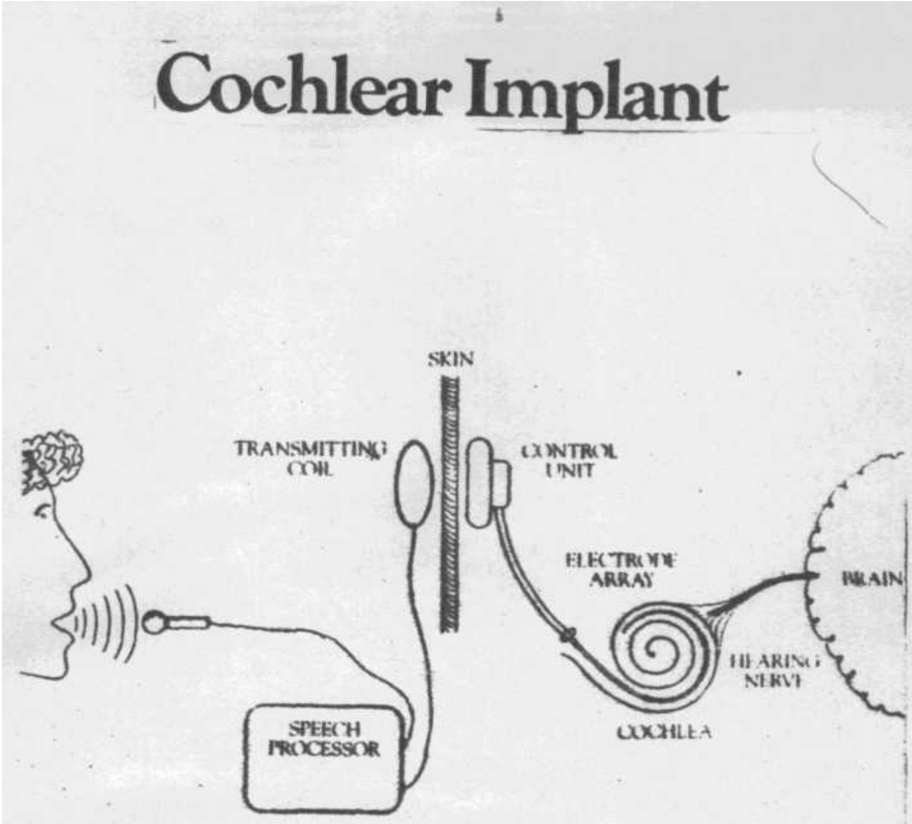


Registration No: 8602

BALJI O

An independent project submitted as part fulfilment for first year Master of Science (Speech and Hearing) to the University of Mysore.

All India institute of Speech & Hearing
MYSORE-570006.

MAY-1987

****

TO MY GRAND PARENTS

****

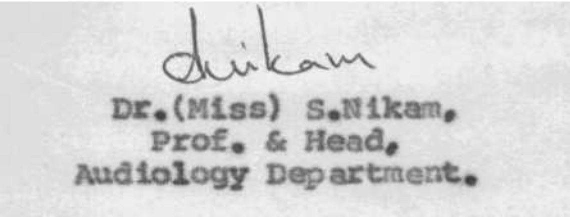
CERTIFICATE

This is to certify that the Independent Project entitled COCHLEAR IMPLANT is the bonafide work in part fulfillment for the degree of Master of Science (Speech & Hearing) of the student with Register No.8602.

Dr.M.Nithya Seelan
Director
All India Indisute of
Speech and Hearing
Mysore - 570 006.

CERTIFICATE

This ia to certify that the Independent Project entitled: COCHLEAR IMPLANT has been done under my supervision and guidance.



DECLARATION

This Independent Project entitled: COCHLEAR IMPLANT is the result of my own study done under the guidance of Dr.(Miss) S.Nikam, Prof. and Head, Dept. of Audiology, All India Institute of Speech and Hearing, Mysore. and has not been submitted earlier at any University for any other Diploma or Degree.

Mysore   Register No.8602
May 1987.

ACKNOWLEDGEMENTS

I express my deep indebtnees to my guide Dr.(Miss) S.Nikam, professor and Head of the Department of Audiology, All India Institute of Speech and Hearing, Mysore for all her inspiration, encouragement and patience listening. Her valuable help, suggestions and guidance at every phase of this work made it possible to carry out and complete the project.

I sincerely thank Dr.M.Nithya seelan. Director, All India Institute of Speech and Hearing, Mysore for his encouragement.

My colleagues and friends undoubtedly made valuable contributions and helped me in innumerable ways. In particular I am thankful to Mrs.Padmaja, Mr.Debashis Ghosh, Ms.Nirsajini Menon and Ms.sheela.

I am also grateful to all those who directly or indirectly are responsible for the present study.

Finally, I am thankful to Ms.Rajalakshmi R Gopal who has typed the manuscript and checked out endless details in very short notice.

TABLE OF CONTENT

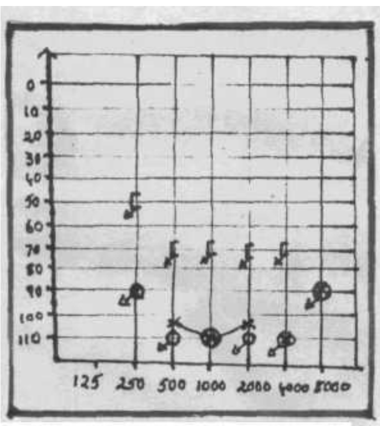
INTRODUCTION

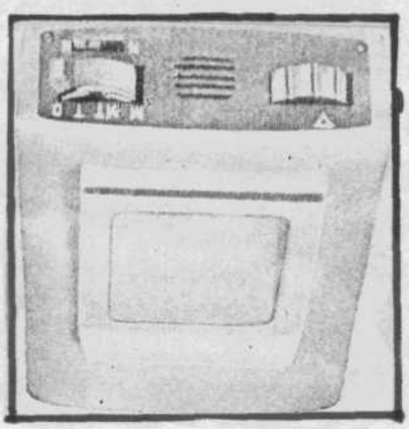
Many severely hard of hearing and profoundly deaf persons seem to get very little help from an ordinary hearing aid. This observation has led to the development of tactile aids, cochlear implants etc.

