COCHLEAR IMPLANT

AND OTHER IMPLANTABLE HEARING AIDS

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DEFINITION

Cochlear implant is a device which helps children and adults with significant sensorineural hearing loss to have hearing and improved communication ability by inserting tiny electrodes which bypasses the damaged hair cells in the cochlear and directly stimulates the Cochlear Nerve producing signals that can then be interpreted by the brain as sound.

For patients who cannot obtain benefit from conventional hearing aids. Mainly for profound hearing loss. Called 'BIONIC EAR'

HISTORICAL BACKGROUND

- 1957 – Direct Auditory Nerve stimulation described by Djourno and Eyrieries (France)
- 1961 – Encouraged William House to develop Cochlea Implant
- OTHERS: Simmons, Michaelson, Banfai, Chouard, Clark, Eddington and Hochmairs
- 1973 – First wearable Single Channel CI developed by House.
- 1978 – First Multichannel CI by Clark
- 1981- First Pre-school aged child implanted.
- 1985 – Widespread Clinical trials as the Nucleus Multichannel CI
- 1987 – FDA approved use of CI in adults
- 1990 - Approved for Children over 2 years
- Till date – over 200,000 CI performed so far.

TYPES OF CI

- SINGLE CHANNEL
- MULTI – CHANNEL
- HYBRID – CI AND HEARING AID

SPEECH CODING STRATEGIES:

FEATURE EXTRACTION: Analysis of speech signal and extraction certain key features (that is Voicing, Intensity and Format frequencies)

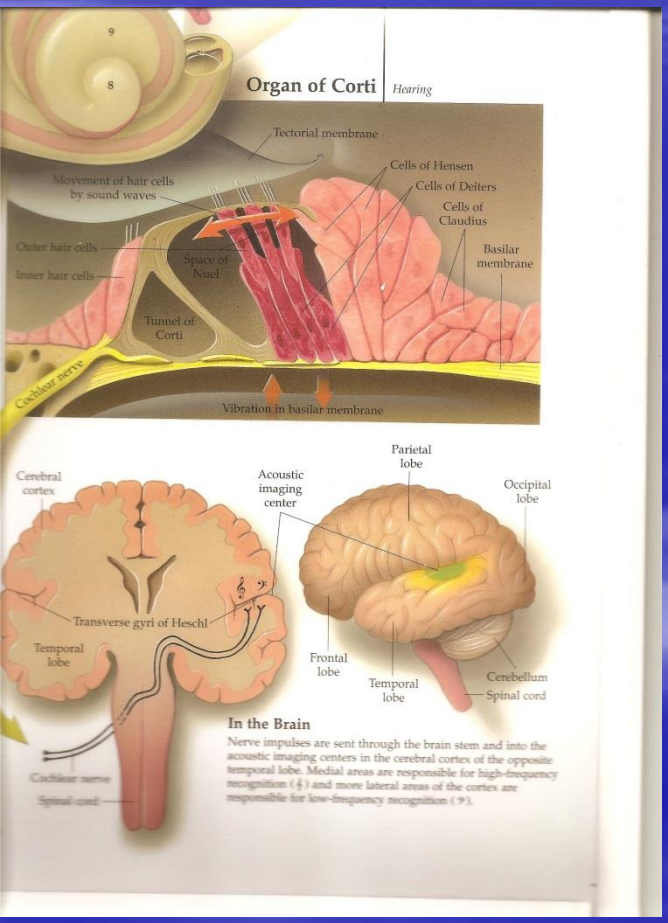
ANALOG : A filter bank separates the speech into frequency bands, transmitting full speech waveform, not just extracted features.

