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# A Brief History of the Cochlear Implant

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Hearing impairment affects an estimated 360 million people worldwide, and is only expected to increase with current demographic trends.[1] With technological advancements, severe hearing impairment that is not adequately treated with properly fitted hearing aids can now be addressed surgically with a cochlear implant.

A cochlear implant is an electronic neuroauditory prothesis that stimulates the auditory nerve within the cochlea directly and is used to improve auditory perception in individuals who have varying degrees of sensorineural hearing loss (SNHL).[2]

A cochlear implant is comprised of an external (receiver) component that includes a microphone to detect sounds, a speech processor for interpretation and conversion of those sounds into an electric stimulation paradigm, and a transmitter. The internal component which is surgically implanted converts the processed information directly into electrical impulses, transmitting this to an electrode array. The electrode array is also directly implanted into the cochlea and lies adjacent to the modiolus which is part of the auditory nerve.[3] Unlike hearing aids which amplify sounds but still relies on the hair cells of the cochlea to process those sounds, cochlear implants interpret sounds and allow the direct stimulation of the auditory nerve, This allows a direct bypass of the auditory hair cells which are often damaged or lost due to aging, trauma, and ototoxicity. Hearing aids are not effective once a certain amount of sensorineural hearing loss is present which commonly represents significant hair cell loss.

The development of this device is based on work by E.F. Evans, who demonstrated that precise stimulation of the auditory nerve via collocated electrodes could be interpreted as various sounds.[4] This landmark finding provided the practical proof that cochlear stimulation could help resolve certain types of hearing loss. Refined, this discovery lead to the first cochlear implants, developed at the University of Vienna and University of Melbourne. The first cochlear implant was performed by

Professor Kurt Burien in Vienna on December 16, 1977. A few months later a 48-year-old patient denoted MC-1 in was implanted in Melbourne in 1978.[5] Since that implantation, advances in medical technology have lead to continual miniaturization of the components. Companies have developed a fully implantable cochlear implant that also internalizes the microphone so no external components are required. However, microphone and battery issues have resulted in most modern day devices having both the battery and microphone still externally worn. In 2012 the Massachusetts Institute of Technology (MIT) developed a fully implantable biological battery that could further facilitate the development of a more viable fully implantable cochlear implant system (FICIS).[6]

The American Federal Drug Administration (FDA) states that as of December 2012, approximately 324,200 patients worldwide have received cochlear implants.[7] Currently the FDA has approved implants from three companies: Advanced Bionics Corp., Cochlear Americas, and MED-EL Corp.[8] In Canada, these three companies are also approved for use in our Canadian programs. There is also a fourth company, Oticon Medical which is available in Canada. These implants are approved for both unilateral and bilateral implantation, and for ages as young as six months.[5]

While individual implantation sites have specific criteria, generally, to be considered for cochlear implants one must have at least moderate to moderate-severe SNHL, although psychosocial and general health considerations also play a role. At Sunnybrook Health Sciences Centre, our audiometric testing uses the Hearing in Noise Test (HINT). Our criteria to be considered for a cochlear implant is for patients to have in their best aided conditions, HINT score of less than 60%. Preoperative imaging (typically a computed tomography scan) is undertaken to ensure there are no significant structural that may preclude implantation success.[9] Other questions which are considered include: Will the patient benefit more from cochlear implantation over an alternative method such as a hearing aid? Is the necessary amount of support present to help with rehabilitation and integration of the new device into everyday life?[10] This combination of patient and audiometric criteria are considered by the entire implant team at Sunnybrook Health Sciences Centre prior to offering the patient the choice of implantation.

The surgery itself is performed under general anaesthesia and takes approximately two to three hours during which time all the internal hardware is implanted and the electrode array is inserted into the scala tympani of the cochlea either through a created cochleostomy or via the round window membrane.[11] After recovery, the speech processor is individually programmed based on the patients hearing tests and feedback.[12]

The advantages of cochlear implants are numerous, and multiple quality of life (QOL) calculations have shown significant patient improvements. These improvements have been shown to include improved hearing, decreased depressive symptoms, social anxiety, and social isolation and improved verbal communication ability.[13,14]

Multiple cost-benefit analysis have shown that these improvements are estimated to be worth between $9,000 to $40,000 /patient year.[15] Recent studies by the authors as well as others have shown that

cochlear implantation is positively associated with improved employability as well as increased annual income.[14]

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