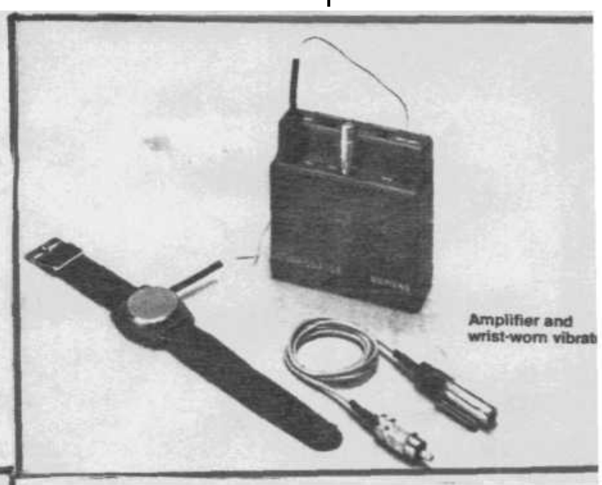
The first ever cochlear implant was developed nearly twenty years ago. Since then many developments have taken place in this area.

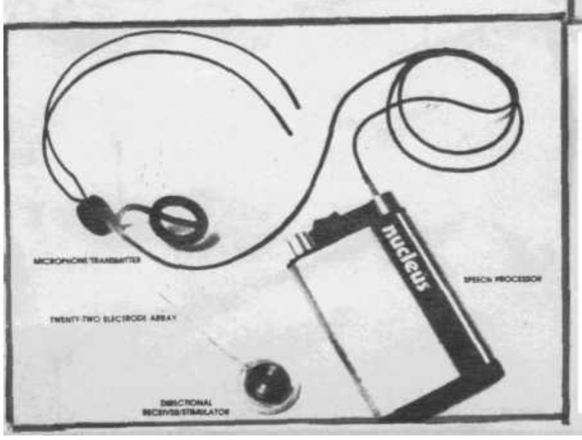
The present project was undertaken to give a general overview of coehlear implants to the people who are concerned with the rehabilitation of the hard of hearing individuals.

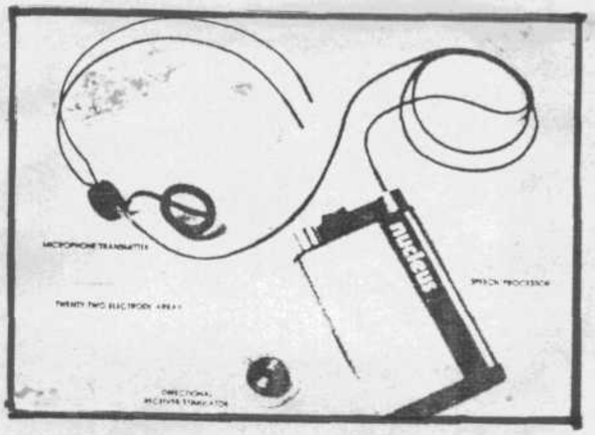
In thia project it is attempted to give basic information regarding the coehlear implant, how it works, determining the candidacy for cochlear implants and then concluding with same views of the rehabilitation concepts with cochlear implants.











Knowledge that hearing could be produced by the application of electrical currents to the ear is nearly aa old as the knowledge of electricity itself.

Year	Historical achievements

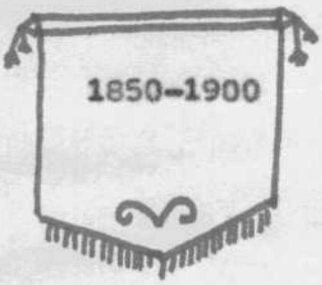
Alessandro volta developed the electrolytic cell in paris* shortly after that, volta inserted metal rods in each ear and attached them to a circuit which produced around 50 volts.....

... The sensation volta felt on closing the circuit, as communicated to the Royal society was likened to a blow on the head followed by a sound like the boiling of a viscid fluid. The sensation being unpleasant experiment was not repeated.

Some years later Ritter attempted the same procedure with a battery of some 100 to 200 cells: This was a dangerous under taking: It is not surprising that the reported disagreeable cerebral effects which discouraged others from experimenting with this phenomenon for many years.

Year Historical achievements

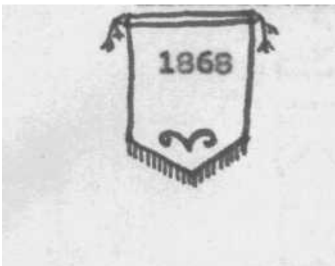
Only sporadic reports on the subjects appeared, calling attention only to the fact that a sound like sensation could be produced by this means. Most seemed to assume that the acoustic sensation resulted from direct stimulation of the acoustic nerve.



In the last half of the 19th century, investigation of electrical stimulation was reviewed aad carried out. Many investigators attributed the origin of the acoustic sensation to the sound-conduction apparatus than to a direct stimulation of the nerve, thus suspecting some inductive effect of the current on the tympanic membrane or ossicles.

Dachenne of Boulogne reported on "stimulation of the acoustic apparatus with AC. He filled one ear with warm saline and inserted an electrode insulated be an ivory speculum into it. He also placed an in diffe-rent electrode over the mastoid process. Then using a condenser and induction coil, he noted (on breaking the circuit) a sensation resembling the "crackling of parchment*. He reported sounds resembling "the beat-ing of a fly's wings between a pane of glass and a curtain" when a vibrator was placed in the circuit to open and close it more rapidly. He belived that the sounds originated in the ear canal through the action of the electrode on the fluid.

Year | Historical achievements



The first attempt at a systematic investigation of electrical stimulation of the auditory system was published by R.Brenner of Leipzig. He set up certain formulas and roles which he felt could be applied to electrical diagnosis of the aaditory apparatus. In relating these. he observed the following phenomen.

(a) Restimulation, after reversing the polarity of the electrodes, resulted in a lower threshold. There was also some lowering of the threshold with repeated cathodic stimulation. He explained that the ear had been placed in an "electrotonic state of increased irritability".

(b) The auditory sensations were different in different observers. but were always identical in the same observer. They resembled buzzing, hissing, rolling, whistling, ringing, etc, at various pitches.

(c) With increased intensity, the pitch of the sound became higher under cathodal stimulation and lower under anodal stimulation.

(d) Perforation of the tympanic membrane or an active suppuration markedly lowered the resistance and the threshold.

Year | Historical achievements

Brenner viewed some of the individual deviations from his formula aa evidence of disease. He attributed all the effects of electrical stimulation to the excitation of the VIII nerve.

During the late i9th century, a new field of study, referred to as "electro-otiatrics" was born.

Neftel extolled the use of electrical treatment in almost every affliction of the ear, from tinnitus to otitis media in his book on Galvano-Therapetics.

Politzaer found no improvement in treating tinnitus with electrical stimulation, but found improvements in accompaning symptoms each as oppression and vertigo.

Gradenige was a strong advocate of electrical methods for diagnosis. He claimed that an acoustic sensation did not result from electrical stimulation of the normal ear, and when it did, this was evidence of disease.

