COCHLEAR IMPLANTS FOR THE UNINITIATED

Reg,No.M9202

AN INDEPENDENT PROJECT WORK SUBMITTED IN PART FULFILMENT FOR FIRST YEAR M.Sc.(SPEECH AND HEARING) TO THE UNIVERSITY OF MYSORE.

ALL INDIA INSTITUTE OF SPEECH AND HEARING, MYSORE 570 06

MAY1993

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TO

Two teachers Whom I hold in
great esteem
Manjula mam and Venkatesh Sir

/AND/

To

Shashi for all the fights, long talks and laughter shared together

CERTIFICATE

This is to certify that this Independent Project entitled: Cochlear Implants For The Uninitiated is the bonafide work in part fulfilment for the degree of Master of Science(Speech and Hearing) of the student with Reg.No.M9202.

Mysore
May 1993.

Director
All India Institute of
Speech and Hearing
Mysore-6.

CERTIFICATE

This is to certify that the Independent Project entitled: Cochlear Implants For The Uninitiated has been prepared under ray supervision and guidance.

Mysore
May 1993.

Dr.(Miss) S.Nikam,
Guide

DECLARATION

I hereby declare that this Independent Project entitled: Cochlear Implants For The **Uninitiated is the result of my own study under the guidance of Dr.(Miss) S.Nikam, Prof. and HOD, Department of Audiology, and Director, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier to any University for any other Diploma or Degree.**

Mysore

May 1993. **Reg.No.M9202**

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INTRODUCTION

The human body is an assembly of remarkable bio-mechanisms igneously integrated and incorporating design features which cannot be duplicated as well or as completely by our current engineering knowledge. There are however, a growing number of artificial organs being manufactured on a production line basis.

The success statistics for a kidney/heart implant is increasing clay-by-day. In view of this patients are often curious to know whether their ear also could be implanted in a similar manner.

Most often, there is the misconception that the "new" ear can serve as well as any other normal ear. Throw away the rotten one and replace it with an efficiency one seems to be the feeling generated especially among **the** more optimistic patients.

Unfortunately, the ear is one nature's gifts which man has found difficult to replieate. In case of a kidney/heart implant it is the organ which is implanted but in a cochlear implant it is the sensation of hearing whieh is surgically simulated. As professionals, we are

aware that the cochlear implant has its limitations. While it does a lot and is a marvel in **itself;** there **are both'pluses'** and 'minuses' involved in using it.

This independent project has been developed as a handout to solve **some** of the queries a person may have with regards to cochlear implants. It addresses the following issues:

(1) What is a cochlear implant? How does it function?
(2) Some basic issues i**nvolved** in practical usage.
{3) Candidacy for cochlear implants - Can anyone use a cochlear implant?
(4) Cochlear implants for children.
(5) Myths and facts.
(6) The cochlear implant programme.

Whatr is a cochlear implant? How does it function?

The cochlear implant is a device that puts snail amounts of electrical current near the hearing nerve. The nerve **"hears"** this electrical current as sound.

In other words its an electronic device, a part of which is implanted in **the** ear and a part of **which** is worn externally like a hearing aid. It produces an electrical

signal that hypasses the damaged/missing hair cells to profound sensori-neural hearing loss and directly stimulates the remaining auditory (natural) elements.

For a better understanding of what a cochlear implant is; it is imperative to have some know-how regarding our ear and its functions.

Our ear is a wonderful organ of hearing. It is divided into: External Ear
Middle Ear
Inner Ear

Sound travels in the forms of waves via the external and middle ear into the inner ear. At the inner ear, the mechanical sound energy is converted into electrical energy. The electrical energy is then transmitted to our brain which gives the sensation of hearing.

Tiny cells in the inner ear (cochlea) called hair cells *are* responsible for this conversion (transduction).

