Present and Future use of Cochlear Implants

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The introduction of many technological advances such as headphones has revolutionized the world. Headphones were created for communication, then entertainment, however while the intention of this technology has been to advance our lifestyles, they have also brought forth negative effects such as deafness.

Figure 1) Normal hearing as shown in the top half occurs when sound travels from the environment, into the middle ear and then hair cells along the basilar membrane detect sound. Once hair cells detect sound; neurotransmitters are released that then trigger action potentials in the spiral ganglion. In a deafened ear, shown in the bottom half, hair cells have deteriorated with no functional movement, which stops the spiral ganglion from producing action potentials. With given time due to the deterioration of the hair cells the neuronal connections of the spiral ganglion begin to die. The dotted lines show different parts of the human in order to distinguish where each event occurs in. Retrieved from: The Design and Function of Cochlear Implants (2004).
In order for humans to hear sound, the biological system has hair cells that detect sound and release neurotransmitters, triggering action potentials in downstream neurons, which carry information to the central nervous system. When someone suffers hearing loss, sensory hair cells and to neural connections in the inner ear begin to deteriorate. This prevents transmitters from triggering action potentials as shown in figure 1 (Dorman & Wilson, 2004). Not only do biological effects occur but psychological issues such as depression, dementia and psychological disturbances (Mo, Lindbaek & Harris, 2005). This is because individuals feel they have lost their way of communicating and feel like they are a burden to society. Researchers, however, have been using cochlear implants since the early 1980s to improve hearing of profoundly deaf people. This is because overcoming deafness has close ties to overcoming depression, anxiety and being less isolated from society (Mo, Lindbaek & Harris, 2005). In the beginning, cochlear implants were used as an aid to lip-reading. Then in the late 1980s and continuing on, multielectrode implants have been made which has produced greater improvements in hearing aid (Dorman & Wilson, 2004). Due to this in the coming years cochlear implants will not only help individuals recover sound but become an irreplaceable hybrid device that will enhance our hearing beyond our regular capabilities.
Figure 2) A cochlear implants have both an external part behind the ear and internal part that is surgically placed under the skin. Cochlear implants stimulates the auditory nerve, which allows a person the ability to perceive sound. In order for this to occur, sound from the environment must travel to the microphone and speech processor. Sound is then transferred from outside of the ear across the skin where sound is converted to signals, which then travel onto the electrode array in the cochlea. This array allows stimulation to pass the hair cells and interact directly to the auditory nerve, which in turn produces sound for the patient. Retrieved by: Cochlear Implants (2014).

Figure 2 shows that cochlear implants consists of a microphone transmitting sound from the environment and sending it to the speech processor. In the processor, sound is converted to high-bandwidth radio frequency traveling to the receiver/stimulator in the temporal bone. The signals then go to the electrode array where electrodes stimulate the cochlea, which then stimulate the auditory nerve by bypassing the hair cells (Dorman & Wilson, 2004). An implant placement begins with surgery. A microscope and bone drill is used to cut open the mastoid bone, which is behind the ear (Jothi, 2015). Then the electrode array is placed into the cochlea and finally the receiver is placed behind the ear attached to a well to avoid the device from
moving and so that the device is close to the skin to allow electrical signals to pass by. After the surgery the patient is monitored for 1-4 weeks to give the opening time to heal and then the speech processor and microphone are placed (Jothi, 2015).

Cochlear implants provide important auditory components for speech perception (Svirsky et al., 2000). A study by Indiana University School of Medicine demonstrated language in profoundly deaf children was not affected by the use of cochlear implants but was instead beneficial to their language development (see figure 3). Children suffer from deafness by both pre-natal causes such as complications in surgery or use of drug such as ototoxic drug or by post-natal causes such as jaundice, lack of oxygen, infections or because of the use of excessively loud headphones (NDCS, 2016).

