

# Breaking the Sound of Silence – Modern Hearing Implants

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Hearing loss is one of the most common medical conditions in Singapore, with as many as 360,000 persons in Singapore affected<sup>1</sup>. Of these, many suffer from disabling hearing loss, which is defined by the World Health Organization (WHO) as hearing loss greater than 40dB in the better hearing ear in adults, and a hearing loss greater than 30dB in the better hearing ear in children.



▲ Eugene Goh, a 5-year-old child with bilateral cochlear implants with his doctor, Dr Barrie Tan.

The WHO estimates that over 5% of the world's population has disabling hearing loss<sup>2</sup>. This increases with age, with approximately one-third of people over 65 years of age affected by disabling hearing loss<sup>2</sup>. This has significant impact for Singapore as our population rapidly ages, with the number of persons over 65 years of age tripling to 900,000 by 2030<sup>3</sup>.

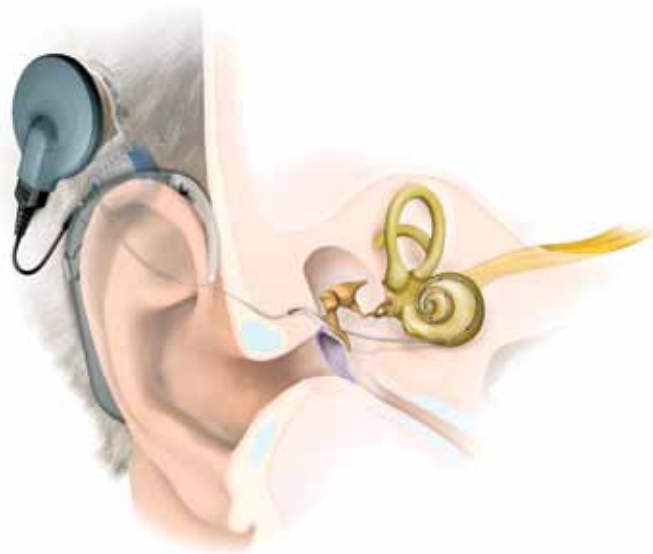
Conventional hearing aids are the most common form of hearing augmentation. They are readily available commercially, do not require surgery and are reasonably well-accepted. However, there are large numbers of patients who are not suitable for hearing aids. Their hearing loss is too severe to receive any reasonable benefit from the

amplification provided by hearing aids. Alternatively, hearing aids worsen their chronic middle ear disease and causes recurrent infections.

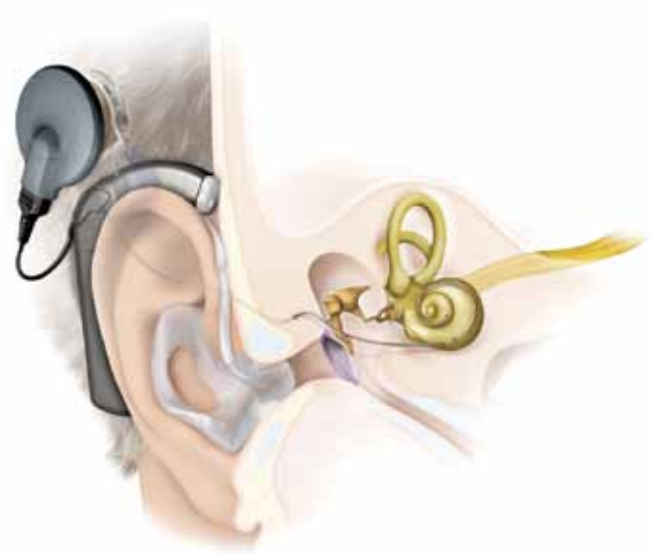
There are also patients where straightforward surgical procedures will remedy the hearing loss without the subsequent need for hearing aids or hearing implants. Examples include stapedotomy operations for patients with otosclerosis. Hearing aids range in cost from \$1,000 to \$5,000 for each set. To fit one inappropriately therefore can be an expensive exercise in frustration.