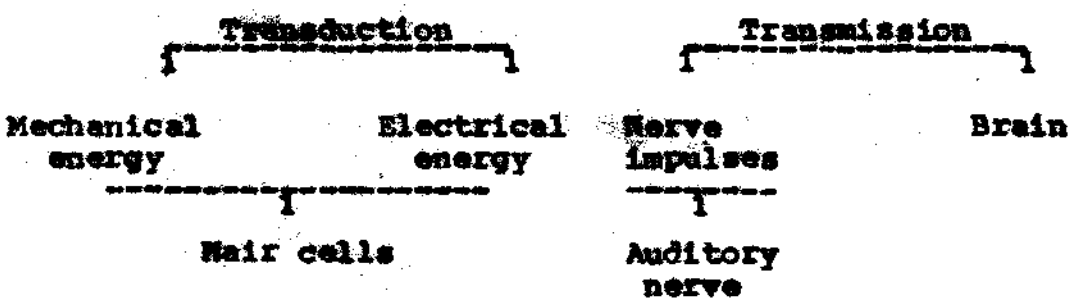
When someone has sensori-neural deafness; it does not necessarily mean) that the hearing nerve is dead. In most cases: the hearing nerve is good (or practically good) but the hair cells in the cochlea are damaged or destroyed.

Because of this there la no mechanism to turn sound into electrical current. The nerve cannot 'fire', so no sound is heard.

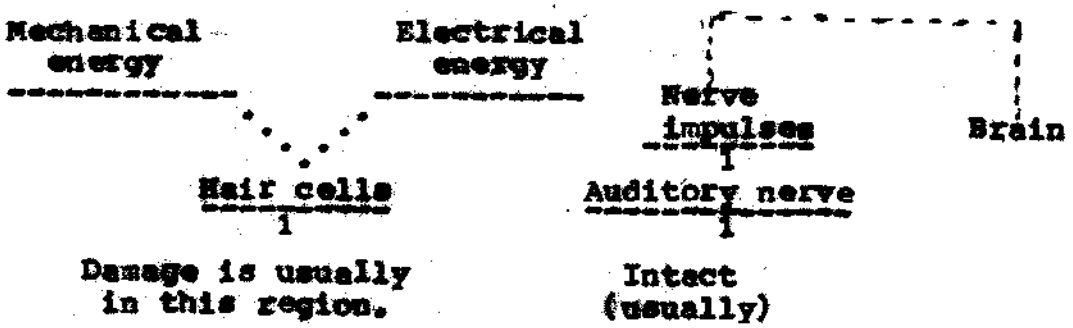
A cochlear implant has the same function as the hair cell. It turns sound into electrical current to stimulate the hearing nerve. A word of caution at this juncture.DO NOT GET OVER-ENTHUSIASTIC. This does not simulate normal hearing. What exactly is its contribution will be discussed in the following sections.

Given below is a pictorial representation of a comparison between normal ear and implant ear functioning.

NORMAL INNER EAR FUNCTION



EAR WITH SENSORI-NEURAL LOSS



EAR WITH COCHLEAR IMPLANT

Electrical energy-------Never impulses ------Brain

Via Electrode

In the inner ear

"Cochlear" in 'cochlear implant' refers to the cochlear part of the inner ear which is the place from which the device stimulates nerve fibres that enables the brain to hear sound, "Implant" refers to way the device is surgically placed under the skin behind the ear.