D.B.St.John Rossa stated that the value of electricity in the diagnosis and treatment of aural diseases had been overrated. He denied the

Year | Historical achievements

existance of an authenticated case, and added that this use of electrical methods has a "very vaunted reputation among inept observers".

To determine the presence of an electrical current in the auditory nerve and to ascertain the limits of auditory sensation in various animals, Besuregard and Duprey attached an electrode to the acoustic nerve of a frog and another to the tympanic membrane. The electrodes were led to a galvanometer, which indicated a perceptible current flow when noise was made near the ear.

Scheppegrell in a book covering the subject stated that, "Electric tests of the ear should be as necessary a part in diagnosis of diseases of this organ as the tuning fork, Galton's whistle, etc." However he was not sure about the therapeutic effects of electricity.

As improved instrumentation became available, Buytendyk demonstrated electrical potential variations in the medulla of the cat in response to acoustic stimuli.

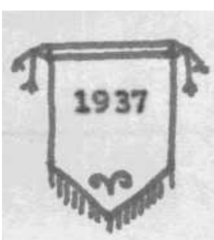
Wever and Bray observed the same phenomenon which now bears their name. Although they initially

Year | Historical achievements

believed that they were recording actual nerve responses. it was later shown that they were mainly recording an end-organ bioelectrical potential, the cochlear microphone.

The concept that the cochlea acts essentially as a transducer of acoustic to electrical energy, which was then transmitted through the nerve in a relatively unchanged fashion, gave impetus for the possibility of artificial hearing through direct stimulation of auditory nerve.

During this time, several radio engineers discovered that tones could be produced by placing electrodes near the ear and stimulating with a modulated alternating current....



.... Stevens teamed this the electrophonic effect. The electrophonic hearing may be produced by placing electrodes in the external or middle ear as well as by having an electrode on the skin. For electrophonic hearing, however, a normal or near normal cochlea is a prerequisitive. Therefore stimulation of hearing in this manner has no application in the hearing impaired.

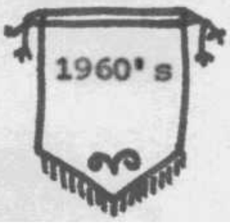
year Historical achievements

Djourno and Eyries electrically stimulated a totally deaf patient by means of a wire implanted into the cochlea. They reported that the subject perceived background sounds and that the device greatly benefitted the patient in lip reading. With practice he was able to recognize a few words.

This report ushered in the modern era of treating of severe sensory hearing impairments by electrical stimulation.

The first human studies were carried out primarily at the Stanford University under the leadership of Blair Simmons. Bipolar stimulation of the auditory nerve was performed. This patient was able to distinguish rate differences easily between 20 and 900 pulses per second. Above that level the rate difference detection diminished considerably.

Simmons implanted some electrodes into the auditory nerve through the modiolus. He concluded that both periodicity and place pitch were possible with modiolar electrodes.



At the Ear Research Institute, Los Angeles, Hou and Urban initiated work on auditory nerve stimulation. Initially three patients were implanted with

Year | Historical achievements

a five-contact electrode placed through the round window into the scale tympani. The patients were able to discriminate both periodicity and place pitch.

1971

At the University of California, San Francisco, Michelson and his associates implanted four patients with bipolar electrode system in the acala tympani and one patient with a bipolar electrode in the base portion of the cochlea. These patients were able to respond to sinusoidal electrical stimulation acre the frequency range of approximately 25–10,000 Hz. They had useful range of discriminative hearing to frequencies below 400-600Hz.

1972

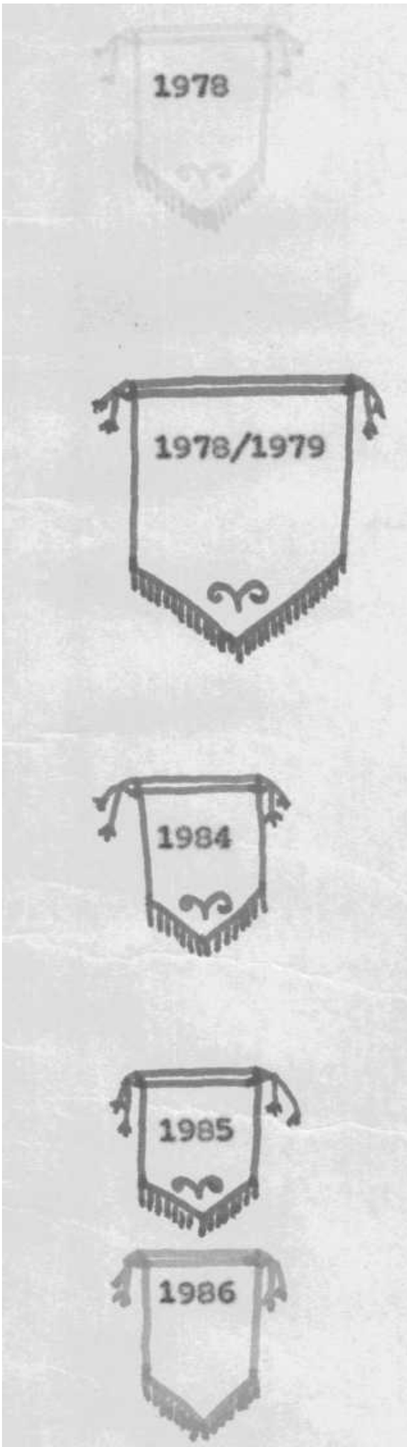
At the Bar Research Institute, cochlear implant clinical trials programme for the post lingually profoundly deaf patients were started.

1976

In France, Chouard and Macleod implanted eight intracochlear electrodes. They found that stimulation of each electrode yields a different sound sensation of a pitch that depends on its location along the cochlea.

under the authority of the Federal food, drug aad cosmetic Act, the food and drug admini–

Year | Historical achievements



stration (FDA) ia U.S.A. requires manufactures of new devices, such as cochiear implants to demonstrat the safety and effectiveness of their devices before marketing them.

Eddington and this associates at the University of Utah, implanted multichannel cochlear implant to 4 patient. They reported that their patients were able to perceive place and periodicit pitches.