**Patients often believe that hearing aids are the only hearing solutions. When these fail, many give up hope and do not seek further treatment. The good news is that in today's context, there is a modern surgical hearing implant for almost all types and degrees of hearing loss.**

In fact, there have been exceptional results attained for the most profoundly deaf patients. Many of our children born deaf and implanted with cochlear implants listen and speak with perfect diction, top their classes in mainstream schools and play sports like all normal-hearing children. The answer is there is hope, with a hearing solution that can be customised to every patient and need.



▲ The components of a Cochlear Implant System with the external speech processor and the internal implant with the electrode inserted in the cochlea. (Source: Med-El)



▲ The components of an Electro-Acoustic Stimulation implant. (Source: Med-El)

### Cochlear implants

The most famous surgical hearing implant is the cochlear implant. Cochlear implants help the most profoundly deaf patients. Many of these patients have severely damaged cochlear hair cells. These hair cells are responsible for converting the physical sound wave transmission in the inner ear/cochlea into electrical impulses, which then travel down the cochlear nerve endings and cochlear nerve to the brain. Cochlear implants help patients as they bypass the damage at the cochlear hair cells and directly electrically stimulate the cochlear nerve endings.

Cochlear implants were made commercially available approximately 30 years ago and up to 2008, there have been a total of approximately 172,000 cochlear implants performed worldwide<sup>4</sup>. In Singapore, the first adult cochlear implant was performed in 1989 and the first child cochlear implant was performed in 1997. Both

cases were performed in Singapore General Hospital (SGH).

Since then, SGH has performed the highest number of cochlear implants of any single institution in Singapore, with a total of 476 cochlear implants performed thus far. It has been performed in adults as old as 80 years old and in children as young as 1 years old.

Of late, cochlear implants have also been indicated in patients with a variety of other hearing loss patterns. One of these patterns is known as partial deafness, where there is complete loss of hearing in the high frequencies, but residual hearing in the low frequencies. Such patients are able to make out only parts of words and sentences as they do not have hearing in the full auditory spectrum.

Such patients are candidates for Electro-acoustic stimulation (EAS) or 'Hybrid' implants. These are cochlear implants that are coupled with an

integrated acoustic hearing aid. The cochlear implant component stimulates the high frequencies electrically whilst the acoustic hearing aid stimulates the low frequencies acoustically. This happens simultaneously. To complement these 'all-in-one' implants, special surgical techniques to preserve the residual low frequency hearing during surgery are employed.

Another recent advance is in the use of cochlear implants to treat single-sided deafness due to sudden sensorineural hearing loss (SSNHL). SSNHL is often idiopathic and can affect individuals in the prime of their adult working lives. Many of them do not recover their hearing and subsequently live with single-sided deafness. SGH has embarked on a pioneering pilot study in Singapore to study the benefits of placing a cochlear implant for such patients. Patients recruited for the study will have their cochlear implants sponsored.

**Cochlear implants help the most profoundly deaf patients, many of whom have severely damaged cochlear hair cells.**

**The BAHA is indicated in 2 types of patients. Firstly, it is indicated in patients with conductive hearing loss. Secondly, the BAHA is also indicated in patients with single-sided deafness.**

**Bone Anchored Hearing Aid (BAHA)**

The next most common surgical hearing implant is the Bone Anchored Hearing Aid (BAHA). This is a form of bone conduction hearing implant. The BAHA comprises a titanium screw that is embedded into the skull, which then attaches to an external vibrating speech processor to allow direct conduction of sound through the skull bone to the cochlea. Worldwide, there have been 100,000 BAHA recipients as of the end of 2013<sup>5</sup> and patients as young as 5 years of age have been implanted with the BAHA.

The BAHA is indicated in 2 types of patients. Firstly, it is indicated in patients with conductive hearing loss. Conductive hearing loss occurs when there is a problem with the transmission of sound waves through the external ear or middle ear. This may be due to diseases that erode the ossicles, damage the tympanic membrane or block the external ear.

In such patients, often the inner ear is unaffected and the sensorineural hearing capability of the cochlea is normal. The BAHA works by converting the sound waves into bone vibrations that bypass the block in the external or middle ear and directly vibrate the fluid in the cochlea, thereby allowing for sound perception by the cochlea.