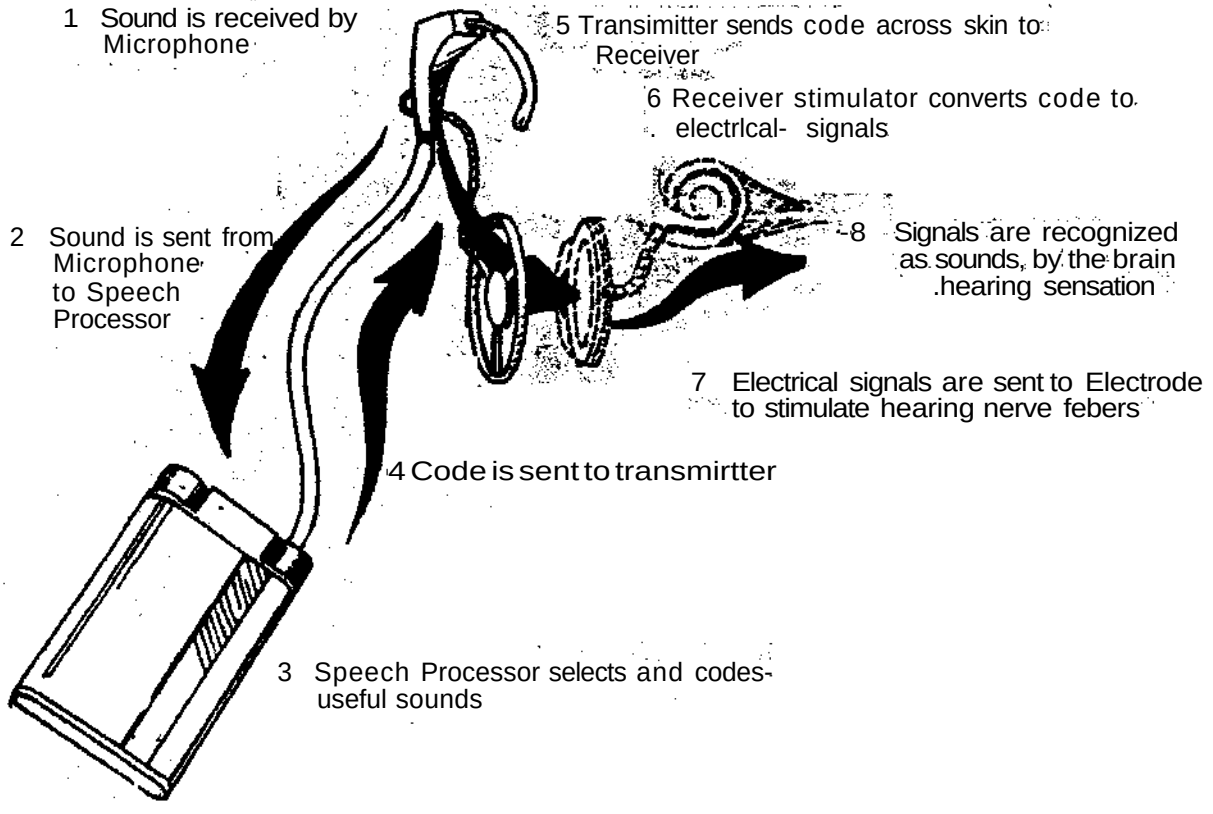
COMPONENTS OF A COCHLEAR IMPLANT

Although there are presently a variety of cochlear implants around the world, they all hare the same basic components. The cochlear implant is composed of two main parts:

(1) The internal part which is surgically implanted.
(ii) The external part which is worn on the outside of the body.

THE EXTERNAL BODY:- It is the one which turns sound into electrical current. It consists of a microphone, a signal processor and an external induction coil (Fig.No. 1).

How the Device Produce Hearing Sensation Step-By-Stop



The microphone picks up the sound changes it into small electric current and sends it to the signal processor. The signal processor modifies the electric current. The electric current is sent by way of a cord to the external coil and changed to a magnitic field. When the external coil is held over the internal coil, the magnetic field causes the current to flow through the internal coil and the electrodes. The electric current "stimulates" the hearing nerve.

Placement :

The signal processor is about the size of a body type hearing aid. Patients carry it in the way they find most comfortable. Men usually put it in a coat or shirt pocket. Women usually put it into a cloth bag and tuck or pin it into their blouses. Some put it into a pouch hung around their neck or strapped to their chest, waist or shoulder. Young children can wear it strapped around their back.

The microphone is put into one of several places:

(i) Mounted on eyeglass frames.