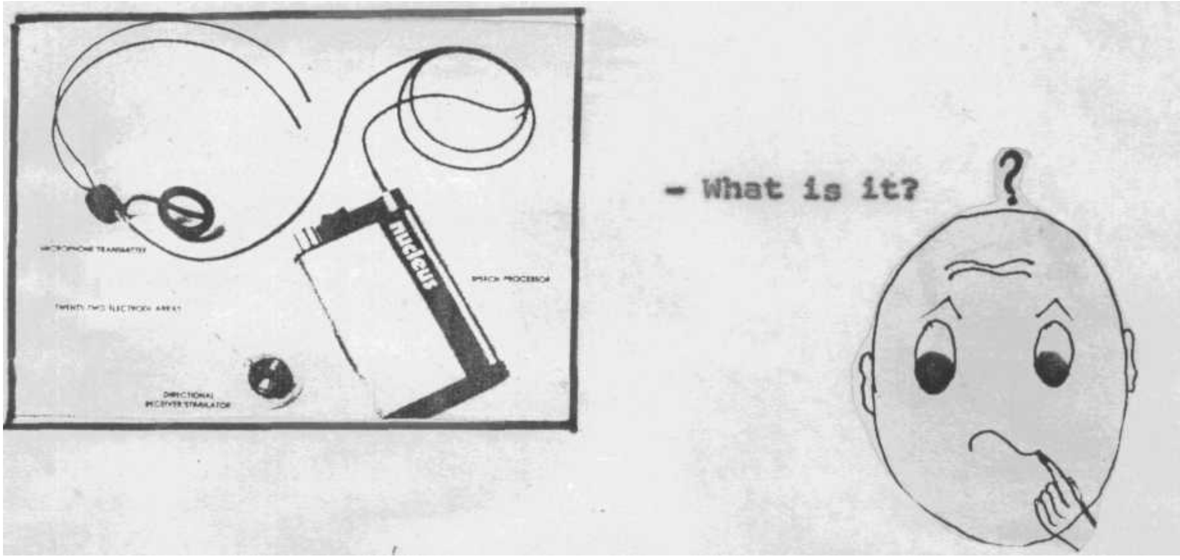
In Australia at the University of Melbourne, Department of Otolaryngology; An experimental hearing prosthesis was developed.

At the Ear Research Institute, a programme for prelingually deafened adults was developed.

FDA approved the 3M cochlear implant device for the adults. (18 years and above). Thus the 38 cochlear implant device became the first of its Kind to get FDA approval.

The Nucleus 22 - channel cochlear implant was approved by the FDA.

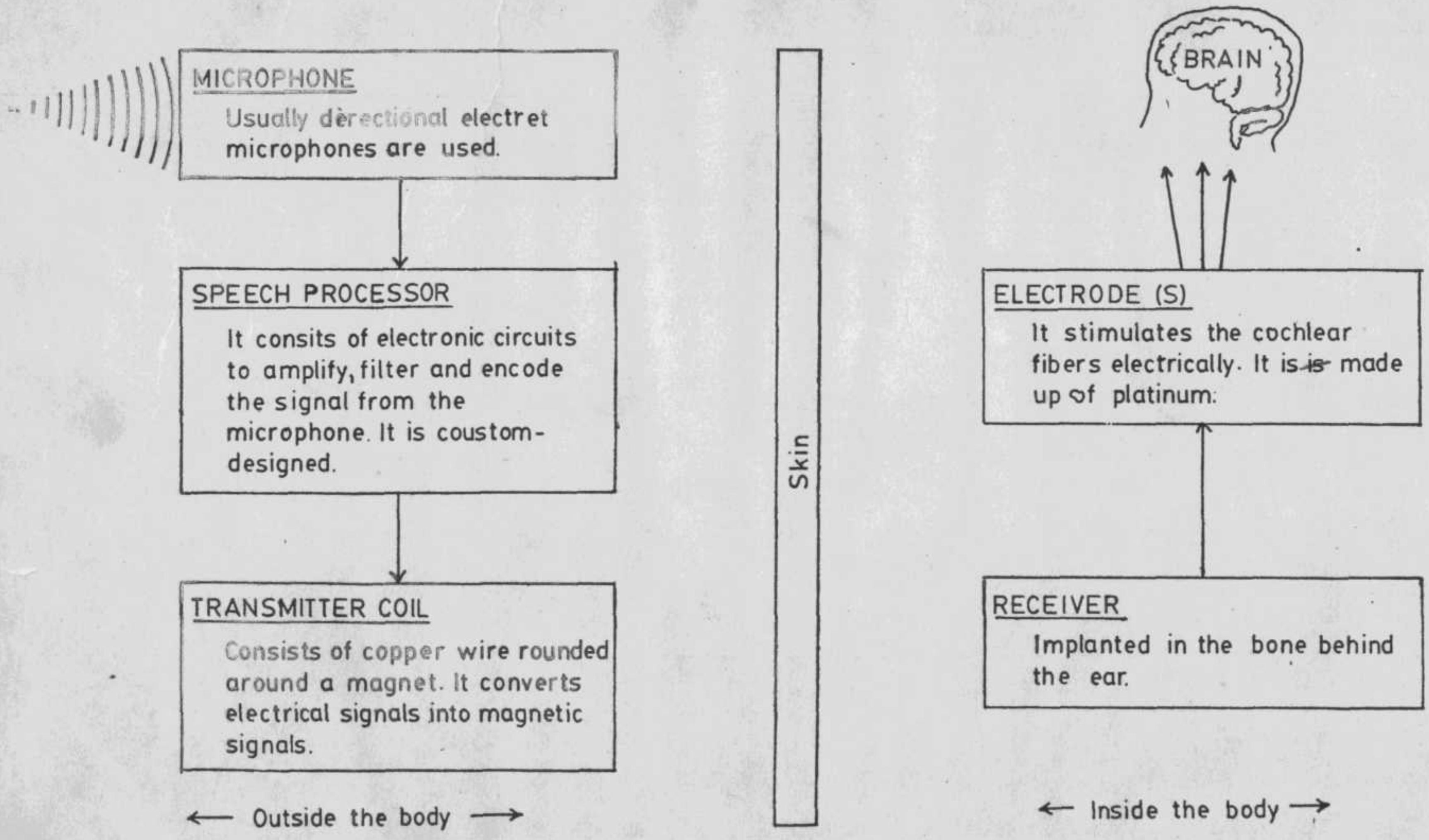
Recently the FDA has approved the 3M cochlear implant for children.

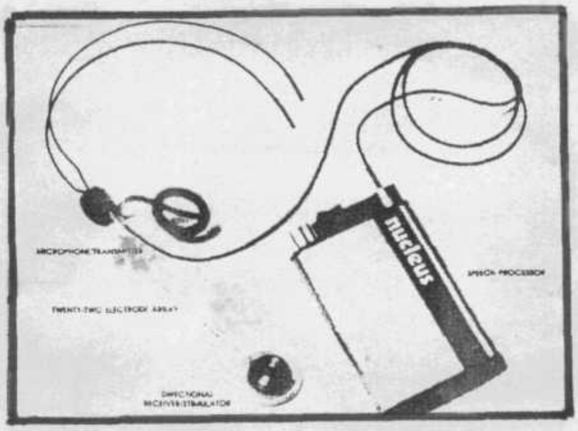


A coehlear implant is a device that helps profoundly deaf people to hear sounds. In ita moat basic form, the cochlear implant is a transducer which changes acoustic signals into electrical signals which stimulate the auditory nerve.

