A REVIEW: COCHLEAR IMPLANTS

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INTRODUCTION

Electrical stimulation of the auditory system in deaf individuals has been first explained in 1935 by Andreev et al. and in 1940 by Jones et al, resulting in sensation of hearing (1,2). These attempts are facilitated by Djourno et al who first implanted electrical devices in two subjects in 1957 (3). But this type of stimulation has been a controversy until 1974, when cochlear implant was successfully implanted by W.F. House. Since that time over 5000 individuals have been implanted with a variety of these devices.

Today by using cochlear implants many profoundly deaf post speech acquisition individuals are being able to achieve some word understanding without the aid of lipreading, but controversy exists on several issues, including determination of appropriate candidates, selection of a single or multichannel device and rehabilitation procedures.

The present generation of cochlear implants does not restore hearing to normal. Ongoing research continues to search for the keys to improve speech perception. Clinical trials are expanding to include pre-speech acquisition adults and children. All these factors contribute to the rapidly changing nature of this field. Several implants undergoing clinical trial since the late 1970's have been abandoned whereas some other new coding strategies are being developed, for example, implantation of a device for profoundly deaf children.

Physical Properties of Cochlear Implants:

All cochlear implant systems consist of four segments, a microphone, sound processor, signal coupler and an electrode that is implanted into the cochlea. Sound processor is a small box of electronics that converts the signal from the microphone into electrical stimuli. This stimuli is delivered to the nerve fibers via implanted electrodes. Because the microphone and the sound processor are worn outside the body, a method is required to get the electrical stimuli inside the body to the implanted electrode. This signal coupler can be a radio transmitter outside the body with a receiver inside or simply a connector that protrudes through the skin just behind the ear, providing a direct connection between the sound processor and the electrode. In both cases the electrical stimuli are sent to the electrodes and produce electrical signal on the auditory nerve fibers and then transferred to the auditory cortex.

Cochlear Implant Programs:

There are various types of devices and programs . They are used in the USA, Australia and Europe. These programs are carried out by some research groups in Europe such as the Laura implant project group in Belgium, the Chorimac and Minimac devices by University of Paris, the University College Hospital/Royal National Institute for the Deaf Program in London, the Vienna/Hochmair implant in Austria, the external pattern input group in London, the Cologne-Duren-Duisburg research group in Germany (4-8). In Australia Nucleus Program is carried out by University of Melbourne (9). In the USA, Federal Drug Administration approved Nucleus and Ineraid type of cochlear implants for federal use whereas the single channel systems are no longer being manufactured (10).

Cochlear implants can be categorized according to the ways that they are implanted. Electrodes may be inserted within the cochlea or placed outside the cochlea. The signals may be transmitted through either one channel or several independent channels.

Cochlear implants also may be categorized according to the types of electrodes used, method of stimulation or signal transmission through the skin by wires or by electromagnetic means.

In an extracochlear implant, the electrodes may be attached to the round window niche or in some cases to the promontory. Single-channel stimulation is more common in this form of implant. In an intracochlear implant an electrode or electrode array is inserted into the cochlea. For multichannel operation the electrode array is inserted quite deeply into the cochlea towards apex whereas, for single channel operation a short single channel electrode that does not extend beyond

the first bend in the cochlea can be used (11, 12).

For multichannel stimulation multiple electrode arrays have been developed with as many as 22 electrodes that can be stimulated independently (13). Exracochlear system in contrast to intracochlear stimulation has the advantage that the procedure does not invade the cochlea and is reversible (14). The disadvantages of extracochlear stimulation are narrower dynamic range, higher current density and a greater potential for stimulating other neural tissue possibly resulting in facial nerve stimulation (15).

The major advantages of intracochlear stimulation are relative ease of placement, closer proximity to neural structures, potential for lower current density, wider dynamic range, and more convenient tonotopic stimulation. The potential disadvantages of intracochlear stimulation include the insertion trauma, the possibility of mechanical damage to the cochlea, osteoneogenesis, possible ease of ototoxic corrosion products and the difficulty of replacing the device (16, 17). Several disadvantages of above are reduced by the use of a short, single channel electrode. There is, however, no general agreement as to the relative advantages of using short electrodes.

The current evidence suggests that multichannel stimulation has the advantage that information can be transmitted in a form that is easier for the user to understand and produces a superior speech-recognition performance compared with single channel stimulation (16).

Risks and Limitations of Cochlear Implantation:

The surgery for placing the implant may traumatize the cochlear endosteum and initiate new bone growth which has the potential for damaging surviving neural elements (18). There is no present evidence to suggest that implanting the device causes an increase in the spread of infection from middle ear to the inner ear (19). There is, however a risk of postsurgical infection at the site of skin flap behind the ear which could necessiate removal of the device (20). The operation also may damage the facial nerve or the vestibular system. Most cases of postimplant facial nerve paralysis and vestibular symptoms appear to have been transient. Passage of current through the implant at levels necessary for auditory stimulation may cause stimulation of facial nerve. Data suggest that current in the implant is unlikely to produce vestibular symptoms (21).

Use of the implant may interfere with the use of residual hearing cues from the other ear or other modalities. The need for replacement surgery after equipment failure or for upgrading to another device exposes the individual with an implant to the same risks and has the potential to cause the same damage as the initial operation. Finally there is a possibility of psychological problems for the individual with an implant and/or his or her family regarding the problems related to the implant use.

The effective use of cochlear implants is limited by a number of considerations. Some disease processes associated with hearing loss cause changes in the temporal bone that may prevent or compromise the appropriate insertion of the device. These are congenital abnormalities, personal anatomical differences, osteoneogenesis secondary to meningitis, suppurative otitis media and obliterative otosclerosis which may obscure the round window niche and make it difficult to insert the electrode (10). Previous otologic trauma or surgery may result in the same difficulties too.

All individuals with implants need to avoid activities that could physically damage or displace the implant (eg. Boxing or contact sports). Several medical tests and treatments are incompatible with preservation of implant function, including the use of magnetic resonance imaging, electrocautery near the implant, diathermy and radiation therapy of the implanted area (16).

CONCLUSION

The cochlear implant is a method of treatment of profoundly deaf postlingual adults and children. The use of implants in prelingual adults has not been so successful and their usefulness in congenitally deaf children is still under investigation.

It has been documented that the multichannel systems have superior performance compared to single channel designs. The most striking difference between multichannel and single channel implant participants is in their ability to recognize words in sentences in the sound only condition. All multichannel designs provide limited speech perception in the sound only open set condition but only a few of the subjects implanted with single channel implants could identify without the aid of lipreading (16, 19).

The risks are few but definite, the limitations are many. Foremost of these is that implantation does not restore normal hearing. Also there are very special needs concerning the evaluation and treatment of children.

Finally future research goals should include improvement in cochlear implants and methods of testing and more importantly a search for the understanding of mechanisms of disorders and diseases of the ear.

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