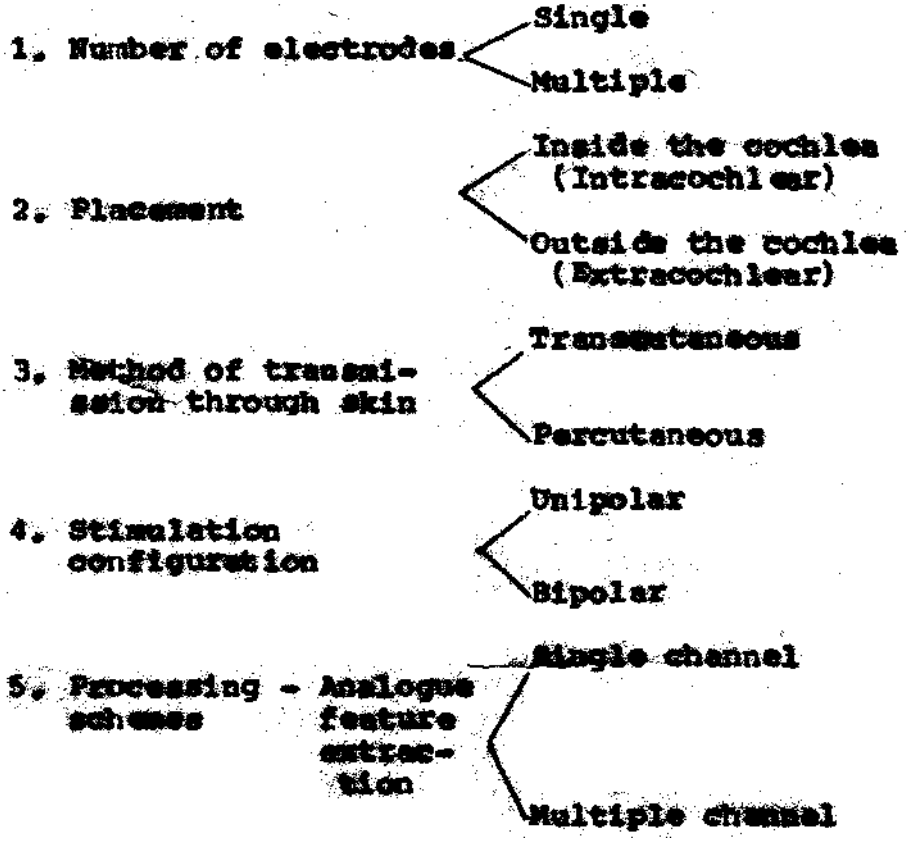
(11) In a loosely fitted earmold which goes into the ear on *the* same side as the implant.

(iii) Fitted over the ear.

(iv) Wipped to the cochlea.

The external coil must go directly over the skin that covers the internal coil, even by 1/8th of an inch, the sound will become softer or fade away completely. Holding the external coil in place is therefore crucial, It is held in place by a magnet incorporated into the internal coil.

Cochlear implants can be of several types. These vary depending upon several aspects vis.



TERMINOLOGY:

1) Electrodes and channels- Electrode pairs represent positive and negative polarity contacts between which electric current passes. A cochlear implant can have one or several electrode pairs.

It is important to remember, that the sound falling on our ear is not of a uniform nature. It is composed of different types of waveforms. At any given moment it can include, low/mid/high frequency sounds or a complex mixture of two/all of the above. Therefore, greater the number of electrode pairs, greater will be the information received at the brain. The word 'channels' is,used to designate the number of electrode pairs that are conveying different stimulus waveforms. Typically, the number of channels equals the number of electrode pairs. Each electrode receives a different waveform during stimulation. In a few cases the number of channels is less than the number of electrodes. In such a case, some/all electrodes receive the same waveform. Thus, its important to distinguish between channels and electrodes.

A.

Single and multiple channels:

Single electrode systems are limited because they can only be single channel devices. Multielectrode systems caa be either single channel or multichannel.

In the normal ear, as explained above, the travelling wave function to separate the frequency components of speech. Different components stimulate different regions on the hearing nerve. This is precisely what multichannel systems attempt to stimulate.

Extracochlear vs. intracochlear

Extra cochlear implants have electrodes placed outside the cochlea, usually with active electrode in the base of the cochlea (near a region called round window). Intra cochlear implants have electrodes placed inside the cochlea (usually inserted through round window). Advantage of intra-cochlear stimulation is that it places the electrodes close to the hearing nerve. Less current is therefore required.

There has been some concern expressed over intracoch-lear placement. It is feared that this might cause bone growth and damage nerve fibres. Although the long-term (30-40) years effects are unknown, many patients have used cochlear implants for over 10 years with no apparent decre-meat in their performance.