"Coehlear refers to the cochles part of the inner ear, which ia the place from which the device stimulates nerve fibers that enables the brain to hear sounds. "Implant" refers to the way the device is surgically placed under the skin, behind the ear.

PARTS OF AN COCHLEAR IMPLANT



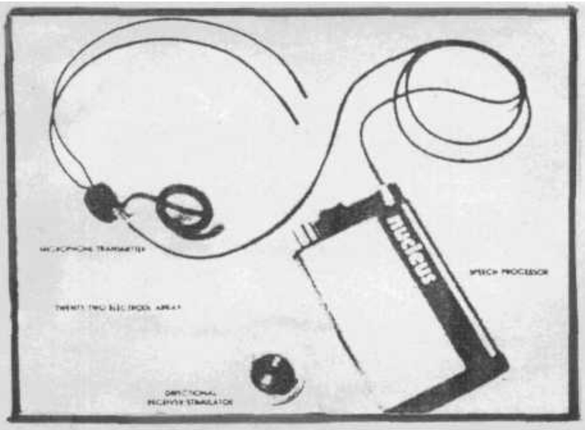


- How does it work?

Cochlear implants operate from the flow of electrical current. The manner in which the current is generated, conditioned (or processed), and applied determines the utility of the device.

The electrical signals are processed to (1) amplify the signal level, (2) compress the signal to limit stimulation levels appropriately, (3) filter the signals to shape or divide the acoustic frequency spectrum to match neural requirements, and (4) encode the information in the signal for transmission to the implanted receiver. These four basic processing steps do not necessarily occur in the order mentioned.

The microphone changes the mechanical sound energy to electrical energy. The signal from most microphones being of the magnitude of several multivolta, it is generally too small for direct use in electronic circuits. Therefore the processor amplifies the electrical energy from the microphone, filters it and sends it to the transmitter. The transmitter changes the electricity into magnetic signals. The magnetic current crosses the skin to the receiver. From the receiver the signal travels to the cochlea via the platinum electrode(s) which are inserted through or near the round window into the scala tympani to a distance of about 6-10 mm. The electrode(s) then stimulate(s) the nerve fibers which in turn send impulses to the brain Where the impulses are perceived as sound.



- Types

Classification of cochlear implants can be baaed on (1) placement of electrodes for stimulation; and (2) the number of electrodes used for stimulation.

Cochlear Implants

Intra cochlear

Here the stimulating electrode(s) is/are placed in the scale tympani of the cochlea near the basilar membrane

- **Single-electrode**: Here only a single electrode pair is used for stimulation.
- **Multi-electrode**: Here more than one electrode is used for stimulation.

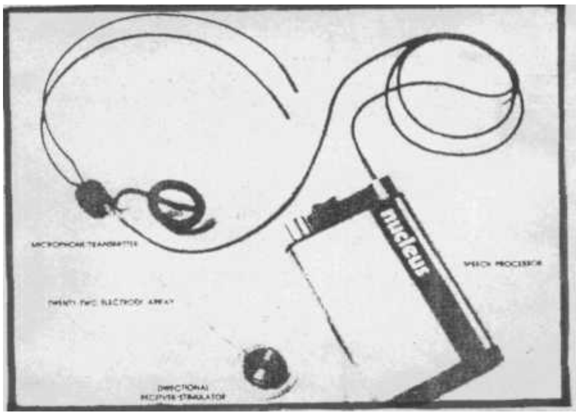
Extra cochlear

Here the stimulating electrode(s) is/are placed outside the cochlea, usually on the round window or promontory.

- **Single-electrode**
- **Multi-electrod**

NOTES:

It is sometimes assumed that a multi-electrode device (most often referred to as the multi channel device) provides more information to the cochlea than the single-electrode device. But, the amount of information coming into the signal processor is the same. The difference is in terms of what ia delivered to the cochlea and how it ia delivered.



- Who is a candidate?

From the last one decade or so, cochlear implants have received wide spread publicity. We do get many patients who eaquire with us about cochlear implants. Therefore, it would seem, important for us to know about - who is a possible candidate for cochlear implant and who is not.

Various cochlear implant groups have various criteria for selecting candidates. However reviewing them, it is found that the following criteria are important.

The patient must be totally deaf, i.e. he/she should have no audiometric response at the equipment limits — especially in the speech range. Even with the most powerful hearing aids. he should not be able to get any satisfactory benefits.

The patient Must have positive response with electrical stimulation through the round window of those cochlear fibers still present. This test is performed with a transmeatal approach by removing the ear drum in order to obtain a good view of the round window fossa in which the tip of the stimulating electrode has to be placed. This positive response sterely signifies that atleast a few auditory fibers are present. It does not say anything concerning the proportion of fibers present, or their distribution on the frequency keyboard of the cochlea, which would be useful to know ia order to predict the quality of future rehabilitation.

It ia preferable that the case has cochlear pathology than retrocochlear pathology because cochlear pathology ia more likely than retroeochlear pathology to have intact auditory nerve fibers suitable for electrical stimulation.

The case should also have normal middle ear and eustachian tube functions. Adequate aeration of the middle ear is a necessary prerequisite to surgery. Otherwise there ia risk of infection or accumulation of fluid in the middle ear and mast old air cells, and this can produce an unfavourable environment for the receiver and electrodes, and also lead to the loss of residual auditory nerve fibers.

Determination of dynamic range is also an important aspect of aelection of candidates. The case should also have favourable lipreading ability as it will assist the post-operative rehabilitation process.

The problem of selection of criteria based upon hearing acuity centers around the evaluation of subjects who show minimal but definite responses with conventional amplification systems in one or both ears. The residual hearing factor is further complicated by subjects who receive some benefits from amplification at one ear but who derive no benefit from the other ear. Although there are several implant recipients who successfully use the cochlear implant in conjucation with conventional amplification at the unimplanted ear, it is difficult, if not impossible, to predict the additional benefits afforded by use of the cochlear implant prior to surgery.

II.Etiological factors:

The etiology in a large number of patients receiving cochlear implants is varied, the majority being either dtotoxic, otosclerotic, or meningitic, and the reminder having diseases of another (lues, Meniere's disease, trauma) or an unknown etiology.

