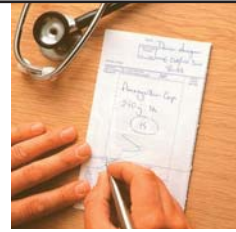


# Implantable hearing devices



## Beyond hearing aids

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A number of implantable hearing devices have recently emerged from the realm of experimentation to that of clinical practice. Implantable hearing devices are now available for patients with hearing loss in whom previously conventional hearing aids were inappropriate or inadequate. What are these devices and who would benefit from these technologies?

Significant hearing loss currently affects one in 10 Australians over the age of 55 years. In adults, it is well established that hearing loss is associated with psychological symptoms, interferes with workplace efficiency, and is a source of frustration in interpersonal communication. In children, untreated hearing loss can result in poor speech and language development as well as educational and developmental difficulties.

### Are hearing aids enough?

The rehabilitation for patients with hearing loss has traditionally been limited to environmental manipulation, educational assistance and hearing aid fitting for amplification. Hearing aids are suitable for the majority of patients with hearing loss.

Over the past decade there have been significant improvements in digital hearing aids.

However, there are a number of patients in whom hearing aids are either unsuitable or offer inadequate amplification. Implantable hearing devices have recently emerged as an alternative option for these patients.

### Implantable hearing aids

The three most common implantable hearing devices currently available are:

- cochlear implants
- bone anchored hearing aids, and
- the RetroX implantable hearing system.

### What are the advantages?

A significant proportion of patients remain dissatisfied and underserved with hearing aids despite appropriate fitting and programming by their audiologist. Implantable hearing devices are suitable for patients experiencing sound distortion, ear canal occlusion, acoustic feedback or adequate amplification with conventional hearing aids.

In addition, there are otological conditions in which conventional hearing aid usage is contraindicated. Chronic otitis externa and media, may be exacerbated by the occlusion of the canal by conventional hearing aids. Congenital atresia of the external ear often makes hearing

aid use impossible. Therefore, implantable hearing aid technology has emerged as the preferred treatment option in these patients.

### What are the disadvantages?

All types of implantable hearing devices require surgery for insertion of the internal portion of the device. These implants are made out of silastic and titanium, materials that are biocompatible. As with any type of artificial implant there is a risk of infection. This is minimised with a sterile insertion technique and the use of prophylactic antibiotics.

All three implantable hearing devices are driven by batteries that are replaceable in the external portion of the device. As technology progresses, implantable devices have the capacity to be upgraded in the future without the need for further surgery.

### Cochlear implants

In the past 2 decades, the cochlear implant has revolutionised the management of adults and children with severe to profound hearing loss. Often hearing aids are not powerful enough to offer these patients amplification adequate to understand speech or hear soft environmental sounds.

### What causes cochlear hearing loss?

Many disease processes may lead to loss of hair cells in the cochlea. The two commonest causes are the natural processing of aging (presbycusis) and chronic noise exposure. It is unusual in either of these conditions for the hearing loss to become complete, therefore total hearing loss is unlikely and treatment with hearing aids is often effective.

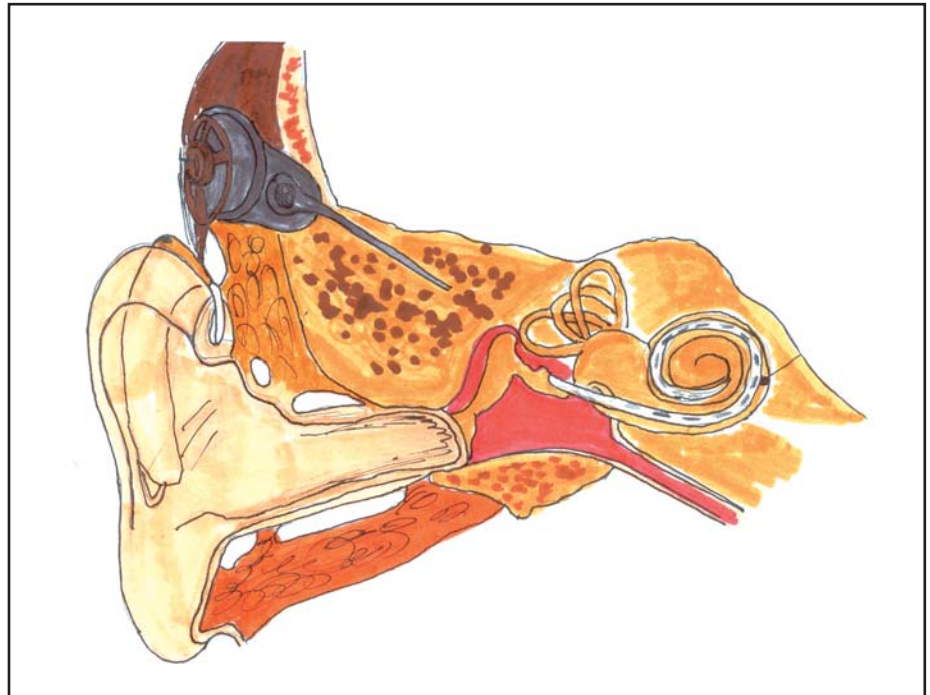
There are a number of acquired causes of hair cells loss that have the potential for total or near total hearing loss and the most common causes are listed in *Table 1*. Profound hearing loss may be present at birth or soon after. Recessively inherited nonsyndromic deafness is the most common.