Analogue and pulsatile

Current presented on the electrodes can be a continuous analogue waveform or a series of pulses. Analogue waveform

can convey all the information about the speech signal. Different nerve fibres are stimulated at different times of the waveform depending upon the current reaching the fibre.

Pulsatile stimulation means a series of pulses Which represents a digitised sample of the original sound wave. It usually results in synchronous neural discharge corresponding to pulse onset.

Transcutaneous vs.Percutaneous:

These refer to the two general ways of passing the stimulus from the speech processor to the electrode. In a transcutaneous system a transmitter worn outside the skin is coupled to a receiver placed under the skin.

In percutaneous system, the signal is directly transmitted through the skin via a wire connection between the processor and a plug inserted into the skull. Such systems do not require either a transmitter or receiver The advantage here is that less power is required.

However, the external plug is susceptible to dirt, moisture and mechanical damage end it provides an external entrance for infection.

SOME QUERIES A USER MAY HAVE

Q. What kind of batteries does a processor use?

A. The processor uses two 1.5V alkaline batteries, the type used in body hearing aid.

Q. How long do the battery last?

A. Approximately three weeks.

Q. Can the signal processor be taken off at night?

A. Yes, It can be taken off any time it is not wanted. Its important however to turn off the volume control on the processor so that the batteries are not drained off.

Q. Will having the implant interfere with sports such aa football, swimming, cricket etc?

A, No. When engaged in these activities, the external part is removed. Same as the hearing aid is removed. A blow on the side of the head would not be more serious after the implant than before. One can participate in contact sports, but a helmet should be worn in sports such as football.

Q. Does the cochlear implant ever need repairs?

A. Yes.

Q. Where are the repairs done?

A. Some of the minor repairs can be done at the clinics where you receive your stimulator. For all the major ones, it must be sent to the manufacturer. This address will be provided in the warranty for the cochlear implant.

Q. Does the implant user pay for the repairs?

A. When the warranty expires, the implant user is responsible for all costs. Details regarding warranty varies depending upon place.

MYTHS AND FACTS ABOUT YOUR COCHLEAR IMPLANT

Myth - With cochlear implant people hear normally.

Fact - Patients who have had normal hearing and have lost it say that sound heard through a cochlear implant is very different from normal hearing. Gradually, over a period of months; the sound becomes clearer and it is reported to be a mechanical sound. They can tell that someone is talking or that there is music but these are not clear enough to be understood.

Patients who have never heard before, (congenital deafness) report of sensations in the head that gradually, over a period of months become sensation in the ear. These patients learn that the sensations are caused by sound.

Myth - A cochlear implant is akin to a kidney/heart implant.

Fact - A cochlea can never be truly replaced.

Myth - One does not need much time to learn to use one's implant.

Pact - Learning to use your implant well is a long process of learning to use a new type of sound. A great deal of learning is done in the first year but users never stop learning about sound through the implant. It is not unusual for a long time implant user (3 years or more) to report that they heard a new sound or that they still cannot identify certain sounds.

Myth - An implant user knows that kind of sounds he is hearing.

Fact - At first all sounds, sound almost alike. With training and experience patients learn to tell differences between sounds. Generally, with practise they can identify more and more sounds. Patients who remember what sounds are like learn to recognise sounds around them fairly easily. Congeaitally deaf patients must first learn that sound can be meaningful, then they can recognise some sounds.

Myth - Cochlear implant users can follow what people are saying without looking at them.

Fact - No. People can hear other people talking but cannot understand them through hearing alone. They cannot know what the other person is talking unless they face him and lip read.

Myth - Cochlear implant helps lip reading.

Fact - True. Implant users can hear the rhythm, pattern and intensity of speech. They report that sound along with watching face and lips makes lipread-ing easier. The amount of benefit derived will also depend upon the person's a priori'experience with sound and speech. Congenitally deaf may not benefit as much as those who once had hearing.

Myth - Implant users can differentiate between voices.

Fact - Many users report that sounds sound the same at first. Intime, most can differentiate between male and female voices. Some of them may learn to recognise familiar voices.

Myth - Implant users can hear their own voice.

Fact - Yes many say the sound of their own voice is strange at first. Very mechanised is the complaint his voice sounded like Donald Duck? After several weeks, they report their voice sounds more natural.

