Cochlear implantation: a panacea for severe hearing loss?

Philip A Bird, Daran Murray

A cochlear implant (CI) is a device which replaces the auditory function of the outer, middle, and inner ears to directly electrically stimulate cells of the spiral ganglion and thus the cochlear nerve. The device consists of an external component which includes a microphone, speech processor, cord and magnetic radiofrequency transmitter, and an internal implanted component including a receiver-stimulator and an electrode array which is coiled inside the cochlea.

The microphone detects sound which it then converts into a coded, electronic signal by the speech processor. This signal is then transferred (via the external cord and magnet) to the internal receiver-stimulator. The complex signal is then transferred to multiple individual electrodes within the cochlea to create multiple, small, electrical fields which then stimulate the adjacent neural elements. As the vast majority of sensorineural hearing loss (SNHL) is caused by hair cell loss, proximal neural elements survive in sufficient numbers to conduct the signals to the auditory cortex.

Over the last 25 years there has been significant improvement in the technology (and subsequent performance) including huge development in speech processing strategies, miniaturisation of components, and improved electrode design. The technology is expensive, costing about NZ$30,000 for the hardware (implanted plus external), plus the costs of surgery, audiology, and habilitation. These costs must of course be balanced against the cost to individuals with severe to profound sensorineural hearing loss in terms of education, reduced workforce participation, and increased incidence of mental health issues, not to mention the huge quality-of-life benefits of this technology.

Cochlear implants are indicated for those individuals for whom hearing aids are not providing enough amplification for the understanding of speech and language. This generally involves severe to profound SNHL, especially in the frequencies above 2 kHz. Suitable candidates fall into two basic groups: postlingually deafened adults and children, and prelingually deafened children. Adults who have previously heard make excellent CI candidates.

Functional clues to candidacy include increasing reliance on lip-reading and inability to effectively use the telephone despite adequate up-to-date hearing aids. The elderly receive significant benefit from cochlear implantation, although patients over 80 years of age may have slightly inferior performance when compared with younger recipients. Adult hearing performance does vary—with length of deafness and level of residual hearing being the most significant prognostic factors—but there is a general expectation of improvement in most adults so that they are able to have a conversation without lip-reading and effectively use the telephone.

To develop normal speech and language (oral-aural communication), children need adequate auditory input as soon as possible. Ideally congenital hearing loss should be diagnosed soon after birth and managed well before 6 months of age. If management
includes a CI, surgery prior to 12 months is desirable, albeit balancing issues with diagnosis, hearing aid trial, and anaesthetic risk, not to mention issues of informed parental consent. The diagnosis of significant congenital SNHL in New Zealand will be hugely improved with universal neonatal hearing screening, planning for which is well under way.

Children who have not heard and are over the age of 4–5 years are highly unlikely to benefit from CI or achieve oral-aural communication and are best advised to be educated in a signing programme. Signing may also be the method of communication preferred by the child’s parents.

The first CI surgery in New Zealand was performed in 1986 by Ron Goodey and Bill Baber in Auckland with the support of an overseas colleague. The procedure had to be performed in the private sector as public hospital management would not support it. Financial support was received from the Deafness Research Foundation. The first recipient, now in her 70s, continues to obtain huge benefit from the device.

Cochlear implantation has come a long way since that time, with two programmes, Northern and Southern, based in Auckland and Christchurch respectively. Currently Government funding for the programmes is based on 25 implants per year per programme, of which 15 are reserved for children and 10 for adults. There have been a number of extra implants done on one-off funding initiatives over the last 3 or 4 years, so that in total 75–80 cochlear implants are performed in this country per annum. There are a small number of private surgeries also performed.

Although CIs now have a much higher profile with funding agencies and health professionals, we still have significant problems with late referrals of both paediatric and adult candidates. We also struggle with funding relative to need. Most health insurers in New Zealand have a bewildering attitude to cochlear implantation. The device is treated as a fancy form of hearing aid, or as a cosmetic item, rather than a means to restore an integral part of the human condition and thus highly enhancing quality of life. This differs from insurers in the United States and Australia, and is most frustrating for both clinicians and patients.

Over the last 5–10 years it has become increasingly apparent that both adults and children benefit significantly with bilateral cochlear implants rather than a single device. Specifically, the functional location of sound and hearing in the presence of background noise may be improved with bilateral implants.\(^1,2\) This obviously has huge implications for funding. As clinicians working in the field we would obviously love to have the funding available for bilaterally implanting all suitable candidates. Given the impossibility of this in New Zealand, a reasonable place to start would be bilateral implants in cases of meningitis where there is a risk of rapid cochlear obstruction. The next level of increased funding would probably be best used in implanting the prelingually diagnosed children (or possibly all children) who are likely to obtain maximal educational and social benefit from this technology.

There are several impending future developments in the field. Already there are devices available for combined acoustic and electrical stimulation of an ear with hearing loss. Essentially a cochlear implant can provide increased hearing in the high frequencies, and if there is preserved hearing in the lower frequencies this can be amplified using a standard hearing aid. Improvements in this type of technology will
undoubtedly increase the pool of people who may benefit. Research is also being undertaken into a fully implantable cochlear implant. A research prototype has been implanted in a handful of patients in Melbourne, Australia with mixed results. The major issue is placement of a microphone in a suitable position.3

Ultimately, the answer for people with severe and profound sensorineural hearing loss may lie with molecular biology. It may be possible in the future to “re-grow” hair cells and supporting elements in the inner ear using growth factors and/or stem cells. There is certainly encouraging research going on to the basic science of this, but clinical applications will be quite a long way off yet.

In the meantime, we feel very privileged to be able to practice otology at a time where significant help is available for those people with what is an enormous handicap.

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Author information: Philip A Bird, Otolaryngologist; Daran Murray, Otolaryngologist; Christchurch Hospital and Southern Cochlear Implant Programme, Christchurch

Correspondence: Mr Philip A Bird, Otolaryngologist, PO Box 4345, Christchurch Hospital, Christchurch, New Zealand. Email: phil.bird@chchorl.co.nz

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