![Figure 3](image.png)

**Figure 3** The average gain in language of children from time 0 to 2.5 years after Cochlear Implant is shown on the x-axis while the average gain in language of non-implanted children and normal children is shown in the y-axis. While not all results are consistent, one can see that children with implants had a similar gain in language to normal children. Retrieved by: Language Development in Profoundly Deaf Children with Cochlear Implants (2000).
Children who receive implants already have a language delay because members of their community do not see being deafness as handicapped, thus those patients prior to implants spent their time learning to communicate in sign language (Svirsky et al., 2000). Figure 3 demonstrates that language development in deaf children with implants comes close to that of normal children and exceeds the development rate of children without implants. The study shows that cochlear implants prevent language from worsening in children (Svirsky et al., 2000). Most studies focus on improvement of audio and speech recognition, but adults that achieved poor audio results still demonstrate a good quality of life. This goes to show that there are more benefits to cochlear implants than just expected auditory outcomes (Lassaletta et al., 2005). Another positive outcome of implants is that gender and level of education does not influence the performance of cochlear implants use (Lazard et al., 2012). Cochlear implants do not show significant differences with implants being placed on the better or worse ear. However in order to avoid bias of potential delayed speech processing, the age patients developed Severe to Profound Hearing Loss must be later than 15 (Lazard et al., 2012). Cochlear implants has continued to give people the ability to hear sound as expected, as well as give people the ability to learn language at a normal rate.

There are however some minor downsides to cochlear implants. Some side effects are self-limited vertigo, tinnitus and discomfort at the implanted site. Although the implant does improve quality of life, it does not restore full hearing but instead it allows for the ability to understand speech through sound thus giving people another option other than lip-reading. (Lassaletta et al., 2005) Another negative aspect of the implant is that even though people can understand 80-100 percent of sentences, their comprehension of isolated words is between 45-55
percent. This is to say, people who have cochlear implants don’t hear the details of many words (Dorman & Wilson, 2004). One factor affecting this is the age which a person receives an implant (see figure 4).

**Figure 4** Cochlear Implants being placed in individuals early in life and others receiving implants later in life do affect have significant effects. It is shown that people that are exposed to implants early eventually reach normal limits of latency whereas implants received by people later in life do not, even with years of experience. Retrieved by: The Design and Function of Cochlear Implants

Even though quality of life can be improved, there are limits to implant success. Children that receive implants before 7 years learn spoken language at a normal or close to normal rate, whereas after 7 children have less success. This is because when neural connections are lacking
stimulation, neurons move from one place to another that has active stimulation and once neural connections have newer tasks, it is difficult to return those connections to their original tasks (Dorman & Wilson, 2004). As of 2012, about 324,000 people worldwide have received cochlear implants (National Institute on Deadness, 2014), however complications for this surgical procedure exist even though it requires a mastoidectomy and posterior tympanotomy. A study was done showing a 10.5% surgical complication rate when surgeons displayed 10+ years prior experience in ontological surgery (Zernotti et al., 2012). This involved a 7.69% in minor complications and 2.88% in major complications. If complications are shown at a high level with experienced surgeons, the percentage of complications for less experienced surgeons is even greater.

Currently researchers are attempting to optimize hearing by using electrical stimulation with bilateral cochlear implants and combined electric and acoustic stimulation for individuals with some residual hearing (Wilson & Dorman, 2008). Wilson & Dorman also mentioned mimicking implants of normal cochlear patients that have good function in the auditory pathways. With more research in electrical stimulation, it is not difficult for us to imagine humans creating implants that could be implanted on humans not only to hear, but also to control the noise level similar to features already present in headphones. We will have the capabilities of lowering and raising the volume of noises in our environment; thus benefiting many people such as soldiers that give them the ability to lower the volume of sound in their environment and thus preventing hair cells from being destroyed during combat, saving people from profound deafness and having to deal with biological and psychological issues. While such advancement would cause social and political debate, what was once an invention in fairytales could become the next breakthrough in neurobiological systems.
References