Myth - An implant can help control the volume of a person's voice.

Fact - Implant users can control the volume of their voice in two ways.

1) They learn since they can hear their own voice.

2) The Implant allows them to hear background noise. Moat patients learn to control the volume of their voice depending upon the level of background noise.

Myth - Implant users can use the telephone.

Pact - They cannot use the telephone to carry on a normal conversation but they may use the telephone in a limited way. They can hear it, ringing and differentiate between a dial tone, busy signal, ring or a voice on the phone. However, it may be necessary to use a telephone amplifier to hear these sounds. They can tell how many words/syllables the other person speaks. This enables them to give or receive a limited message using a code. The same may be learnt in therapy if desired.

Myth - The implant user understands TV better.

Fact - Many patients do not find it useful while watching TV. It should be borne in mind the lip reading is an essential part of a cochlear implant user. Most TV characters including news broadcasters are very difficult to speech read and this makes understanding difficult. Competing sounds such as laughter, music, background noise also may cause interference.

Myth - Implant users enjoy music.

Fact - *No*t true. Music is different from what they remember. Music is usually described as a jumble of noises. They can hear the rhythm of music and this helps them distinguish it from speech. They cannot tell many pitch differences however and cannot tell one song from another. Some of the users however, enjoy being able to hear rhythm and many can tell the difference between two instruments. Others feel they do not get enough information to enjoy music. Patients who are congenitally deaf are not acoustomed to the sound of music as normal hearing are and therefore enjoy it more than those deafned later in life.

Myth - Very soft sounds can be heard with an implant.

Fact - The implant allows patients to hear sounds that are of a medium or loud intensity. Very soft sounds such as whisper will not be heard.

Myth - Certain equipment around the implant may pose a problem.

fact — True. (1) If the signal processor is on and the Implant user is within 50 ft, of a powerful two-way radio transmitter they may hear a loud sound.

Powerful transmitters are usually found in police cars, ambulances or construction equipment. (2) Using any electronic device such as hair clippers, near the internal coil may cause the implant user to hear a sound like a hum. Usually this sound is soft. But, if the electric device is powerful the sound may be loud. No damage is done to the internal coil but it may be uncomfortable.

Myth - Implant effects tinnitus.

Fact - Many have found that they have less tinnitus while using the implant. Usually the reduction occurs only on the side of the implant. Not all patients however, have a reduction in headnoise.

Myth - Implant users can tell the direction from which the sound is coming.

Fact - No. The only exception is if a hearing aid is worn on the opposite ear or a patient has/implants on both ears.

It is hoped that the. above facts would have cleared many of the misconceptions an implant user might have had.

SURGICAL RISKS

Is an important consideration for a potential implant user. The surgical approach for the cochlear implant is essentially a mastoid operation and involves the same risks as other common otologic procedure: infection, facial paralysis and anaesthetic risks. These are all unusual complications and are often not serious in implanted patients.

There is not sufficient data on the long term risks of the electrical stimulation of the auditory nerve. However, there have been no serious complications observed in users.

Other conceivable risks, of cochlear implantation might be an increase in otologic symptoms such as tinnitus or diziness. Although temporary changes in these symptoms often occur following aa otologic surgery, there has been no permanent increase in symptoms as a result of the cochlear implant.

Another disadvantage is the susceptibility to internal coil. If an implanted coil device fails,revision surgery under local anaesthesia is essential. It should be borne in mind that this device is a rehabilitative device. No

matter what "benefit" can be shown on objective measures, no benefit will occur unless the patient uses the prosthesis. Willingness to use is an important indicator of its subjective value to the individual. Most users wear the device all day long every day. This is inspite of its rather bulky size and frequent expense of buying batteries. The **use** of implant by profoundly deaf individual must be regarded as the ultimate judgement that it is of significant benefit.

So far, we have discussed in lay-man terms. What a cochlear implant person hears. Technically he hears thus -

Auditory warble tone thresholds can be obtained across the frequency range **tested** (125-8000 Hz). With the signal processor set at **MCL** for speech thresholds range approximately from 30 dB HL to 65 dB HL at all frequencies which means at 45 to 55 dB HL, Thus, implant patients can hear some soft and most medium and loud sounds that occur in **the** environment (eg. normal conversational speech occurs at around 55 dB HL). Patients can also score significantly above chance on a number of closed set auditory discrimination tasks that include speech and environmental sounds stimuli.

