhUfvQNh7LIIVBv78PI9W2VSIUC0ooknznAdwcqFcOvutliGLjP1uvFHGc%252FI45aqo5ORM69G%252B4xRKNEjDjGLuJJZjuoxvMeOpsTESiWcToXs2fc8rNfdXu93ELXhDk5393CiOxaQERrNf0xEQ0vH37ky4QQtw2l%252BVYNOGnWVf%252FGWfLPbW6YLuQYgbx49cm8NIQGEuZuav%252BFSDFTDgo3bBB0342C2NaMKsLKkrp%252BIbV3nz7u9kc2nG0ew%253D>

What should I do if my child hits their head near the cochlear implant region?

If there are no symptoms, do not panic and continue to monitor your child closely. Contact the clinic during working hours or go to NUH Emergency department or the nearest Emergency department if there are symptoms such as extreme pain, swelling, dizziness and vomiting.

Are there any sports or activities that are not permitted?

Activities that involve high risk of physical impact on the head (e.g. rugby and combat sports) can result in failure of the external device and/or internal implant. Implant failure will normally require surgical replacement. If the risk of high impact contact cannot be avoided, take suitable precautions (e.g., wearing a protective headgear) to minimise risk of damage to the cochlear implant system. For activities that involve extreme changes in air pressure (e.g., skydiving and scuba diving), please consult your child's ENT doctor first.

What should I do if my child needs to go through security scanners (e.g., before a flight)?

Present your child's implant ID card to the security staff and airline personnel. They may or may not ask your child to turn off or take out the speech processor during the security scan. Passing through the metal detector, undergoing body scans, and passing the speech processor through an X-ray machine **will not** damage the device. Your child may however, experience distorted sounds when passing through or going near these devices.