Secondly, the BAHA is also indicated in patients with single-sided deafness. The BAHA is implanted on the side of the deafness so that it is able to receive and process the sounds on the deaf side. The BAHA then transmits the bone vibrations to the cochlea on the opposite ear.

This allows the opposite good ear to hear sounds originating from the deafened side. This is called 'pseudo-binaural' hearing where patients no longer miss sounds coming from their deaf ear. However, all hearing goes through the only normal hearing ear.



▲ The internal component of a Bonebridge embedded under the skin and the external speech processor attached to the skin via a magnet. (Source: Med-El)

**Bone conduction hearing implant**

Similar to the BAHA, there is also a new bone conduction hearing implant known as the Bonebridge, launched 2 years ago. The Bonebridge is different in that there is no exposed screw. The speech processor sticks to the skin via a magnet communication to the internal vibrating component, which is embedded under the skin.

The indications for the Bonebridge are similar to the BAHA, except that the minimum age requirement is 18 years of age.

**Active middle ear implants**

Active middle ear implants are another entirely different class of surgical hearing implants. Examples include the Vibrant Soundbridge® system and the Carina® system. They comprise an internal vibrating prosthesis that directly vibrates the middle ear ossicles or the round window. This results in greater vibration energy being transmitted to the inner ear, leading to better hearing.



▲ A patient with a Bone Anchored Hearing Aid (BAHA) with a speech processor attached (left) and without a speech processor attached, showing the exposed titanium screw (right). (Source: Cochlear Ltd)



▲ A Vibrant Soundbridge system applied onto the incus. (Source: Med-El)



▲ The components of a Vibrant Soundbridge Active Middle Ear Implant. (Source: Med-El)

These devices are indicated in two situations. The first situation is where there is significant sensorineural hearing loss, usually affecting the higher frequencies more than the lower frequencies. These patients usually do not achieve sufficient benefit from conventional hearing aids as the amplification of the higher frequencies in a hearing aid is usually limited. Active middle ear implants are able to give greater increase in high frequency hearing than conventional hearing aids.

The second situation where active middle ear implants is indicated is where there are missing ossicles or

other forms of conductive hearing loss. The vibration can be directly applied to the remaining ossicles or to the inner ear so as to bypass the block in the transmission of the acoustic sound waves.

These active middle ear implants can be semi-implantable like most other surgical hearing implants, where the speech processor is exposed and communicates with the internal components via a magnet. They can also be totally implantable where all the components are entirely embedded under the skin and the patient has 24-hour continuous hearing.

### Auditory Brainstem Implant (ABI)

The last type of surgical hearing implants is called the Auditory Brainstem Implant (ABI). These implants have an active plate-shaped electrode that is applied onto the brainstem where the cochlear nucleus is, to electrically stimulate the brainstem nucleus and thereby the auditory pathway.

ABIs are indicated in patients with hearing loss due to Vestibular Schwannomas or other tumours that have affected the cochlear nerve. NeuroFibromatosis Type 2 patients particularly require these implants as they have bilateral Vestibular Schwannomas.

### SGH Centre for Hearing and Ear Implants

Complementing the surgeons who perform this entire gamut of possible surgical hearing implant solutions, the SGH Centre of Hearing and Ear Implants has the largest complete team of hearing professionals in Singapore.

Multiple Audiologists perform the necessary digital programming of

the hearing implants after surgery, in a process called 'mapping'. Auditory Verbal Therapists help with the auditory rehabilitation process through specialised therapy sessions that focus on using the new hearing input for speech and language communication. Medical Social Workers help navigate the funding application process and look into the social issues for families of our hearing-impaired patients.

It is the mission of our team that every hearing-impaired person is helped and given the necessary hearing solution to aid him in independent living. Indeed patients no longer have to live under the sentence of a life in silence. This modern hearing story continues with more surgical hearing implants being designed and refined to help countless patients with hearing impairment!

### GP CONTACT

GPs can call for appointments through the GP Appointment Hotline at 6321 4402.

### References

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