Patients can tell differences in intensity and timing very well. Frequency discrimination is good for low frequencies.

WHO IS THE CANDIDATE FOR A COCHLEAR IMBLANT?

Not all patients of profound sensorineural deafness are eligible for cochlear implants. From the last one decade or so, cochlear implants have received wide spread publicity - and people often assume anyone with deafness is eligible. This is not so an individual must satisfy the following minimum criteria before he can go in for a cochlear implant.

I. Residualhearing:

- The patient must be totally deaf ie. in technical terms he must have no audiometric response even at maximum equipment limits. This is especially applicable to the speech ranges.

He must be unable to get any aid from even the most powerful of hearing aid.

- The second test involves some surgery. When the electrode is placed close to the round window and stimulated. One must get a positive response. In other words, testing must indicate that atleast a few auditory fibres are present.

There should be normal middle ear and eustachian tube functioning.

Good lip reading ability will assist post-operative rehabilitation procedure.

II Etiological factors:

Causes for profound sensorineural deafness are many. Certain cases of sensorineural deafness that might prevent implantation are:

a) Temporal bone fractures which results in extensive cochlear damage,
b) Bilateral acoustic neurema.
c) Congenital malformations Involving the cochlea.
d) Certain disease processes or syndromes in which deafness is present with other neurological/physical disabilities that may not make an implant feasible. With physical disabilities a patient may find it difficult to undergo the complex and lengthy rehabilitation process,
e) Obliteration of cochlea following meningitis should be ruled out through tomography of the cochlea.

III Age of the subjects:

Earlier only subjects ranging in age from (18-65 years) were considered. Of date children as young as 2 years have been implanted. Adults over the age of 75 years have also

been implanted. Age in itself is no longer an important variable in patient selection provided the subject is in good health for general anaesthesia and all other selection criteria are met.

IV. Age of onset of hearing loss:

Onset of 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. In case the deafness has been acquired consequent to toxic or traumatic causes, a minimum of 12 months must elapse after the first recognition of total (profound) deafness to allow for every possibility of spontaneous improve. ment of deafness. However, most practical purposes, the acquired hearing loss patients are at an advantage.

V. Psychological factors:

a) Non-institutionalised patients are only usually considered as candidates.
b) Cognitive dysfunctions (mental retardation etc) might severely retaind a subject's ability to integrate and use minimal auditory cues.
c) Motivation of the candidate is another important factor. Candidate must have realistic expectations.

COCHLEAR IMPLANTS FOR CHILDREN

Over the past few years, there have been rapid advances in this area of cochlear implants. Post-implantation results with children have been very promising. Following are the major benefits:

a) Positive effect on development of speech and language.
b) Positive effect on development of central auditory nervous system.
c) Better speech perception.

Selection criteria: The ones outlined below are quite general because each child must be considered in light of his/her own particular circumstances.

Paediatric patient selection criteris:

. Bilateral profound deafness
- Ages (2-17 years)
- No radiological contradictions.

Candidates should

* Demonstrate little or no benefit from amplification.
* Be enrolled in an educational programme with a strong auditory/oral component.

* Be psychologically and motivation ally suitable.
* Have appropriate family and educational expectations and support.

OTHER RELATED BENIFITS TO CHILDREN:

Besides those benefits related to communication skills, there are a number of other areas for potential benefit to children from the implant. Sound is important for the quantity, quality and effectiveness of the child's experience with objects. Noises made by objects and by actions upon objects excite the children towards exploration.

Early experience with sound may be important in developing basic concepts about sound and its meaningfulness Some early opportunities to learn that objects produce sounds, that sound signals an action in the environment and therefore the sound contains meaningful information about events in the environment may be an important determinant in whether a child can later in life make use of auditory input.