Despite this diversity in etiology, there remain certain cases of profound sensorineural deafness that might prevent implantation. They are -

a) temporal bone factures (particularly transverse) resulting in extensive cochlear damage.

b) bilateral acoustic neuroma (Von Recklinphausen's disease). However, House has successfully stimulated a patient who had bilateral acoustic neuromas with an electrode implanted directly in the cochlear nuclei.

c) Congenital malformations of the bony and membraneous labyrinths. eg. Mondini type of aplasia.

d) Certain disease processes or syndromes in which deafness is present with other neurological or physical disabilities that would either preclude implantation or make the rehabilitation process so complex and lengthy as to be not feasible. eg. retinitis pigmentosa with associated blindness, severe head trauma, cerebrovascular accident, degenerative neurological disorders.

Tomography of the cochlea should be obtained especially in those patients whose deafness has resulted from meningitis so as to exclude an obliteration of the cochlea as a result of Labyrinthitis. In such cases, only an extracochlear electrode can be used.

III. Age of the subjects:

In the initial years of patient selection and implantation, only subjects ranging in age from 18 to 65 years were considered as potential candidates.

Recently, however, a number of children have been implanted, the youngest being 3 years old. Adults over the age of 75 have also been implanted. Age is in itself no longer an important variable in patient selection, provided the subject is in good health for general anesthesia and all other selection criteria are met.

IV. Onset of hearing loss: Congenital vs acquired losses:

As with subject age, the onset of the hearing loss is no longer an important variable in subject selection. A growing number of both adults and children with congenital losses are being successfully implanted. although initially only adults with acquired losses were selected for implantation.

No patients are implanted whose deafness is of recent onset. In case of antibiotic or traumatic deafness, a minimum of 12 months must elapse from the first recognition of profound (total) deafness, to allow for every possibility of spontaneous improvement of hearing.

In the case of acquired deafness patient must be made aware that his new hearing will not be the same as that which he remembers, and that a long auditory training period will be necessary in order to hear again.

The important consideration for congenital losses is the ability of the rehabilitative staff to accommodate the additional needs of the congenital deaf. Rehabilitation for subjects with congenital losses is much more complex and of a longer duration than that of acquired losses, and may involve lengthy training in the use of auditory cues as an aid to speech reading, voice therapy and voice monitoring, speech correction, and possibly some language therapy in addition to auditory training.

V.Psychological factors:

A careful psychological examination is necessary to rule out any personality abbrevations or cognitive dysfunction that would either preclude implantation or severely limit a subject's ability to integrate and use minimal auditory cues. Usually only non-institutionalized patients are considered for candidacy.

In addition to standardized psychometric testing, an indepth interview with a potential implant subject and his family is helpful in identifying other psychological factors that might preclude implantation, such aa unrealistic expectations regarding the benefits or limitations of the implant, or poor or questionable motivation.

The question of subject motivation is probably the most critical psychological factor to be evaluated in subject selection and is also the most difficult to assess.

Inspite of other selection criteria, if the subject is not motivated for the right reasons, does not have realistic expectations of the potential benefits and limitations of the implant.

or is not willing to commit the time necessary for the rehabilitative process, it is doubtful that the outcome will be satisfactory.

VI. Additional Rehabilitation Needs:

In some subjects who are otherwise good candidates may have additional rehabilitative needs that would make the post-surgical rehabilitation too long or too complex or otherwise not feasible. Besides, the rehabilitative staff may be inadequate to meet the subjects' needs. These additional needs do not by themselves preclude implantation; rather than rehabilitative staff must decide whether they have the resources and the time required and whether they are adequately prepared and trained to deal with these additional factors in the rehabilitative process.

Rehabilitation Protocols for Cochlear Implant Recipients:

The cochlear implant is different from other types of implants such as the heart and kidney implants which begin functioning independently upon completion of the surgical procedure. In the case of cochlear implants, rehabilitation protocols for the recipients are needed which help them to overcome the handicap of profound deafness, by improving their overall communication function.

For effective communication to take place the recipient of cochlear implant must undergo a period of training. To accomplish this, the audiologists and speech pathologists are entrusted with the responsibility for training after the actual implant procedure is over.

There are some who do not advocate rehabilitation programs. There is no further step beyond adjustment and fitting of the equipment for them. Those who do advocate a training program have different goals. Protocols vary in the procedures used as well as in the intensity of the rehabilitation efforts advocated. Lack of consistency regarding rehabilitation following implantation results in frustration.

At present due to identical rehabilitation and communication needs, the training programs have borrowed directly and extensively from strategies developed for the rehabilitation of post-lingually deafened adults. So, the initial goal is to propose a hierarchy of communication appropriate for all individuals. This would lead to the development of communication assessment procedures and subsequent rehabilitation tools with which to work.

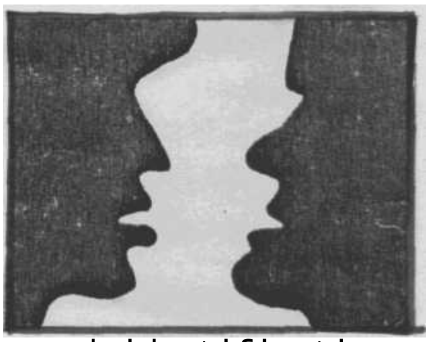
Protocols for rehabilitation:

The major emphasis of aural rehabilitation is analytic in nature. The elemental aspects of speech and language - vowels, consonants, closed set sentences and repetition of sentences - receive the greatest attention.

One of the major activities is a procedure called SPEECH TRACKING developed by Defilippo and Scott (1978). A passage which is appropriate for the patient is read. The patient than has to repeat the passage verbatim. In the event of an error. the section read ia repeated or an alternative cue ia selected from a hierarchy of possible strategies applied to elicit a word - for - word response. Strategies include repeating or rephrasing, segmenting the phrase etc. The session last for two 10-minute segments. Performance is measured in terms of the number of words repeated during the session.

The passages are read under atleast three conditions: (i) Lip-reading only; (ii) Speech processor only; and (iii) Lip-reading - speech processor combined. Progress in each condition is charted over a period of time. This method closely simulates running speech and appears to have good validity as a measure of receptive communication function. It also gives a numerical objective score.

The word-for-word identification used in speech-tracking ia analogous to the analytic approach of lipreading. The analytic approach emphasizes the necessity of perceiving the basic parts before the whole can be identified. This is in contrast to the synthetic approach to lipreading in that the lip reader is to comprehend the general idea of the sentence,



Depending upon the implant design, the rapeutic procedures include drills with suprasegmental cues of speech, stress and intensity cues of auditory signals, vowel and consonant discrimination, word identification, and closed — and - open - set sentences identification. These stimutli may be presented through visual modality only, through auditory modality only, and through both auditory - visual modalities. The patients are allowed to guess if unsure of the stimuli. Verbatim repetition of stimuli is the goal.