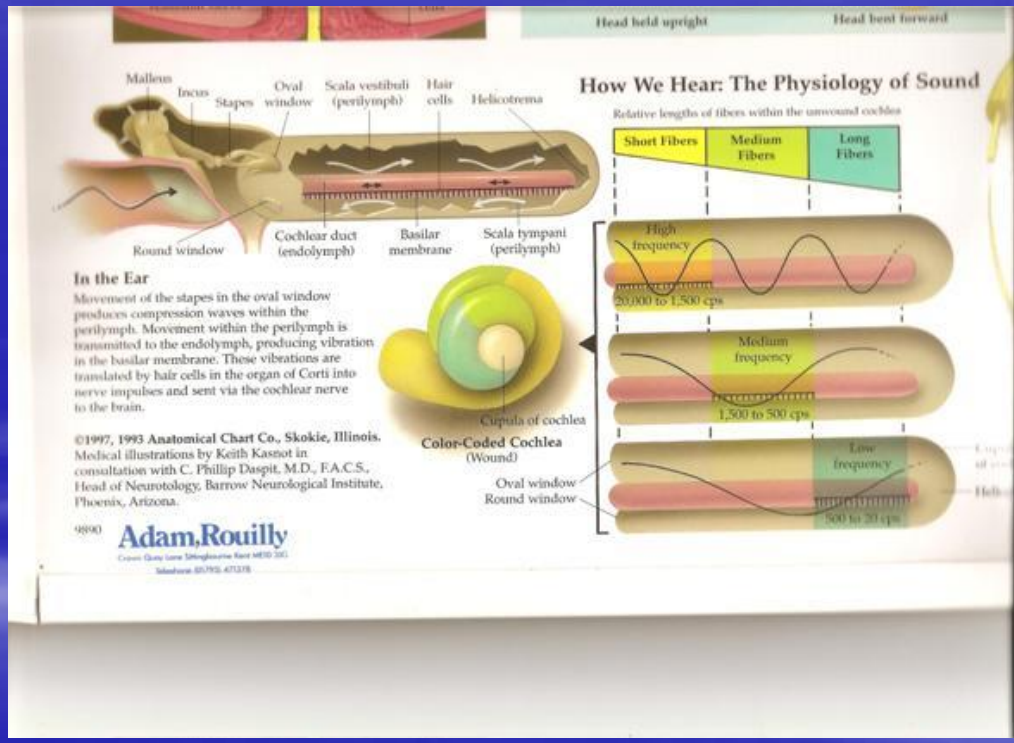
MECHANISM OF HEARING

- Sound travels by vibration of alternating phases of compression and rarefaction
- Pinna and ear canal directs the sound towards the tympanic membrane (TM).
- Tympanic Membrane conducts the sound through the ossicles to the footplate of stapes to oval window
- sound travels from oval window though the scala vestibuli and scala tympani
- The Bekesy wave causes the movement of basilar and tectorial membranes which are hinged at different points. The movement causes a “shearing” effect which bends the hair cell stereocilia. The bending depolarises the hair cell and hence sendng afferent electrical nerve impulses through the cochlear nerve to the brain (temporal lobe).

MECHANISM OF HEARING

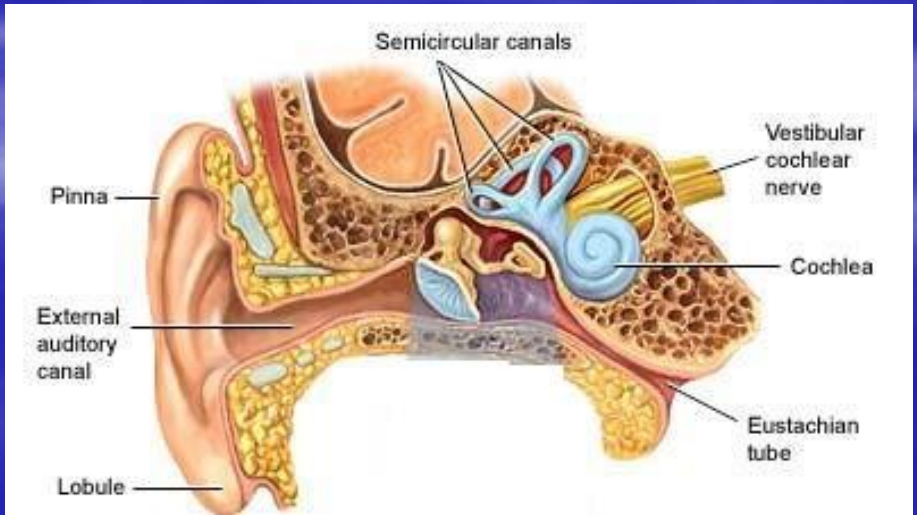
- SOUND CONDUCTION IN THE COCHLEAR





TYPES OF DEAFNESS

- CONDUCTIVE
- SENSORINEURAL (?NERVE DEAFNESS)



COMPONENTS

2 main parts:

The internal implant:

consists of an electronic package and magnet that is placed in the temporal bone and an electrode array that is placed inside the cochlea.