HELPING YOUR CHILD USE HIS IMPLANT :

The best way to help children get the most from the implant use is to make listening fun. It takes a lot of

practice to learn how to use auditory information the implant can provide. It is most important toset realistic goals for children. All sounds heard through the implant are initially similar. For this reason, the child should not be expected to respond to his/her name being called in a noisy environment (classroom) or to make sense of sounds occuring simultaneously. With practise, however, these goals can be accomplished. Spend a short time each day on auditory training tasks within the child's capabilities. Tasks such as developing spontaneous awareness to sounds or discriminating environmental sounds from one another, speech from non-speech would be appropriate. This should be done with sets of two, three/ four sounds.

Initially work upon gross discrimination about environmental sounds. For eg. the child may be asked to distinguish one from two door knocks; or a door knock from a bell. The number of items included is gradually increased. Next discrimination of speech sounds from environmental sounds is worked upon. Do not expect the child to make

fine discriminations without speech reading cues. It would not be realistic to expect the child to discriminate between several one syllable words with similar vowels. This will only make the task frustrating and listening is no longer fun.

THE COCHLEAR IMPLANT PROGRAM

A person going for a cochlear implant has lots of queries regarding the nature of hospital stay, duration, cost etc. The following section attempts to answer any such queries an individual may have.

There are six parts to a cochlear implant program:

a) Selection-two days

b) Pre-surgery appointments, surgery and hospital stay-three days.

c) Basic guidance - This occurs six months after surgery and takes approximately 20 hours of time with a therapist.

d) Six months follow-up - Occurs six months after the first day of rehabilitation and takes approximately two days.

e) Annual follow-up - This occurs at one year intervals from the first day of rehabilitation and takes approximately one/two days each year.

The two month wait before stimulation begins is necessary to ensure that the incision heals completely. Electrical stimulation begins once the incision is healed and the smelling is gone.

The basic guidance programe has three main parts:

a) Fitting the device -This involves setting and adjusting the signal processor so that sound is comfortable.

b) Audiological testing -This is done to see if the sotting is correct and to measure What the patient is hearing before any training.

c) Learning to use the device - This involves the training that will teach the patient how to use the sound heard through the signal processor. Different techniques that help make communication easier will also be taught.

Appointments for the basic guidance programme are scheduled at times that are convenient for both the patient and the therapist.

Whenever possible, it is adviseable to have a close friend, relative, spouse accompany the patient to the basic guidance sessions. This person can take part in the therapy session and can assist the patient with home assignments. He/she can give support at home.

Once the basic training has been completed and adequate information received, the follow-up sessions need not be provided at the same implant clinic.

Some cases may require intensive training. This might be suggested by the therapist to improve specific skills such as speech reading, speech/noise production or critical listening. In other cases, the patient may want to continue working with the therapist to improve these skills.

Follow- up sessions:

(i) The six-month follow-up session includes the following -

1) Updating of equipment
2) Adjusting and resetting signal processor
3) Testing
4) Additional training if required.

(ii) The first annual follow-up occurs one year after the person receives the cochlear implant ie. one year after the basic guidance period• Subsequently the patient is expected to report to the clinics once a year for as long as the doctor feels its necessary.

Team work in cochlear implantation:

Cochlear implantation is not the domain of the otologist alone. Surgery is infact a small part of the entire process. Several allied professionals work together to make this process a success. The following join hands -

1. Otologist
2. Audiologist
3. Physician
4. Speech Therapist
5. Teacher of the deaf
6. Psychologist and psychiatrist
7. Technician

MISCELLANEOUS

Some information that may come in handy for a potential user.

Some addresses where cochlear implantation is done:

Address	Appraximate	cost
1. Guys Hospital University College London.		Unknown
2. University of San Francisco Storz, USA.	CA	Rs.3,00,000 (for hardware only)
3. Vijaya Hospital Arcot Road Vadapalni Madras.	Rs.	1,50,000

Addresses of patients in our country who have been operated.

1. Bobby Parwaney
   6, Heel Kamal
   Peddar Road
   Bombay,

2. Ashish Kamath
   c-18
   Century staff flats
   World
   Bombay.

COMPILED FROM THE FOLLCWIHG SOURCES .

Questions and answers about the cochlear implant.

From the House Ear Institute

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