A technique used to help patients repeat the sentence is cueing. The use of cues in sentence materials is more typical of the synthetic approach, but verbatim response is wore analytic in nature.

The recognition, of environmental sounds is included in all existing cochlear implant rehabilitation programs. The sounds may be presented through a language master . Cards with magnetic tapes are played through this special recorder.

A major tool used to screen prospective patients and assessing postoperative performance is the minimal auditory capabilities (MAC) Battery. Tasks presented to patients, include vowel recognition, familiar sounds, spondees recognition, nouns, syllabic word identification, lip-reading testing and so on.

Other tasks, such as recognizing male vs female speakers, and evaluating audio-visual perception with videotaped materials were believed to be worthwhile for evaluation.

Now one would begin to wonder, if there is really a difference in rehabilitation for the cochlear implant patient as compared with rehabilitation for hearing impaired adults using hearing aids?

Maximum communication is required at the home, work and social situations. Any analysis of the patient's function in these situations enables us to plan an aural rehabilitation program to overcome any barriers which exist. So the elemental therapy approach described in cochlear implant protocols relate to the broader concept of communication.

According to Eagerton(1985), the goals of early rehabilitation period are 4-fold: (1) to obtain an optimal electrical setting of the device; (2) to provide patient and family with the necessary foundation for long-term care and maintenance of the cochlear implant stimulation; (3) to introduce the patient to strategies that yield necessary critical listening and communication skills, and (4) to assess the need for specific long-term rehabilitation programs.

If we were to substitute hearing aid for cochlear implant, a major difference probably would be the amount of time in direct clinical contact with the patient; it is considerably longer for the cochlear implant patient.

Alpiner (1974) developed a flow chart of the rehabilitative audiology process-part of this approach deals with a more total approach:-

a) Assessment of communication functions: Client input provides significant information regarding communication ability, apart from the various assessment scales available.

b) Remediation process: The rehabilitation processes racommended are counselling, lip-reading* communication training, auditory training, speech therapy.

c) Aucillary Referrals: The patient's condition may require referrals to other professional's like the Psychologist, Social workers, Vocational Counsellors and Family Counsellors.

d) success of therapy: During the rehabilitation period, periodic evaluation will measure the patient's success and eventual termination of therapy. Testing will include - lipreading, auditory training, speech and communication function.

Banfai et al. (1984) state (based on 5 years experience) that rehabilitation program is just as important as the surgical procedure. The cochlear implant can be further developed only if patients are continuously seen in early rehabilitation phase for 4-6 weeks. They reported that the results were poorer when patients left the program early and attempt to have therapy in the home. Considering this situation it appears to be even more significant to develop rehabilitation programs that are more communication oriented than elemental.

RISKS AND BENEFITS

Risks:

The risks associated with the CI device falls into three basic categories.

a) Risks of mastoid surgery:

The surgical approach for the CI is essentially a mastoid operation and involves the same risks as that of common otologic procedures: infection, facial paralysis, fluid damage resulting in meningitis and anesthetic risks.

b) Risks of the implantation of electrodes and induction coil:

Risks of the implantation of electrodes and induction coil falls into two categories.

i) Biovompatibility:

The materials currently used for the CI have a long history of biocompatibility. There have been no "rejections" of the internal coil, nor any evidence of production of toxic substances from wire electrolysis. Electron microscopic studies of electrodes implanted and used in human subjects, then removed, show no evidence of breakdown of insulation or wire.

ii) Surgical trauma:

Does insertion of the electrode(s) into the cochlea cause damage to the cochlear structures or more elements? Most answers to this question comes from animal studies, and these have indicated good tolerance for insertion and presence of electrodes into the cochlea.

There is potentially a risk that insertion of the electrode(s) might scratch the endosteum and stimulate new bone growth. Should bone growth in the scala occur, it would probably make replacement of a nonfunctioning implant more difficult.

Several studies have shows that serious, irreversible damage may result from inserting a multi-electrode cluster into the cochlea. This damage may be due to the presence of multiple electrodes (upto 22 in one device) as well as to the length of the electrodes (upto 25 mm long).

If an electrode is inserted past the first turn of the cochlea, mechanical rupture of the basilar membrane, Reisner's membrane, and the osseous spiral lamina can occur. After the electrode has moved 10 mm into the cochlea, the path is determined by the curvature of the seala tympani. The mechanical rupture of these delicate cochlear components significantly accelerated on going neural degeneration inthe deaf cochlea.

Once the membranes are ruptured, the natural barriers between the fluids of the cochlea are removed, allowing the fluids to mix. The combination of perilymph, Which is high insodium, and endolymph, which is high in potassium and toxic to nerve cells, changes the electrolytic balance of the fluid that bathes the nerve. Over a period of time it may actually Kill the nerves.

Animal studies indicated that cochlear damage, should it occur, would produce degeneration of the sensory and neural elements in a normal ear. This risk however, must be viewed in the light of the fact that the ears suitable for cochlear implantation have already undergone severe degeneration of these elements as a consequence of the etiology of deafness. Those nerve fibers surviving are probably among the hardiest and may therefore be nerve resistant to further trauma.

c) <u>Risks of stimulation of the auditory system by electrical current</u>

The cochlear implants were put into clinical use since only the past 1-2 decades. Therefore we donot have substantial information regarding the long term effects of electrical stimulation on auditory system of man. At present, what little information we have gathered is mainly from the animal studies.

It is well known that direct current (DC) would destroy nerve tissue. Literature shows that stimuli such as monopolar pulses introduced directly without capacitor or transformer coupling would introduce a net DC charge which produces neural damage.

In animal studies, with scala tympani stimulation, histopathological damage, including new bone growth were observed. Less damage was reported in subjects stimulated via electrodes placed on the round window and promontary, as compared to the scala tympani. Myelinated fiber density in the osseous spiral lamina was less in the region immediately adjacent to electrode sites.

Damage to the auditory nerve aad cochlear nuclear complex when a current is passed through the implanted electrodes is reported. There are also reports which indicate more pronounced degeneration ia the coehlear nucleus ipailateral to a stimulated implant than in the conatralateral (implanted but unstimalated) side.

Because of the close proximity of the vestibular apparatus to the cochlea, any deliverance of an electrical stimulus to the hearing mechanism may also activate the balance system. Some investigators have found evidences that the implant might disrupt postural stability. But there is also evidence to indicate that postural stability may actually improve with the cochlear implant activated (Eisenberg et al. 1982). It is speculated that this phenomenon may be a result of cochlear induced CNS. effect that may same how sharpen postural equilibrium.