The external part:

consists of a microphone, cables, coil and a speech processor.

COMPONENTS OF CI

COMPONENTS OF CI

HEARING WITH A COCHLEAR IMPLANT

1. The microphone picks up sound.

2. A cable carries the sound to the speech processor.

3. The speech processor filters, analyses and digitises the sound into coded signals.

4. The coded signals are sent from the speech processor to the transmitting antenna, or coil.

5. When the coded signals get to the coil, they are converted to FM radio signals.

HEARING WITH A COCHLEAR IMPLANT 2

6. **The FM radio signals are sent or transmitted to the cochlear implant under the skin by electro-magnetic induction.**

7. **The cochlear implant delivers the electrical energy to the electrodes (up to 22 Electrodes) in the cochlear, based on the coded signals from the speech processor.**

8. **The electrodes stimulate the auditory nerve fibres, sending electrical sound information to the brain.**

***** REMOTE CONTROL FOR SPEECH PROCESSOR**

AETIOLOGY OF DEAFNESS

	Adult	Children
Unknown	64.3%	61.7%
Hereditary	21.4%	21.7%
Meningitis	1.8%	8.3%
Meniere's Disease	1.8%	-
Otoslerosis	1.8%	-
Ototoxicity	1.8%	-
Viral	1.8%	1.7%
Mondini Deformity	-	3.3%
Other	5.4%	3.3%

CI TEAM

- Neuro-Otologist or Ear Surgeon (Otologist)
- An Audiologist / Audiological Scientist.
- A Radiologist to read the CT Scan of the Inner Ear.
- Speech and Language Therapist.
- A Psychologist or Counsellor

INVESTIGATION

- Pure Tone Audiometry
- Speech Discrimination
- Tympanometry
- ABR
- Soundfield Testing

  Hearing in Noise Test (HINT)

  Early Speech Perception test (ESP)

  Meaningful Auditory Integration Scale (MAIS)

  Lexical Neighbourhood Test (LNT)

  Multisyllabic Lexical Neighbourhood Test (MLNT)

  Phonetically Balanced Kindergarten (Monosyllabic word lists) (PBK)
- CT Scan – to exclude cochlear ossification, inner ear deformities, internal auditory symmetry, mastoid pneumatisation and status of the middle ear.

CRITERIA

The deaf child **must** be issued with high-powered Digital hearing aids binaurally. Acceptable hearing aids include: Phonak Supero, Phonak Aero 311, Phonak Power Max 411, Oticon Spirit III SP.

Hearing aids **must** be set optimally using the Modernisation of Children's Hearing Aids Services (MCHAS) guidelines.

The deaf child **must** be consistently wearing their hearing aids for at least 6 hours per day across various environments (e.g. home, nursery, school etc). Children who are referred without hearing aid compliance will be discharged back to local services until compliance is achieved.

The deaf child **must** be suspected to have a severe to profound (greater than 90dB four frequency average) unaided hearing loss. Audiogram must be included

The deaf child **must** have been tested objectively with a click evoked Auditory Brainstem Response (ABR) test and/or high frequency Steady State Evoked Potentials (SSEP) and has a greater than 90dB threshold.

The deaf child will have an average, low frequency, aided hearing loss of greater than 40dB, and an average, high frequency loss of greater than 50dB

PRE-OPERATIVE EVALUATION

- Case History and Hearing Aid History
- Appraisal of Expectations (Hearing with CI is different)
- Commitment to attend all scheduled appointments during first year.
- Attendance of Cochlear Implant Support Group.
- The risks and complications of surgery. To be discussed and give printed sheets.
- Discuss the various devices available and explain features of each. Patients to decide on what they want.