### How do cochlear implants work?

A cochlear implant is an electronic device surgically implanted behind the ear providing auditory sensation by direct stimulation of the cochlear nerve. Over the past 5 years there have been dramatic advances in both the software and hardware of cochlear implants, together with improved surgical techniques. This has led to a significant widening of the candidacy of patients who could potentially benefit from their use. The hardware of the cochlear implant consists of both an external and implanted component (*Figure 1*).

The externally worn component of the cochlear implant is presently contained entirely behind the ear (*Figure 2, 3*). It contains a microphone at the level of the ear that detects sound. The sound is then transformed from an acoustic signal to an electromagnetic signal by the inbuilt speech processor. The transformed signal is then transmitted to the internal portion of the implant through the intact scalp by communicating magnetic coils.

The implanted internal component lies within a bony seat created within the thickness of the cranium behind the auricle (*Figure 4*). This component transforms electromagnetic signal to electrical impulses that travel to each of the 22 electrodes situated within the cochlea (*Figure 5*). The sound information is subsequently sent along the cochlear nerve to the higher centres of the brain for interpretation.



### Surgery – what's involved?

The procedure for insertion of the cochlear implant is performed under a general anaesthetic. It takes approximately 2 hours. Both adult and paediatric patients are admitted overnight.

A small incision is made within a skin crease behind the ear. A pocket is created beneath the skin and muscle for the internal portion of the implant as it sits within the thickness of the skull. The cochlea is accessed by the removal of the bone of the mastoid behind the ear.

The device is switched on and programmed by a trained audiologist 3 weeks following surgery. This allows time for the wound to heal and the mild soft tissue swelling to settle.

In the office setting, the cochlear implant is connected directly to a computer via a magnetic coil for programming. Each of the 22 sites of stimulation of the electrode in the cochlea is programmed individually. As the patient becomes familiar with the implant through its use over the ensuing weeks, the programming of the cochlear implant is refined to attain the best sound quality for the patient.

### What do patients hear with a cochlear implant?

At the time of 'switch on' patients often initially describe speech perception with the implant as having an electronic or robot-like quality. With time and use the quality of audition rapidly approaches that of natural and normal hearing.

Adult patients with hearing loss that has occurred following the acquisition of speech and language (postlingual hearing impaired) perform exceedingly well. Generally these patients are able to detect all audible environmental sounds and speech. Most patients



understand speech through audition alone without the assistance of lip reading, and are therefore able to use the telephone.

In infants with hearing impairment, the earlier a child is identified with a hearing impairment and is implanted with a hearing aid the better that child will perform. Infants implanted at an appropriately early age develop normal or near normal language and speech. It is becoming increasingly clear that the majority of congenitally deaf children implanted by the age of 2 years are able to take their place in mainstream schools after 3 years of implant use and training, albeit with some degree of continued support.

#### **Who is suitable for a cochlear implant?**

Cochlear implants are suitable for patients of any age with a sensorineural hearing loss who receive minimal benefit from hearing aids. No child is too young and no adult is

too old to be considered for cochlear implantation. The elderly are able to benefit from cochlear implantation equally as well as infant implantees.

Severe congenital malformations (eg. absence of the cochlea or cochlear nerve) preclude cochlear implantation. Meningitis as a cause of deafness necessitates the early consideration of cochlear implantation. An early sequela of meningitis is ossification of the cochlea that can make cochlear implantation more difficult.

#### **Bone anchored hearing aids**

## **What is it?**

With a bone anchored hearing aid the sound is transmitted directly to the cochlea independently of the external and middle ear (*Figure 6*) and is used in patients with conductive hearing loss or unilateral profound hearing loss (as sound is transmitted to the

contralateral cochlea).