1. Implant patients can hear some soft and most medium and loud environmental sounds. (eg. normal conversational speech occurs at about 70dB SPL).

2. Patients can also score significantly above chance on a number of closed-set auditory discrimination tasks that include speech and environmental sound stimuli.

3. Patients cannot understand speech with the implant alone, but those aspects of speech based on intensity and time are accessible to the implant recipient.

4. Most subjects can distinguish between voice and other sounds and they can also distinguish between male and female voices.

5. They can hear their own voices and this allows better control of volume, intonation and other aspects of voice production.

6. Some indicate that they can recognize the voices of highly familiar persons.

7. Implant recipients report feeling safer since they canhear warning signals such as sirens and fire alarms.

8. They feel more secure because they are able to hear door bells, telephones, someone's calling out to get their attention etc.

9. Many also are able to enjoy music, eventhough the postlingually deaf do not find it as pleasant as they did prior to their deafness.

10. some subjects have experienced a "nonauditory" benefit: a reduction in the level or amount of their tinnitus and vertigo.

BIBLIOGRAPHY

Alpiner, J.C., Cheurette, W., Glascoe, G., et al. The Denver scale of communicative function. Unpublished study, The University of Denver, Denver, Colorado, 1974.

Alpiner, J.G., Rehabilitation concepts with cochlear iaplant, Otolaryngol.Clin.North Am., 19 2), 1982.

Ballantyne, et al. Electrical auditory stimulation in the management of profound hearing loss. J.Laryngol. Oto.92, (Suppl), 1-117, 1978.

Banfai, P., Karczag, A., lucrs, S.P., Clinical results of rehabilitation. Acta Otolaryngol (stocKh), 411; 183-194, 1904.

Bebout. J., u.bdot: Cochlear implants-beyond the first generation. The Hq.J., 39, 7-15, 1986.

Berlinger, K.I., House, W.F., The cochlear implant program: An overview. Ann.Otol.Rhinol.Laryngol(Suppl), 91, (2 pt.3) 11-14, 1982.

Berlinger, K.I., Risks versus benefit in cochlear implantation. Ann.0tol.Rhinol.Laryngol(Suppl.), 91, 2 pt.3) 90-98, 1982.

Berlinger, K.I, and Edgerton, B.J., Issues in the assessment of candidates for cochlear implants (Letter). Arch. Otolaryngol. 109(4), 275-277. 1983.

Clark, et al. Clinical assessment of cochlear implant patients. J.Larvngol.Otol. 91(8), 697.1977.

Clark,, G.M., O'Loughtin, B.J., Rickards, F.W.Tona, Y.C., and Williams, A.J., The clinical assessment of cochlear implant patients. J.Laryngol.Otol. 91(8), 697-708, 1977.

Clark, et al. A multiple electrode cochlear implant. J.Lary. Otol., 91, 935-945, 1977.

Chouard and Macleod, Implantation of multiple intra cochlear electrodes for rehabilitation of total deafness. Preliminary report. Laryngoscope. 86, 1743-1751, 1976.

Chouard, C.H., The surgical rehabilitation of total deafness with the multichannel cochlear implant: indication and results, Audiology, 19, 137, 1980.

Chouard, C.H., The surgical rehabilitation of total deafness with the multiple cochlear implants. Radiology. 19, 137-145, 1980.

De Filippo, C.L., and Scott, B.L., A method for training and evaluating for reception of ongoing speech. JASA, 61, 1337-1351, 1978.

De Filippo, C.L., and Scott, B.L., A method for training and evaluating the reception of ongoing speech. JASA 63(4), 1186-1192, 1978.

Eddington, et al. Auditory prosthesis research with multiple channel intracochlear stimulation in man. Ann. Otol.Rhino.Laryngol.(suppl), 53-59, 1978.

Edgerton, B.J.,Rehabilitation and training of postlingually deaf adult cochlear implant patient. Sem.Hear. 6: 65-89, 1985.

Eisenberg, L.S., Nelson, J.R., and House, W.F., Effects of the single-electrode cochlear implant on the vestibular system of the profoundly deaf adult. Ann. Otol.Rhinol.Laryngol(Suppl), 91(2 pt 3), 47-54, 1982.

Fravel, Cochlear implant electronics made simple, Otolaryngol. Clin.North.Am. 19(2), 1982.

House, W.F., and Berlinger, K.I., Cochlear implant: Progress and perspectives. Ann.Otol.Rhinol.Laryngol(Suppl), 91, 1-124, 1982.

House, W.F., and Berlinger, K.I., The cochlear implant. Otolaryngol, Clin.North.Am, 15(4), 917-923, 1982.

Johnson, L.G., House, W.F., and Linthicum, F.H., Bilateral cochlear implants, histological findings in a pair of human temporal bones. Laryngoscope, 89, 759, 1978.

Lawrence, M., Otologic research and the Zeitgeist, In the 1982 Carhart Memorial Lecture. Ear Hear, 4(2), 72-78.

Lason, S.A., Asher, D.L., Balkany, T.J., and Rucker, N.C., Histopathology of the auditory nerve and cochlear electrical stimulation. Otolaryngol.Clin.North.Am. 16(1), 233-243, 1983.

Maddbx, H.E., and Porter, T.H., Who is a candidate for cochlear implantation? Otolaryngol.Clin.Nprth.Am., 16(1), 249-255, 1983.

Michelson,R.P., Electrical stimulation of the human cochlear, A Preliminary report. Arch.Otolary.93, 317-323, 1971.

Miller, J.M., Duckert, L.G., Malone, M.A., and Pfingst, B.E., Cochlear prosthesis; Stimulation-induced damage. Ann.Otol.Rhinol.Laryngol. 92(6 pt.1). 599-609,1983.

^ Owens, E., Kessler, D.K., and schubert, E.D., The minimal auditory capabilities (MAC) Battery. Hearing Aid J. 34, 9-34, 1981.

Owens, E., Kesslev, D.K., and Schubert, E.D., Interum assessment of candidates for cochlear implants. Arch.Otolaryngol. 108, 147-483, 1982.

Pialoux, P., Chouard, C.H., Meyer, B., and Fugain, C, Indications and results of the multicochlear implant. Acta. Otolaryngol. 87, 185-189, 1979.

Schindler, et al. Multiple channel cochlear implant: Patient selection, Laryngoscope, 96, 597-603, 1986.

Simmons, F.B., Electrical stimulation of the auditory nerve in man. Arch.Otolaryngol, 84, 2-54, 1966.

Sutton, D., and Miller, J.M., Cochlear implant effects on the Spiral ganglion. Ann.Otol+Rhinol.Laryngol. 92(1), 53-58, 1983.