SURGICAL PROCEDURE

- Routine Preparation
- Under G. A., Endotracheal Intubation with continuous intraoperative facial nerve monitoring.
- Post auricular Incision
- Mastoidectomy with bone overhang.
- Facial recess is opened
- Cochleostomy at the round window must be adequate
- Part of Temporalis muscle is removed and a seat is formed for the internal receiver. Suture tunnel holes are drilled adjacent to the seat to secure the internal receiver with Silk ties.
- Wound is closed in layers. Head dressing for 24hrs
- Operation takes about 3 hours.
- Could be done as day cases, some 2-3 days in hospital.

POST OPERATIVE CARE

- Routine care
- STEPS IN THE FIRST FITTING

Usually after 1 month after surgery.

1. Determine magnet strength for the transmitter
2. Measure electrical threshold levels
3. Measure electrical comfort levels.
4. Sweep electrode array and determine appropriate pitch perception
5. Balance volume of comfort levels across array in pairs or groups
6. Create map
7. Manipulate map for comfort

POST OPERATIVE CARE

8. Discuss and demonstrate speech processor control.
9. Demonstrate and dispense items in accessory kit
10. Warranty Information
11. Aural rehabilitation – practice with patients, learning to listen through CI, discuss adaptation and expectations and involve other members of the family in adjustment process.
12. Appts – next day, 2 weeks, 1 month and 3 months

OUTCOMES

- **The duration of hearing loss - the shorter the period of severe or profound deafness, the greater the benefit is likely to be.**
- **Status of the cochlea - some children are born with a malformed cochlea which can prevent insertion of cochlear implant or impact on the expected benefit with a cochlear implant**
- **Other medical conditions - in some children other medical conditions (for example an absent Cochlear nerve) can impact upon expected outcomes and benefits.**
- **Additional intellectual or language difficulties will also impact upon expected benefits and outcomes with a cochlear implant. Social factors also.**

COMPLICATIONS

- **General**

Facial weakness or Paralysis (rare).

Wound Infection.

Cerebrospinal fluid leakage

Meningitis

Usual risk of Anaesthesia

- **Specific**

Extrusion or failure of the device (2-5%) requiring removal and reimplantation.

Loss of residual hearing – unavoidable and must be discussed with patients pre-operatively.

COST

- IN USA - $45,000 TO $105,000 PER PERSON IMPLANTED
- IN UK – ABOUT £50,000 PER PERSON IMPLANTED

FACTORS AFFECTING OUTCOME

- Age at the onset of deafness
- Post lingual deaf perform better than prelingual
- Duration of deafness
- Surgery
- Motivation

RESULTS

- CI improves auditory cues, speech discrimination and speech production.
- Best candidates are

a) Post lingually deaf adults with a short duration of deafness.

b) Children implanted at a young age.

c) Postlingually deaf children in aural programs progress more rapidly

d) Prelingually deaf children show substantial benefit when implanted early but may not achieve maximum benefits if implanted at an older age.

COCHLEAR IMPLANT - HYBRID

- CI combined with hearing aid
- integrating high frequency information provided by a cochlear implant with low frequency information provided by a hearing aid.

BONE ANCHORED HEARING AID

- Hearing aid is attached to the temporal bone behind the ear with titanium screw which fuses with the bone (Osteo-integration) within six weeks.
- Transcranial conduction of sound to the cochlear.

MIDDLE EAR IMPLANT

- **The middle ear implant was invented in the early 90's. The first patient was implanted in 1996. FDA approval was granted in 2002. There are over 800 middle ear implant recipients worldwide.**

- **Sound is picked up from the Audio Processor and is transferred across the skin electromagnetically to the implanted receiver. The receiver then transmits the signal to the floating mass transducer which directly vibrates the ossicles (copying the way a "normal" ear moves the ossicular chain) and sends the signal to the cochlea. This ossicular motion moves the fluid in the cochlea that stimulates the hair cells in the cochlea. The hair cell movement stimulates the auditory nerve, which sends the signal to the brain for interpretation.**

BRAIN STEM IMPLANT

- In patients having surgery for Acoustic Neuroma in patients with Neurofibromatosis 2 (NF2)
- Electrodes are placed on the Cochlear Nucleus

DO CIs WORK?

- Better Communication - 90%
- Increased Confidence - 82%
- More social oppportunities – 62%
- Improved job performance – 33%
- Additional job opportunities – 28%

Thank you.