## **How does it work?**

The bone anchored hearing aid consists of a minute titanium fixture implanted into the skull behind the auricle. A small external hearing aid is attachable to the implanted titanium fixture (*Figure 7*). Sound is detected by a microphone in the external hearing aid and is transformed into vibratory signals to the underlying bone. The skull bone serves as an ideal conductor of sound vibrations (*Figure 8*). Therefore these vibratory signals are transmitted directly to both inner ears, bypassing the external and middle ears.

## **Who is suitable for a bone anchored hearing aid?**

The bone anchored hearing aid is suitable for patients with a conductive hearing loss where hearing aids are not suitable because of chronic ear infection, ear canal atresia and discomfort caused by the occlusion of the ear canal. In addition, the bone anchored hearing aid is suitable for patients with a total unilateral sensorineural hearing loss due to such conditions as Meniere disease, acoustic neuroma and sudden sensorineural hearing loss.

## **Surgery – what's involved?**

Surgery to insert the titanium implant takes 1 hour and is performed as a day surgical procedure. It is usually performed under general anaesthetic. In selective cases it is possible for the procedure to be performed under local anaesthetic. The operation is safe and is associated with minimal pain and risk.

## **The benefits**

The bone anchored hearing aid offers patients with a conductive hearing loss the ability to hear without occlusion or irritation of the ear canal. In particular it is suitable for patients with congenital malformation of the outer ear. In addition, the bone anchored hearing aid offers patients with a total unilateral sensorineural hearing loss the ability to hear on the side of the deaf ear. Therefore patients have improved hearing in the presence of background noise and are able to localise sound.



## RetroX implantable hearing device

### What is it?

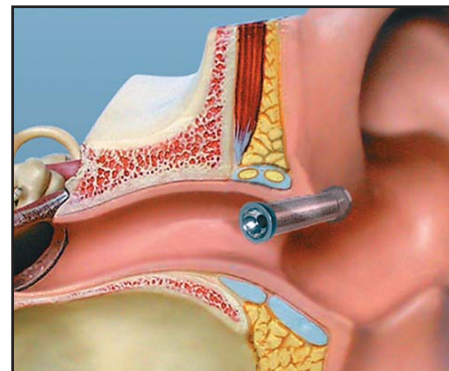
The RetroX implantable hearing device is an innovative type of hearing system that works without occluding the ear canal. Discomfort commonly experienced by users of conventional hearing aids such as the occlusion effect, moisture build up, and ear mould irritation are eliminated. The RetroX implantable hearing device is suitable for high tone sensorineural hearing loss. This is the most common type of hearing loss as seen with presbycusis, infection, noise exposure and ototoxicity.

### How does it work?

The RetroX implantable hearing device consists of an implanted titanium tube and a minute external digital hearing aid (*Figure 9*). The digital aid attaches to and sends the amplified acoustic signal through the titanium tube that is surgically implanted through the soft tissue of the external ear (*Figure 10*). As the digital aid is detachable, the patient is able to swim and shower without any water precautions.

### Who is suitable for a RetroX implantable hearing device?

The RetroX implantable hearing device should be considered as an option in any adult patient with a high tone sensorineural hearing loss who has not been satisfied with conventional hearing aids. Dissatisfaction with conventional hearing aids may be as a result of a variety of factors including: lack of tolerance of the occlusion effect, allergic reaction



to otoplastics, chronic ear infections exacerbated by moisture trapped by an occluded ear, and frequent wax occlusion. In addition, the RetroX implantable hearing device is completely behind the ear crease and is therefore more cosmetically desirable (*Figure 11*).

### Surgery – what's involved?

The 30 minute procedure to fit the titanium tube component is usually performed under local anaesthetic in the office or operating theatre setting.

### What are the benefits?

The RetroX implantable hearing device has a number of advantages over conventional hearing aids that occupy the ear canal. These include superior clarity of sound, comfort and cosmesis in selected patients.

## Conclusion

In the future, hearing aid technology will be totally implantable underneath the skin and may well be driven by biological energy. Devices will be wirelessly linked to technology such as telecommunication and global satellite positioning. The greatest advance will be when cochlear hair cell regeneration is possible. Within the next few decades the neurotrophic factors that make this possible may be discovered; until then, conventional and implanted hearing aid technology will offer significant benefit to appropriately selected patients with hearing impairment.

Conflict of interest: none declared.